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ENGINE MECHANICAL

4.8L AND 6.0L

Engine Mechanical - 4.8L and 6.0L

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Cleaner Outlet Duct Clamp	7 N·m	62 lb in
Air Conditioning Belt Tensioner Bolt	50 N·m	37 lb ft
Battery Cable Channel Bolt	12 N·m	106 lb in
Camshaft Retainer Bolts	25 N·m	18 lb ft
Camshaft Sensor Bolt	25 N·m	18 lb ft
Camshaft Sprocket Bolts	35 N·m	26 lb ft
Connecting Rod Bolts – First Pass	20 N·m	15 lb ft
Connecting Rod Bolts – Final Pass	75 degrees	
Coolant Temperature Sensor	20 N·m	15 lb ft
Crankshaft Balancer Bolt – Installation Pass – to Ensure the Balancer is Completely Installed	330 N·m	240 lb ft
Crankshaft Balancer Bolt – First Pass – Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	50 N·m	37 lb ft
Crankshaft Balancer Bolt – Final Pass	140 degrees	
Crankshaft Bearing Cap Bolts – Inner Bolts – First Pass in Sequence	20 N·m	15 lb ft
Crankshaft Bearing Cap Bolts – Inner Bolts – Final Pass in Sequence	80 degrees	
Crankshaft Bearing Cap Bolts – Outer Bolts – First Pass in Sequence	20 N·m	15 lb ft
Crankshaft Bearing Cap Bolts – Outer Bolts – Final Pass in Sequence	51 degrees	
Crankshaft Bearing Cap Side Bolts	25 N·m	18 lb ft
Crankshaft Oil Deflector Nuts	25 N·m	18 lb ft
Crankshaft Position Sensor Bolt	25 N·m	18 lb ft
Crossbar Bolt	100 N·m	74 lb ft
Cylinder Head Bolts – First Pass all M11 Bolts in Sequence	30 N·m	22 lb ft
Cylinder Head Bolts – Second Pass all M11 Bolts in Sequence	90 degrees	
Cylinder Head Bolts – Final Pass all M11 Bolts in Sequence	70 degrees	
Cylinder Head Bolts – M8 Inner Bolts in Sequence	30 N·m	22 lb ft
Cylinder Head Coolant Plug	20 N·m	15 lb ft
Differential Carrier Lower Mounting Bolt/Nut	100 N·m	74 lb ft
Drive Belt Idler Pulley Bolt	50 N·m	37 lb ft
Drive Belt Tensioner Bolt	50 N·m	37 lb ft
Engine Block Coolant Drain Plugs	60 N·m	44 lb ft
Engine Block Heater	40 N·m	30 lb ft
Engine Block Oil Gallery Plugs	60 N·m	44 lb ft
Engine Coolant Air Bleed Pipe and Cover Bolts	12 N·m	106 lb in
Engine Flywheel Bolts – First Pass	20 N·m	15 lb ft
Engine Flywheel Bolts – Second Pass	50 N·m	37 lb ft
Engine Flywheel Bolts – Final Pass	100 N·m	74 lb ft
Engine Front Cover Bolts	25 N·m	18 lb ft
Engine Harness Ground Bolt – Right Rear	16 N·m	12 lb ft
Engine Harness Ground Bolt-to-Block	25 N·m	18 lb ft
Engine Mount Bolt-to-Engine Bracket	50 N·m	37 lb ft
Engine Mount Frame Bracket Through Bolt	75 N·m	55 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Engine Mount Frame Side Mount Bolt	65 N·m	50 lb ft
Engine Mount-to-Engine Bracket Bolt	50 N·m	37 lb ft
Engine Rear Cover Bolts	25 N·m	18 lb ft
Engine Service Lift Bracket M10 Bolts	50 N·m	37 lb ft
Engine Service Lift Bracket M8 Bolt	25 N·m	18 lb ft
Engine Shield Bolt	20 N·m	15 lb ft
Engine Valley Cover Bolts	25 N·m	18 lb ft
Engine Wiring Harness Bracket Nut	5 N·m	44 lb in
Evaporative Emission (EVAP) Purge Solenoid Bolt	10 N·m	89 lb in
Exhaust Manifold Bolts – First Pass	15 N·m	11 lb ft
Exhaust Manifold Bolts – Final Pass	25 N·m	18 lb ft
Exhaust Manifold Heat Shield Bolts	9 N·m	80 lb in
Fuel Rail Bolts	10 N·m	89 lb in
Fuel Rail Cover Bolt	9 N·m	80 lb in
Fuel Rail Crossover Tube Bolts	3.8 N·m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N·m	37 lb ft
Generator Bracket Bolt	50 N·m	37 lb ft
Generator Cable Nut	9 N·m	80 lb in
Heater Hose Bracket Nut	9 N·m	80 lb in
Hood Hinge Bolt	25 N·m	18 lb ft
Ignition Coil-to-Bracket Bolts	10 N·m	89 lb in
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolts	12 N·m	106 lb in
Inner Axle Housing Nut	100 N·m	74 lb ft
Intake Manifold Bolts – First Pass in Sequence	5 N·m	44 lb in
Intake Manifold Bolts – Final Pass in Sequence	10 N·m	89 lb in
Intake Manifold Sight Shield Bolts	10 N·m	89 lb in
Intake Manifold Sight Shield Bracket Bolts	5 N·m	45 lb in
Intake Manifold Sight Shield Retainer Bolt	5 N·m	44 lb in
Intake Manifold Wiring Harness Stud	10 N·m	89 lb in
Knock Sensors	20 N·m	15 lb ft
Mass Airflow/Intake Air Temperature (MAF/IAT) Sensor Clamp	7 N·m	62 lb in
Oil Filter	30 N·m	22 lb ft
Oil Filter Fitting	55 N·m	40 lb ft
Oil Level Indicator Tube Bolt	25 N·m	18 lb ft
Oil Level Sensor	13 N·m	115 lb in
Oil Pan Baffle Bolts	12 N·m	106 lb in
Oil Pan Closeout Cover Bolt – Left Side	9 N·m	80 lb in
Oil Pan Closeout Cover Bolt – Right Side	9 N·m	80 lb in
Oil Pan Cover Bolts	12 N·m	106 lb in
Oil Pan Drain Plug	25 N·m	18 lb ft
Oil Pan M8 Bolts – Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N·m	18 lb ft
Oil Pan M6 Bolts – Oil Pan-to-Rear Cover	12 N·m	106 lb in
Oil Pan Skid Plate Bolt	20 N·m	15 lb ft
Oil Pressure Sensor	20 N·m	15 lb ft
Oil Pump-to-Engine Block Bolts	25 N·m	18 lb ft
Oil Pump Cover Bolts	12 N·m	106 lb in
Oil Pump Relief Valve Plug	12 N·m	106 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Oil Pump Screen Nuts	25 N·m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N·m	106 lb in
Positive Battery Cable Clip Bolt	9 N·m	80 lb in
Power Steering Pump Rear Bolt	50 N·m	37 lb ft
Spark Plugs – New Cylinder Heads	20 N·m	15 lb ft
Spark Plugs – All Subsequent Installations	15 N·m	11 lb ft
Throttle Body Nuts	10 N·m	89 lb in
Throttle Body Studs	6 N·m	53 lb in
Torque Converter Bolt – 4L60-E/4L65-E Transmissions	63 N·m	47 lb ft
Torque Converter Bolt – 4L80-E/4L85-E Transmissions	60 N·m	44 lb ft
Transmission Bolt/Stud	50 N·m	37 lb ft
Transmission Cover Bolt	12 N·m	106 lb in
Transmission Oil Level Indicator Tube Nut	18 N·m	13 lb ft
Valve Lifter Guide Bolts	12 N·m	106 lb in
Valve Rocker Arm Bolts	30 N·m	22 lb ft
Valve Rocker Arm Cover Bolts	12 N·m	106 lb in
Water Inlet Housing Bolts	15 N·m	11 lb ft
Water Pump Bolts – First Pass	15 N·m	11 lb ft
Water Pump Bolts – Final Pass	30 N·m	22 lb ft

Engine Mechanical Specifications (LR4 VIN V)

Application	Specification	
	Metric	English
General		
Bore	96.0–96.018 mm	3.779–3.78 in
Compression Ratio	9.47:1	
Displacement	4.8L	293 CID
Engine Type	V8	
Firing Order	1–8–7–2–6–5–4–3	
RPO	LR4	
Stroke	83.0 mm	3.268 in
VIN	V	
Spark Plug Gap	1.02 mm	0.04 in
Block		
Camshaft Bearing Bore 1 and 5 Diameter	59.62–59.67 mm	2.347–2.349 in
Camshaft Bearing Bore 2 and 4 Diameter	59.12–59.17 mm	2.327–2.329 in
Camshaft Bearing Bore 3 Diameter	58.62–58.67 mm	2.307–2.309 in
Crankshaft Main Bearing Bore Diameter	69.871–69.889 mm	2.75–2.751 in
Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
Cylinder Bore Diameter	96.0–96.018 mm	3.779–3.78 in
Cylinder Bore Taper – Thrust Side	0.018 mm	0.0007 in
Cylinder Head Deck Height – Measuring from the Centerline of Crankshaft to the Deck Face	234.57–234.82 mm	9.235–9.245 in
Cylinder Head Deck Surface Flatness – Measured within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
Cylinder Head Deck Surface Flatness – Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in

Engine Mechanical Specifications (LR4 VIN V) (cont'd)

Application	Specification	
	Metric	English
Valve Lifter Bore Diameter	21.417–21.443 mm	0.843–0.844 in
Camshaft		
Camshaft End Play	0.025–0.305 mm	0.001–0.012 in
Camshaft Journal Diameter	54.99–55.04 mm	2.164–2.166 in
Camshaft Journal Out-of-Round	0.025 mm	0.001 in
Camshaft Lobe Lift – Exhaust	6.96 mm	0.274 in
Camshaft Lobe Lift – Intake	6.82 mm	0.268 in
Camshaft Runout – Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
Connecting Rod Bearing Clearance – Production	0.023–0.065 mm	0.0009–0.0025 in
Connecting Rod Bearing Clearance – Service	0.023–0.076 mm	0.0009–0.003 in
Connecting Rod Bore Diameter – Bearing End	56.505–56.525 mm	2.224–2.225 in
Connecting Rod Bore Out-of-Round – Bearing End – Production	0.004–0.008 mm	0.00015–0.0003 in
Connecting Rod Bore Out-of-Round – Bearing End – Service	0.004–0.008 mm	0.00015–0.0003 in
Connecting Rod Side Clearance	0.11–0.51 mm	0.00433–0.02 in
Crankshaft		
Connecting Rod Journal Diameter – Production	53.318–53.338 mm	2.0991–2.0999 in
Connecting Rod Journal Diameter – Service	53.308 mm	2.0987 in
Connecting Rod Journal Out-of-Round – Production	0.005 mm	0.0002 in
Connecting Rod Journal Out-of-Round – Service	0.01 mm	0.0004 in
Connecting Rod Journal Taper – Maximum for 1/2 of Journal Length – Production	0.005 mm	0.0002 in
Connecting Rod Journal Taper – Maximum for 1/2 of Journal Length – Service	0.02 mm	0.00078 in
Crankshaft End Play	0.04–0.2 mm	0.0015–0.0078 in
Crankshaft Main Bearing Clearance – Production	0.02–0.052 mm	0.0008–0.0021 in
Crankshaft Main Bearing Clearance – Service	0.02–0.065 mm	0.0008–0.0025 in
Crankshaft Main Journal Diameter – Production	64.992–65.008 mm	2.558–2.559 in
Crankshaft Main Journal Diameter – Service	64.992 mm	2.558 in
Crankshaft Main Journal Out-of-Round – Production	0.003 mm	0.000118 in
Crankshaft Main Journal Out-of-Round – Service	0.008 mm	0.0003 in
Crankshaft Main Journal Taper – Production	0.01 mm	0.0004 in
Crankshaft Main Journal Taper – Service	0.02 mm	0.00078 in
Crankshaft Rear Flange Runout	0.05 mm	0.002 in
Crankshaft Reluctor Ring Runout – Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
Crankshaft Thrust Surface – Production	26.14–26.22 mm	1.029–1.0315 in
Crankshaft Thrust Surface – Service	26.22 mm	1.0315 in
Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
Cylinder Head Height/Thickness – Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
Surface Flatness – Block Deck – Measured within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
Surface Flatness – Block Deck – Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
Surface Flatness – Exhaust Manifold Deck	0.13 mm	0.005 in
Surface Flatness – Intake Manifold Deck	0.08 mm	0.0031 in

Engine Mechanical Specifications (LR4 VIN V) (cont'd)

Application	Specification	
	Metric	English
Valve Guide Installed Height – Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
Surface Flatness – Measured at Gasket Sealing Surfaces and Measured within a 200 mm (7.87 in) Area that Includes Two Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
Oil Capacity – with Filter	5.68 liters	6.0 quarts
Oil Capacity – without Filter	4.73 liters	5.0 quarts
Oil Pressure – Minimum – Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM
Oil Pan		
Front Cover Alignment – at Oil Pan Surface	0.0–0.5 mm	0.0–0.02 in
Rear Cover Alignment – at Oil Pan Surface	0.0–0.5 mm	0.0–0.02 in
Oil Pan Alignment – to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0–0.25 mm	0.0–0.01 in
Piston Rings		
Piston Ring End Gap – First Compression Ring – Measured in Cylinder Bore – Production	0.23–0.44 mm	0.009–0.017 in
Piston Ring End Gap – First Compression Ring – Measured in Cylinder Bore – Service	0.23–0.5 mm	0.009–0.0196 in
Piston Ring End Gap – Second Compression Ring – Measured in Cylinder Bore – Production	0.44–0.7 mm	0.017–0.027 in
Piston Ring End Gap – Second Compression Ring – Measured in Cylinder Bore – Service	0.44–0.76 mm	0.0173–0.03 in
Piston Ring End Gap – Oil Control Ring – Measured in Cylinder Bore – Production	0.18–0.75 mm	0.007–0.029 in
Piston Ring End Gap – Oil Control Ring – Measured in Cylinder Bore – Service	0.18–0.81 mm	0.007–0.032 in
Piston Ring to Groove Clearance – First Compression Ring – Production	0.04–0.085 mm	0.00157–0.00335 in
Piston Ring to Groove Clearance – First Compression Ring – Service	0.04–0.085 mm	0.00157–0.00335 in
Piston Ring to Groove Clearance – Second Compression Ring – Production	0.04–0.078 mm	0.00157–0.0031 in
Piston Ring to Groove Clearance – Second Compression Ring – Service	0.04–0.078 mm	0.00157–0.0031 in
Piston Ring to Groove Clearance – Oil Control Ring – Production	0.012–0.2 mm	0.0005–0.0078 in
Piston Ring to Groove Clearance – Oil Control Ring – Service	0.012–0.2 mm	0.0005–0.0078 in
Pistons and Pins		
Pin – Piston Pin Clearance to Piston Pin Bore – Production	0.002–0.01 mm	0.00008–0.0004 in
Pin – Piston Pin Clearance to Piston Pin Bore – Service	0.002–0.015 mm	0.00008–0.0006 in
Pin – Piston Pin Diameter	23.952–23.955 mm	0.943–0.943 in
Pin – Piston Pin Fit in Connecting Rod Bore – Production	0.007–0.02 mm	0.00027–0.00078 in
Pin – Piston Pin Fit in Connecting Rod Bore – Service	0.007–0.022 mm	0.00027–0.00086 in
Piston – Piston Diameter – Measured Over Skirt Coating	96.002–96.036 mm	3.779–3.78 in
Piston – Piston to Bore Clearance – Production	–0.036 to 0.016 mm	–0.0014 to 0.0006 in
Piston – Piston to Bore Clearance – Service Limit with Skirt Coating Worn Off	0.071 mm	0.0028 in

Engine Mechanical Specifications (LR4 VIN V) (cont'd)

Application	Specification	
	Metric	English
Valve System		
Valves ± Valve Face Angle	45 degrees	
Valves ± Valve Face Width	1.25 mm	0.05 in
Valves ± Valve Lash	Net Lash ± No Adjustment	
Valves ± Valve Lift ± Intake	11.6 mm	0.457 in
Valves ± Valve Lift ± Exhaust	11.85 mm	0.466 in
Valves ± Valve Seat Angle	46 degrees	
Valves ± Valve Seat Runout	0.05 mm	0.002 in
Valves ± Valve Seat Width ± Exhaust	1.78 mm	0.07 in
Valves ± Seat Width ± Intake	1.02 mm	0.04 in
Valves ± Valve Stem Diameter ± Production	7.955±7.976 mm	0.313±0.314 in
Valves ± Valve Stem Diameter ± Service	7.95 mm	0.313 in
Valves ± Stem-to-Guide Clearance ± Production ± Intake	0.025±0.066 mm	0.001±0.0026 in
Valves ± Stem-to-Guide Clearance ± Service ± Intake	0.093 mm	0.0037 in
Valves ± Stem-to-Guide Clearance ± Production ± Exhaust	0.025±0.066 mm	0.001±0.0026 in
Valves ± Stem-to-Guide Clearance ± Service ± Exhaust	0.093 mm	0.0037 in
Rocker Arms ± Valve Rocker Arm Ratio	1.70:1	
Valve Springs ± Valve Spring Free Length	52.9 mm	2.08 in
Valve Springs ± Installed Height	45.75 mm	1.8 in
Valve Springs ± Valve Spring Load ± Closed	340 N at 45.75 mm	76 lb at 1.8 in
Valve Springs ± Valve Spring Load ± Open	980 N at 33.55 mm	220 lb at 1.32 in

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Engine Mechanical Specifications (LQ4 VIN U)

Application	Speci®cation	
	Metric	English
General		
Engine Type	V8	
Displacement	6.0L	364 CID
RPO	LQ4	
VIN	U	
Bore	101.618±101.636 mm	4.0007±4.0014 in
Stroke	92.0 mm	3.622 in
Compression Ratio	9.41:1	
Firing Order	1-8-7-2-6-5-4-3	
Spark Plug Gap	1.02 mm	0.04 in
Block		
Camshaft Bearing Bore 1 and 5 Diameter	59.62±59.67 mm	2.347±2.349 in
Camshaft Bearing Bore 2 and 4 Diameter	59.12±59.17 mm	2.327±2.329 in
Camshaft Bearing Bore 3 Diameter	58.62±58.67 mm	2.307±2.309 in
Crankshaft Main Bearing Bore Diameter	69.871±69.889 mm	2.75±2.751 in
Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
Cylinder Bore Diameter	101.618±101.636 mm	4.0007±4.0017 in

Engine Mechanical Specifications (LQ4 VIN U) (cont'd)

Application	Specification	
	Metric	English
Cylinder Bore Taper – Thrust Side	0.018 mm	0.0007 in
Cylinder Head Deck Height – Measuring from the Centerline of Crankshaft to the Deck Face	234.57–234.82 mm	9.235–9.245 in
Cylinder Head Deck Surface Flatness – Measured within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
Cylinder Head Deck Surface Flatness – Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in
Valve Lifter Bore Diameter	21.417–21.443 mm	0.843–0.844 in
Camshaft		
Camshaft End Play	0.025–0.305 mm	0.001–0.012 in
Camshaft Journal Diameter	54.99–55.04 mm	2.164–2.166 in
Camshaft Journal Out-of-Round	0.025 mm	0.001 in
Camshaft Lobe Lift – Exhaust	7.13 mm	0.281 in
Camshaft Lobe Lift – Intake	6.96 mm	0.274 in
Camshaft Runout – Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
Connecting Rod Bearing Clearance – Production	0.023–0.065 mm	0.0009–0.0025 in
Connecting Rod Bearing Clearance – Service	0.023–0.076 mm	0.0009–0.003 in
Connecting Rod Bore Diameter – Bearing End	56.505–56.525 mm	2.224–2.225 in
Connecting Rod Bore Out-of-Round – Bearing End – Production	0.006 mm	0.0002 in
Connecting Rod Bore Out-of-Round – Bearing End – Service	0.006 mm	0.0002 in
Connecting Rod Side Clearance	0.11–0.51 mm	0.00433–0.02 in
Crankshaft		
Connecting Rod Journal Diameter – Production	53.318–53.338 mm	2.0991–2.0999 in
Connecting Rod Journal Diameter – Service	53.308 mm	2.0987 in
Connecting Rod Journal Out-of-Round – Production	0.005 mm	0.0002 in
Connecting Rod Journal Out-of-Round – Service	0.01 mm	0.0004 in
Connecting Rod Journal Taper – Maximum for 1/2 of Journal Length – Production	0.005 mm	0.0002 in
Connecting Rod Journal Taper – Maximum for 1/2 of Journal Length – Service	0.02 mm	0.00078 in
Crankshaft End Play	0.04–0.2 mm	0.0015–0.0078 in
Crankshaft Main Bearing Clearance – Production	0.02–0.052 mm	0.0008–0.0021 in
Crankshaft Main Bearing Clearance – Service	0.02–0.065 mm	0.0008–0.0025 in
Crankshaft Main Journal Diameter – Production	64.992–65.008 mm	2.558–2.559 in
Crankshaft Main Journal Diameter – Service	64.992 mm	2.558 in
Crankshaft Main Journal Out-of-Round – Production	0.003 mm	0.000118 in
Crankshaft Main Journal Out-of-Round – Service	0.008 mm	0.0003 in
Crankshaft Main Journal Taper – Production	0.01 mm	0.0004 in
Crankshaft Main Journal Taper – Service	0.02 mm	0.00078 in
Crankshaft Rear Flange Runout	0.05 mm	0.002 in
Crankshaft Reluctor Ring Runout – Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
Crankshaft Thrust Surface – Production	26.14–26.22 mm	1.029–1.0315 in
Crankshaft Thrust Surface – Service	26.22 mm	1.0315 in
Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
Cylinder Head Height/Thickness – Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in

Engine Mechanical Specifications (LQ4 VIN U) (cont'd)

Application	Specification	
	Metric	English
Surface Flatness – Block Deck – Measured within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
Surface Flatness – Block Deck – Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
Surface Flatness – Exhaust Manifold Deck	0.13 mm	0.005 in
Surface Flatness – Intake Manifold Deck	0.08 mm	0.0031 in
Valve Guide Installed Height – Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
Surface Flatness – Measured at Gasket Sealing Surfaces and Measured within a 200 mm (7.87 in) Area that Includes Two Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
Oil Capacity – with Filter	5.68 liters	6.0 quarts
Oil Capacity – without Filter	4.73 liters	5.0 quarts
Oil Pressure – Minimum – Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM
Oil Pan		
Front Cover Alignment – at Oil Pan Surface	0.0–0.5 mm	0.0–0.02 in
Rear Cover Alignment – at Oil Pan Surface	0.0–0.5 mm	0.0–0.02 in
Oil Pan Alignment – to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0–0.25 mm	0.0–0.01 in
Piston Rings		
Piston Ring End Gap – First Compression Ring – Measured in Cylinder Bore – Production	0.31–0.52 mm	0.012–0.02 in
Piston Ring End Gap – First Compression Ring – Measured in Cylinder Bore – Service	0.31–0.59 mm	0.0122–0.023 in
Piston Ring End Gap – Second Compression Ring – Measured in Cylinder Bore – Production	0.51–0.77 mm	0.02–0.03 in
Piston Ring End Gap – Second Compression Ring – Measured in Cylinder Bore – Service	0.51–0.84 mm	0.02–0.033 in
Piston Ring End Gap – Oil Control Ring – Measured in Cylinder Bore – Production	0.31–0.87 mm	0.0122–0.034 in
Piston Ring End Gap – Oil Control Ring – Measured in Cylinder Bore – Service	0.31–0.94 mm	0.0122–0.037 in
Piston Ring to Groove Clearance – First Compression Ring – Production	0.04–0.08 mm	0.00157–0.0031 in
Piston Ring to Groove Clearance – First Compression Ring – Service	0.04–0.08 mm	0.00157–0.0031 in
Piston Ring to Groove Clearance – Second Compression Ring – Production	0.039–0.079 mm	0.0015–0.0031 in
Piston Ring to Groove Clearance – Second Compression Ring – Service	0.039–0.079 mm	0.0015–0.0031 in
Piston Ring to Groove Clearance – Oil Control Ring – Production	0.015–0.199 mm	0.0006–0.0078 in
Piston Ring to Groove Clearance – Oil Control Ring – Service	0.015–0.199 mm	0.0006–0.0078 in
Pistons and Pins		
Pin – Piston Pin Clearance to Piston Pin Bore – Production	0.002–0.01 mm	0.00008–0.0004 in
Pin – Piston Pin Clearance to Piston Pin Bore – Service	0.002–0.015 mm	0.00008–0.0006 in
Pin – Piston Pin Diameter	23.952–23.955 mm	0.943–0.943 in

Engine Mechanical Specifications (LQ4 VIN U) (cont'd)

Application	Specification	
	Metric	English
Pin – Piston Pin Fit in Connecting Rod Bore – Production	0.007-0.02 mm	0.00027-0.00078 in
Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
Piston - Piston Diameter - Measured Over Skirt Coating	101.606-101.640 mm	4.0002-4.0016 in
Piston - Piston to Bore Clearance - Production	0.022-0.03 mm - interference	0.0009-0.0012 in - interference
Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.07 mm	0.0028 in
Valve System		
Valves - Valve Face Angle	45 degrees	
Valves - Valve Face Width	1.25 mm	0.05 in
Valves - Valve Lash	Net Lash - No Adjustment	
Valves - Valve Lift - Intake	11.79 mm	0.464 in
Valves - Valve Lift - Exhaust	12.16 mm	0.479 in
Valves - Valve Seat Angle	46 degrees	
Valves - Valve Seat Runout	0.05 mm	0.002 in
Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
Valves - Valve Seat Width - Intake	1.02 mm	0.04 in
Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
Valve Springs - Valve Spring Installed Height	45.75 mm	1.8 in
Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

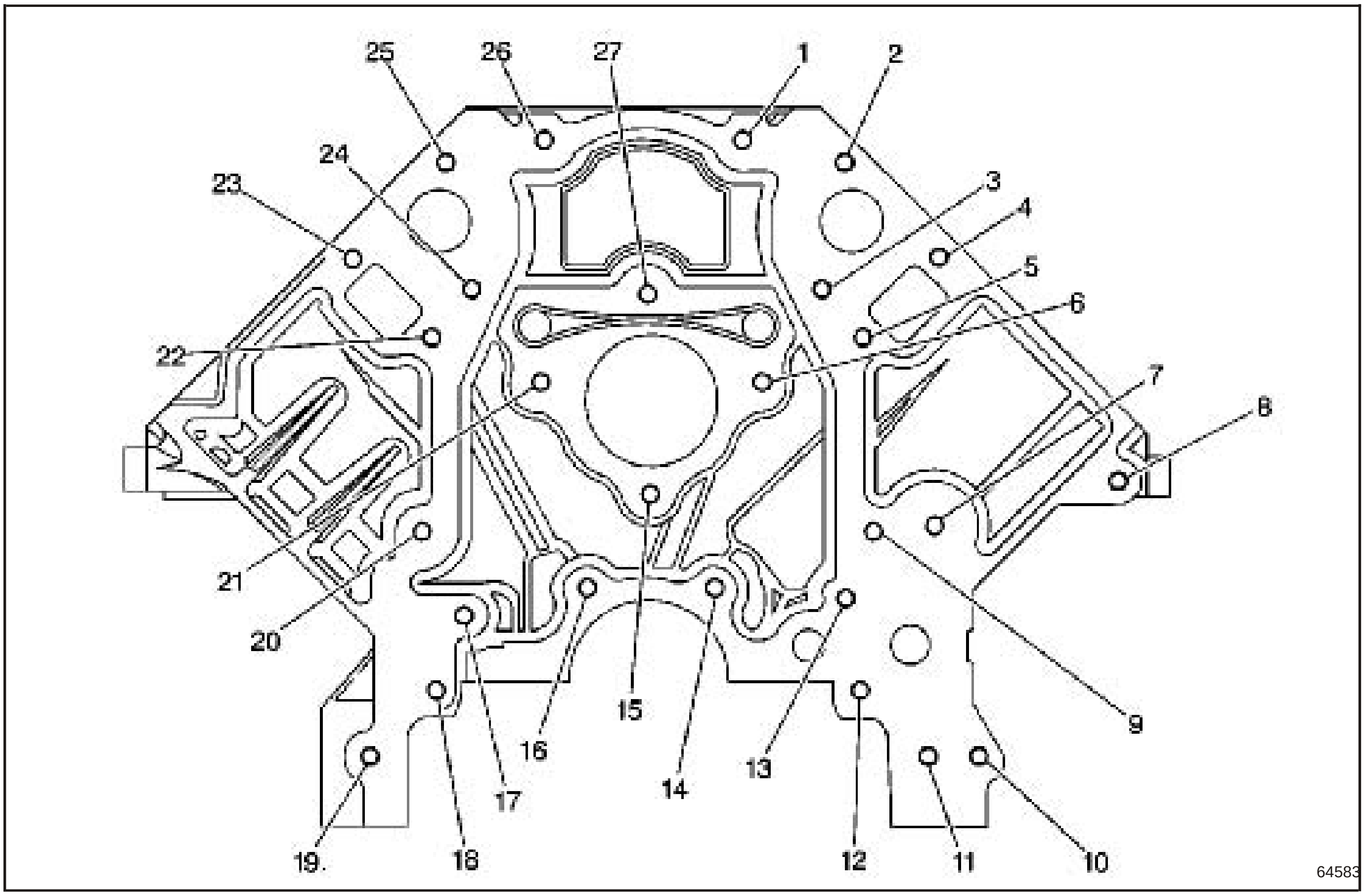
PAGES 6-6- AND 6-17 BLANK

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Sensor Threads	Sealant	12346004	10953480
Cylinder Head Core Hole Plugs	Threadlock	12345382	10953489
Cylinder Head Expansion Plugs ± Aluminum	Threadlock	12345382	10953489
Engine Block Front Oil Gallery Plug	Threadlock	12345382	10953489
Engine Block Plug Sealing Washers	Sealant	12346004	10953480
Engine Flywheel Bolt Threads	Threadlock	12345382	10953489
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolt Threads	Threadlock	12345493	10953488
Fuel Rail Bolt Threads	Threadlock	12345382	10953489
Ignition Coil and Bracket Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket Bolts	Threadlock	12345382	10953489
Intake Manifold Bolt Threads	Threadlock	12345382	10953489
Oil Pan Surface at Front and Rear Covers	Sealant	12378190	Ð
Oil Pressure Sensor Threads	Sealant	12346004	10953480
Thread Repair Component Cleaner	Cleaner	12346139	10953463
Thread Repair Component Cleaner	Cleaner	12377981	10953463
Thread Repair Cutting Oil	Lubricant	1052864	992881

Thread Repair Specifications

Engine Block – Front View



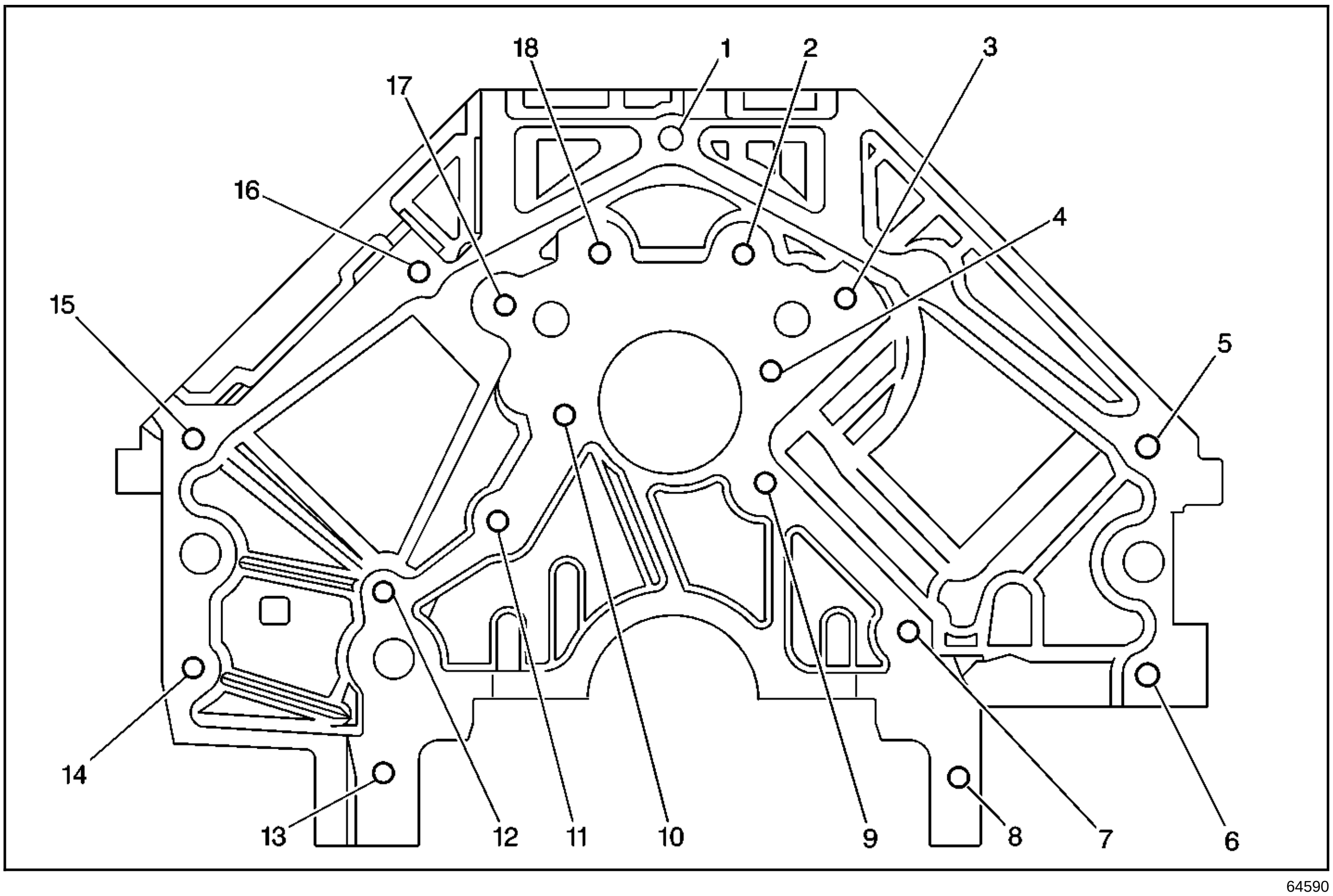
Engine Block - Front View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1–6	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
7	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	25.0 (0.984)	19.5 (0.767)
8	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	32.5 (1.28)	25.0 (0.984)
9	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
10	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	Thru	Thru

Engine Block – Front View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
11–13	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
14	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
15	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
16	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
17–27	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block – Rear View



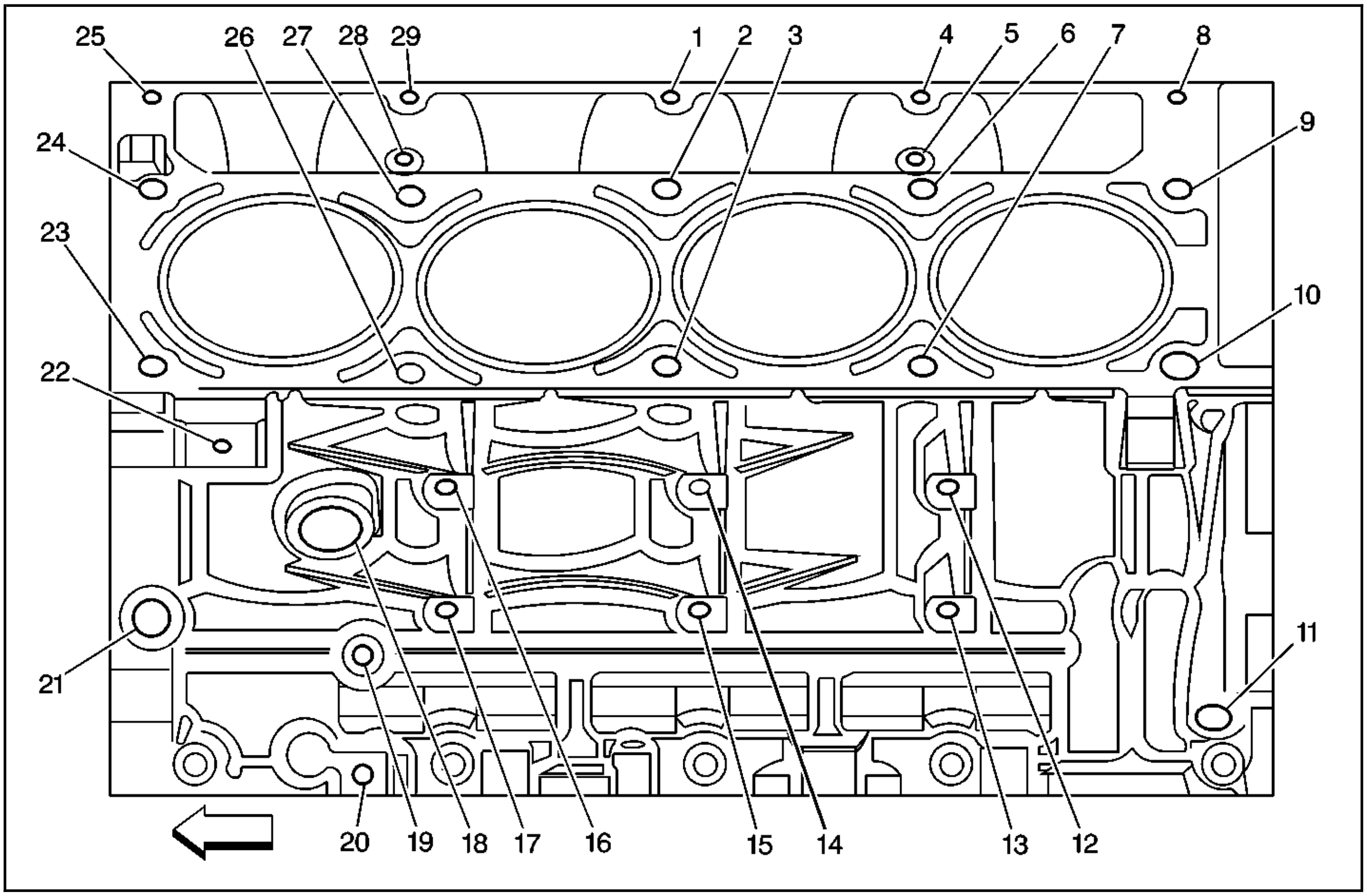
Engine Block – Rear View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
2–4	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
5–6	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
7–13	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block – Rear View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
14–16	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
17–18	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block – Left Side View

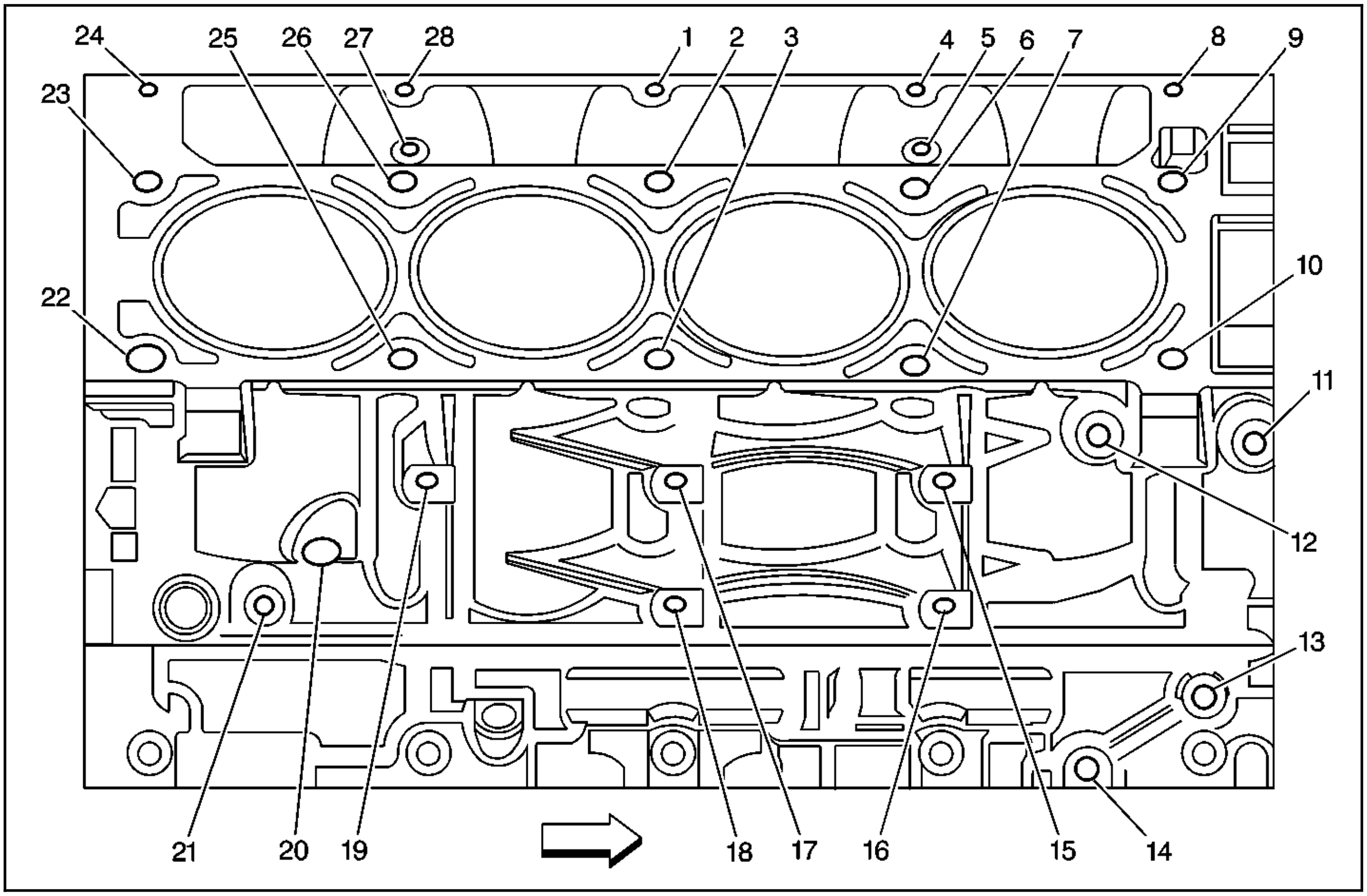


Engine Block – Left Side View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
2–3	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
4	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
5	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	16.0 (0.629)
6–7	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
8	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
9	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)

Engine Block – Left Side View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
10	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
11	M16 x 1.5	—	—	—	—	—	—	—
12–17	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	29.0 (1.14)	23.0 (0.905)
18	M28 x 1.25	—	—	—	—	—	—	—
19–20	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
21	M16 x 1.5	—	—	—	—	—	—	—
22	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
23	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
24	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
25	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
26–27	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
28	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	16.0 (0.629)
29	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
Bolt holes 2, 3, 6, 7, 9, 10, 23, 24, 26, and 27 have a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.								



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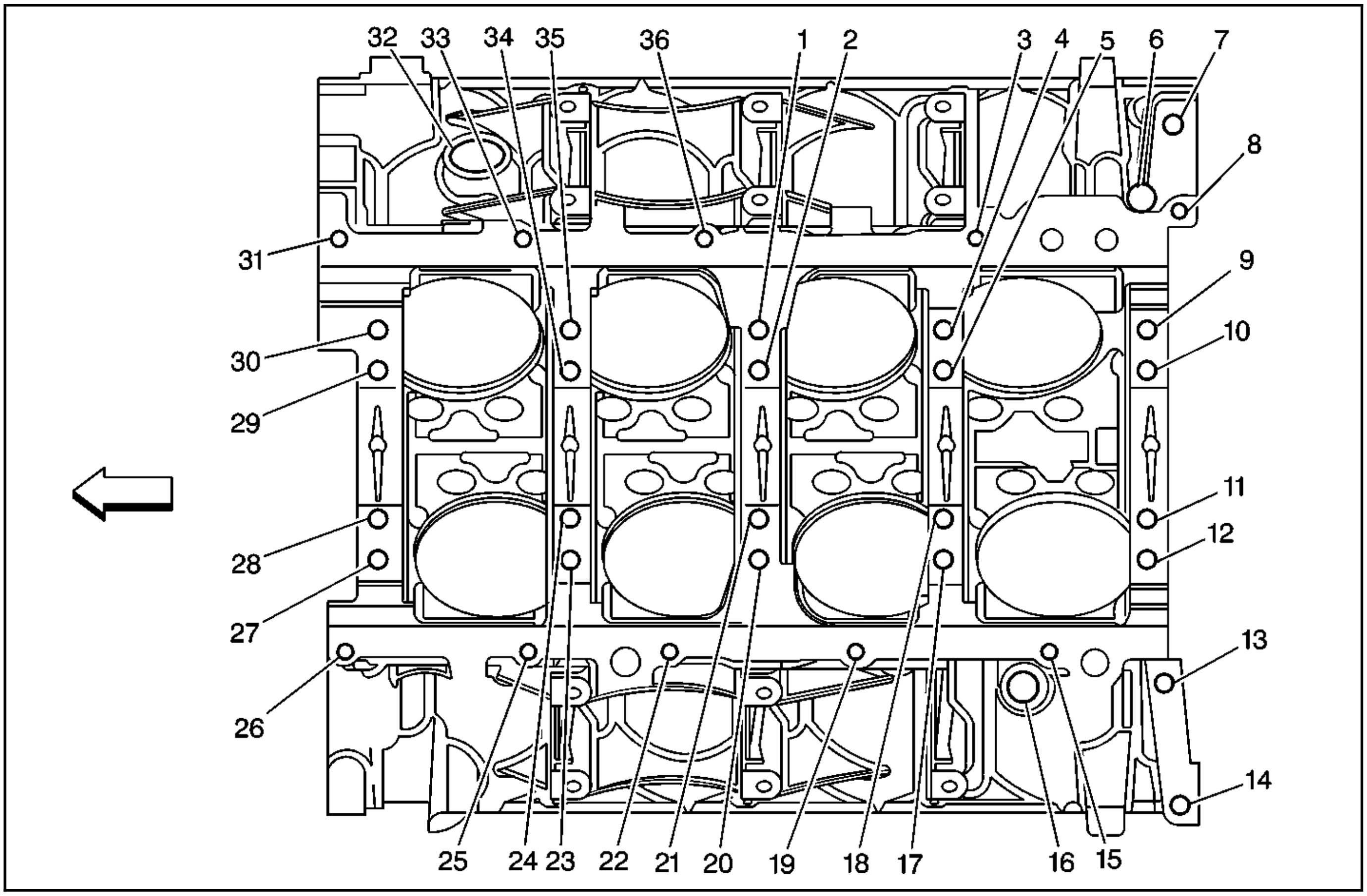
Engine Block – Right Side View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
2–3	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
4	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
5	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.590)
6–7	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
8	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
9	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
10	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
11–14	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
15–19	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	29.0 (1.14)	23.0 (0.905)
20	M16 x 1.5	—	—	—	—	—	—	—
21	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block – Right Side View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
22	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
23	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
24	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
25–26	M11 x 2.0	J 42385-108	J 42385-105	—	J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
27	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.590)
28	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
Bolt holes 2, 3, 6, 7, 9, 10, 22, 23, 25, and 26 have a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.								

Engine Block – Bottom View



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Engine Block – Bottom View

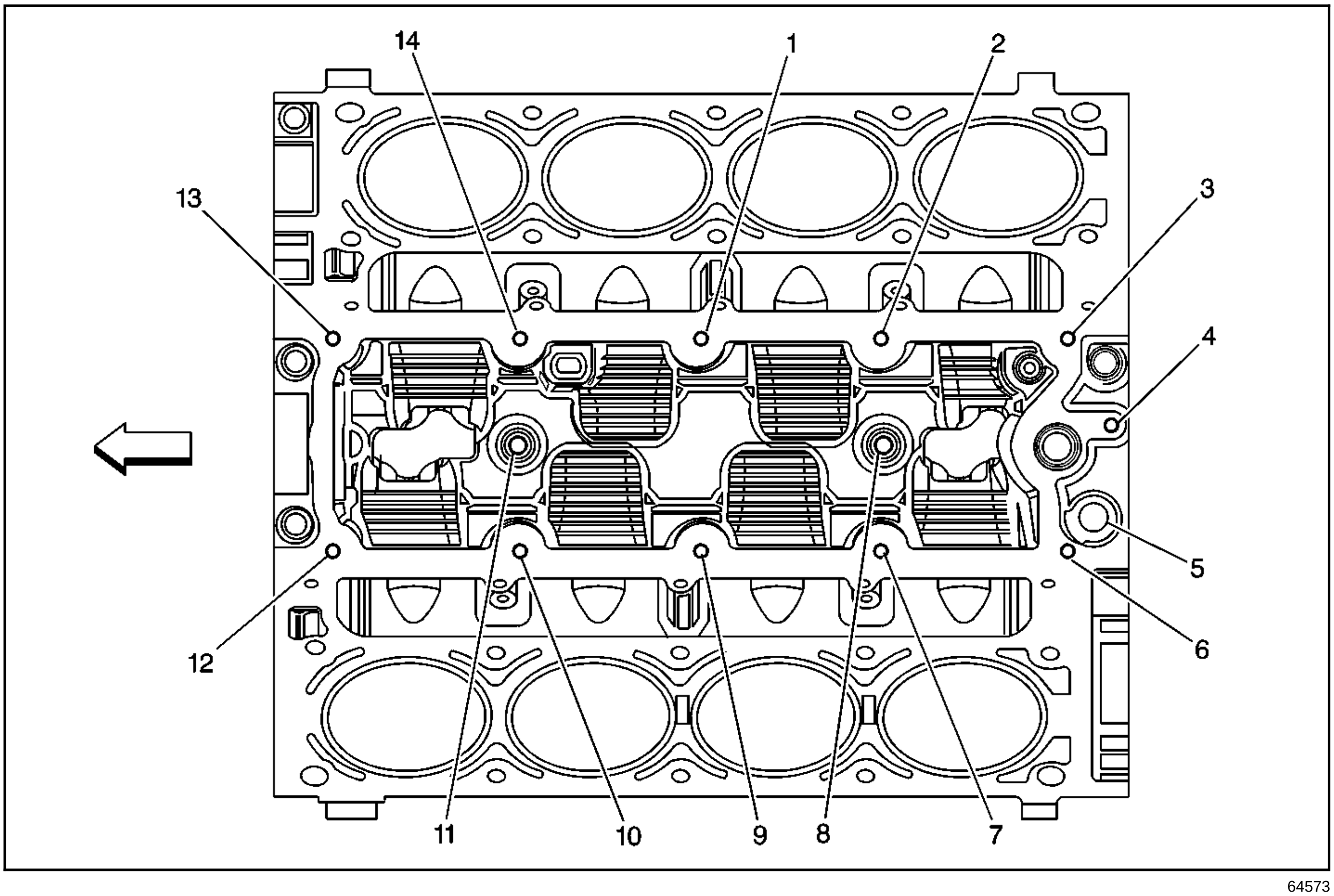
Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
2	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
3	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
4	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
5	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
6	M16 x 1.5	—	—	—	—	—	—	—
7	N/A	—	—	—	—	—	—	—
8	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
9	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
10–11	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
12	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
13–14	M10 x 1.5	J 42385-215	J 42385-101	—	J 42385-213	J 42385-214	42.5 (1.67)	37.0 (1.45)
15	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
16	M16 x 1.5	—	—	—	—	—	—	—
17	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
18	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
19	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
20	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
21	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
22	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
23	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
24	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
25–26	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
27	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
28–29	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
30	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
31	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block – Bottom View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
32	M28 x 1.25	—	—	—	—	—	—	—
33	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
34	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
35	M10 x 2.0	J 42385-104	J 42385-101	—	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
36	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

- Bolt holes 2, 5, 10, 11, 18, 21, 24, 28, 29, and 34 have a 20.5 mm (0.807 in) counterbore included in the 53.5 mm (2.10 in) drill depth.
- Bolt holes 1, 4, 9, 12, 17, 20, 23, 27, 30, and 35 have a 1.5 mm (0.059 in) counterbore included in the 31.0 mm (1.22 in) drill depth. Use sleeve J 42385-316 with the drill and tap.
- Bolt holes 13 and 14 have a 11.5 mm (0.452 in) counterbore included in the 42.5 mm (1.67 in) drill depth. Use sleeve J 42385-311 with the drill and tap.

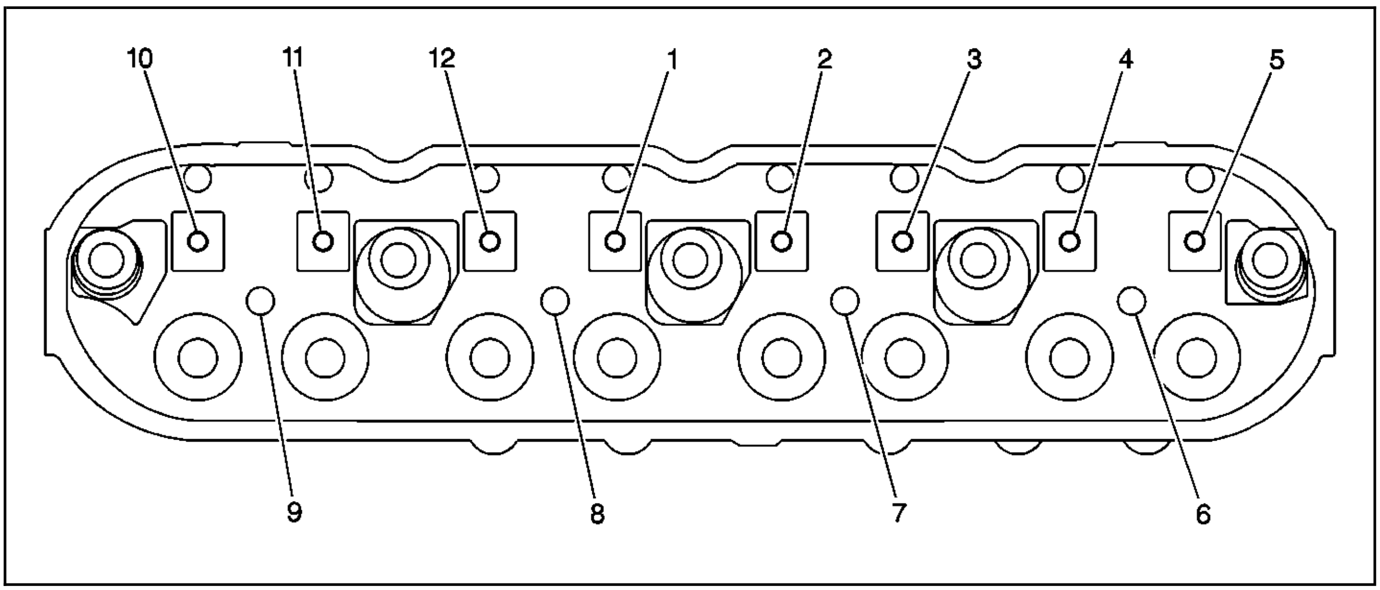
Engine Block – Top View



Engine Block – Top View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1–4	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
5	M16 x 1.5	—	—	—	—	—	—	—
6–7	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
8	M10 x 1.5	J 42385-216	J 42385-211	J 42385-212	J 42385-213	J 42385-214	22.5 (0.885)	17.0 (0.669)
9–10	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
11	M10 x 1.5	J 42385-216	J 42385-211	J 42385-212	J 42385-213	J 42385-214	22.5 (0.885)	17.0 (0.669)
12–14	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)

Cylinder Head – Top View



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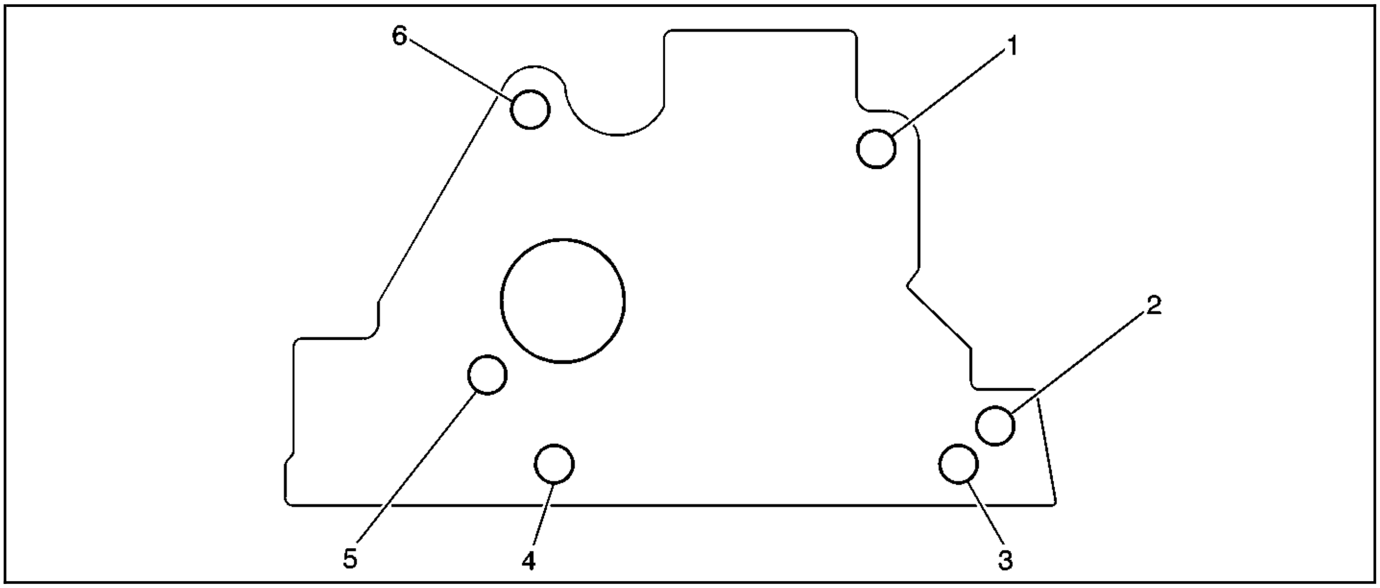
Cylinder Head – Top View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1–5	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
6–9	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	20.05 (0.789)	16.05 (0.632)
10–12	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)



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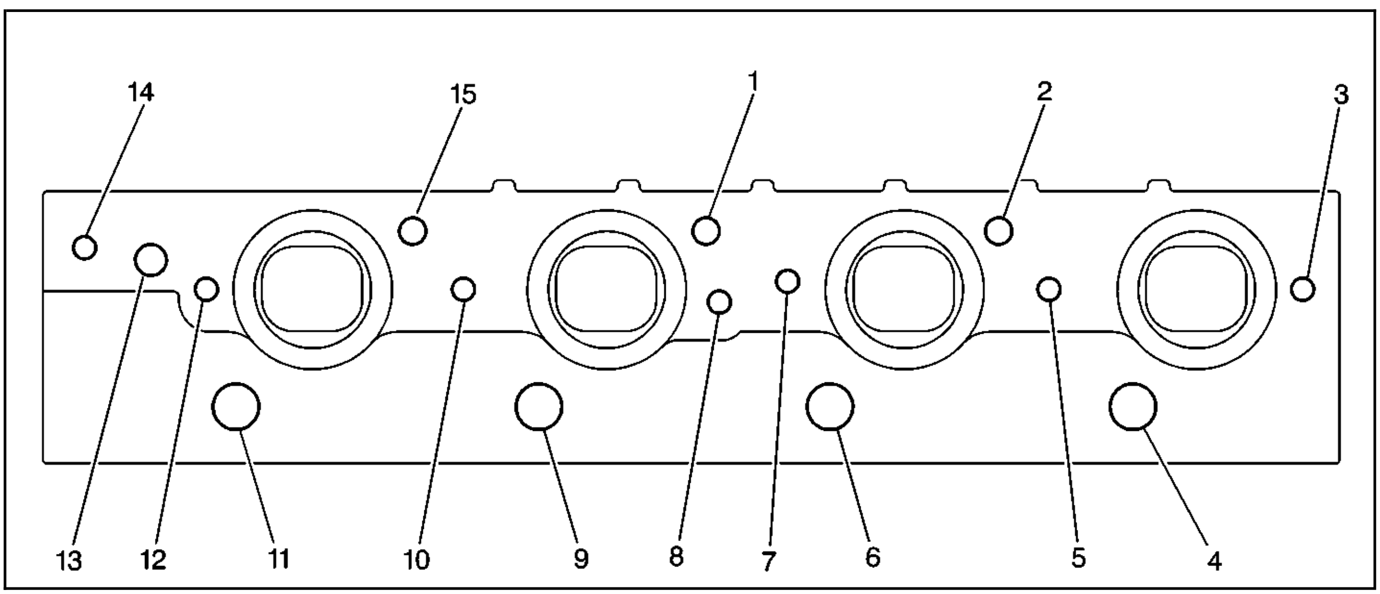
Cylinder Head – End View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)
2	—	N/A	—	—	—	—	—	—
3	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)
4	N/A	—	—	—	—	—	—	—
5–6	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)

Cylinder Head – Exhaust Manifold Deck View



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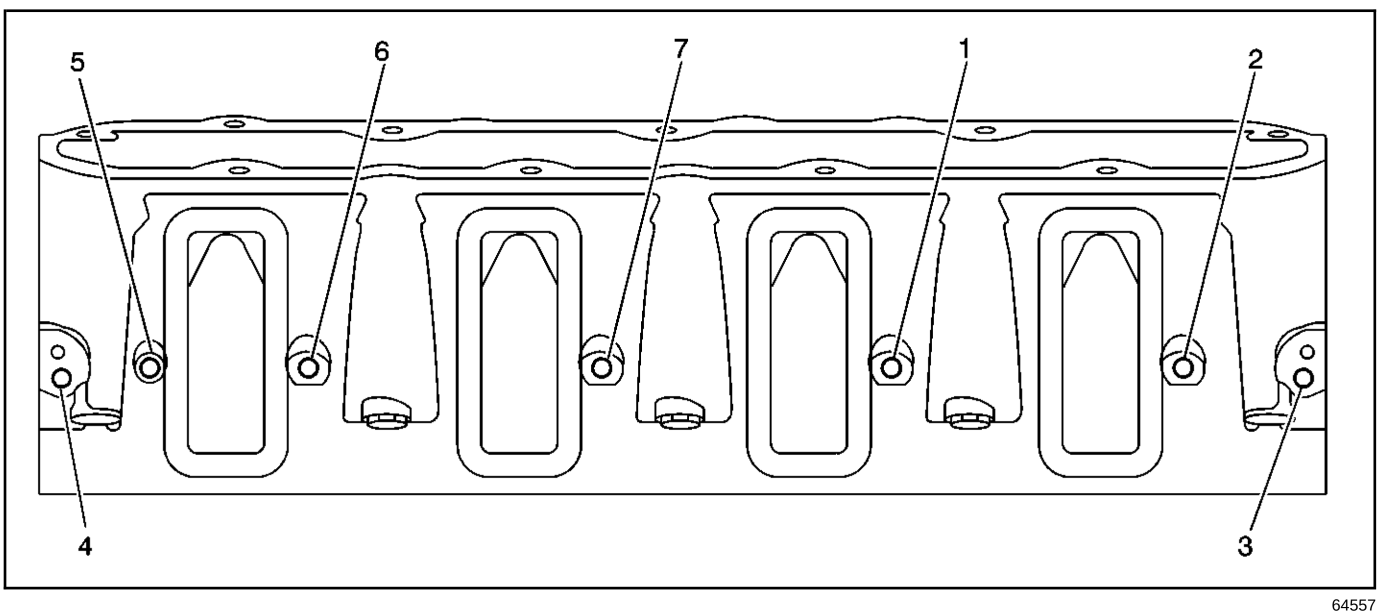
Cylinder Head – Exhaust Manifold Deck View

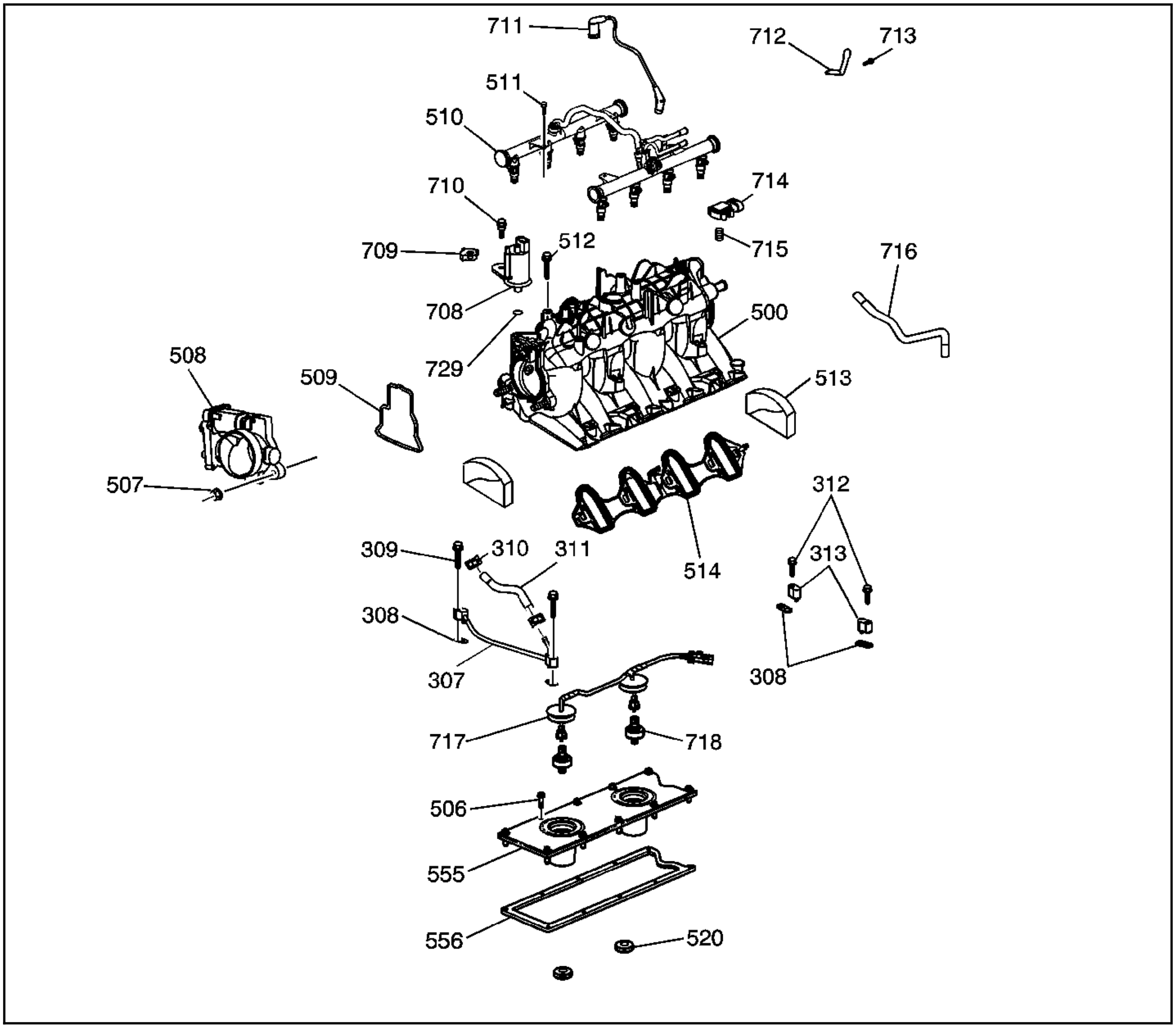
Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1–2	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)
3	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
4	M14 x 1.25	—	—	—	—	—	—	—
5	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
6	M14 x 1.25	—	—	—	—	—	—	—
7–8	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
9	M14 x 1.25	—	—	—	—	—	—	—
10	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
11	M14 x 1.25	—	—	—	—	—	—	—
12	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
13	M12 x 1.5	—	—	—	—	—	—	—
14–15	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)

Cylinder Head – Intake Manifold Deck View



Cylinder Head – Intake Manifold Deck View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth – Maximum mm (in)	Tap Depth – Maximum mm (in)
1–2	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	Thru	Thru
3–4	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.688)
5–7	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	Thru	Thru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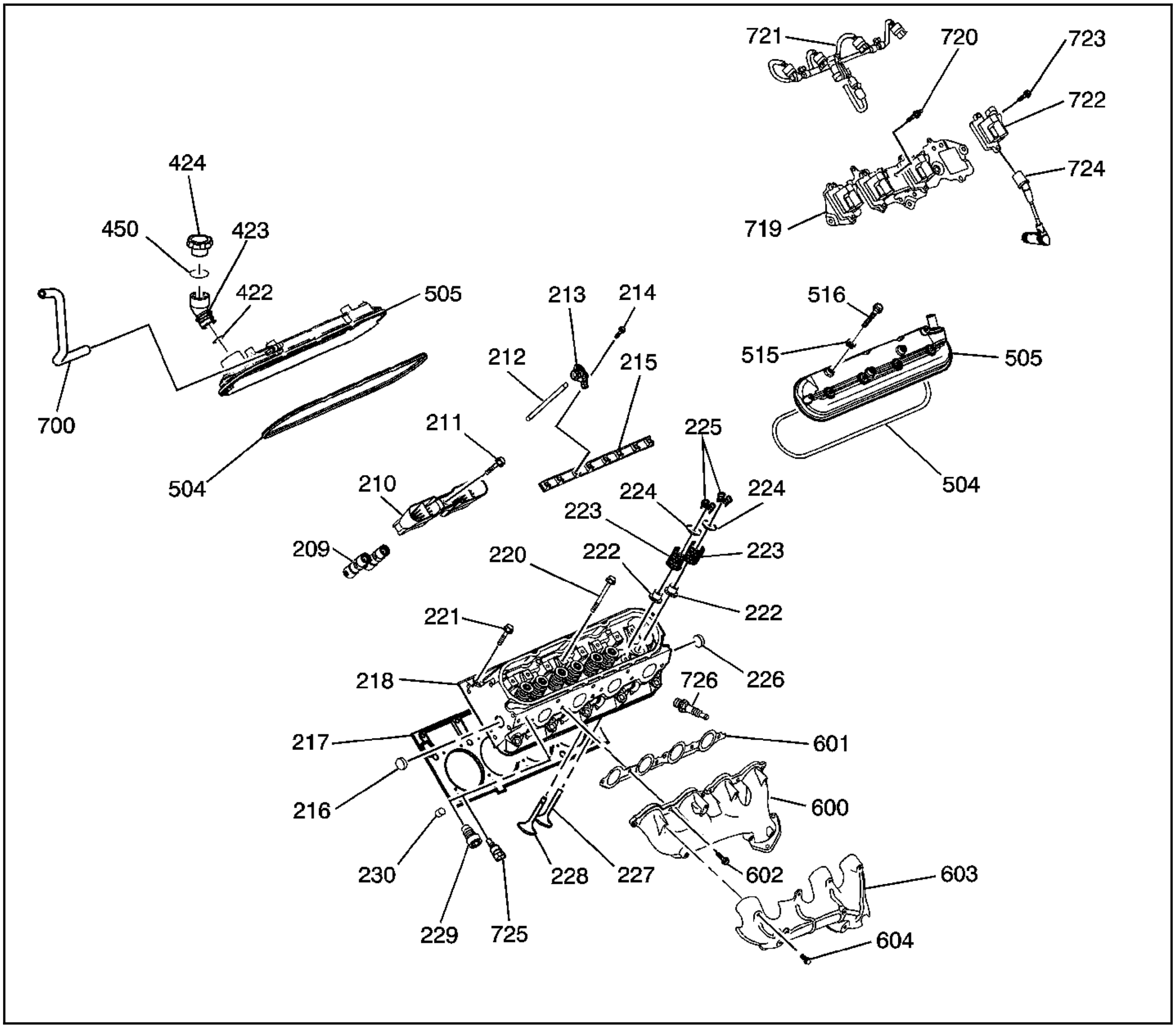
(710) EVAP Purge Valve Bolt
(711) Fuel Pressure Regulator Vacuum Hose – RPO L59
(712) Fuel Rail Stop Bracket
(713) Fuel Rail Stop Bracket Bolt
(714) Manifold Absolute Pressure (MAP) Sensor
(715) MAP Sensor Grommet
(716) Positive Crankcase Ventilation (PCV) Hose – Dirty Air
(717) Knock Sensor Wire Harness
(718) Knock Sensor
(729) EVAP Purge Valve O-Ring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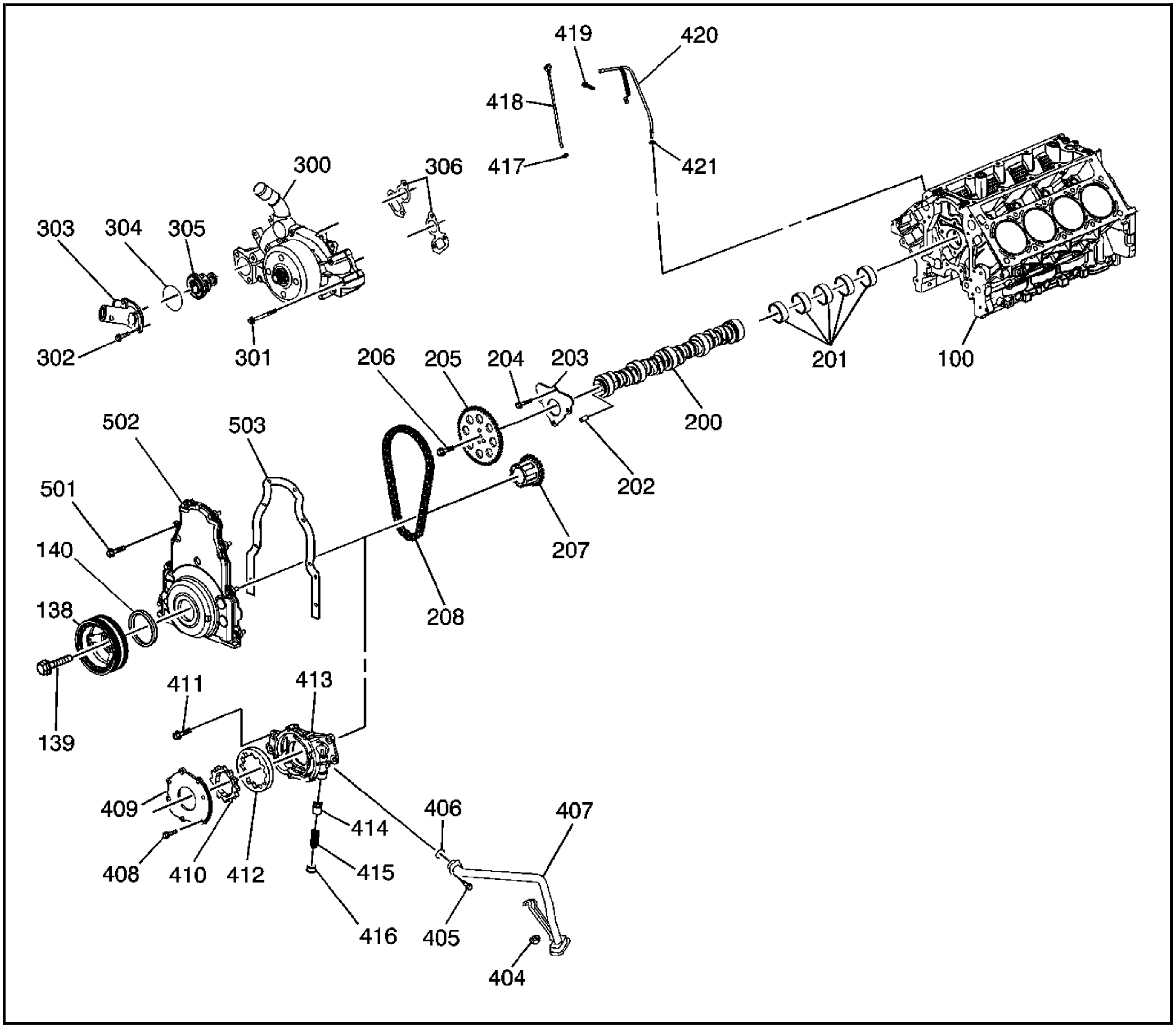
(601) Exhaust Manifold Gasket
(602) Exhaust Manifold Bolt
(603) Exhaust Manifold Heat Shield
(604) Exhaust Manifold Heat Shield Bolt
(700) Positive Crankcase Ventilation (PCV) Hose – Fresh Air
(719) Ignition Coils and Bracket Assembly
(720) Ignition Coil and Bracket Assembly Bolt
(721) Ignition Coil Wire Harness
(722) Ignition Coil
(723) Ignition Coil Bolt
(724) Spark Plug Wire
(725) Coolant Temperature Sensor
(726) Spark Plug

Front of Engine

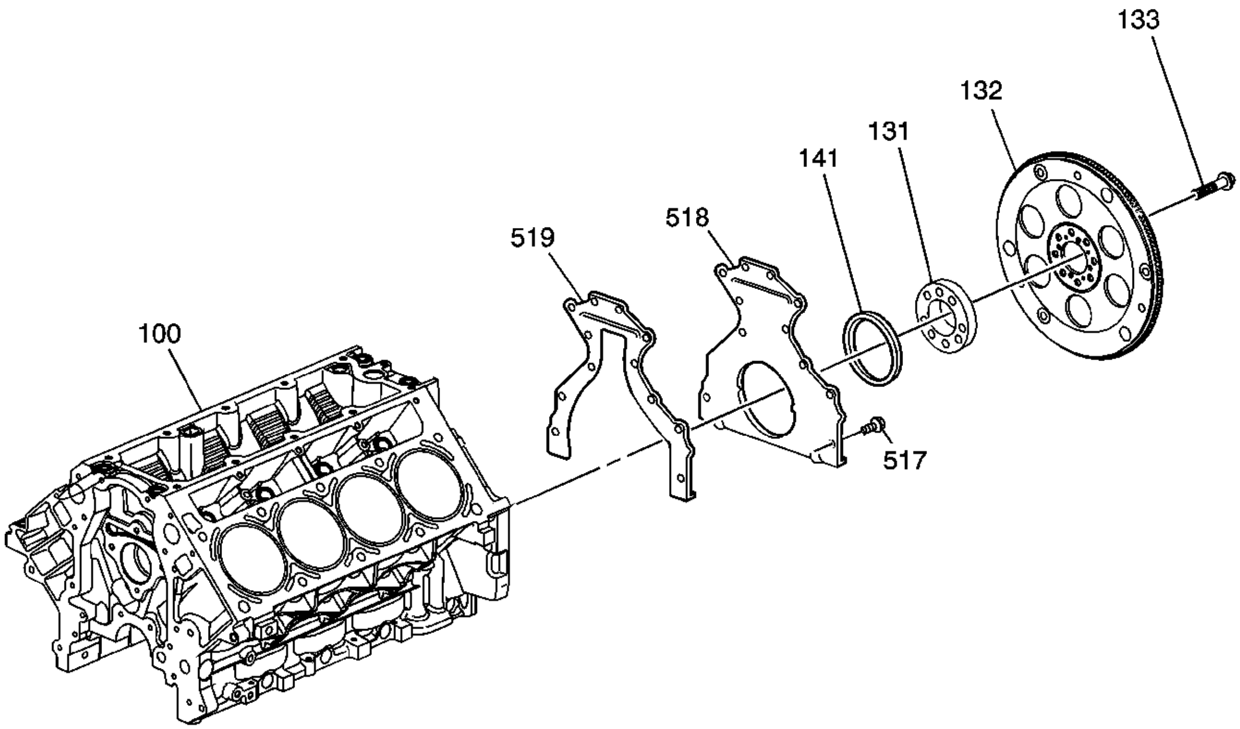


Legend

(100) Engine Block
(138) Crankshaft Balancer
(139) Crankshaft Balancer Bolt
(140) Crankshaft Front Oil Seal
(200) Camshaft
(201) Camshaft Bearings
(202) Camshaft Sprocket Locating Pin
(203) Camshaft Retainer Plate
(204) Camshaft Retainer Plate Bolt
(205) Camshaft Sprocket
(206) Camshaft Sprocket Bolt
(207) Crankshaft Sprocket
(208) Timing Chain
(300) Water Pump
(301) Water Pump Bolt
(302) Thermostat Housing Bolt
(303) Thermostat Housing
(304) O-Ring
(305) Thermostat
(306) Water Pump Gasket
(404) Crankshaft Oil Deflector Nut
(405) Oil Pump Screen Bolt
(406) Oil Pump Screen O-Ring
(407) Oil Pump Screen
(408) Oil Pump Cover Bolt
(409) Oil Pump Cover
(410) Drive Gear
(411) Oil Pump Bolt
(412) Driven Gear
(413) Oil Pump Assembly

(414) Pressure Regulator Valve
(415) Pressure Regulator Valve Spring
(416) Plug
(417) Oil Level Indicator O-Ring
(418) Oil Level Indicator
(419) Oil Level Tube Bolt
(420) Oil Level Tube
(421) Oil Level Tube O-Ring
(501) Front Cover Bolt
(502) Front Cover
(503) Front Cover Gasket

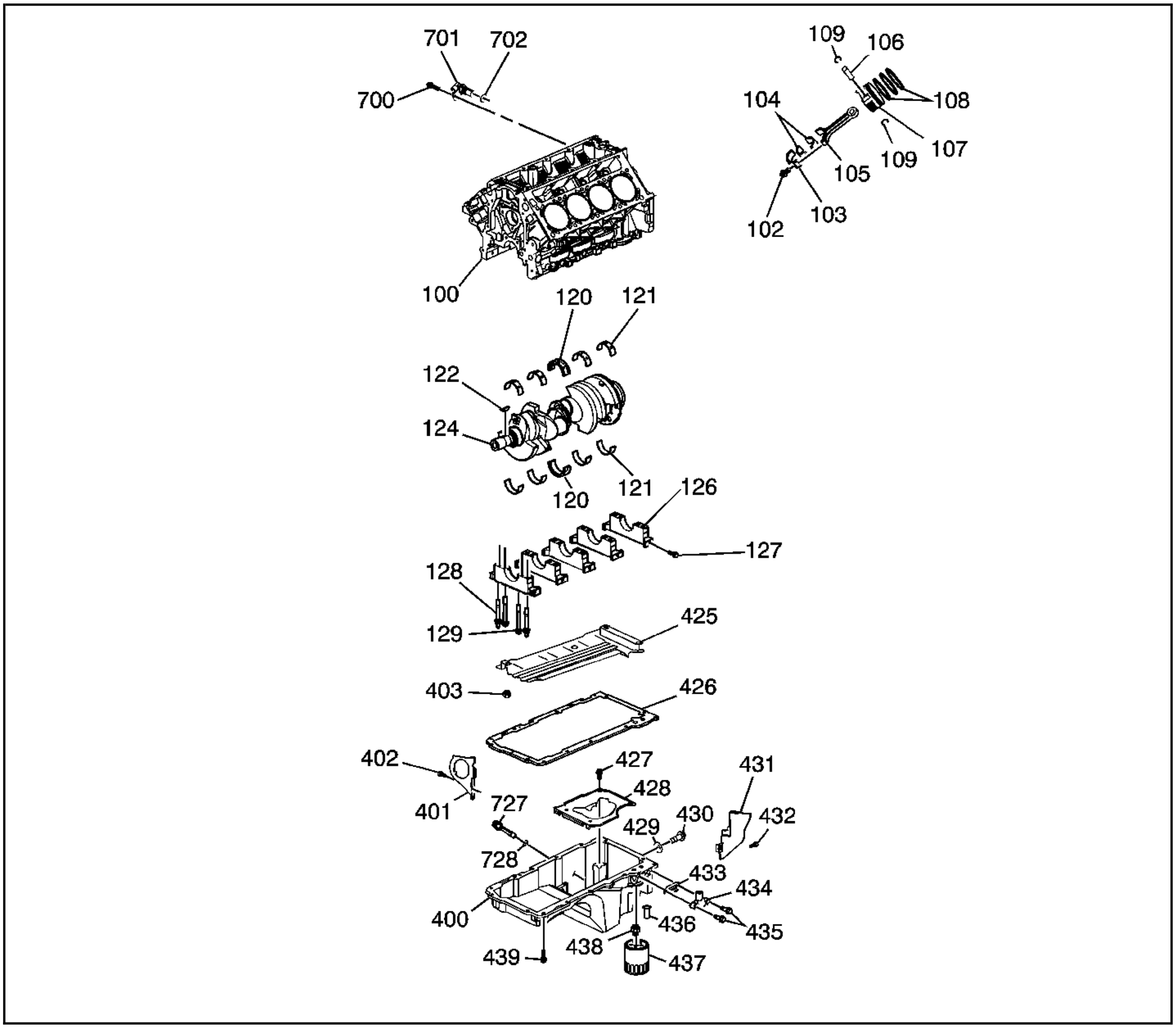
Rear of Engine



Legend

(100)	Engine Block	(141)	Crankshaft Rear Oil Seal
(131)	Flywheel Spacer	(517)	Rear Cover Bolt
(132)	Flywheel	(518)	Rear Cover
(133)	Flywheel Bolt	(519)	Rear Cover Gasket

Lower Engine Assembly

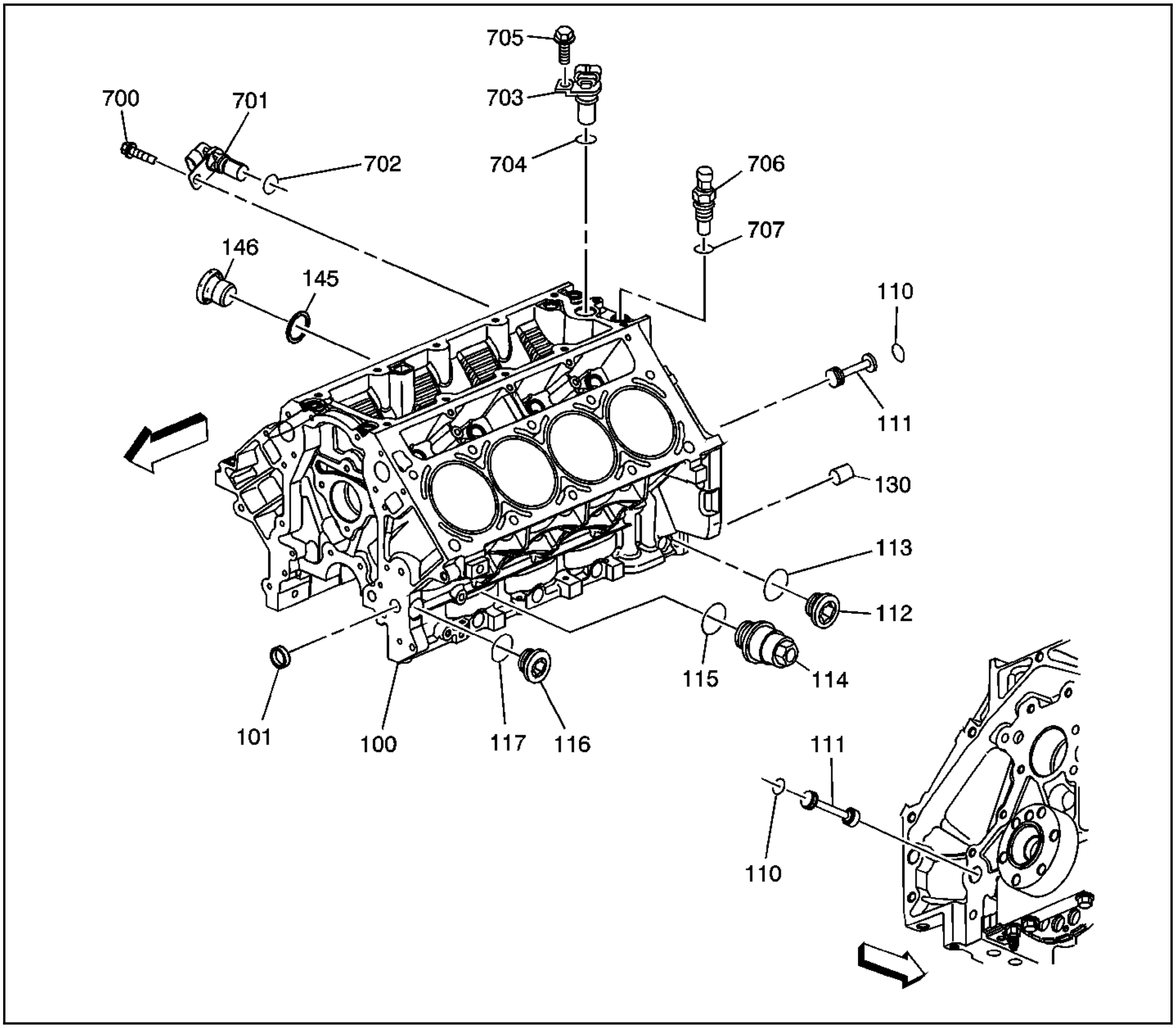


Legend

- (100) Engine Block
- (102) Connecting Rod Bolt
- (103) Connecting Rod Cap
- (104) Connecting Rod Bearings
- (105) Connecting Rod
- (106) Piston Pin
- (107) Piston
- (108) Piston Rings
- (109) Piston Pin Clips
- (120) Crankshaft Thrust Bearing
- (121) Crankshaft Main Bearing
- (122) Crankshaft Sprocket Key
- (124) Crankshaft
- (126) Bearing Cap
- (127) Bearing Cap Side Bolt
- (128) Bearing Cap Bolt/Stud
- (129) Bearing Cap Bolt
- (400) Oil Pan
- (401) Closeout Cover – Right
- (402) Closeout Cover Bolt – Right
- (403) Crankshaft Oil Deflector Nut
- (425) Crankshaft Oil Deflector
- (426) Oil Pan Gasket
- (427) Oil Pan Baffle Bolt
- (428) Oil Pan Baffle
- (429) Oil Pan Drain Plug O-Ring
- (430) Oil Pan Drain Plug
- (431) Closeout Cover – Left
- (432) Closeout Cover Bolt – Left
- (433) Oil Pan Cover Gasket

(434) Oil Pan Cover
(435) Oil Pan Cover Bolts
(436) Oil Filter Bypass Valve
(437) Oil Filter
(438) Oil Filter Adapter
(439) Oil Pan Bolt
(700) Crankshaft Position Sensor Bolt
(701) Crankshaft Position Sensor
(702) Crankshaft Position Sensor O-Ring
(727) Oil Level Sensor
(728) O-Ring

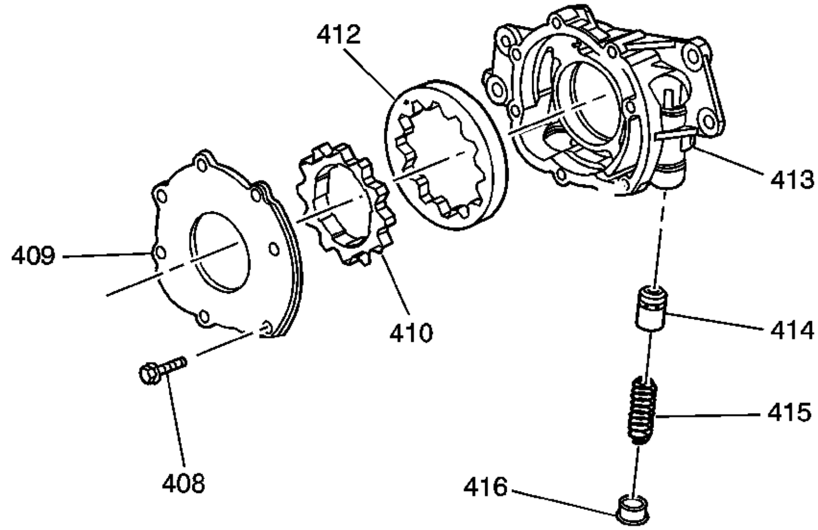
Engine Block Plugs/Sensors



Legend

(100) Engine Block
(101) Engine Block Front Oil Gallery Plug
(110) Engine Block Rear Oil Gallery Plug O-Ring
(111) Engine Block Rear Oil Gallery Plug
(112) Oil Gallery Plug
(113) Oil Gallery Plug Washer
(114) Coolant Heater
(115) Coolant Heater Washer
(116) Oil Gallery Plug
(117) Oil Gallery Plug Washer
(130) Transmission Housing Locating Pin
(145) Coolant Drain Plug Washer – Right
(146) Coolant Drain Plug – Right
(700) Crankshaft Position (CKP) Sensor Bolt
(701) CKP Sensor
(702) CKP Sensor O-Ring
(703) Camshaft Position (CMP) Sensor
(704) CMP Sensor O-Ring
(705) CMP Sensor Bolt
(706) Oil Pressure Sensor
(707) Oil Pressure Sensor Washer

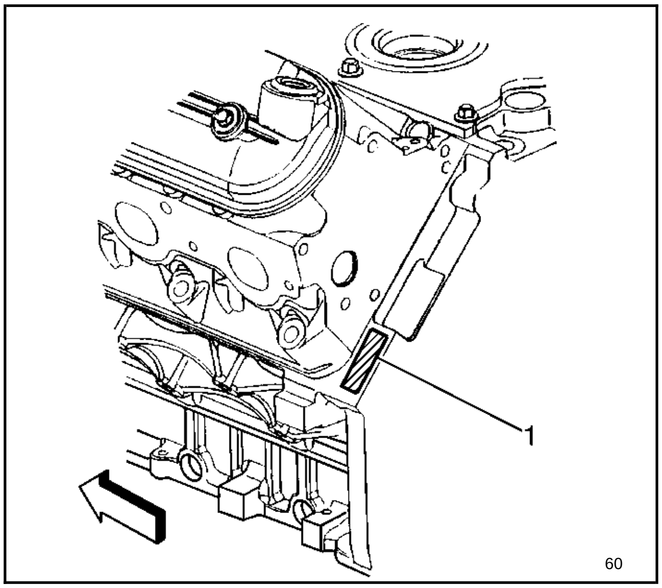
Oil Pump Assembly



Legend

(408) Cover Bolt
(409) Cover
(410) Drive Gear
(412) Driven Gear
(413) Oil Pump
(414) Pressure Relief Valve
(415) Pressure Relief Valve Spring
(416) Plug

Engine Identification



The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a nine digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the VIN.

Diagnostic Information and Procedures

Diagnostic Starting Point - Engine Mechanical

Begin the system diagnosis by reviewing the *Disassembled Views*, *Engine Component Description*, *Lubrication Description*, *New Product Information*, and *Drive Belt System Description*. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to *Symptoms - Engine Mechanical* in order to identify the correct procedure for diagnosing the system and where the procedure is located.

Symptoms - Engine Mechanical

Strategy Based Diagnostics

1. Perform the *Diagnostic System Check - Vehicle* in Vehicle DTC Information before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to *Disassembled Views*,*Engine Component Description*, *Lubrication Description*, *New Product Information*, and *Drive Belt System Description*.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Strategy Based Diagnosis* in General Information.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine. Refer to *Checking Aftermarket Accessories* in Wiring Systems.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- *Base Engine Misfire without Internal Engine Noises*
- *Base Engine Misfire with Abnormal Internal Lower Engine Noises*
- *Base Engine Misfire with Abnormal Valve Train Noise*
- *Base Engine Misfire with Coolant Consumption*
- *Base Engine Misfire with Excessive Oil Consumption*
- *Engine Noise on Start-Up, but Only Lasting a Few Seconds*
- *Upper Engine Noise, Regardless of Engine Speed*
- *Lower Engine Noise, Regardless of Engine Speed*
- *Engine Noise Under Load*
- *Engine Will Not Crank - Crankshaft Will Not Rotate*
- *Coolant in Combustion Chamber*
- *Coolant in Engine Oil*
- *Engine Compression Test*
- *Cylinder Leakage Test*
- *Oil Consumption Diagnosis*
- *Oil Pressure Diagnosis and Testing*
- *Oil Leak Diagnosis*
- *Crankcase Ventilation System Inspection/Diagnosis*
- *Drive Belt Chirping Diagnosis*
- *Drive Belt Squeal Diagnosis*
- *Drive Belt Whine Diagnosis*
- *Drive Belt Rumbling Diagnosis*
- *Drive Belt Vibration Diagnosis*
- *Drive Belt Falls Off Diagnosis*
- *Drive Belt Excessive Wear Diagnosis*
- *Drive Belt Tensioner Diagnosis*

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to *Drive Belt Replacement - Accessory*.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout – May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to *Engine Flywheel Replacement* or *Crankshaft Balancer Replacement*.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing*. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages – Refer to *Diagnostic Starting Point - Engine Cooling* in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Inspect the cylinder heads, engine block, and/or head gaskets. Refer to *Coolant in Combustion Chamber*. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test*. • Perform cylinder leak down and compression testing to identify the cause. Refer to *Cylinder Leakage Test*. • Repair or replace as required.

Base Engine Misfire without Internal Engine Noises (cont'd)

Cause	Correction
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to *Drive Belt Replacement - Accessory*.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to *Engine Flywheel Replacement* or *Crankshaft Balancer Replacement*.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test*. • Perform cylinder leak down and compression testing to determine the cause. Refer to *Cylinder Leakage Test*. • Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.

Base Engine Misfire with Abnormal Valve Train Noise (cont'd)

Cause	Correction
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages – Refer to *Diagnostic Starting Point - Engine Cooling* in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Perform a cylinder leak down test. Refer to *Cylinder Leakage Test*. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to *Coolant in Combustion Chamber*. • Repair or replace as required.

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Inspection* in Engine Controls – 4.8L, 5.3L, and 6.0L. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test*. • Perform cylinder leak down and compression testing to determine the cause. Refer to *Cylinder Leakage Test*. • Repair or replace as required.

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train, upper engine, concern, or a low rumble/knocking may indicate a crankshaft or piston, lower engine concern.	
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters as required.
Worn crankshaft thrust bearing	1. Check the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train, upper engine concern. During certain conditions, the evaporative emission solenoid and the fuel injectors may also create a sound similar to valve train noise.	
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing.* • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm, bolt, and pedestal. • Repair or replace as required.
Worn or damaged valve rocker arm	• Inspect the rocker arm for wear or missing needle bearings • Replace the valve rocker arms as required.
Bent or damaged push rod	Inspect the following components and replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The valve lifter guide • The piston Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components and repair as required: • The valves • The valve guides

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A low rumble/knocking may indicate a crankshaft or piston, lower engine, concern.	
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing.* • Repair or replace damaged components as required.

Lower Engine Noise, Regardless of Engine Speed (cont'd)

Cause	Correction
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to *Detonation/Spark Knock* in Engine Controls – 4.8L, 5.3L, and 6.0L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, pin, and connecting rod. • Replace the piston and pin as an assembly, as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	• Verify the pistons, piston pins and connecting rods are installed correctly. Refer to *Piston, Connecting Rod, and Bearing Installation.* • Repair as required.

Engine Noise Under Load

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A low rumble/knocking may indicate a crankshaft or piston, lower engine concern.	
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing.* • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to *Detonation/Spark Knock* in Engine Controls – 4.8L, 5.3L, and 6.0L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel – automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft

Engine Noise Under Load (cont'd)

Cause	Correction
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flywheel bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Broken timing chain	• Inspect the timing chain and gears. • Repair or replace the components as required.
Seized timing chain or timing gears	• Inspect the timing chain and gears for foreign material or a seized chain. • Repair or replace the components as required.
Seized or broken camshaft	• Inspect the camshaft and the camshaft bearings. • Repair or replace the components as required.
Bent valve in the cylinder head	• Inspect the valves and the cylinder heads. • Repair or replace the components as required.
Seized oil pump	• Inspect the oil pump assembly. • Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in the cylinder • Oil in the cylinder • Fuel in the cylinder	1. Remove spark plugs and check for fluid in the cylinder. When rotating the engine with the spark plugs removed, the piston, on compression stroke, will push fluid from the combustion chamber. Refer to *Coolant in Combustion Chamber*. 2. Inspect for failed/broken head gaskets. 3. Inspect for a cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace the components as required.
Material in the cylinder • Broken valve • Broken piston rings • Piston material • Foreign material	• Inspect the cylinder for damaged components and/or foreign materials. • Repair or replace the components as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair or replace the components as required.
Bent or broken connecting rod	• Inspect the connecting rods. • Replace the piston and pin as an assembly, as required.
Broken crankshaft	• Inspect the crankshaft. • Repair or replace the components as required.

Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to *Engine Will Not Crank - Crankshaft Will Not Rotate*. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to *Engine Compression Test*.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to *Cylinder Head Cleaning and Inspection* and *Cylinder Head Replacement - Left* or *Cylinder Head Replacement - Right*.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to *Cylinder Head Cleaning and Inspection*.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to *Lower Engine Noise, Regardless of Engine Speed*. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to *Engine Compression Test*.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to *Cylinder Head Cleaning and Inspection* and *Cylinder Head Replacement - Left* or *Cylinder Head Replacement - Right*.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to *Cylinder Head Cleaning and Inspection*.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

Engine Compression Test

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gage at zero and crank the engine through four compression strokes, four puffs.
8. Check the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Check the compression again and record the reading.
10. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than

690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1 035 x 70% = 725) (150 x 70% = 105).

- Normal — Compression builds up quickly and evenly to the specified compression for each cylinder.
- Piston Rings Leaking — Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
- Valves Leaking — Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
- If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

Cylinder Leakage Test

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Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

Important: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate one or more of the following conditions:

- Worn or burnt valves
- Broken valve springs
- Stuck valve lifters
- Incorrect valve lash
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to *Spark Plug Replacement* in Engine Controls – 4.8L, 5.3L, and 6.0L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the *J 35667-A* or equivalent.

Important: It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.

5. Apply shop air pressure to the *J 35667-A* and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
   - Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

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Oil Consumption Diagnosis

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or more of engine oil within 3 200 kilometers (2,000 miles).	

Oil Consumption Diagnosis (cont'd)

Checks	Causes
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to *Oil Leak Diagnosis*. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time, 2–3 minutes, and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or not fitted to the cylinder bore

Oil Pressure Diagnosis and Testing

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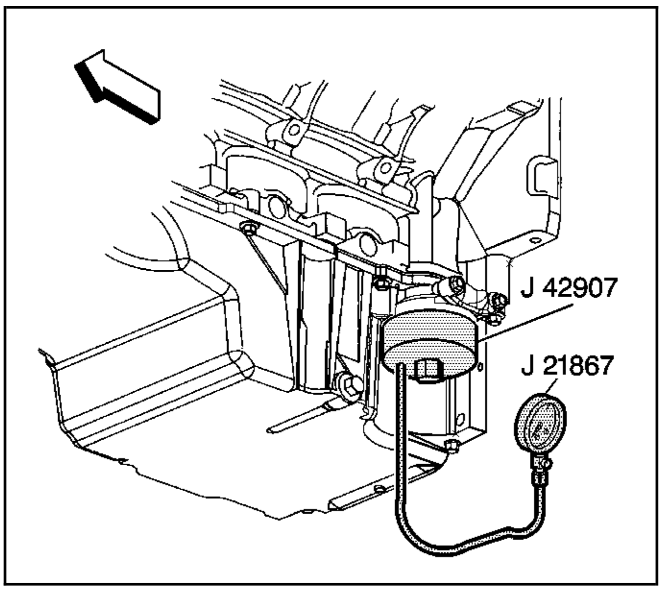
Tools Required

- *J 21867* Pressure Gage
- *J 42907* Oil Pressure Testing Tool



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1. With the vehicle on a level surface, run the vehicle for a few minutes. Allow adequate drain down time, 2–3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10–15 seconds, and verify low or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
   - Oil diluted by water or glycol anti freeze
   - Foamy oil
6. Remove the oil filter and install the *J 42907*.
7. Install *J 21867* or equivalent to the *J 42907*.
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to *Engine Mechanical Specifications (LR4 VIN V)* *Engine Mechanical Specifications (LQ4 VIN U)*.
10. If the engine oil pressure is below specifications, inspect the engine for one or more of the following conditions:
    - Oil pump worn or dirty
      Refer to *Oil Pump Cleaning and Inspection*.
    - Oil pump-to-engine block bolts loose
      Refer to *Oil Pump, Pump Screen and Deflector Installation*.
    - Oil pump screen loose, plugged, or damaged
    - Oil pump screen O-ring seal missing or damaged
    - Malfunctioning oil pump pressure regulator valve
    - Excessive bearing clearance
    - Cracked, porous, or restricted oil galleries
    - Oil gallery plugs missing or incorrectly installed
      Refer to *Engine Block Plug Installation*.
    - Broken valve lifters
      Repair as necessary.
11. If the oil pressure reading on the *J 21867* or equivalent is within specifications, inspect for the following conditions:

• Plugged or incorrect oil filter and/or malfunctioning oil bypass valve • Malfunctioning oil pressure gage or sensor	Repair as necessary.

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Oil Leak Diagnosis

Step	Action	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings. Are drippings present?	Go to *Step 2*	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 3*
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 4*
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers – miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 5*
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 6*
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 7*

Oil Leak Diagnosis (cont'd)

Step	Action	Yes	No
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 8*
8	Use *J 28428-E* High Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 9*
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to *Step 11*	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to *Step 1*	System OK

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Crankcase Ventilation System Inspection/Diagnosis

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose

Crankcase Ventilation System Inspection/Diagnosis (cont'd)

Symptom	Correction
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

Drive Belt Chirping Diagnosis

Diagnostic Aids

The chirping noise may be intermittent due to moisture on the drive belt(s) or the accessory drive pulley(s). In order to duplicate the customer's concern, it may be necessary to spray a small amount of water onto the drive belt(s). If spraying water onto the drive belt(s) duplicates the symptom, cleaning the accessory drive pulley(s) may be the most probable solution.

A loose or improper installation of a body or suspension component, or other item(s) on the vehicle may also cause the chirping noise.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2. The chirping noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed any further in this table.
3. The noise may be an internal engine noise. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the chirping noise is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.
4. Inspect the drive belt(s) for signs of pilling. Pilling is the small balls, pills, or strings in the drive belt grooves caused by the accumulation of rubber dust.
6. Misalignment of the accessory drive pulley(s) may be caused from improper mounting or incorrect installation of an accessory drive component, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned accessory drive pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper removal and installation procedure for that pulley.
10. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.
12. Inspection of the accessory drive pulley(s) should include inspecting for bends, dents, or other damage to the pulley(s) that would prevent the drive belt(s) from seating properly in the pulley grooves or on the smooth surface of the pulley when the back side of the drive belt is used to drive the pulley.
14. Replacing the drive belt(s) when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt(s) or a accessory drive pulley. • Chirping may occur on cold damp startup conditions and will subside once the vehicle reaches normal operating temperature.		
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to *Engine Noise on Start-Up, but Only Lasting a Few Seconds*	Go to *Step 4*
4	Inspect for severe drive belt pilling exceeding 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to *Step 5*	Go to *Step 6*
5	Clean the accessory drive pulley(s) with a suitable wire brush. Were the accessory drive pulley(s) cleaned?	Go to *Step 15*	—

Drive Belt Chirping Diagnosis (cont'd)

Step	Action	Yes	No
6	Inspect for a misaligned accessory drive pulley(s). Is there a misaligned accessory drive pulley(s)?	Go to *Step 7*	Go to *Step 8*
7	Replace and/or repair the misaligned accessory drive pulley(s). Were the misaligned accessory drive pulley(s) replaced and/or repaired?	Go to *Step 15*	—
8	Inspect for a bent or cracked accessory drive bracket(s). Did you find any bent or cracked accessory drive bracket(s)?	Go to *Step 9*	Go to *Step 10*
9	Replace the bent and/or cracked accessory drive bracket(s). Was the bent and/or cracked accessory drive bracket(s) replaced?	Go to *Step 15*	—
10	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose, and/or missing fasteners found?	Go to *Step 11*	Go to *Step 12*
11	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to *Fastener Tightening Specifications.* Were the fasteners replaced and/or tightened?	Go to *Step 15*	—
12	Inspect for a bent accessory drive pulley(s). Was a bent accessory drive pulley(s) found?	Go to *Step 13*	Go to *Step 14*
13	Replace the bent accessory drive pulley(s). Was the bent accessory drive pulley(s) replaced?	Go to *Step 15*	—
14	Replace the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning.* Was the drive belt(s) replaced?	Go to *Step 15*	—
15	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the chirping noise still exist?	—	System OK

Drive Belt Squeal Diagnosis

Diagnostic Aids

A loose or improper installation of a body, or suspension component, or other item(s) on the vehicle may cause the squeal noise.

If the squeal is intermittent, verify that it is not the accessory drive component(s) by varying their load(s), making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2. The squeal may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further in this table
3. The squeal may be an internal engine noise. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the squealing noise is related to the drive belt(s) or an accessory drive component. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.
4. This test is to verify that an accessory drive component(s) does not have a seized bearing. With the belt(s) removed, test the bearings in the accessory drive component(s) for smooth operation. Also test the accessory drive component(s) with the engine operating by varying the load on the accessory drive component(s) to verify that the component(s) is operating properly.
5. This test is to verify that the drive belt(s) tensioner(s) are not operating properly. If the drive belt tensioner(s) are not operating properly, proper belt tension may not be achieved to keep the drive belt(s) from slipping which could cause a squealing noise.
6. This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner(s) from operating properly. Also if the incorrect length drive belt(s) was installed, it may not be routed correctly and may be turning an accessory drive component in the incorrect direction.

7. Misalignment of the accessory drive pulley(s) may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper removal and installation procedure for that pulley.
8. Inspect the accessory drive pulley(s) to verify that they are the correct diameter or width. Using a known good vehicle, compare the accessory drive pulleys.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt(s) (this is unusual for a drive belt with multiple ribs) • The squeal occurs when a heavy load is applied to the drive belt(s), such as an A/C compressor engagement, snapping the throttle, slipping on a seized pulley, or a faulty accessory drive component.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Verify that there is a squealing noise. Does the engine make the squeal noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Operate the engine for no longer than 30 to 40 seconds. Does the squealing noise still exist?	Go to *Engine Noise on Start-Up, but Only Lasting a Few Seconds*	Go to *Step 4*
4	Inspect for a seized accessory drive component bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 5*
5	Inspect the drive belt tensioner for proper operation. Refer to *Drive Belt Tensioner Diagnosis*. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 6*
6	Check for the correct length drive belt(s). Did you find and correct the condition?	Go to *Step 9*	Go to *Step 7*
7	Inspect for a misaligned pulley. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 8*
8	Inspect for an incorrect size pulley. Did you find and correct the condition?	Go to *Step 9*	—
9	1. Install the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Clear any codes. 3. Run the engine in order to verify the repair. Does the squealing noise still exist?	—	System OK

Drive Belt Whine Diagnosis

Diagnostic Aids

The drive belt(s) will not cause the whine.

If the whine is intermittent, verify that it is not the accessory drive component(s) by varying their loads, making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

3. This test is to verify that the whine is being caused by the accessory drive component(s). Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the whining noise is related to the accessory drive component. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.

4. This inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt(s) may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper removal and installation procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Verify that there is a whining noise. Does the engine make the whining noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Operate the engine for no longer than 30 to 40 seconds. Does the whining noise still exist?	Go to *Engine Noise on Start-Up, but Only Lasting a Few Seconds*	Go to *Step 4*
4	1. Inspect for a failed accessory drive component bearing. 2. Install the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. Did you find and correct the condition?	Go to *Step 5*	—
5	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the whining still exist?	—	System OK

Drive Belt Rumbling Diagnosis

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise.

The drive belt(s) may have a condition that can not be seen or felt. Sometimes replacing the drive belt(s) may be the only repair for the symptom.

If after replacing the drive belt(s) and completing the diagnostic table, the rumbling is only heard with the drive belt(s) installed, there might be an accessory drive component failure. Varying the load on the accessory drive component(s) may aid in identifying which component is causing the rumbling noise.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that the drive belt(s) is causing the rumbling. Rumbling may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. Operate the engine for a few seconds, this will verify if the rumbling noise is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.
4. Inspect the drive belt(s) to ensure that the drive belt(s) is not the cause of the noise. Small cracks across the ribs of the drive belt(s) will not cause the noise. Belt separation is identified by the plys of the belt separating, this may be seen at the edge of the belt or felt as a lump in the belt.
5. Small amounts of pilling is a normal condition and acceptable. When the pilling is severe the drive belt(s) does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt(s) or pulley(s). • Rumbling may be caused from: − Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt(s) pulley groove − The separation of the drive belt(s) − A damaged drive belt(s)			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to *Engine Noise on Start-Up, but Only Lasting a Few Seconds*	Go to *Step 4*
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. Were any of these conditions found?	Go to *Step 7*	Go to *Step 5*
5	Inspect for severe pilling of more than 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to *Step 6*	Go to *Step 7*
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. Did you complete the repair?	Go to *Step 8*	—
7	Install a new drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. Did you complete the replacement?	Go to *Step 8*	—
8	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the rumbling noise still exist?	—	System OK

Drive Belt Vibration Diagnosis

i

Diagnostic Aids

The accessory drive components may have an affect on engine vibration. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or an extra load placed on the generator are suggested items to inspect. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2. This test is to verify that the vibration is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
3. This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the vibration is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.
4. The drive belt(s) may cause a vibration. While the drive belt(s) is removed this is the best time to inspect the condition of the drive belt(s).
6. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.
8. This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smooth operation. Inspect for a bent fan shaft or bent mounting flange.
9. Inspect the water pump drive shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known, good water pump.

10. Accessory drive component brackets that are bent, cracked, or loose may put an extra strain on that accessory drive component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to *Diagnostic Starting Point - Vibration Diagnosis and Correction* in Vibration Diagnosis and Correction	Go to *Step 4*
4	Inspect the drive belt(s) for wear, damage, debris build-up and missing drive belt ribs. Were any of these conditions found?	Go to *Step 5*	Go to *Step 6*
5	Install a new drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. Did you complete the replacement?	Go to *Step 11*	—
6	Inspect for incorrect, loose, and/ or missing fasteners. Were any of these conditions found?	Go to *Step 7*	Go to *Step 8*
7	Replace any incorrect and/or missing fastener. Tighten any loose fasteners. Refer to *Fastener Tightening Specifications*. Were the fasteners replaced and/or tightened?	Go to *Step 11*	—
8	Inspect for damaged fan blades or a bent fan clutch shaft. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 9*
9	Inspect for a bent water pump drive shaft. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 10*
10	Inspect for a bent or cracked accessory drive bracket(s). Did you find and correct the condition?	Go to *Step 11*	—
11	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the vibration still exist?	—	System OK

Drive Belt Falls Off Diagnosis

Diagnostic Aids

If the drive belt(s) repeatedly falls off the accessory drive pulley(s), this may be caused by a pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may also cause the drive belt(s) to fall off. Verify that the accessory drive component(s) are operating properly.

If the drive belt(s) is the incorrect length, the drive belt tensioner may not maintain the proper tension on the drive belt(s).

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2. This inspection is to verify the condition of the drive belt(s). Damage may have occurred to the drive belt(s) when the drive belt(s) fell off the pulley. Inspect the drive belt(s) for cuts, tears, sections of ribs missing, or damaged belt plys.
4. Misalignment of the accessory drive pulley(s) may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is

found, refer to that accessory drive component for the proper removal and installation procedure of that pulley.

5. Inspection of the accessory drive pulley(s) should include inspecting for bends, dents, or other damage that would prevent the drive belt from seating properly in the pulley grooves or on the smooth surface of a pulley when the back side of the drive belt(s) is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will also cause the drive belt(s) to fall off.
7. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed. Missing, loose, or incorrect fasteners may cause pulley misalignment from the accessory drive bracket(s) moving under load. Over tightening the fasteners may cause misalignment of the accessory component bracket(s).

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: The drive belt(s) falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Inspect for a damaged drive belt(s). Was a damaged drive belt(s) found?	Go to *Step 3*	Go to *Step 4*
3	Install a new drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning*. Does the drive belt(s) continue to fall off?	Go to *Step 4*	System OK
4	Inspect for a misaligned accessory drive pulley(s). Did you find and correct the condition?	Go to *Step 12*	Go to *Step 5*
5	Inspect for a bent or dented accessory drive pulley(s). Did you find and correct the condition?	Go to *Step 12*	Go to *Step 6*
6	Inspect for a bent or a cracked accessory drive bracket(s). Did you find and correct the condition?	Go to *Step 12*	Go to *Step 7*
7	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose and/or missing fasteners?	Go to *Step 8*	Go to *Step 9*
8	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to *Fastener Tightening Specifications*. Does the drive belt continue to fall off?	Go to *Step 9*	System OK
9	Test the drive belt tensioner for correct operation. Refer to *Drive Belt Tensioner Diagnosis*. Does the drive belt tensioner operate correctly?	Go to *Step 11*	Go to *Step 10*
10	Replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement - Accessory* or *Drive Belt Tensioner Replacement - Air Conditioning*. Does the drive belt continue to fall off?	Go to *Step 11*	System OK
11	Inspect for a failed drive belt idler and/or tensioner pulley bearing. Did you find and repair the condition?	Go to *Step 12*	—
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	—	System OK

Drive Belt Excessive Wear Diagnosis

Diagnostic Aids

Excessive wear on a drive belt(s) is usually caused by incorrect installation or the incorrect drive belt(s) for the application.

Minor misalignment of the accessory drive pulley(s) will not cause excessive wear, but will probably cause the drive belt(s) to make a noise or fall off.

Excessive misalignment of the accessory drive pulley(s) will cause excessive wear and may also make the drive belt(s) fall off.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

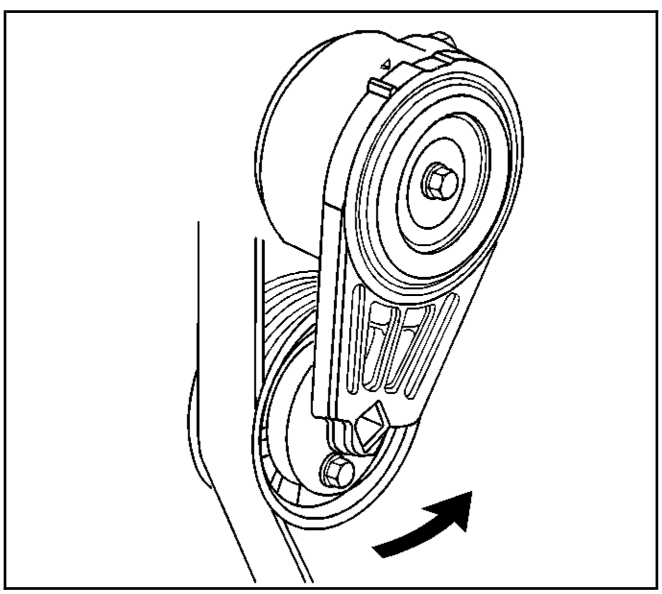
2. This inspection is to verify that the drive belt(s) is correctly installed on all of the accessory drive pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one or more grooves on a pulley(s).
3. The installation of a drive belt(s) that is too wide or too narrow will cause wear on the drive belt(s). The drive belt(s) ribs should match all of the grooves on the pulleys.
4. This inspection is to verify that the drive belt(s) is not contacting any part of the engine or body while the engine is operating. There should be sufficient clearance when the accessory drive components load varies. The drive belt(s) should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: Wear at the outside ribs of the drive belt(s) due to incorrect installation of the drive belt(s).			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Engine Mechanical*
2	Inspect the drive belt(s) for proper installation. Is the drive belt(s) installed properly?	Go to *Step 5*	Go to *Step 3*
3	Inspect for the correct drive belt(s). Is the correct drive belt installed?	Go to *Step 5*	Go to *Step 4*
4	Inspect the drive belt(s) for signs of rubbing against a bracket, hose, or wiring harness. Was the drive belt(s) rubbing against anything?	Go to *Step 5*	Go to Diagnostic Aids
5	Replace the drive belt(s). Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning.* Did you complete the replacement?	Go to *Step 6*	—
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	—	System OK

Drive Belt Tensioner Diagnosis

Inspection Procedure



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Notice: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

Important: When the engine is operating the drive belt tensioner arm will move. Do not replace the drive belt tensioner because of movement in the drive belt tensioner arm.

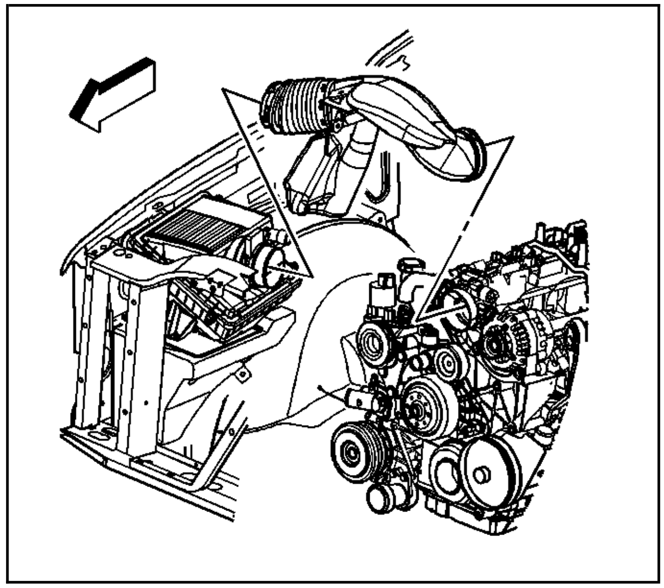
1. Remove the drive belt. Refer to *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning.*
2. Move the drive belt tensioner through its full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
3. If any binding is observed, replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement - Accessory* or *Drive Belt Tensioner Replacement - Air Conditioning.*
4. Install the drive belt. Refer to of *Drive Belt Replacement - Accessory* or *Drive Belt Replacement - Air Conditioning.*

Repair Instructions

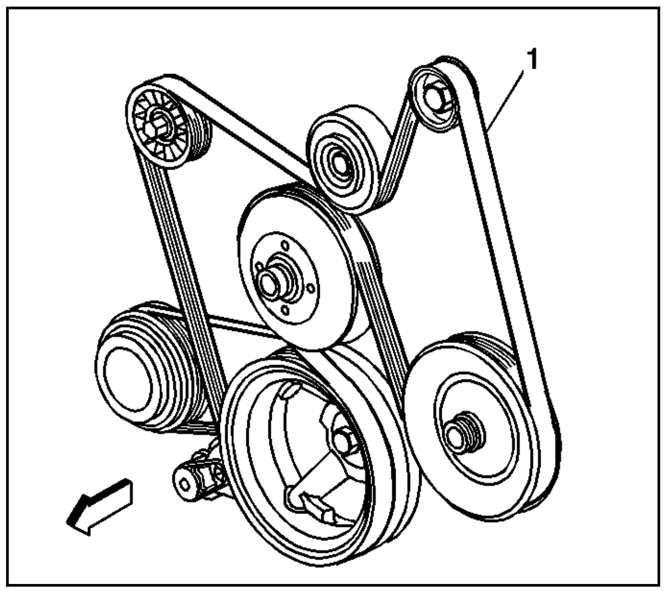
Drive Belt Replacement - Accessory

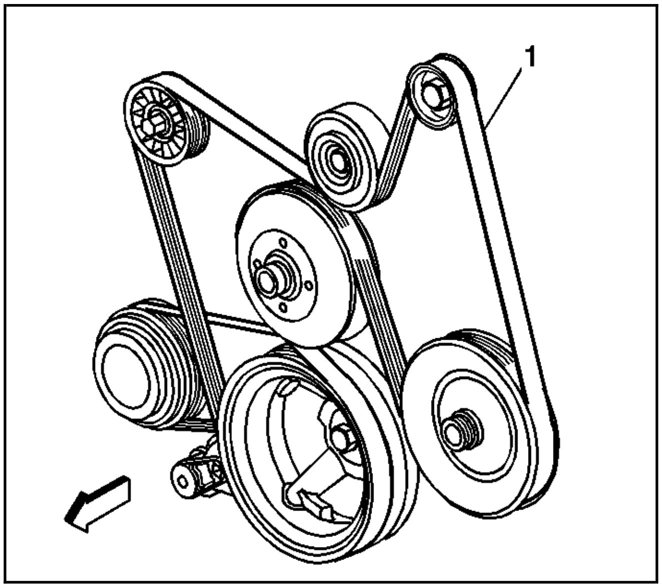
Removal Procedure

1. Loosen the air cleaner outlet duct clamps at the following locations:
   - The throttle body
   - The mass airflow/intake air temperature (MAF/IAT) sensor
2. Disconnect the radiator inlet hose clip from the outlet duct.
3. Remove the air cleaner outlet duct.



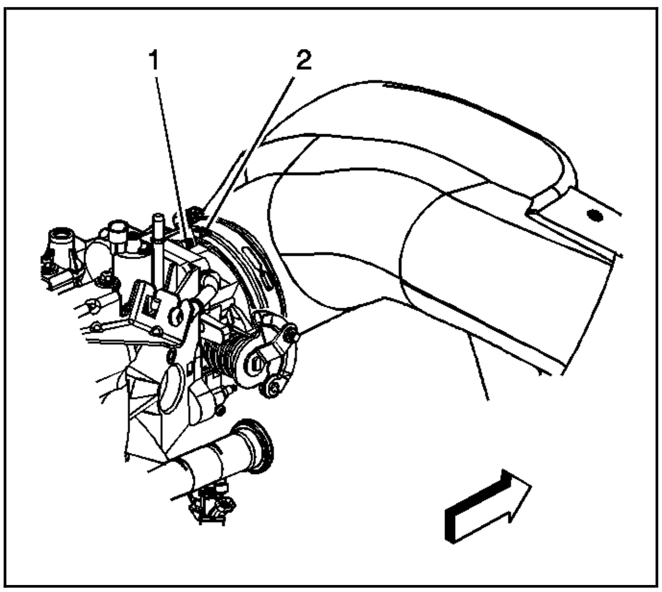
4. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.
5. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt (1).
6. Remove the belt (1) from the pulleys and the drive belt tensioner.
7. Slowly release the tension on the drive belt tensioner.
8. Remove the breaker bar and socket and from the drive belt tensioner bolt.
9. Clean and inspect the belt surfaces of all the pulleys.



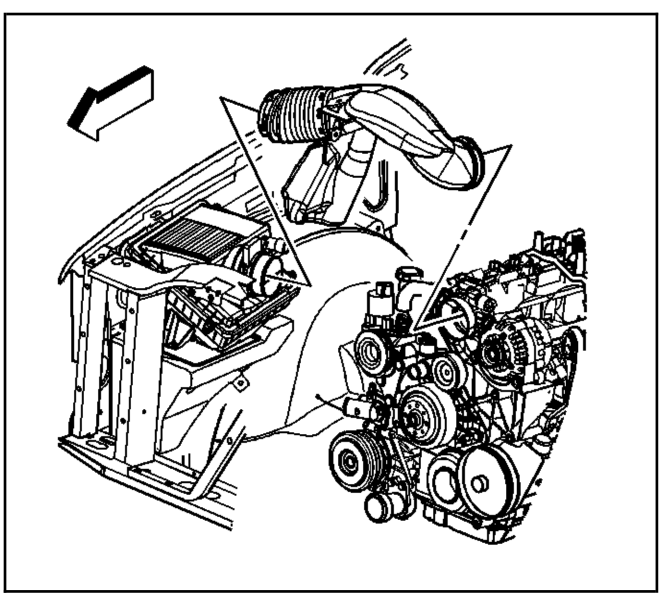


Installation Procedure

1. Route the drive belt (1) around all the pulleys except the idler pulley.
2. Install the breaker bar with hex-head socket to the belt tensioner bolt.
3. Rotate the belt tensioner clockwise in order to relieve the tension on the tensioner.
4. Install the drive belt (1) under the idler pulley.
5. Slowly release the tension on the belt tensioner.
6. Remove the breaker bar and socket from the belt tensioner bolt.
7. Inspect the drive belt (1) for proper installation and alignment.



8. Align the arrow (2) at the throttle body end of the duct with the throttle body attaching stud (1).



9. Install the air cleaner outlet duct.
10. Connect the radiator inlet hose clip to the outlet duct.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

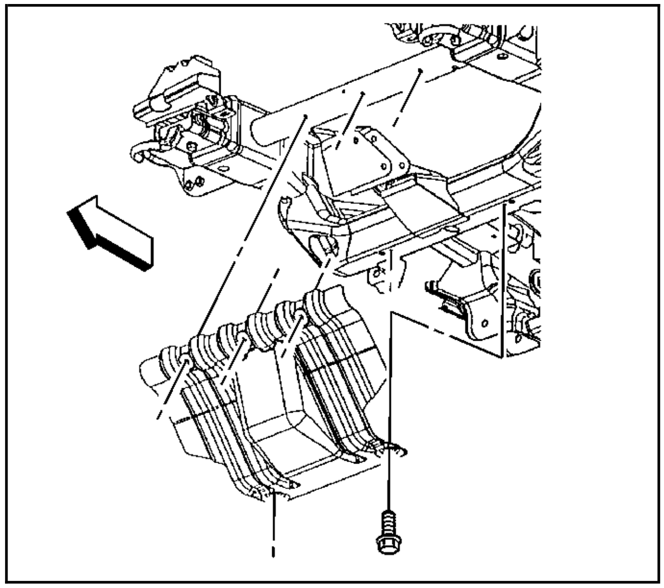
11. Tighten the air cleaner outlet duct clamps at the following locations:
    - The throttle body
    - The MAF/IAT sensor

    Tighten
    Tighten the clamps to 4 N·m (35 lb in).

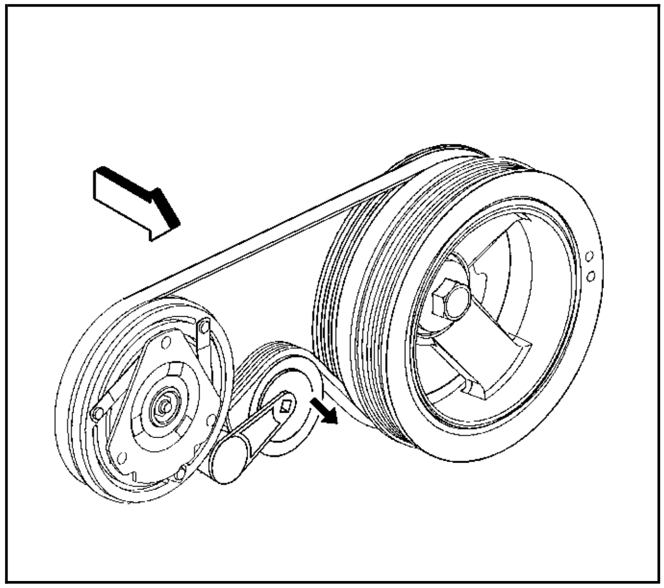
Drive Belt Replacement - Air Conditioning

Removal Procedure

1. Remove the accessory drive belt. Refer to *Drive Belt Replacement - Accessory*.
2. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the engine shield bolts.
4. Remove the engine shield.

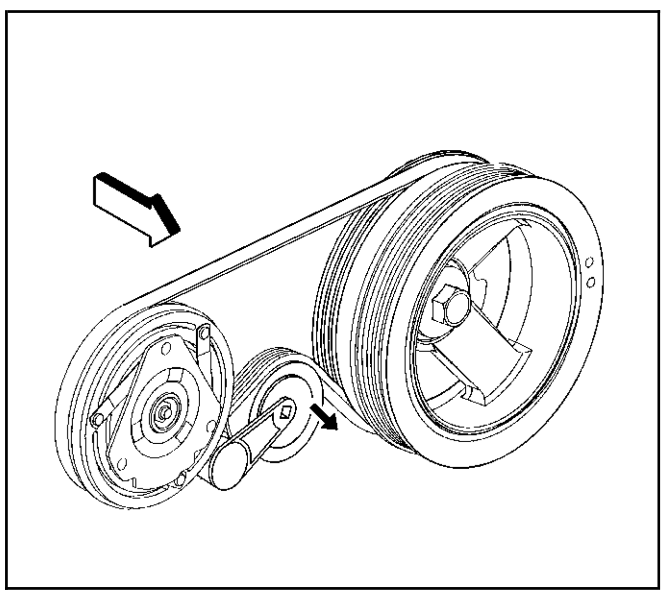


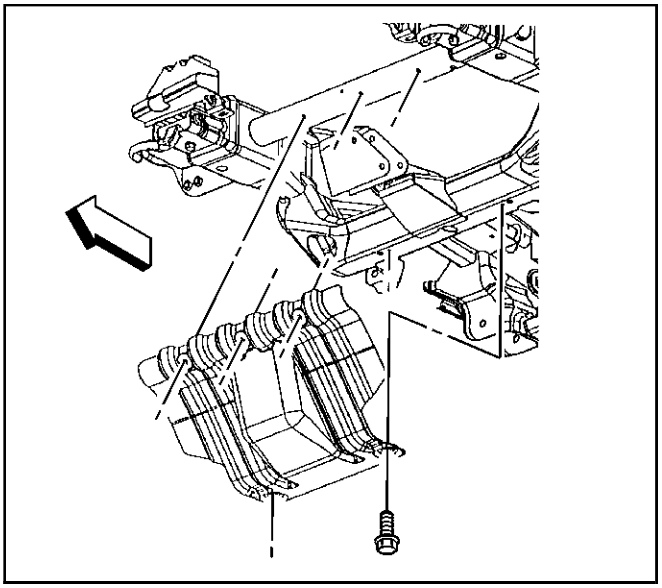
5. Install a ratchet into the air conditioning (A/C) belt tensioner adapter opening.
6. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
7. Remove the A/C belt from the pulleys.
8. Slowly release the tension on the A/C belt tensioner.
9. Remove the ratchet from the A/C belt tensioner.
10. Clean and inspect the belt surfaces of all the pulleys.



Installation Procedure

1. Install the A/C belt around the crankshaft balancer.
2. Install a ratchet into the A/C drive belt tensioner adapter opening
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the tensioner.
4. Install the A/C belt over the idler pulley.
5. Install the A/C belt around the A/C compressor pulley.
6. Slowly release the tension on the A/C belt tensioner.
7. Remove the ratchet from the A/C belt tensioner.
8. Inspect the A/C belt for proper installation and alignment.





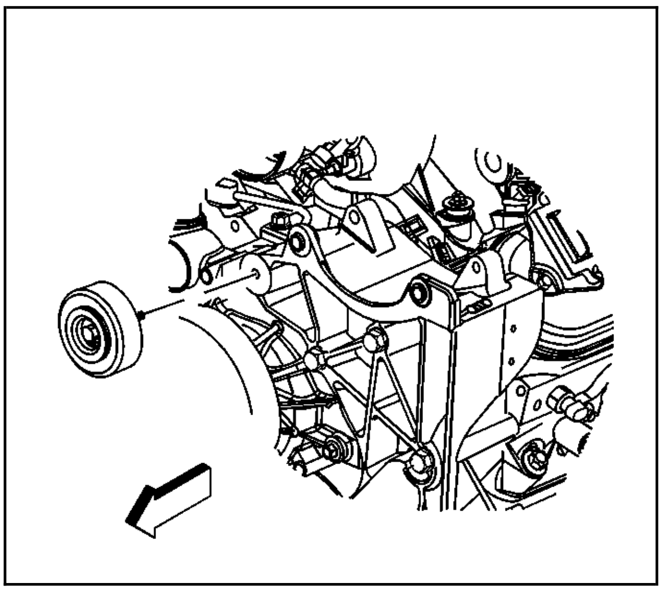
9. Install the engine shield.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

10. Install the engine shield bolts.

    Tighten

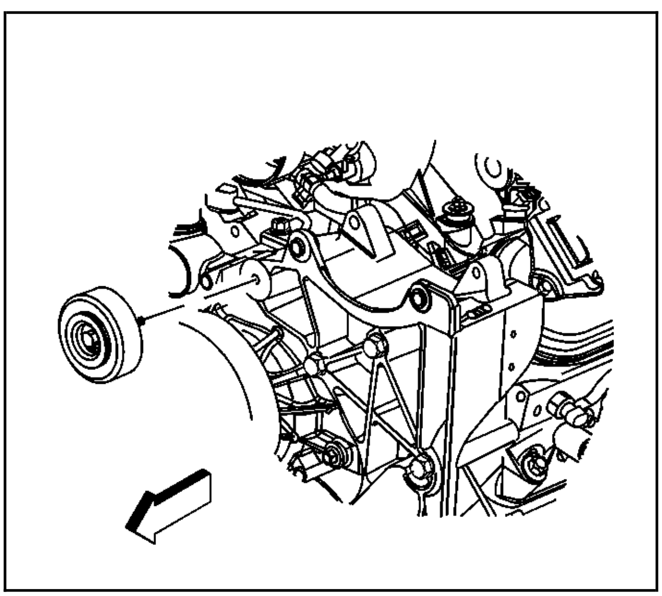
    Tighten the bolts to 20 N·m (15 lb ft).
11. Lower the vehicle.
12. Install the accessory drive belt. Refer to *Drive Belt Replacement - Accessory*.



Drive Belt Idler Pulley Replacement

Removal Procedure

1. Loosen the drive belt idler pulley bolt.
2. Remove the accessory drive belt. Refer to *Drive Belt Replacement - Accessory*.
3. Remove the drive belt idler pulley and bolt.



Installation Procedure

1. Install the drive belt idler pulley and bolt to the generator bracket.

   Snug the bolt finger tight.
2. Install the drive belt. Refer to *Drive Belt Replacement - Accessory*.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Tighten the drive belt idler pulley bolt.

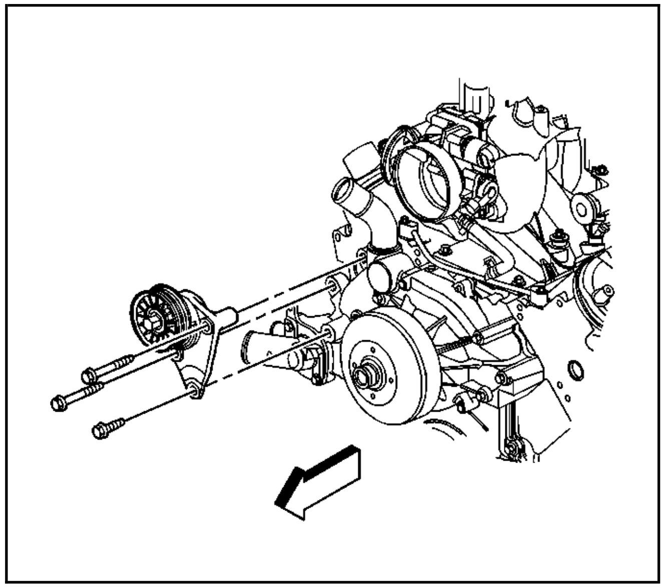
   Tighten

   Tighten the bolt to 50 N·m (37 lb ft).

Drive Belt Tensioner Replacement - Accessory

Removal Procedure

1. Remove the accessory drive belt. Refer to *Drive Belt Replacement - Accessory*.
2. Remove the drive belt tensioner bolts.
3. Remove the drive belt tensioner.



Installation Procedure

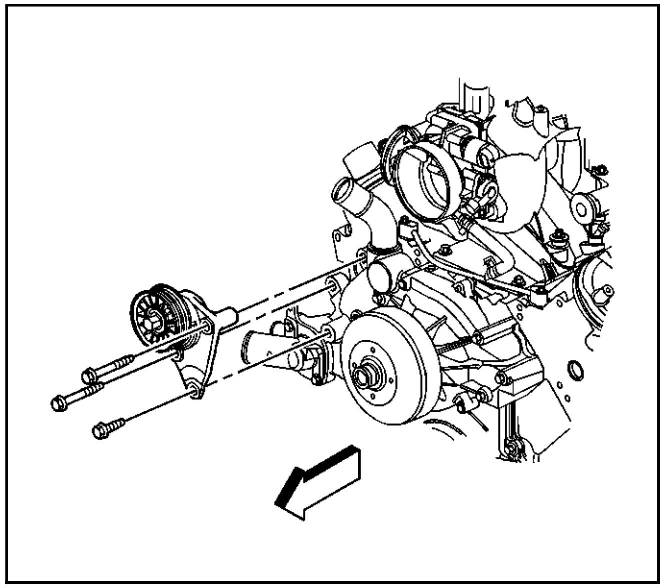
1. Install the drive belt tensioner.
2. Install the drive belt tensioner bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Tighten the drive belt tensioner bolts.

   Tighten

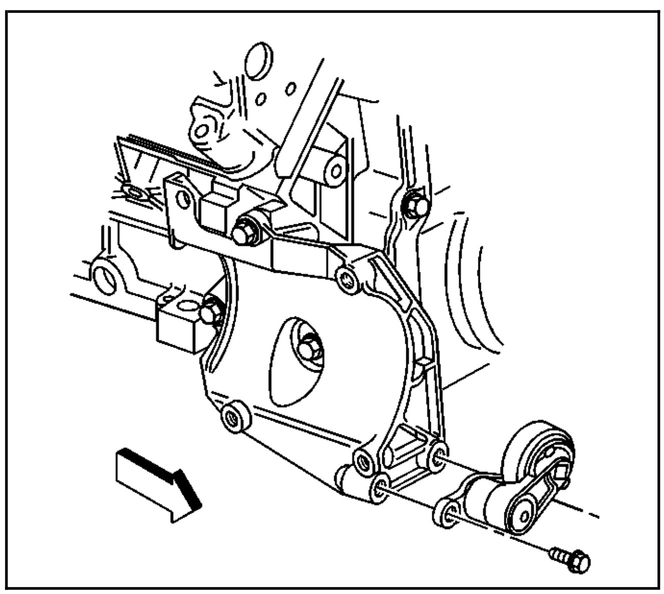
   Tighten the bolts to 50 N·m (37 lb ft).
4. Install the accessory drive belt. Refer to *Drive Belt Replacement - Accessory*.

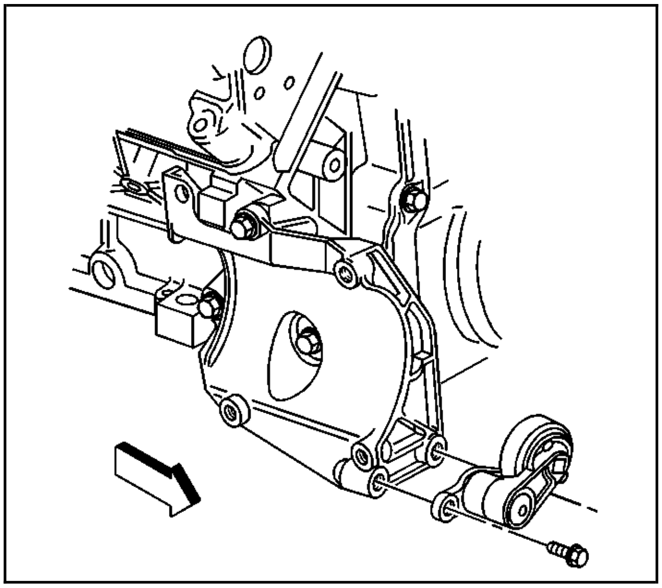


Drive Belt Tensioner Replacement - Air Conditioning

Removal Procedure

1. Remove the air conditioning (A/C) drive belt. Refer to *Drive Belt Replacement - Air Conditioning*.
2. Remove the A/C belt tensioner bolts.
3. Remove the A/C belt tensioner.





Installation Procedure

1. Install the A/C belt tensioner.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the A/C belt tensioner bolts.

   Tighten

   Tighten the bolts to 50 N·m (37 lb ft).

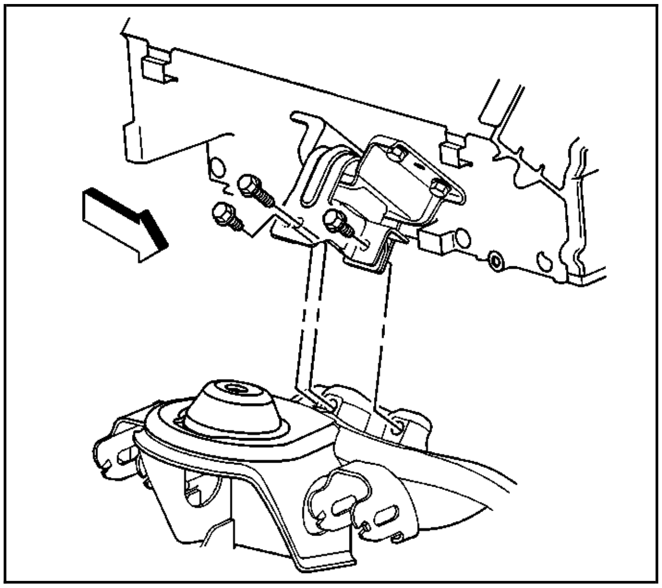
3. Install the A/C drive belt. Refer to *Drive Belt Replacement - Air Conditioning*.

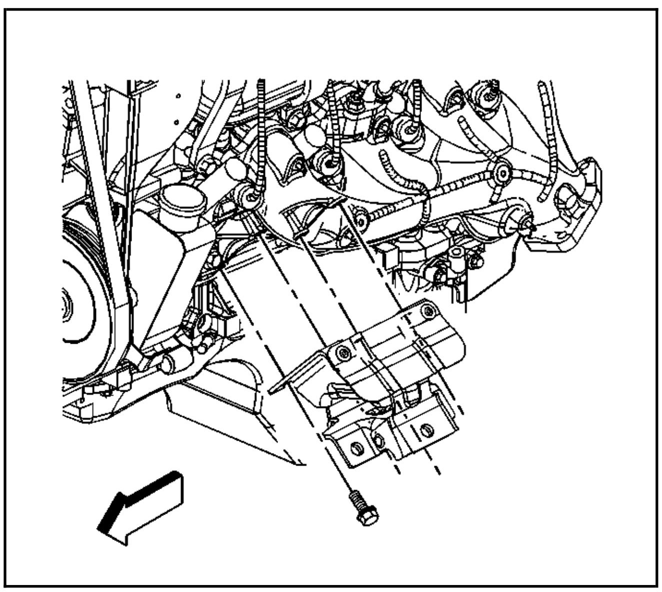
Engine Mount Inspection

Notice: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Measure the engine movement at the engine mount in order to check for damage to the rubber portions of the mount.
   1.1. Apply the park brake.
   1.2. Start the engine.
   1.3. Firmly apply and hold the primary brakes.
   1.4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
   1.5. Slightly load the engine shifting from drive to reverse a few times.
   1.6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, check for loose engine mount bolts.
2. If the engine mount bolt torque is within specifications, check the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:
   - Heat check cracks cover the rubber cushion surface.
   - The rubber cushion is separated from the metal plate of the mount.
   - There is a split through the rubber cushion.





Engine Mount Replacement - Left

Removal Procedure

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the tire and wheel. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.
3. Remove the wheelhouse panel from the vehicle. Refer to *Wheelhouse Panel Replacement* in Body front End.
4. For vehicles with 4WD, remove the front propeller shaft. Refer to *Propeller Shaft Replacement - Front* in Propeller Shaft.

Important: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.

5. Raise and suitably support the engine using adjustable (screw type) jack stands.
6. Remove the engine mount-to-engine mount bracket bolts. (Right side shown, left side similar).
7. Remove the engine mount bolts.
8. Remove the left engine mount.

Installation Procedure

1. Install the left engine mount to the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

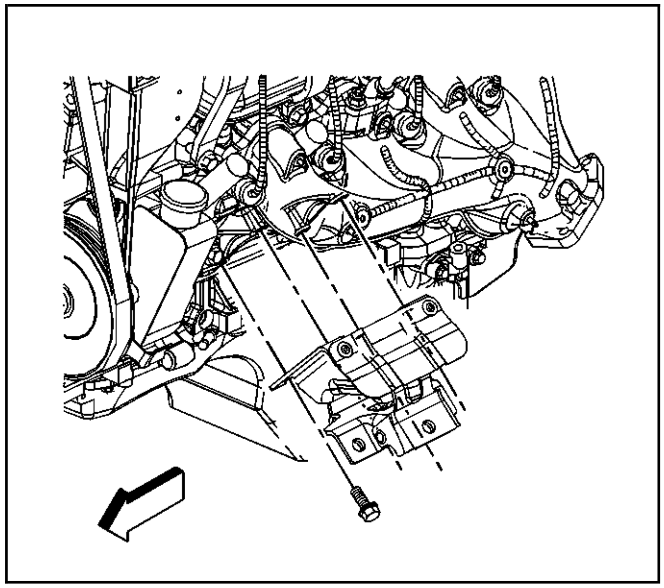
2. Install the engine mount bolts to the engine.

   Tighten

   Tighten the engine mount bolts to 50 N·m (37 lb ft).

3. Lower the engine.
4. Remove the adjustable jack stands.

5.LeftBlankintentionally.

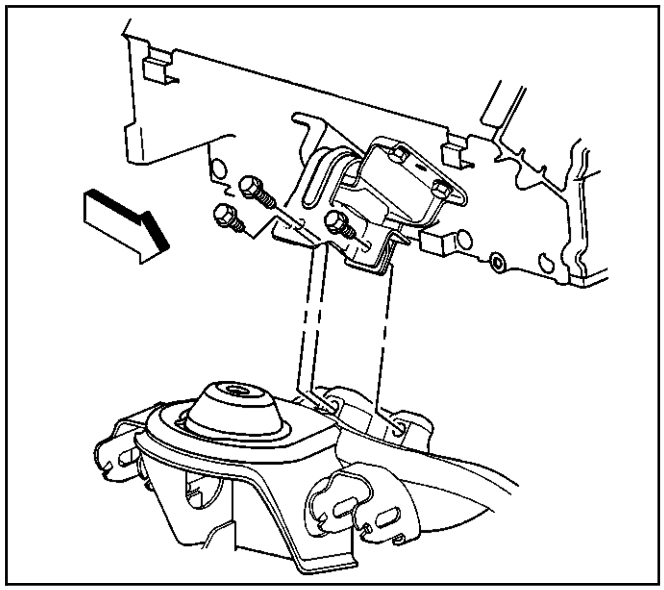


6. Install the engine mount-to-engine mount bracket bolts. (Right side shown, left side similar).

   Tighten

   Tighten the engine mount-to-engine mount bracket bolts to 65 N·m (48 lb ft).

7. Install the wheelhouse panel from the vehicle. Refer to *Wheelhouse Panel Replacement* in Body front End.
8. Install the tire and wheel. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.
9. Lower the vehicle.



Engine Mount Replacement - Right

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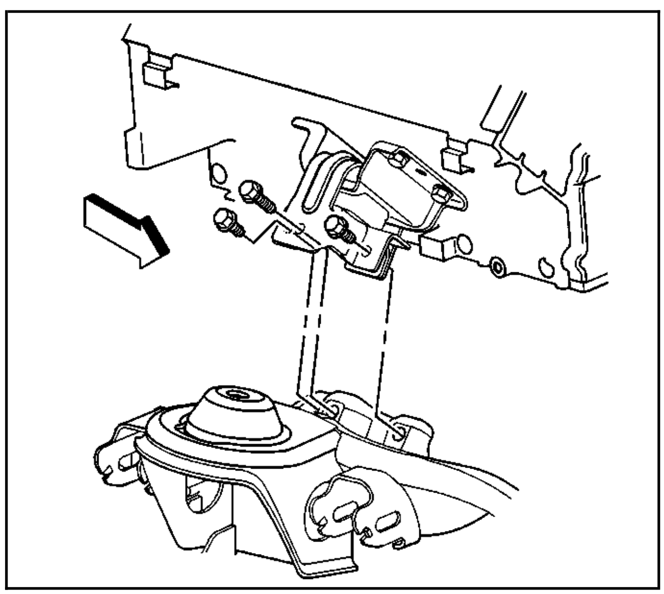
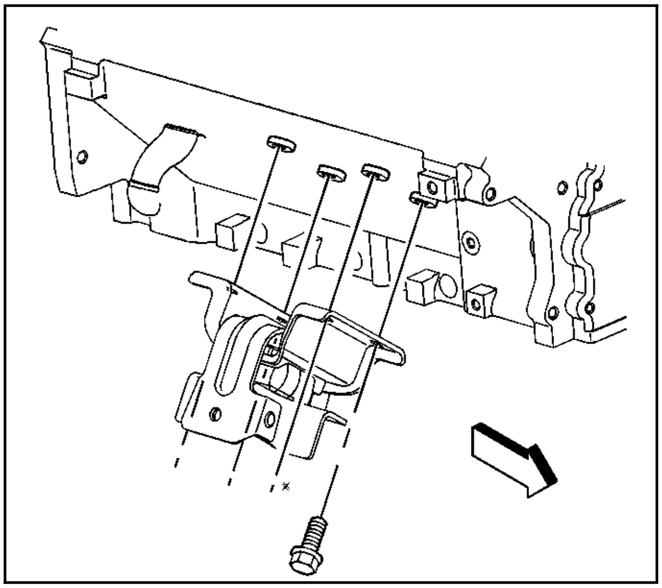
Removal Procedure

1. Remove the exhaust manifold. Refer to *Exhaust Manifold Replacement - Right (4.8L and 6.0L Engines)* or *Exhaust Manifold Replacement - Right (8.1L Engine)* in Engine Exhaust.
2. Remove the engine mount-to-engine mount bracket bolts.
3. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Remove the tire and wheel. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.

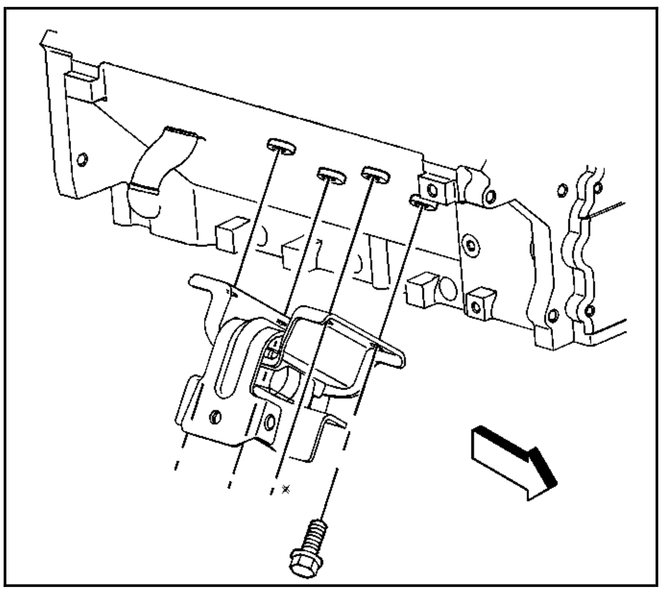




5. Remove the inner wheelhouse panel. Refer to Refer to *Wheelhouse Panel Replacement* in Body Front End.
6. Remove the engine protection shield, if equipped. Refer to *Engine Protection Shield Replacement* in Frame and Underbody.

Important: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.

7. Raise and suitably support the engine using adjustable (screw type) jack stands.
8. Remove the engine mount to engine bolts.
9. Remove the right engine mount.



Installation Procedure

1. Position the right engine mount to the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the engine mount bolts.

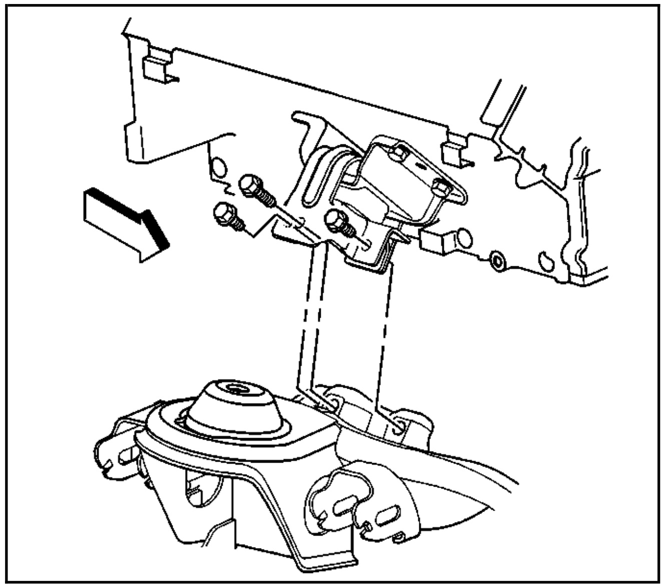
   Tighten

   Tighten the engine mount bolts to 50 N·m (37 lb ft).
3. Lower the engine.
4. Remove the adjustable jack stands.

5. Install the engine mount-to-engine mount bracket bolts.

   Tighten

   Tighten the engine mount-to-engine mount bracket bolts to 65 N·m(48 lb ft).
6. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement - Right (4.8L and 6.0L Engines)* or *Exhaust Manifold Replacement - Right (8.1L Engine)* in Engine Exhaust.
7. Install the inner wheelhouse panel. Refer to Refer to *Wheelhouse Panel Replacement* in Body Front End.
8. Install the tire and wheel. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.
9. Install the engine protection shield, if equipped. Refer to *Engine Protection Shield Replacement* in Frame and Underbody.
10. Lower the vehicle.



Engine Mount Bracket Replacement - Left

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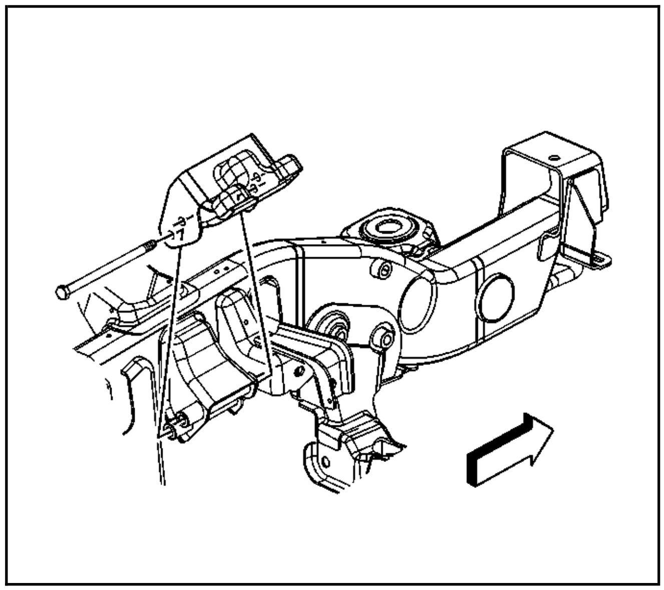
Removal Procedure

1. Remove the engine mount. Refer to *Engine Mount Replacement - Left*.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.



Installation Procedure

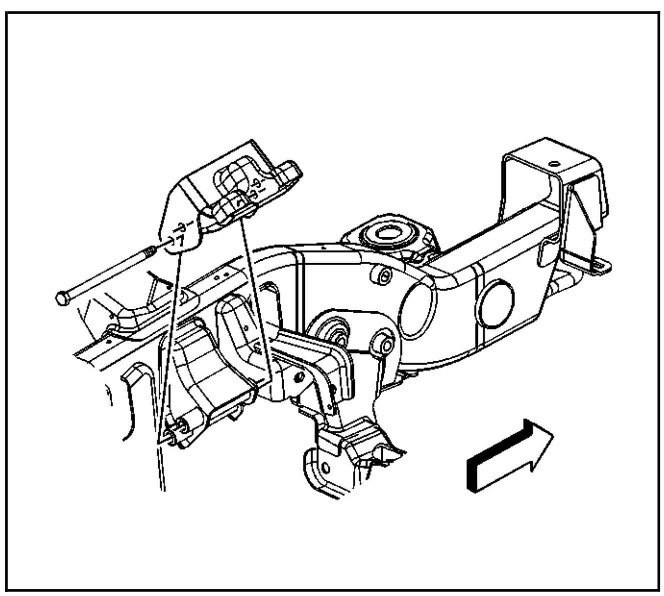
1. Install the engine mount bracket.

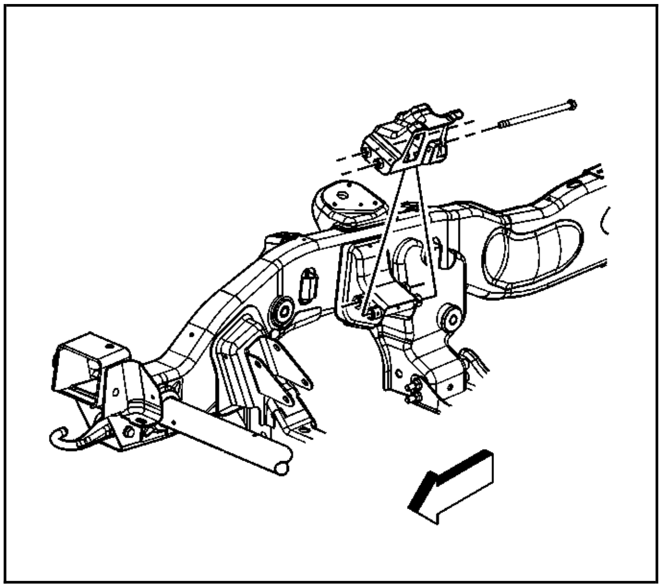
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the engine mount bracket bolts.

   Tighten

   Tighten the engine mount bracket bolts to 75 N·m (55 lb ft).
3. Install the engine mount. Refer to *Engine Mount Replacement - Left*.

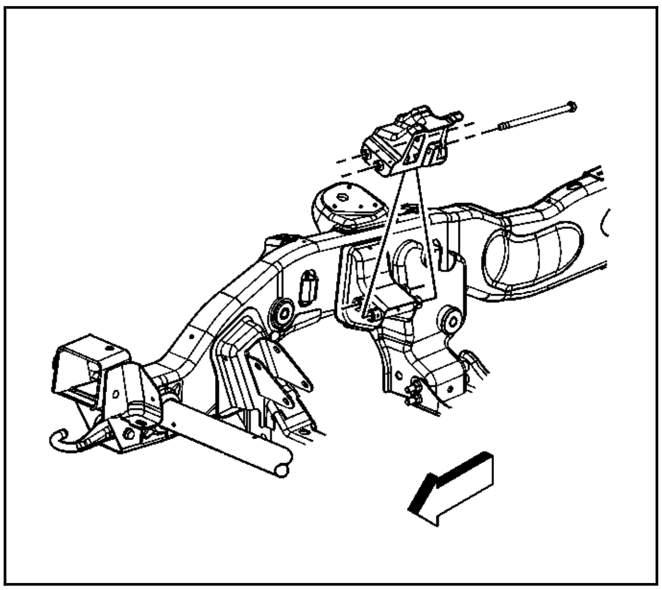




Engine Mount Bracket Replacement - Right

Removal Procedure

1. Remove the engine mount. Refer to *Engine Mount Replacement - Right*.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.



678846

Installation Procedure

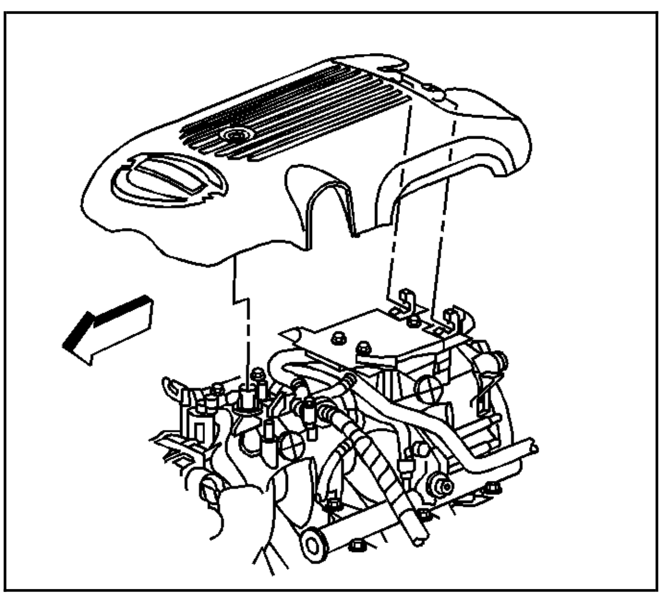
1. Install the engine mount bracket.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the engine mount bracket bolts.

   Tighten

   Tighten the engine mount bracket bolts to 75 N·m (55 lb ft).
3. Install the engine mount. Refer to *Engine Mount Replacement - Right*.



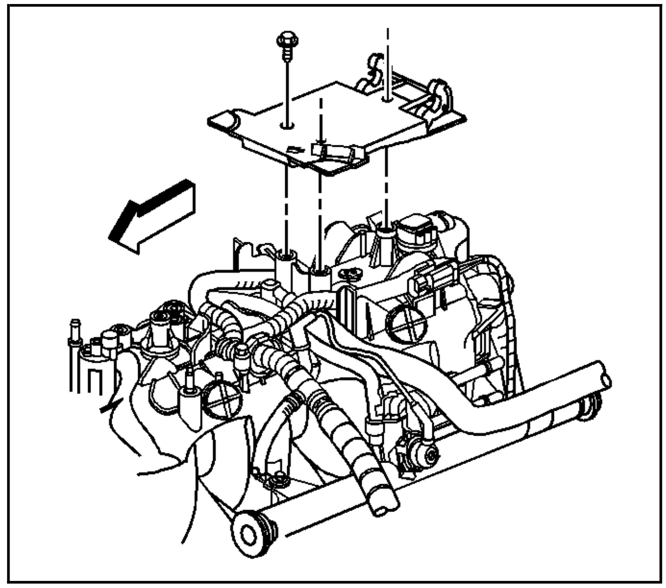
832094

Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4))

Removal Procedure

1. Loosen the intake manifold sight shield bolt.
2. Remove the sight shield from the sight shield retainer.

3. Remove the sight shield retainer bolts and the retainer, if required.



832095

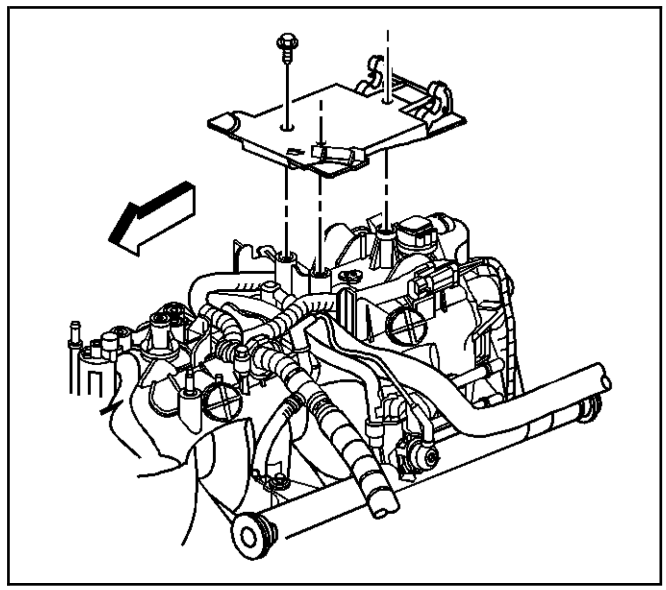
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the sight shield retainer and the bolts, if required.

   Tighten

   Tighten the bolts to 5 N·m (44 lb in).



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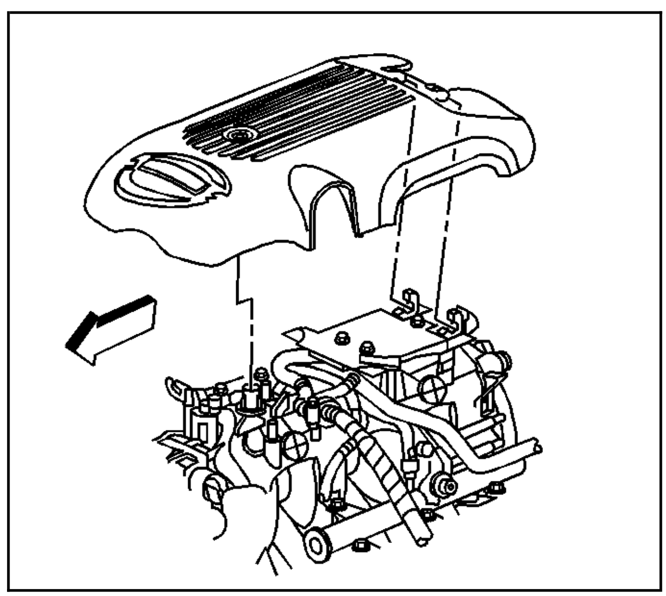
Notice: Use care when installing the engine sight shield to avoid contacting the manifold absolute pressure (MAP) sensor wire harness connector. Loss of engine performance or engine damage may result.

2. Install the intake manifold sight shield to the retainer.

   Tighten

   Tighten the bolt to 10 N·m (89 lb in).



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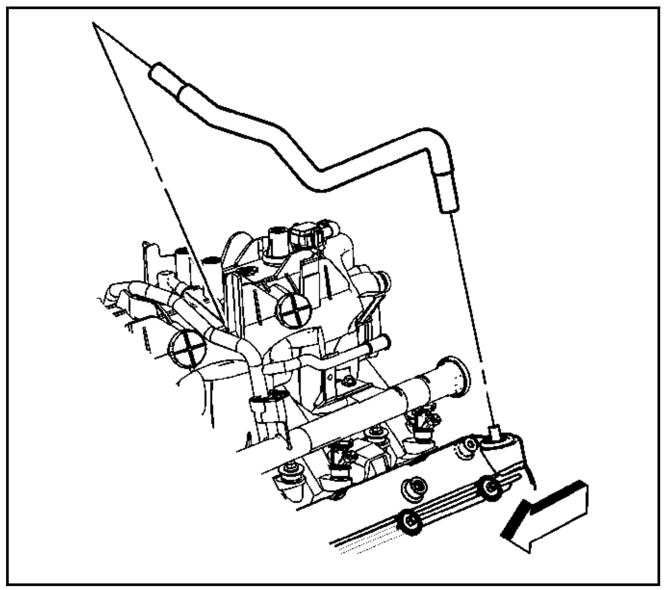
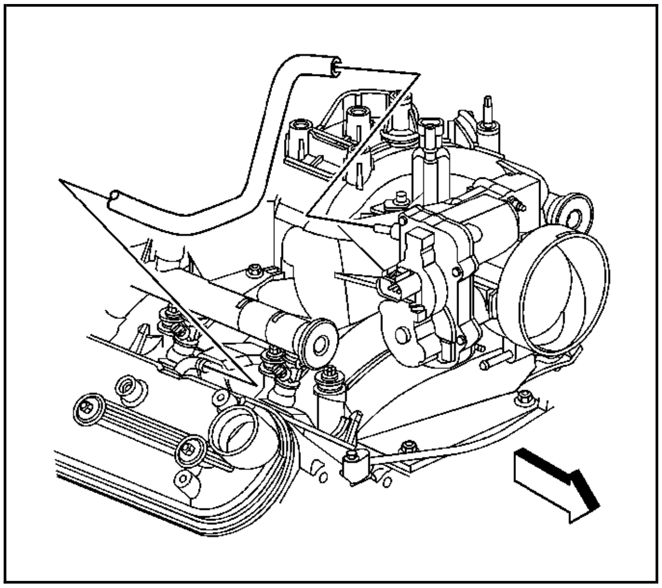
Crankcase Ventilation Hoses/Pipes Replacement

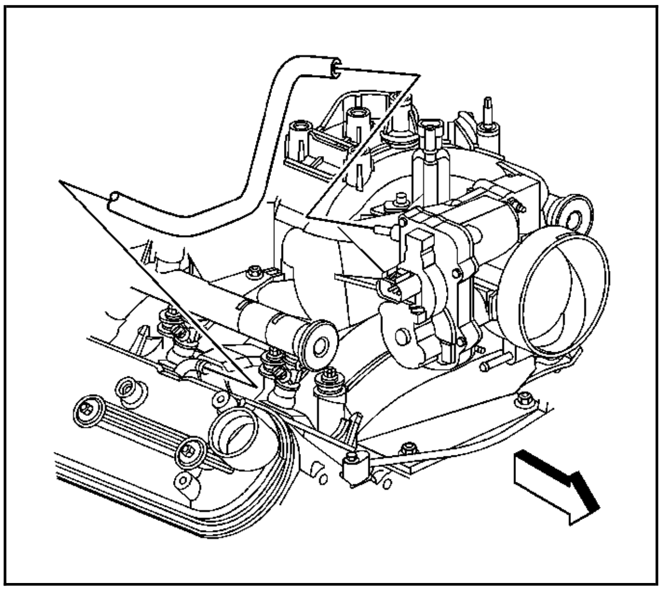
Removal Procedure

1. Remove the engine sight shield. Refer to *Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4))*.
2. Remove the positive crankcase ventilation (PCV) hose from the intake manifold and valve rocker arm cover.



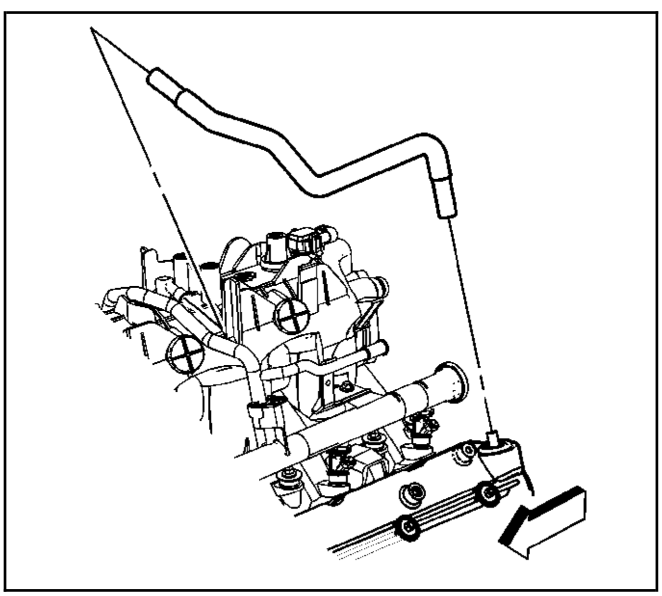


3. Remove the vent hose from the throttle body and the valve rocker arm cover.
4. Replace the hose as necessary.



Installation Procedure

1. Install the hose as necessary.
2. Install the vent hose to the throttle body and the valve rocker arm cover.



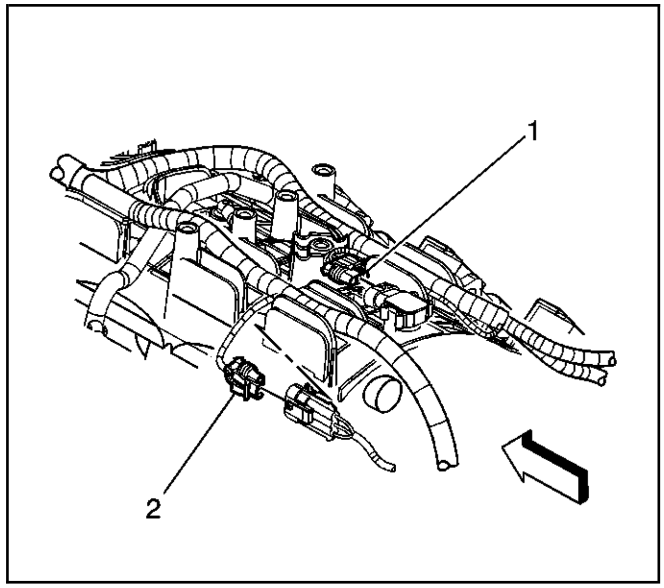
3. Install the PCV hose to the intake manifold and valve rocker arm cover.
4. Install the engine sight shield. Refer to *Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4)*.

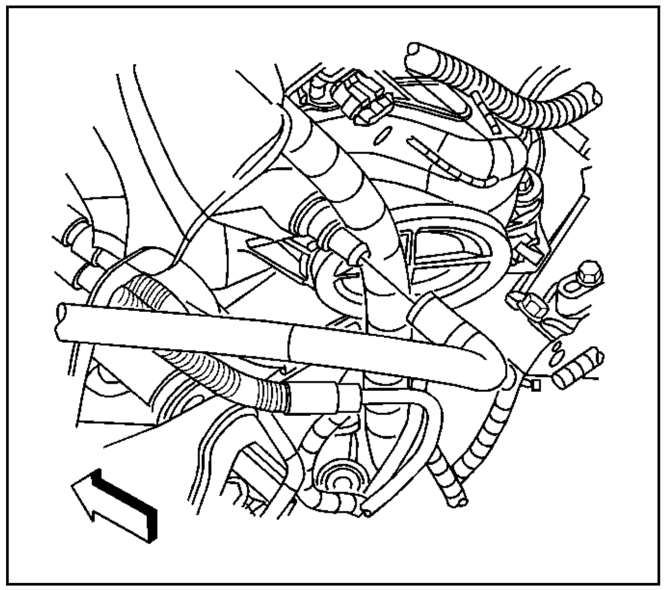
Intake Manifold Replacement

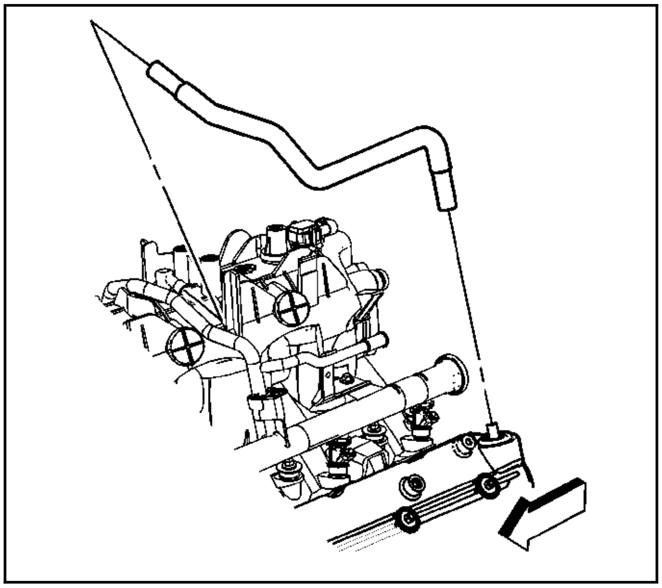
Removal Procedure

Important: The intake manifold, throttle body, fuel rail, and injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

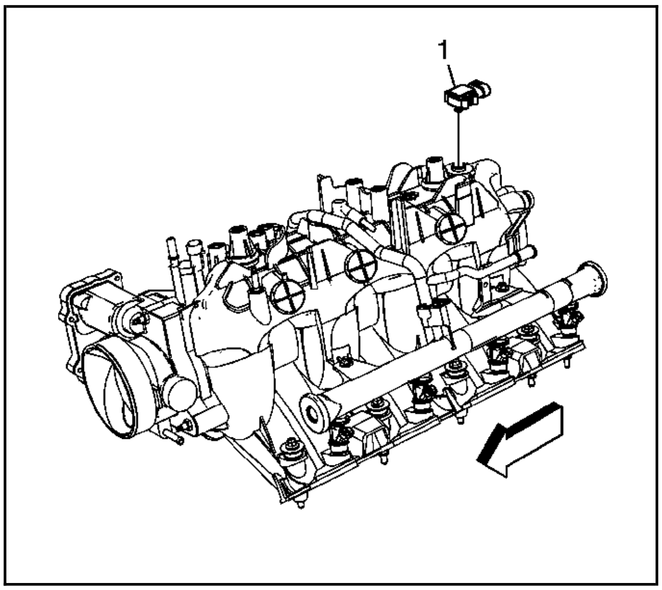
1. Remove the throttle body. Refer to *Throttle Body Assembly Replacement* in Engine Controls – 4.8 and 6.0L.
2. Remove the fuel injectors. Refer to *Fuel Injector Replacement* in Engine Controls – 4.8L and 6.0L.
3. Disconnect the following electrical connectors:
   - Manifold absolute pressure (MAP) sensor (1)
   - Knock sensor (2)
4. Remove the knock sensor harness electrical connector from the intake manifold.
5. Set the electrical harness aside.
6. If equipped with vacuum assisted brakes, remove the vacuum brake booster hose from the rear of the intake manifold.



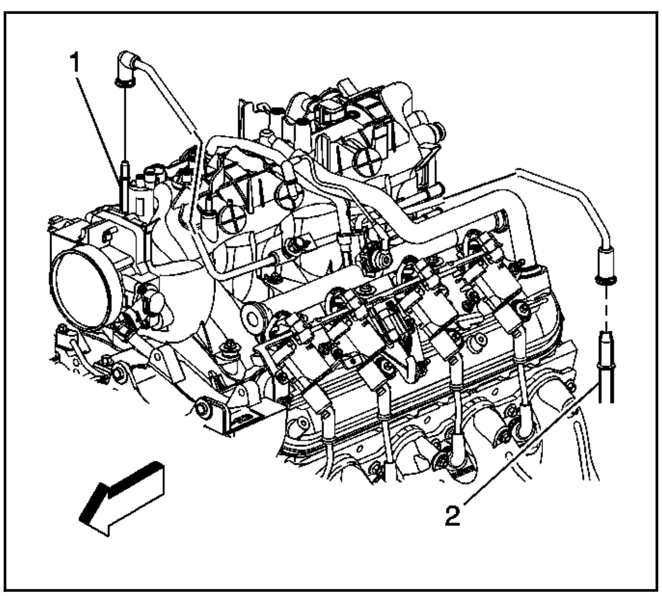




7. Remove the positive crankcase ventilation (PCV) hose.

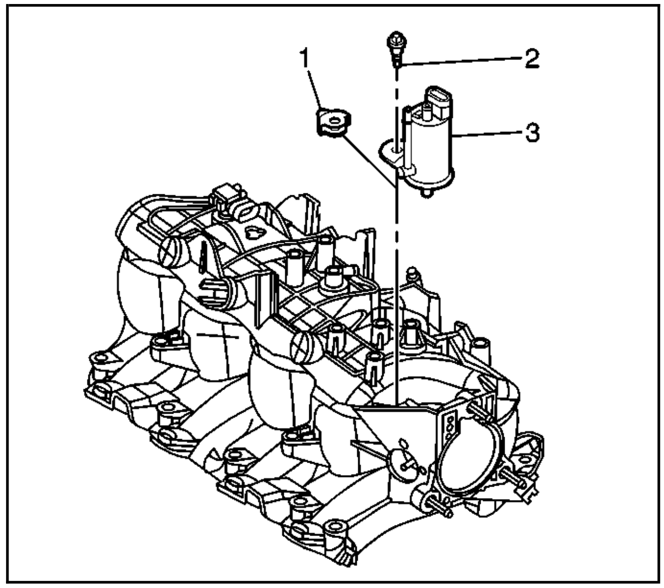


8. Remove the MAP sensor (1) from the intake manifold.

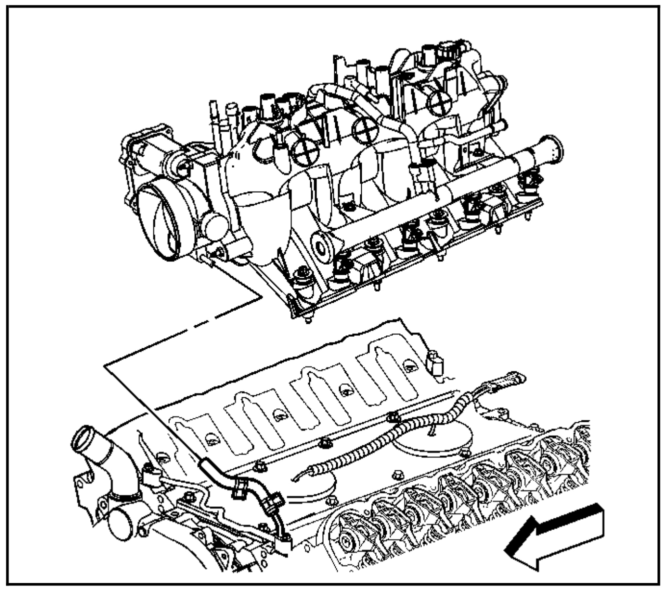


9. Remove the evaporative emission (EVAP) purge solenoid vent tube by performing the following:
   9.1. Remove the EVAP tube end from the solenoid (1).
   9.2. Remove the EVAP tube end from the vapor pipe (2).

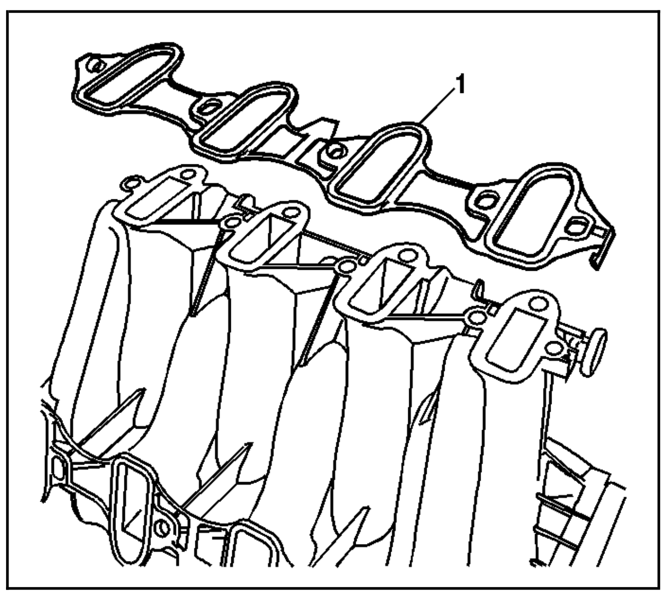
10. Remove the EVAP purge solenoid bolt (2), solenoid (3), and isolator (1) from the intake manifold.

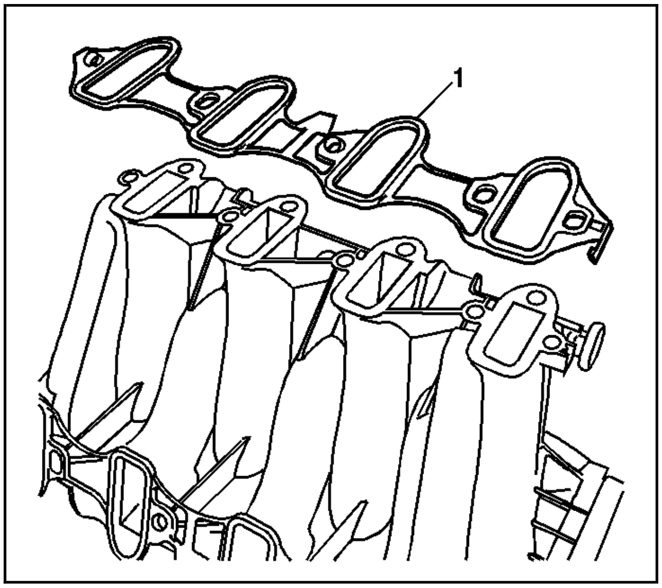


11. Loosen the intake manifold bolts.
12. Remove the intake manifold.



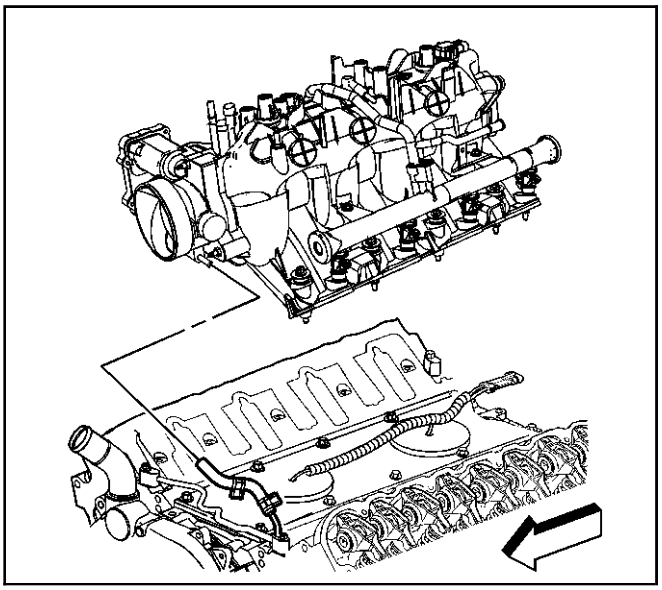
13. Remove the intake manifold gaskets (1) from the intake manifold.
14. Discard the old intake manifold gaskets.
15. If required, clean and inspect the intake manifold. Refer to *Intake Manifold Cleaning and Inspection*.



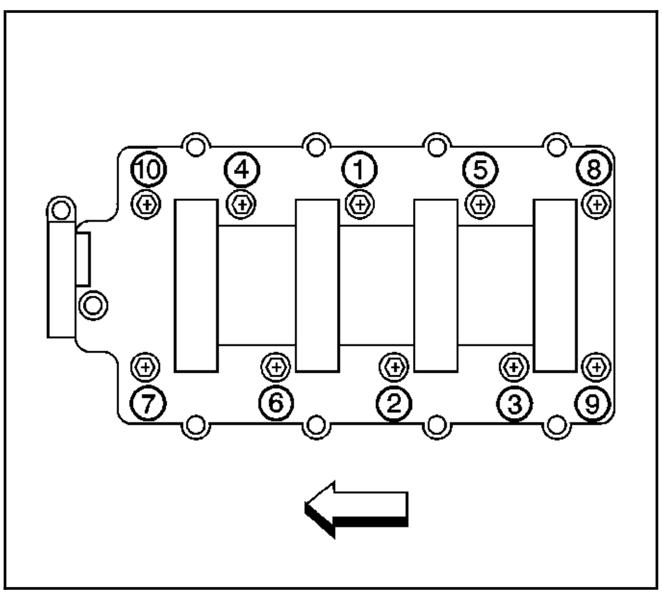


Installation Procedure

1. Install NEW intake manifold gaskets (1) to the intake manifold.



2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent to the threads of the intake manifold bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Tighten the intake manifold bolts.

   Tighten

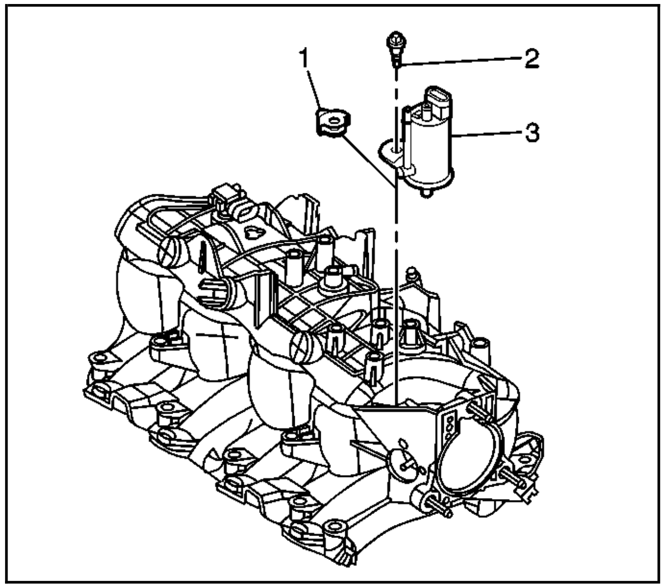
   4.1. Tighten the bolts a first pass in sequence to 5 N·m (44 lb in).

   4.2. Tighten the bolts a final pass in sequence to 10 N·m (89 lb in).

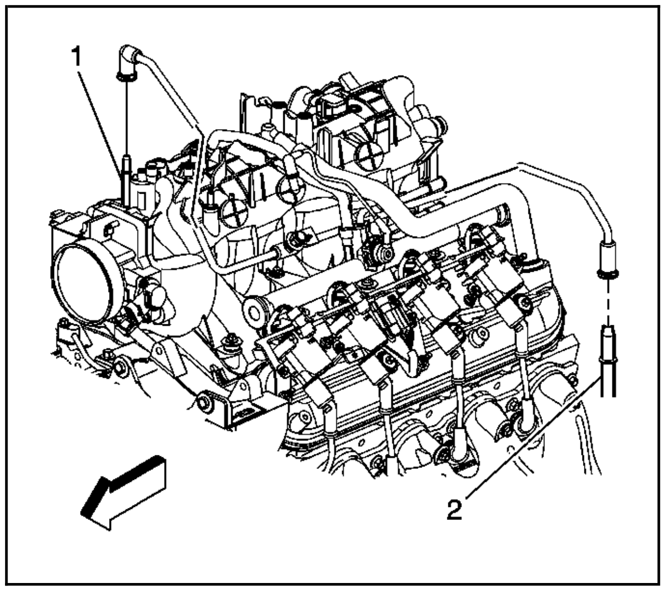
5. Install the EVAP purge solenoid (3), isolator (1), and bolt (2) to the intake manifold.

   Tighten

   Tighten the bolt to 10 N·m (89 lb in).

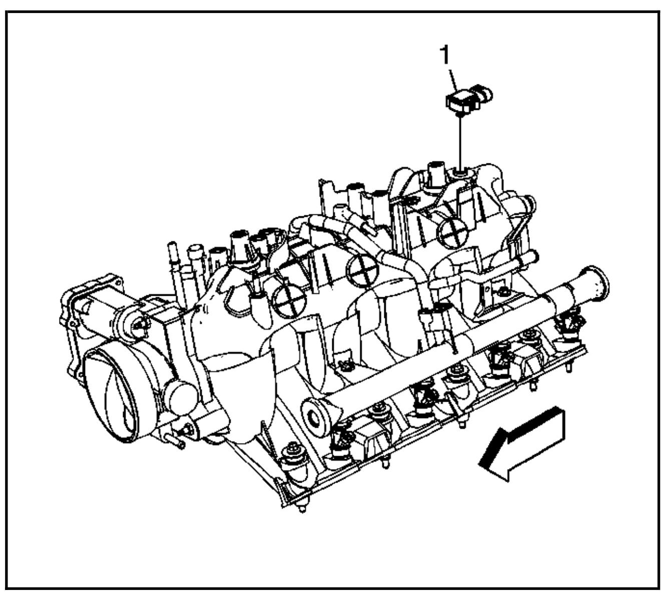


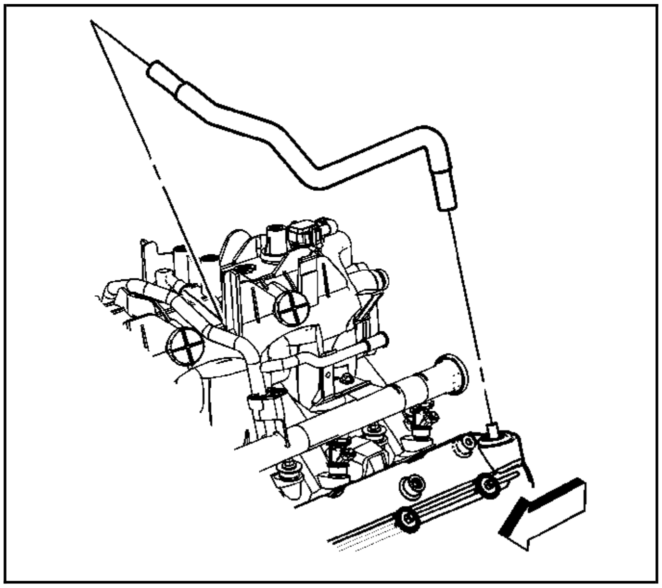
6. Install the EVAP purge solenoid vent tube to the solenoid (1) and vapor pipe (2).



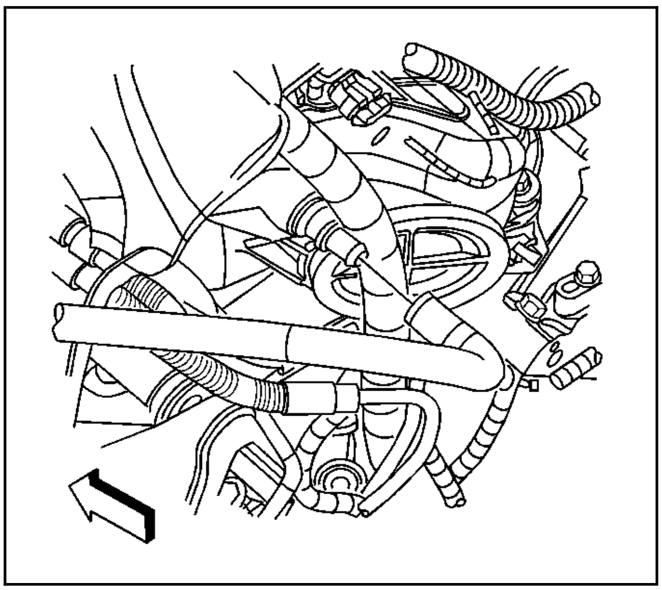
Important: Lightly coat the MAP sensor seal with clean engine oil before installing.

7. Install the MAP sensor (1) to the intake manifold.

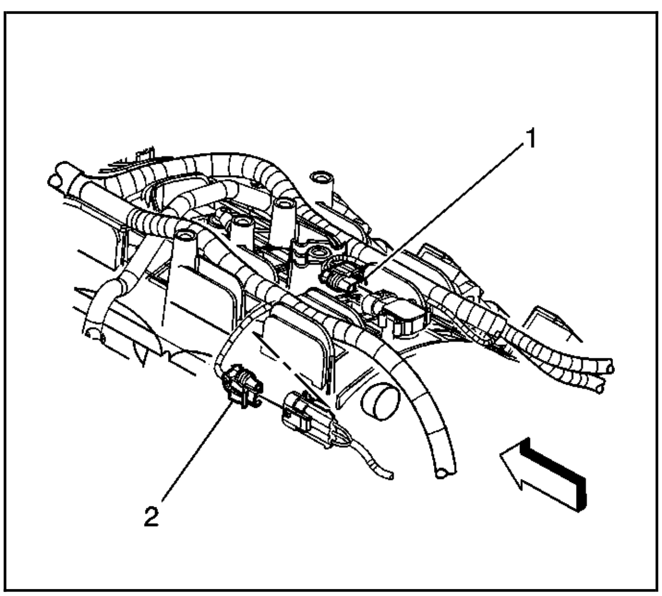




8. Install the PCV hose.



9. If equipped with vacuum assisted brakes, install the vacuum brake booster hose to the rear of the intake manifold.
10. Route the electrical harness into position over the engine.

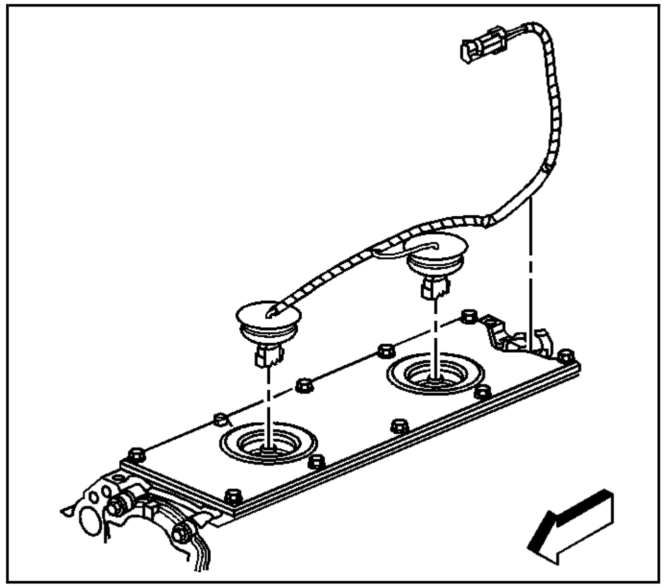


11. Connect the knock sensor harness electrical connector to the intake manifold.
12. Connect the following electrical connectors.
    - MAP sensor (1)
    - Knock sensor (2)
13. Install the fuel injectors. Refer to *Fuel Injector Replacement* in Engine Controls – 4.8L and 6.0L.
14. Install the throttle body. Refer to *Throttle Body Assembly Replacement* in Engine Controls – 4.8L and 6.0L.

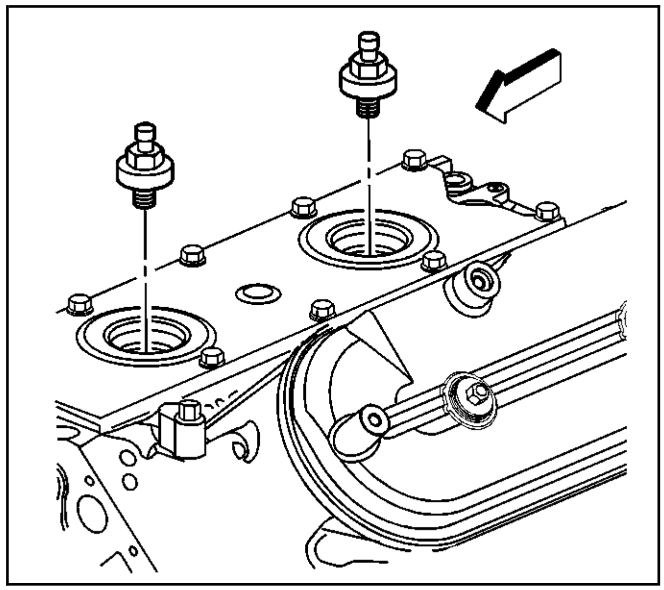
Engine Valley Cover Replacement

Removal Procedure

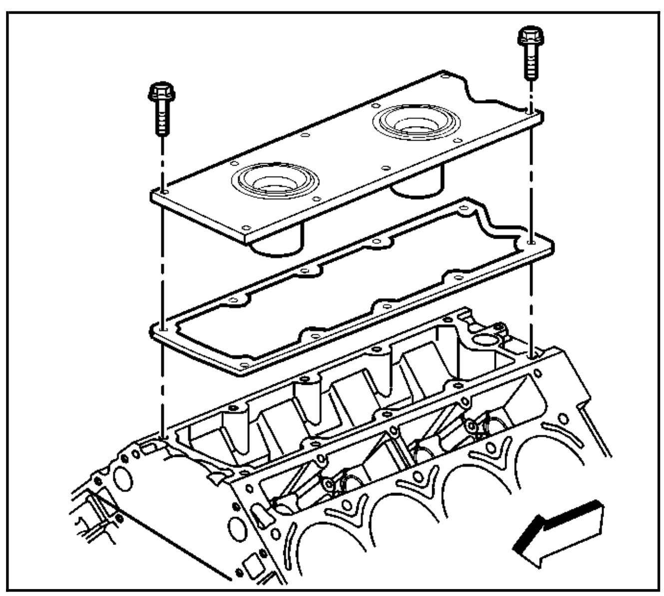
1. Remove the intake manifold. Refer to *Intake Manifold Replacement*.
2. Gently pry up the rubber covers.
3. Disconnect the knock sensor electrical connectors.

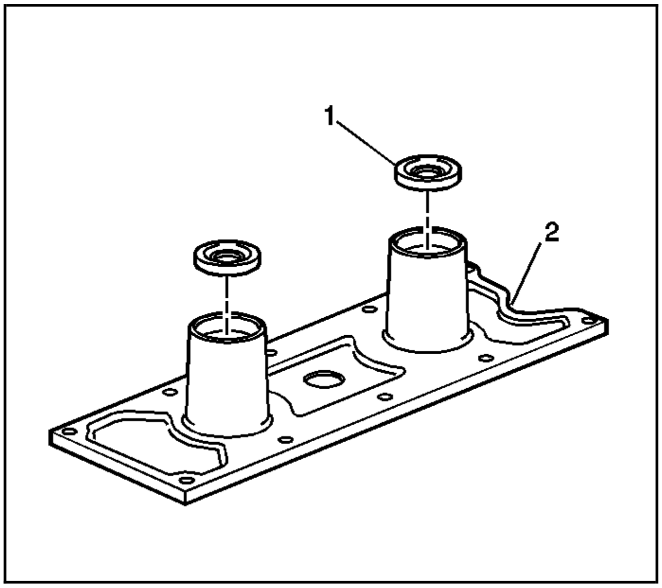


4. Remove the knock sensors.

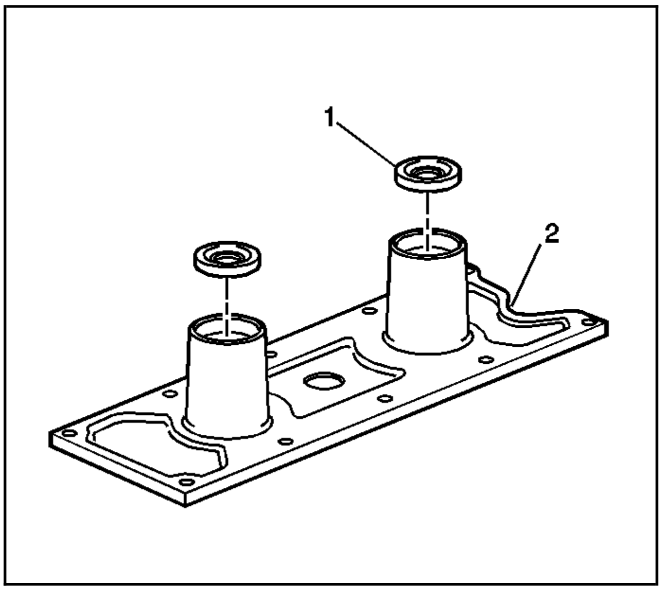


5. Remove the engine valley cover bolts.
6. Remove the engine valley cover and gasket.
7. Discard the old gasket.





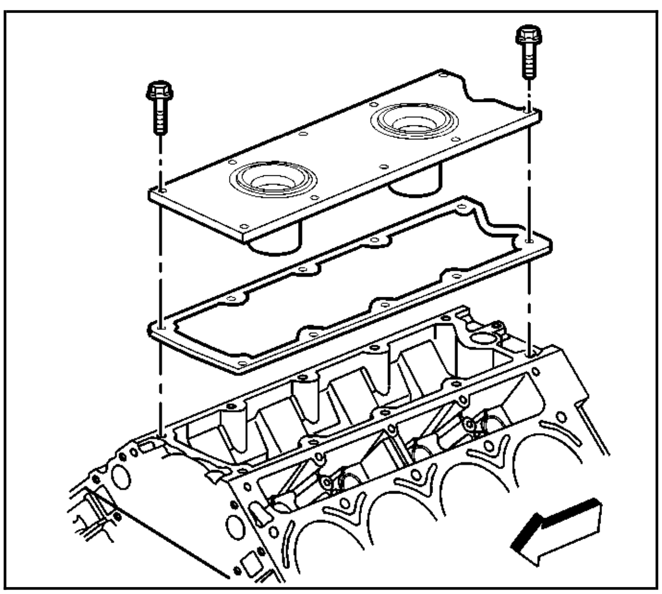
8. Remove the knock sensor oil seals (1) from the cover (2).
9. If required, clean and inspect the engine valley cover. Refer to *Engine Valley Cover Cleaning and Inspection*.



Installation Procedure

Important: All gasket surfaces should be free of oil or other foreign material during assembly.

1. Lubricate the NEW knock sensor seals (1) with clean engine oil.
2. Install the knock sensor oil seals (1) into the engine valley cover (2).



3. Install the engine valley cover with a NEW gasket onto the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the engine valley cover bolts.

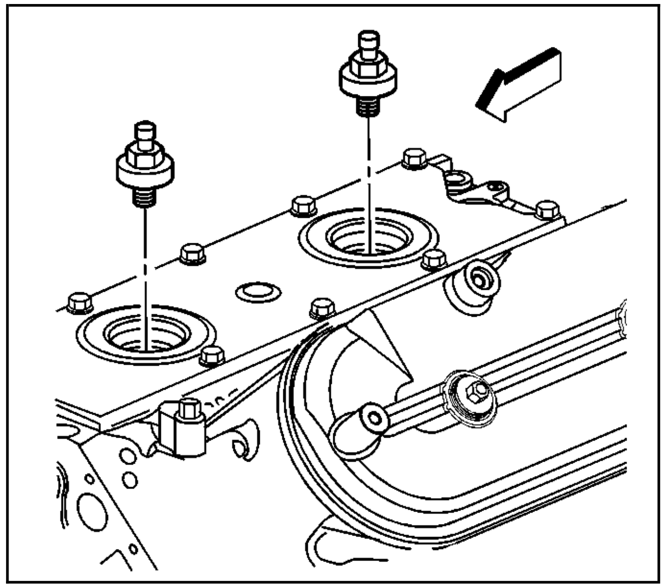
   Tighten

   Tighten the bolts to 25 N·m (18 lb ft).

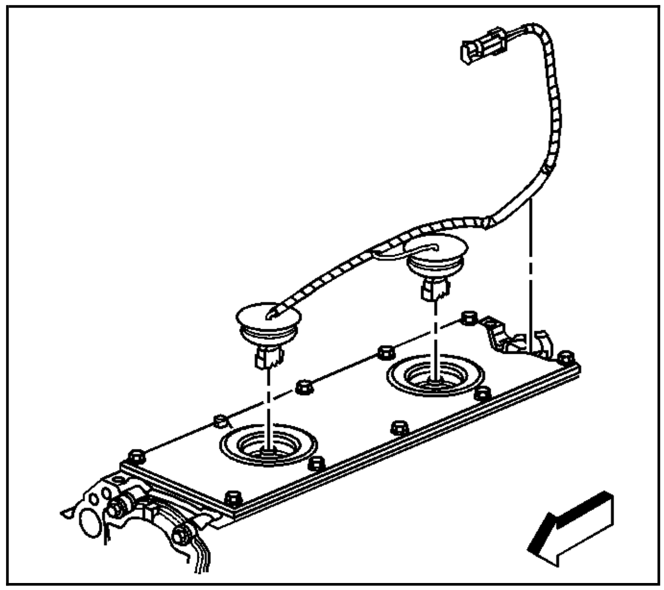
5. Install the knock sensors.

   Tighten

   Tighten the sensors to 20 N·m (15 lb ft).



6. Connect the knock sensor electrical connectors.
7. Push down on the rubber covers.
8. Install the intake manifold. Refer to *Intake Manifold Replacement*.

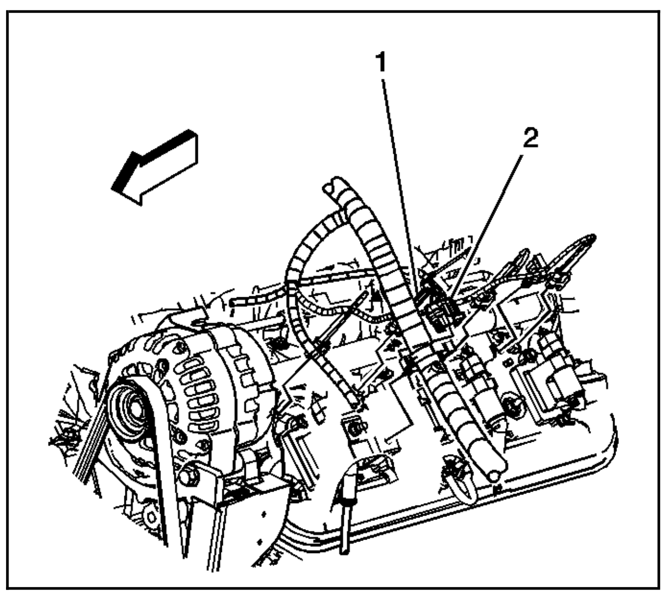


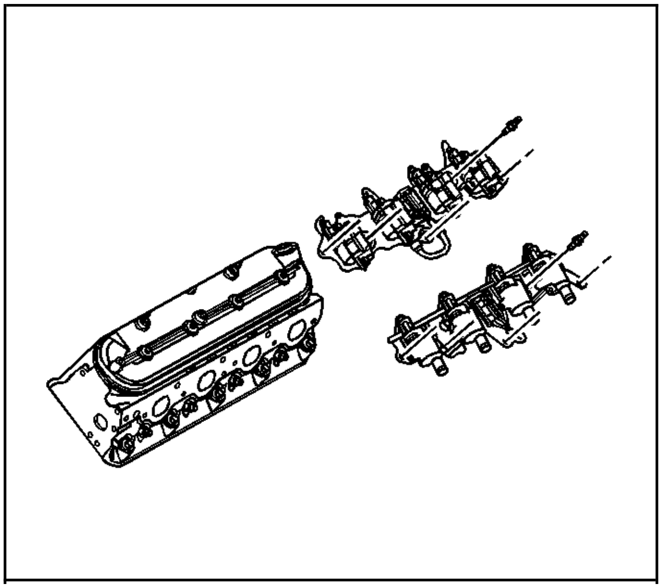
Valve Rocker Arm Cover Replacement - Left

Removal Procedure

1. Remove the engine sight shield, if required. Refer to *Engine Sight Shield Replacement (4.8L, and 6.0L (RPO LQ4)* .

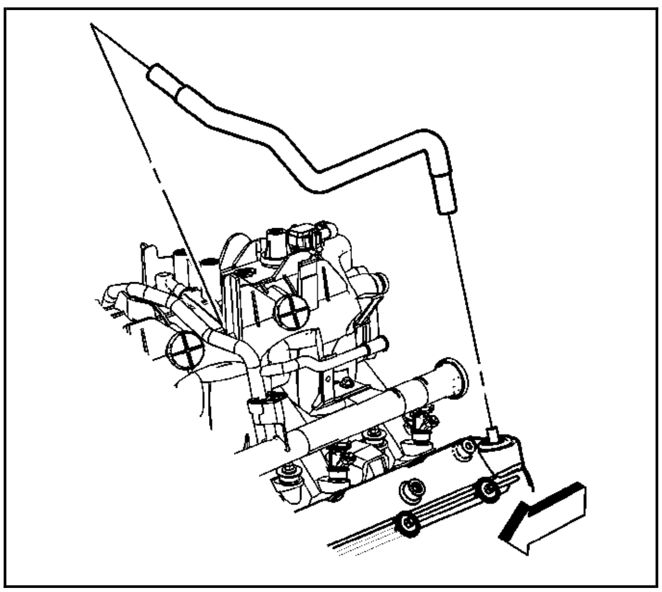
   .
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (2) to the ignition coil wire harness.
4. Remove the harness clips (1).
5. Reposition the engine harness, if necessary.
6. Remove the spark plug wires from the ignition coils.





- Twist each plug wire 1/2 turn.
- Pull only on the boot in order to remove the wire from the ignition coil.

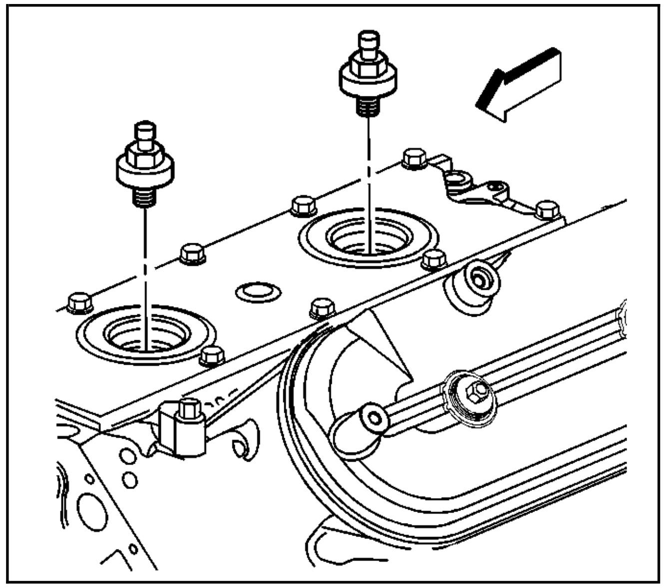
7. Remove the ignition coil bracket studs.
8. Remove the ignition coil bracket.



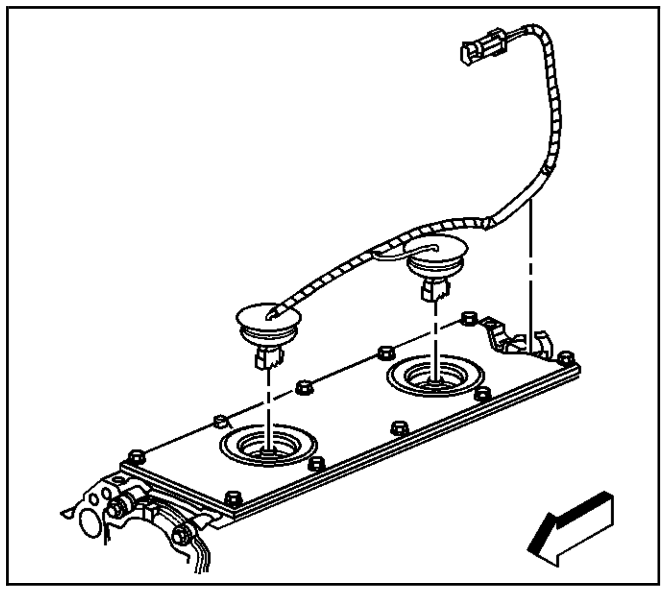
9. Remove the positive crankcase ventilation (PCV) hose.

5. Install the knock sensors.

   Tighten
   Tighten the sensors to 20 N·m (15 lb ft).



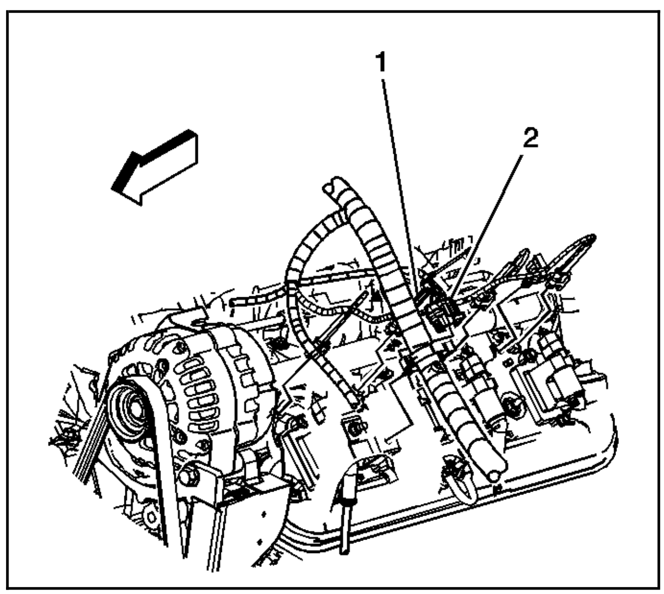
6. Connect the knock sensor electrical connectors.
7. Push down on the rubber covers.
8. Install the intake manifold. Refer to *Intake Manifold Replacement*.

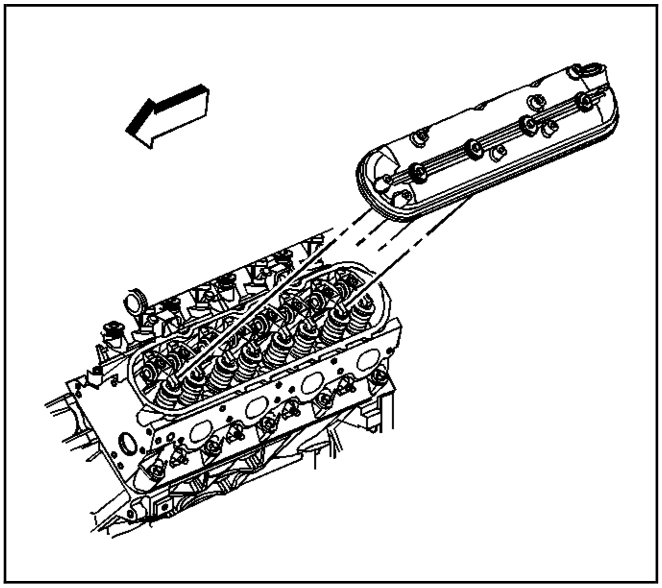


Valve Rocker Arm Cover Replacement - Left

Removal Procedure

1. Remove the engine sight shield, if required. Refer to *Engine Sight Shield Replacement (4.8L. and 6.0L (RPO LQ4)* .
   .
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (2) to the ignition coil wire harness.
4. Remove the harness clips (1).
5. Reposition the engine harness, if necessary.
6. Remove the spark plug wires from the ignition coils.





3

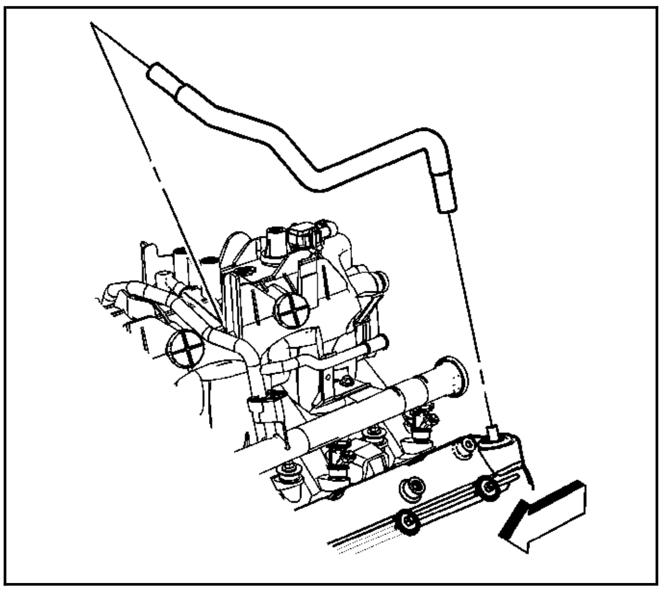
2. Install the valve rocker arm cover.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

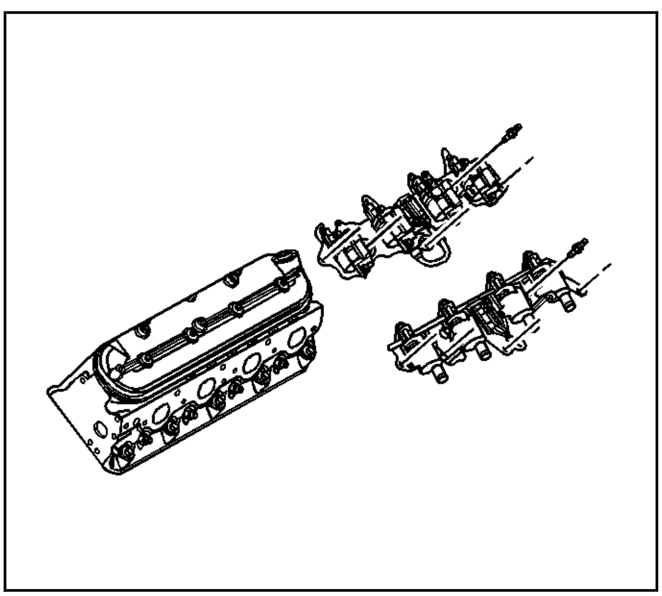
3. Tighten the rocker arm cover bolts.

   Tighten

   Tighten the bolts to 12 N·m (106 lb in).



4. Install the PCV hose.

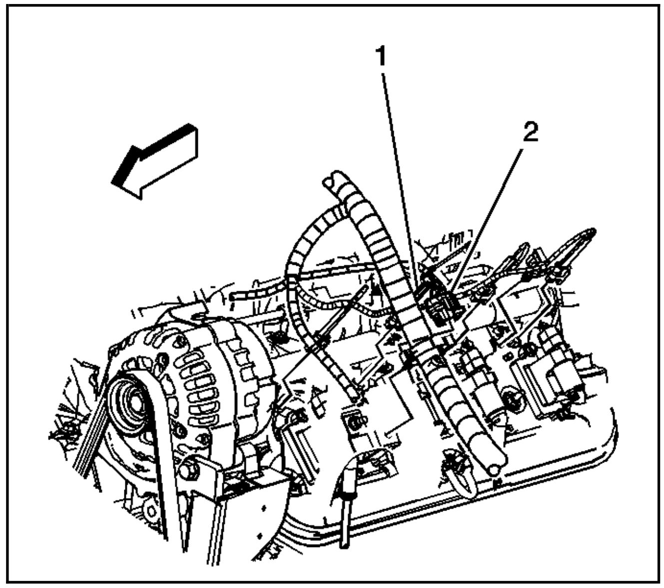


5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent to the threads of the bracket bolts.
6. Install the ignition coil bracket.
7. Install the ignition coil bracket studs.

   Tighten

   Tighten the studs to 12 N·m (106 lb in).

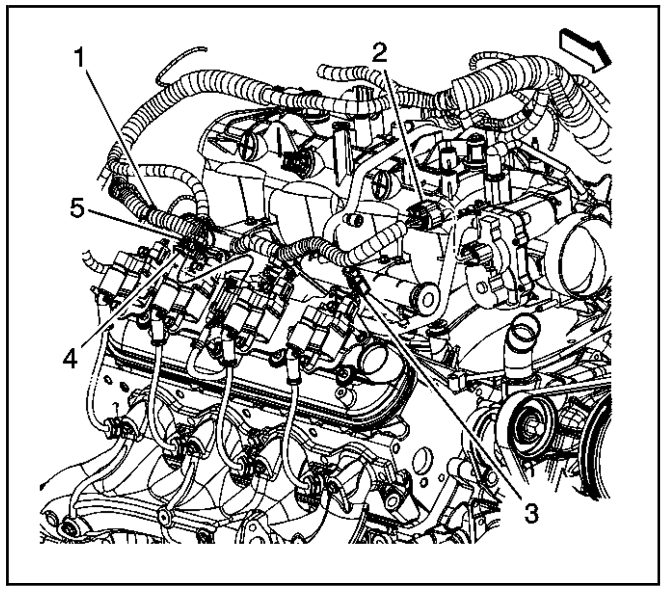
8. Install the spark plug wires to the ignition coils.
9. Position the engine harness, if necessary.
10. Install the harness clips (1).
11. Connect the main electrical connector (2) to the ignition coil wire harness.
12. Install the CPA lock.
13. Install the engine sight shield, if required. Refer to *Engine Sight Shield Replacement (4.8L, and 6.0L (RPO LQ4)*.

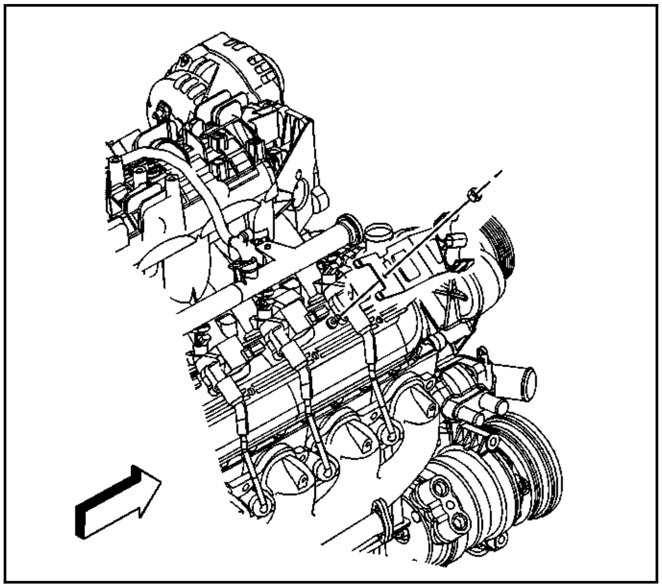


Valve Rocker Arm Cover Replacement - Right

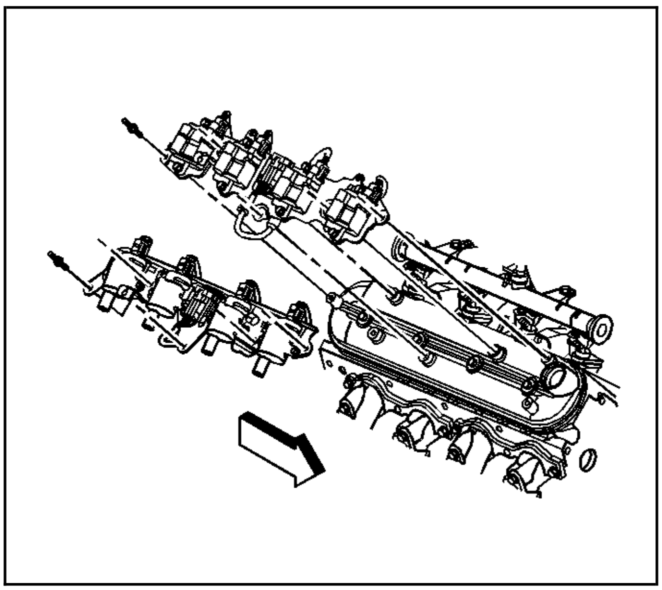
Removal Procedure

1. Remove the engine sight shield, if required. Refer to *Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4)*.
2. Remove the connector position assurance (CPA) lock (5).
3. Disconnect the main electrical connector (4) to the ignition coil wire harness.
4. Remove the harness clips (1).
5. Reposition the engine harness, if necessary.
6. Remove the spark plug wires from the ignition coils.
   - Twist each plug wire 1/2 turn.
   - Pull only on the boot in order to remove the wire from the ignition coil.

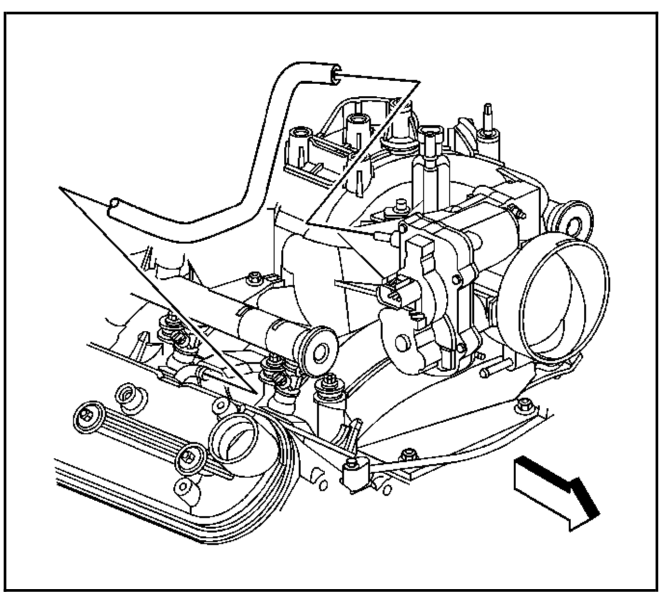




7. Reposition the surge tank/heater hoses from the heater hose bracket.
8. Remove the heater hose bracket nut and bracket.

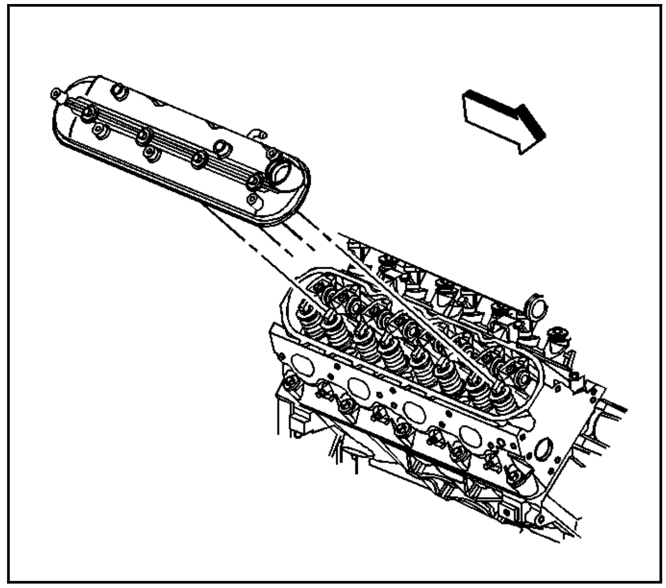


9. Remove the ignition coil bracket studs.
10. Remove the ignition coil bracket.

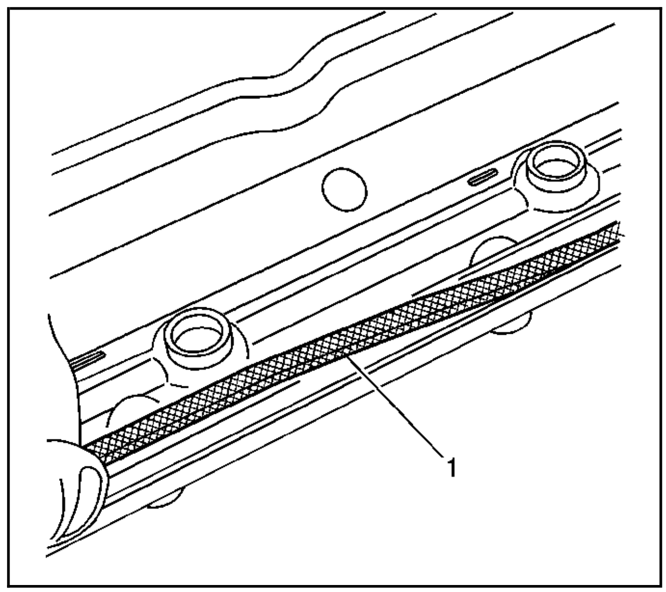


11. Remove the positive crankcase ventilation (PCV) hose.

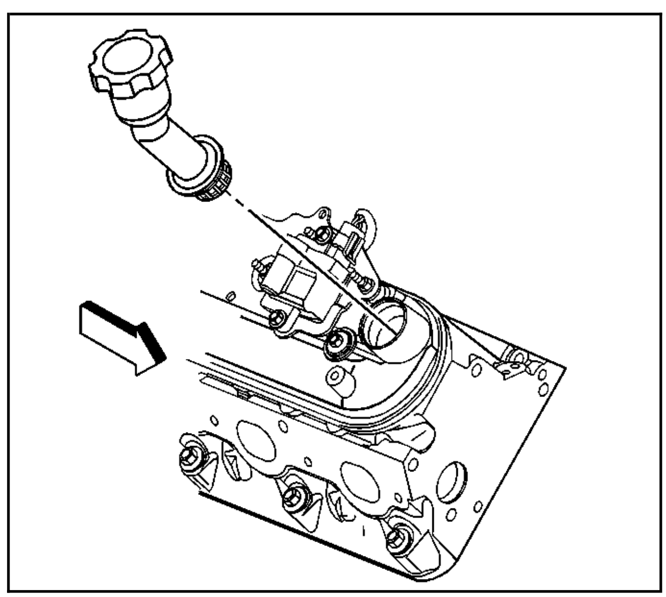
12. Loosen the valve rocker arm cover bolts.
13. Remove the valve rocker arm cover.



14. Remove and discard the old gasket (1).



15. Remove the oil fill tube from the rocker cover, if required.
16. If required, clean and inspect the rocker arm cover. Refer to *Valve Rocker Arm Cover Cleaning and Inspection*.



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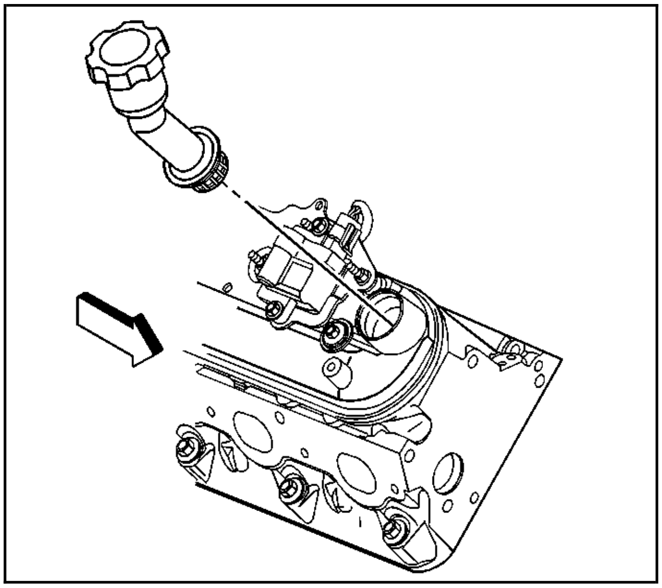


Installation Procedure

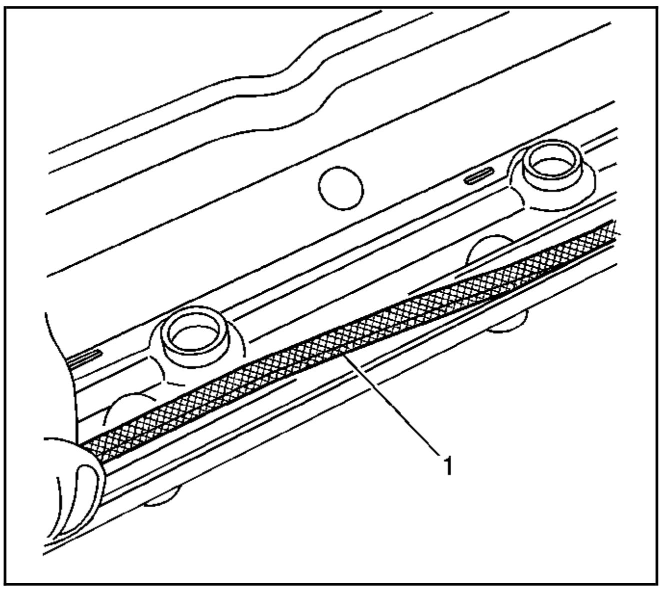
Important:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- DO NOT reuse the valve rocker arm cover gasket.
- If the oil fill tube has been removed from the rocker arm cover, install a NEW fill tube during assembly.

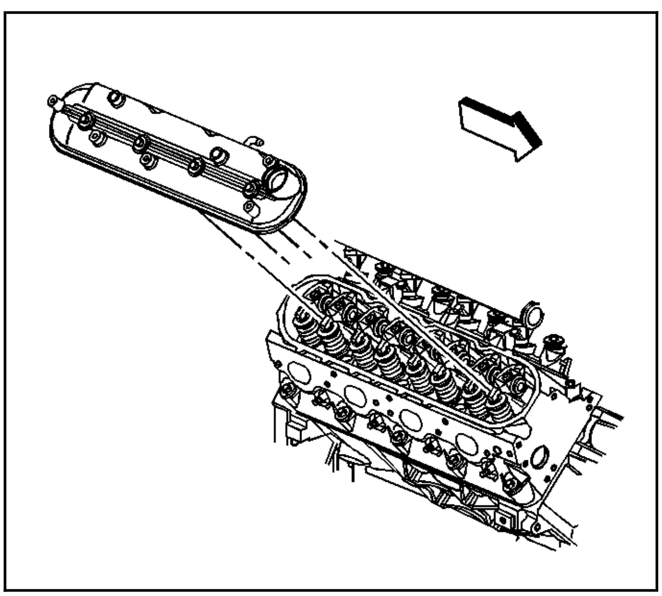
1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.
2. Insert the NEW oil fill tube into the rocker arm cover.

   Rotate the tube clockwise until locked in the proper position.
3. Install the oil fill cap into the tube.

   Rotate the cap clockwise until locked in the proper position.



4. Install a NEW rocker cover gasket (1) into the valve rocker arm cover lip.



5. Install the valve rocker arm cover.

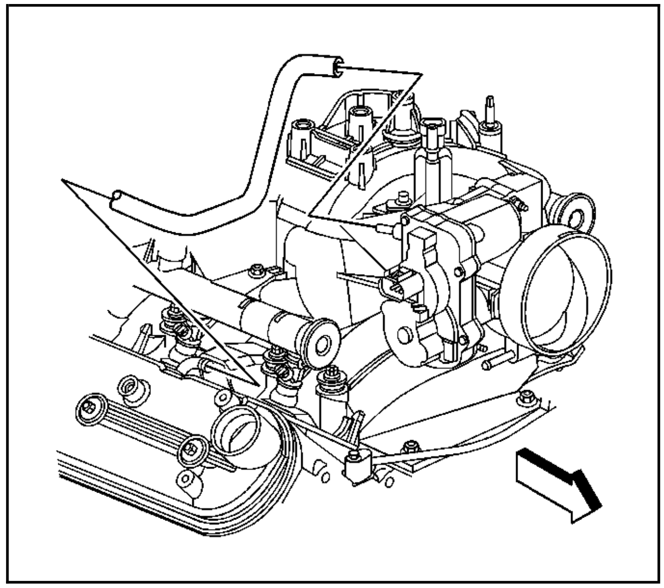
Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Tighten the rocker arm cover bolts.

   Tighten

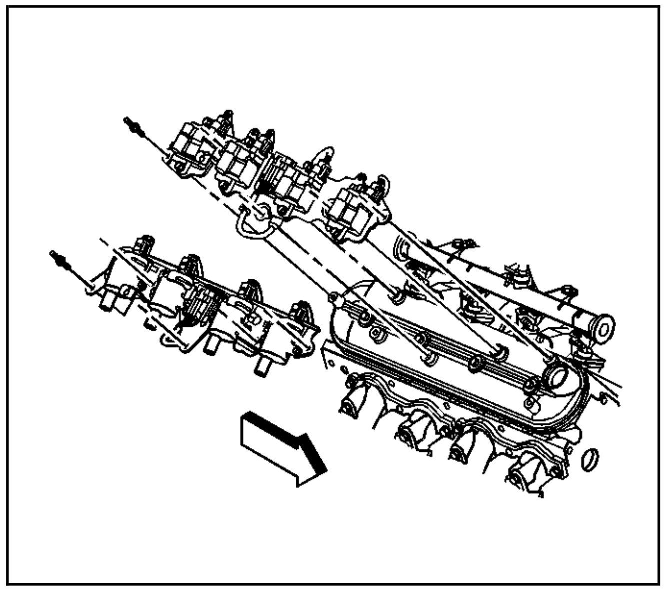
   Tighten the bolts to 12 N·m (106 lb in).

7. Install the PCV hose.



8. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent to the threads of the bracket bolts.
9. Install the ignition coil bracket.
10. Install the ignition coil bracket studs.

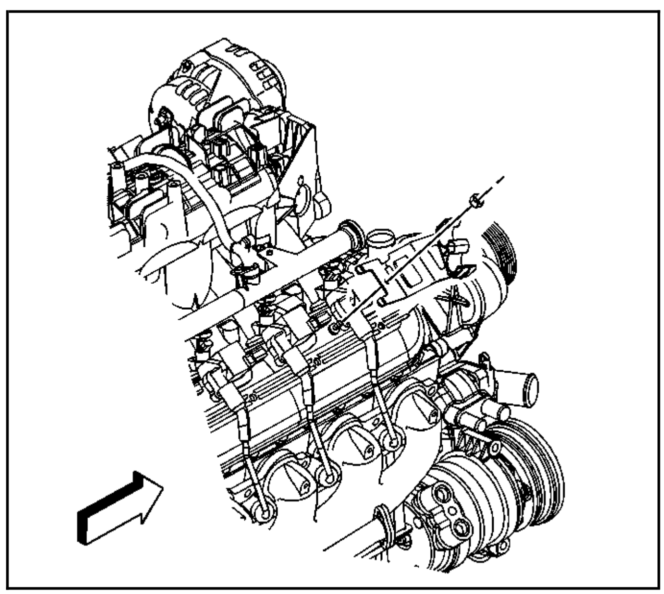
Tighten
Tighten the studs to 12 N·m (106 lb in).

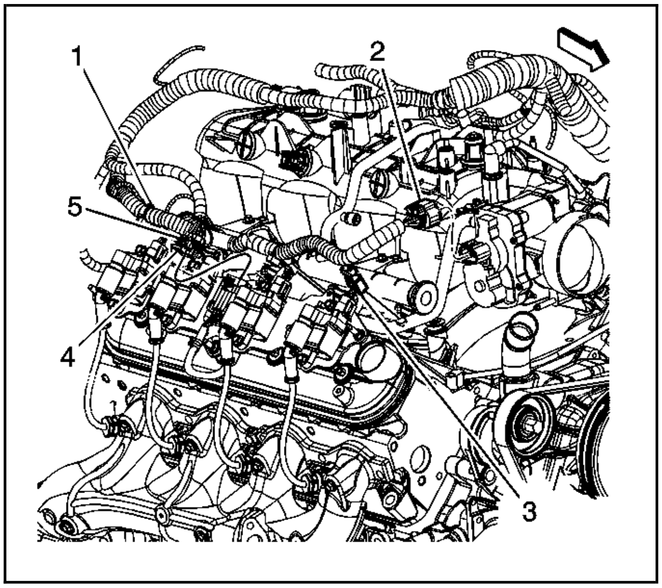


11. Install the heater hose bracket and nut.

Tighten
Tighten the nut to 9 N·m (80 lb in).

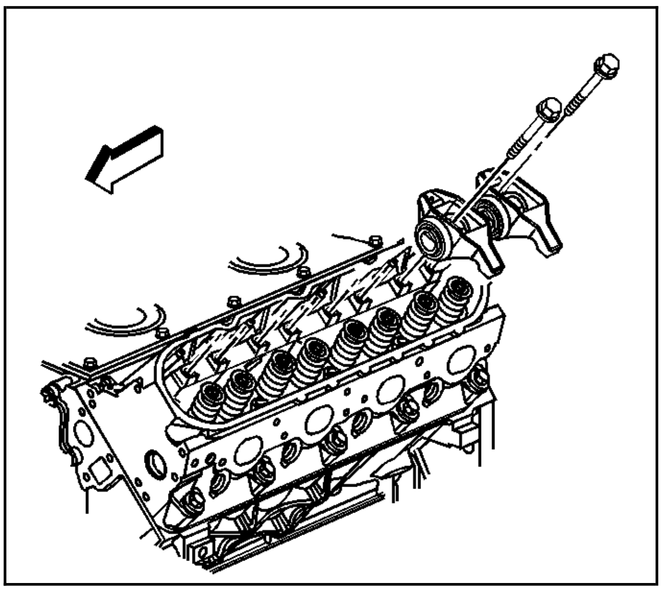
12. Position the surge tank/heater hoses to the heater hose bracket.





13. Install the spark plug wires to the ignition coils.
14. Position the engine harness, if necessary.
15. Install the harness clips (1).
16. Connect the main electrical connector (4) feeding the ignition coils.
17. Install the CPA lock (5).
18. Install the engine sight shield, if required. Refer to *Engine Sight Shield Replacement (4.8L, 5.3L, and 6.0L (RPO LQ4)*.

Valve Rocker Arm and Push Rod Replacement

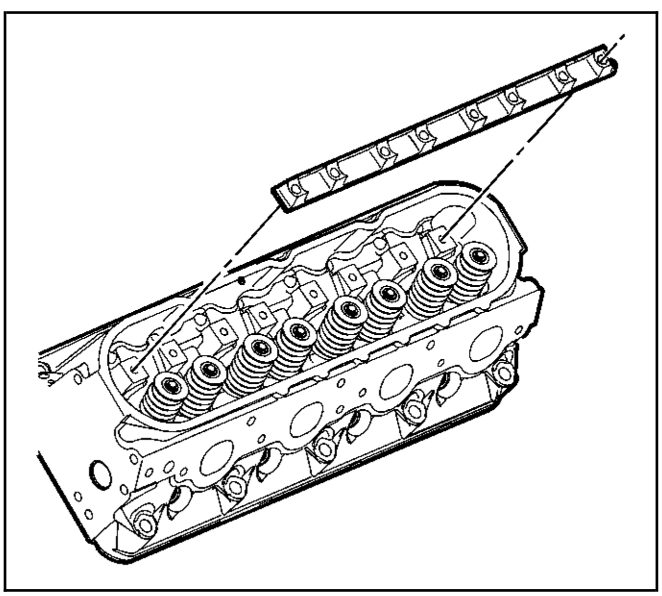


Removal Procedure

1. Remove the rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement - Left* or *Valve Rocker Arm Cover Replacement - Right*.

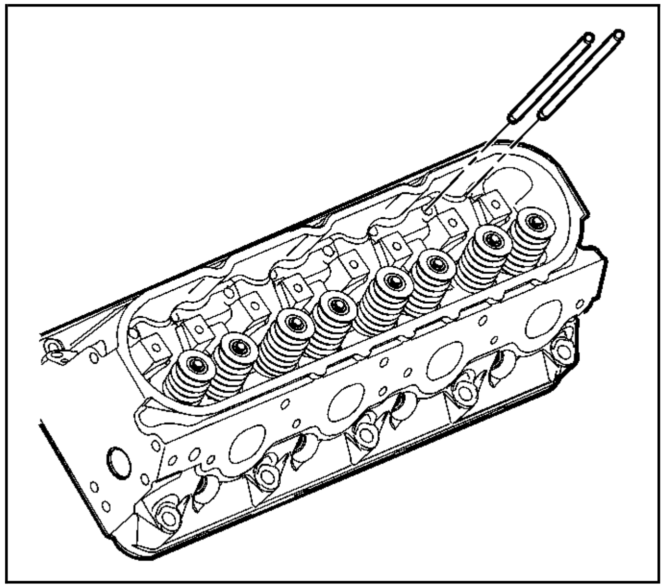
Important: Place the rocker arms, pushrods, and pivot support, in a rack so that they can be installed in the same location from which they were removed.

2. Remove the rocker arm bolts.
3. Remove the rocker arms.



4. Remove the rocker arm pivot support.

5. Remove the pushrods.
6. If required, clean and inspect the rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rods Cleaning and Inspection*.



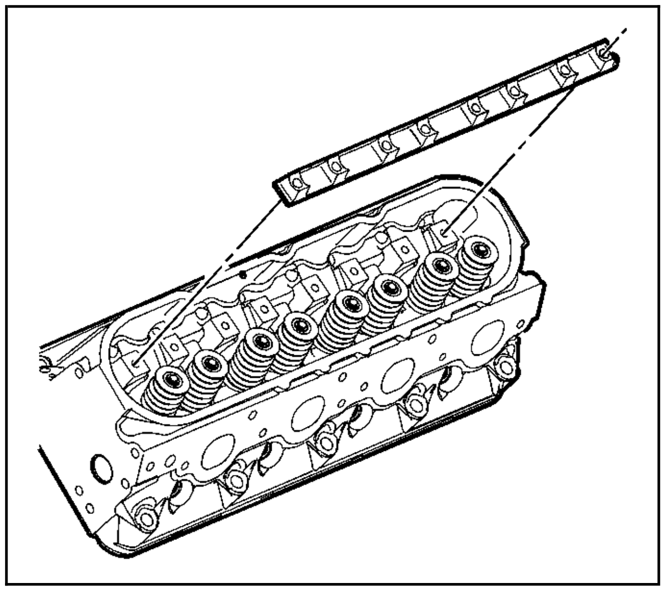
Installation Procedure

Important: When reusing the valve train components, always install the components to the original location and position.

Valve lash is net build, no valve adjustment is required.

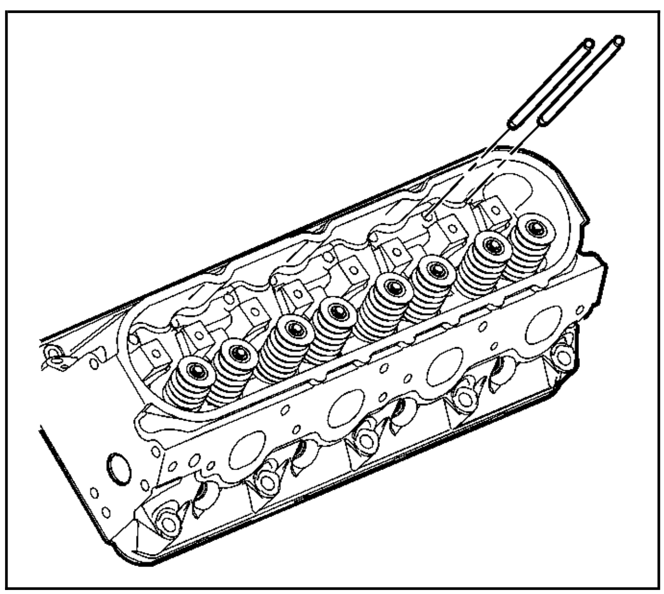
1. Lubricate the rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the rocker arm bolts with clean engine oil.

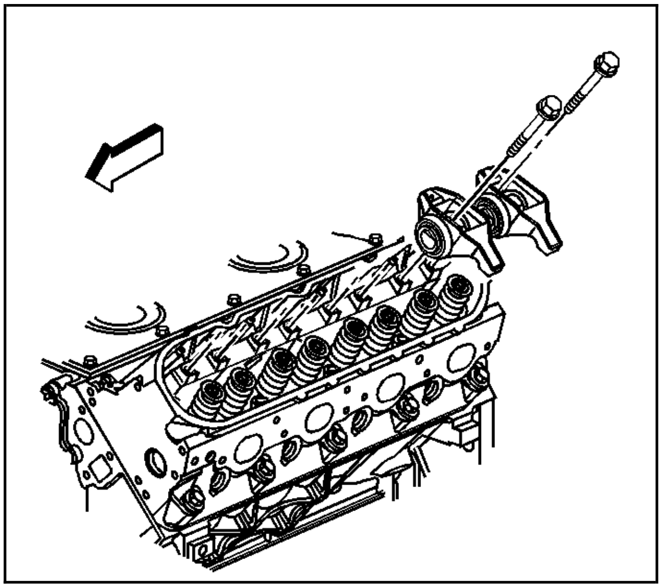
   Lubricate the flange or washer surface of the bolt that will contact the rocker arm.
3. Install the rocker arm pivot support.



Important: Make sure that the pushrods seat properly to the valve lifter sockets.

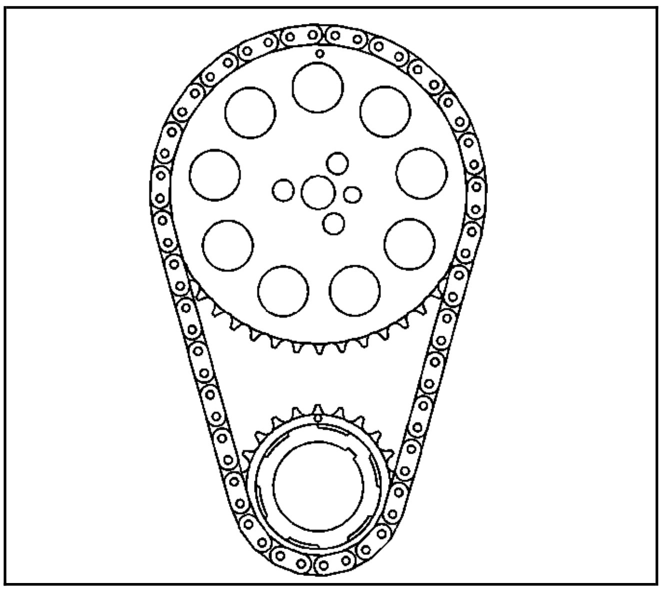
4. Install the pushrods.





Important: Make sure that the pushrods seat properly to the ends of the rocker arms. DO NOT tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.



6. Rotate the crankshaft until the number one piston is at top dead center (TDC) of the compression stroke.

   In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position.

   The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

   Cylinders 1, 3, 5 and 7 are the left bank.

   Cylinder 2, 4, 6 and 8 are the right bank.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. With the engine in the number one firing position, tighten the following rocker arm bolts:

   Tighten

   - Tighten cylinders 1,2,7 and 8 exhaust valve rocker arm bolts to 30 N·m (22 lb ft).
   - Tighten cylinders 1,3,4 and 5 intake valve rocker arm bolts to 30 N·m (22 lb ft).

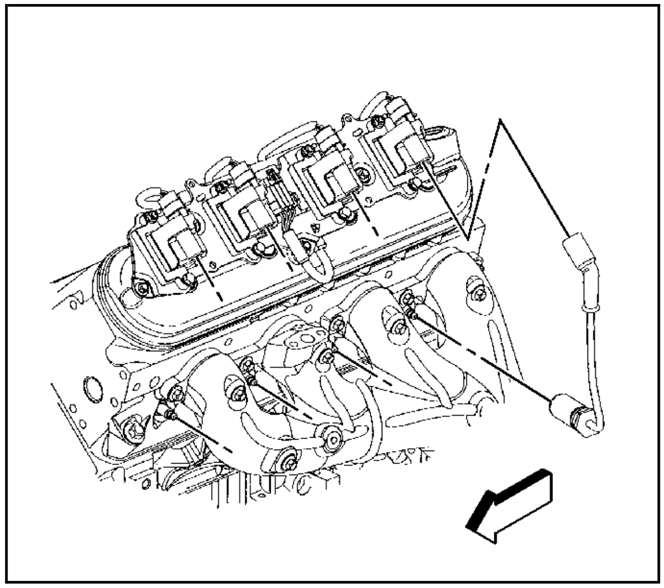
8. Rotate the crankshaft 360 degrees.
9. Tighten the following rocker arm bolts:

   Tighten

   - Tighten cylinders 3, 4, 5 and 6 exhaust valve rocker arm bolts to 30 N·m (22 lb ft).
   - Tighten cylinders 2, 6, 7 and 8 intake valve rocker arm bolts to 30 N·m (22 lb ft).

10. Install the rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement - Left* or *Valve Rocker Arm Cover Replacement - Right*.

Valve Stem Oil Seal and Valve Spring Replacement

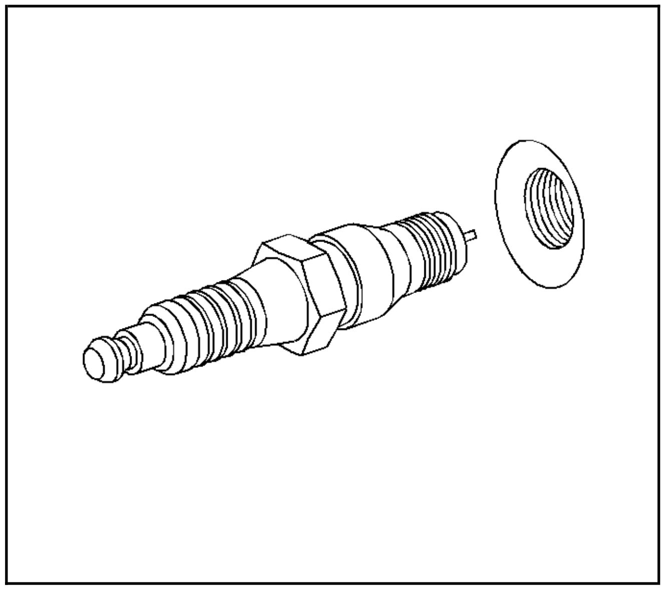


Tools Required

- *J 22794* Spark Plug Port Adapter
- *J 38606* Valve Spring Compressor

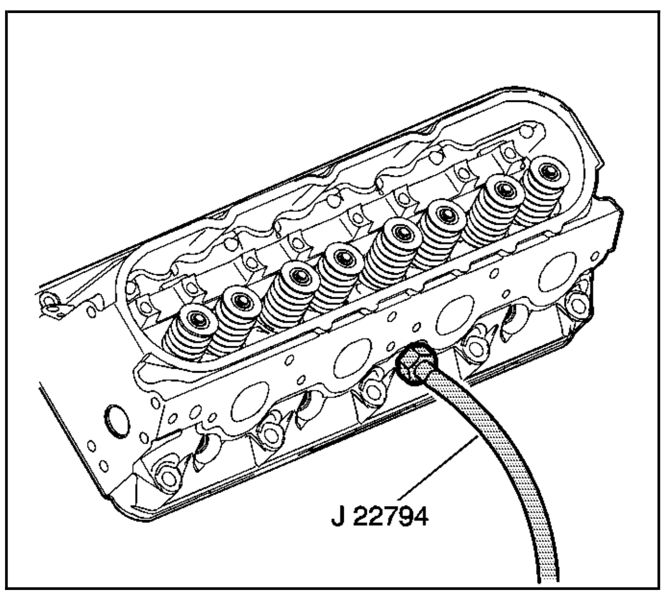
Removal Procedure

1. Remove the rocker arm. Refer to *Valve Rocker Arm and Push Rod Replacement*.
2. Disconnect the spark plug wire at the spark plug.
   - Twist each plug wire boot 1/2 turn.
   - Pull only on the boot in order to remove the wire from the spark plug.

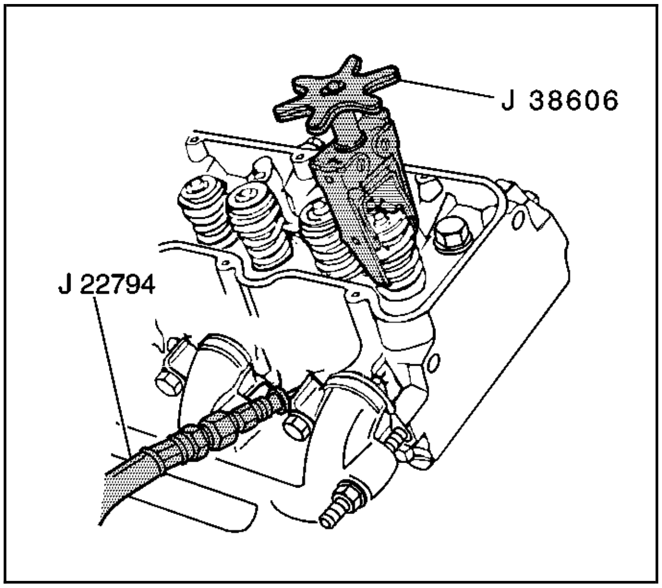


Important: Remove the spark plugs from the cylinder head with the engine at room temperature.

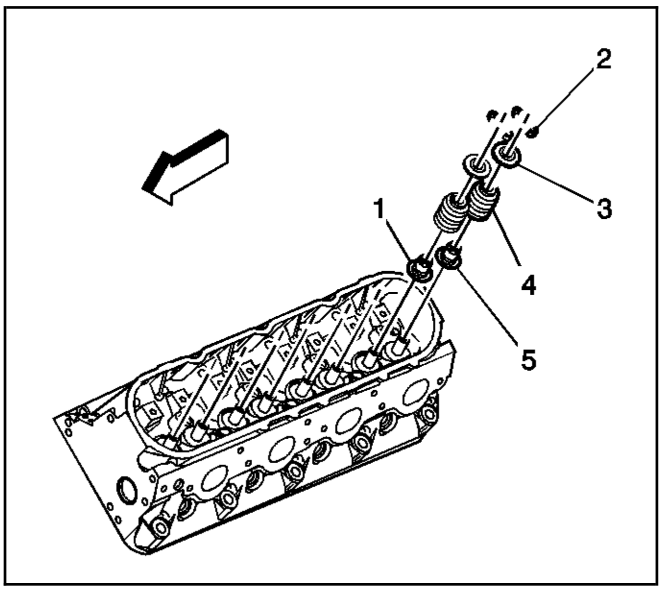
3. Loosen the spark plug 1 or 2 turns.
4. Brush or air blast away any dirt or debris from around the spark plug.
5. Remove the spark plug.



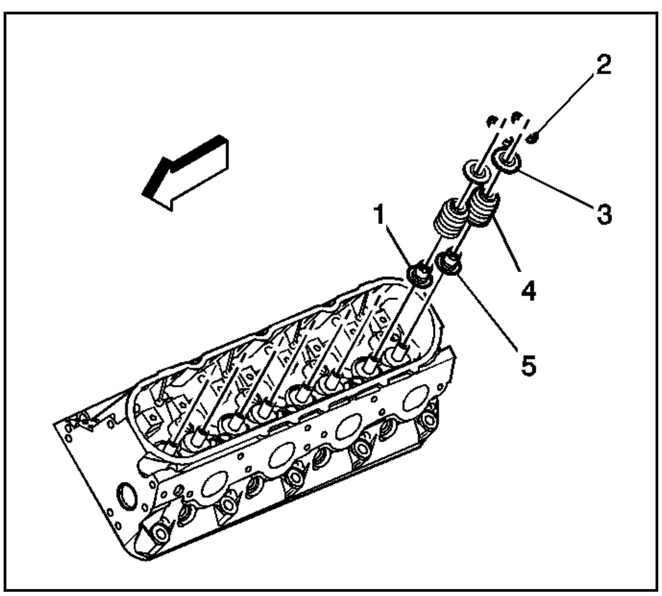
6. Install the *J 22794* into the spark plug hole.
7. Attach an air hose to the *J 22794*.
8. Apply compressed air to the *J 22794* in order to hold the valves in place.



9. Use the *J 38606* in order to compress the valve spring.



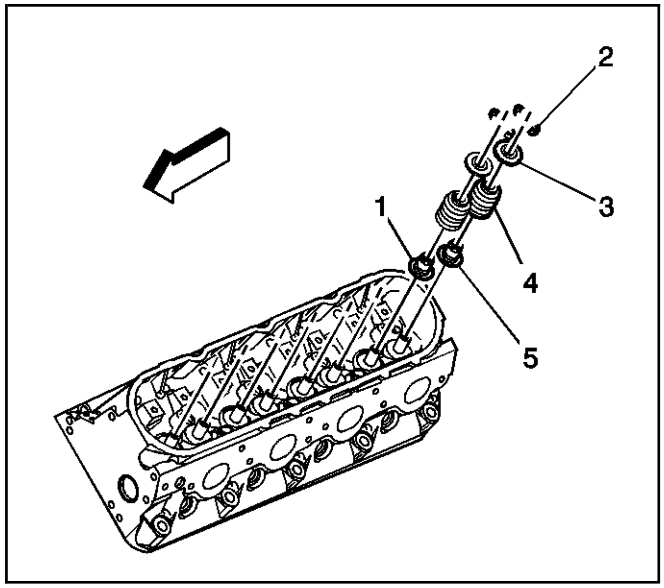
10. Remove the valve stem keys (2).
11. Carefully release the valve spring tension.
12. Remove the *J 38606*.
13. Remove the valve spring cap (3).
14. Remove the valve spring (4).
15. Remove the valve stem oil seal and shim (1, 5)



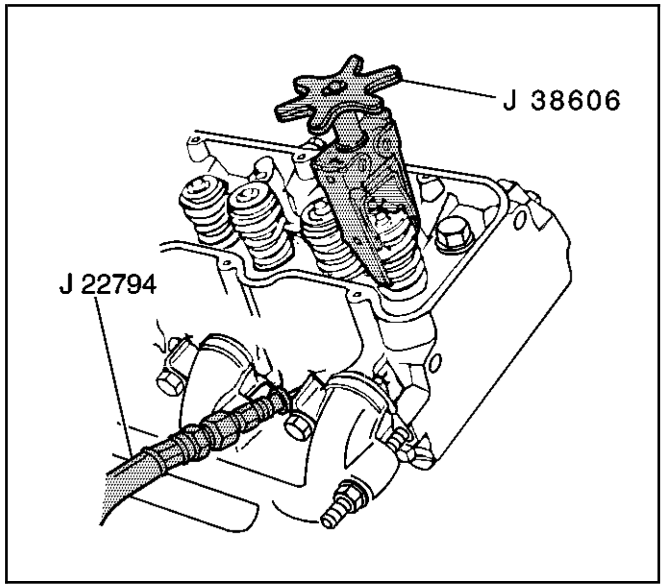
Installation Procedure

1. Clean the cylinder head valve spring seat and/or shim area.
2. Lubricate the valve guide and valve stem oil seal with clean engine oil.
3. Install the valve stem oil seal and shim (1, 5).

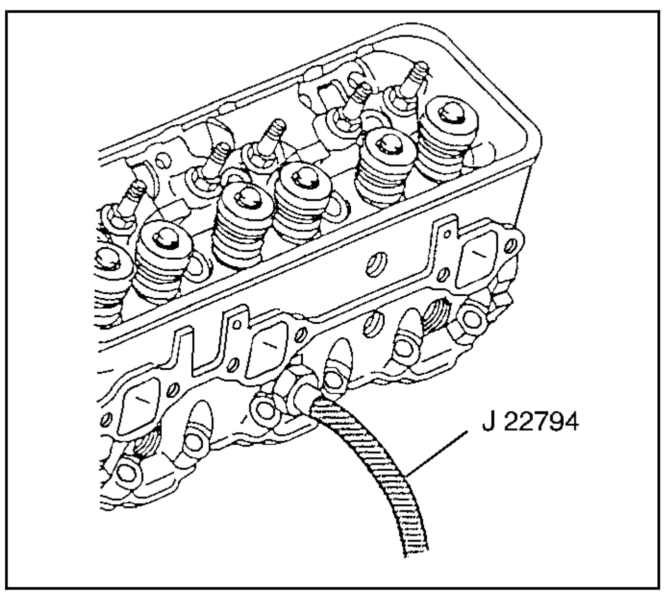
4. Install the valve spring (4).
5. Install the valve spring cap (3).

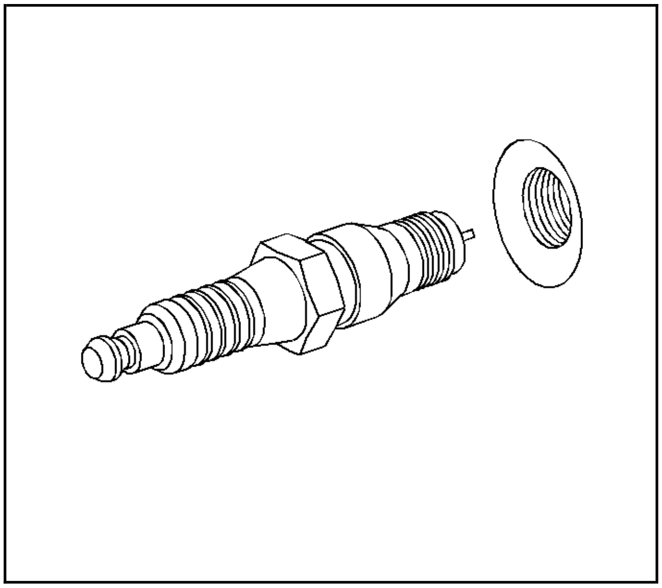


6. Compress the valve spring using the *J 38606*.
7. Install the valve keys.
   - Use grease in order to hold the valve keys in place.
   - Make sure the keys seat properly in the groove of the valve stem.
   - Carefully release the valve spring pressure, making sure the valve keys stay in place.
   - Remove the *J 38606*.
   - Tap the end of the valve stem with a plastic faced hammer to seat the keys, if necessary.



8. Remove the *J 22794* from the spark plug port.



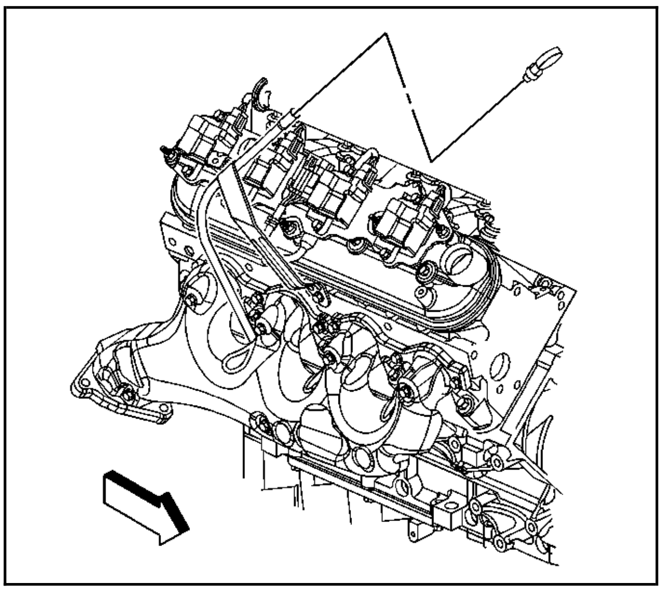


Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Hand start the spark plug.

   Tighten

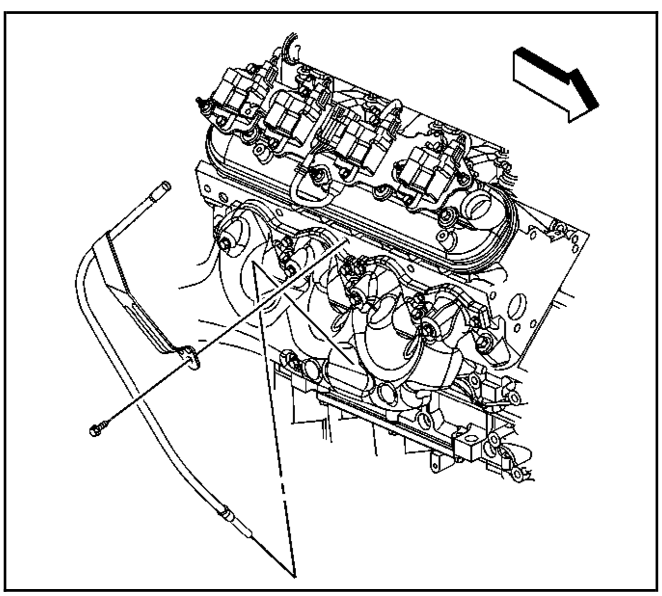
   Tighten the spark plug to 15 N·m (11 lb ft).
10. Install the spark plug wires at the ignition coil.
11. Install the spark plug wire to the spark plug.
12. Inspect the wires for proper installation:
    - Push sideways on each boot in order to check for proper installation.
    - Reinstall any loose boot.
13. Install the rocker arm. Refer to *Valve Rocker Arm and Push Rod Replacement*.



Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the oil level indicator.

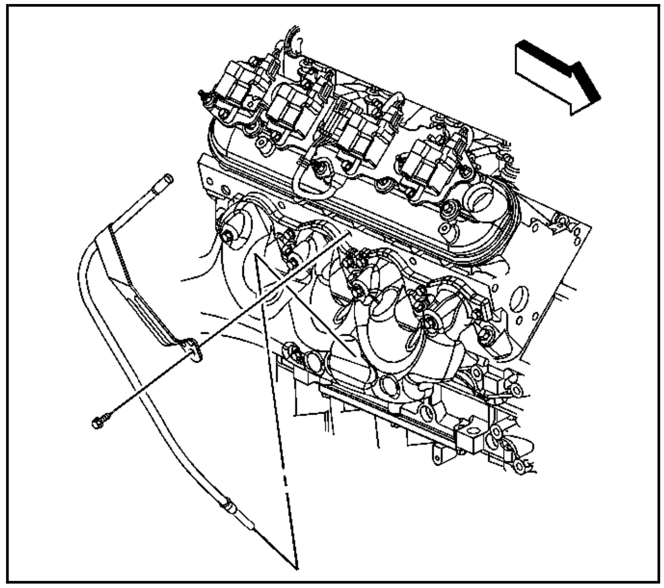


2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

Important: The O-ring seal may be reused if not cut or damaged.

4. Inspect the O-ring seal for cuts or damage.
5. Remove the O-ring seal from the tube, if required.

Installation Procedure



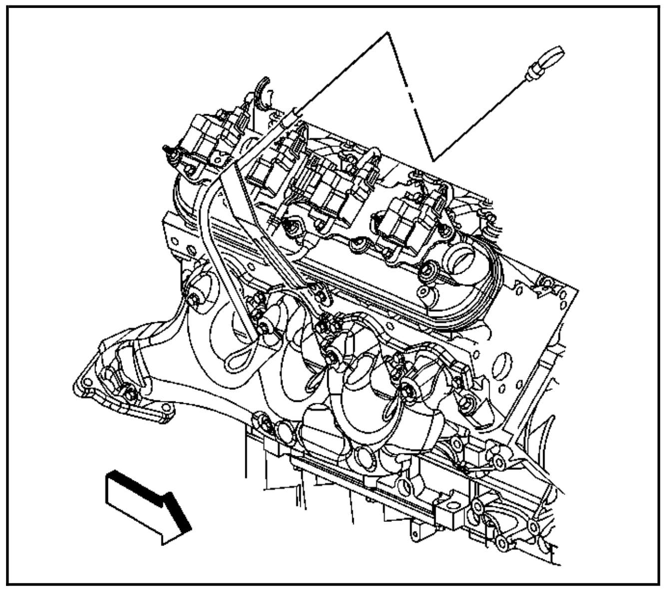
1. Lubricate the O-ring seal with clean engine oil.
2. Install a NEW O-ring seal onto the oil level indicator tube, if required.
3. Install the oil level indicator tube between the exhaust manifold and engine block.
4. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Install the oil level indicator tube into the block. The tube must be installed with the collar flush to the block.
6. Lower the vehicle.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the oil level indicator tube bolt

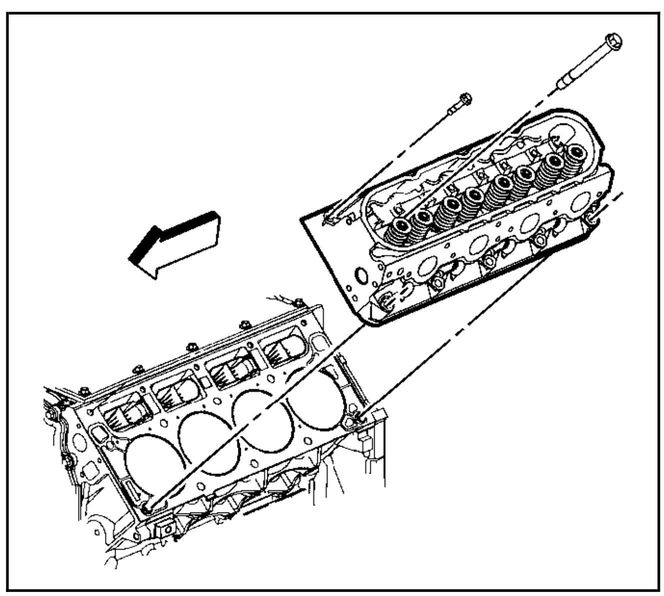
   Tighten

   Tighten the bolt to 25 N·m (18 lb ft).



8. Install the oil level indicator.

Cylinder Head Replacement - Left

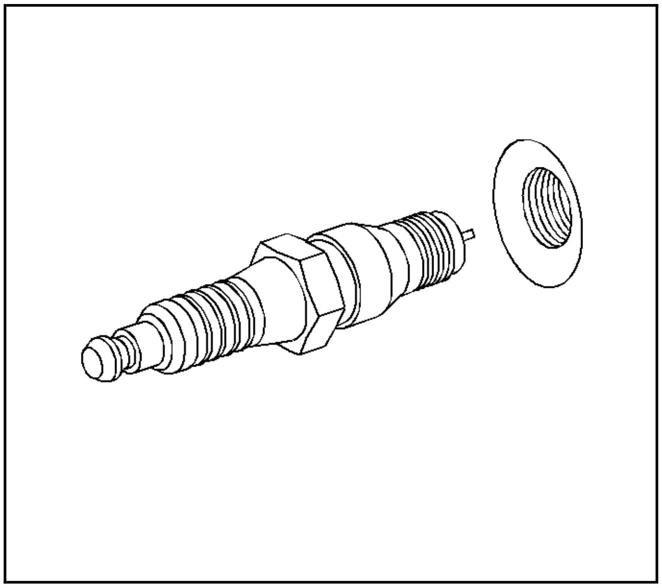


Tools Required

- *J 45059* Angle Meter
- *J 42385-200* Thread Repair Kit

Removal Procedure

1. Remove the generator bracket. Refer to *Generator Replacement (4.8L and 6.0L Engines)* or *Generator Replacement (8.1L Engine)* in Engine Electrical.
2. Remove the coolant air bleed pipe. Refer to *Coolant Air Bleed Pipe Assembly Replacement (4.8L and 6.0L Engines)* in Engine Cooling.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

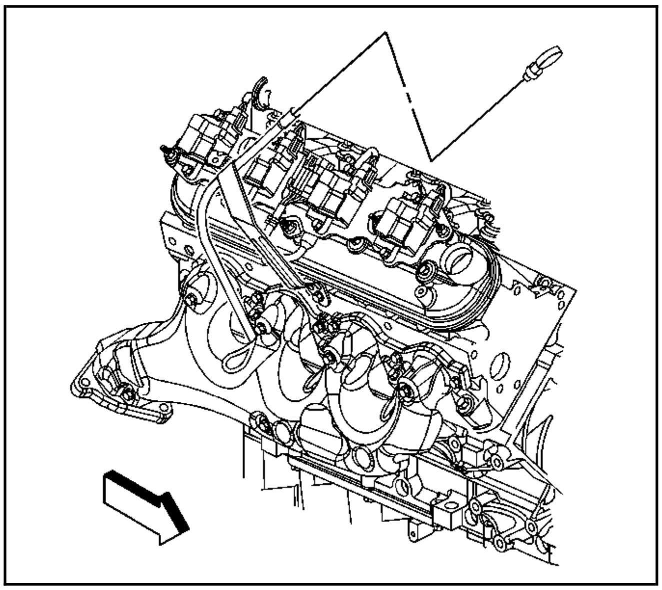
9. Hand start the spark plug.

   Tighten

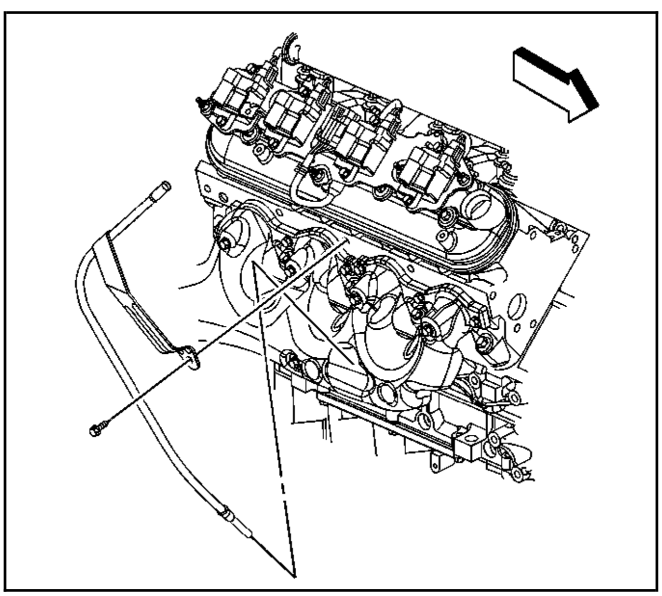
   Tighten the spark plug to 15 N·m (11 lb ft).
10. Install the spark plug wires at the ignition coil.
11. Install the spark plug wire to the spark plug.
12. Inspect the wires for proper installation:
    - Push sideways on each boot in order to check for proper installation.
    - Reinstall any loose boot.
13. Install the rocker arm. Refer to *Valve Rocker Arm and Push Rod Replacement*.

Oil Level Indicator and Tube Replacement

Removal Procedure



1. Remove the oil level indicator.



2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

Important: The O-ring seal may be reused if not cut or damaged.

4. Inspect the O-ring seal for cuts or damage.
5. Remove the O-ring seal from the tube, if required.

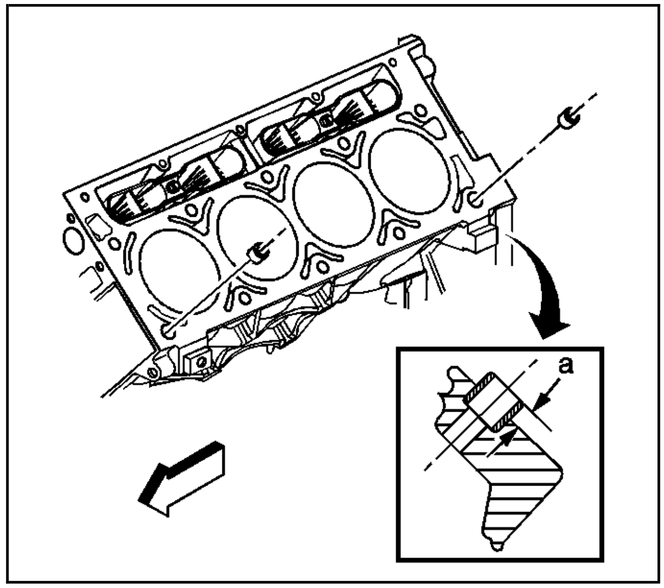
Installation Procedure

Caution: Wear safety glasses in order to avoid eye damage.

Notice: *C*lean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

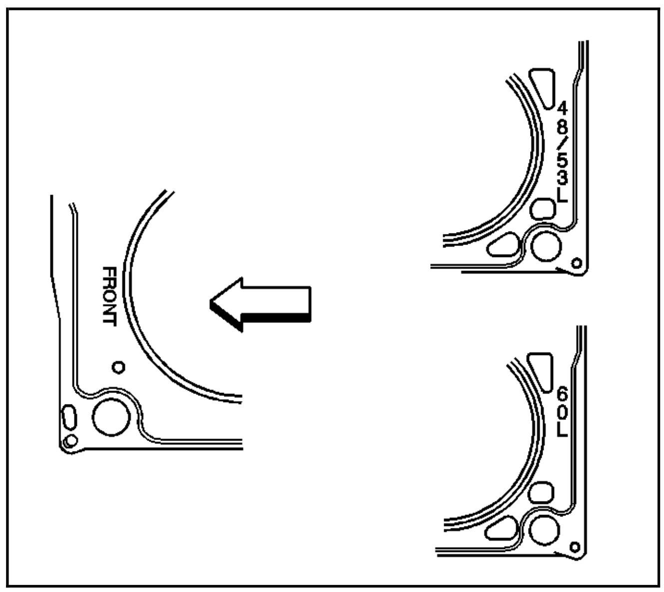
Important:

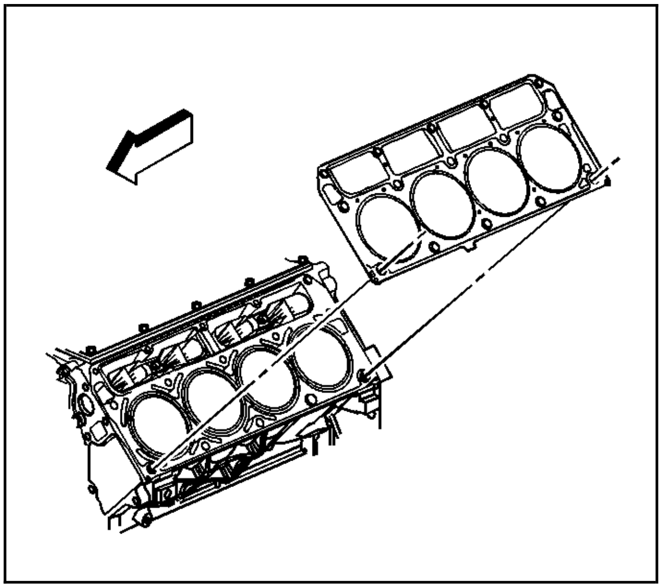
- Do not reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket (unless specified).
- The cylinder head gaskets must be installed in the proper direction and position.



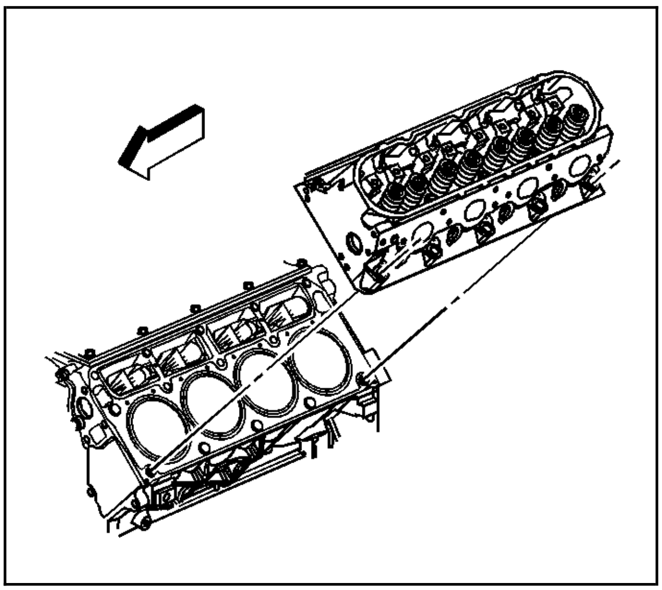
1. Clean the engine block cylinder head bolt holes (if required).

   Thread repair tool J 42385-107, found in *J 42385-200* may be used to clean the threads of old threadlocking material.
2. Use spray cleaner GM P/N 12346139, P/N 12377981 (Canadian P/N 10953463), or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation, location (a) 8.3 mm (0.327 in).
5. When properly installed, with FRONT on the left side, the tab on the cylinder head gasket should be located left of center or closer to the front of the engine.

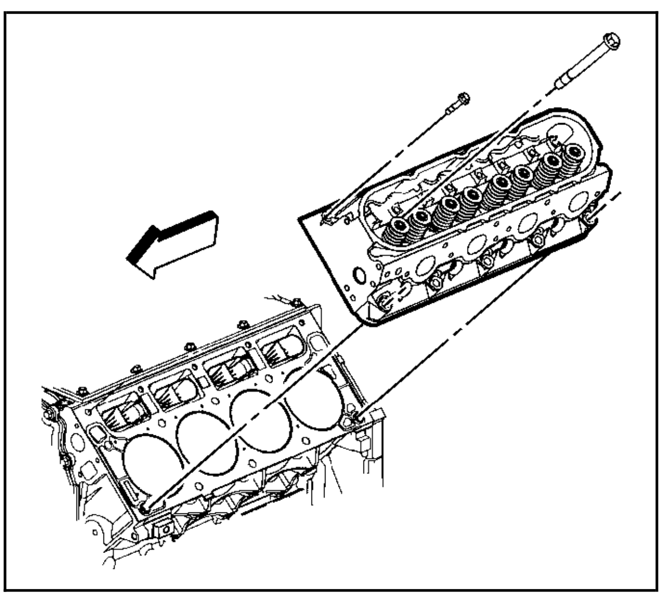




6. Install the NEW cylinder head gasket.



7. Install the cylinder head.



8. Install NEW cylinder head bolts.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Tighten the cylinder head bolts.

   Tighten

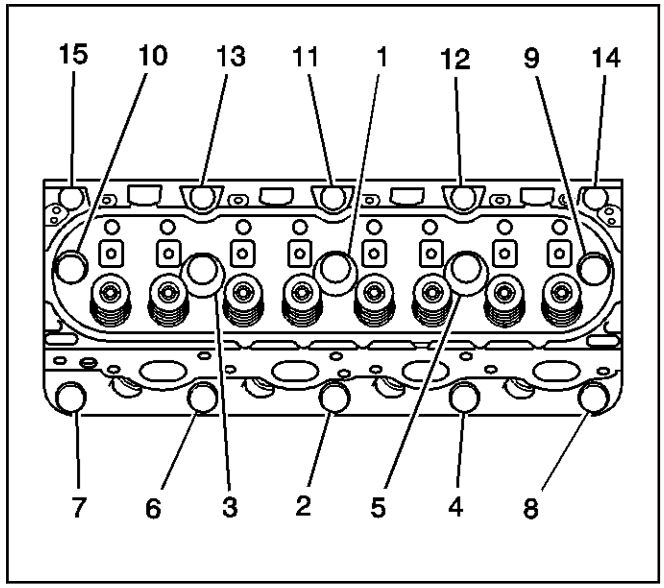
   9.1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N·m (22 lb ft).

   9.2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using *J 45059*.

   9.3. Tighten the M11 cylinder head bolts (1-10) a final pass to 70 degrees using *J 45059*.

   9.4. Tighten the M8 cylinder head bolts (11-15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

10. Install the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
11. Install the left exhaust manifold. Refer to *Exhaust Manifold Replacement - Left (4.8L and 6.0L Engines)* or *Exhaust Manifold Replacement - Left (8.1L Engine)* in Engine Exhaust.
12. Install the coolant air bleed pipe. Refer to *Coolant Air Bleed Pipe Assembly Replacement (4.8L and 6.0L Engines)* in Engine Cooling.
13. Install the generator bracket. Refer to *Generator Replacement (4.8L and 6.0LEngines)* or *Generator Replacement (8.1L Engine)* in Engine Electrical.



Cylinder Head Replacement - Right

Tools Required

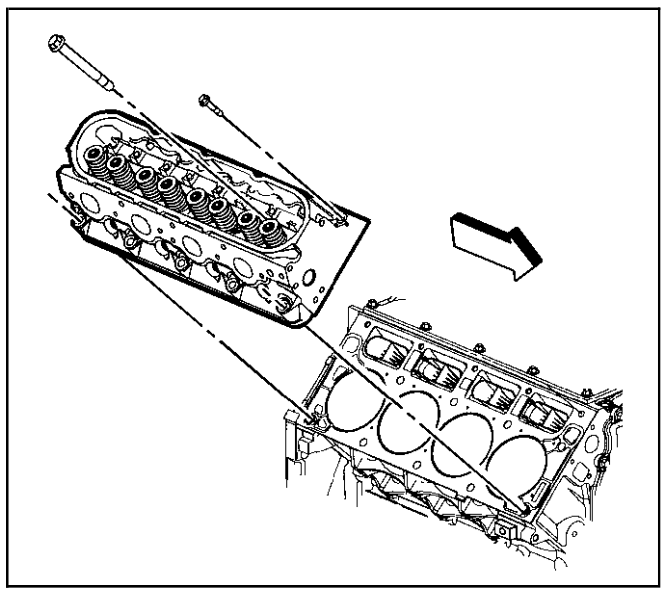
- *J 45059* Angle Meter
- *J 42385-200* Thread Repair Kit

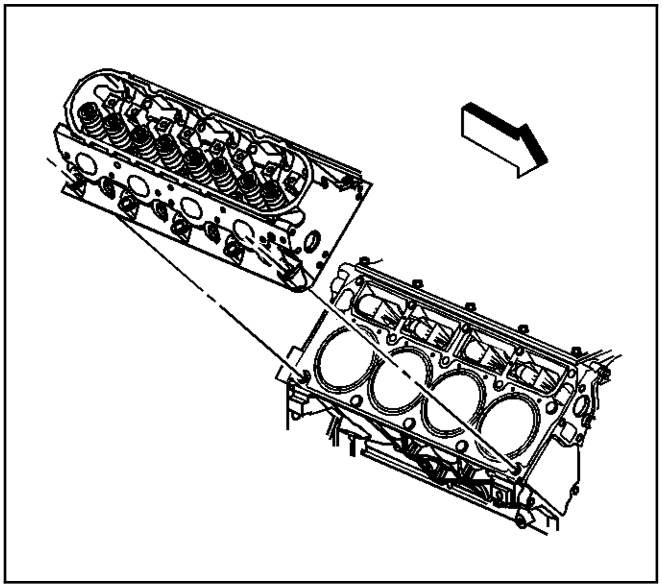
Removal Procedure

1. Remove the oil level indicator. Refer to *Oil Level Indicator and Tube Replacement*.
2. Remove the coolant air bleed pipe. Refer to *Coolant Air Bleed Pipe Assembly Replacement (4.8L and 6.0L Engines)* in Engine Cooling.
3. Remove the right exhaust manifold. Refer to *Exhaust Manifold Replacement - Right (4.8L and 6.0L Engines)* or *Exhaust Manifold Replacement - Right (8.1L Engine)* in Engine Exhaust.
4. Remove the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.

Important: The cylinder head bolts are NOT reusable.

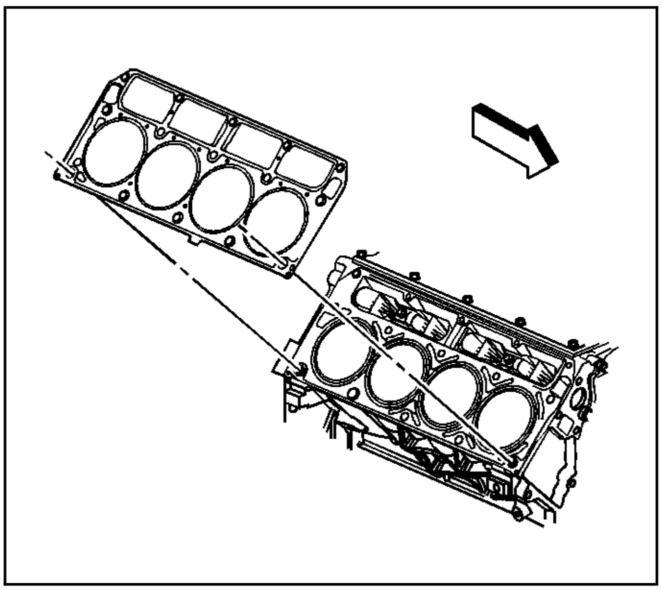
5. Remove the cylinder head bolts.



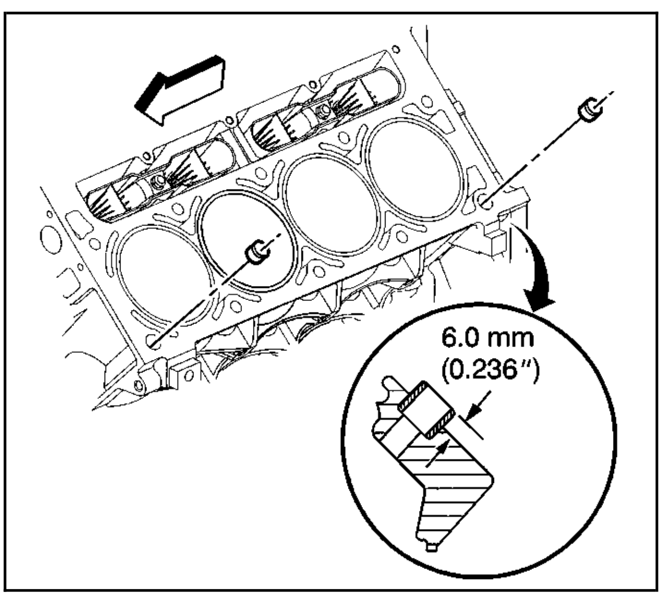


Notice: *A* fter removal,
place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

6. Remove the cylinder head.



7. Remove and discard the cylinder head gasket.
8. If required, clean and inspect the cylinder head. Refer to *Cylinder Head Cleaning and Inspection*.



Installation Procedure

Caution: Wear safety glasses in order to avoid eye damage.

Notice: *C* lean all dirt,
debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

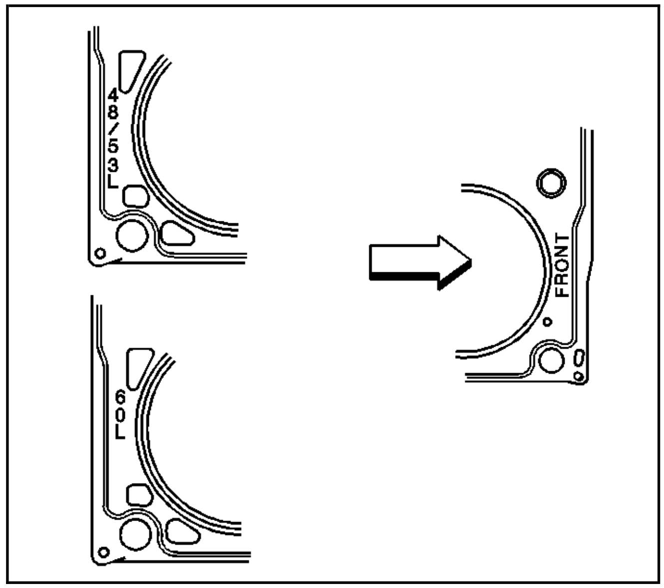
Important:

- Do not reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket (unless specified).
- The cylinder head gaskets must be installed in the proper direction and position.

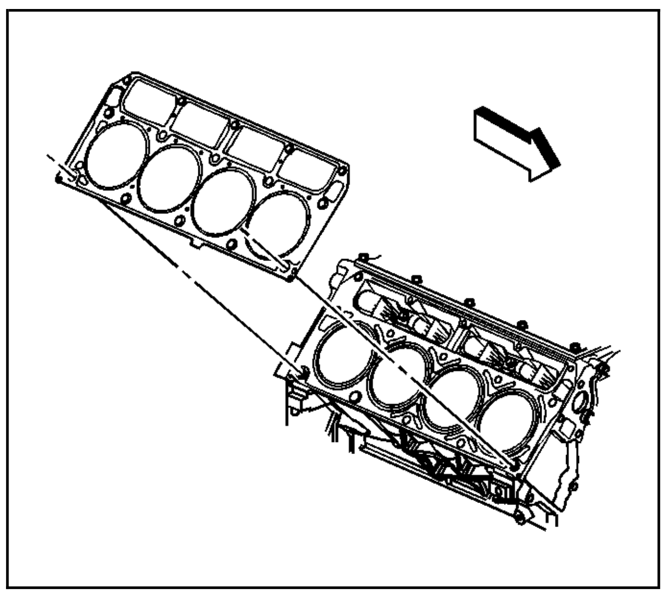
1. Clean the engine block cylinder head bolt holes (if required).

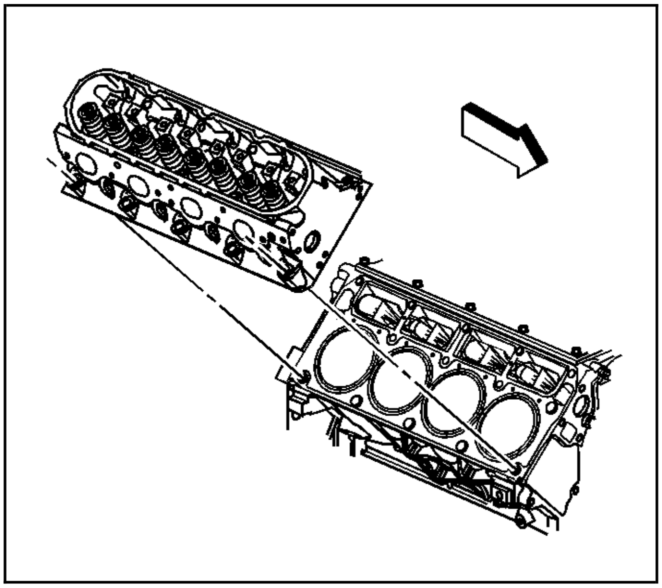
Thread repair tool J 42385-107, found in *J 42385-200* may be used to clean the threads of old threadlocking material.

2. Use spray cleaner GM P/N 12346139, P/N 12377981 (Canadian P/N 10953463), or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation, location (a) 8.3 mm (0.327 in).
5. When properly installed, with FRONT on the right side, the tab on the cylinder head gasket should be located right of center or closer to the front of the engine.

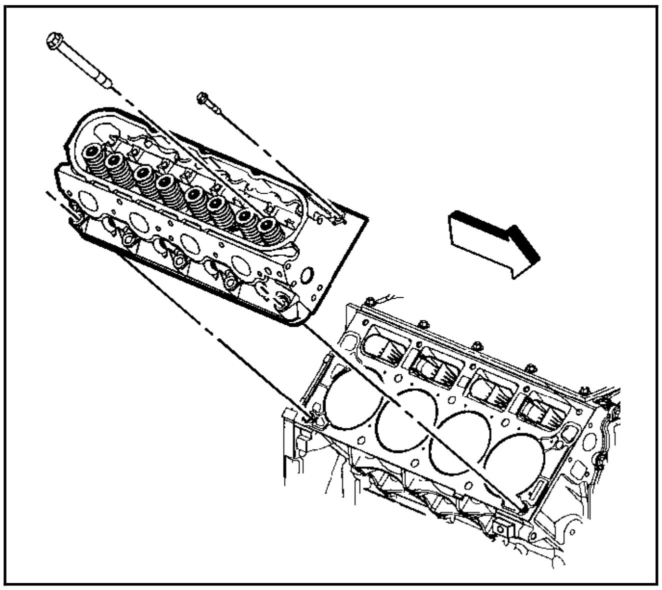


6. Install the NEW cylinder head gasket.

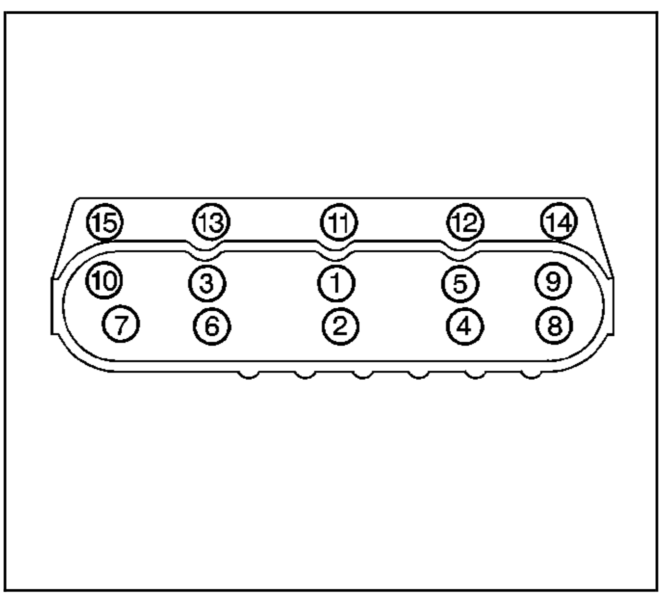




7. Install the cylinder head.



8. Install the NEW cylinder head bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Tighten the cylinder head bolts.

Tighten

9.1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N·m (22 lb ft).

9.2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using *J 45059*.

9.3. Tighten the M11 cylinder head bolts (1-10) a final pass to 70 degrees in sequence using *J 45059*.

9.4. Tighten the M8 cylinder head bolts (11-15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

10. Install the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.

11. Install the right exhaust manifold. Refer to *Exhaust Manifold Replacement - Right (4.8L and 6.0L Engines)* or *Exhaust Manifold Replacement - Right (8.1L Engine)* in Engine Exhaust.
12. Install the coolant air bleed pipe. Refer to *Coolant Air Bleed Pipe Assembly Replacement (4.8L and 6.0LEngines)* in Engine Cooling.
13. Install the oil level indicator. Refer to *Oil Level Indicator and Tube Replacement*.

Valve Lifter

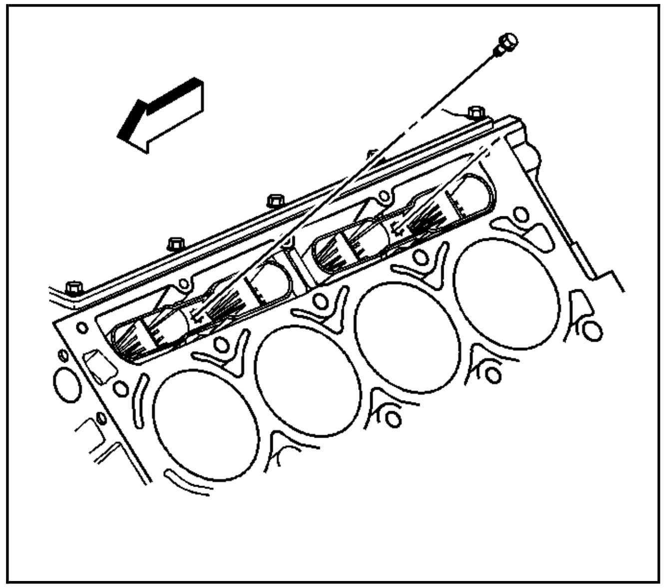
Replacement

Tools Required

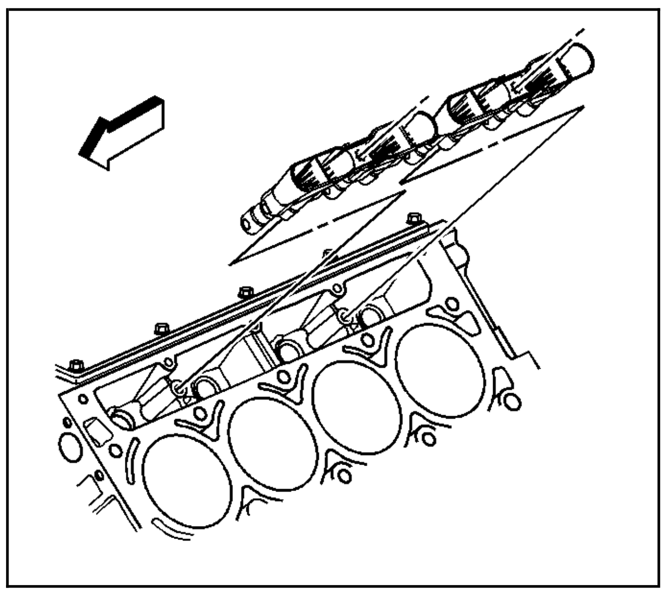
J 3049-A Valve Lifter Remover

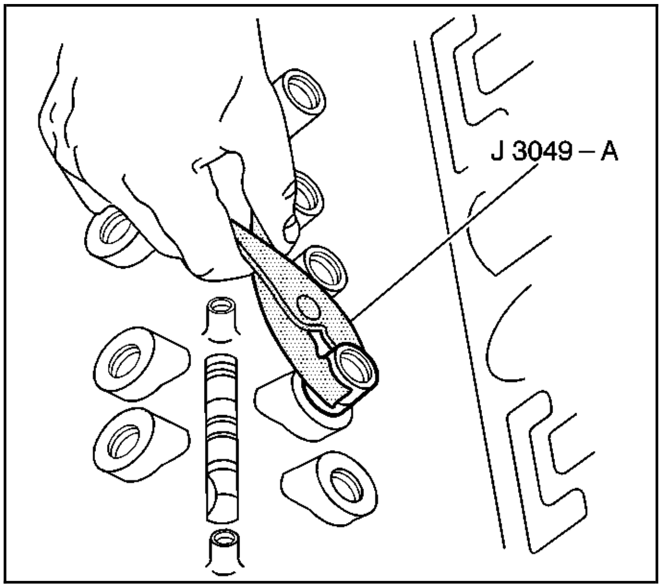
Removal Procedure

1. Remove the cylinder head and gasket. Refer to *Cylinder Head Replacement - Left* or *Cylinder Head Replacement - Right*.
2. Remove the valve lifter guide bolts.



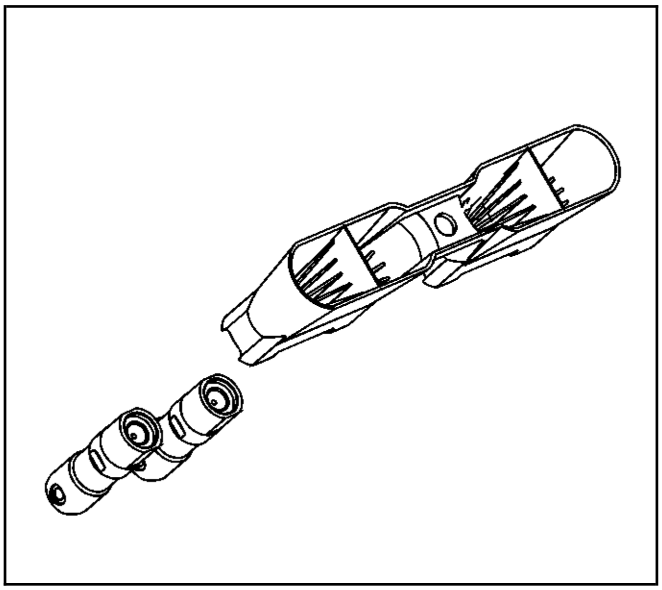
3. Remove the valve lifters and guide.



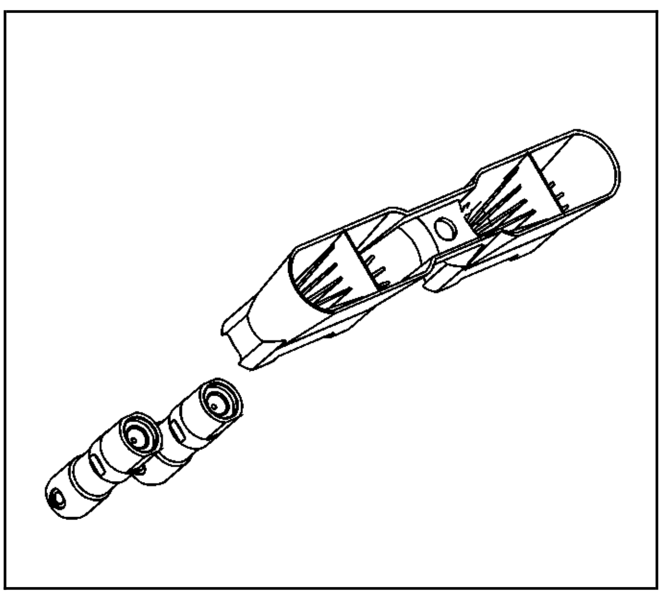


Important: Some valve lifters may be stuck in their bores because of gum or varnish deposits.

4. Use *J 3049-A* or equivalent in order to remove the valve lifters, if required.



5. Remove the valve lifters from the guide.
6. Organize or mark the components so that they can be installed in the same location from which they were removed.
7. If required, clean and inspect the valve lifters. Refer to *Valve Lifters and Guides Cleaning and Inspection*.



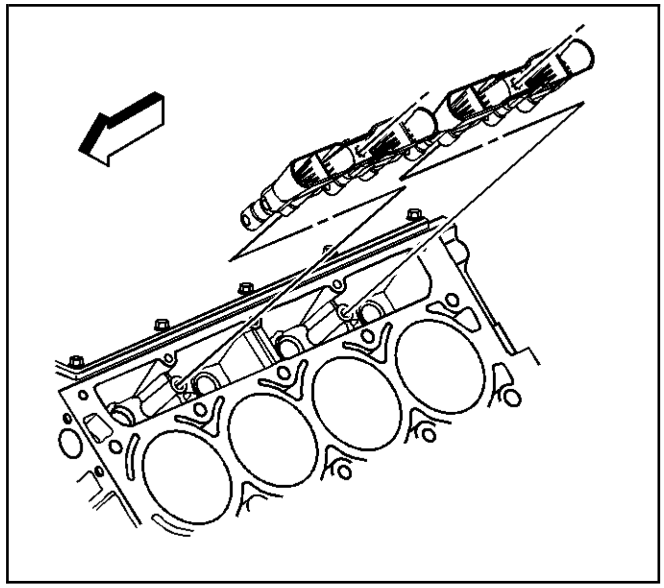
Installation Procedure

Important: When reusing valve lifters, install the lifters to their original locations.

1. Lubricate the valve lifters and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides.

   Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

3. Install the valve lifters and guide to the engine block.

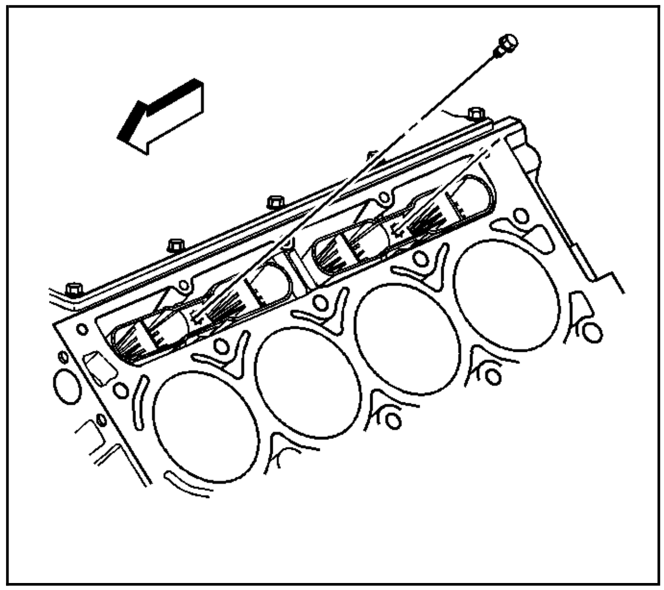


Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the valve lifter guide bolts.

   Tighten

   Tighten the bolt to 12 N·m (106 lb in).
5. Install the cylinder head and gasket. Refer to *Cylinder Head Replacement - Left* or *Cylinder Head Replacement - Right*.



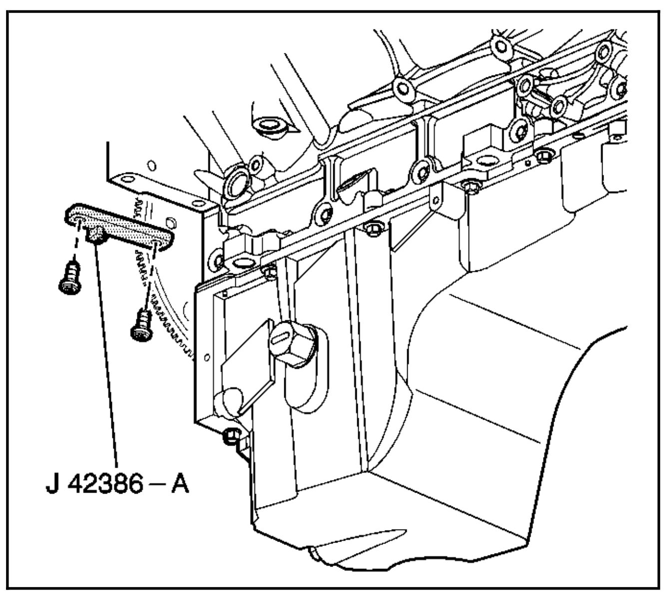
Crankshaft Balancer Replacement

Tools Required

- *J 41816* Crankshaft Balancer Remover
- *J 41816-2* Crankshaft End Protector
- *J 42386-A* Flywheel Holding Tool
- *J 41665* Crankshaft Balancer and Sprocket Installer
- *J 45059* Angle Meter

Removal Procedure

1. Remove the air conditioning (A/C) drive belt, if equipped. Refer to *Drive Belt Replacement - Air Conditioning*.
2. Remove the accessory drive belt, if not equipped with A/C. Refer to *Drive Belt Tensioner Replacement - Air Conditioning*.



3. Remove the fan shroud - lower. Refer to *Fan Shroud Replacement - Lower* in Engine Cooling.
4. Remove the starter motor. Refer to *Starter Motor Replacement (8.1L Engine)* or *Starter Motor Replacement (4.8L and 6.0L Engines)* in Engine Electrical.

Important:

- Make sure that the teeth of the *J 42386-A* mesh with the teeth of the engine flywheel.
- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.

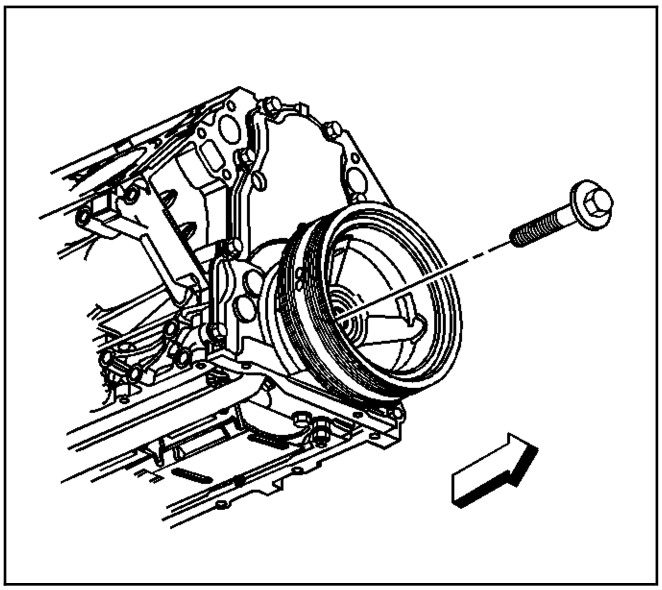
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the *J 42386-A* and bolts.

   Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool operation.

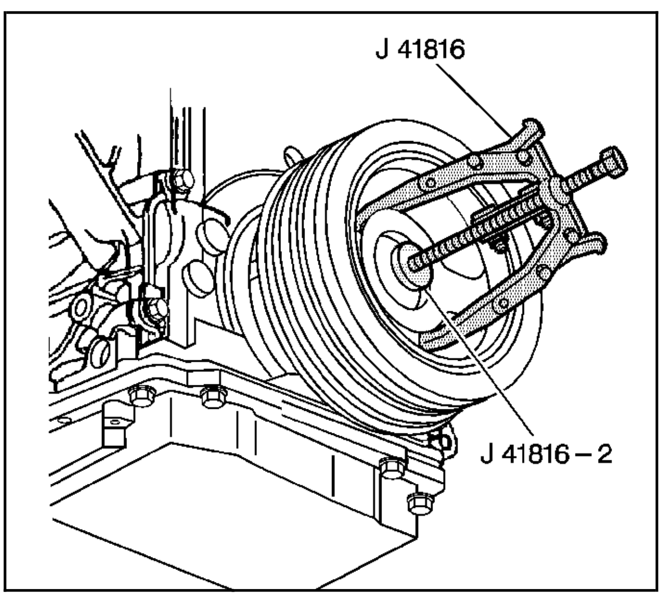
   Tighten

   Tighten the *J 42386-A* bolts to 50 N·m (37 lb ft).



6. Remove the crankshaft balancer bolt.

   Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.



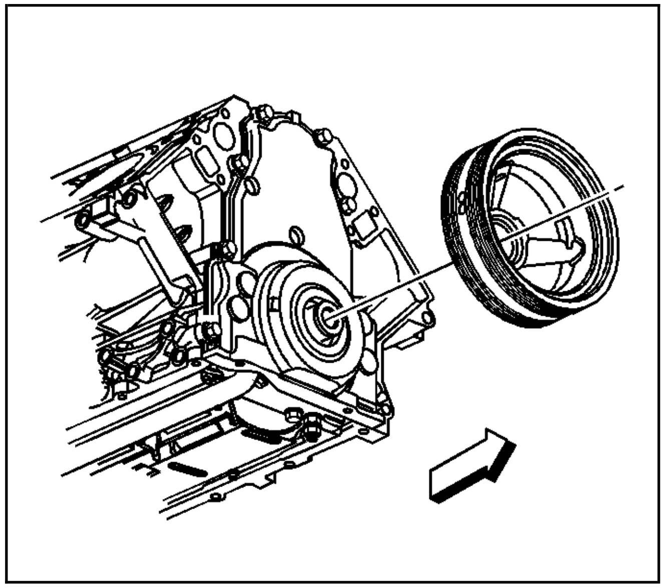
7. Install the *J 41816* and *J 41816-2* in order to remove the crankshaft balancer.
8. Remove the *J 41816* and the *J 41816-2* from the crankshaft balancer.
9. If required, clean and inspect the crankshaft balancer. Refer to *Crankshaft Balancer Cleaning and Inspection*.

Installation Procedure

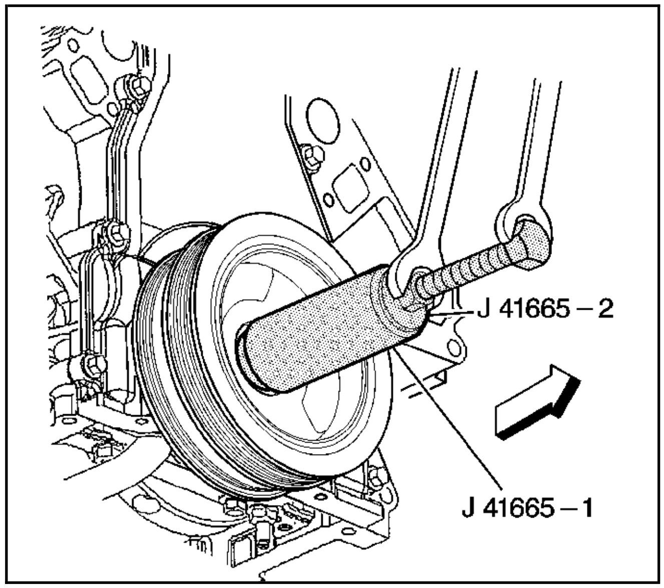
Important:

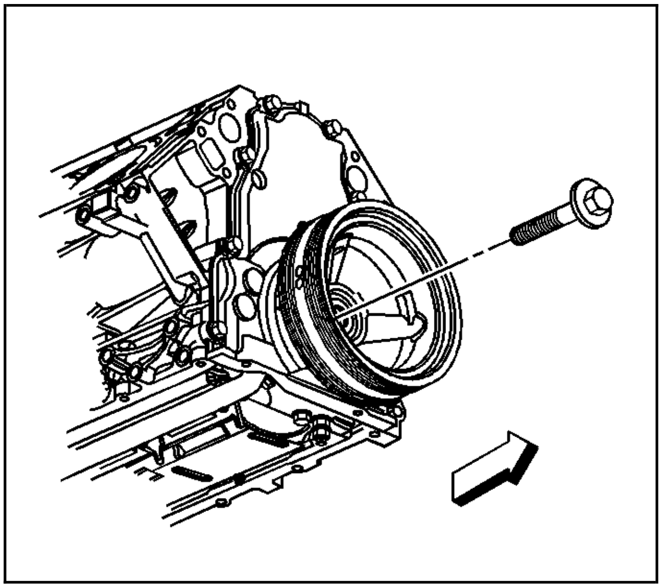
- Make sure that the teeth of *J 42386-A* mesh with the teeth of the engine flywheel.
- The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW bolt and tighten as described in the second, third and forth passes of the balancer bolt tightening procedure.
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and forth passes tighten the new bolt to the proper torque.

Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.



1. Install the crankshaft balancer onto the end of the crankshaft.
2. Use the *J 41665* in order to install the crankshaft balancer.
   - 2.1. Assemble the threaded rod, nut, washer and installer.
     Insert the smaller end of the installer into the front of the balancer.
   - 2.2. Use a wrench and hold the hex end of the threaded rod.
   - 2.3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
   - 2.4. Remove the tool and reverse the installation tool.
     Position the larger end of the installer against the front of the balancer.
   - 2.5. Use a wrench and hold the hex end of the threaded rod.
   - 2.6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
   - 2.7. Remove the balancer installation tool.





3. Install the used crankshaft balancer bolt.

   Tighten

   Tighten the USED bolt to 330 N·m (240 lb ft).
4. Remove the used crankshaft balancer bolt.

Important: The nose of the crankshaft should be recessed 2.4–4.48 mm (0.094–0.176 in) into the balancer bore.

5. Measure for a correctly installed balancer.

   If the balancer is not installed to the proper dimensions, install the *J 41665* and repeat the installation procedure.
6. Install a NEW crankshaft balancer bolt.

   Tighten

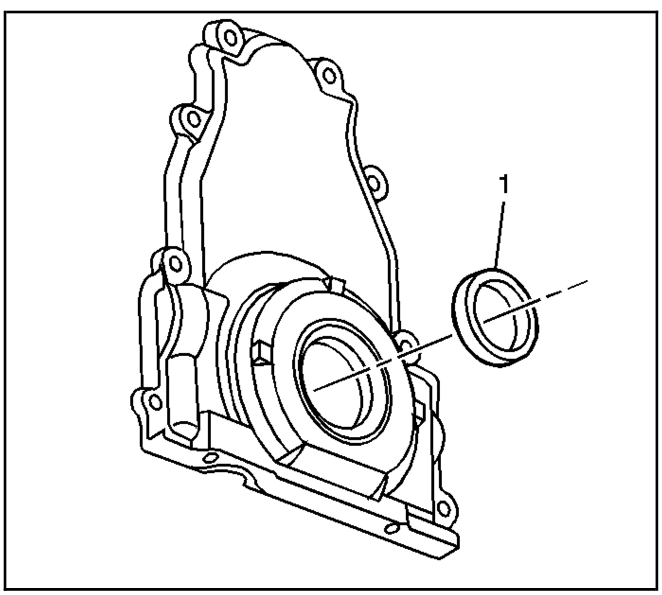
   6.1. Tighten the bolt a first pass to 50 N·m (37 lb ft).

   6.2. Tighten the bolt a second pass to 140 degrees using *J 45059*.
7. Remove the *J 42386-A* and bolts.
8. Install the starter motor. Refer to *Starter Motor Replacement (8.1L Engine)* or *Starter Motor Replacement (4.8L and 6.0L Engines)* in Engine Electrical.
9. Install the fan shroud - lower. Refer to *Fan Shroud Replacement - Lower* in Engine Cooling.
10. Install the accessory drive belt (if not equipped with A/C). Refer to *Drive Belt Replacement - Accessory*.
11. Install the A/C drive belt (if equipped). Refer to *Drive Belt Replacement - Air Conditioning*.
12. Perform the crankshaft position (CKP) system variation learn procedure. Refer to *CKP System Variation Learn Procedure* in Engine Controls – 4.8L and 6.0L.

Crankshaft Front Oil Seal Replacement

Tools Required

J 41478 Crankshaft Front Oil Seal Installer



Removal Procedure

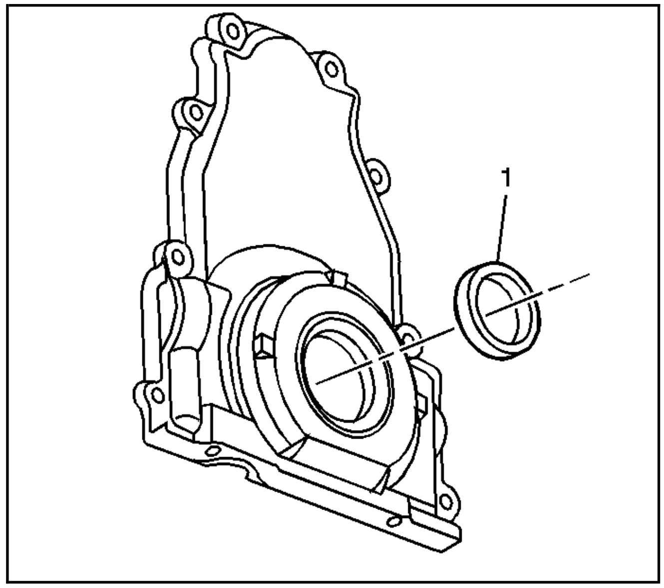
1. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
2. Remove the crankshaft oil seal (1) from the front cover.

Installation Procedure

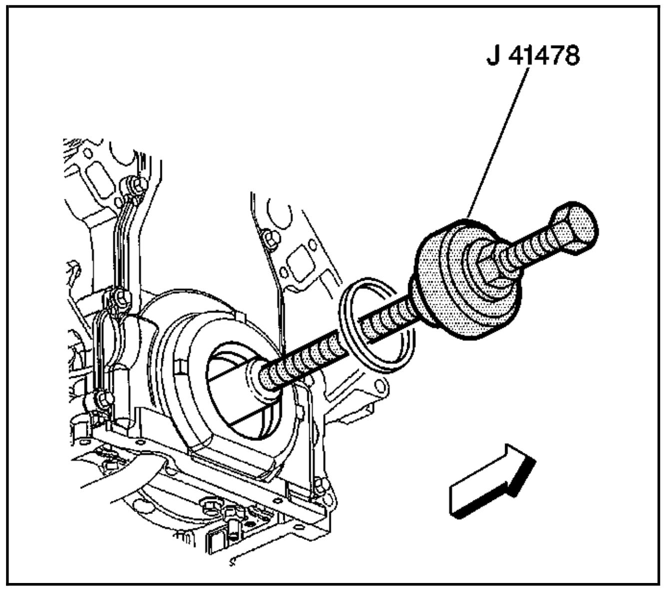
Important:

- Do not lubricate the oil seal sealing surface.
- Do not reuse the crankshaft oil seal.

1. Lubricate the outer edge of the oil seal (1) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.



3. Install the crankshaft front oil seal onto the *J 41478* guide.
4. Install the *J 41478* threaded rod (with nut, washer, guide, and oil seal) into the end of the crankshaft.
5. Use the *J 41478* in order to install the oil seal into the cover bore.
   - 5.1. Use a wrench and hold the hex on the installer bolt.
   - 5.2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
   - 5.3. Remove the *J 41478*.
   - 5.4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.
6. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.



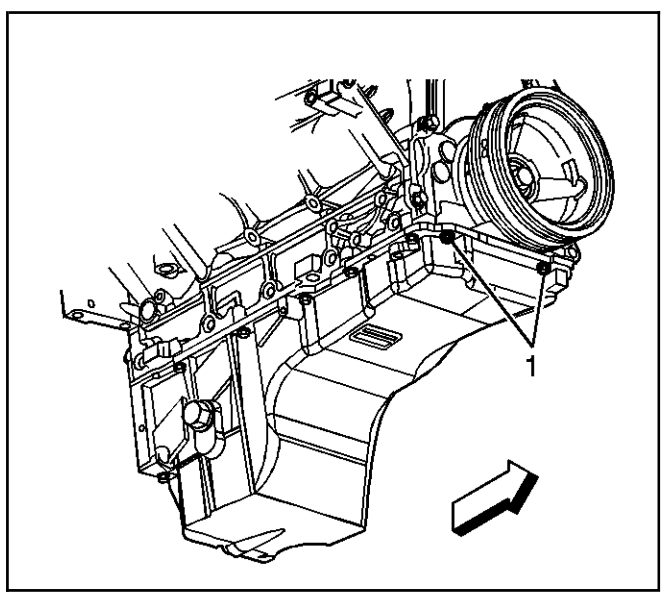
Engine Front Cover Replacement

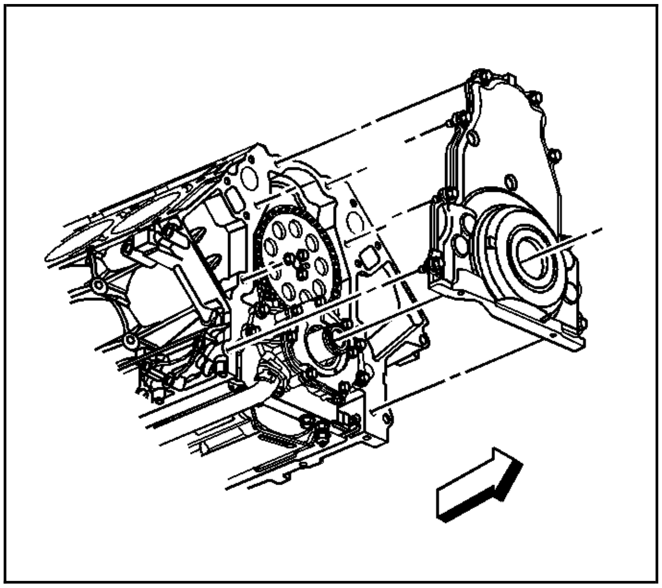
Tools Required

J 41476 Front and Rear Cover Alignment Tool

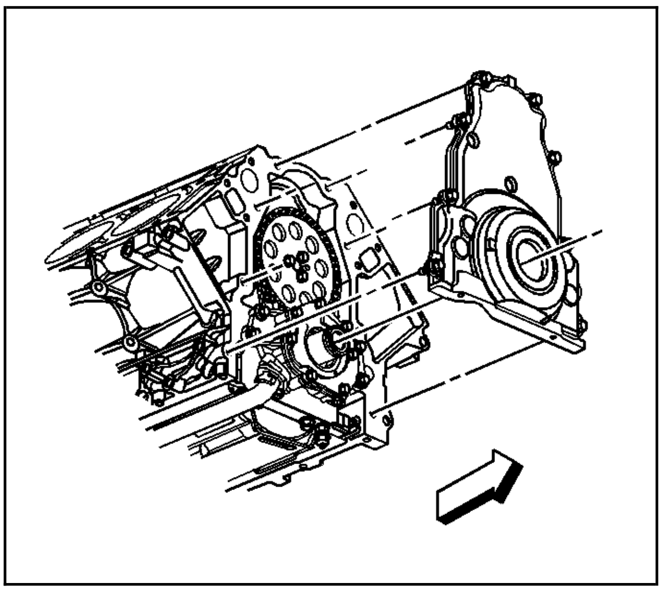
Removal Procedure

1. Remove the water pump. Refer to *Water Pump Replacement (4.8L and 6.0L Engines)* or *Water Pump Replacement (8.1L Engine)* in Engine Cooling.
2. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
3. Remove the oil pan-to-front cover bolts (1).





4. Remove the front cover bolts.
5. Remove the front cover and gasket.
6. Discard the front cover gasket.
7. If required, clean and inspect the engine front cover. Refer to *Engine Front Cover Cleaning and Inspection*.



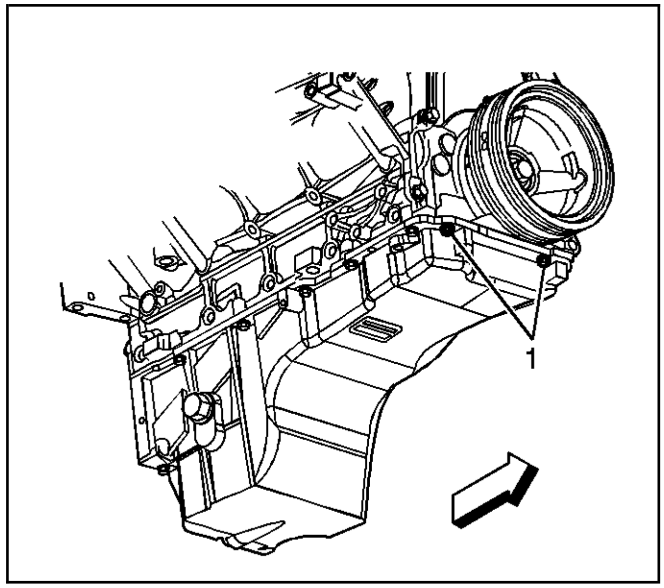
Installation Procedure

Important:

- Do not reuse the crankshaft oil seal or front cover gasket.
- Do not apply any type of sealant to the front cover gasket, unless specified.
- The special tool in this procedure is used to properly center the front crankshaft front oil seal.
    - All gasket surfaces should be free of oil or other foreign material during assembly.
    - The crankshaft front oil seal MUST be centered in relation to the crankshaft.
    - An improperly aligned front cover may cause premature front oil seal wear and/or engine oil leaks.

1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the oil pan to engine block junction.
2. Install the front cover gasket and cover.
3. Install the front cover bolts until snug. Do not overtighten.

4. Install the oil pan-to-front cover bolts (1) until snug. Do not over tighten.



5. Install *J 41476* to the front cover.
6. Align the tapered legs of the *J 41476* with the machined alignment surfaces on the front cover.

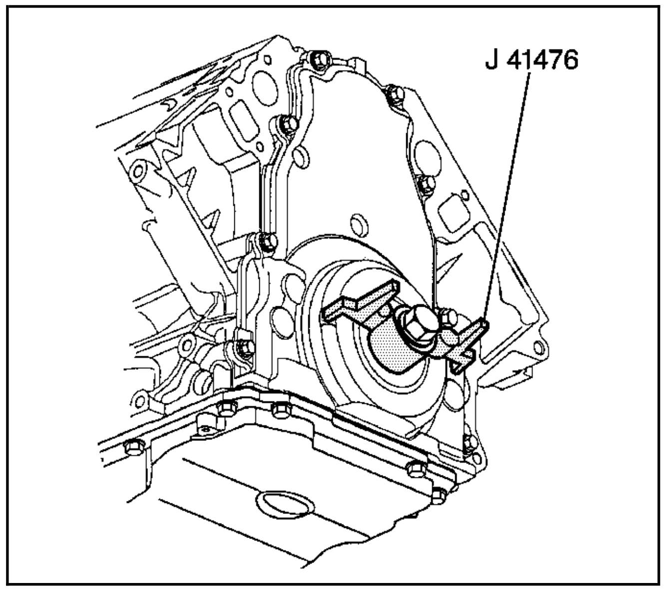
Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the crankshaft balancer bolt until snug. Do not overtighten.

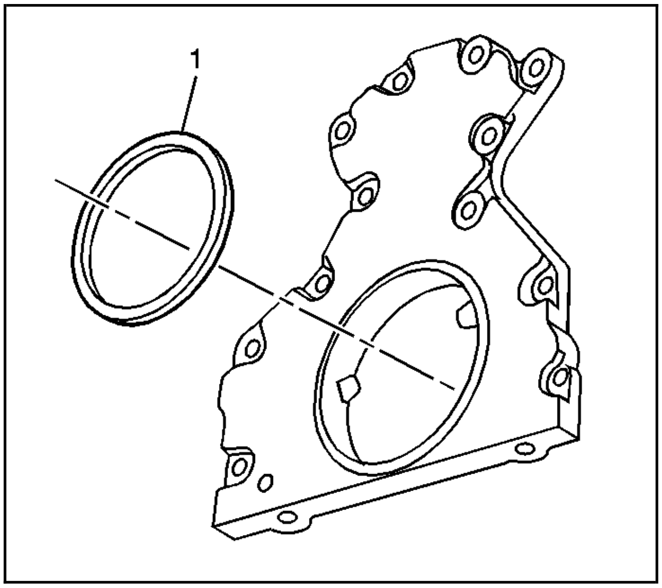
   Tighten

   7.1. Tighten the oil pan to front cover bolts to 25 N·m (18 lb ft).

   7.2. Tighten the engine front cover bolts to 25 N·m (18 lb ft).
8. Remove the *J 41476*.
9. Install a NEW crankshaft front oil seal. Refer to *Crankshaft Front Oil Seal Replacement*.
10. Install the water pump. Refer to *Water Pump Replacement (4.8L and 6.0L Engines)* or *Water Pump Replacement (8.1L Engine)* in Engine Cooling.



Crankshaft Rear Oil Seal Replacement

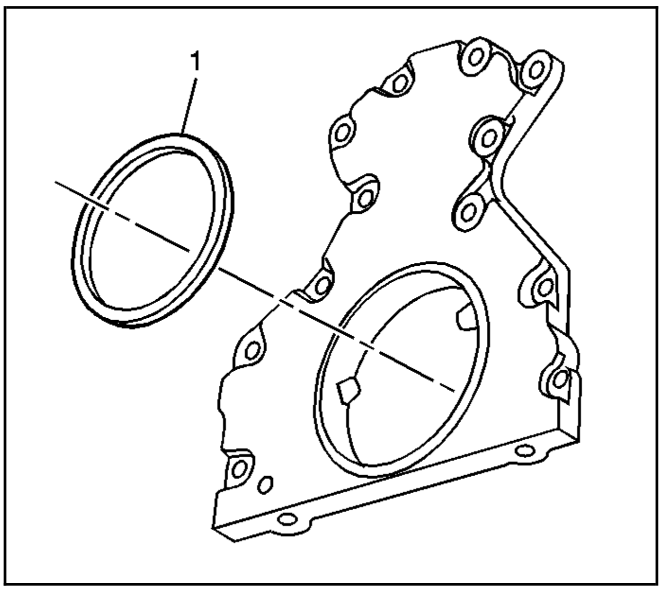


Tools Required

J 41479 Crankshaft Rear Oil Seal Installer

Removal Procedure

1. Remove the engine flywheel. Refer to *Engine Flywheel Replacement*.
2. Remove the crankshaft rear oil seal (1) from the rear cover.



Installation Procedure

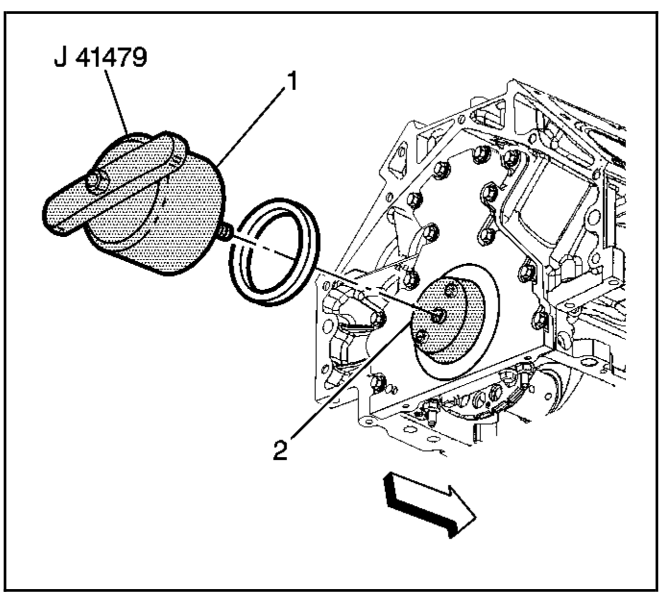
Important:

- The flywheel spacer (if applicable) must be removed prior to oil seal installation.
- Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.
- Do not reuse the crankshaft rear oil seal.

1. Lubricate the outside diameter (OD) of the oil seal (1) with clean engine oil.

   DO NOT allow oil or other lubricants to contact the seal surface.
2. Lubricate the rear cover oil seal bore with clean engine oil.

   DO NOT allow oil or other lubricants to contact the crankshaft surface.



3. Install the *J 41479* tapered cone (2) and bolts onto the rear of the crankshaft.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the *J 41479* threaded rod into the tapered cone until the tool (1) contacts the oil seal.
7. Align the oil seal into the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the *J 41479*.
10. Install the engine flywheel. Refer to *Engine Flywheel Replacement*.

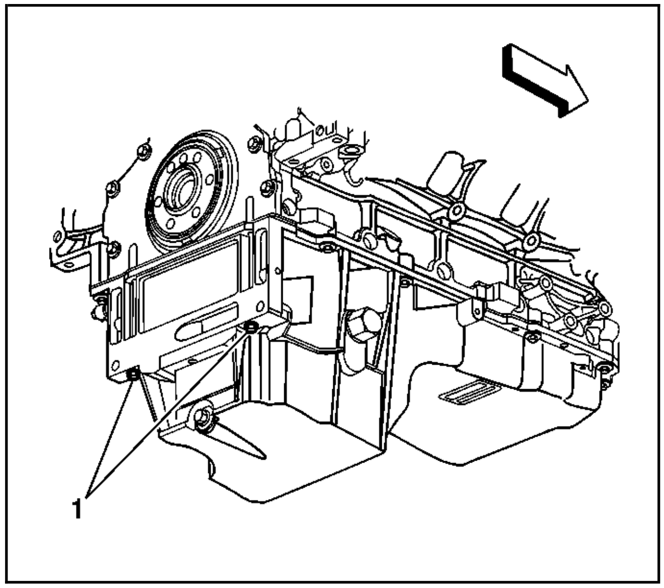
Engine Rear Cover Replacement

Tools Required

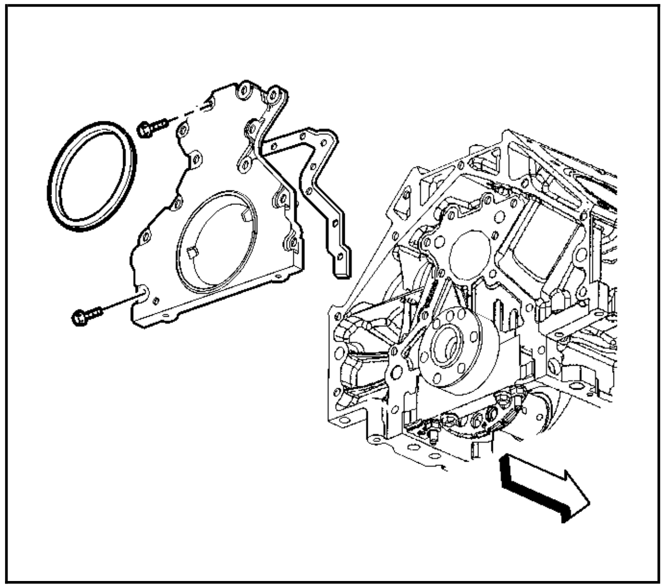
J 41476 Front and Rear Cover Alignment Tool

Removal Procedure

1. Remove the engine flywheel. Refer to *Engine Flywheel Replacement*.
2. Remove the oil pan-to-rear cover bolts (1).



3. Remove the rear cover bolts.
4. Remove the rear cover and gasket.
5. Discard the rear cover gasket.
6. If required, clean and inspect the rear cover. Refer to *Engine Rear Cover Cleaning and Inspection*.



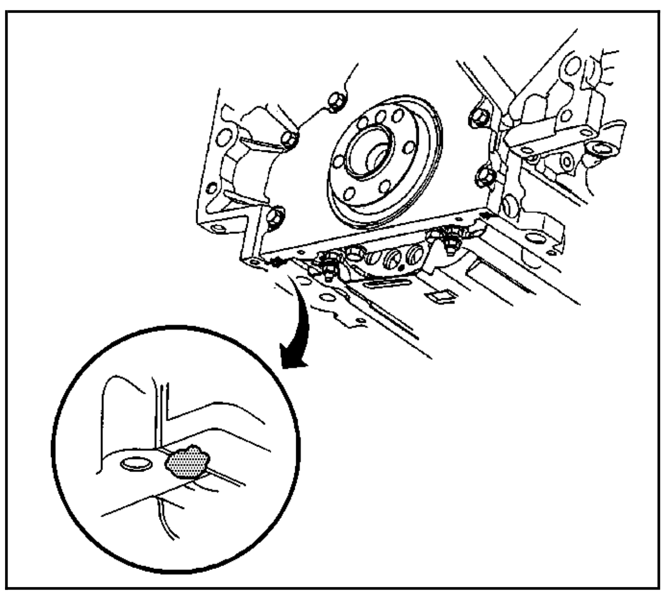
Installation Procedure

Important:

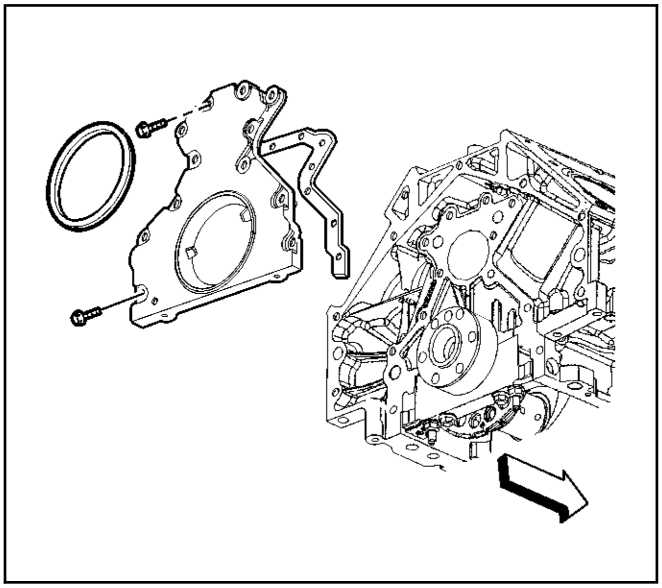
- Do not reuse the crankshaft oil seal or rear cover gasket.
- Do not apply any type of sealant to the rear cover gasket (unless specified).
- The special tool in this procedure is used to properly center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned.

Install the rear cover without the crankshaft oil seal.

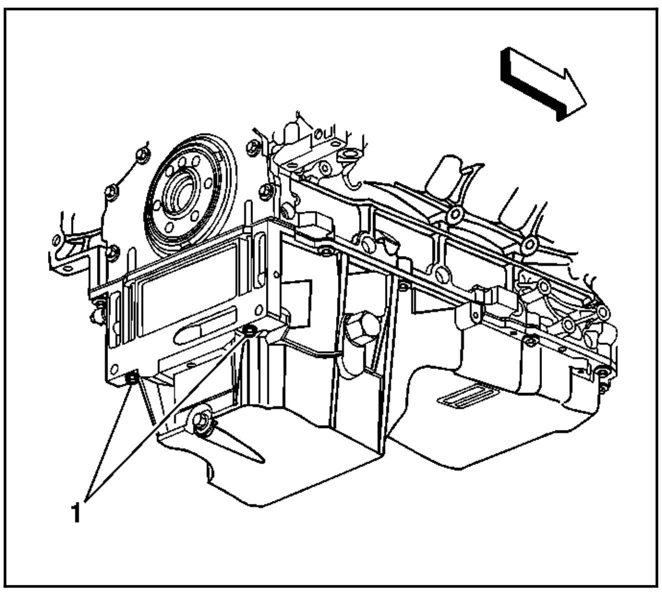
  - All gasket surfaces should be free of oil or other foreign material during assembly.
  - The crankshaft rear oil seal MUST be centered in relation to the crankshaft.



- An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.



1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the oil pan to engine block junction.
2. Install the rear cover gasket and cover.
3. Install the rear cover bolts until snug. Do not overtighten.



4. Install the oil pan-to-rear cover bolts (1) until snug. Do not overtighten.

5. Rotate the crankshaft until two opposing flywheel bolt holes are parallel to the oil pan surface.

Important: The tapered legs of the alignment tool must enter the rear cover oil seal bore.

6. Install the *J 41476* and bolts onto the rear of the crankshaft.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

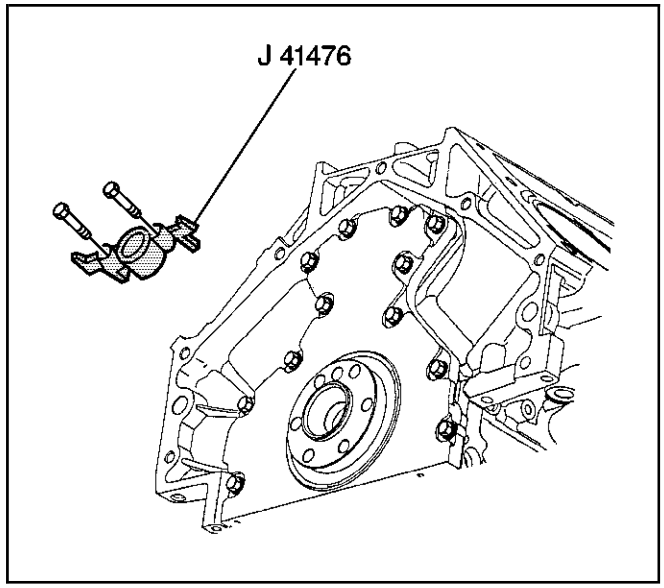
7. Tighten the *J 41476* mounting bolts until snug. Do not overtighten.

   Tighten

   7.1. Tighten the oil pan-to-rear cover bolts to 12 N·m (106 lb in).

   7.2. Tighten the engine rear cover bolts to 25 N·m (18 lb ft).

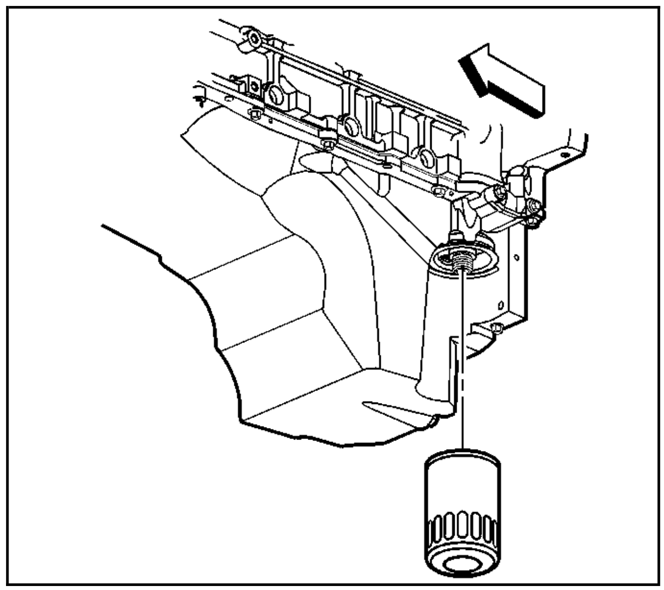
8. Remove the *J 41476*.
9. Install a NEW crankshaft rear oil seal. Refer to *Crankshaft Rear Oil Seal Replacement*.
10. Install the engine flywheel. Refer to *Engine Flywheel Replacement*.

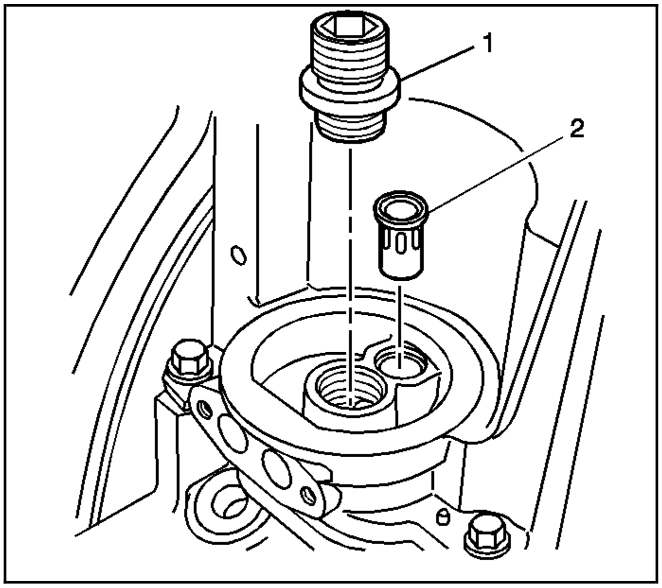


Oil Filter Adapter Replacement

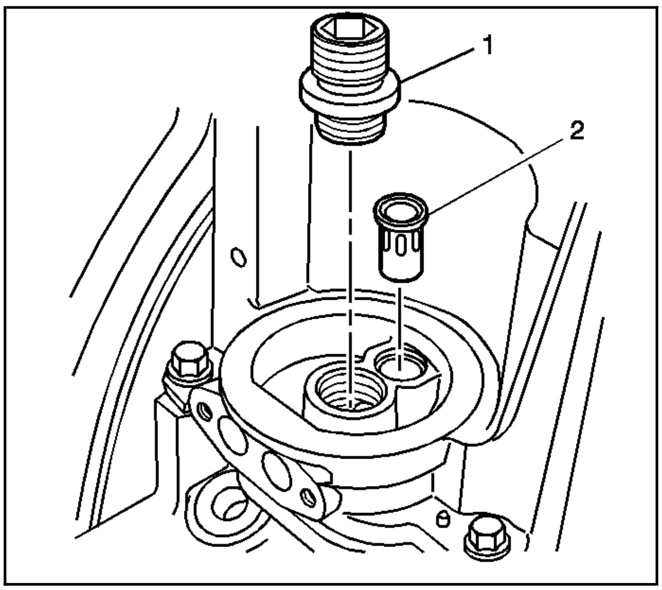
Removal Procedure

1. Drain the engine oil.
2. Remove the oil filter.





3. Remove the oil filter adapter (1).



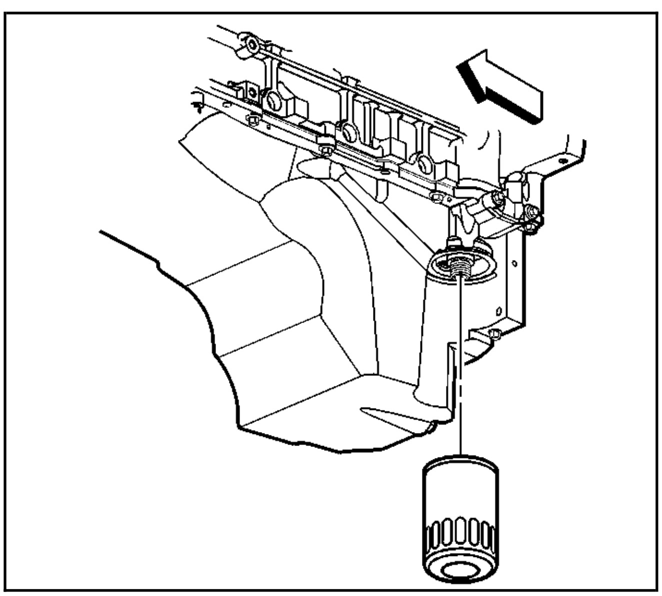
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the oil filter adapter (1).

   Tighten

   Tighten the adapter to 55 N·m (40 lb ft).

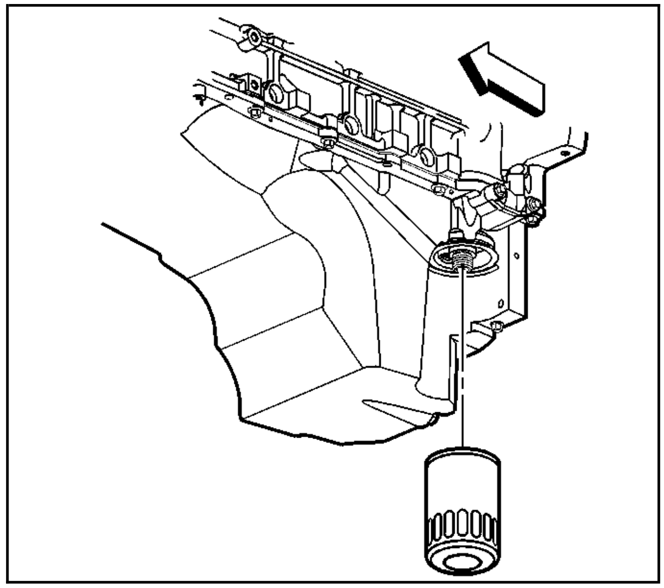


2. Install the oil filter.
3. Refill the engine oil. Refer to *Capacities - Approximate Fluid* and/or *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

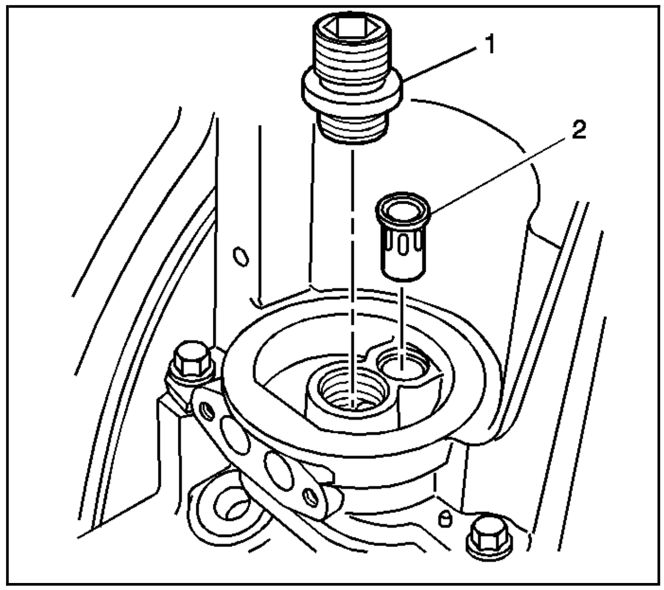
Oil Filter Bypass Valve Replacement

Removal Procedure

1. Drain the engine oil.
2. Remove the oil filter.



3. Remove the oil filter adapter (1).
4. Remove the oil filter bypass valve (2).



Installation Procedure

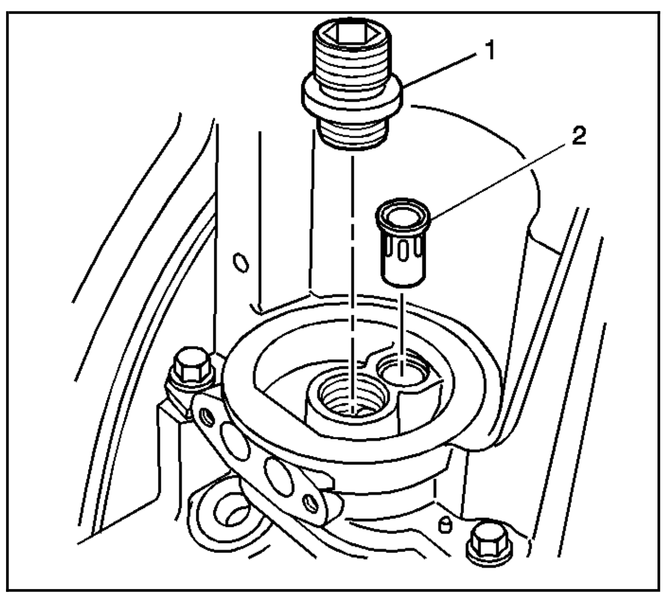
1. Install the oil filter bypass valve (2).

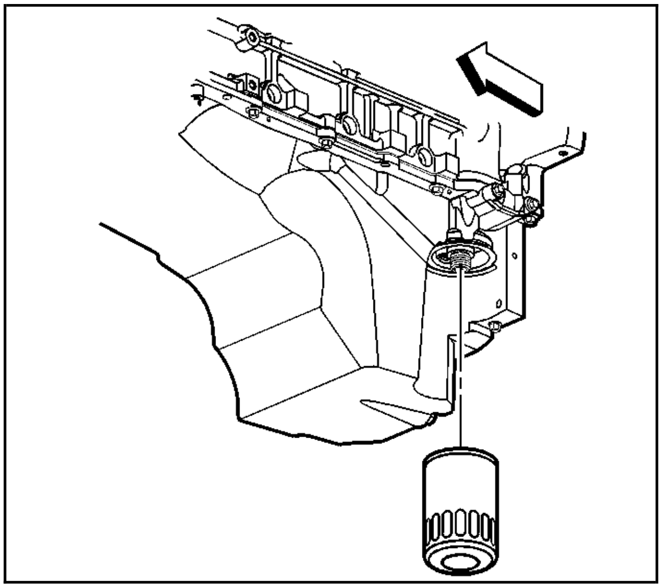
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the oil filter adapter (1).

   Tighten

   Tighten the oil filter adapter to 55 N·m (40 lb ft).

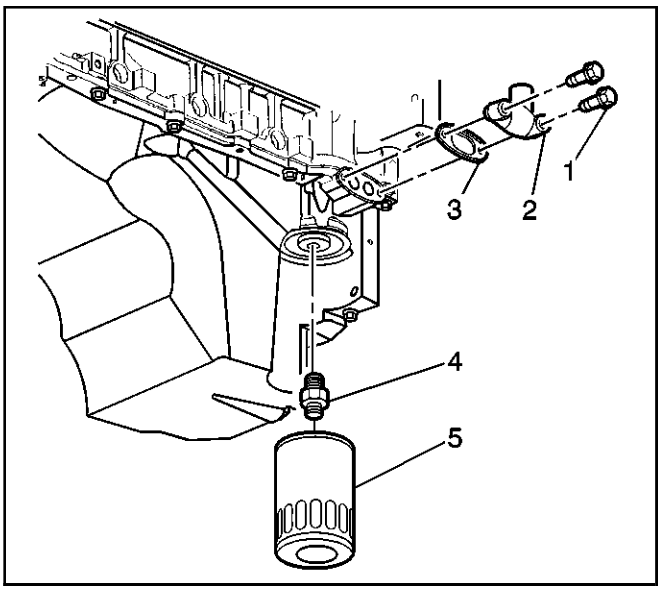




3. Install the oil filter.

   Tighten

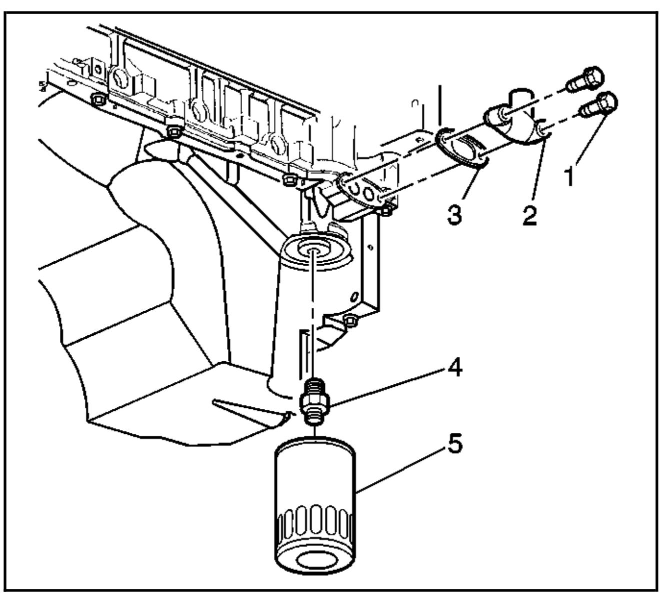
   Tighten the oil filter to 30 N·m (22 lb ft).
4. Refill the engine oil. Refer to *Capacities - Approximate Fluid* and/or *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.



Oil Pan Cover Replacement

Removal Procedure

1. Drain the engine oil.
2. Remove the oil pan cover bolts (1), cover (2), and gasket (3).
3. Discard the gasket.



Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install a new oil pan cover gasket (3), the cover (2) and bolts (1).

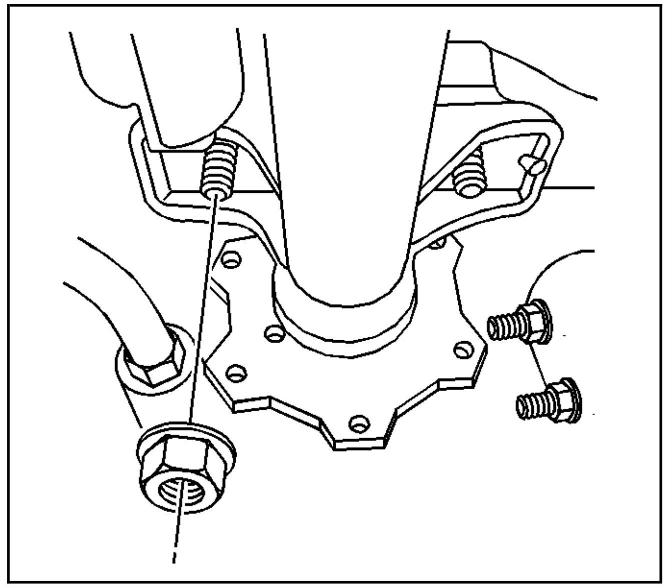
   Tighten

   Tighten the bolts to 12 N·m (106 lb in).
2. Refill the engine oil. Refer to *Capacities - Approximate Fluid* and/or *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.

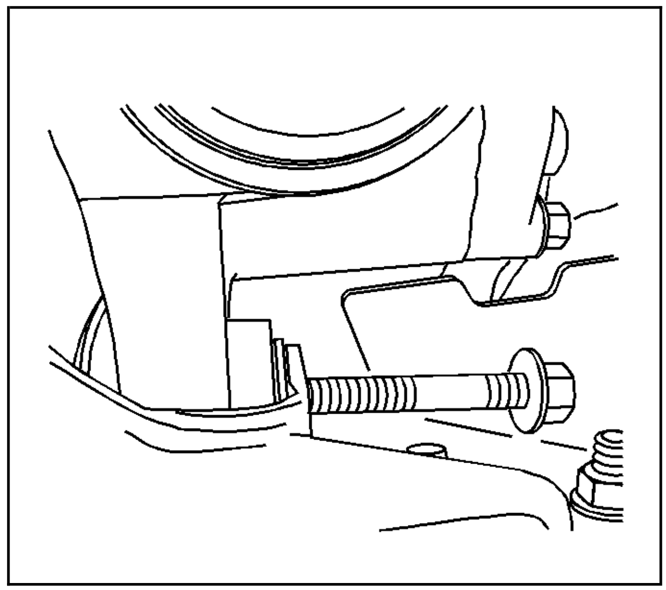
Oil Pan Replacement

Removal Procedure

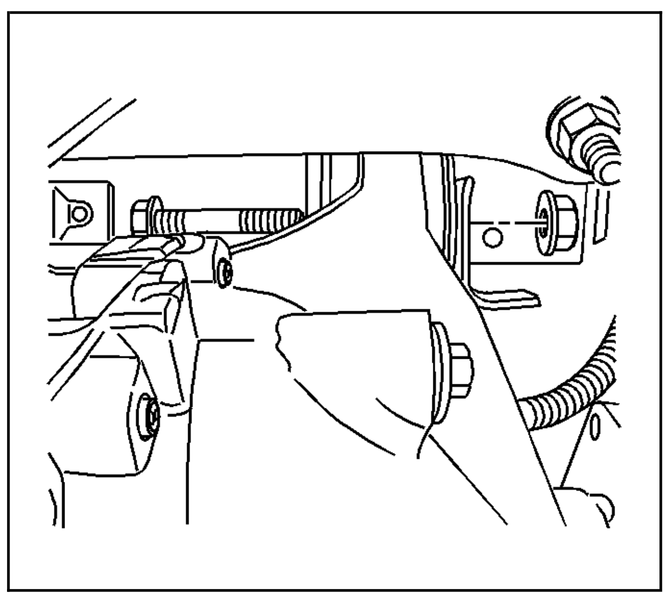
1. If equipped with four wheel drive (4WD), remove the inner axle housing nuts and washers from the bracket.
2. Support the front drive axle with a suitable jack.

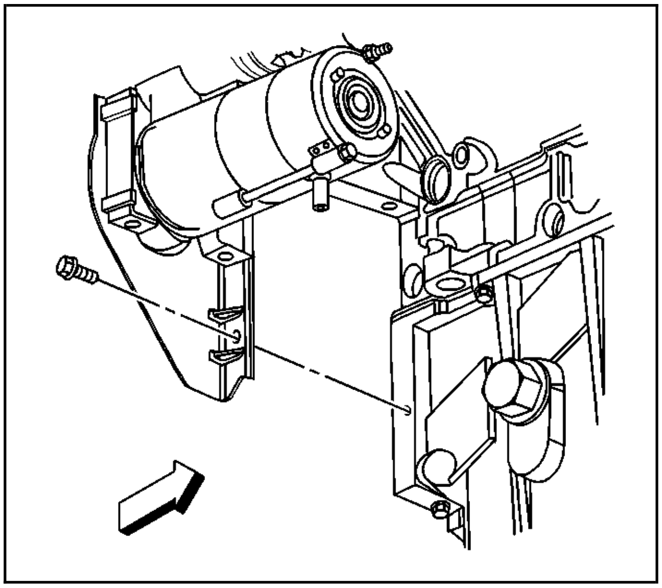


3. If equipped with 4WD, remove the differential carrier lower mounting bolt and nut.

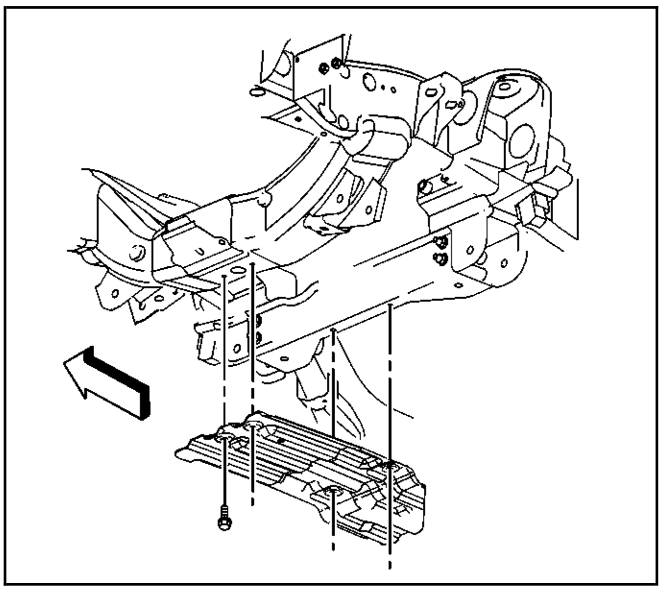


4. If equipped with 4WD, remove the differential carrier upper mounting bolt and nut.
5. Lower the front drive axle.

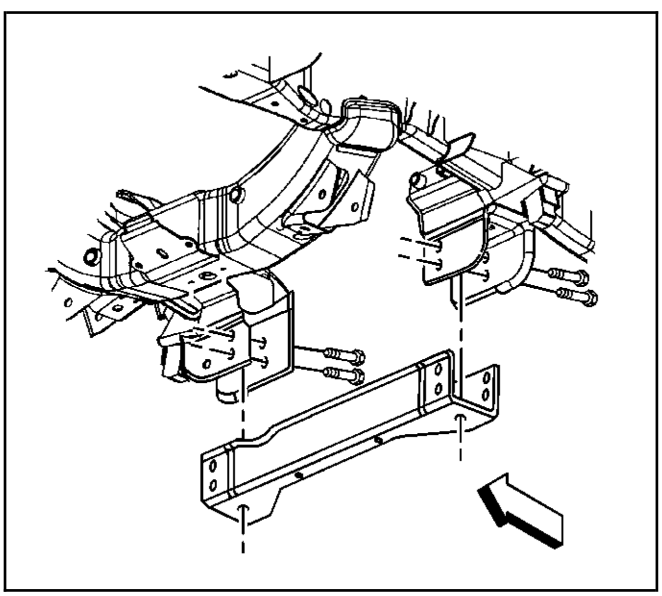




6. Remove the transmission cover bolt.

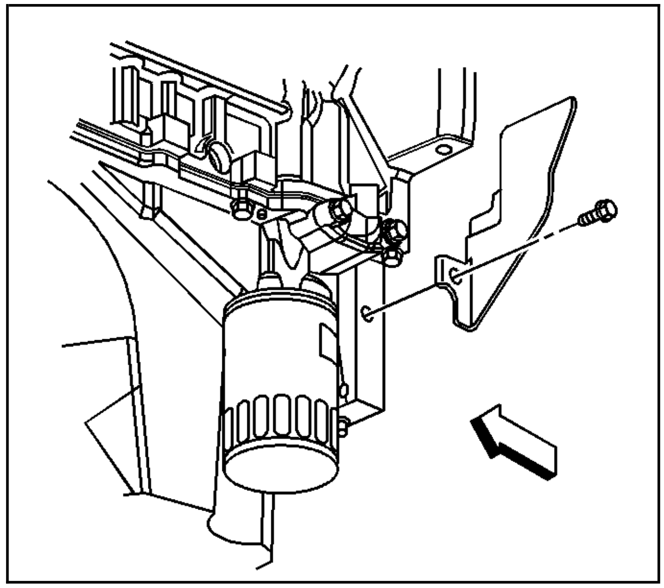


7. If equipped, remove the oil pan skid plate bolts.
8. Remove the oil pan skid plate.



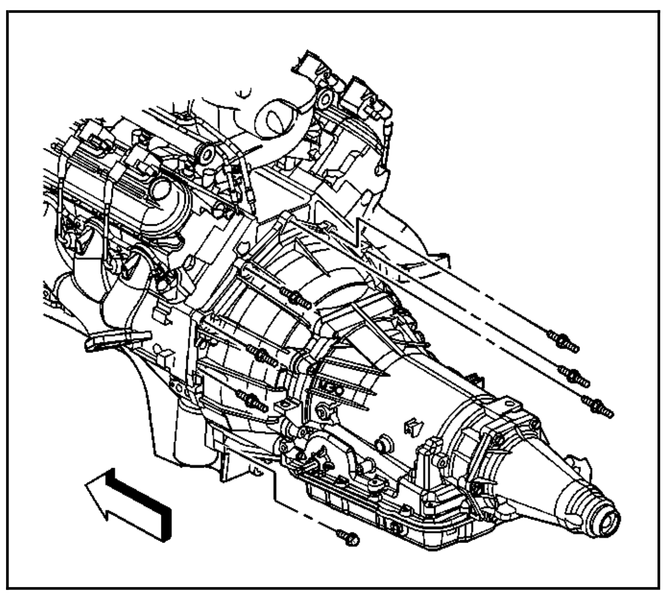
9. Remove the crossbar bolts.
10. Remove the crossbar.

11. Remove the transmission cover bolt and cover.
12. Drain the engine oil and remove the engine oil filter.
13. Re-install the drain plug and oil filter until snug.



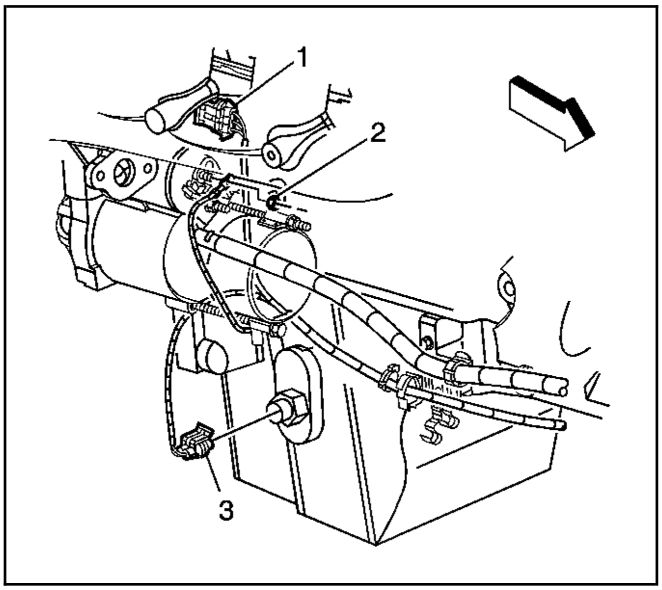
14.Leftblankintentionally.

15. Remove the bottom bolt on the left side.

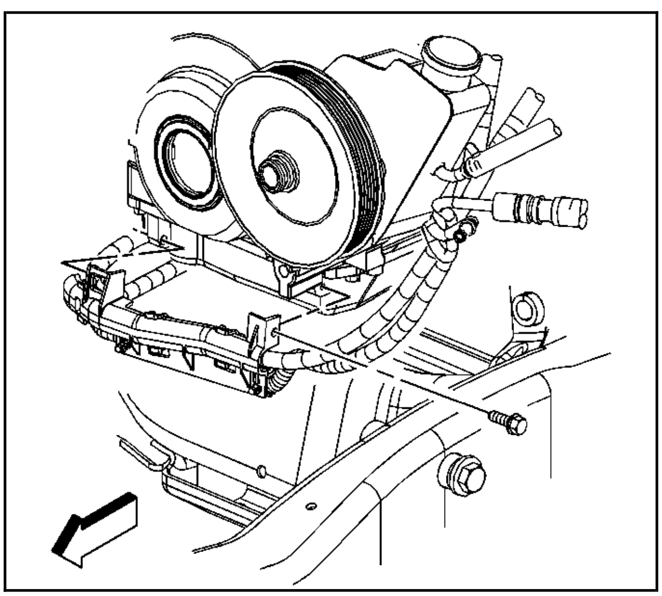


16.Leftblankintentionally.

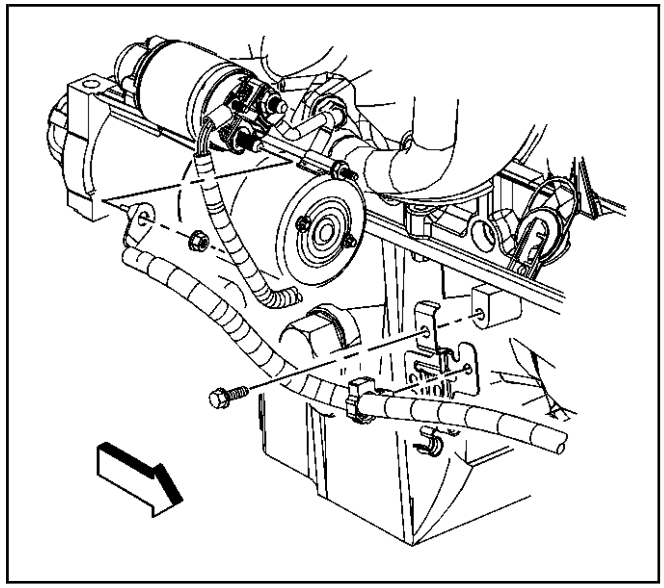
17. Disconnect the oil level sensor electrical connector (3).



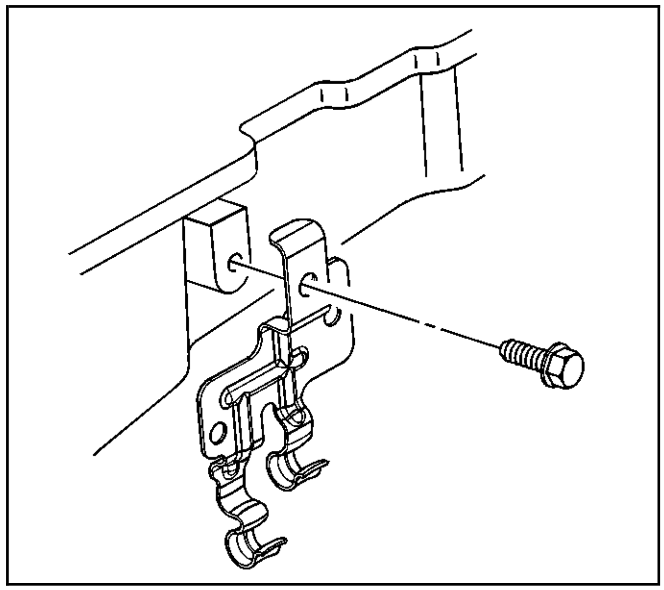
18. Remove the battery cable channel bolt.
19. Slide the channel pin out of the oil pan tab.



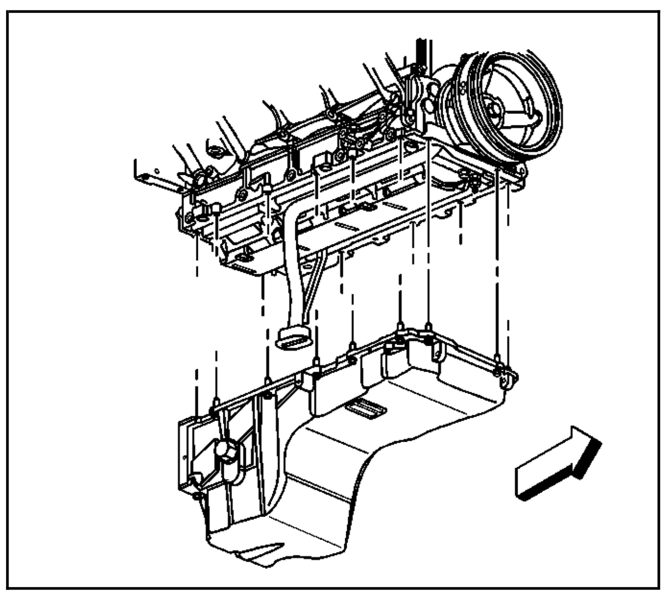
20. Remove the following from the positive battery cable clip:
    - Engine wiring harness clip
    - Positive battery cable clip

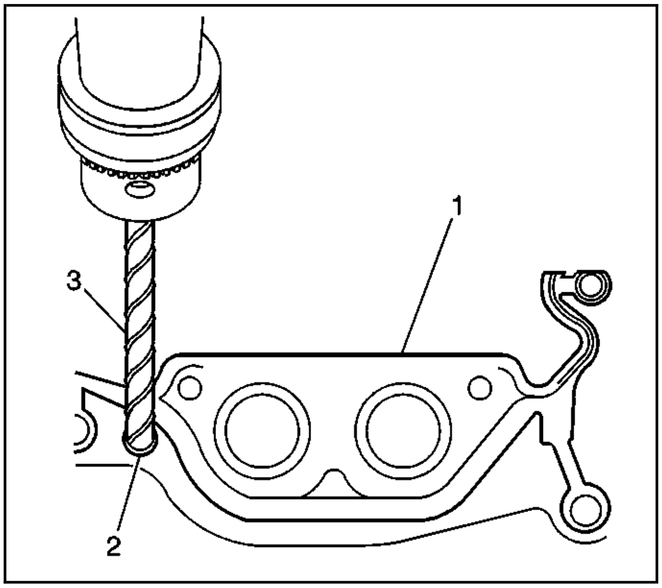


21. Remove the engine oil cooler lines from the positive battery cable clip.
22. Remove the positive battery cable clip bolt and clip.



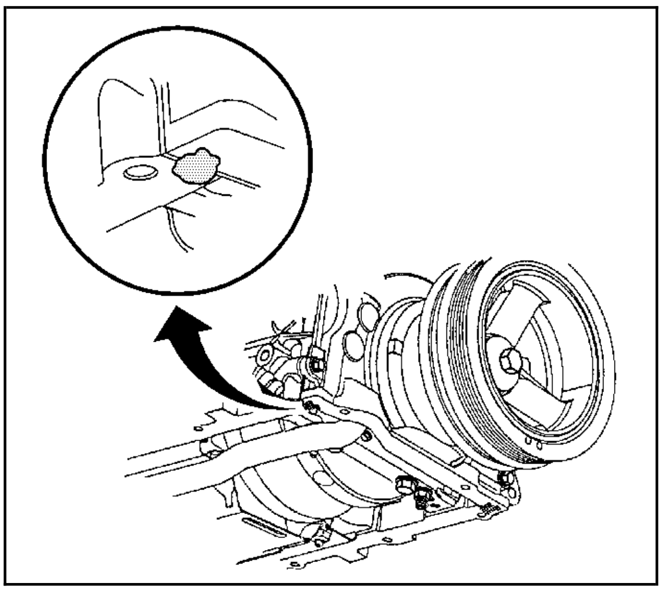
23. Remove the oil pan bolts.
24. Remove the oil pan.





Important: DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.

25. Drill (3) out the oil pan gasket retaining rivets (2), if required.
26. Remove the gasket (1) from the pan.
27. Discard the gasket and rivets.
28. If required, clean and inspect the engine oil pan. Refer to *Oil Pan Cleaning and Inspection*.

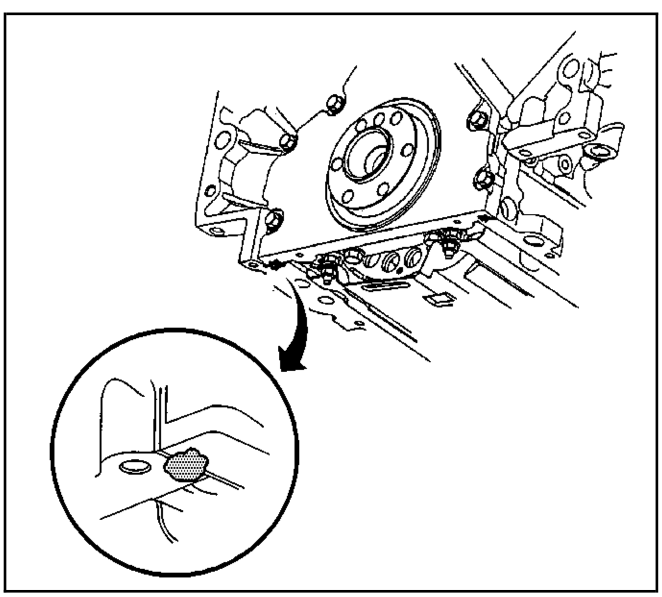


Installation Procedure

Important:

- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission bellhousing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan must NEVER protrude beyond the engine block and transmission bellhousing plane.
- Do not reuse the oil pan gasket.
- It is not necessary to rivet the NEW gasket to the oil pan.

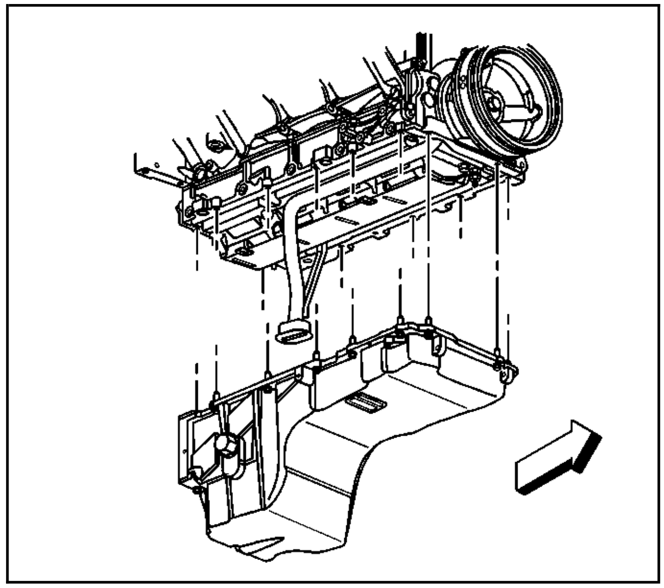
1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrudes into the oil pan surface.



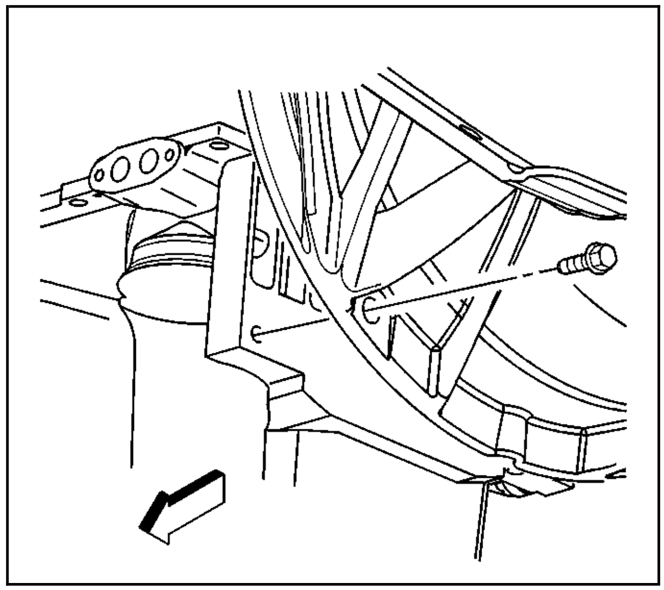
2. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrudes into the oil pan surface.

Important: Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

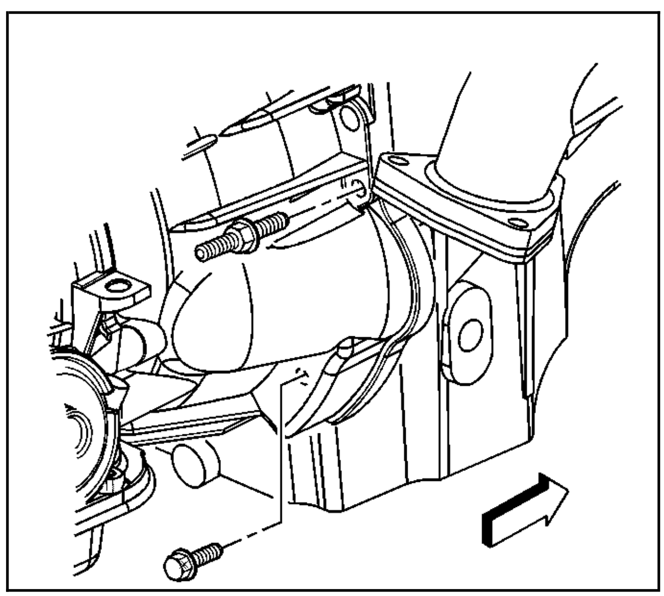
3. Pre-assemble the oil pan gasket to the pan.
   - Install the gasket onto the pan.
   - Install the oil pan bolts to the pan and through the gasket.
4. Install the oil pan, gasket and bolts to the engine block.
5. Tighten the oil pan bolts until snug. Do not overtighten.

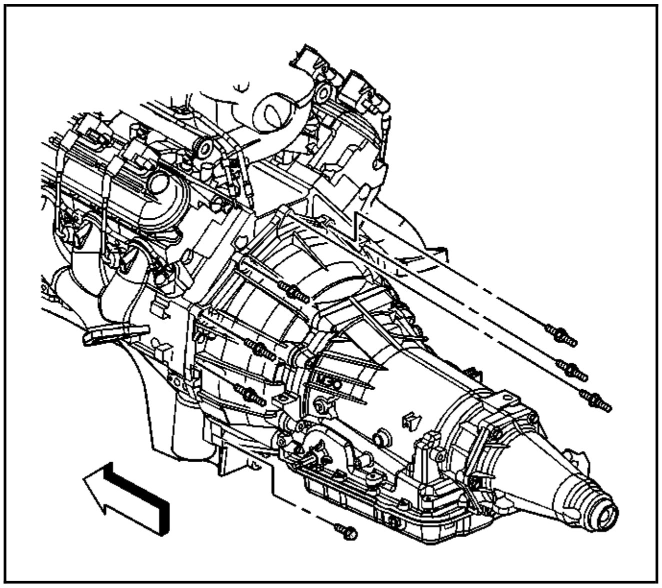


6. Install the transmission converter cover bolts until snug, if equipped with the 4L80-E automatic transmission.



7. Install the transmission bolt and stud on the right side until snug, If equipped with the 4L60-E automatic transmission.





Notice: Refer to *Fastener Notice* in Cautions and Notices.

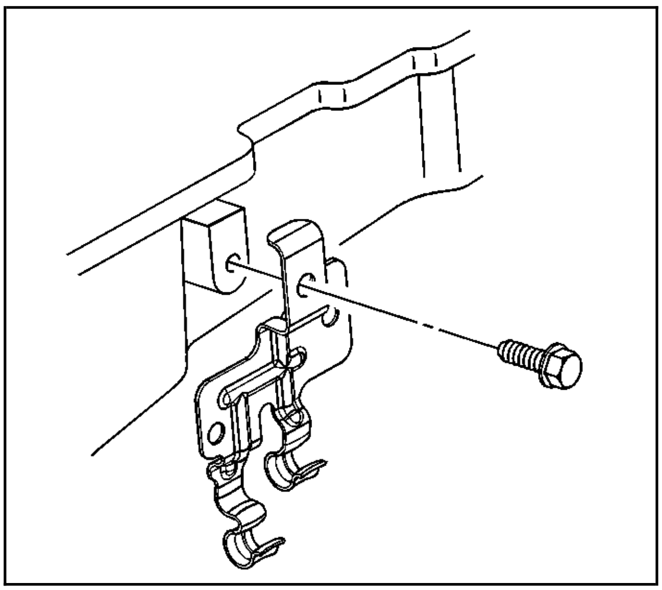
8. Install the bottom bolt on the left side until snug.

   Tighten

   8.1. Tighten the oil pan and oil pan-to-oil pan front cover bolts to 25 N·m (18 lb ft).

   8.2. Tighten the oil pan-to-rear cover bolts to 12 N·m (106 lb in).

   8.3. Tighten the bellhousing, converter cover, and transmission bolts/stud to 50 N·m (37 lb ft).

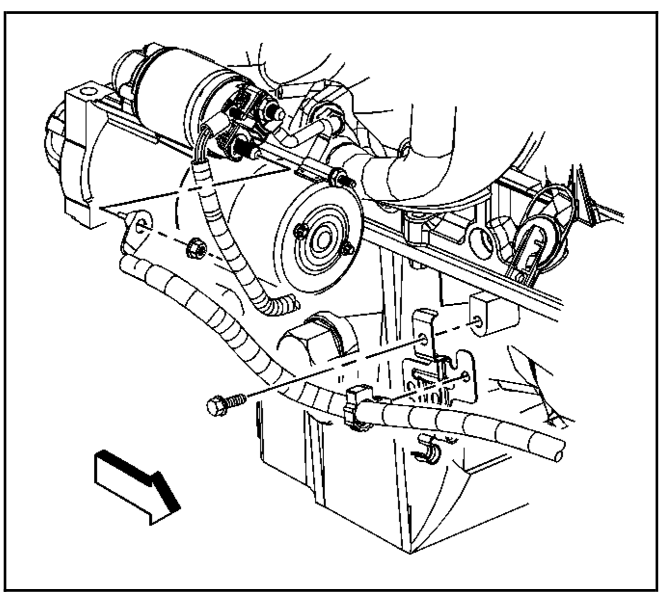


9. Install the positive battery cable clip and bolt to the oil pan.

   Tighten

   Tighten the bolt to 9 N·m (80 lb in).

10. Install the engine oil cooler lines to the positive battery cable clip.

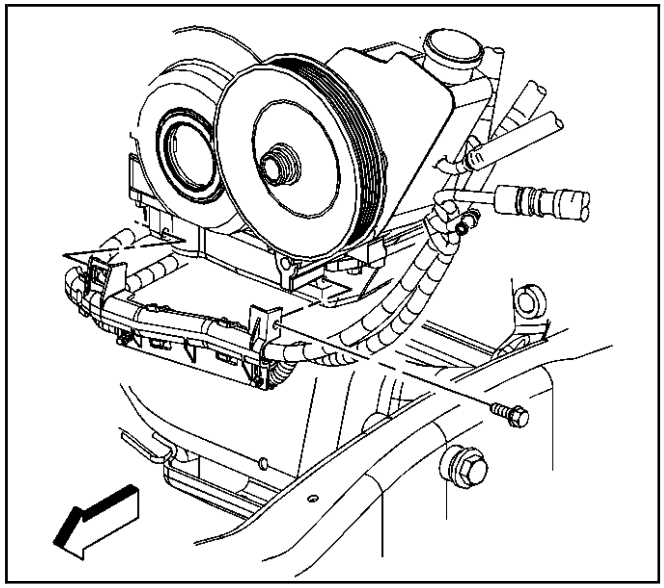


11. Install the following to the positive battery cable clip:
    - Engine wiring harness clip
    - Positive battery cable clip

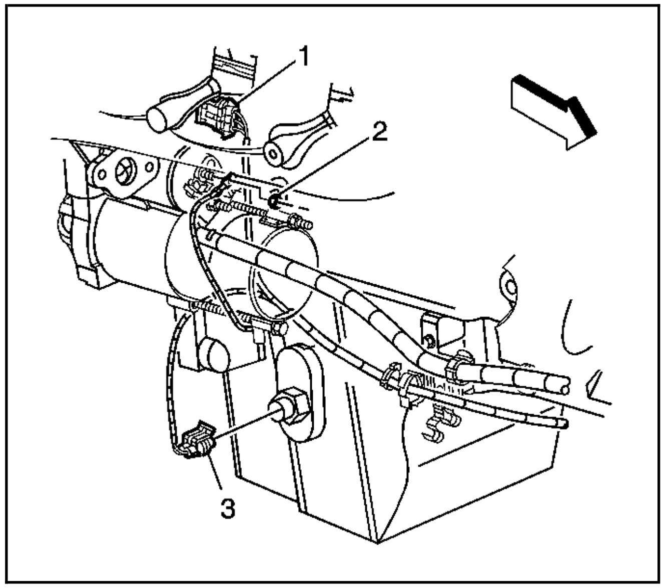
12. Slide the channel pin in to the oil pan tab.
13. Install the battery cable channel bolt.

Tighten

Tighten the bolt to 12 N·m (106 lb in).



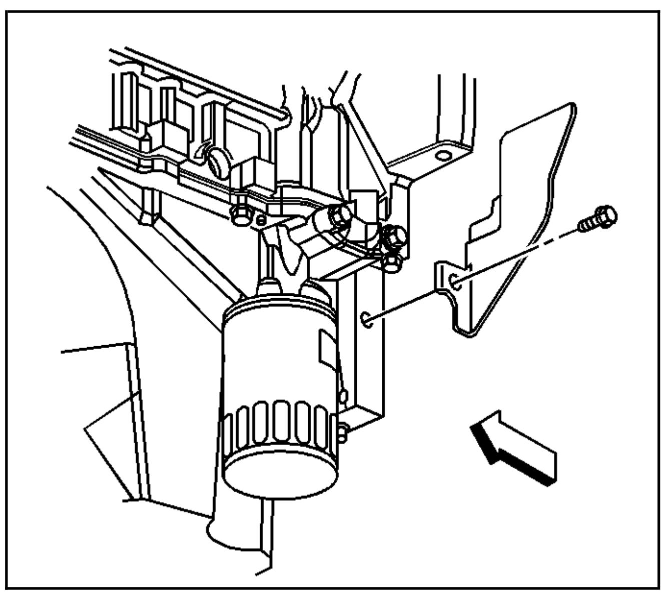
14. Connect the oil level sensor electrical connector (3).

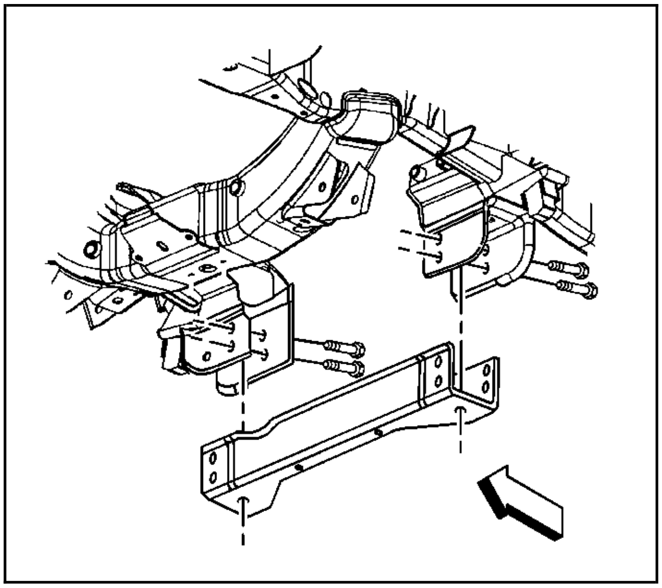


15. Install the transmission cover and bolt.

Tighten

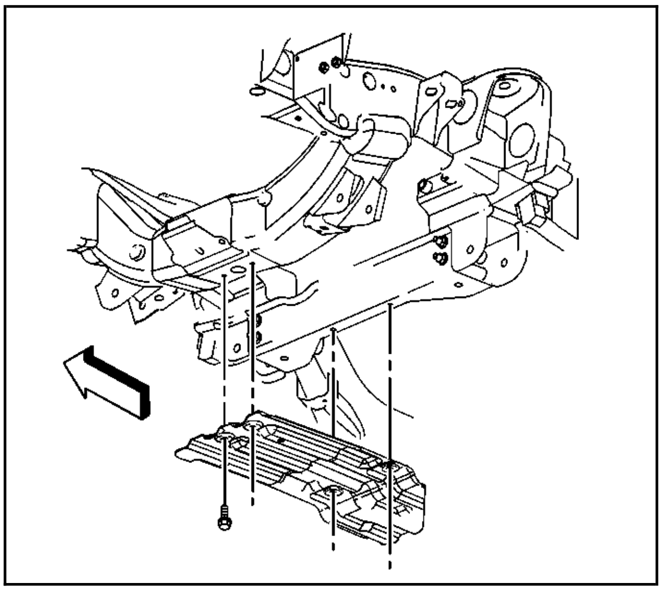
Tighten the bolt to 12 N·m (106 lb in).





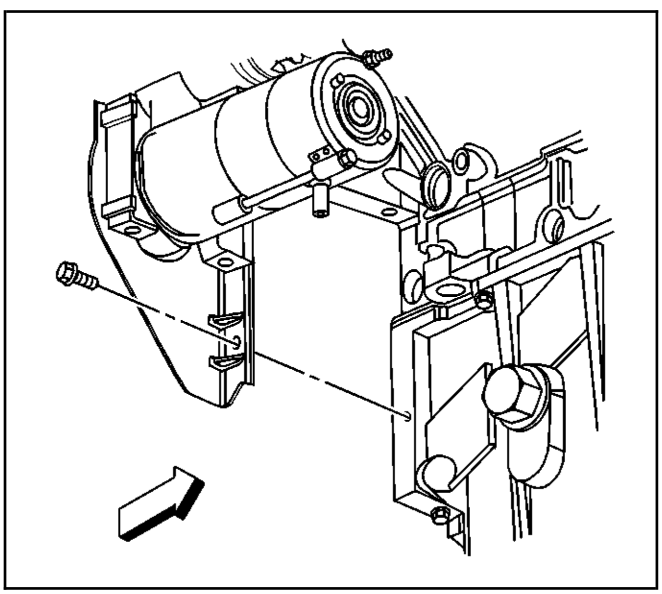
16. Install the crossbar.
17. Install the crossbar bolts.

    Tighten
    Tighten the bolts to 100 N·m (74 lb ft).



18. If equipped, install the oil pan skid plate.
19. Install the oil pan skid plate bolts.

    Tighten
    Tighten the bolts to 20 N·m (15 lb ft).



20. Install the transmission cover bolts

    Tighten
    Tighten the bolt to 12 N·m (106 lb in).

21.Leftblankintentionally.

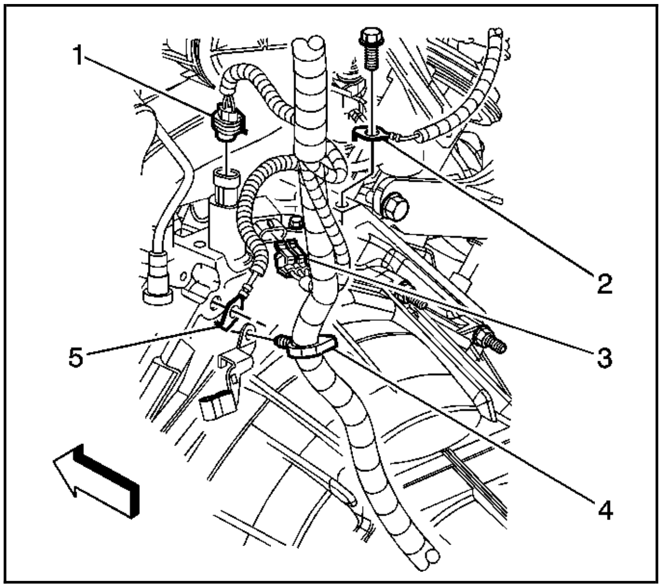
22.Leftblankintentionally.

23.Leftblankintentionally.

24.Leftblankintentionally.

25.Leftblankintentionally.

26. Install new engine oil and a new oil filter. Refer to *Engine Oil and Oil Filter Replacement*.



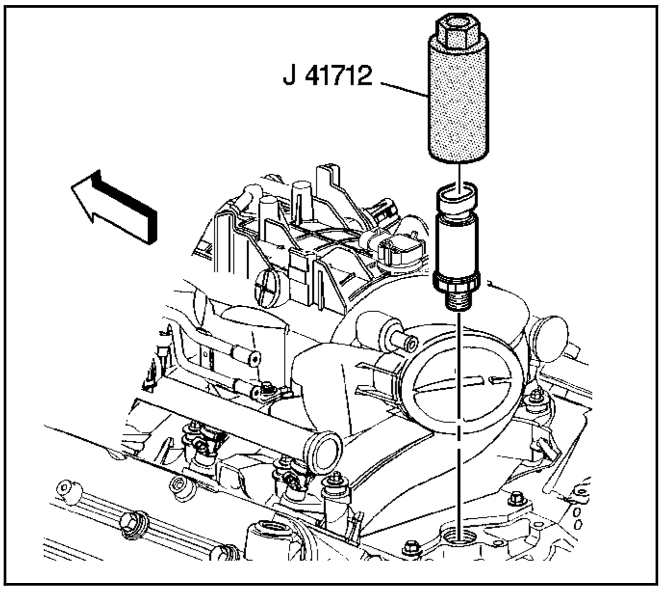
Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

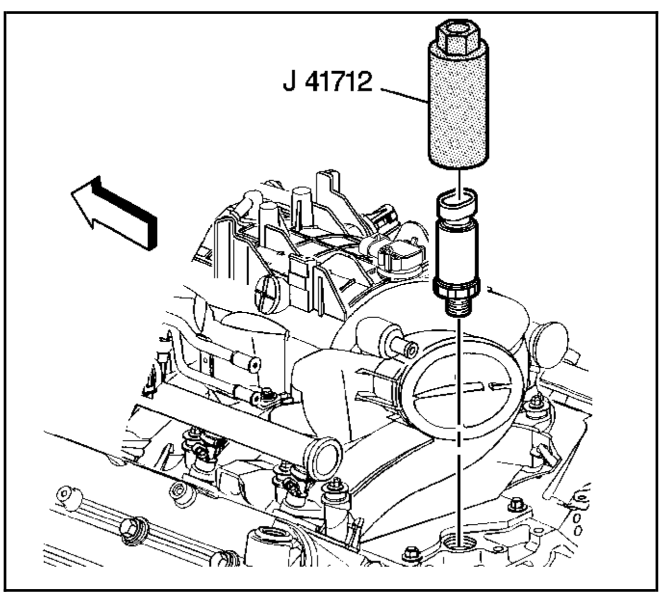
J 41712 Oil Pressure Switch Socket

Removal Procedure

1. If necessary, remove the engine sight shield. Refer to *Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4)*.
   .
2. Disconnect the oil pressure sensor electrical connector (1).



3. Using *J 41712* or equivalent, remove the oil pressure sensor.



Installation Procedure

1. Apply sealant GM P/N 12346004, (Canadian P/N 10953480), or equivalent, to the threads of the oil pressure sensor.

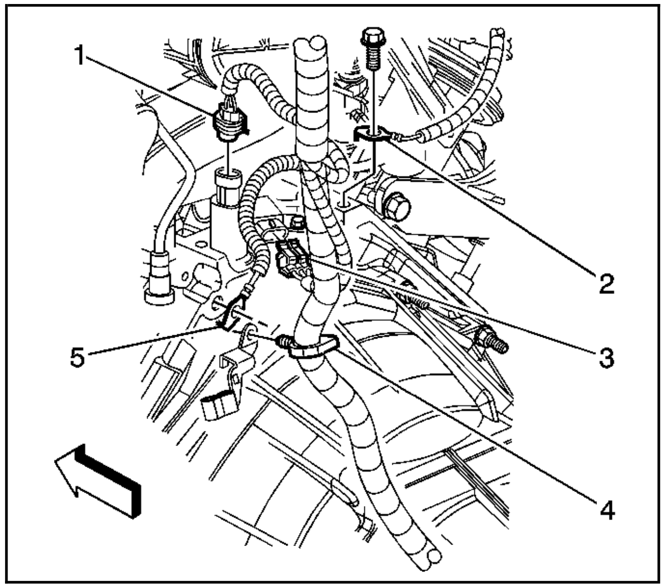
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Using *J 41712* or equivalent, install the oil pressure sensor.

   Tighten

   Tighten the oil pressure sensor to 30 N·m (22 lb ft).

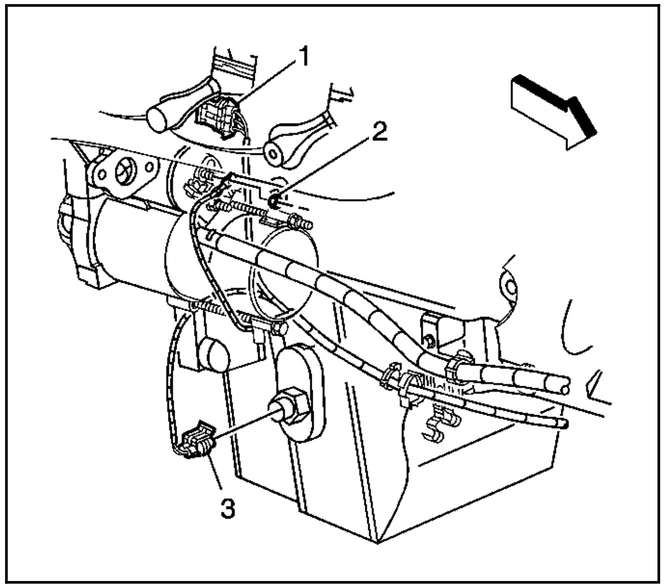
3. Connect the oil pressure sensor electrical connector (1).
4. If necessary, install the engine sight shield. Refer to *Engine Sight Shield Replacement (4.8L and 6.0L (RPO LQ4)*.



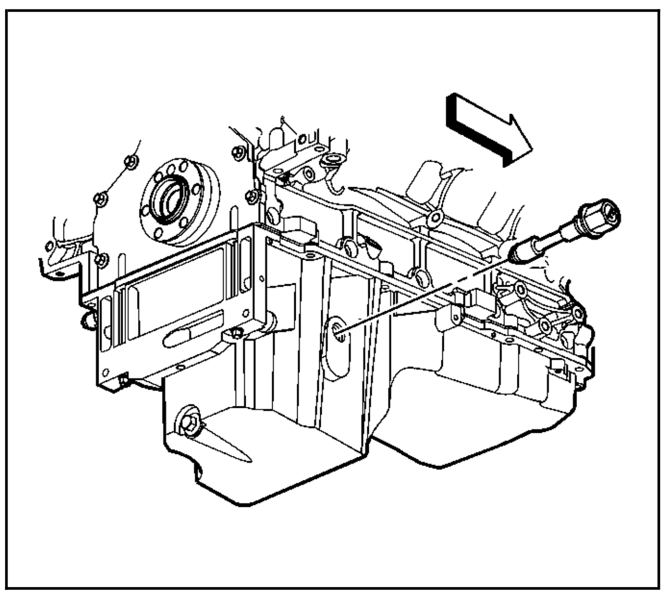
Engine Oil Level Sensor and/or Switch Replacement

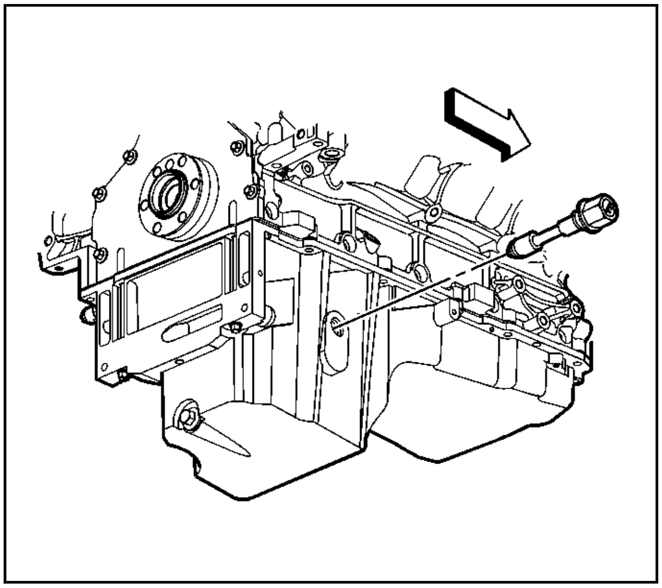
Removal Procedure

1. Drain the engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
2. Disconnect the oil level sensor electrical connector (3).



3. Remove the oil level sensor from the oil pan.





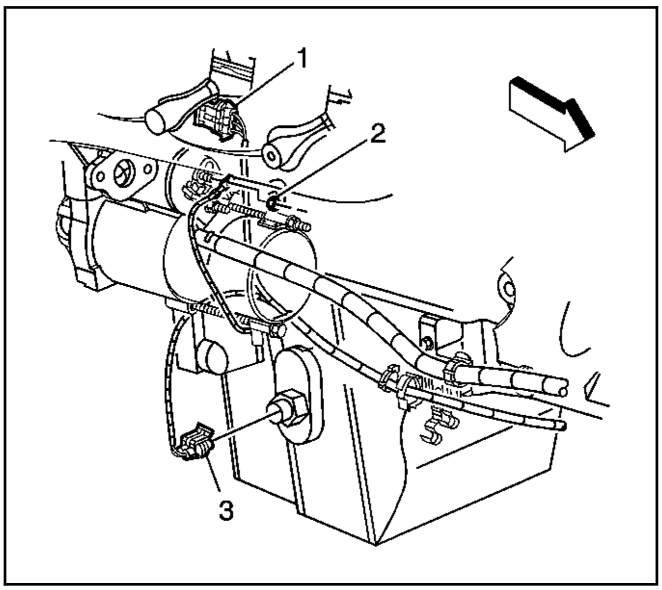
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

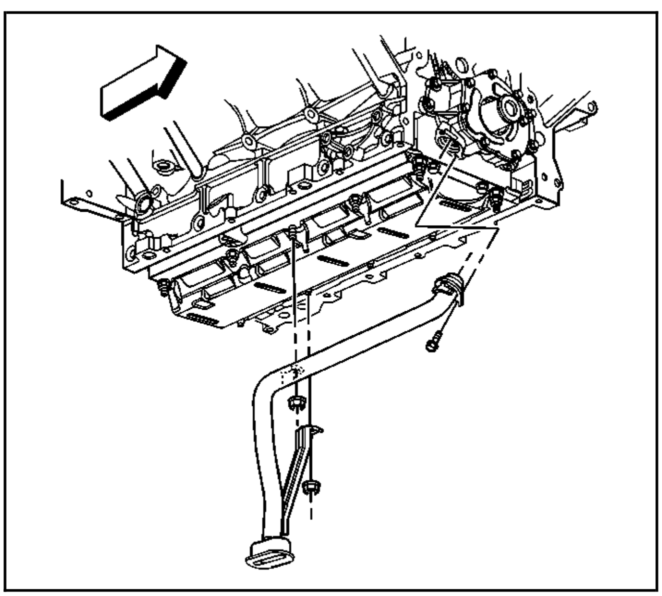
1. Install the oil level sensor to the oil pan.

   Tighten

   Tighten the sensor to 13 N·m (115 lb in).



2. Connect the oil level sensor electrical connector (3).
3. Fill the engine oil. Refer to *Engine Oil and Oil Filter Replacement*.

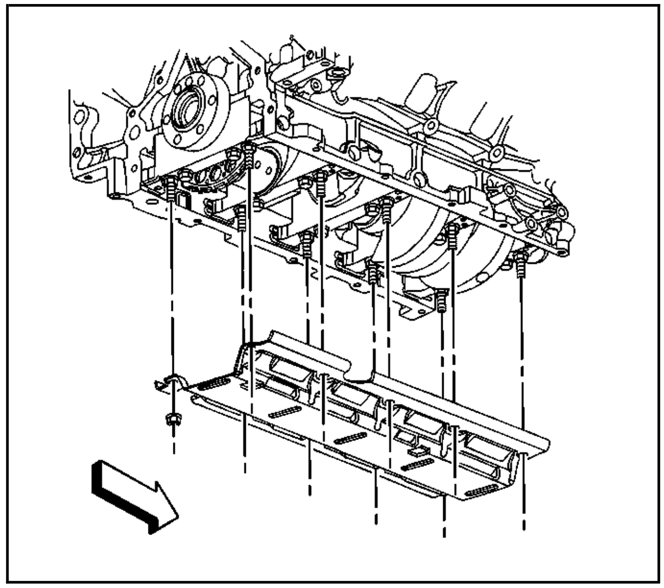


Oil Pump, Pump Screen and Deflector Replacement

Removal Procedure

1. Remove the oil pan. Refer to *Oil Pan Replacement*.
2. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
3. Remove the oil pump screen bolt and nuts.
4. Remove the oil pump screen with O-ring seal.
5. Remove the O-ring seal from the pump screen.
6. Discard the O-ring seal.

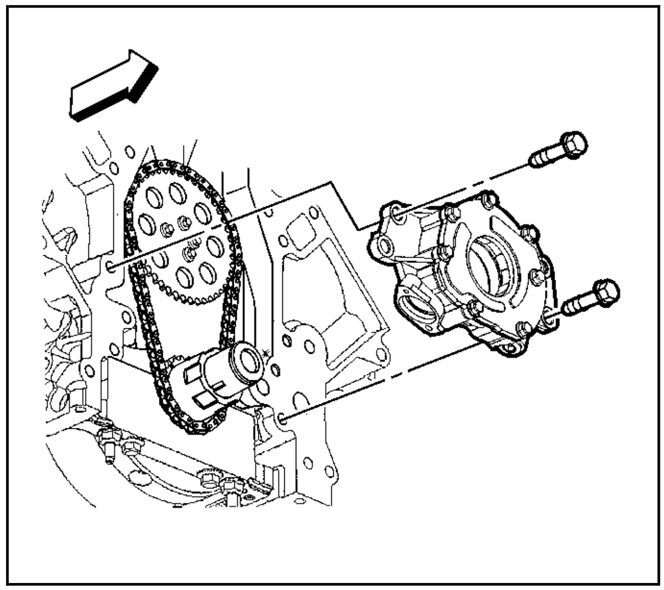
7. Remove the remaining crankshaft oil deflector nuts.
8. Remove the crankshaft oil deflector.



9. Remove the oil pump bolts.

Important: Do not allow dirt or debris to enter the oil pump assembly, cap end as necessary.

10. Remove the oil pump.
11. If required, clean and inspect the oil pump. Refer to *Oil Pump Cleaning and Inspection*.



Installation Procedure

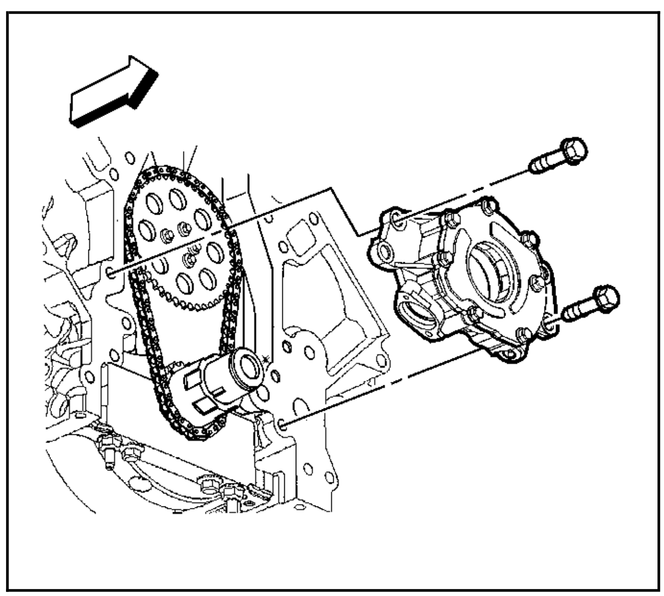
1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

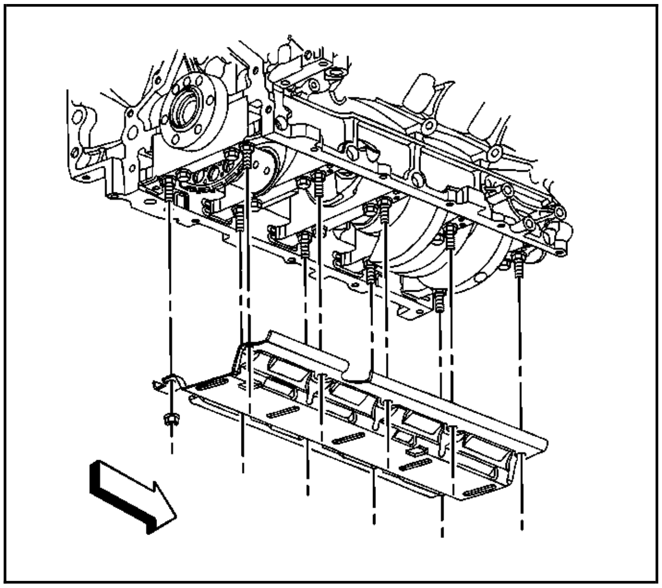
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil pump bolts.

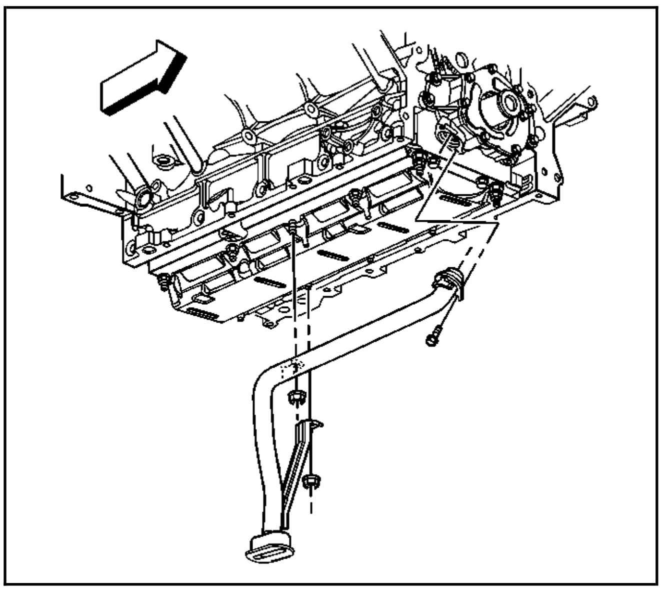
   Tighten

   Tighten the bolts to 25 N·m (18 lb ft).





4. Install the crankshaft oil deflector and nuts until snug.



5. Lubricate a NEW oil pump screen O-ring seal with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

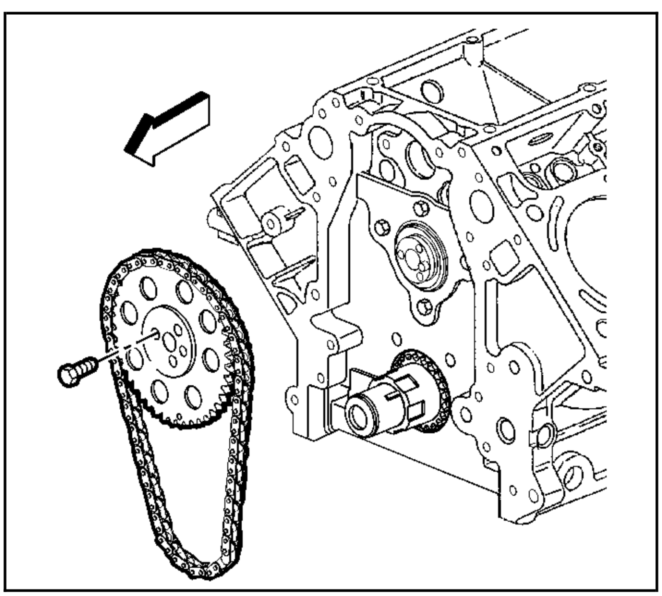
Important: Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.

7. Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.
8. Install the oil pump screen.
9. Install the oil pump screen bolt and nuts.

   Tighten

   9.1. Tighten the bolt to 12 N·m (106 lb in).

   9.2. Tighten the nuts to 25 N·m (18 lb ft).
10. Install the engine front cover. Refer to *Engine Front Cover Replacement*.
11. Install the oil pan. Refer to *Oil Pan Replacement*.



Timing Chain and Sprockets Replacement

Tools Required

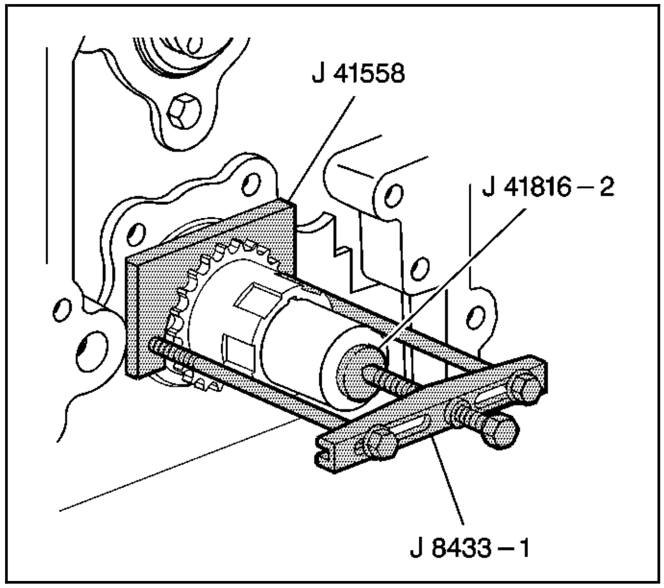
- *J 8433* Two Jaw Puller
- *J 41816-2* Crankshaft End Protector
- *J 41558* Crankshaft Sprocket Remover
- *J 41665* Crankshaft Balancer and Sprocket Installer

Removal Procedure

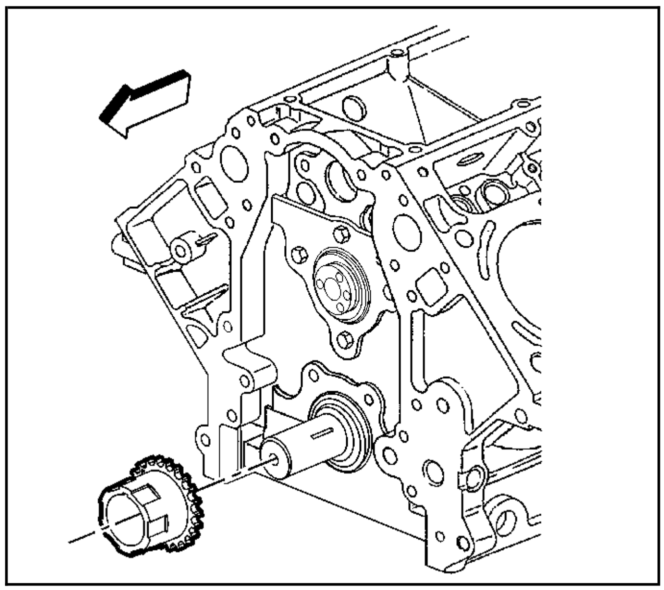
1. Remove the oil pump. Refer to *Oil Pump, Pump Screen and Deflector Replacement*.
2. Rotate the crankshaft until the timing marks on the crankshaft and the camshaft sprockets are aligned.

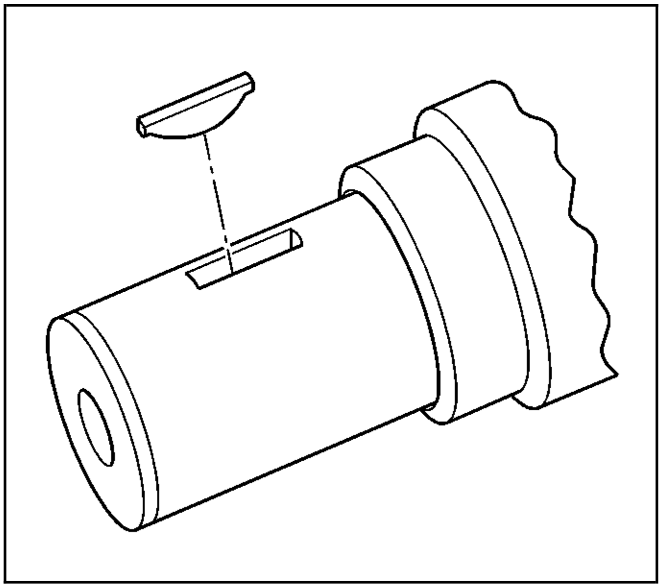
Notice: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

3. Remove the camshaft sprocket bolts.
4. Remove the camshaft sprocket and timing chain.
5. Use the *J 8433*, the *J 41816-2* and the *J 41558* in order to remove the crankshaft sprocket.

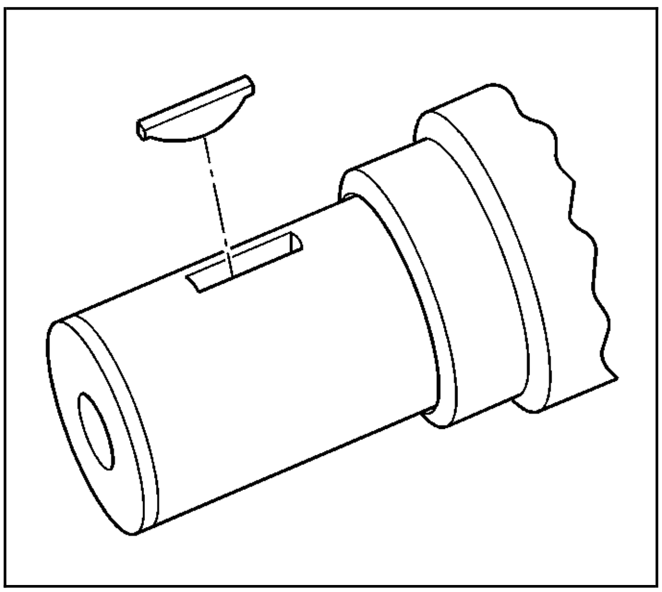


6. Remove the crankshaft sprocket.



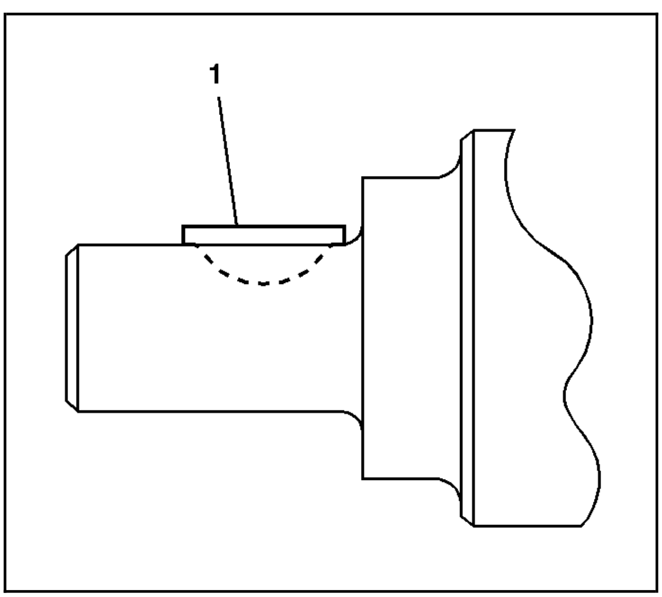


7. Remove the crankshaft sprocket key, if required.
8. If required, clean and inspect the timing chain and sprockets. Refer to *Timing Chain and Sprockets Cleaning and Inspection*.



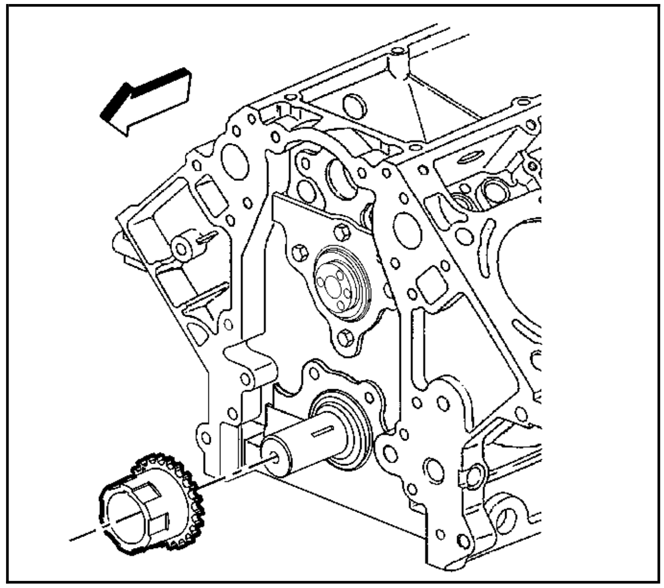
Installation Procedure

1. Install the key into the crankshaft keyway, if previously removed.



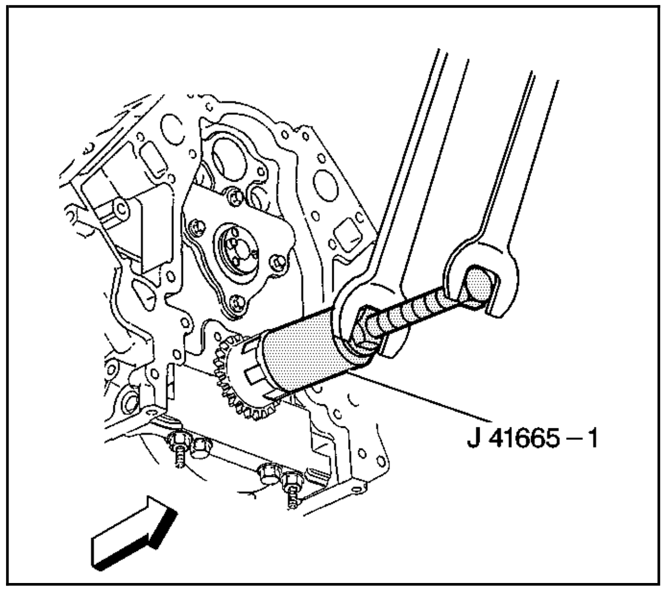
2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.

3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.



4. Use the *J 41665* in order to install the crankshaft sprocket.

   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.

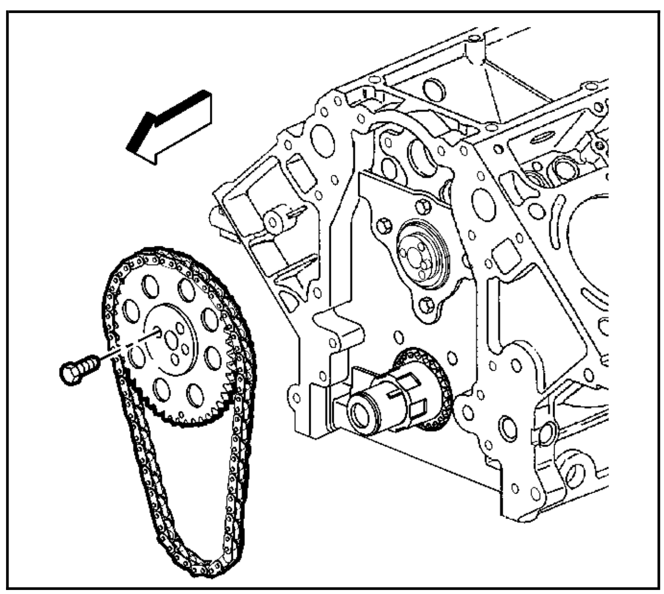


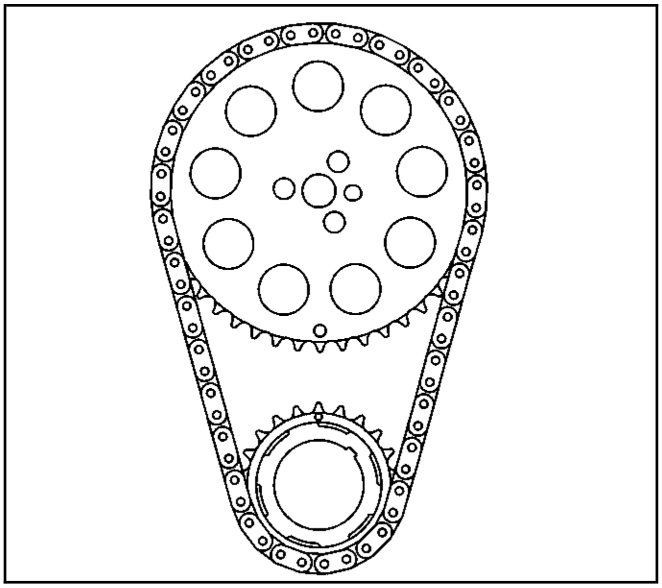
Important:

- Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.

  Locate the camshaft sprocket alignment mark in the 6 o'clock position.

6. Install the camshaft sprocket and timing chain.





7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

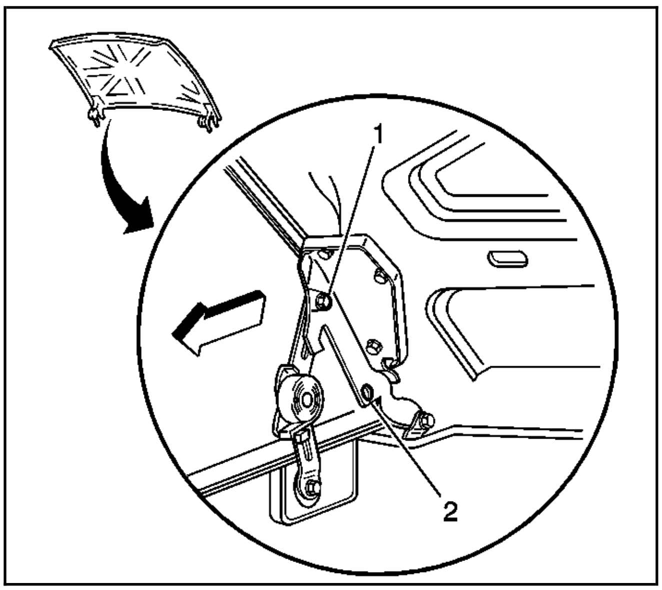
Notice: Refer to *Fastener Notice* in Cautions and Notices.

8. Install the camshaft sprocket bolts.

   Tighten

   Tighten the bolts to 35 N·m (26 lb ft).

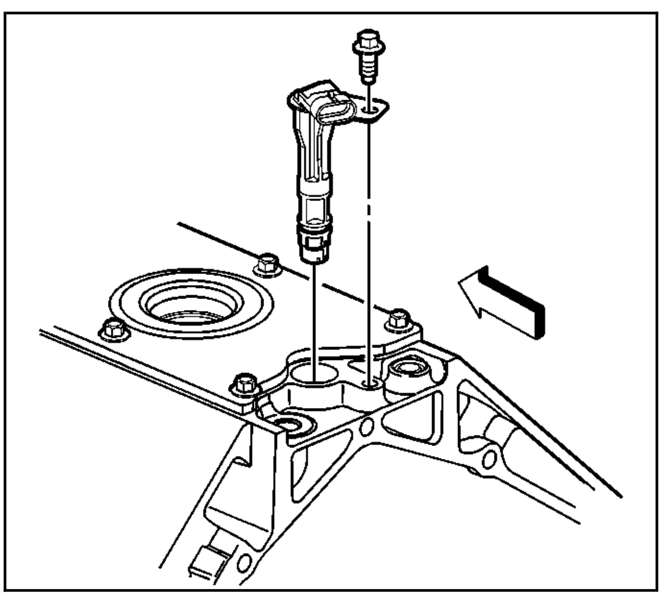
9. Install the oil pump. Refer to *Oil Pump, Pump Screen and Deflector Replacement*.



Camshaft Replacement

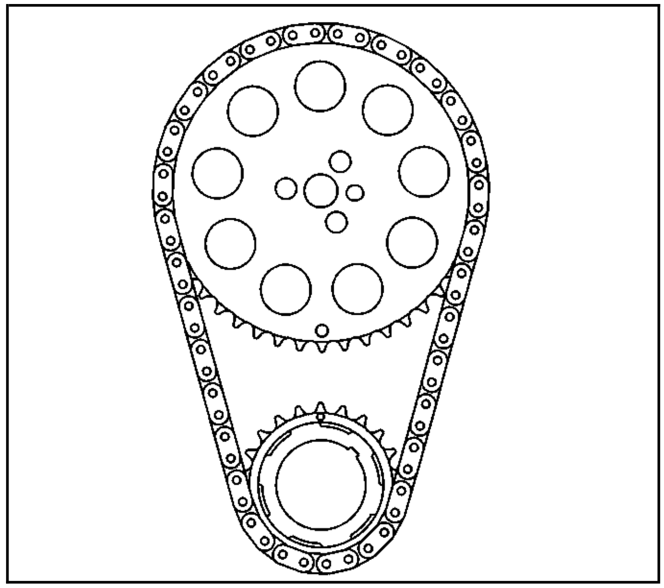
Removal Procedure

1. Raise the hood to the service position, perform the following:
   - Remove the hood hinge bolts (1).
   - Raise the hood until vertical.
   - Install the hood hinge bolts until snug in the service position (2).
2. Remove the radiator support. Refer to *Radiator Support Replacement* in Body Front End.
3. Remove the front cover. Refer to *Engine Front Cover Replacement*.
4. Remove the valve lifters. Refer to *Valve Lifter Replacement*.



5. Remove the camshaft sensor bolt and sensor.

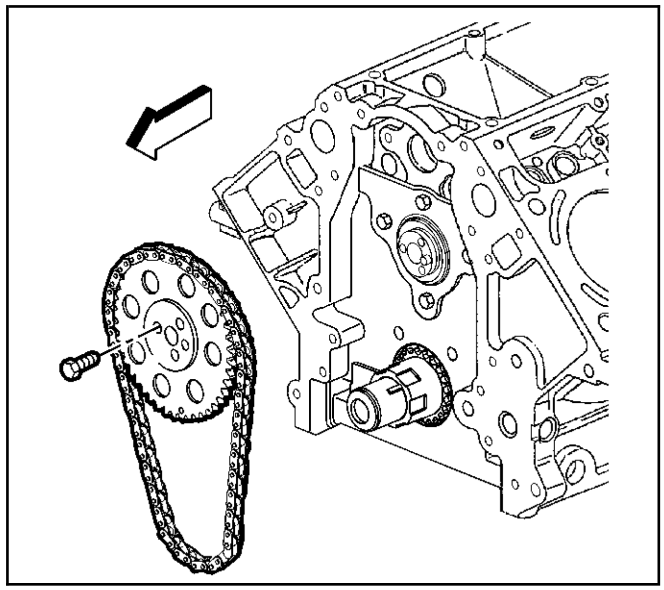
6. Rotate the crankshaft until the timing marks on the crankshaft and camshaft sprockets are aligned.



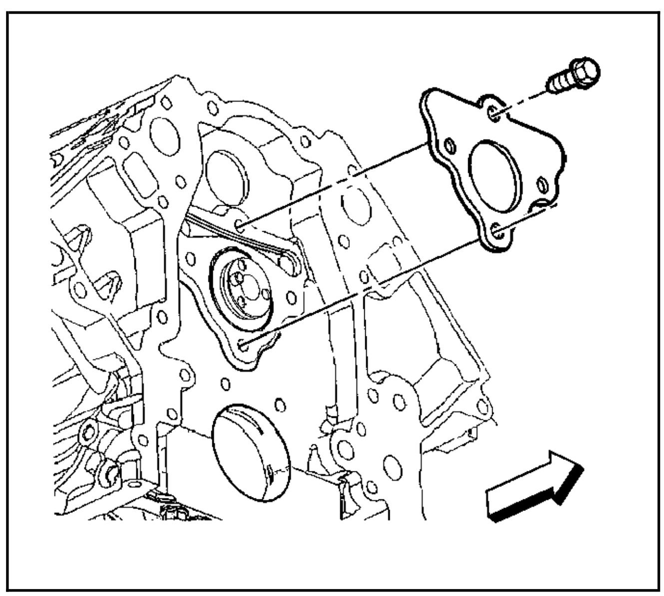
7. Remove the camshaft sprocket bolts.

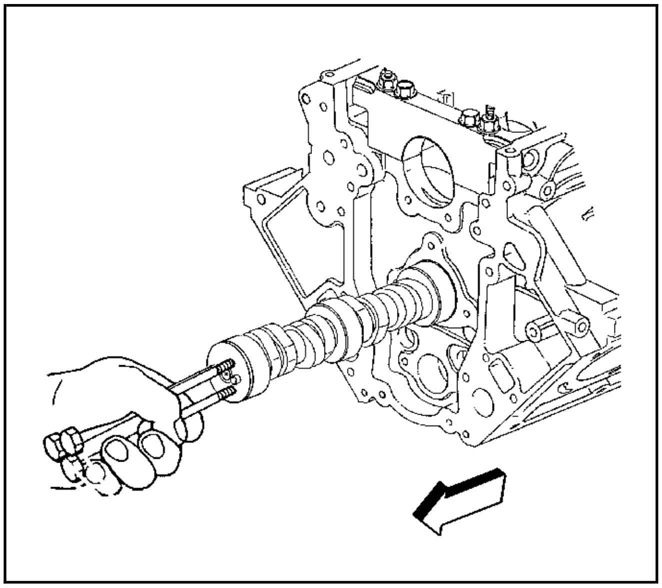
Notice: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

8. Remove the camshaft sprocket and reposition the timing chain.



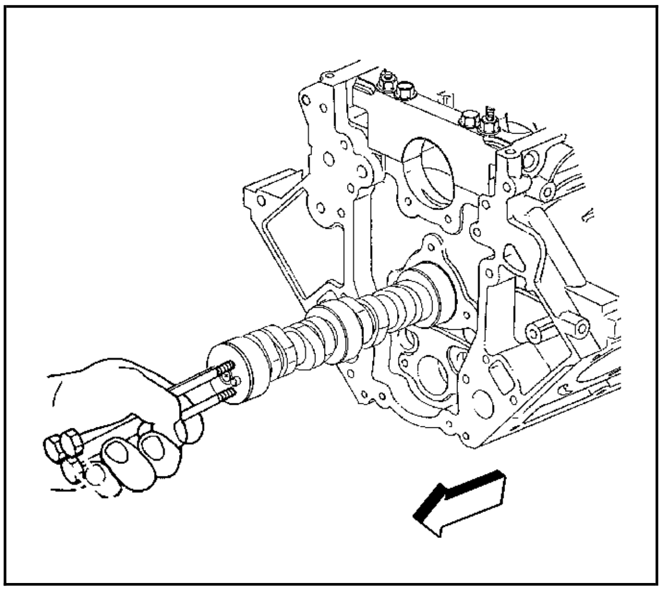
9. Remove the camshaft retainer bolts and retainer.





Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

10. Remove the camshaft.
    10.1. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.
    10.2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
    10.3. Remove the three bolts from the camshaft.
11. If required, clean and inspect the camshaft and bearings. Refer to *Camshaft and Bearings Cleaning and Inspection*.



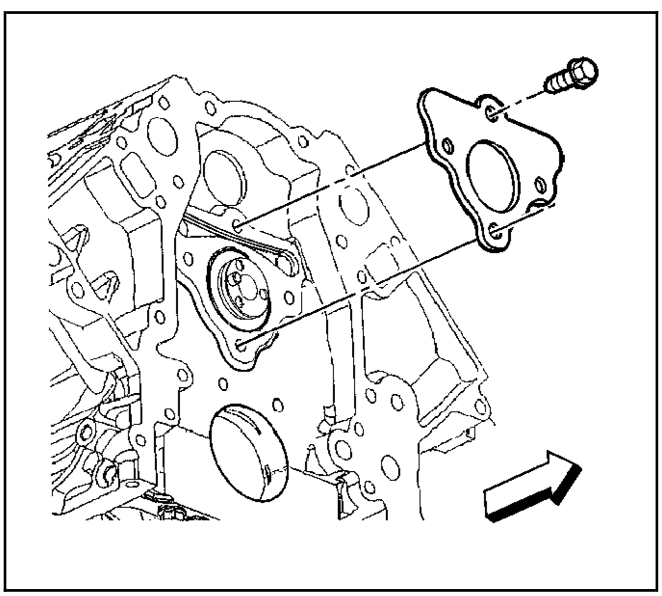
Installation Procedure

Important: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.

Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the three bolts from the front of the camshaft.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Install the retainer plate with the sealing gasket facing the engine block.

The gasket surface on the engine block should be clean and free of dirt and/or debris.

5. Install the camshaft retainer and bolts.

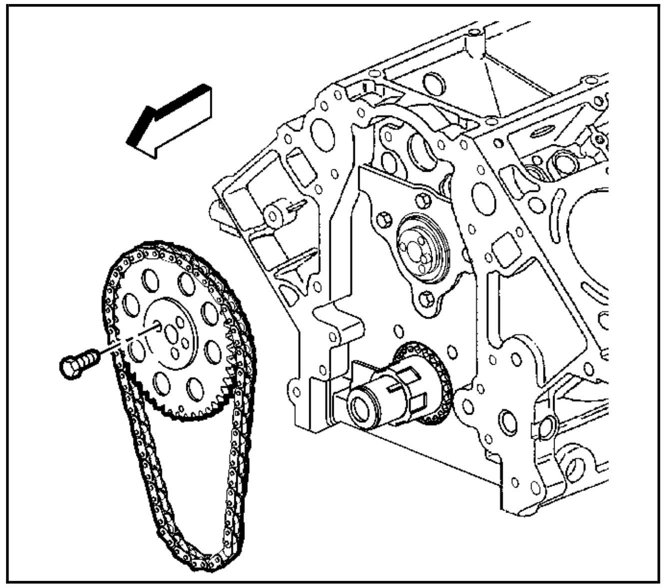
   Tighten

   Tighten the bolts to 25 N·m (18 lb ft).

6. Install the camshaft sprocket and position the timing chain.
7. Install the camshaft sprocket bolts.

   Tighten

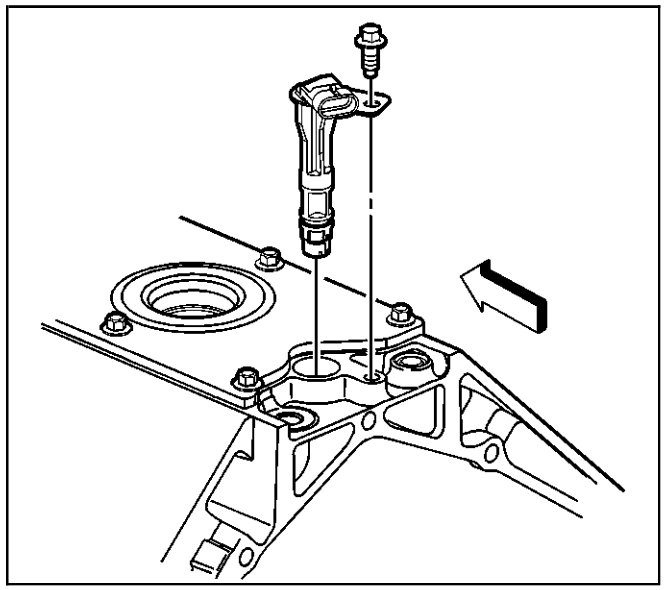
   Tighten the bolts to 35 N·m (26 lb ft).



8. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be reused.
9. Lubricate the O-ring seal with clean engine oil.
10. Install the camshaft sensor and bolt.

    Tighten

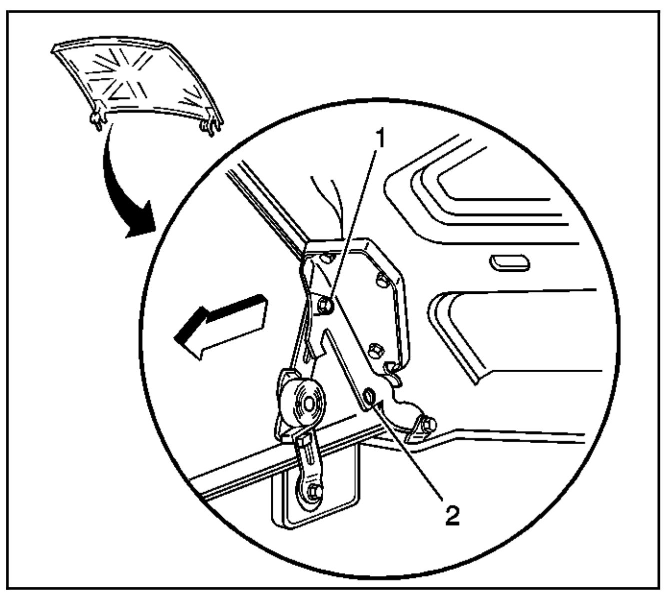
    Tighten the bolt to 25 N·m (18 lb ft).
11. Install the valve lifters. Refer to *Valve Lifter Replacement*.
12. Install the front cover. Refer to *Engine Front Cover Replacement*.
13. Install the radiator support. Refer to *Radiator Support Replacement* in Body Front End.



14. Remove the hood hinge bolts from the service position (2).
15. Lower the hood to the normal position.
16. Install the hood hinge bolts.

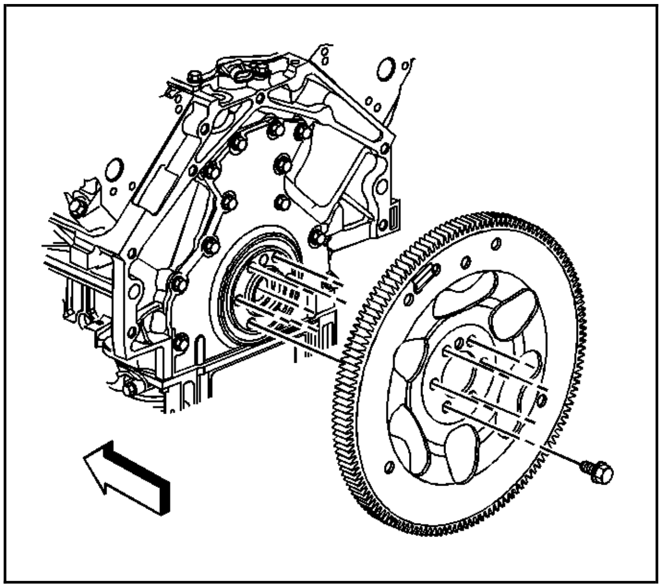
    Tighten

    Tighten the bolts to 25 N·m (18 lb ft).



Engine Flywheel Replacement

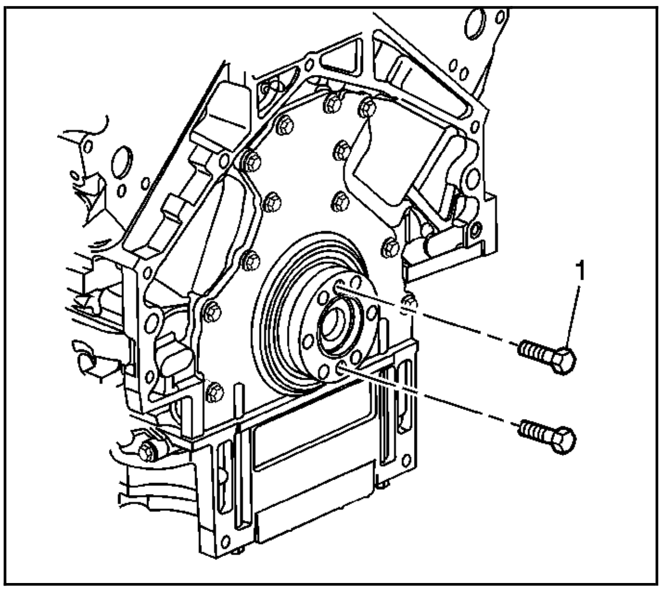
Removal Procedure



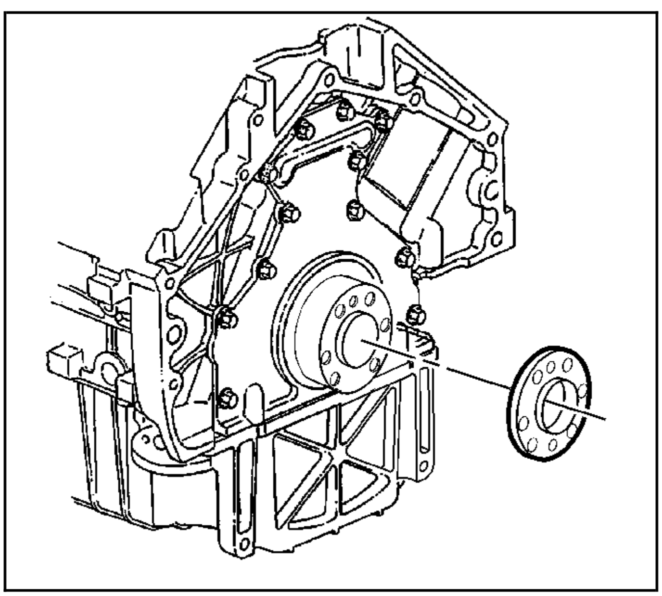
1. Remove the automatic transmission. Refer to *Transmission Replacement* in Automatic Transmission – 4L60-E or *Transmission Replacement* in Automatic Transmission – 4L80-E.

Important: Note the position and direction of the engine flywheel before removal.

2. Remove the flywheel bolts.
3. Remove the flywheel.

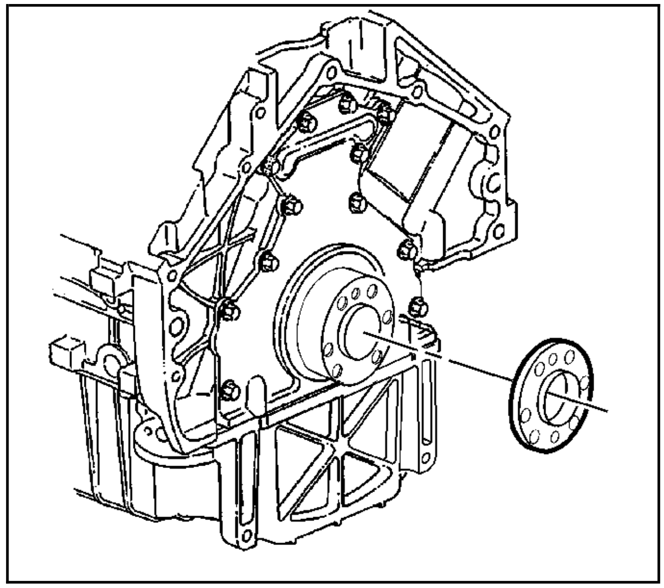


4. Install two M11x1.5 mm bolts (1) to the threaded holes of the spacer, if applicable.
5. Rotate the bolts clockwise to remove the spacer.



6. Remove the spacer from the rear of the crankshaft, if applicable.

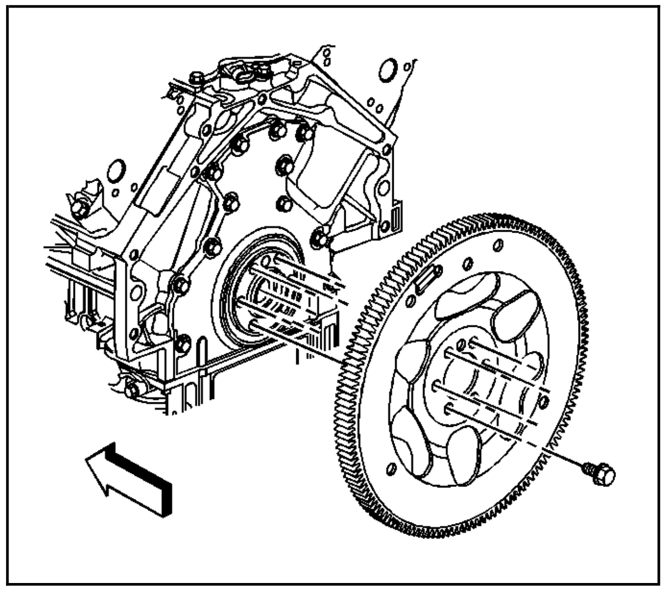
Installation Procedure



Important:

- The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.
- Certain applications (6.0L) require a spacer and longer bolts for proper flywheel position.

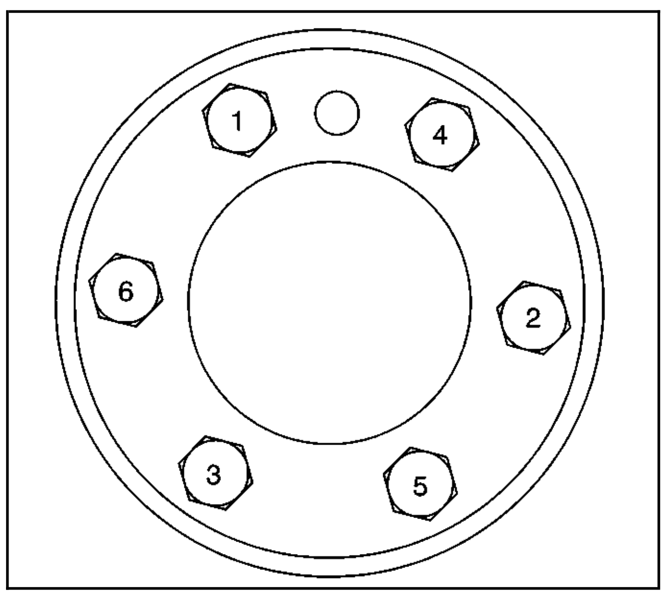
1. Install the spacer, if applicable, onto the rear of the crankshaft.



2. Install the flywheel and bolts to the crankshaft.

Important: Longer flywheel bolts must be used on applications using a flywheel spacer.

3. Apply threadlock GM P/N 12345382, (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Tighten the flywheel bolts.

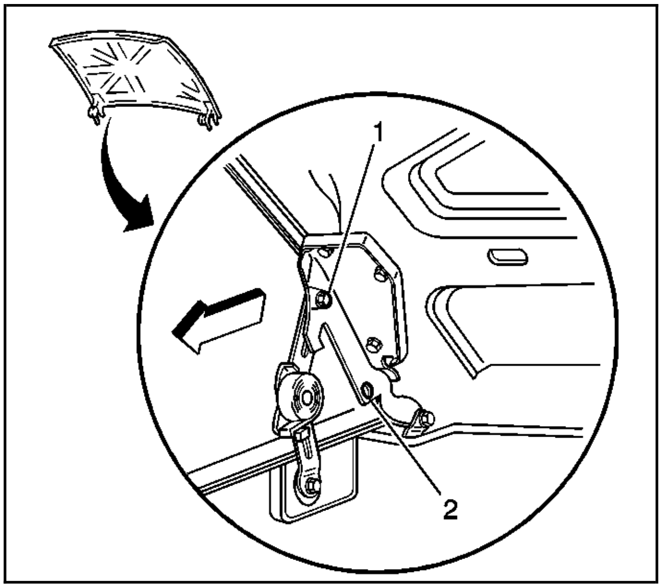
   Tighten

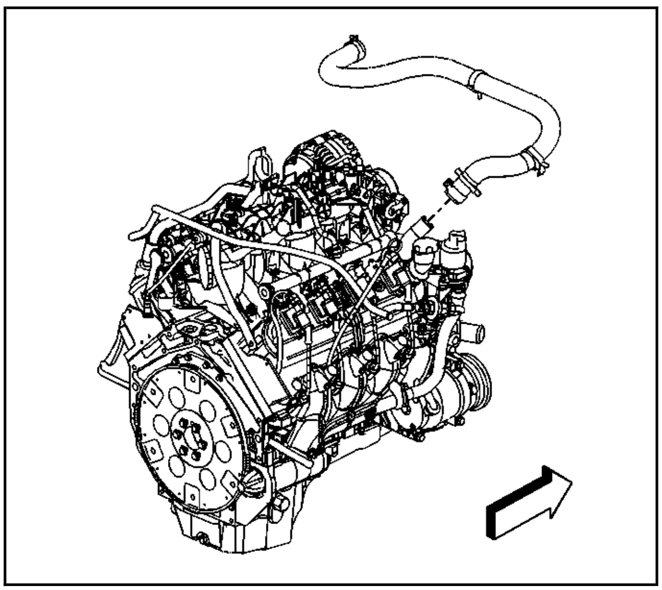
   4.1. Tighten the bolts a first pass in sequence to 20 N·m (15 lb ft).

   4.2. Tighten the bolts a second pass in sequence to 50 N·m (37 lb ft).

   4.3. Tighten the bolts a final pass in sequence to 100 N·m (74 lb ft).

5. Install the automatic transmission. Refer to *Transmission Replacement* in Automatic Transmission – 4L60-E or *Transmission Replacement* in Automatic Transmission – 4L80-E.





Engine Replacement

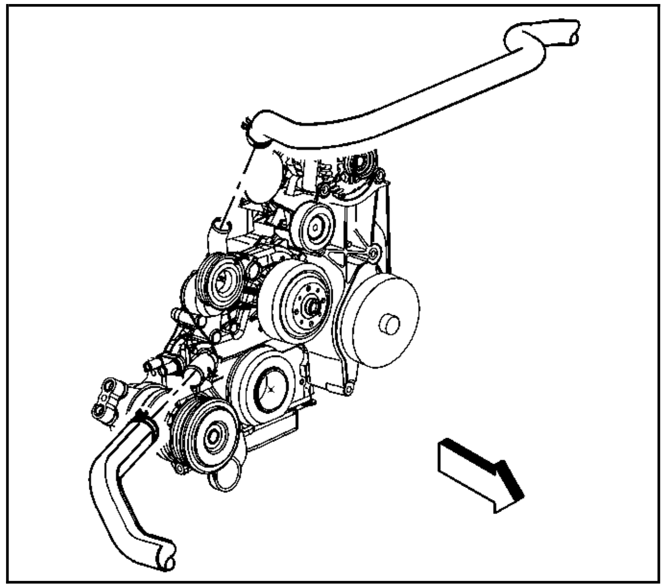
Tools Required

- *J 41798* Engine Lifting Brackets
- *J 21366* Converter Holding Strap

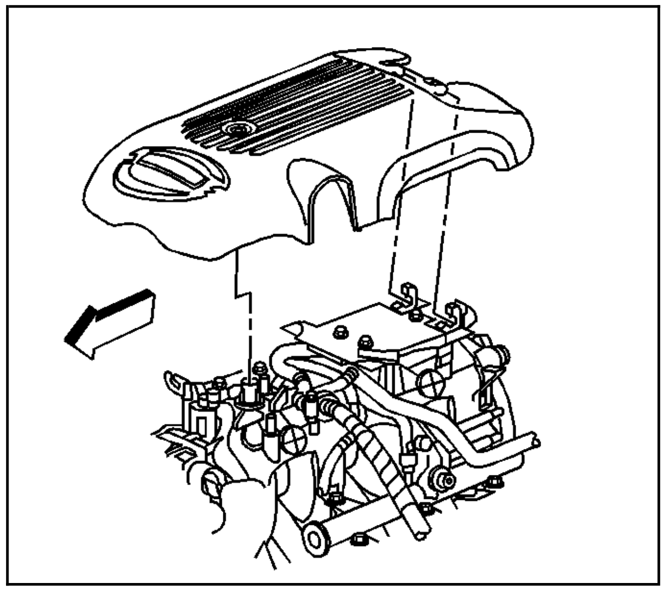
Removal Procedure

1. Open the hood.
2. Place fender covers over both fenders.
3. Raise the hood to the service position, then perform the following:
   3.1. Remove the hood hinge bolts (1).
   3.2. Raise the hood until vertical.
   3.3. Install the hood hinge bolts until snug in the service position (2).
4. Remove the air conditioning (AC) compressor. Refer to *Compressor Replacement (LR4, LM7, and LQ4)* in HVAC Systems – Manual.
5. Remove the radiator supports. Refer to *Radiator Support Replacement* in Body Front End.
6. Reposition the radiator inlet hose clamp at the water pump.
7. Remove the radiator inlet hose from the water pump.

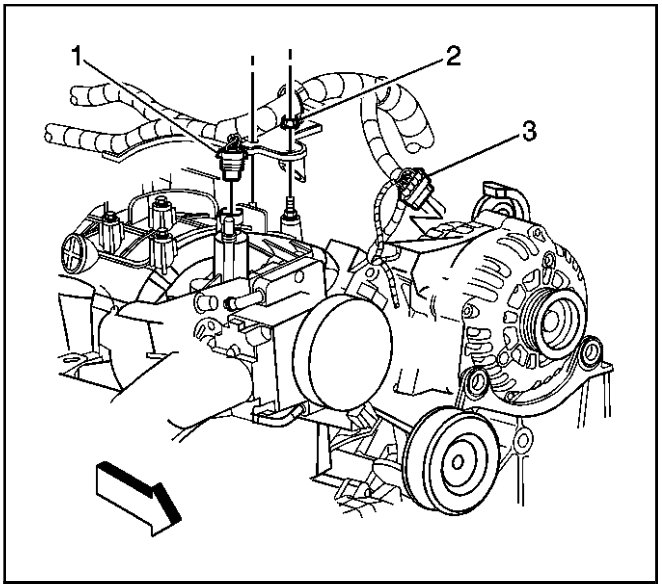
8. Reposition the radiator outlet hose clamp at the water pump.
9. Remove the radiator outlet hose from the water pump.
10. Remove the heater hoses.



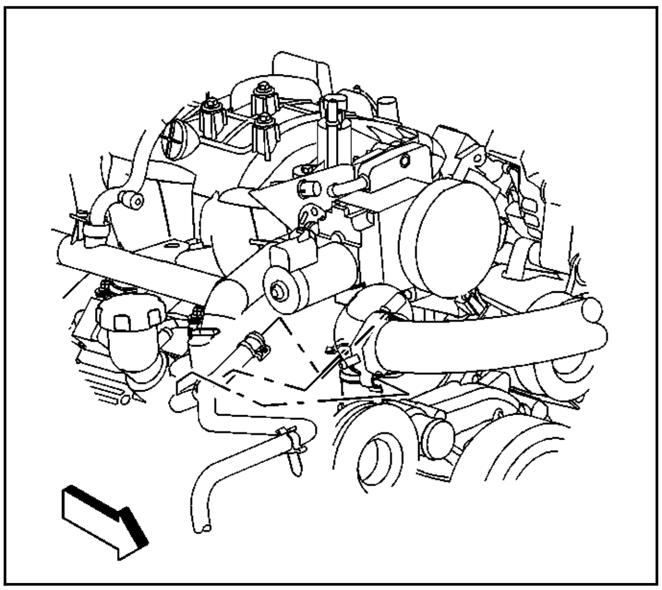
11. If equipped with the 4.8L or 6.0L regular production option (RPO) LQ4, loosen the intake manifold sight shield bolt.
12. Remove the sight shield from the retainer.



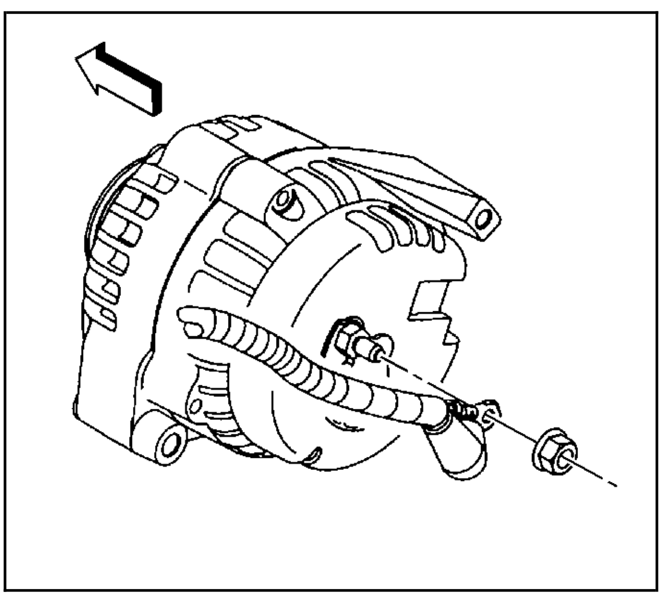
13.Leftblankintentionally



14. Disconnect the following electrical connectors:
    - Evaporative emissions (EVAP) canister purge solenoid (1)
    - Generator (3)
15. Remove the harness bracket nut (2) in order to remove the engine harness from the intake manifold.

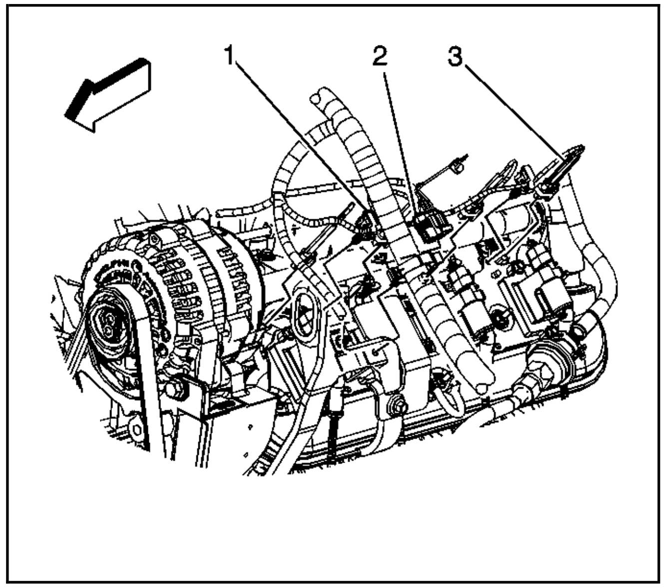


16. Reposition the vent inlet hose clamp at the throttle body.
17. Remove the radiator vent inlet hose from the throttle body.

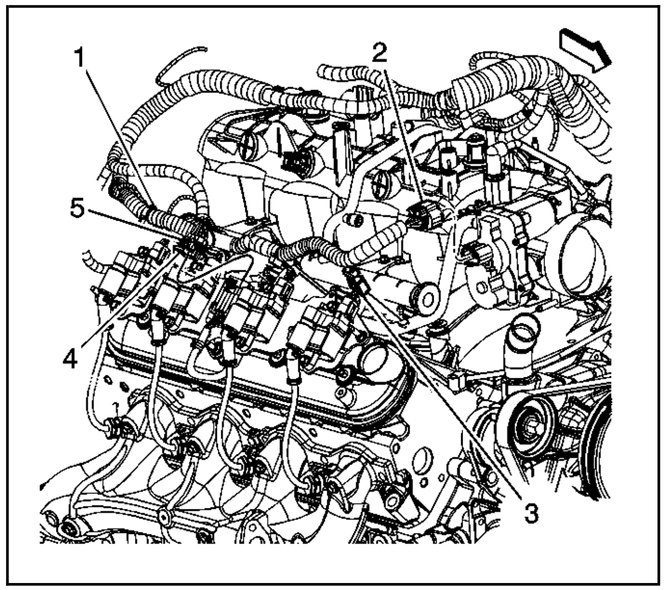


18. Remove the generator cable from the generator, perform the following:
    - 18.1. Slide the boot down revealing the terminal stud.
    - 18.2. Remove the generator cable nut from the terminal stud.
    - 18.3. Remove the generator cable.

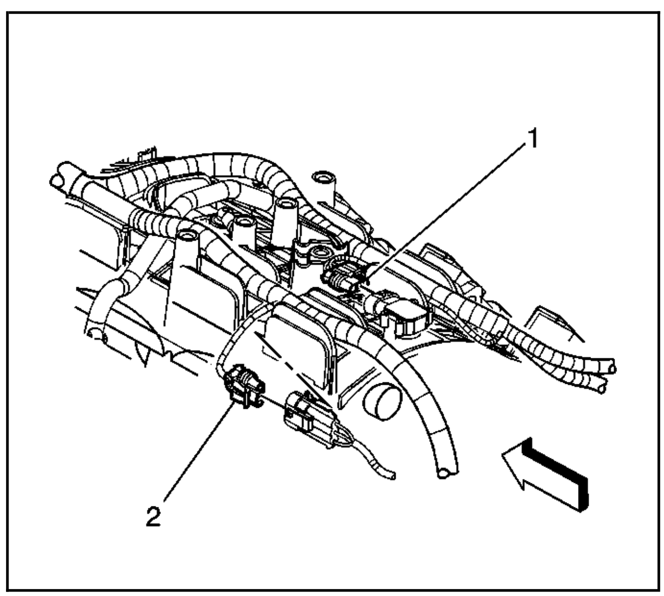
19. Disconnect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.

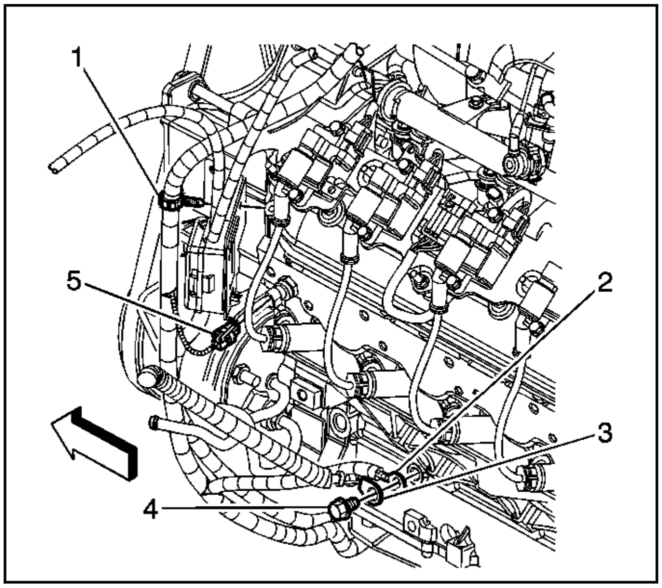


20. Remove the connector position assurance (CPA) retainer (5).
21. Disconnect the following electrical connectors:
    - The main coil harness (4)
    - The fuel injectors (3)
    - The electronic throttle control (ETC) (2)

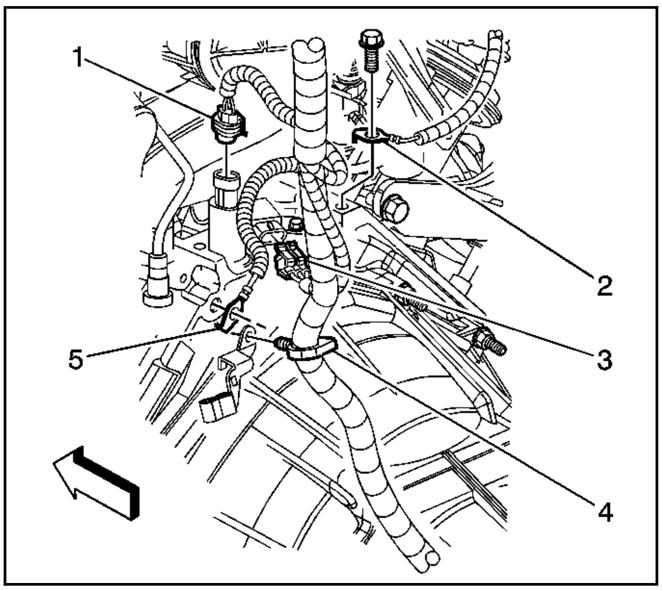


22. Disconnect the manifold absolute pressure (MAP) sensor (1) and knock sensor (2) electrical connectors.

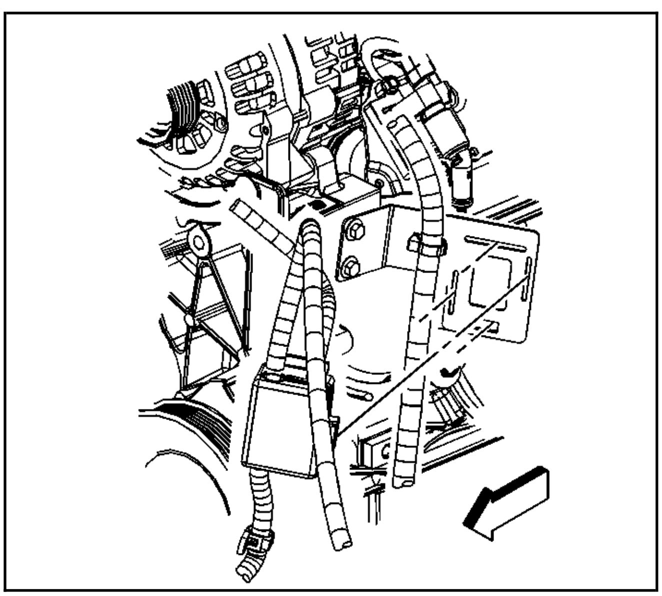




23. Remove the harness ground bolt.
24. Reposition the harness ground and negative battery cable from the block.
25. Disconnect the following electrical connectors:
    - The coolant temperature sensor (5)
    - The electronic variable orifice switch

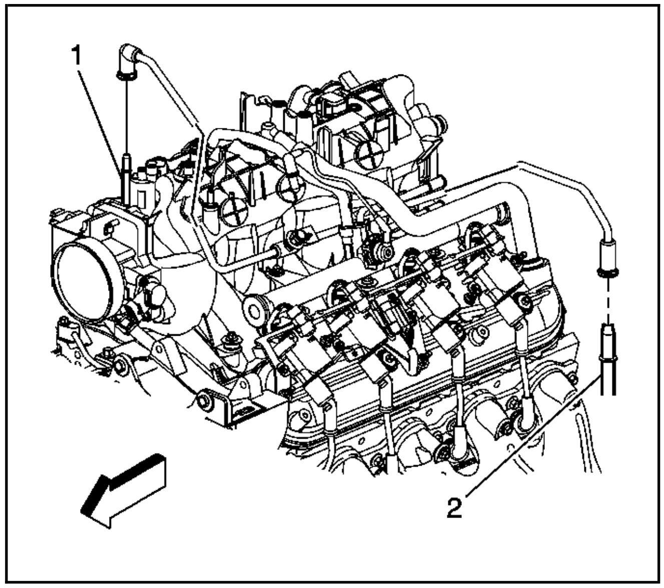


26. Remove the harness ground bolt at the right rear of the engine block.
27. Reposition the harness ground, and auxiliary negative battery cable, if equipped from the block.
28. Remove the harness ground bolt at the left rear of the engine block.
29. Reposition the harness ground, and engine ground strap from the block.
30. Disconnect the following electrical connectors:
    - The oil pressure sensor (1)
    - The camshaft position (CMP) sensor (3)
31. Unclip all of the engine harness clips from the engine.

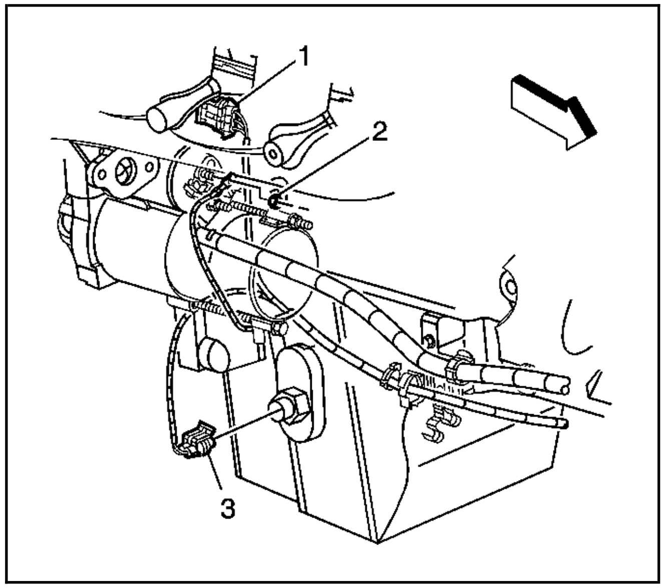


32. Remove the battery cable junction block from the junction block bracket.

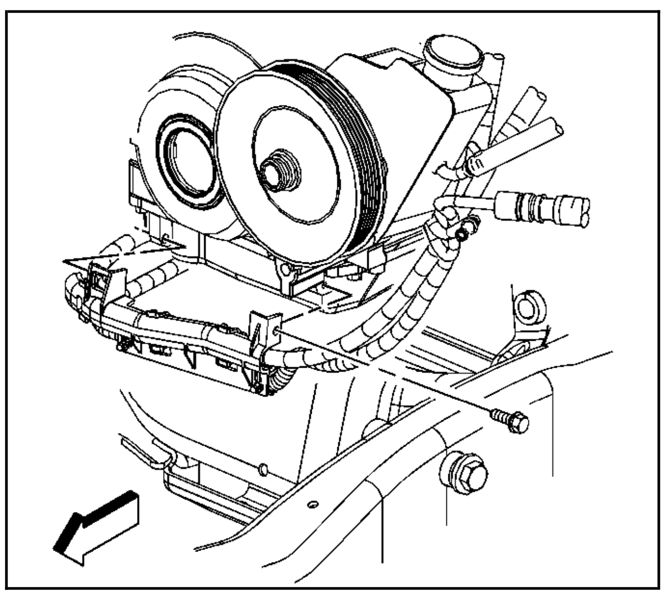
33. Remove the EVAP purge solenoid vent tube, perform the following:
    33.1. Remove the EVAP tube end from the solenoid (1).
    33.2. Remove the EVAP tube end from the vapor pipe (2).
34. Disconnect the fuel pipes. Refer to *Quick Connect Fitting(s) Service (Metal Collar)* in Engine Controls – 4.8L and 6.0L.
35. Raise the vehicle.

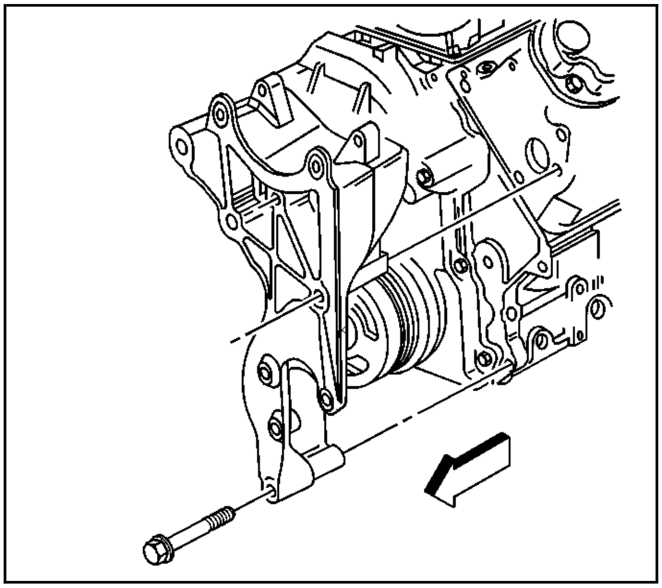


36. Disconnect the following electrical connectors:
    - The crankshaft position (CKP) sensor (1)
    - The engine oil level sensor (3)
    - The coolant heater, if equipped

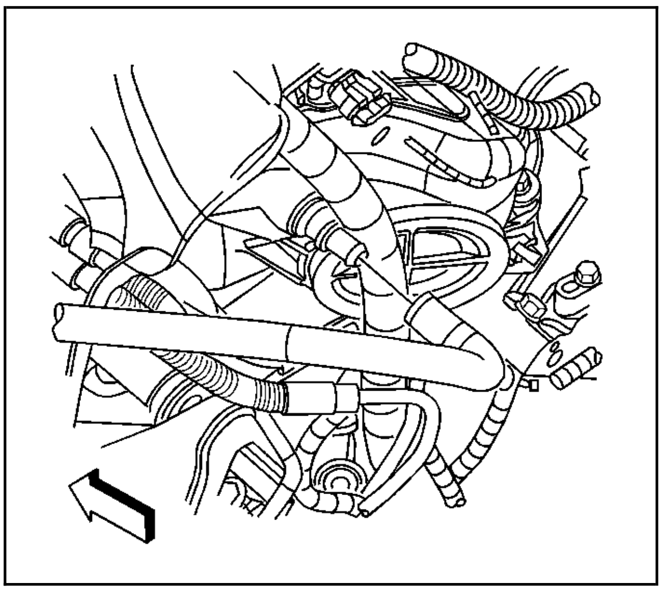


37. Remove the battery cable channel bolt.
38. Slide the channel pin out of the oil pan tab.
39. Gather all branches of the engine wiring harness and reposition off to the side.
40. Lower the vehicle.

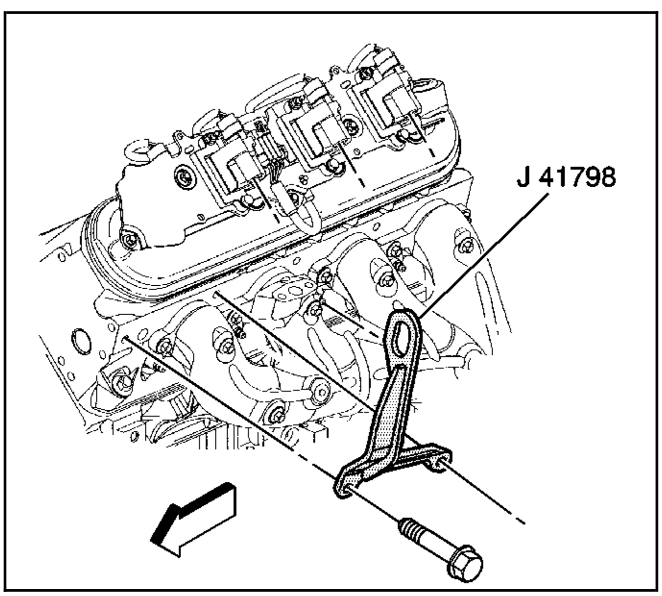




41. Remove the rear power steering pump-to-engine block bolt.
42. Remove the generator bracket mounting bolts.
43. Position the bracket aside.



44. Remove the vacuum brake booster hose.
45. Remove the ignition coil, as required for the proper fit of the *J 41798* before lifting the engine. Refer to *Ignition Coil(s) Replacement* in Engine Controls – 4.8L and 6.0L.



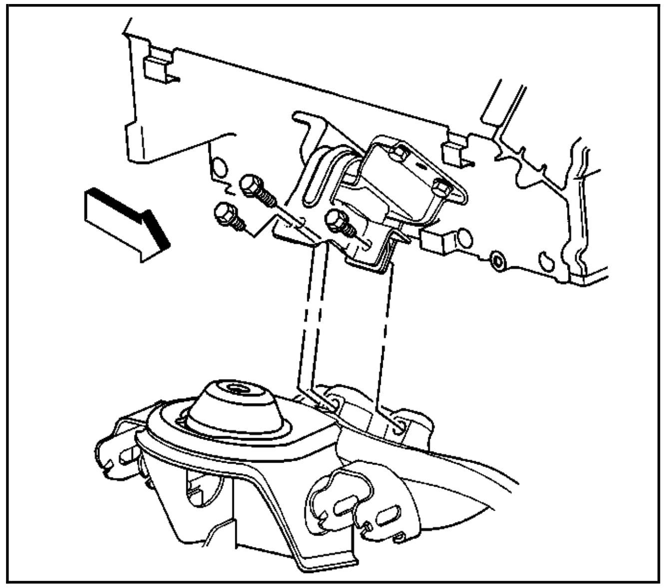
Notice: Refer to *Fastener Notice* in Cautions and Notices.

46. Install the *J 41798* to the cylinder heads.

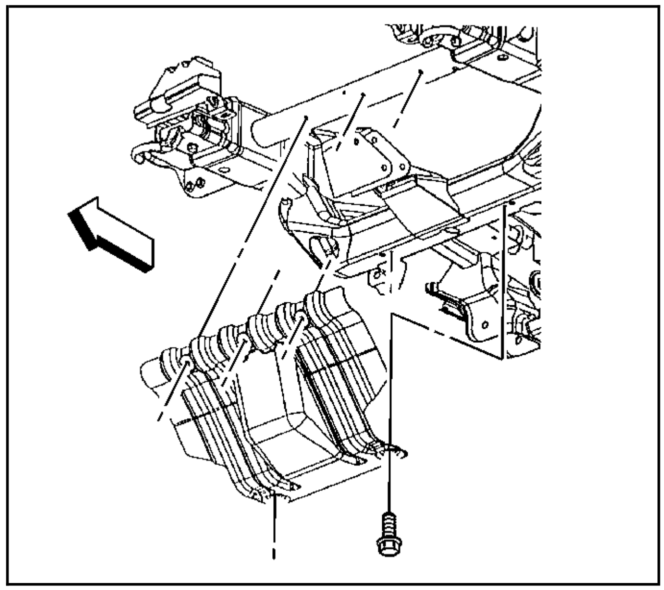
Tighten

- Tighten the M8 engine lift bracket bolts to 25 N·m (18 lb ft).
- Tighten the M10 engine lift bracket bolts to 50 N·m (37 lb ft).

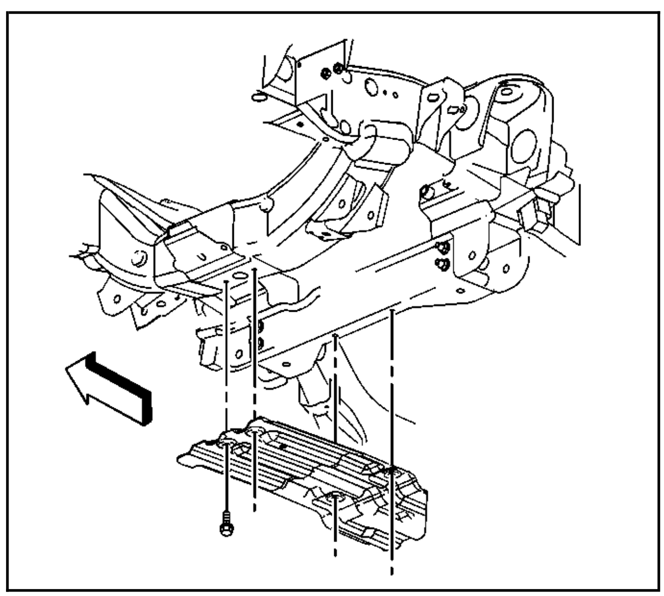
47. Remove the left and right engine mount-to-engine mount bracket bolts.
48. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

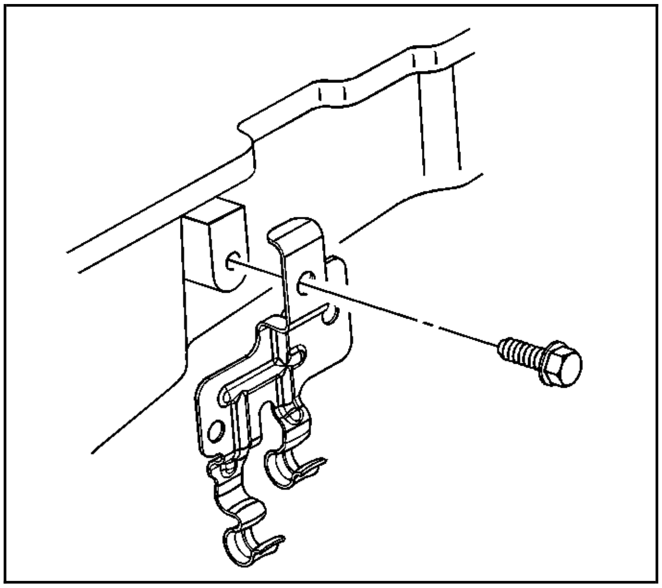


49. Remove the engine shield bolts and shield.

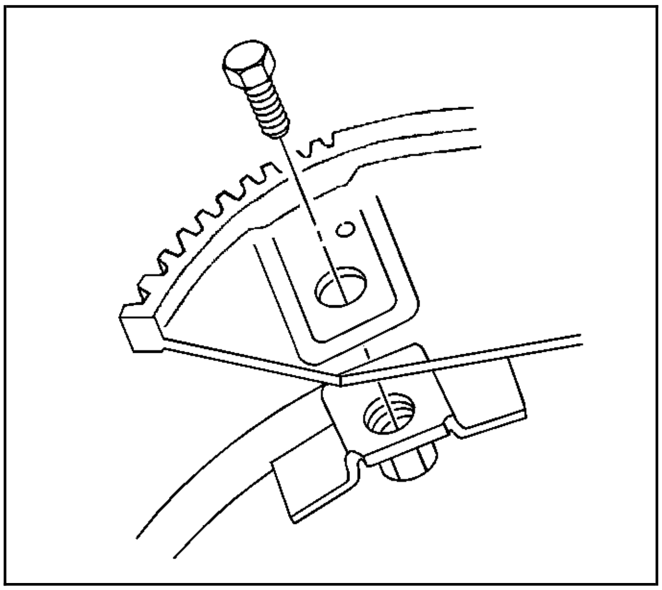


50. Remove the oil pan skid plate bolts and plate, if equipped.
51. Drain the engine oil.
52. Remove the starter motor. Refer to *Starter Motor Replacement (8.1L Engine)* or *Starter Motor Replacement (4.8L and 6.0L Engines)* in Engine Electrical.
53. Remove the catalytic converter. Refer to *Catalytic Converter Replacement (4.8L Engines)* or *Catalytic Converter Replacement (6.0L and 8.1L Engines)* in Engine Exhaust.

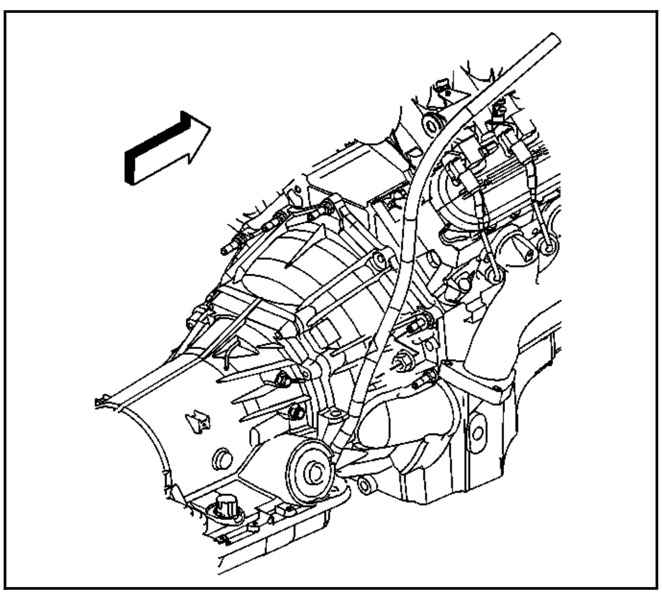




54. Remove the positive battery cable clip bolt and clip.

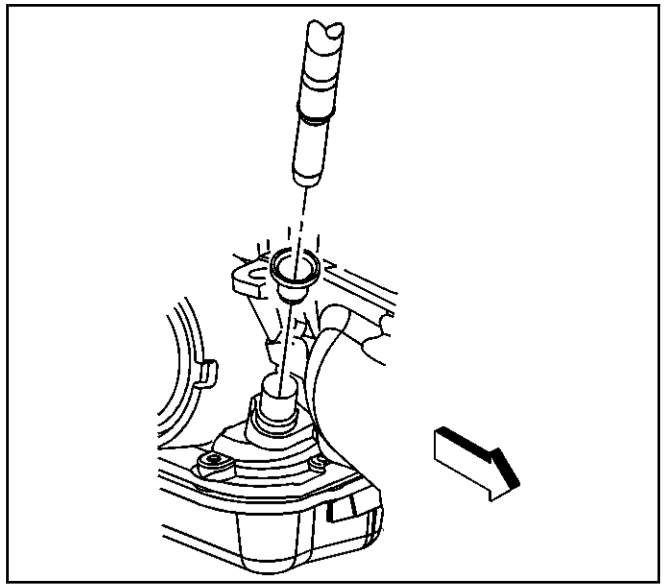


55. Remove the flywheel to torque converter bolts.

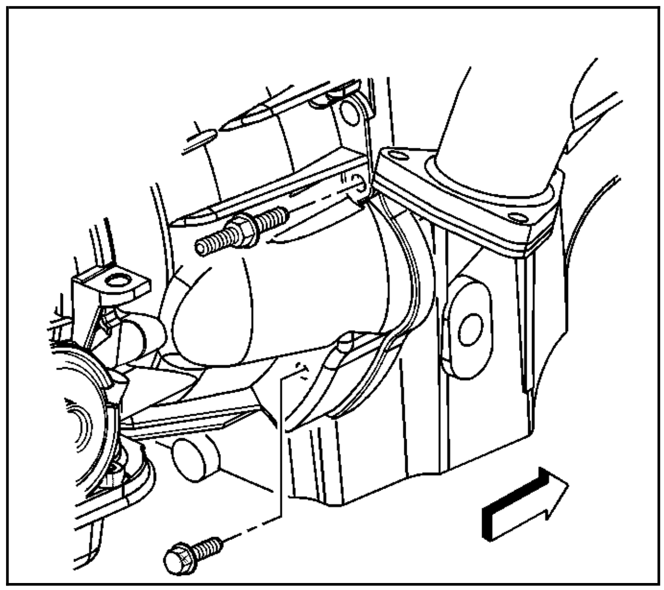


56. Remove the transmission oil level indicator tube nut, if equipped.

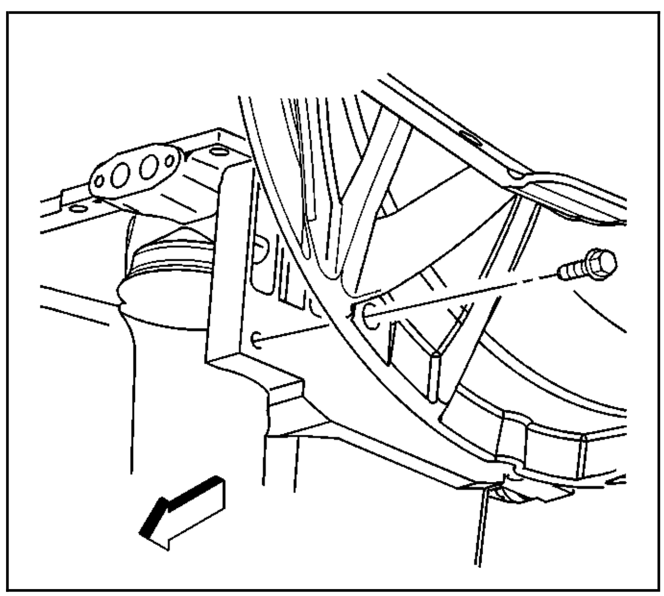
57. Remove the transmission oil level indicator tube, if equipped.

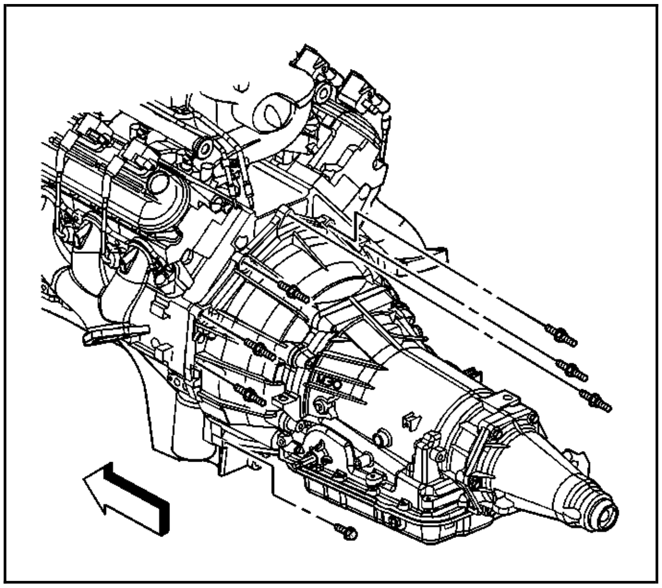


58. If equipped with the 4L60-E automatic transmission, remove the transmission bolt and stud on the right side.



59. If equipped with the 4L80-E automatic transmission, remove the transmission converter cover bolts.



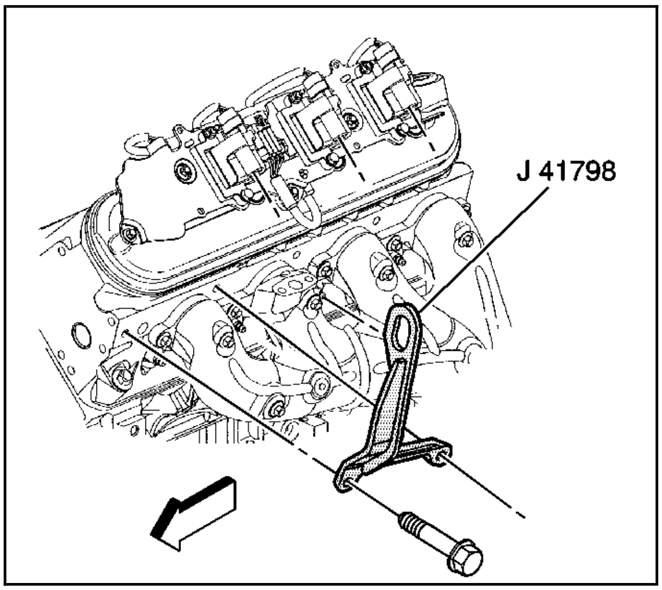


60. Remove the automatic transmission bolt/studs, if equipped.
61. Separate the engine from the automatic transmission.

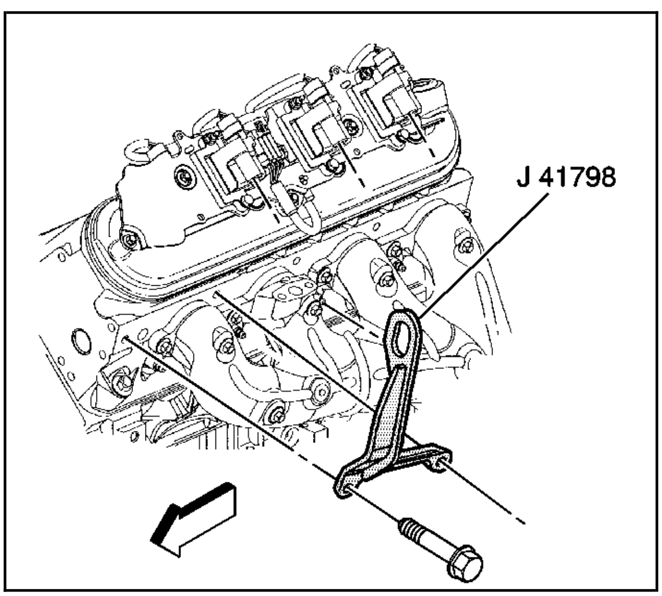
    Install the *J 21366* to the transmission in order to hold the torque converter.
62. Lower the vehicle.
63. Install an engine hoist to the *J 41798*.
64. Install a floor jack under the transmission for support.

Notice: Use care while moving the engine assembly in order to avoid breaking the MAP sensor locating tabs. Broken MAP sensor tabs may result in decreased engine performance.

65. Remove the engine.
66. Install the engine to an engine stand.
67. Remove the engine hoist.



68. Remove the *J 41798* from the engine.



Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

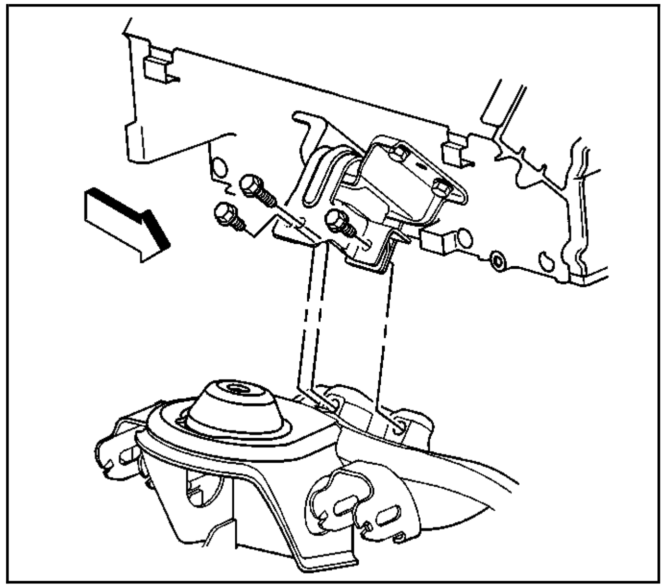
1. Install the *J 41798* to the engine.

   Tighten
   - Tighten the M8 engine lift bracket bolts to 25 N·m (18 lb ft).
   - Tighten the M10 engine lift bracket bolts to 50 N·m (37 lb ft).
2. Install an engine hoist to the *J 41798*.
3. Remove the engine from the engine stand.
4. Install the engine to the vehicle.
5. Align the engine and transmission.

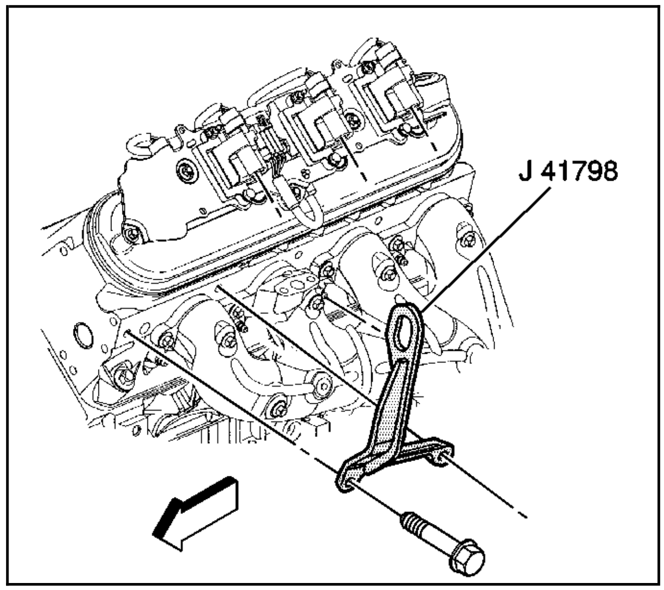
6. Install the left and right engine mount-to-engine mount bracket bolts.

   Tighten

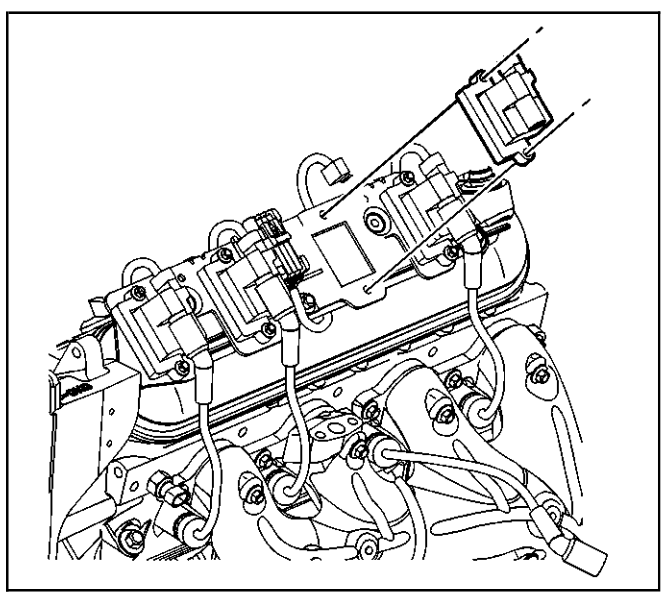
   Tighten the engine mount-to-engine mount bracket bolts to 65 N·m (48 lb ft).
7. Install the upper transmission bolts until snug.
8. Remove the floor jack from under the transmission.
9. Remove the engine hoist.

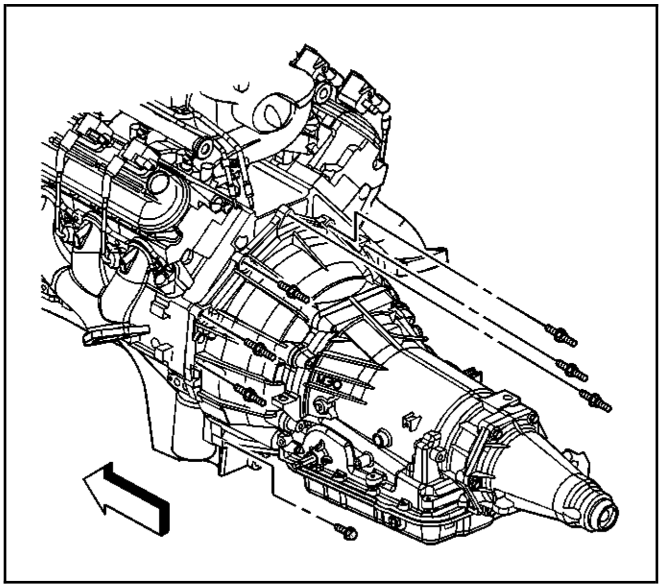


10. Remove the *J 41798* from the engine.

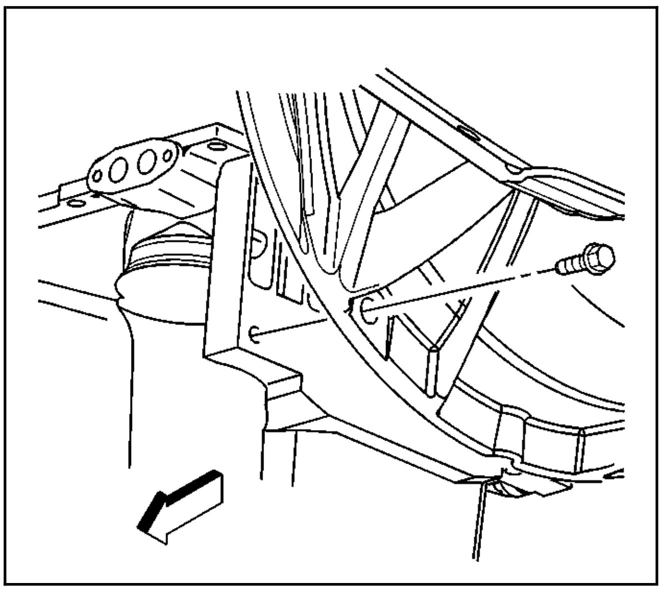


11. Install the ignition coils and the spark plug wires. Refer to *Ignition Coil(s) Replacement* in Engine Controls – 4.8L and 6.0L.
12. Raise the vehicle.

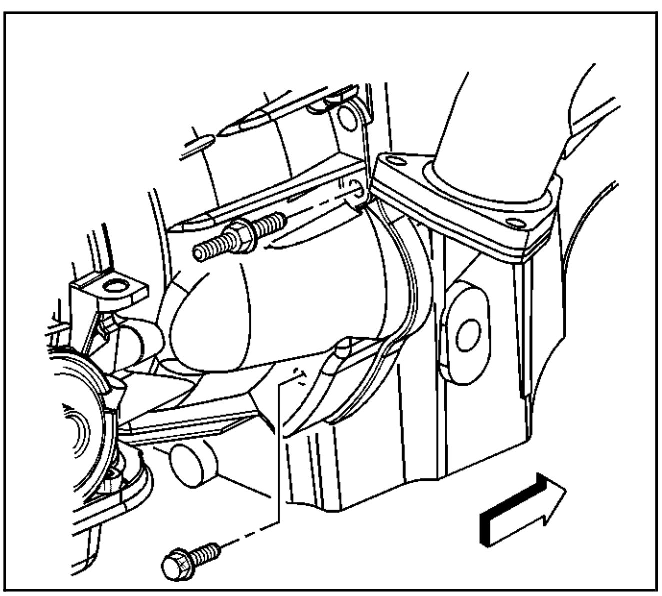




13. Remove the *J 21366* from the transmission.
14. Install the automatic transmission bolt/studs.



15. If equipped with the 4L80-E automatic transmission, install the transmission converter cover bolts.

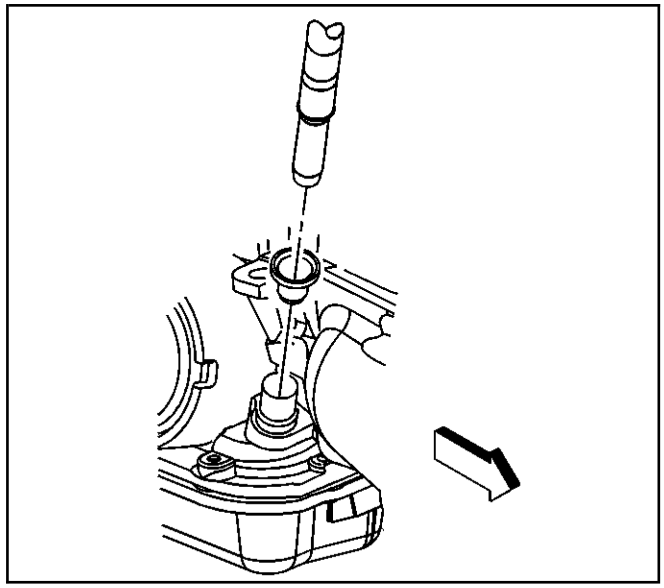


16. If equipped with the 4L60-E automatic transmission, install the transmission bolt and stud on the right side.

Tighten

Tighten the automatic transmission bolts/studs to 50 N·m (37 lb ft).

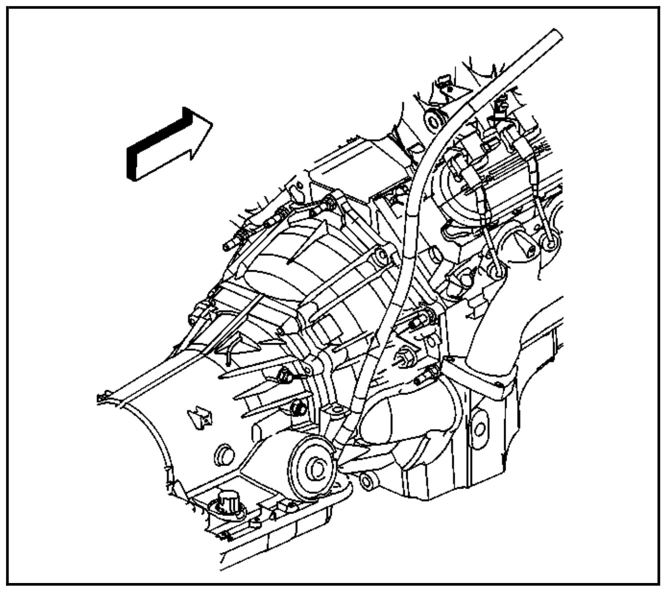
17. Install the automatic transmission oil level indicator tube.



18. Install the automatic transmission oil level indicator tube nut.

Tighten

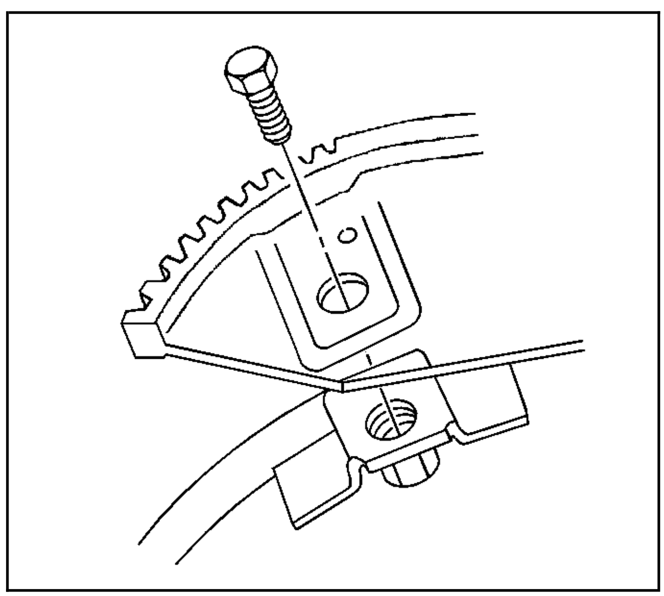
Tighten the nut to 18 N·m (13 lb ft).

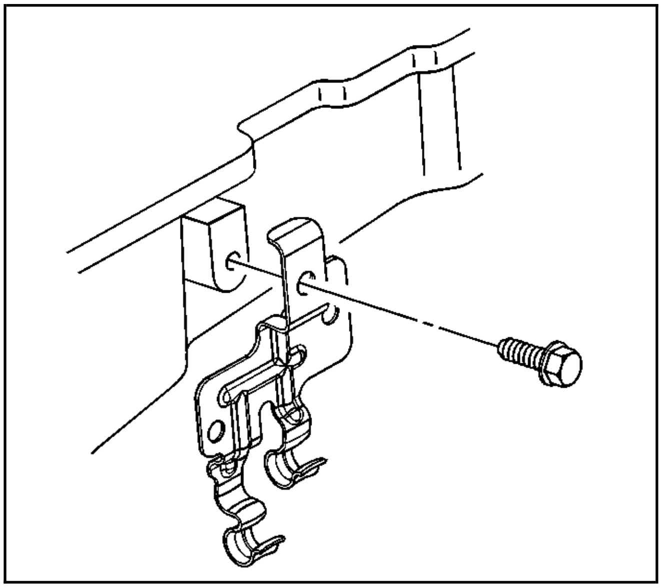


19. Install the flywheel to torque converter bolts.

Tighten

- If equipped with a 4L60E transmission, tighten the bolts to 63 N·m (47 lb ft).
- If equipped with a 4L80E transmission, tighten the bolts to 60 N·m (44 lb ft).

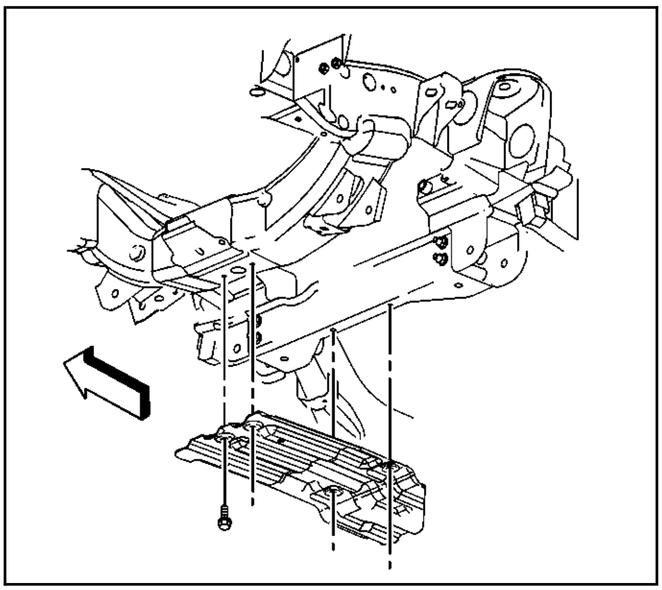




20. Install the positive battery cable clip and bolt.

    Tighten

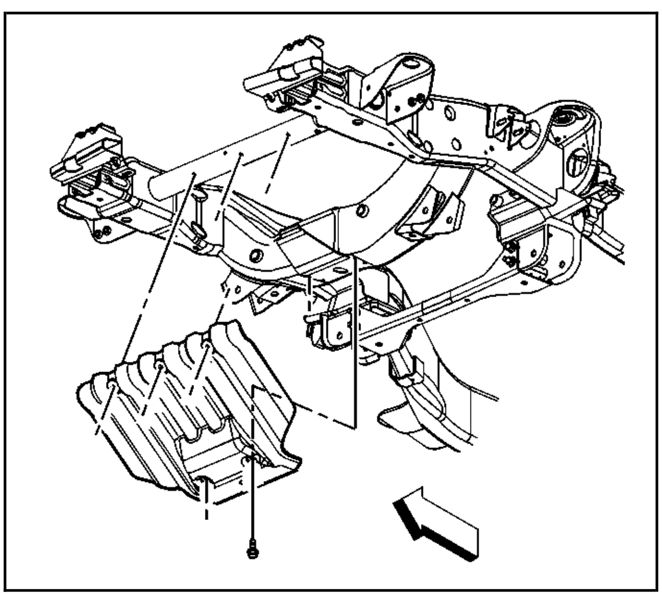
    Tighten the bolt to 9 N·m (80 lb in).
21. Install the catalytic converter. Refer to *Catalytic Converter Replacement (4.8L Engines)* or *Catalytic Converter Replacement (6.0L and 8.1L Engines)* in Engine Exhaust.
22. Install the starter motor. Refer to *Starter Motor Replacement (8.1L Engine)* or *Starter Motor Replacement (4.8L and 6.0L Engines)* in Engine Electrical.



23. Install the oil pan skid plate and bolts, if equipped.

    Tighten

    Tighten the bolts to 20 N·m (15 lb ft).

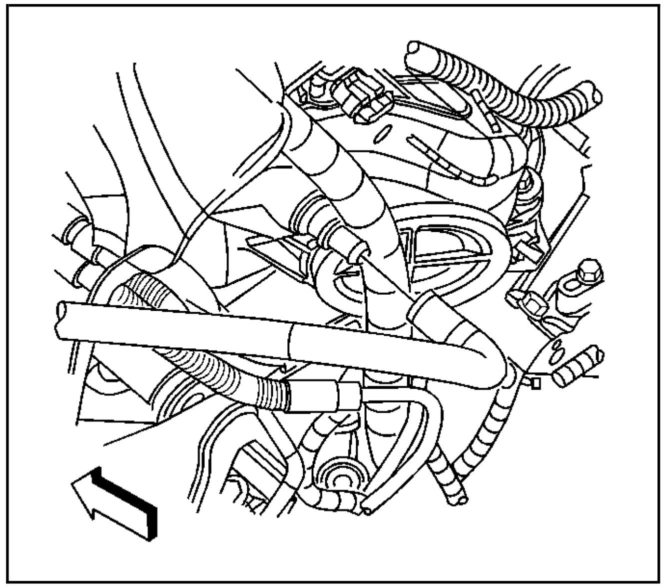


24. Install the engine shield and bolts.

    Tighten

    Tighten the bolts to 20 N·m (15 lb ft).
25. Lower the vehicle.

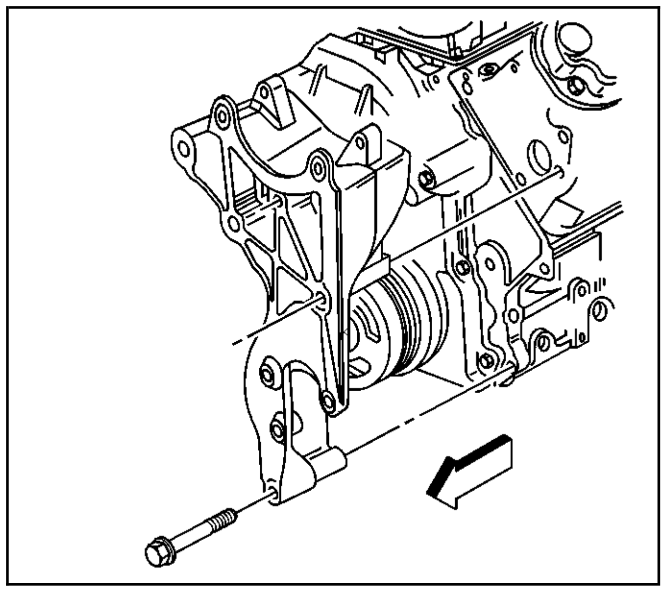
26. Install the vacuum brake booster hose.



27. Position the generator bracket to the front of the engine.
28. Install the generator bracket bolts until snug.
29. Install the rear power steering pump-to-engine block bolt until snug.

    Tighten

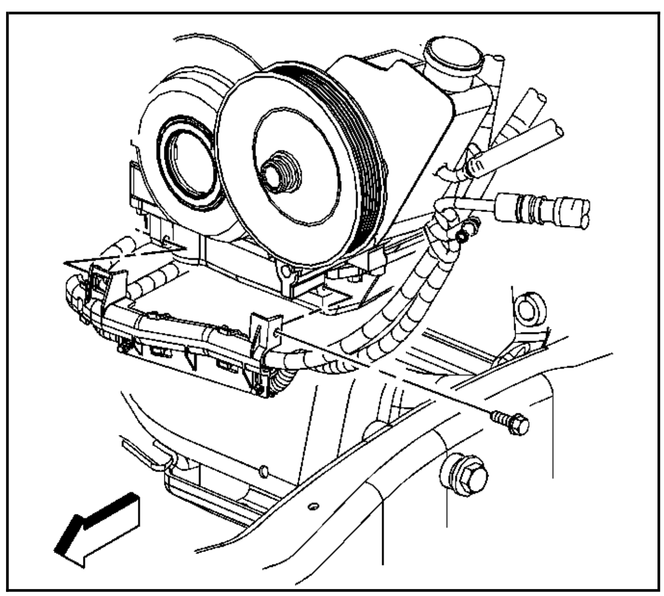
    - Tighten the rear power steering pump bolt to 50 N·m (37 lb ft).
    - Tighten the generator bracket bolts to 50 N·m (37 lb ft).
30. Route the engine wiring harness to the lower engine area.
31. Raise the vehicle.

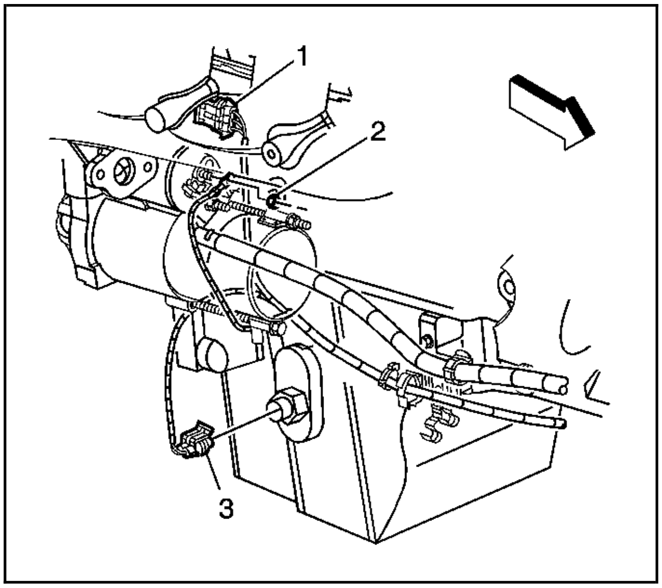


32. Slide the channel pin into the oil pan tab.
33. Install the battery cable channel bolt.

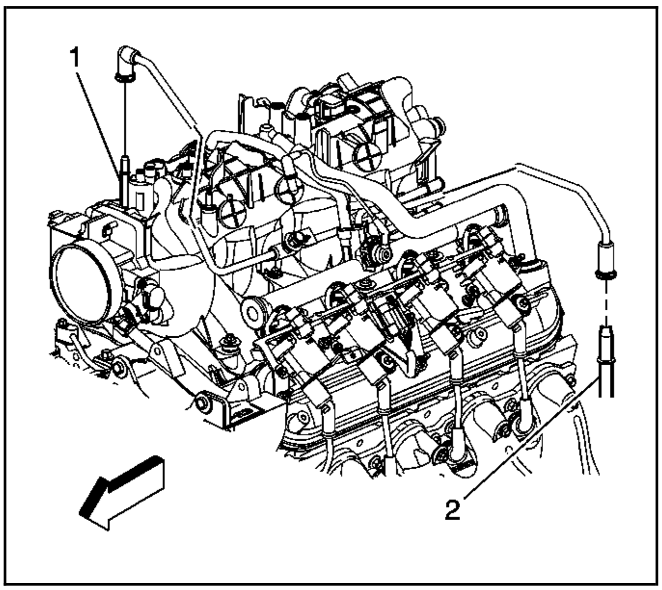
    Tighten

    Tighten the bolt to 12 N·m (106 lb in).

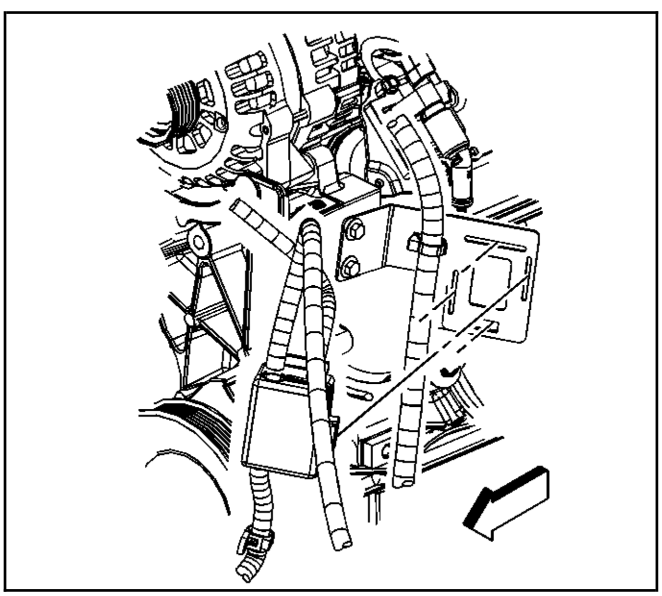




34. Connect the following electrical connectors:
    - The CKP sensor (1)
    - The engine oil level sensor (3)
    - The coolant heater, if equipped
35. Lower the vehicle.
36. Connect the fuel pipes.



37. Install the EVAP purge solenoid vent tube to the solenoid (1).
38. Install the EVAP tube end to the vapor pipe (2).

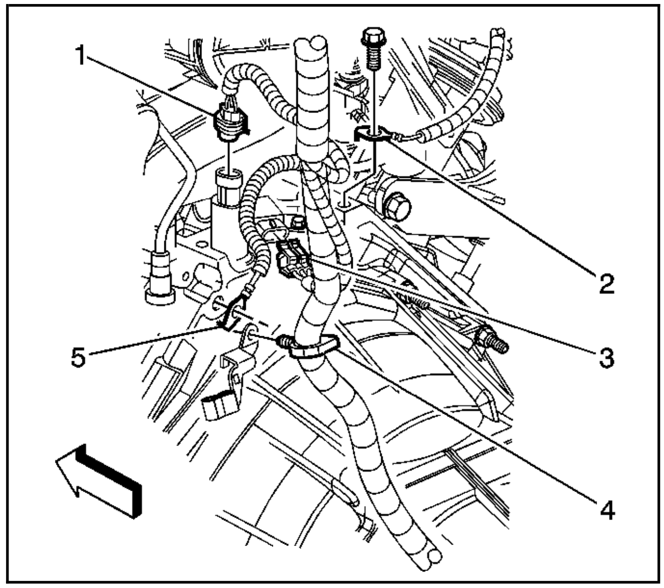


39. Install the battery cable junction block to the junction block bracket.
40. Clip all of the engine wiring harness clips to their correct location.

41. Connect the following electrical connectors:
    - The oil pressure sensor (1)
    - The CMP sensor (3)
42. Position the harness ground and the engine ground strap to the block.
43. Install the harness ground bolt at the left rear of the engine block.
44. Position the harness ground, and auxiliary negative battery cable, if equipped to the block.
45. Install the harness ground bolt at the right rear of the engine block.

    Tighten

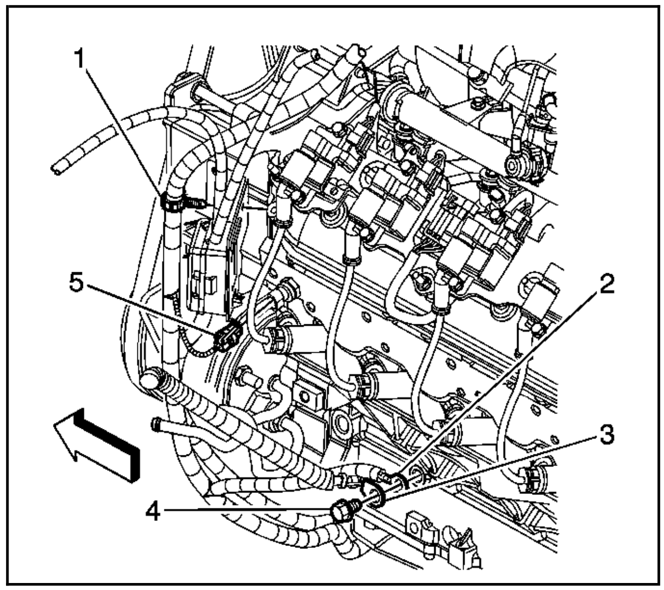
    Tighten the bolts to 16 N·m (12 lb ft).



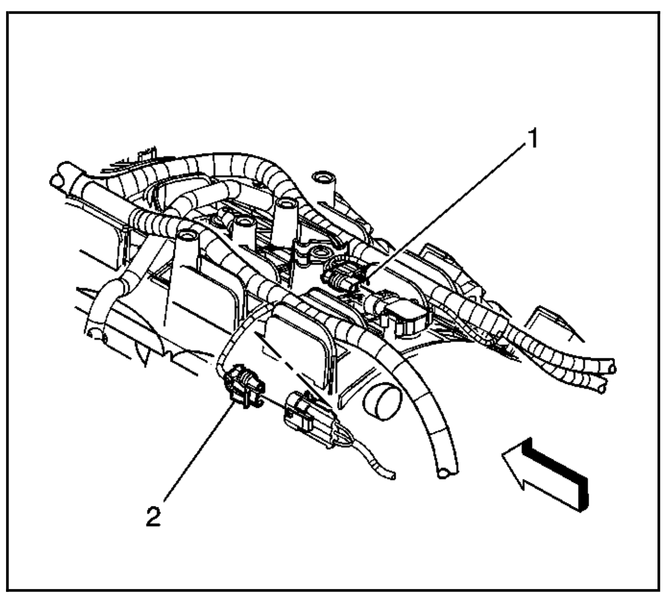
46. Connect the following electrical connectors:
    - The coolant temperature sensor (5)
    - The electronic variable orifice switch
47. Position the harness ground and negative battery cable to the block.
48. Install the harness ground bolt.

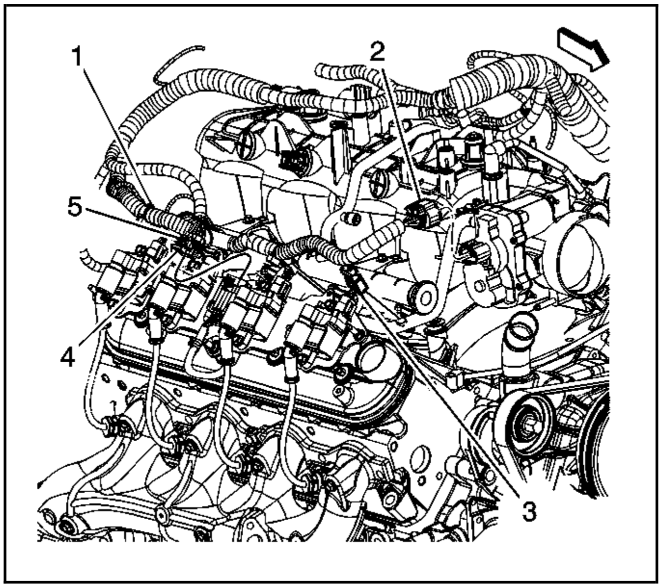
    Tighten

    Tighten the bolt to 25 N·m (18 lb ft).

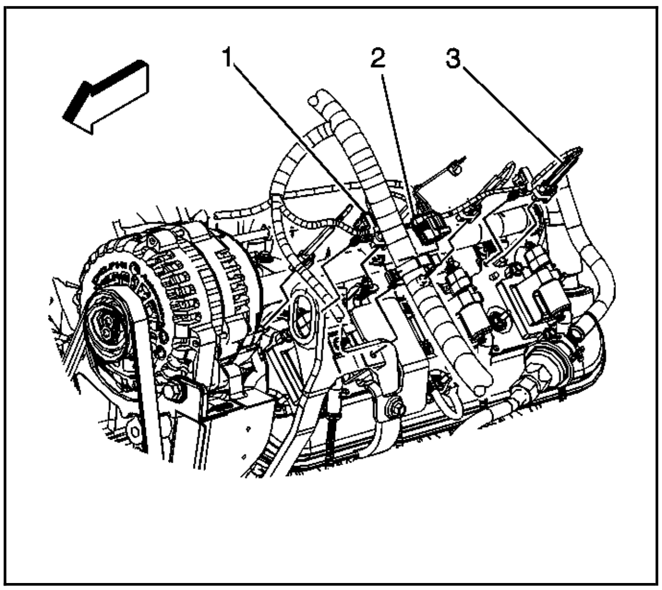


49. Connect the MAP sensor (1) and knock sensor (2) electrical connectors.

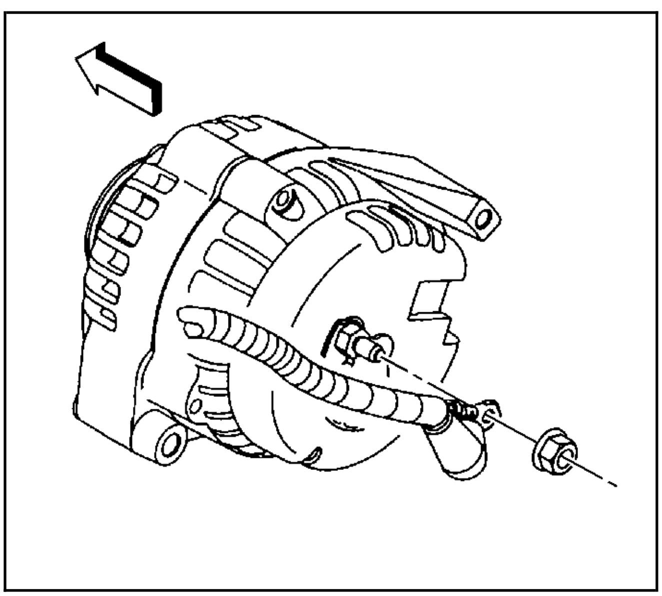




50. Connect the following electrical connectors:
    - The main coil harness (4)
    - The fuel injectors (3)
    - The ETC (2)
51. Install the CPA retainer (5).



52. Connect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.



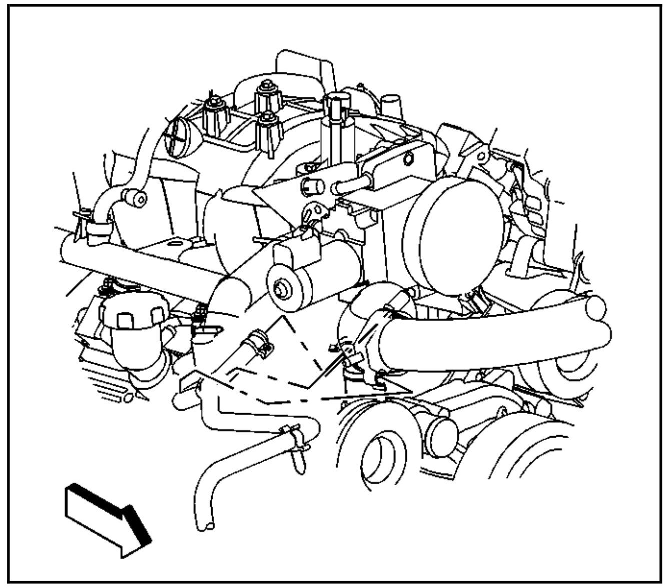
53. Install the generator cable to the generator, perform the following:
    53.1. Install the generator cable.
    53.2. Install the generator cable nut to the terminal stud.

    Tighten

    Tighten the nut to 9 N·m (80 lb in).

    53.3. Slide the boot over the terminal stud.

54. Install the radiator vent inlet hose to the throttle body.
55. Position the vent inlet hose clamp at the throttle body.

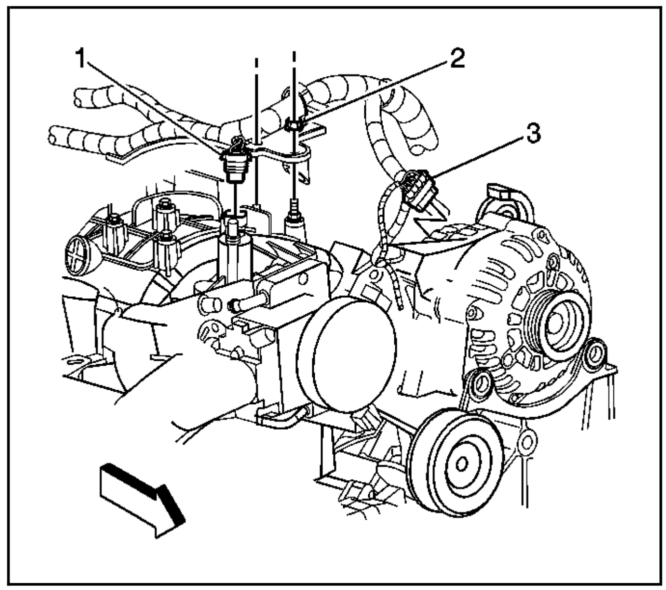


56. Install the engine wiring harness bracket and nut (2).

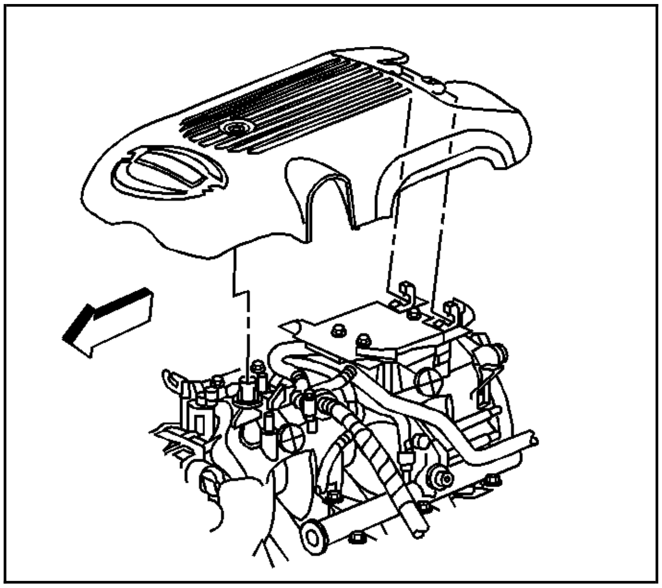
Tighten

Tighten the nut to 5 N·m (44 lb in).

57. Connect the following electrical connectors:
    - The EVAP canister purge solenoid (1)
    - The Generator (3)



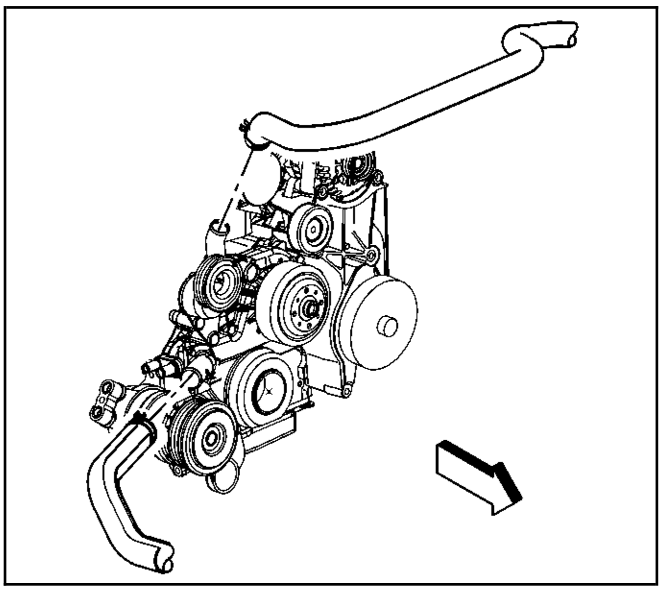
58.Leftblankintentionally.



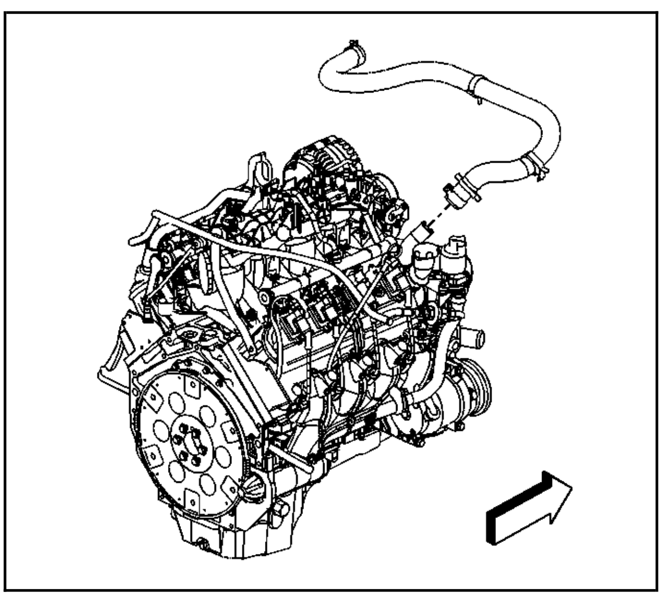
59. If equipped with the 4.8L, or 6.0L with RPO LQ4, install the engine sight shield to the retainer.
60. Tighten the engine sight shield bolt.

    Tighten

    Tighten the bolt to 10 N·m (89 lb in).
61. Install the heater hoses. R



62. Install the radiator outlet hose to the water pump.
63. Position the radiator outlet hose clamp at the water pump.

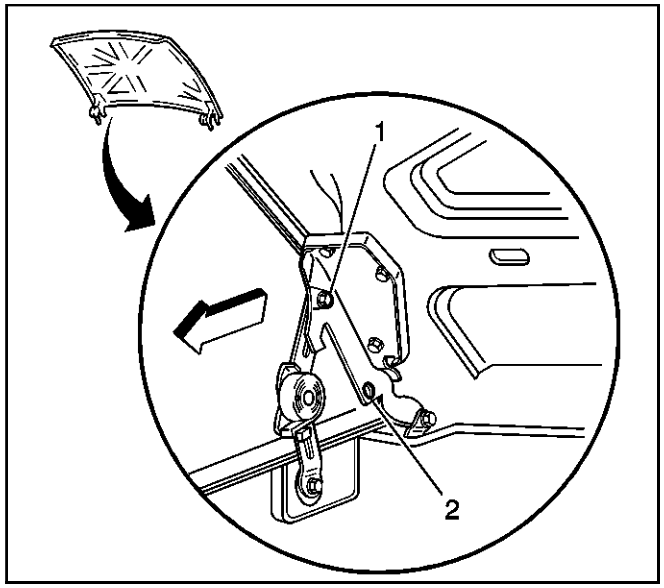


64. Install the radiator inlet hose to the water pump.
65. Position the radiator inlet hose clamp at the water pump.
66. Install the radiator supports. Refer to *Radiator Support Replacement* in Body Front End.
67. Install the A/C compressor. Refer to *Compressor Replacement (LR4 and LQ4)* in HVAC System – Manual.

68. Remove the hood hinge bolts from the service position (2).
69. Lower the hood to the normal position.
70. Install the hood hinge bolts.

    Tighten

    Tighten the bolts to 25 N·m (18 lb ft).
71. Remove the fender covers.
72. Perform the engine prelubing procedure. Refer to *Engine Prelubing*.
73. Perform the CKP system variation learn procedure. Refer to *CKP System Variation Learn Procedure* in Engine Controls – 4.8L and 6.0L.



Important: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.

- 73.1. Disable the ignition system.
- 73.2. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
- 73.3. Enable the ignition system.
- 73.4. Start the engine and listen for unusual noises.
- 73.5. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
- 73.6. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
- 73.7. Listen for sticking lifter and other unusual noises.
- 73.8. Inspect for fuel, oil and/or coolant leaks while the engine is running.
- 73.9. Perform a final inspection for the proper engine oil and coolant levels.

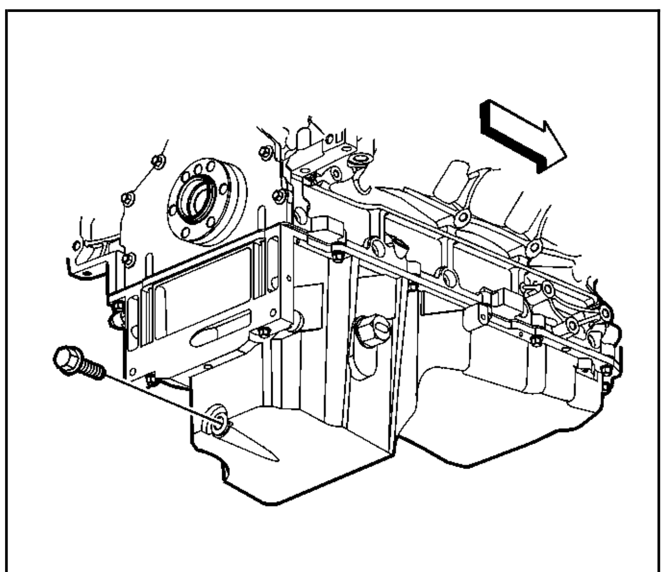
74. Close the hood.

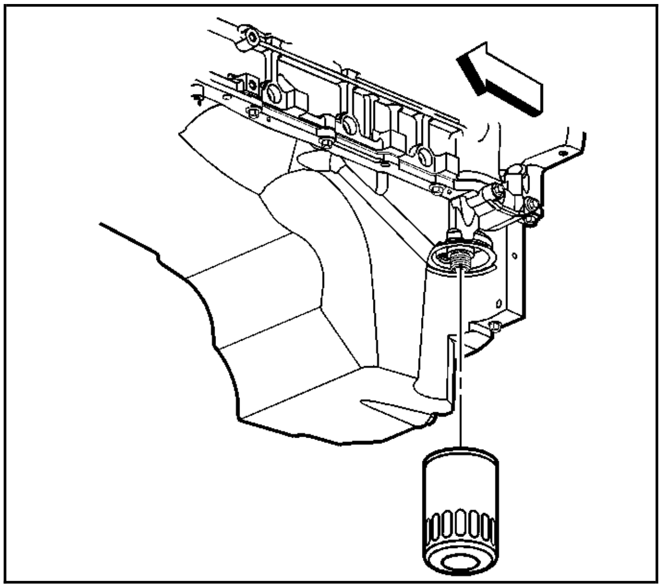
Engine Oil and Oil Filter Replacement

Removal Procedure

Important: In order to completely drain the oil from the oil pan internal baffling, the bottom of the oil pan must be level during the oil drain procedure.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Place a oil drain pan under the oil pan drain plug.
5. Remove the oil pan drain plug.
6. Drain the engine oil.
7. Wipe the excess oil from the drain plug hole and plug.

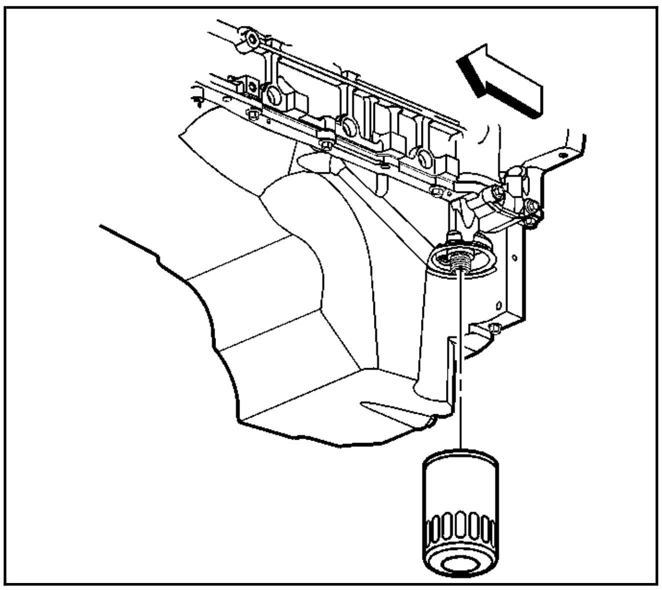




8. Remove the oil filter from the engine block.

Important: Check the old oil filter to ensure that the filter seal is not left on the engine block.

9. Wipe the excess oil from the oil filter mounting.



Installation Procedure

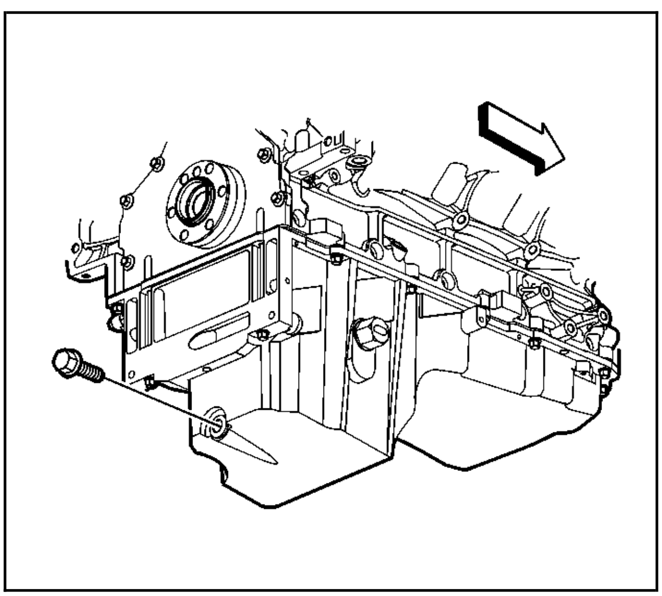
1. Lubricate the oil filter seal with clean engine oil.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the oil filter to the engine block.

   Tighten

   Tighten the oil filter to 30 N·m (22 lb ft).



3. Install the oil drain plug to the engine block.

   Tighten

   Tighten the oil pan drain plug to 25 N·m (18 lb ft).
4. Lower the vehicle.
5. Fill the crankcase with the proper quantity and grade of engine oil. Refer to *Capacities - Approximate Fluid* and *Fluid and Lubricant Recommendations* in Maintenance and Lubrication.
6. Remove the oil level indicator.
7. Wipe the indicator with a clean cloth.
8. Install the oil level indicator.
9. Remove the oil level indicator in order to check the level.
10. Add oil if necessary.
11. Close the hood.

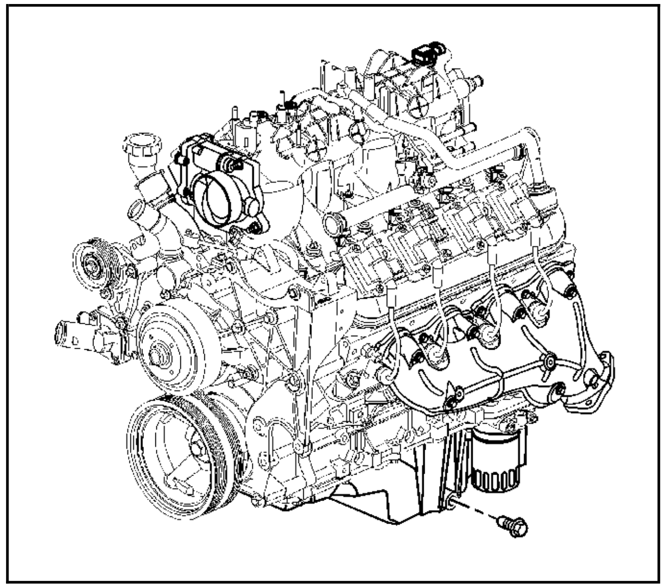
Draining Fluids and Oil Filter Removal

Tools Required

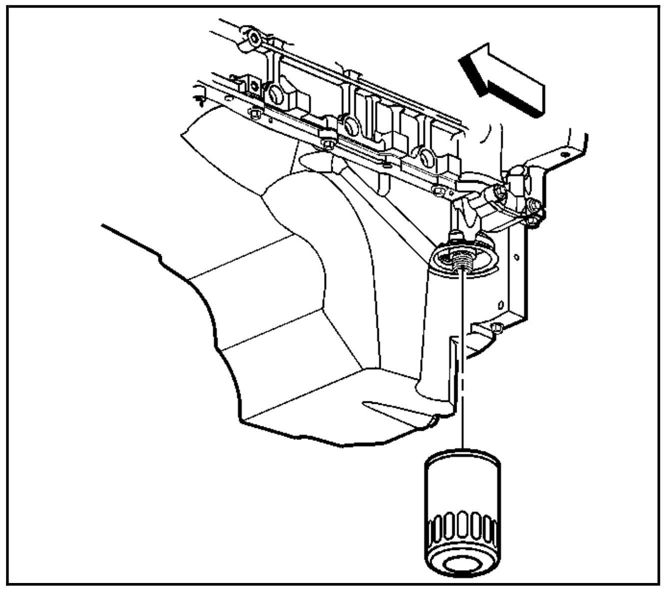
J 41712 Oil Pressure Switch Socket

Important: In order to completely drain the oil, the bottom of the oil pan must be level during the oil drain procedure.

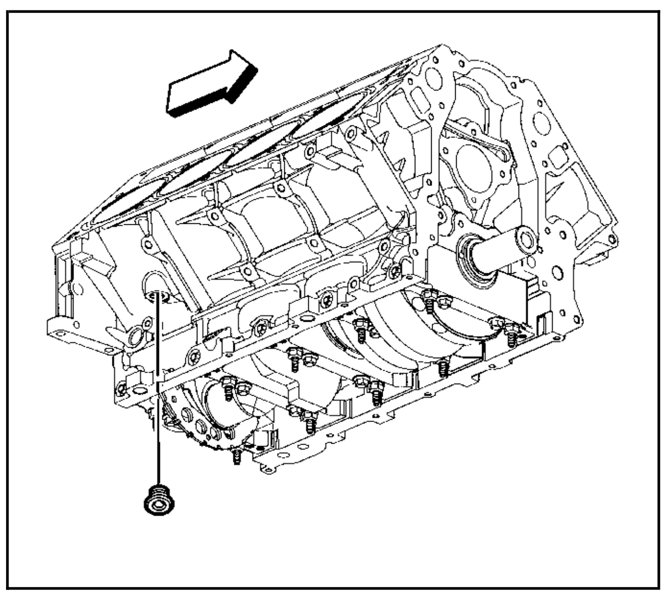
1. Remove the oil pan drain plug and allow the oil to drain.

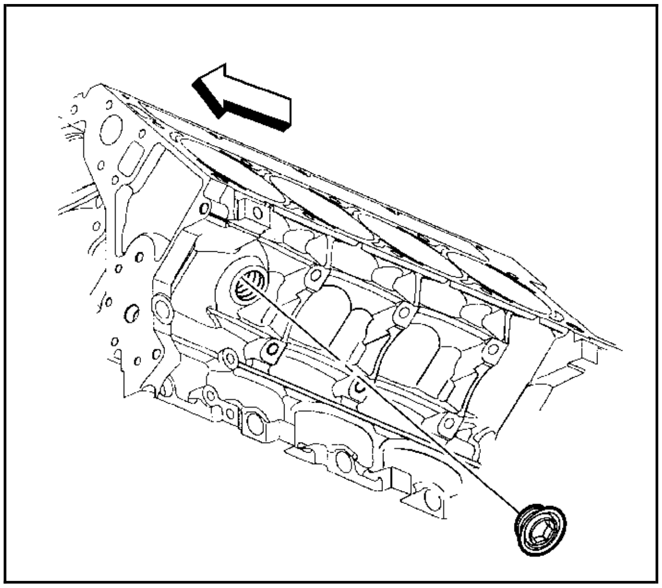


2. Remove the engine oil filter.

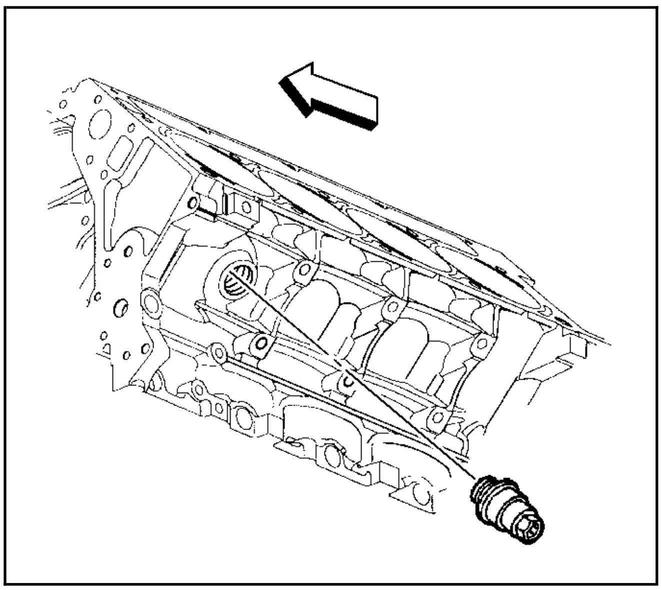


3. Remove the right rear engine block coolant drain plug and allow the coolant to drain.

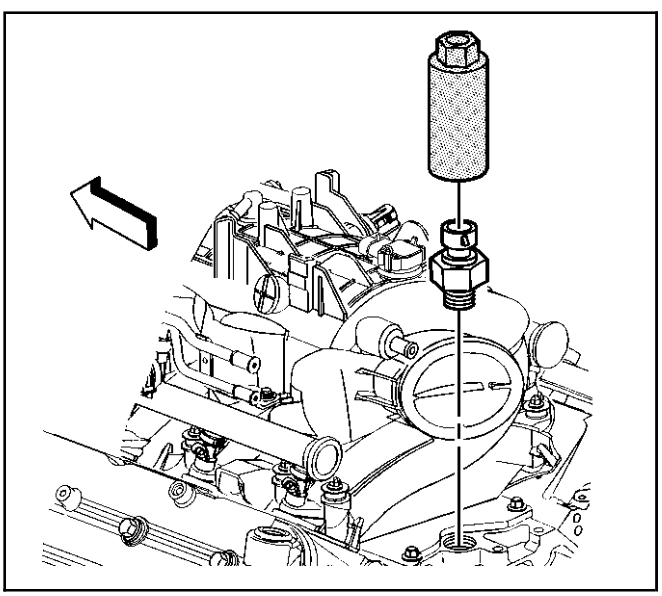




4. Remove the left front engine block coolant drain plug, if applicable, and allow the coolant to drain.



5. Remove the engine block coolant heater, if applicable, and allow the coolant to drain.



6. Use the *J 41712* or equivalent in order to remove the oil pressure sensor, if required.

Crankshaft Balancer Removal

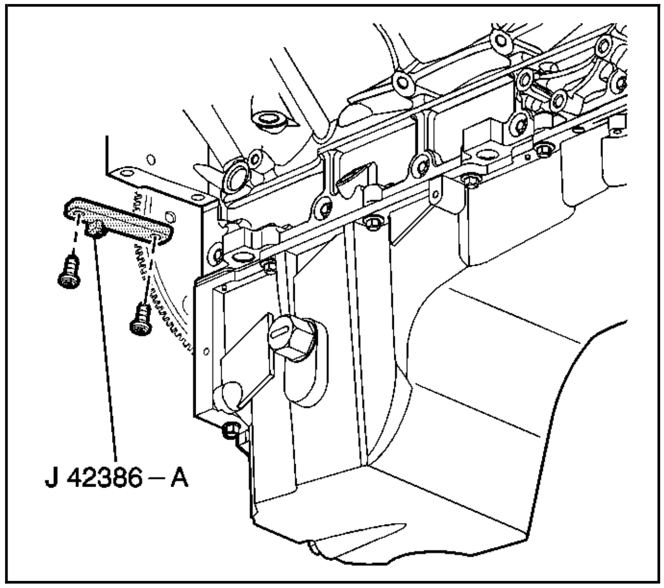
Tools Required

- *J 41816* Crankshaft Balancer Remover
- *J 41816-2* Crankshaft End Protector
- *J 42386-A* Flywheel Holding Tool

Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important:

- Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.
- Ensure the teeth of the flywheel holding tool mesh with the teeth of the engine flywheel.

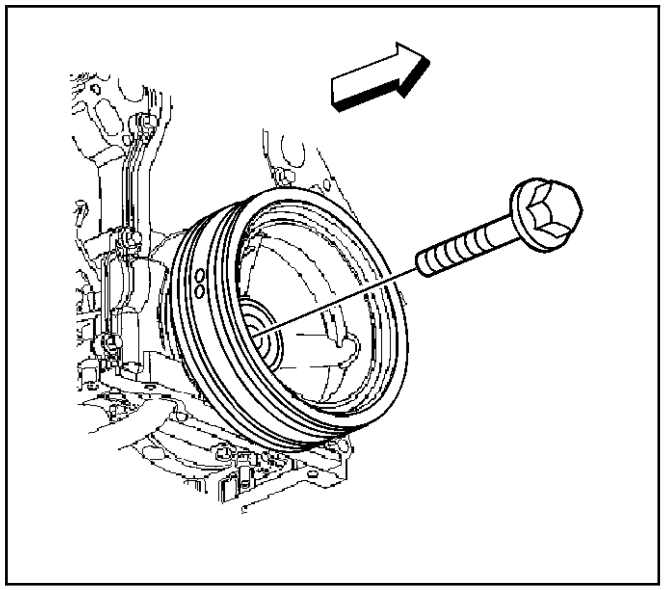


1. Install the *J 42386-A* and bolts.

   Use one M10 – 1.5 x 120 mm and one M10 – 1.5 x 45 mm bolt for proper tool operation.

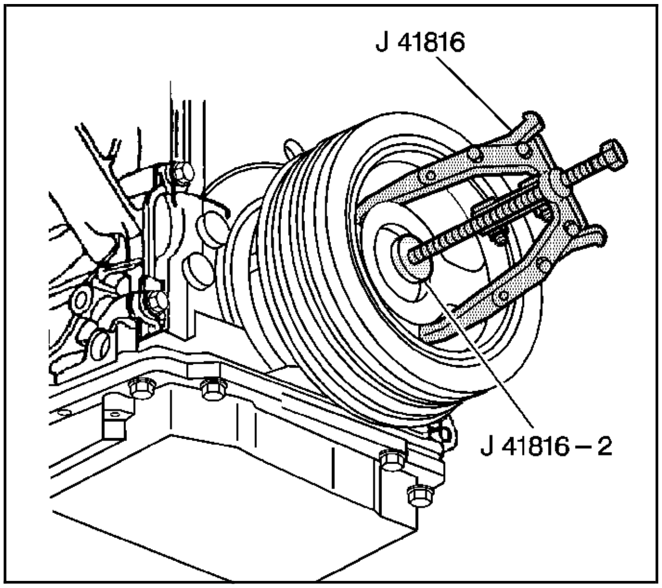
   Tighten

   Tighten the *J 42386-A* bolts to 50 N·m (37 lb ft).

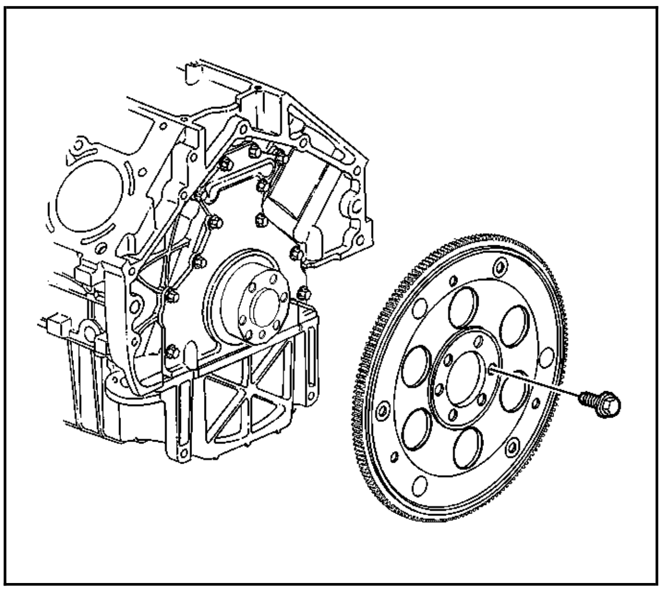


2. Remove the crankshaft balancer bolt.

   Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.



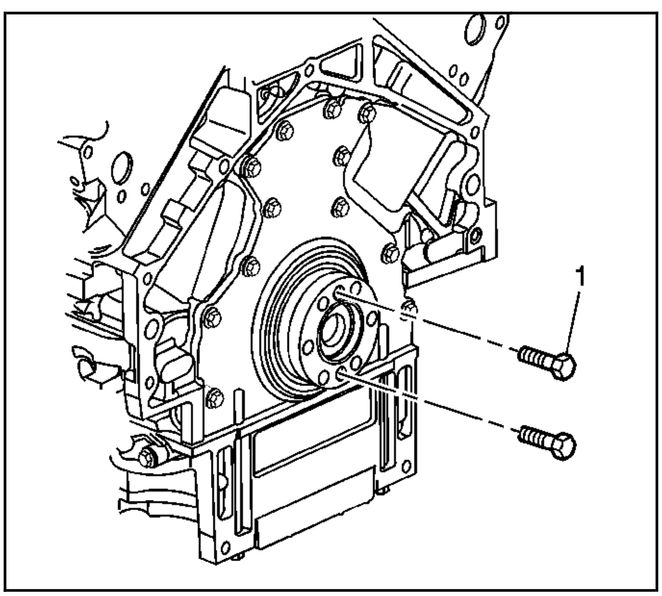
3. Use the *J 41816* and the *J 41816-2* in order to remove the crankshaft balancer.
4. Remove the *J 42386-A* and bolts.



Engine Flywheel Removal

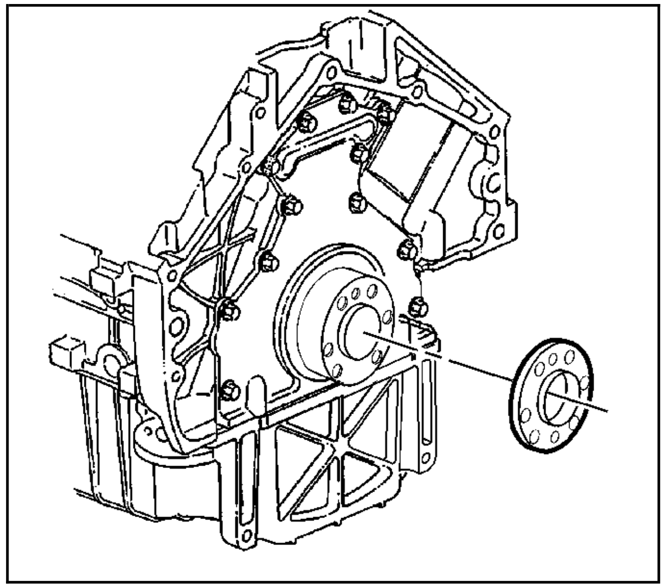
Important: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a 3 stage tightening process.

1. Remove the engine flywheel bolts.
2. Remove the automatic transmission engine flywheel.



3. Install 2 M11x1.5 mm bolts (1) into the threaded holes of the spacer, if applicable.
4. Rotate the bolts clockwise to remove the spacer.

5. Remove the spacer from the rear of the crankshaft, if applicable.

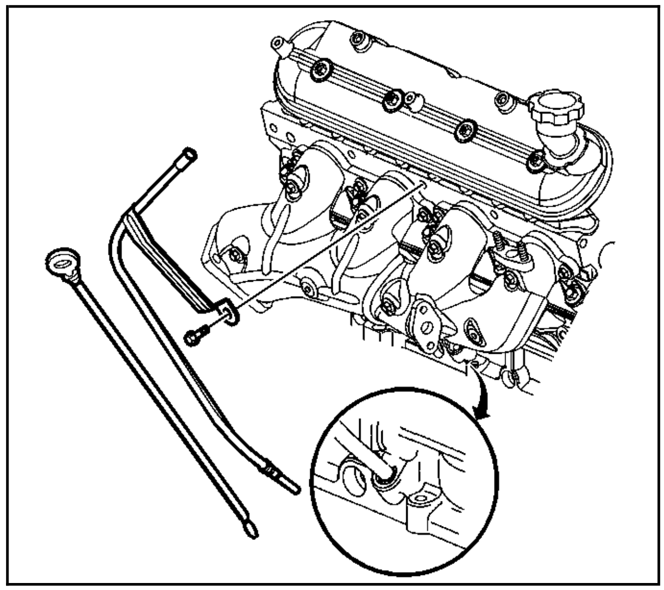


Oil Level Indicator and Tube Removal

1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

Important: Inspect the O-ring seal for cuts or damage. The O-ring seal may be used again if it is not cut or damaged.

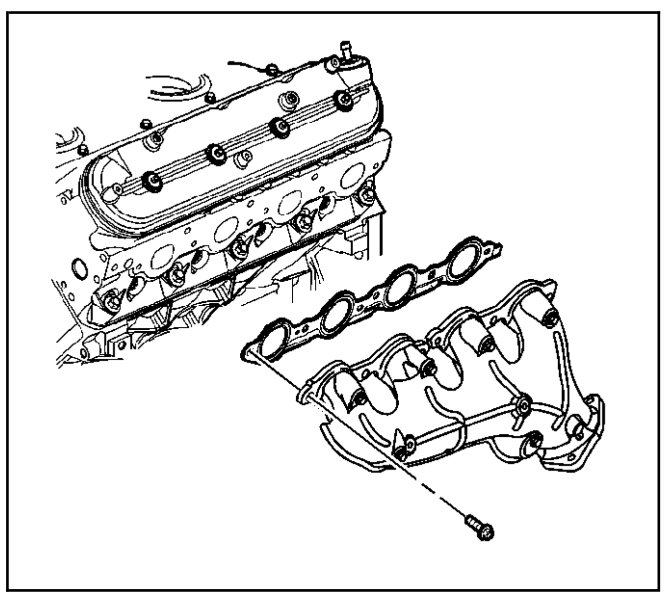
4. Remove the O-ring seal from the tube, if required.

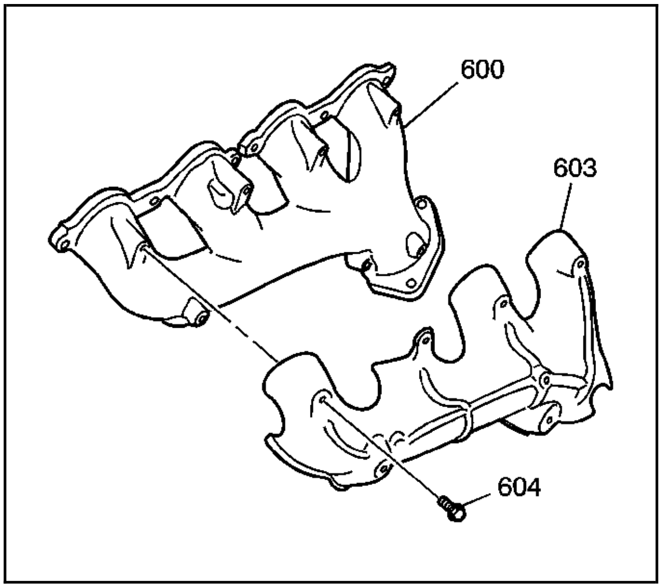


Exhaust Manifold Removal - Left

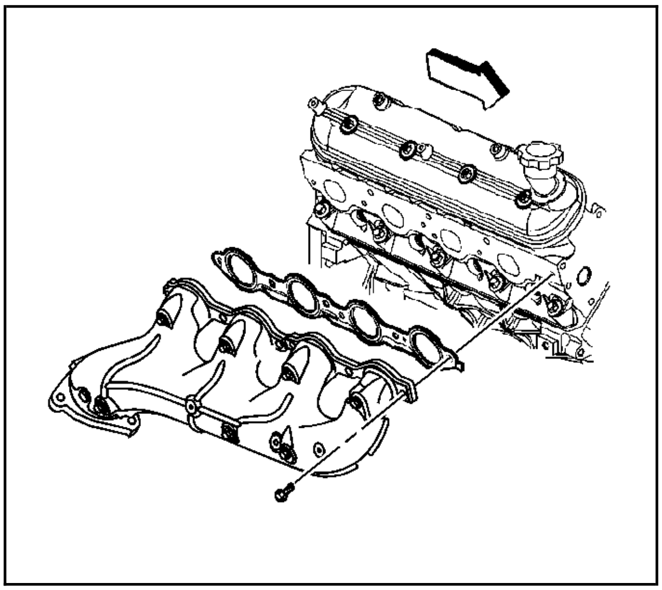
1. Remove the spark plug wires from the spark plugs.

   Do not remove the spark plug wires from the ignition coils unless required.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.





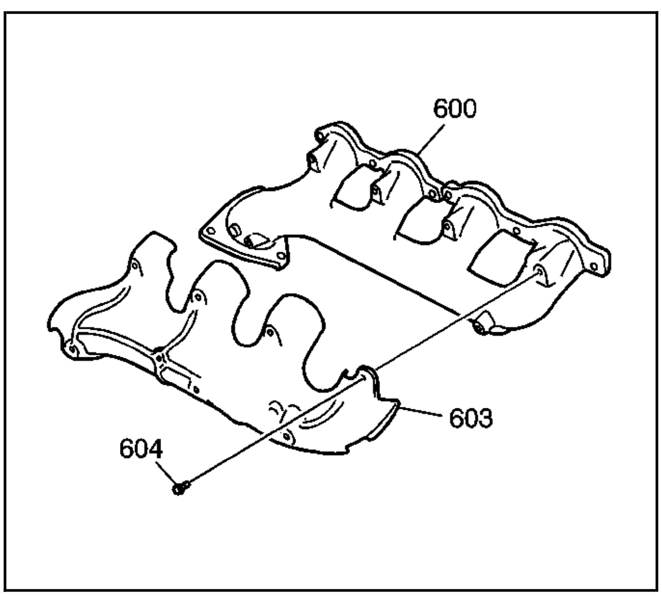
4. Remove the heat shield (603) and bolts (604) from the manifold (600), if required.



Exhaust Manifold Removal - Right

1. Remove the spark plug wires from the spark plugs.

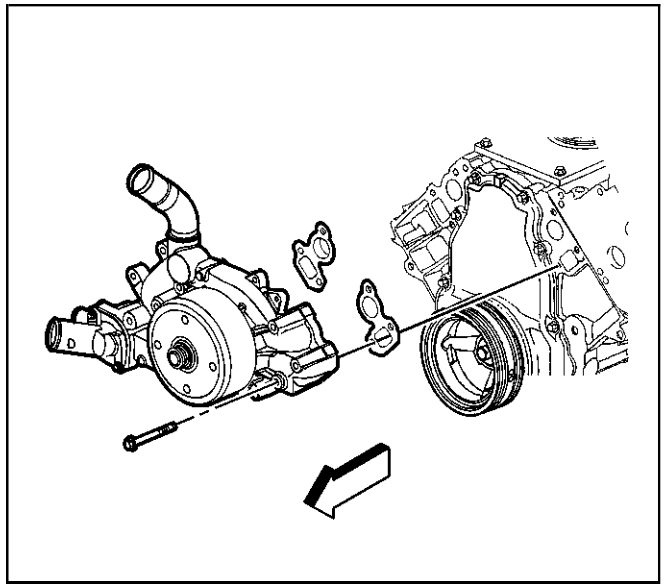
   Do not remove the spark plug wires from the ignition coils unless required.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.



4. Remove the heat shield (603) and bolts (604) from the manifold (600), if required.

Water Pump Removal

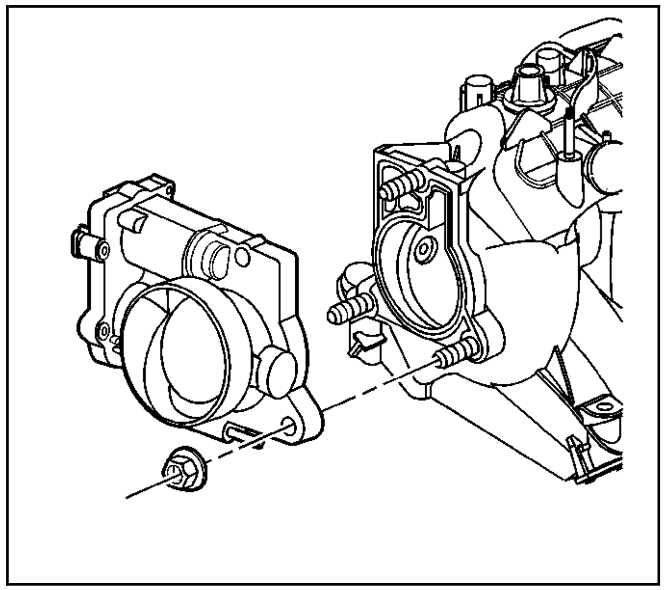
1. Remove the water pump bolts.
2. Remove the water pump and gaskets.
3. Discard the water pump gaskets.



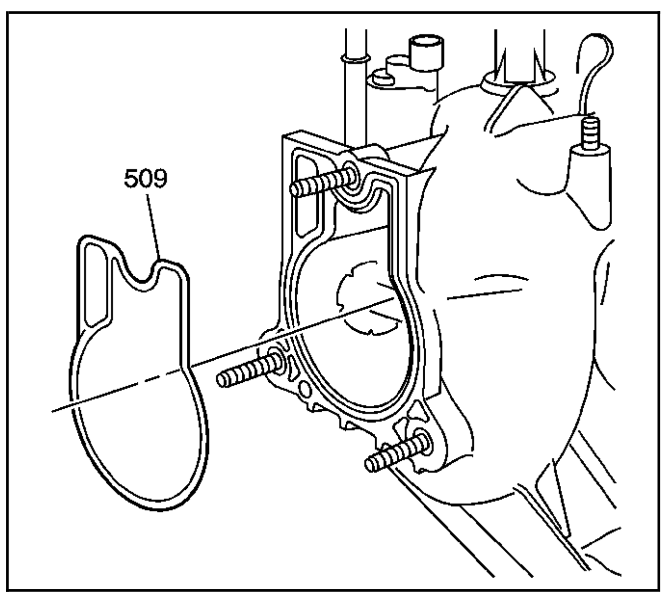
Throttle Body Removal

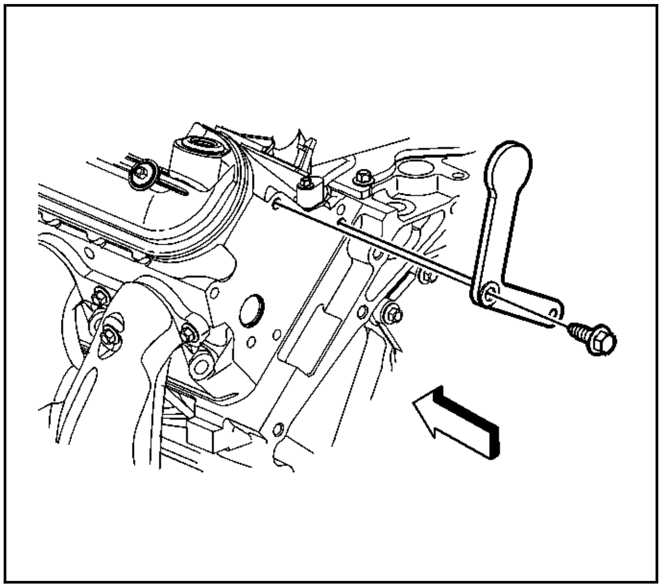
Important: The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

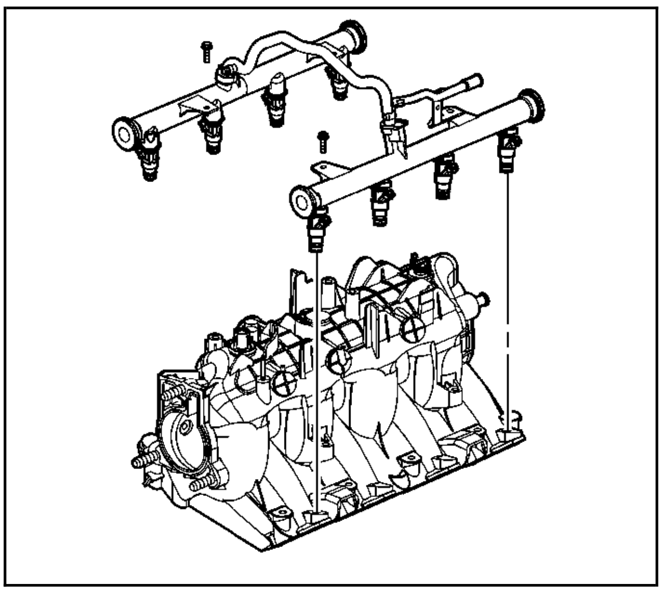
1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the engine coolant air bleed hose and clamp.
3. Remove the throttle body nuts.
4. Remove the throttle body.



5. Remove the throttle body gasket (509).
6. Discard the gasket.
7. Remove the throttle body studs, if required.







Fuel Rail and Injectors Removal

Caution: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

Notice:

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

Important: The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the intake manifold as a complete assembly.

1. Remove the fuel rail stop bracket and bolt, if required.

2.Leftblankintentionally.

3. Loosen the crossover tube-to-right fuel rail retaining bolt.
4. Remove the fuel rail bolts.

Important:

- Do not separate the fuel injectors from the fuel rail unless component service is required.
- Use cleanliness and care when handling the fuel system components.
- Do not allow dirt or debris to enter the fuel injectors or fuel rail components, cap ends as necessary.

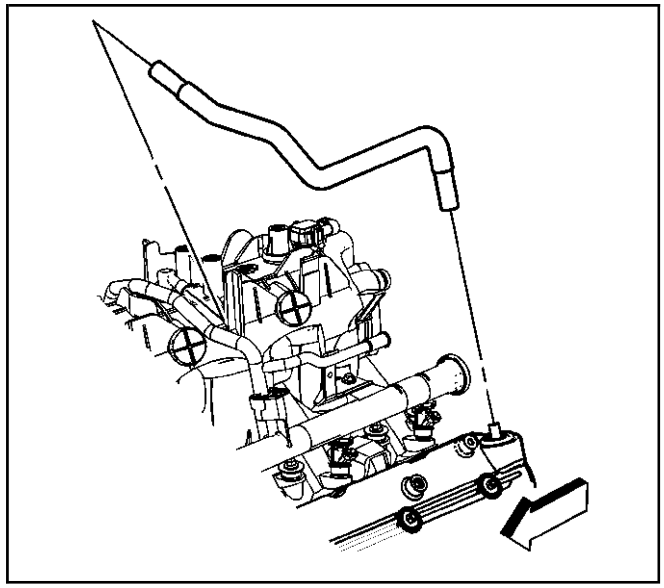
5. Remove the fuel rail, with injectors, lifting evenly from both sides of the fuel rail until all the injectors have left their bores.

Intake Manifold Removal

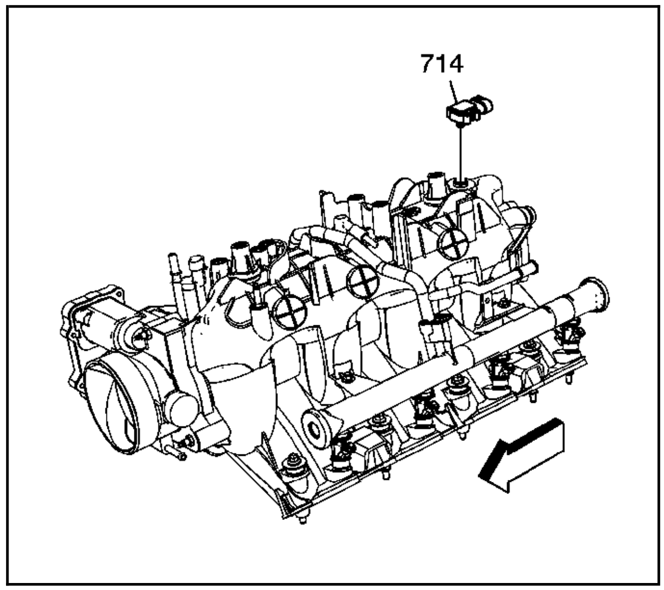
Important:

- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.
- DO NOT use the intake manifold-to-cylinder head gaskets again.

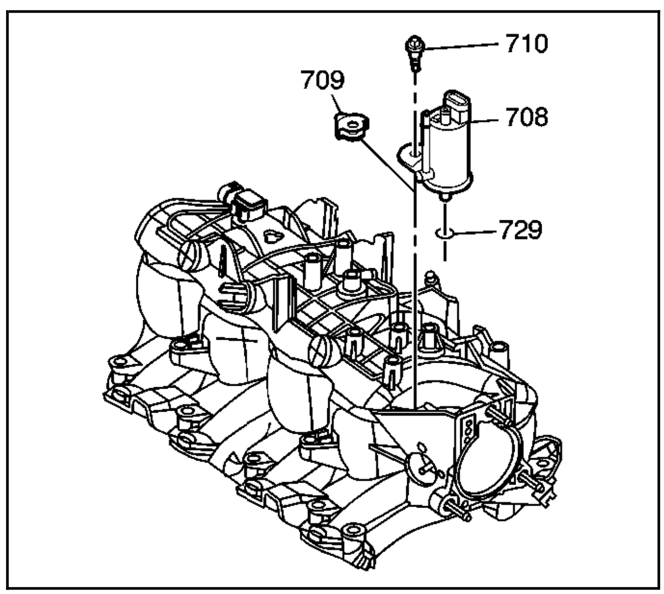
1. Remove the positive crankcase ventilation (PCV) hose – dirty air.

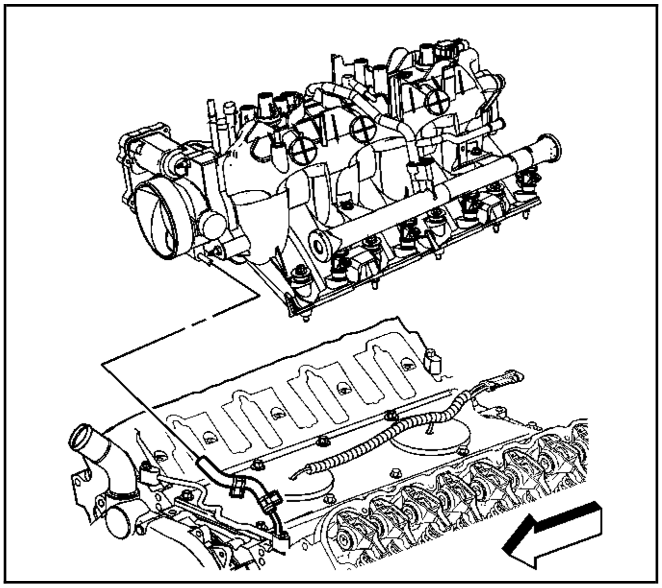


2. Remove the manifold absolute pressure (MAP) sensor (714), if required.
3. Remove the engine coolant air bleed clamp and hose from the throttle body.

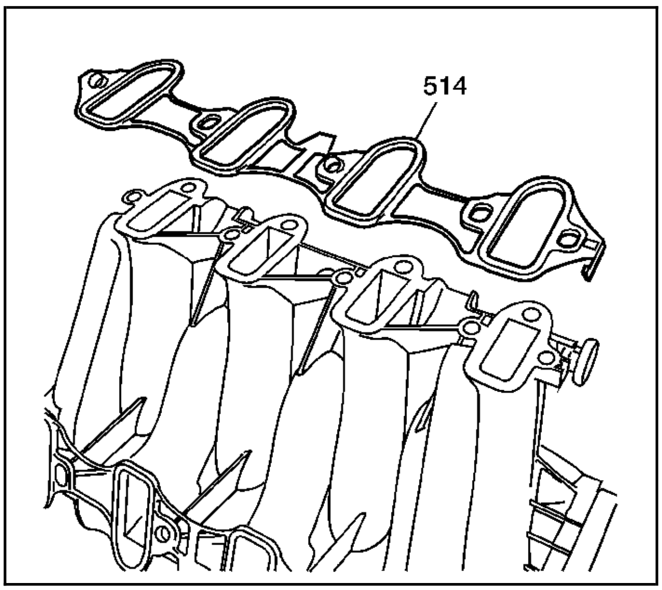


4. Remove the evaporative emission (EVAP) solenoid (708), bolt (710), and isolator (709).

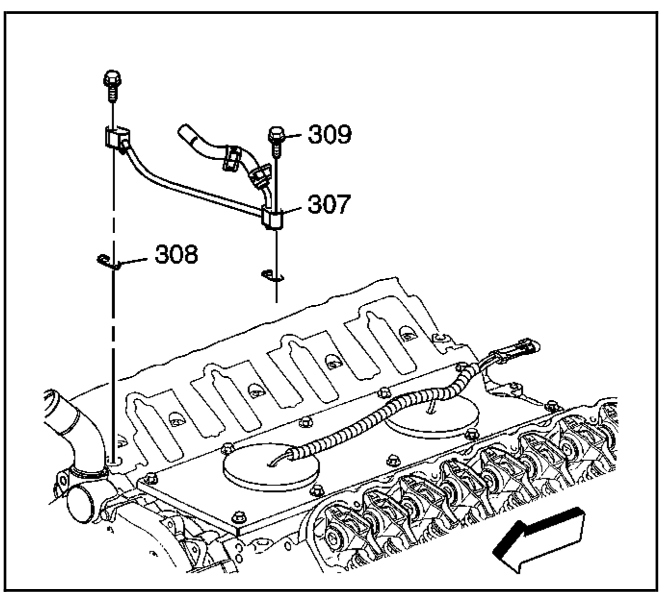




5. Remove the intake manifold bolts.
6. Remove the intake manifold with gaskets.



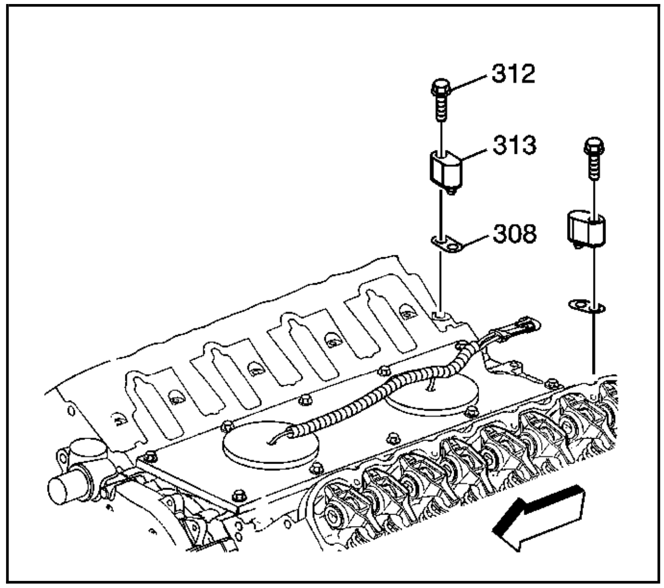
7. Separate the intake manifold-to-cylinder head gaskets (514) from the manifold.
8. Discard the intake manifold gaskets.



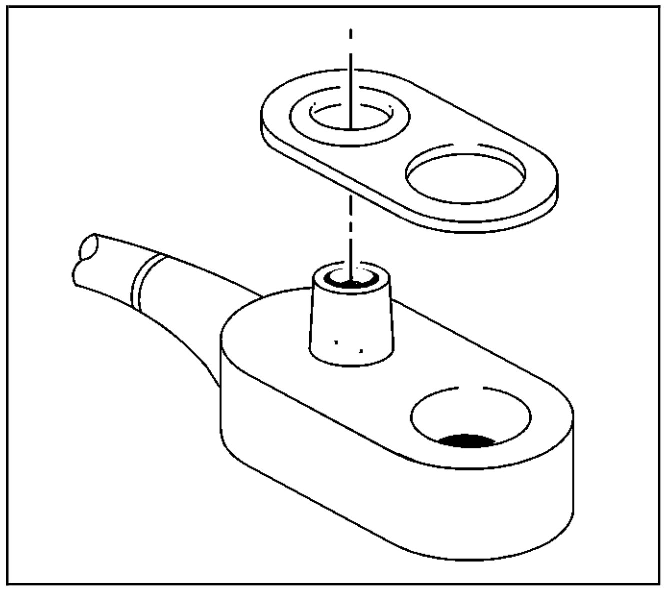
Coolant Air Bleed Pipe Removal

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with hose and gaskets (308).

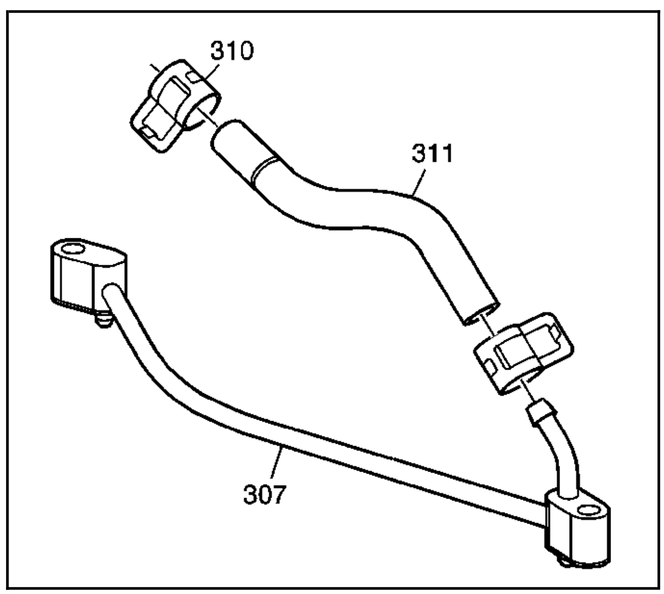
3. Remove the engine coolant air bleed cover bolts (312), covers (313), and gaskets (308).



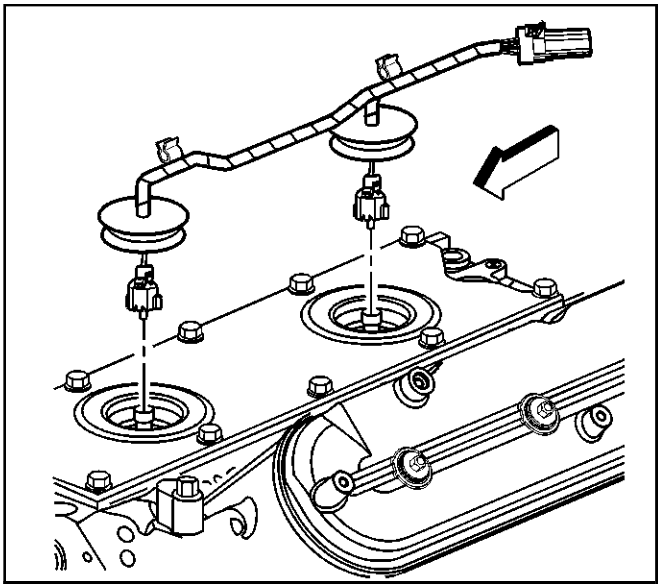
4. Remove the gaskets from the pipe and covers.
5. Discard the gaskets.



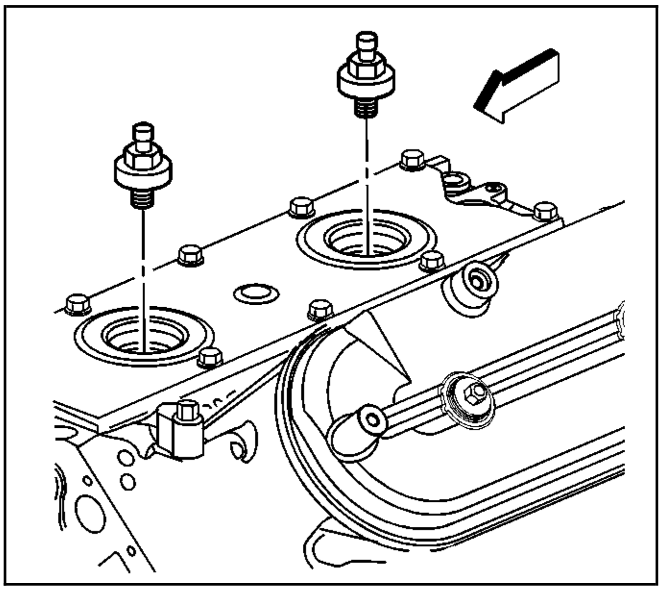
6. Remove the hose (311) and clamps (310) from the pipe (307).



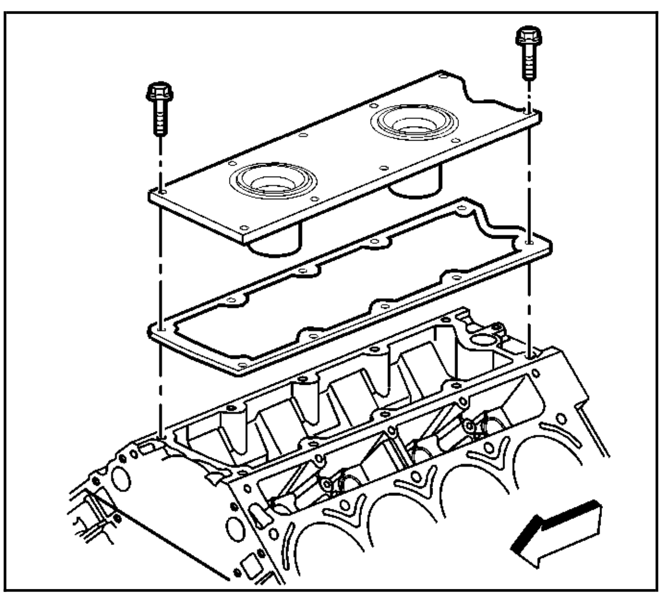
Engine Valley Cover Removal



1. Remove the knock sensor wire harness.

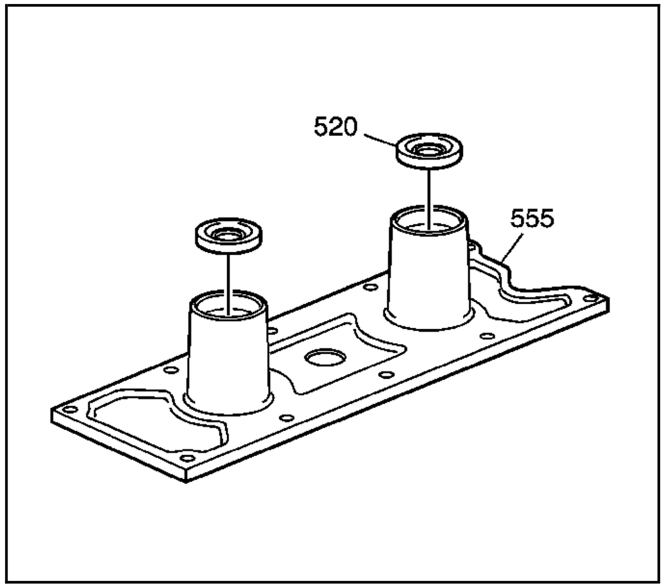


2. Remove the knock sensors.



3. Remove the valley cover bolts.
4. Remove the valley cover and gasket.
5. Discard the valley cover gasket.

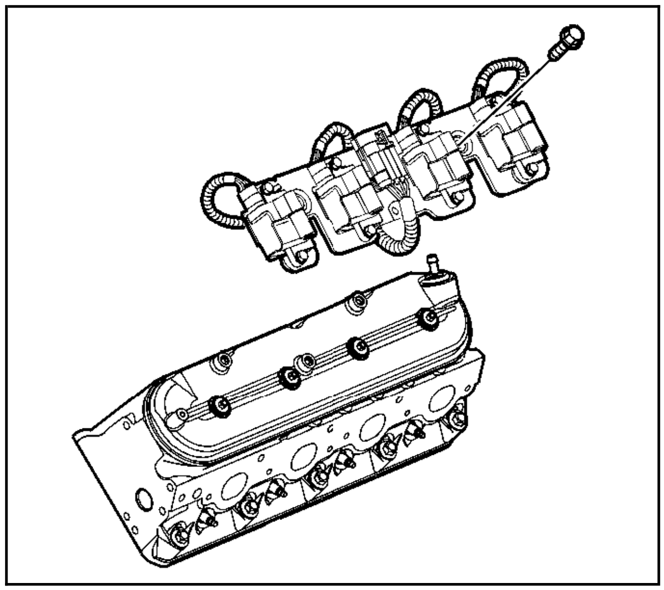
6. Remove the knock sensor oil seals (520) from the cover (555).



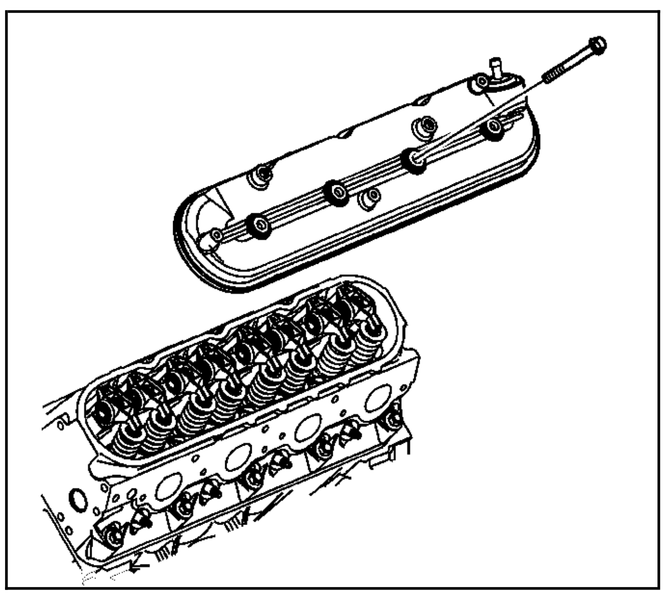
Valve Rocker Arm Cover Removal - Left

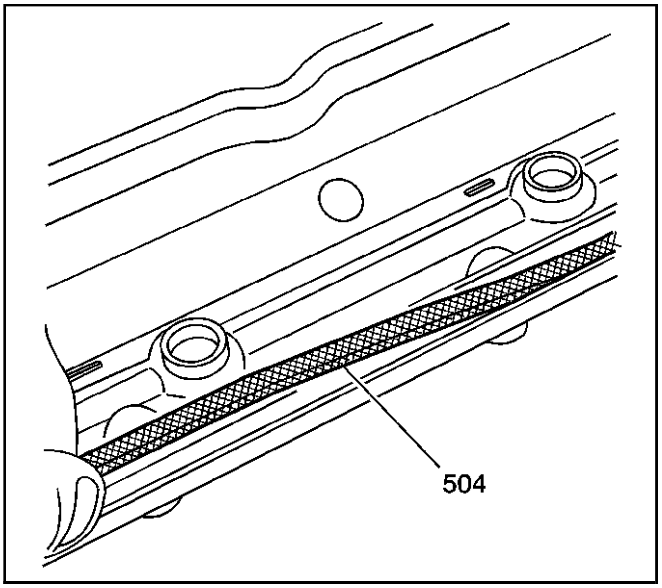
Important: Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.

1. Remove the ignition coil bracket bolts from the rocker arm cover, if required.
2. Remove the ignition coil and bracket assembly from the cover.



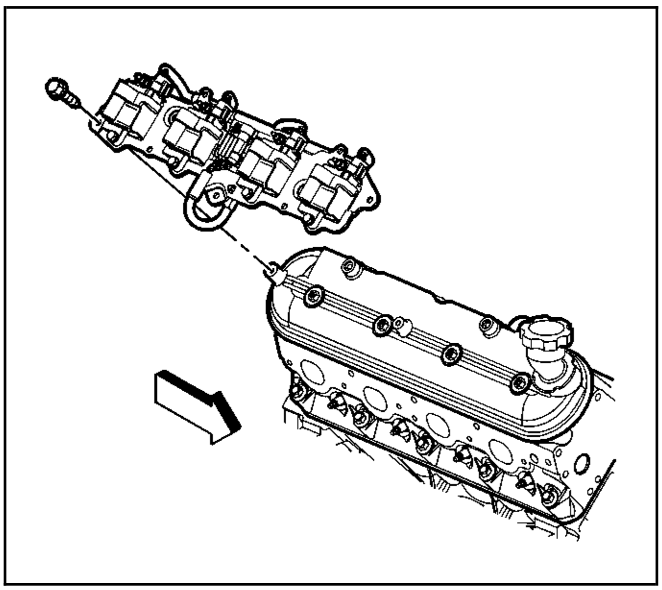
3. Remove the valve rocker arm cover bolts.
4. Remove the valve rocker arm cover.





5. Remove the gasket (504) from the left cover.
6. Discard the gasket.

   The bolt grommets may be used again if they are not damaged.

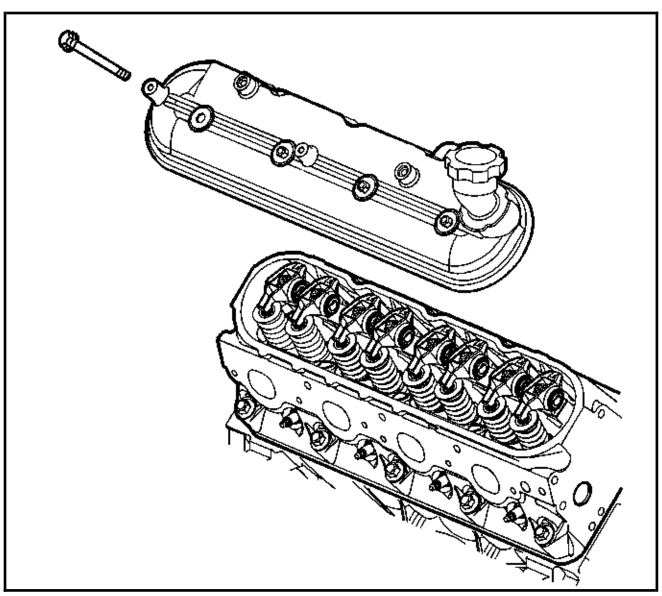


Valve Rocker Arm Cover Removal - Right

Important:

- Do not remove the ignition coils from the valve rocker arm cover unless required.
- Do not remove the oil fill tube from the cover unless service is required.
- If the oil fill tube has been removed from the cover, install a NEW tube during assembly.

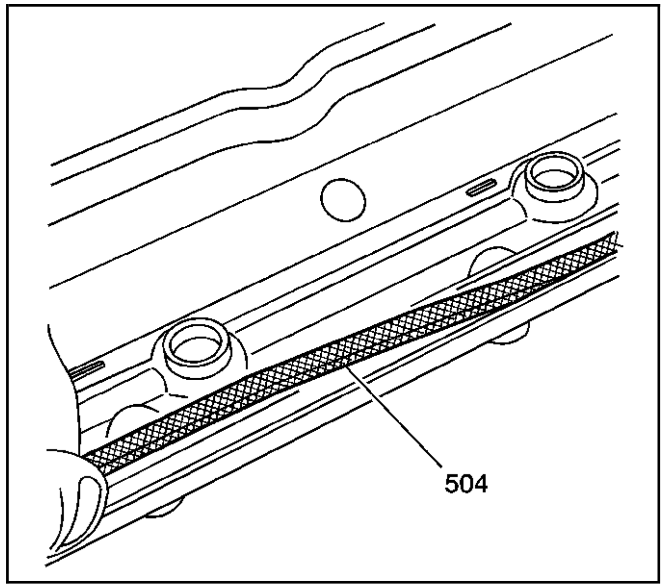
1. Remove the ignition coil bracket bolts from the rocker arm cover, if required.
2. Remove the ignition coil and bracket assembly from the cover.



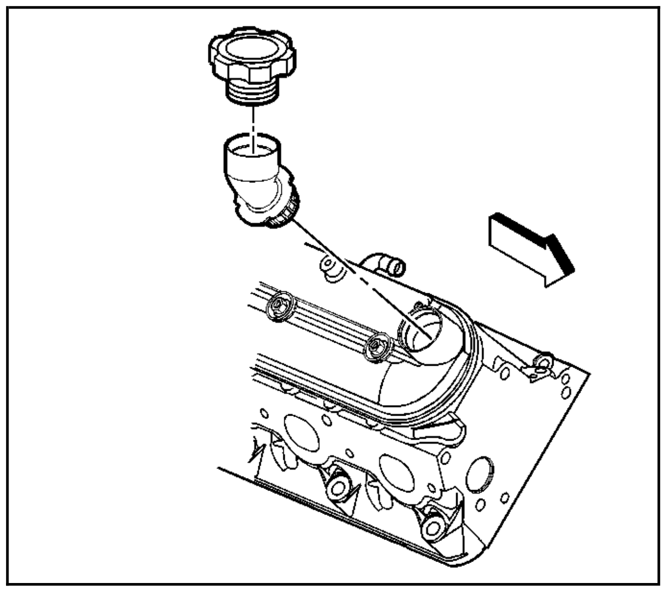
3. Remove the valve rocker arm cover bolts.
4. Remove the valve rocker arm cover.

5. Remove the gasket (504) from the right cover.
6. Discard the gasket.

   The bolt grommets may be used again if they are not damaged.



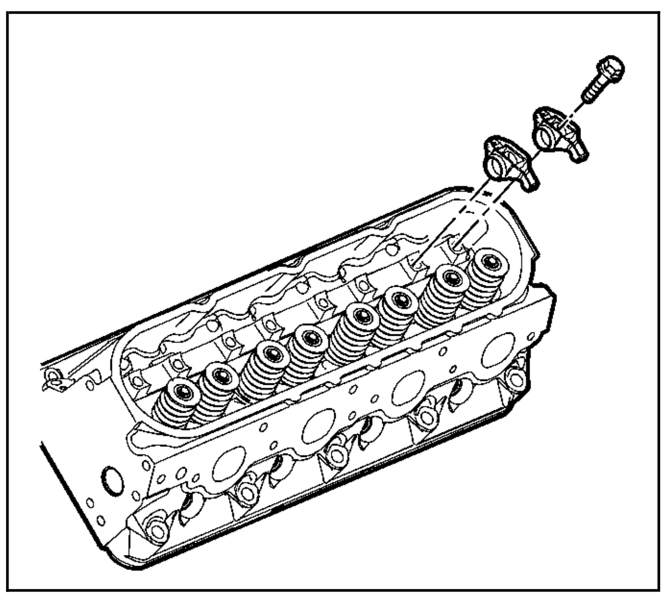
7. Remove the oil fill cap from the oil fill tube.
8. Remove the oil fill tube, if required.
9. Discard the oil fill tube.

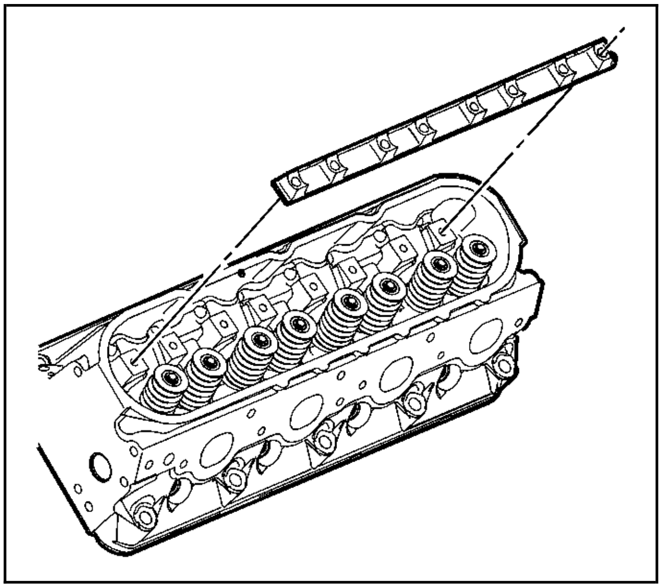


Valve Rocker Arm and Push Rod Removal

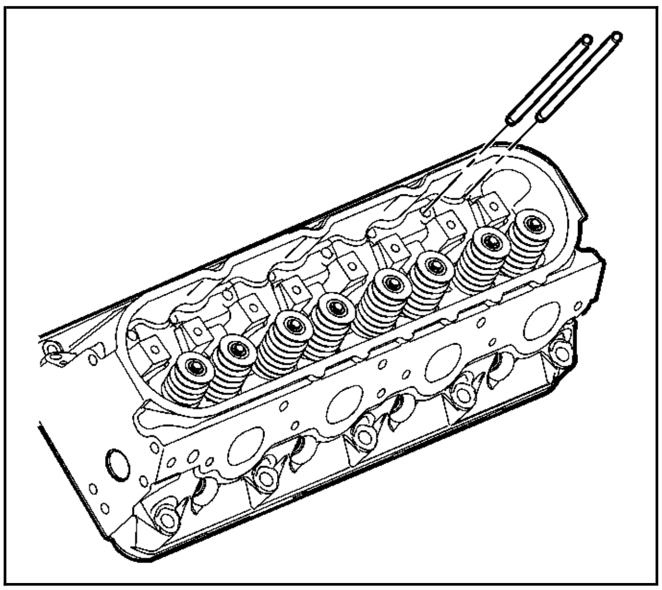
Important: Place valve rocker arms, valve pushrods, and pivot support, in a rack so that they can be installed in the same location from which they were removed.

1. Remove the valve rocker arm bolts.
2. Remove the valve rocker arms.

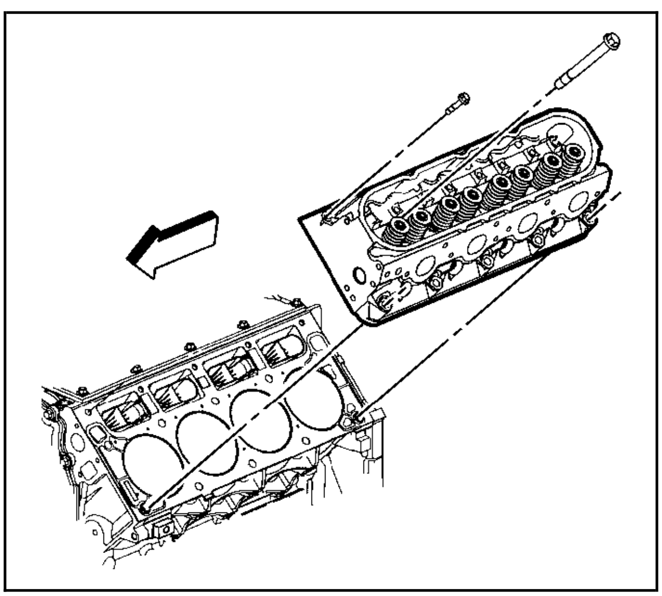




3. Remove the valve rocker arm pivot support.



4. Remove the pushrods.



Cylinder Head Removal - Left

1. Remove the spark plugs from the cylinder head.

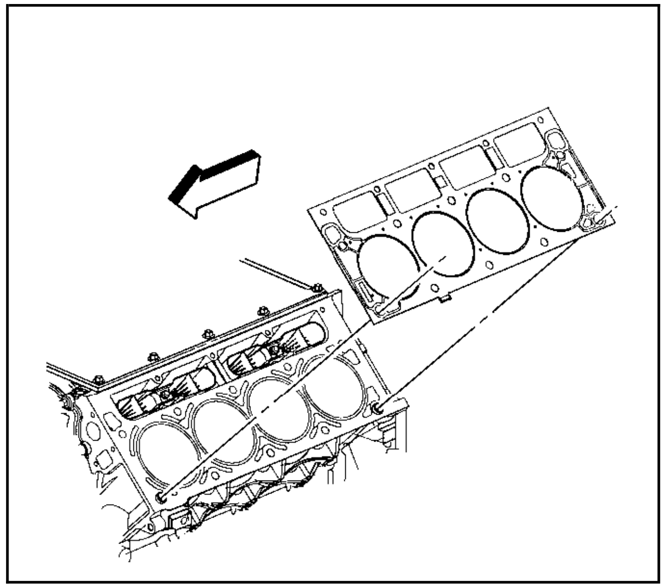
Important: The cylinder head bolts can NOT be used again. Install NEW cylinder head bolts during assembly.

2. Remove the cylinder head bolts.

Notice: After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

3. Remove the cylinder head.

4. Remove the gasket.
5. Discard the gasket.
6. Discard the cylinder head bolts.



Cylinder Head Removal - Right

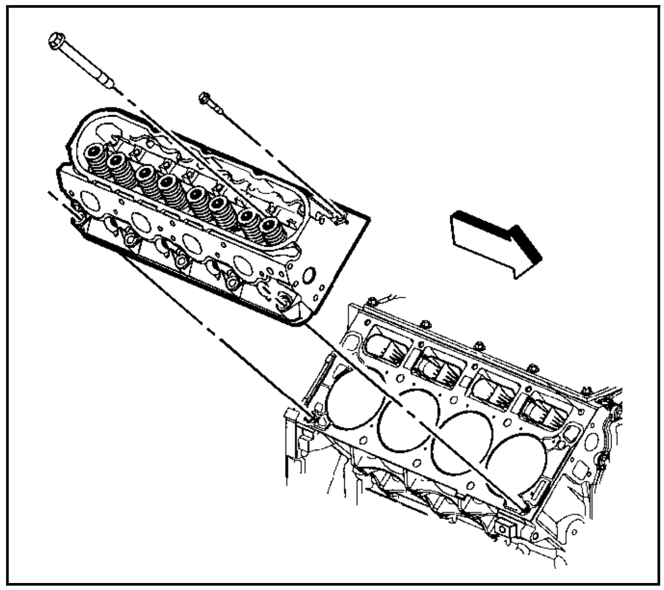
1. Remove the spark plugs from the cylinder head.

Important: The cylinder head bolts can NOT be used again. Install NEW cylinder head bolts during assembly.

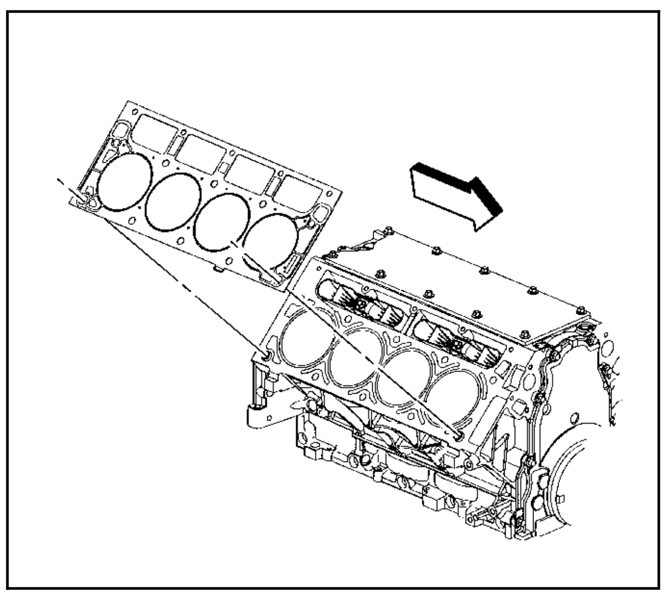
2. Remove the cylinder head bolts.

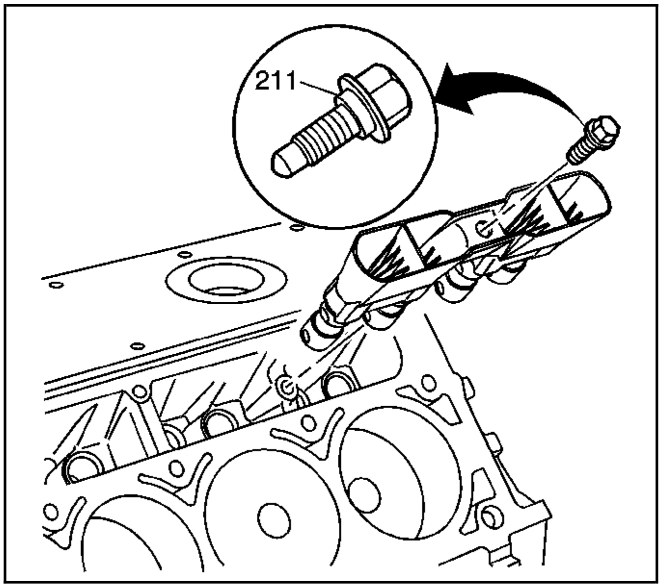
Notice After removal,
place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

3. Remove the cylinder head.



4. Remove the gasket.
5. Discard the gasket.
6. Discard the cylinder head bolts.



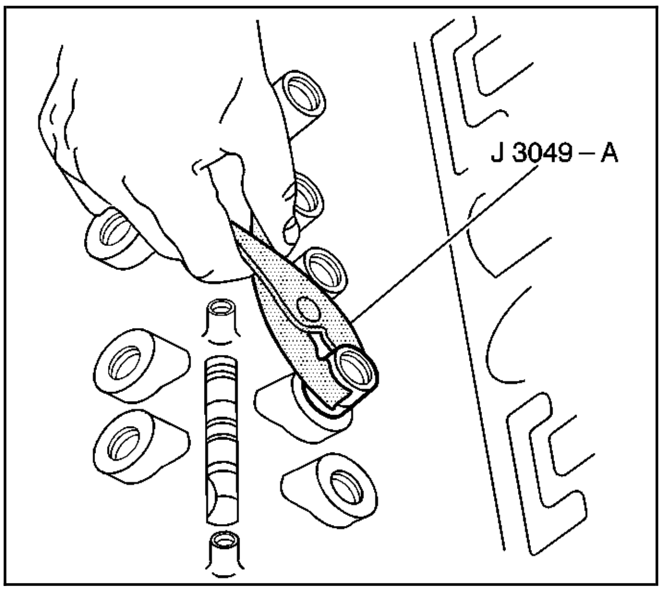


Valve Lifter Removal

Tools Required

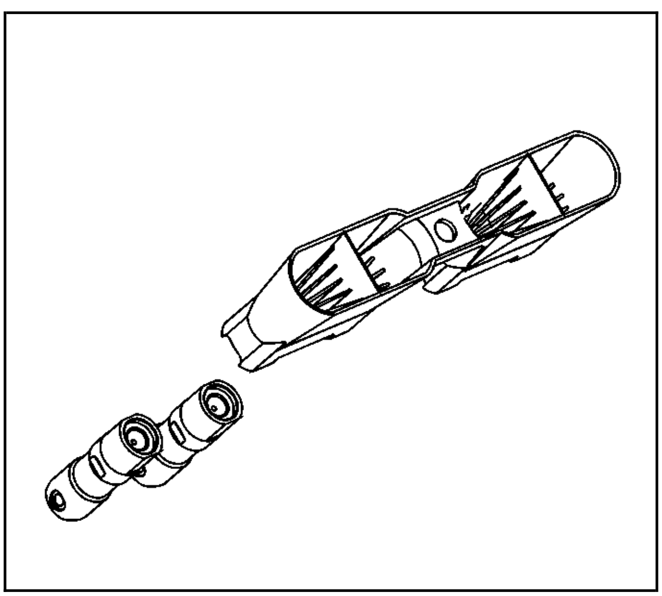
J 3049-A Valve Lifter Remover

1. Remove the valve lifter guide bolts (211).
2. Remove the valve lifters and guide.



Important: Some valve lifters may be stuck in their bores because of gum or varnish deposits.

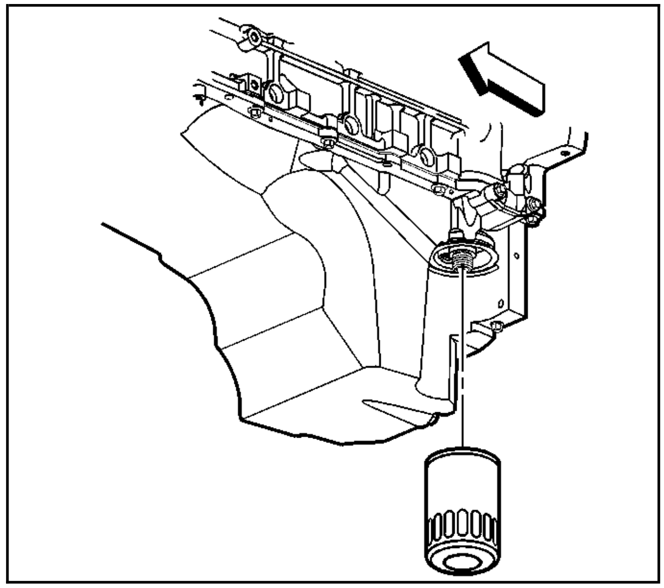
3. Use the *J 3049-A* or equivalent in order to remove the valve lifters, if required.



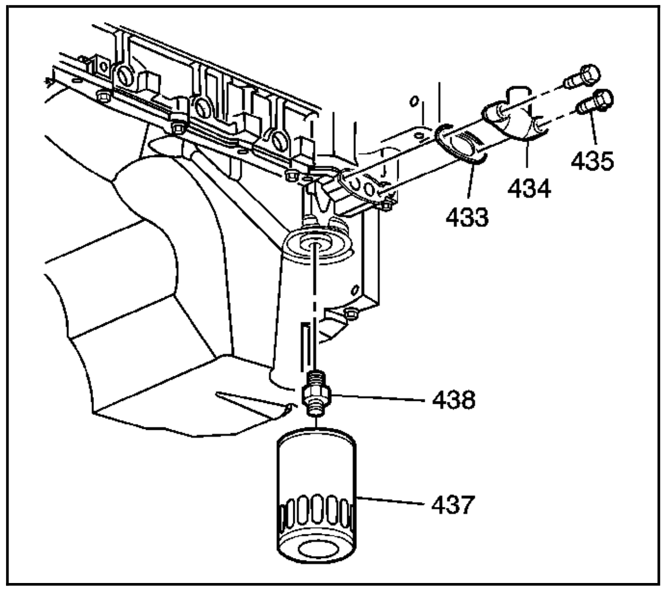
4. Remove the valve lifters from the guide.
5. Organize or mark the components so that they can be installed in the same location from which they were removed. Refer to *Separating Parts*.

Oil Filter, Adapter and Pan Cover Removal

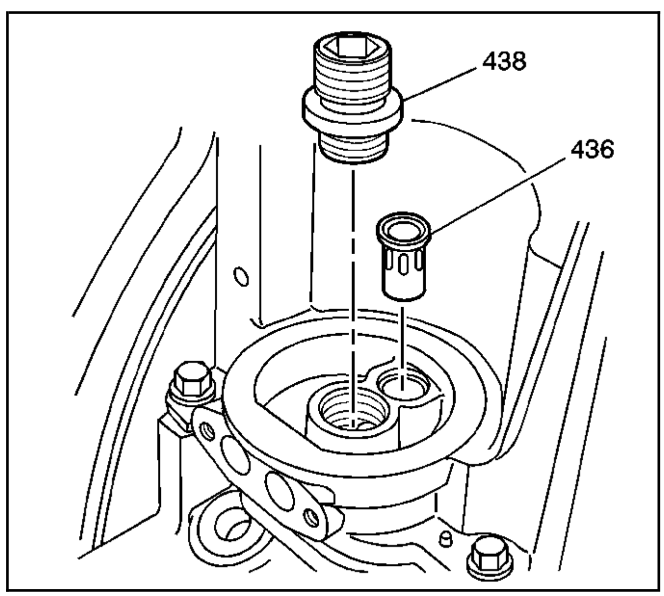
1. Remove the oil filter.



2. Remove the oil pan cover (434), bolts (435), and gasket (433).
3. Discard the gasket.



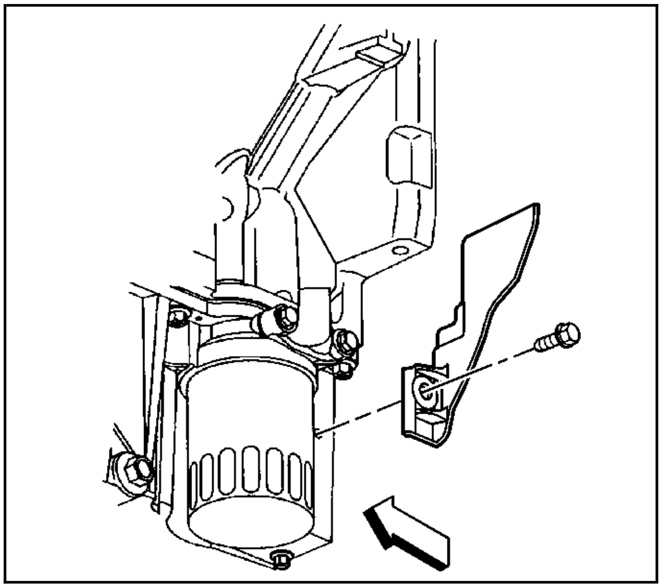
4. Remove the oil filter fitting (438) and bypass valve (436), if required.



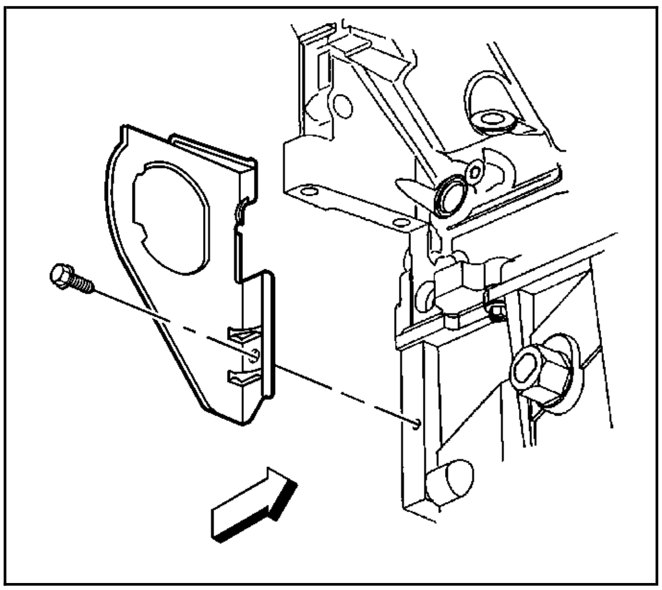
Oil Pan Removal

Important:

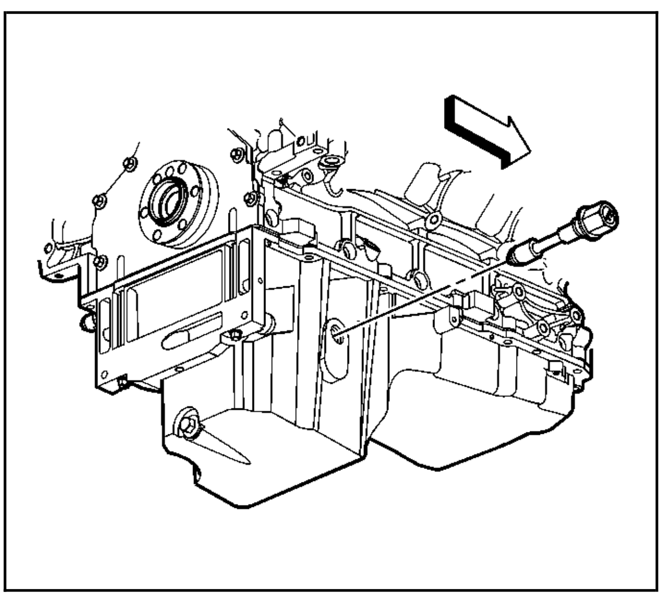
- The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing a new gasket, it is not necessary to install new oil pan gasket rivets.
- DO NOT use the oil pan gasket again. When installing the oil pan, install a NEW oil pan gasket.
- It is not necessary to remove the oil level sensor prior to oil pan removal. Remove the oil level sensor if service is required.



1. Remove the left closeout cover and bolt.

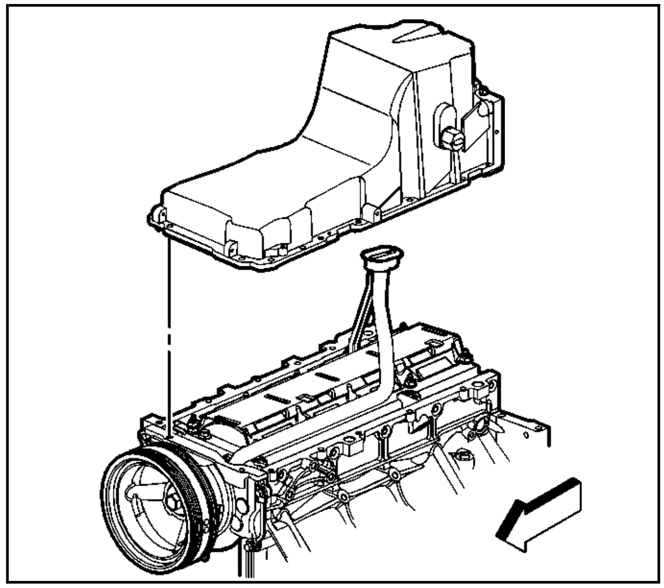


2. Remove the right closeout cover and bolt.



3. Remove the oil level sensor from the oil pan, if required.

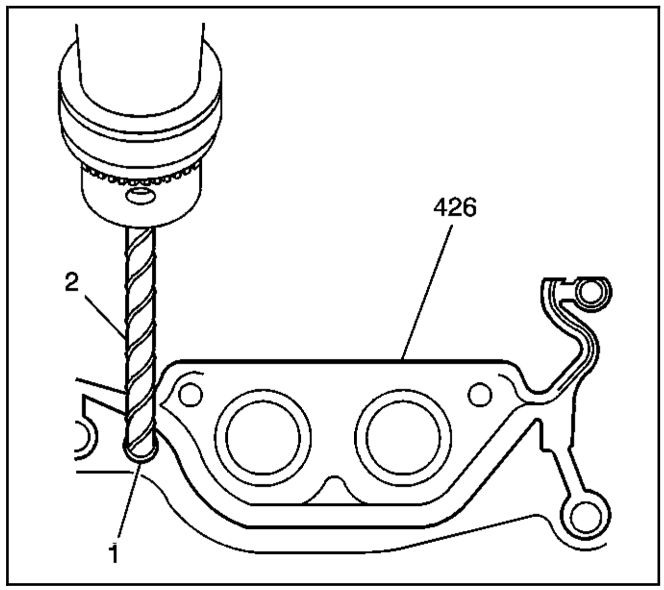
4. Remove the oil pan bolts.
5. Remove the oil pan.



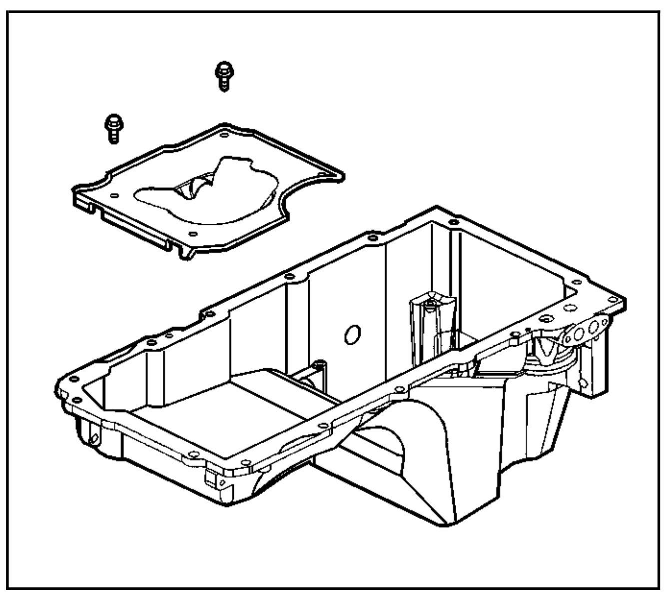
Important:

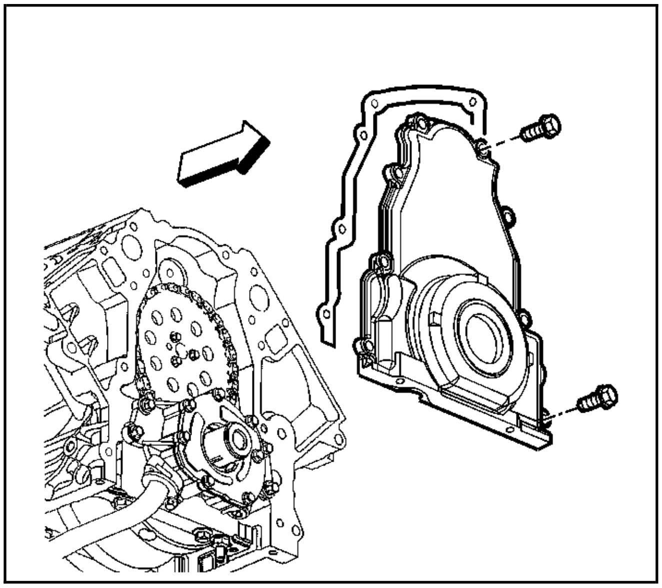
- DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.
- Use care not to gouge, score, or damage the oil pan sealing surface.

6. Drill (2) out the oil pan gasket retaining rivets (1), if required.
7. Remove the gasket (426) from the pan.
8. Discard the gasket and rivets.



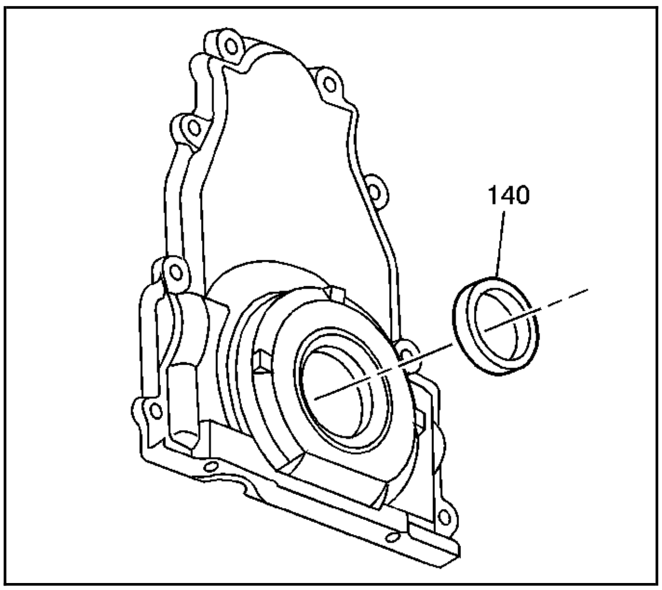
9. Remove the oil pan baffle bolts and baffle, if required.



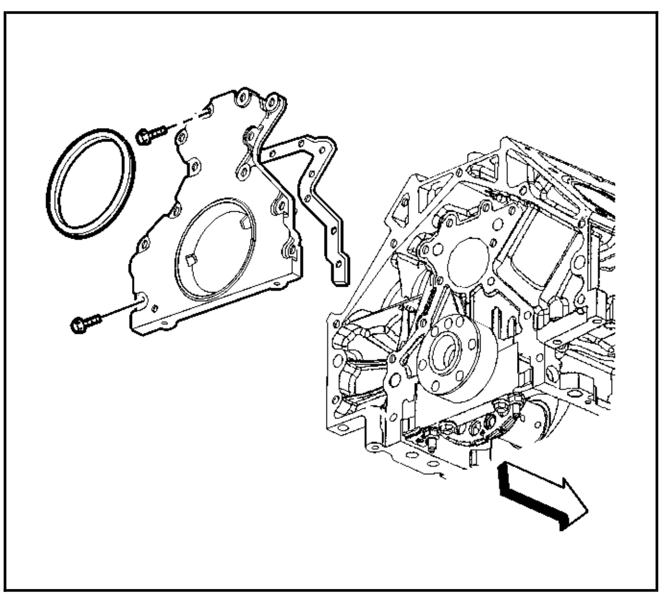


Engine Front Cover Removal

1. Remove the front cover bolts.
2. Remove the front cover and gasket.
3. Discard the front cover gasket.



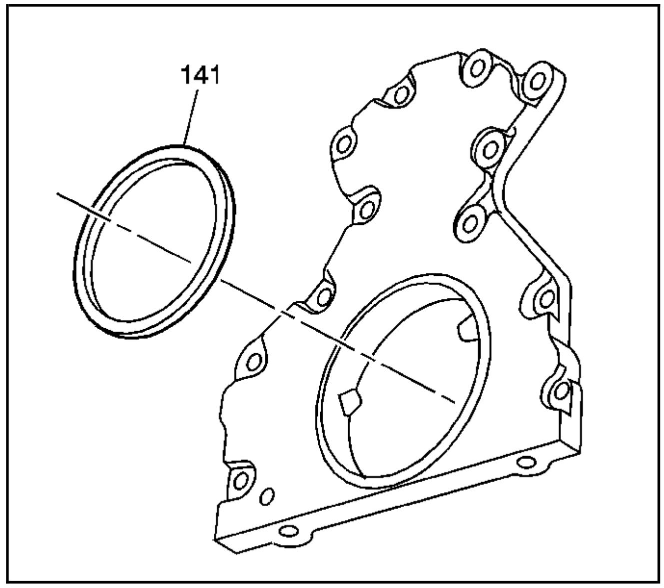
4. Remove the crankshaft front oil seal (140) from the cover.



Engine Rear Cover Removal

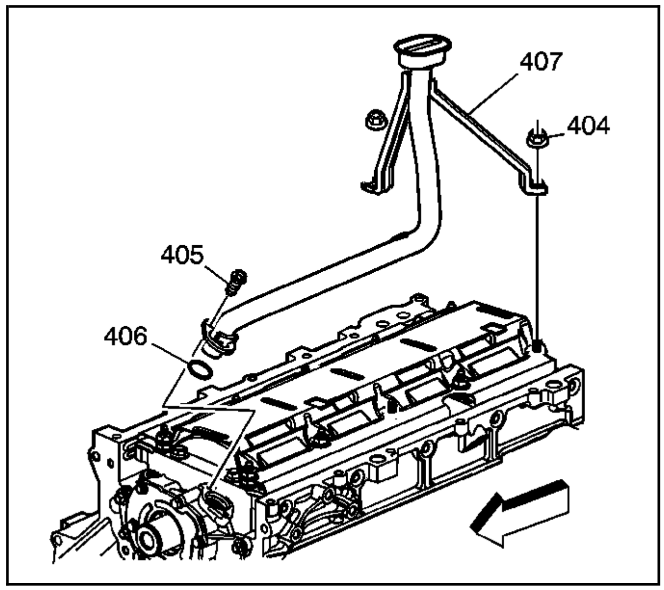
1. Remove the rear cover bolts.
2. Remove the rear cover and gasket.
3. Discard the rear cover gasket.

4. Remove the crankshaft rear oil seal (141) from the cover.

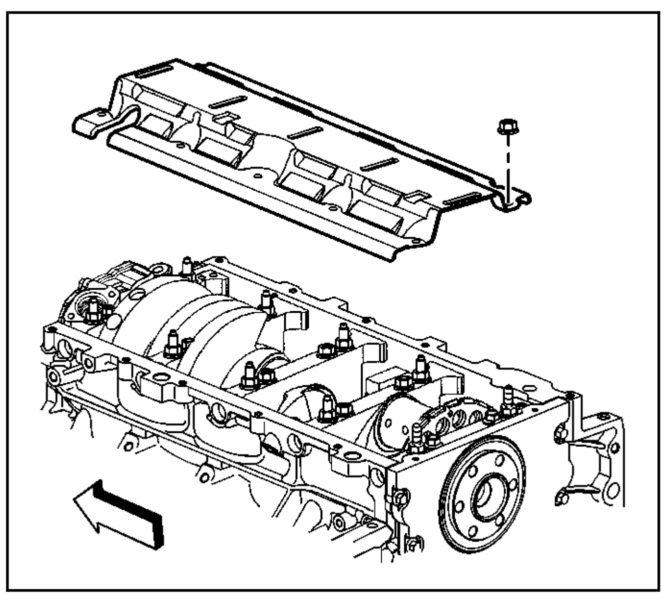


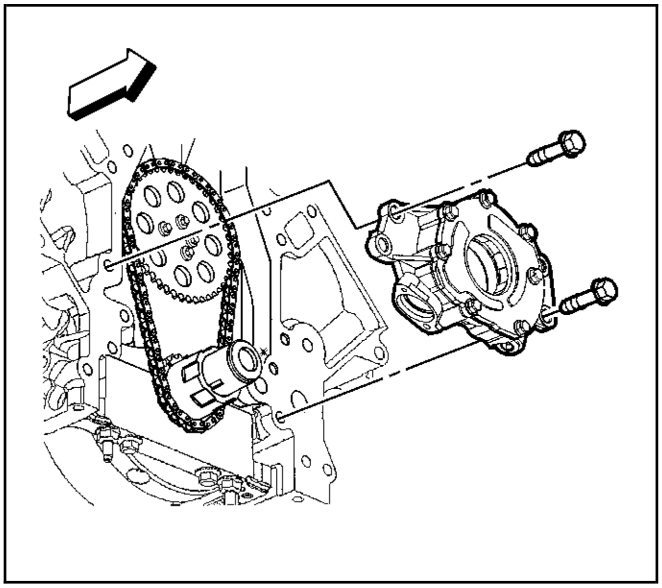
Oil Pump, Pump Screen and Deflector Removal

1. Remove the oil pump screen bolt (405) and nuts (404).
2. Remove the oil pump screen (407) with O-ring seal (406).
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.



5. Remove the remaining crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

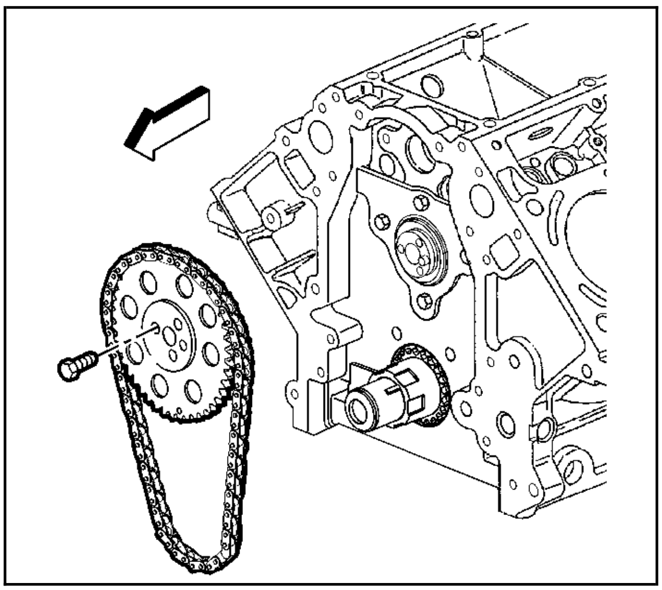




7. Remove the oil pump bolts.

Important: Do not allow dirt or debris to enter the oil pump assembly, cap ends as necessary.

8. Remove the oil pump.



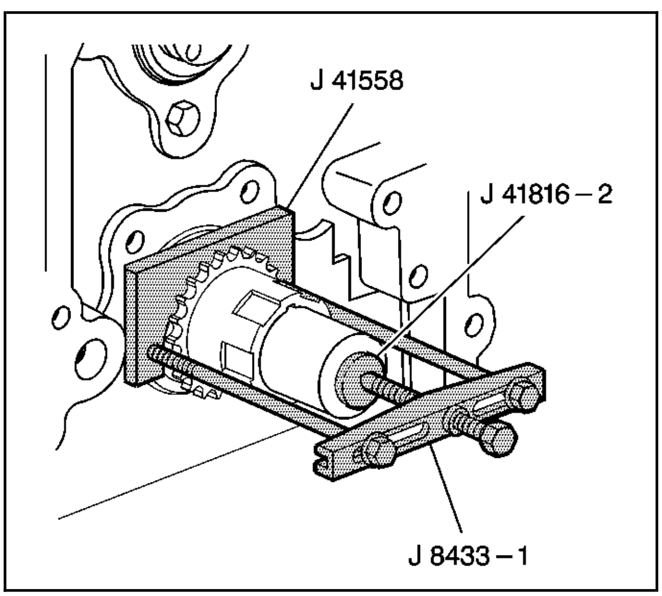
Timing Chain and Sprockets Removal

Tools Required

- *J 8433-1* Puller Bar
- *J 41558* Crankshaft Sprocket Remover
- *J 41816-2* Crankshaft End Protector

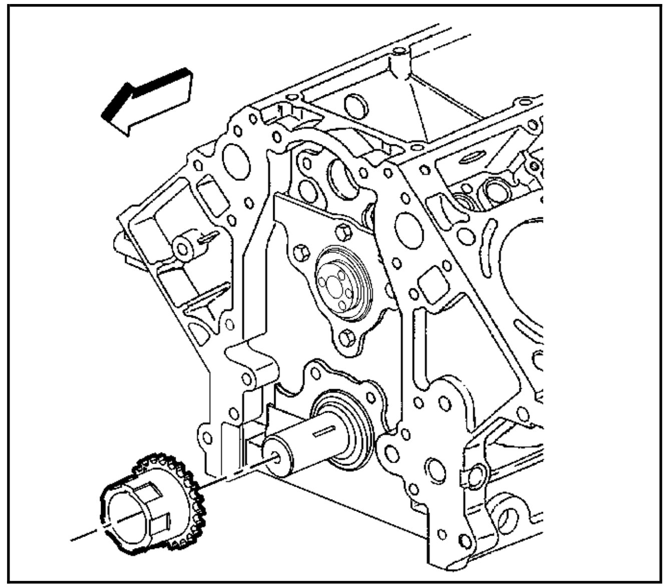
Notice: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

1. Remove the camshaft sprocket bolts.
2. Remove the camshaft sprocket and timing chain.

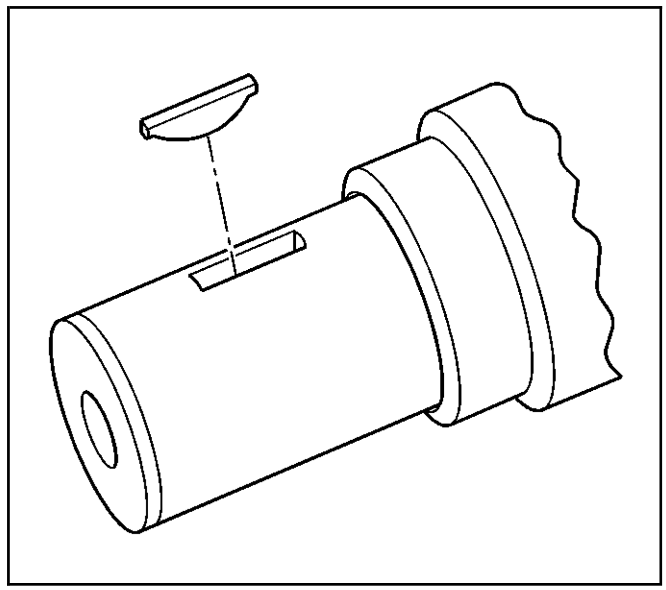


3. Use the *J 8433-1*, the *J 41816-2*, and the *J 41558* in order to remove the crankshaft sprocket.

4. Remove the crankshaft sprocket.

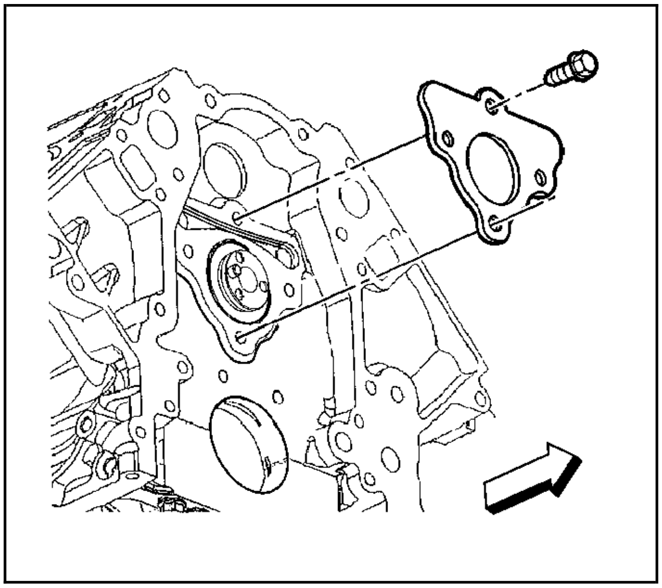


5. Remove the crankshaft sprocket key, if required.

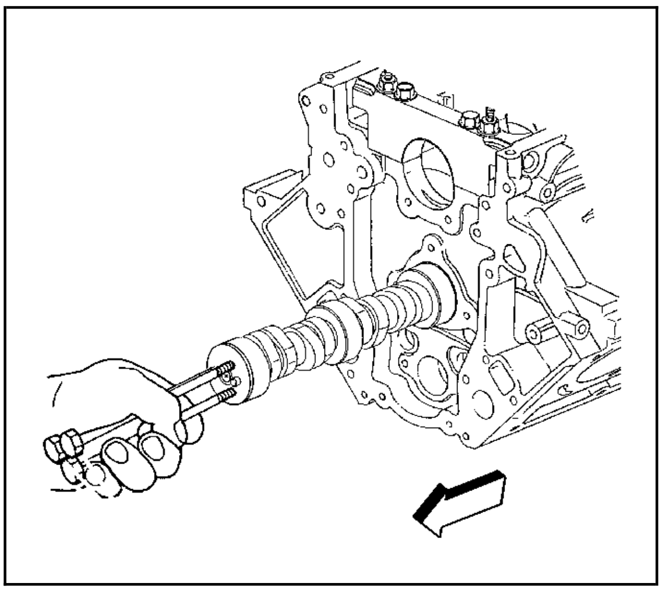


Camshaft Removal

1. Remove the camshaft position sensor bolt and the sensor.

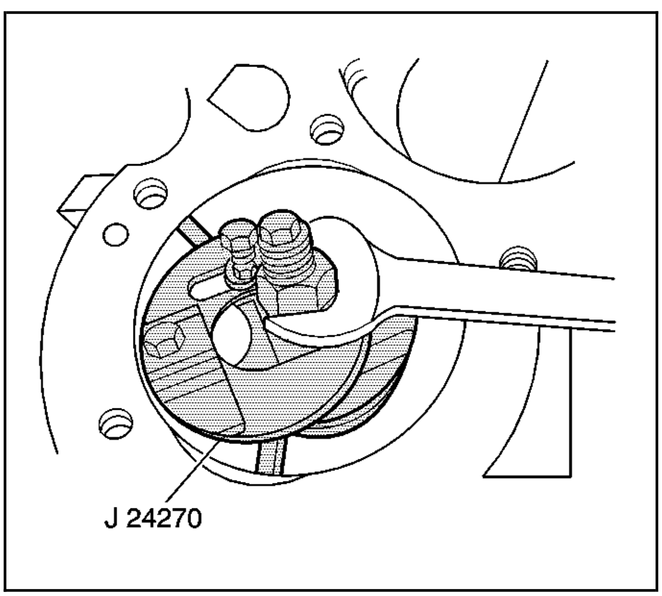


2. Remove the camshaft retainer bolts and the retainer.



Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Remove the camshaft.
   3.1. Install the 3 M8 – 1.25 x 100 mm bolts in the camshaft front bolt holes.
   3.2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
   3.3. Remove the bolts from the front of the camshaft.



Piston, Connecting Rod, and Bearing Removal

Tools Required

- *J 24270* Cylinder Bore Ridge Reamer
- *J 41556* Connecting Rod Guide

Important: The connecting rods and the bearing caps are NOT interchangeable.

1. Use the *J 24270* in order to remove the cylinder bore ring ridge, if required.
   1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
   1.2. Place a cloth on top of the piston.
   1.3. Use the *J 24270* or equivalent in order to remove a cylinder ring ridge.
   1.4. Turn the crankshaft so the piston is at the top of the stroke.

1.5. Remove the cloth.

1.6. Remove the cutting debris from the cylinder and piston.

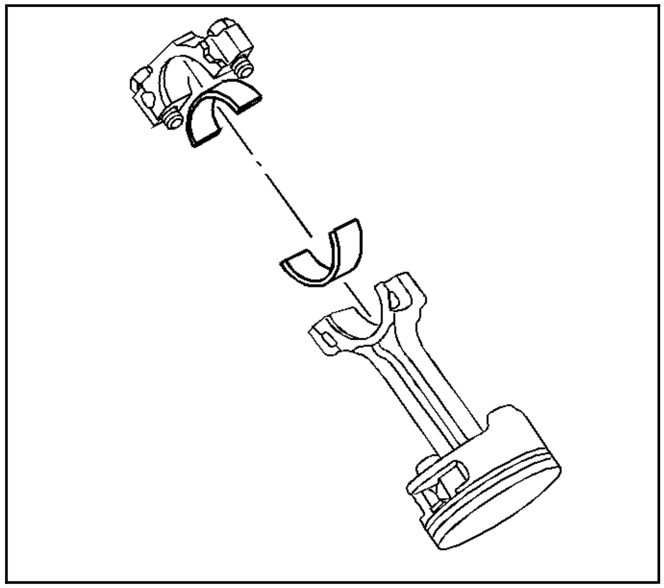
Important:

- Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
- A stamping mark on the side of the connecting rod, at the crank journal, may affect component geometry.
- Mark the top of the piston to the specific cylinder bore.

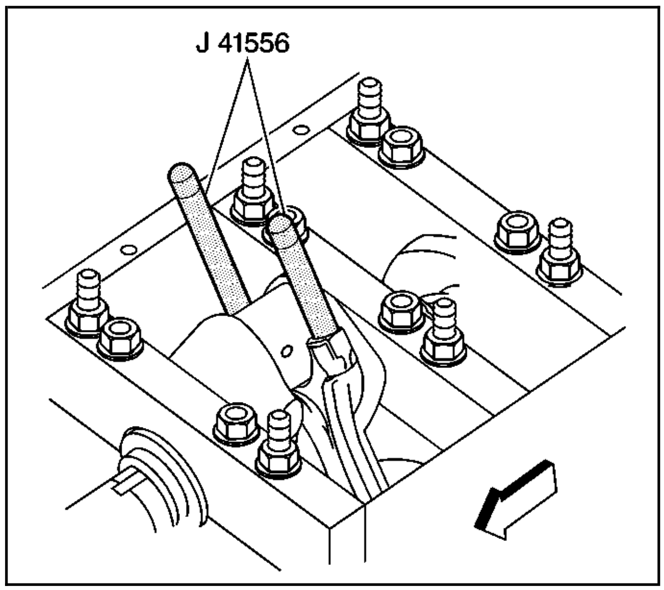
2. Remove the connecting rod bolts.

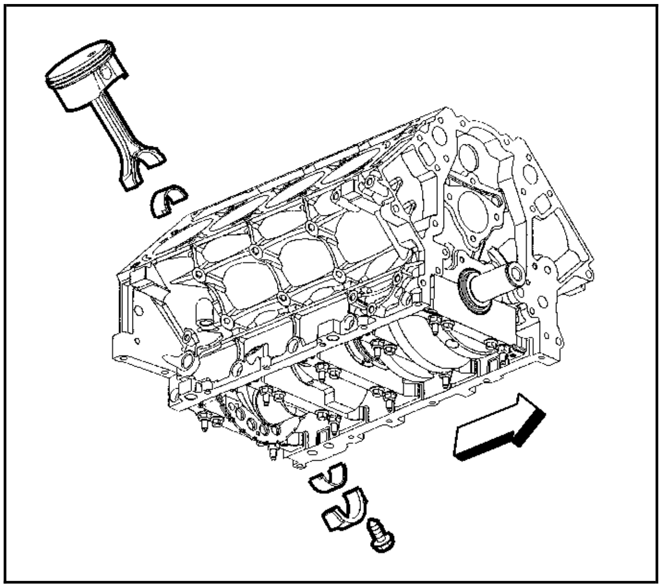
Important: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location.

3. Remove the connecting rod cap. Refer to *Separating Parts*.

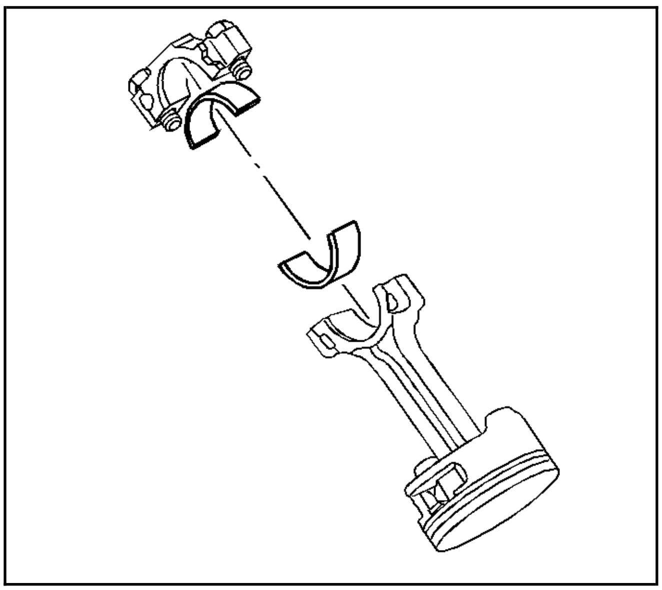


4. Install the *J 41556* to the connecting rod.

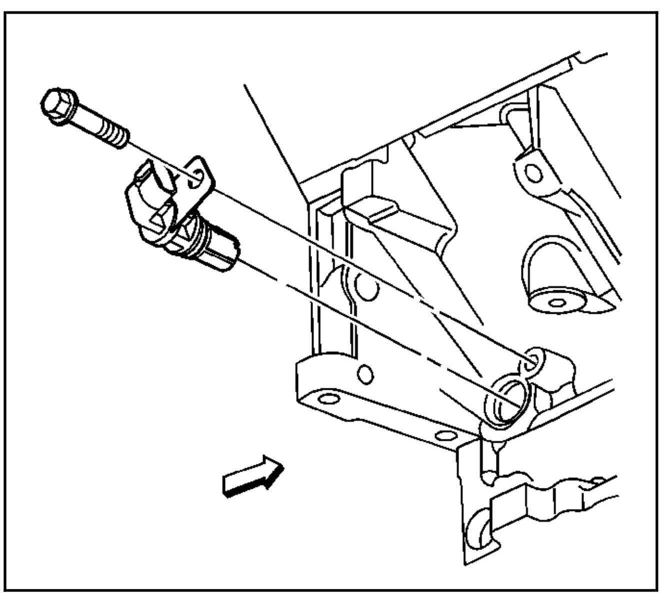




5. Use a hammer and tap lightly on the end of the *J 41556* in order to remove the piston and connecting rod assembly from the cylinder bore.



6. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.



Crankshaft and Bearings Removal

Tools Required

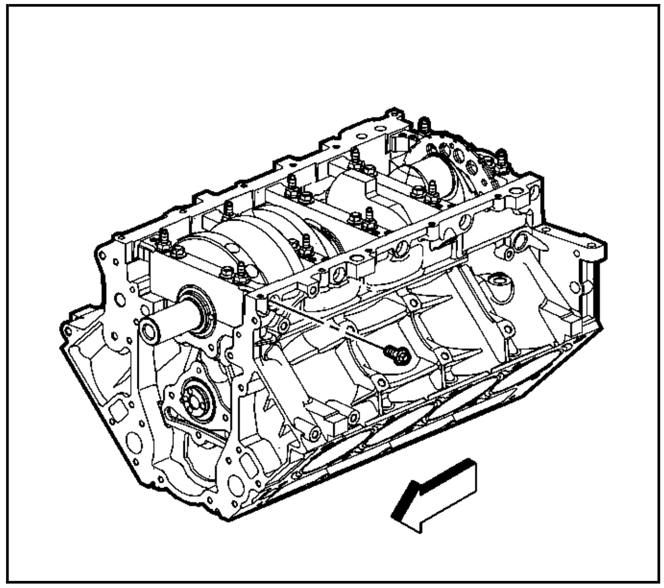
- *J 6125-1B* Slide Hammer
- *J 41818* Crankshaft Bearing Cap Remover

Important:

- The crankshaft bearing caps are machined with the engine block, for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps MUST be installed to their original position and direction.
- Do not use the bearing cap M8 side bolts again.
- Remove the bearing cap M8 side bolts prior to cap removal.

1. Remove the crankshaft position sensor bolt.
2. Remove the crankshaft position sensor.

3. Remove the crankshaft bearing cap M8 side bolts.
4. Remove the bearing cap M10 bolts and bolt/studs. Note the M10 bolt/stud locations.

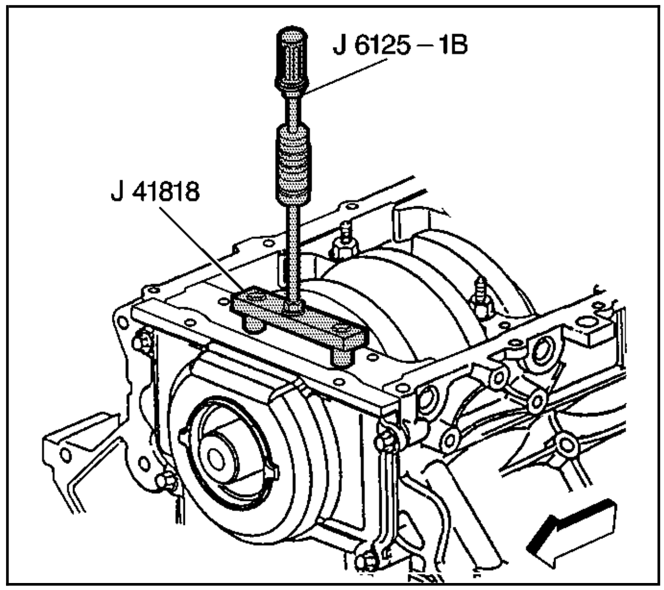


Notice: Refer to *Fastener Notice* in Cautions and Notices.

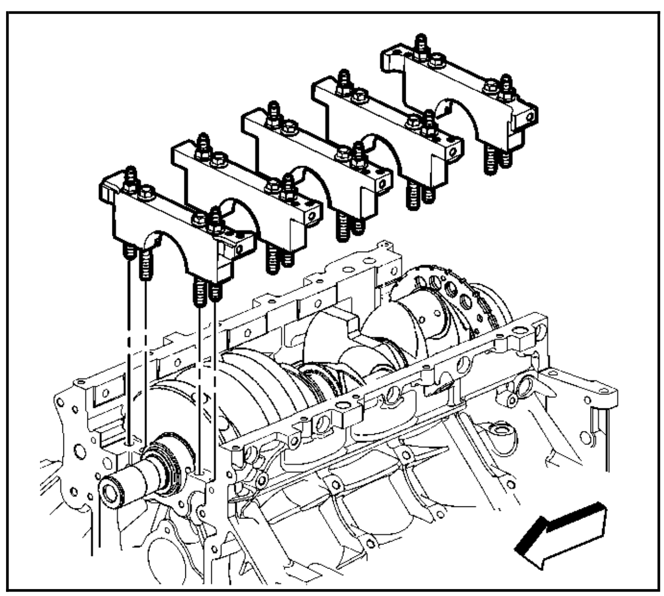
5. Install the *J 41818*.

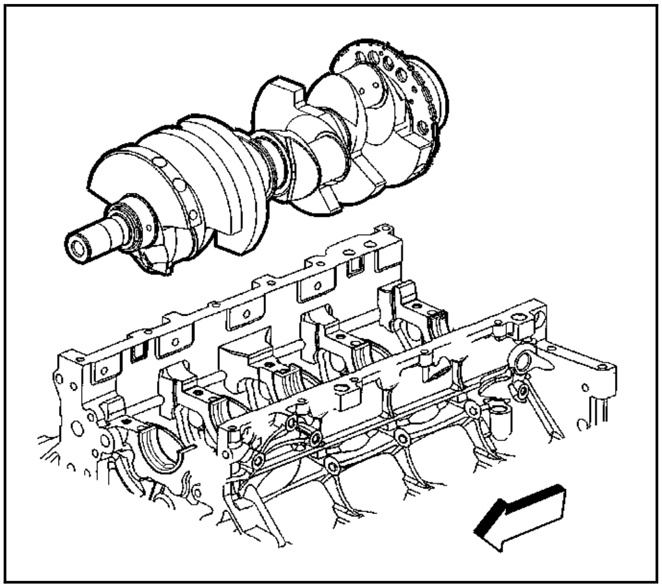
   Tighten

   Tighten the *J 41818* bolts to 11 N·m (100 lb in).
6. Install the *J 6125-1B* to the *J 41818* in order to remove the crankshaft bearing caps.

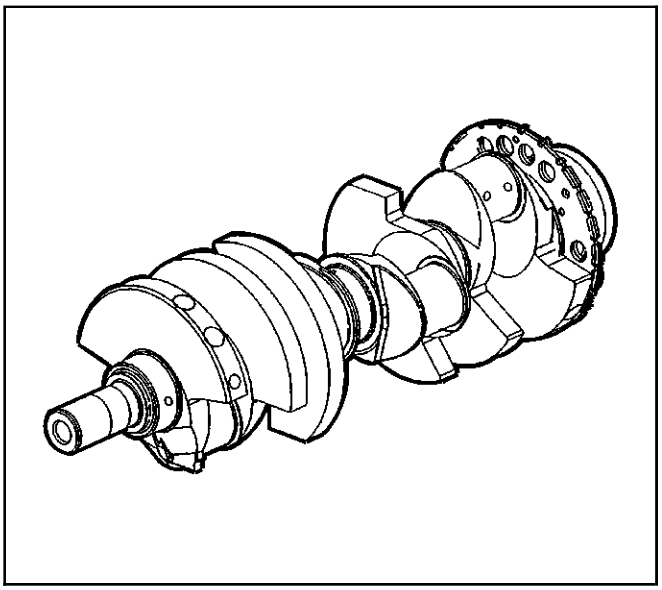


7. Remove the bearing caps.



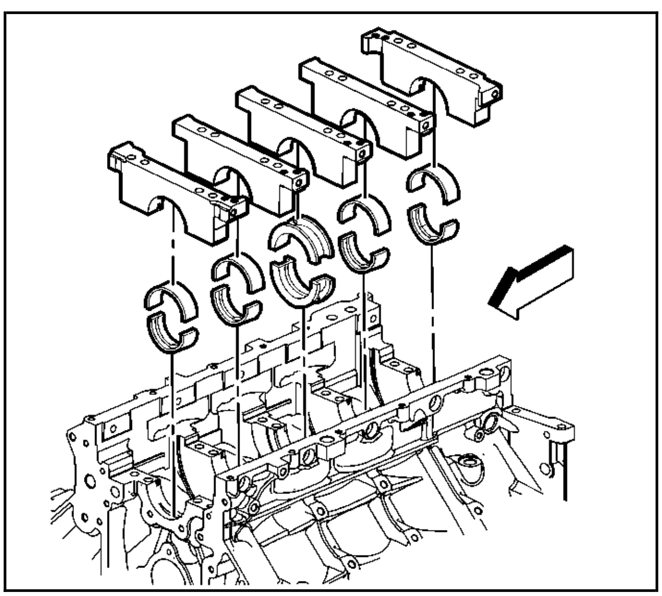


8. Remove the crankshaft.



Important: Use care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may effect On-Board Diagnostics (OBD) II system performance.

9. Lay the crankshaft onto two wooden V blocks or other protective surface.



10. Remove the crankshaft bearings from the bearing caps and the engine block.
11. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to *Separating Parts*.

Engine Block Plug Removal

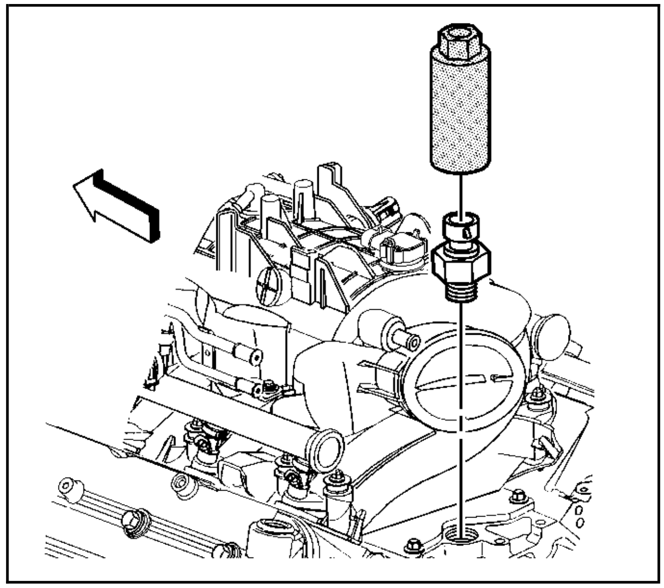
Tools Required

J 41712 Oil Pressure Switch Socket

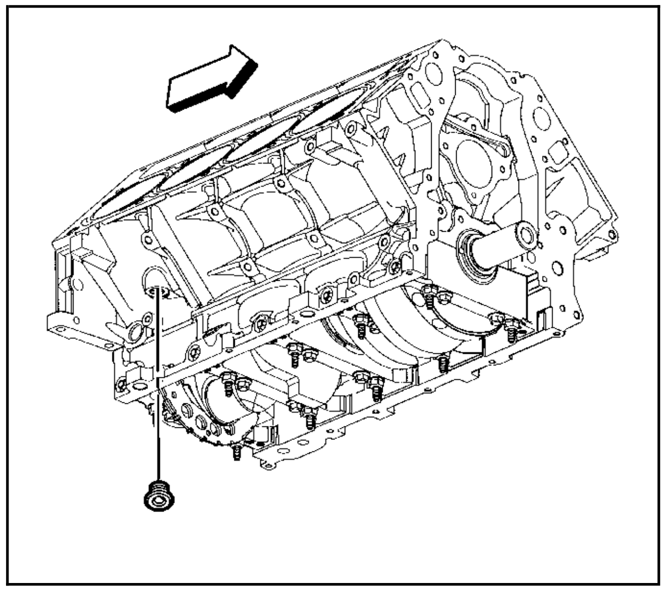
Important:

- Do not remove the engine block front oil gallery plug unless service is required.
- If the front oil gallery plug is removed for service, a NEW oil gallery plug must be installed.

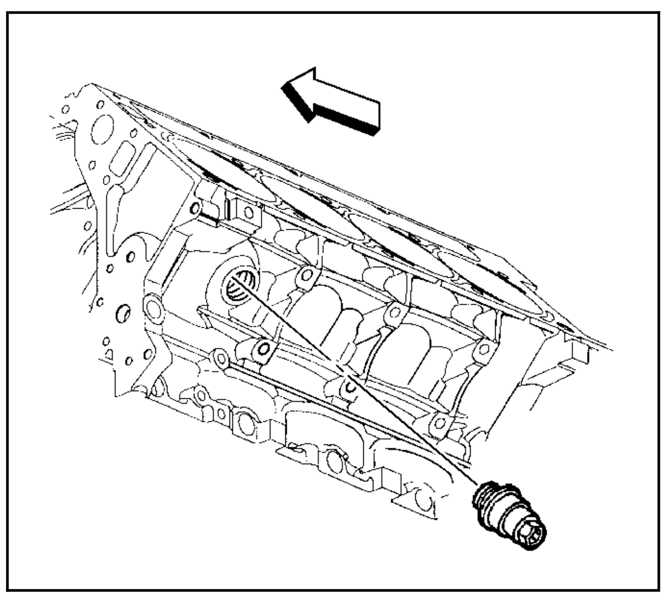
1. Remove the oil pressure sensor, if not previously removed, using the *J 41712* or equivalent.

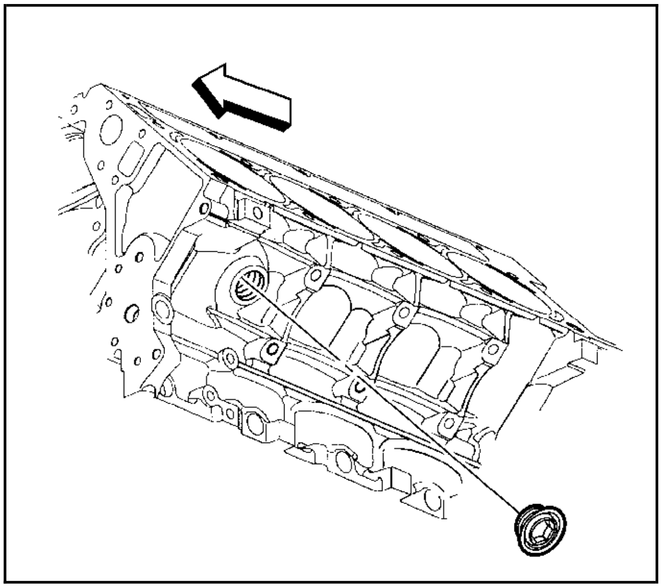


2. Remove the engine block right rear coolant plug.

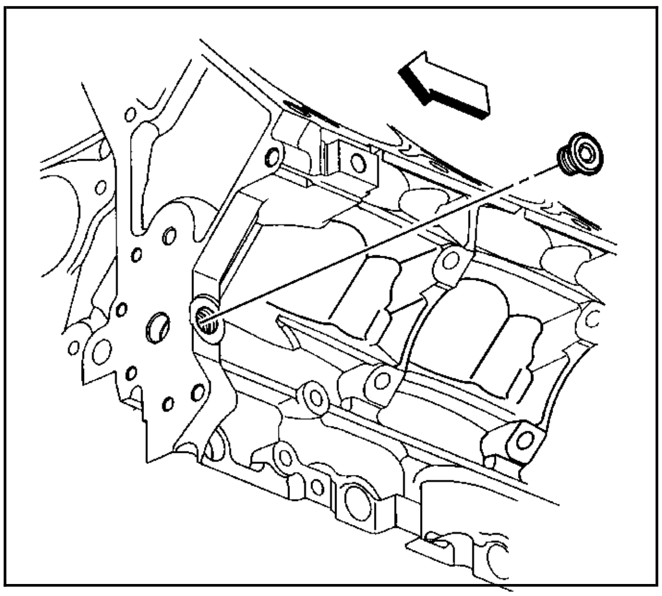


3. Remove the engine block coolant heater, if applicable.

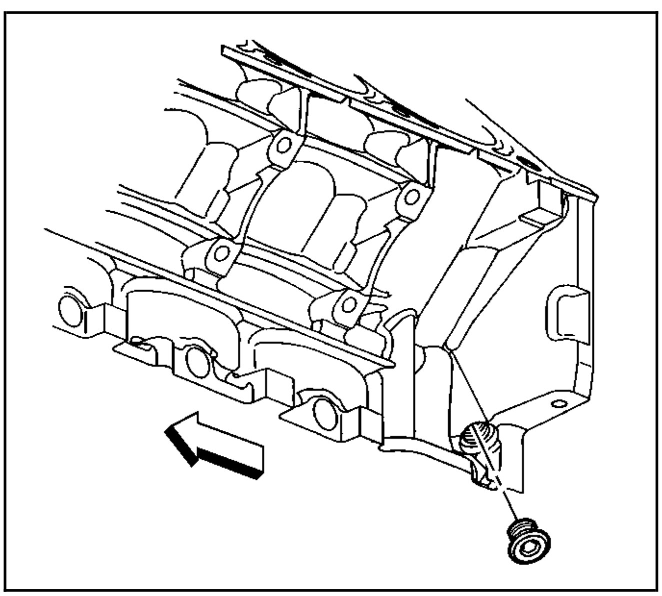




4. Remove the engine block left front coolant plug, if applicable.



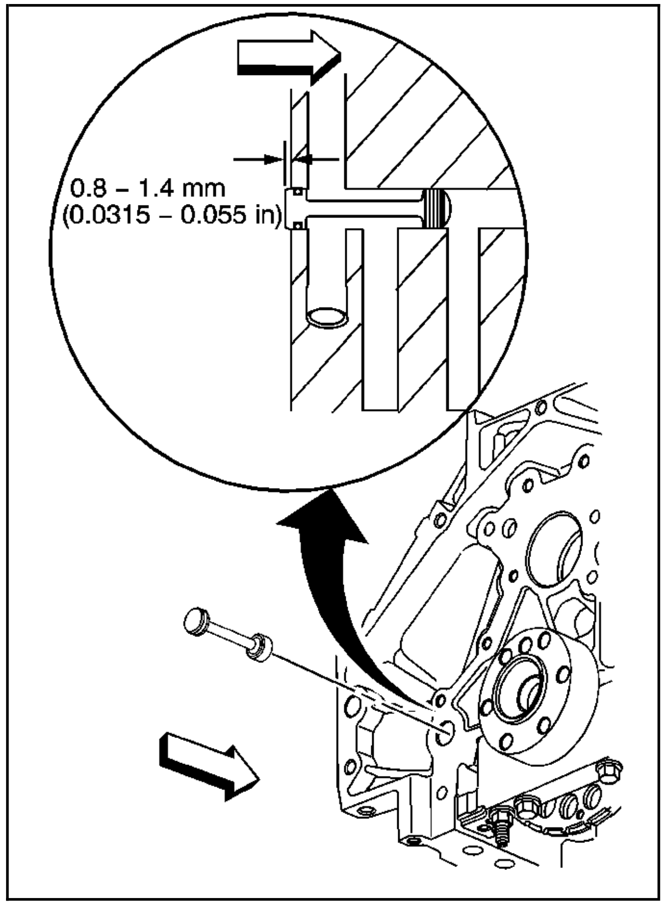
5. Remove the engine block left front oil gallery plug.



6. Remove the engine block left rear oil gallery plug.
7. Inspect the block plug sealing washers.

   If the block plug and heater sealing washers are not damaged, they may be used during assembly.

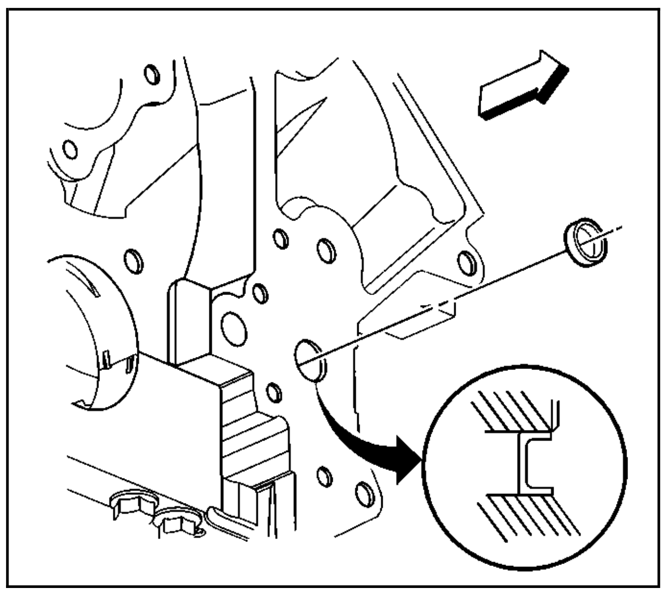
8. Remove the engine block rear oil gallery plug.
9. Inspect the O-ring seal of the rear oil gallery plug.
   If the O-ring seal is not cut or damaged, the plug and O-ring seal may be use during assembly.

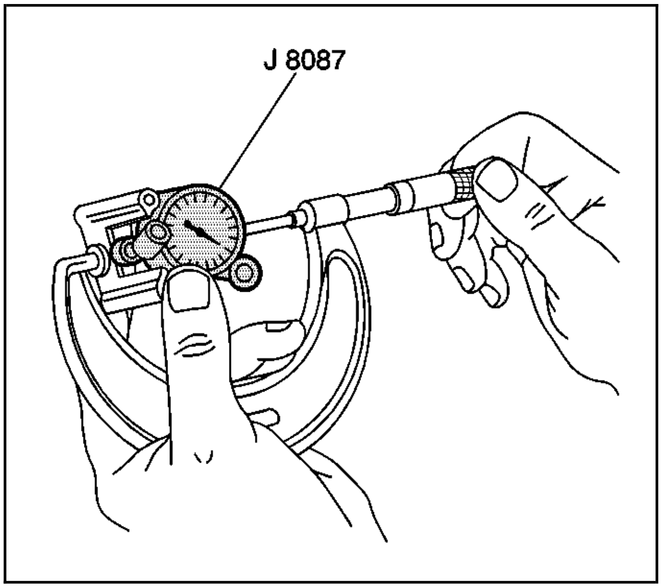


Important:

- Remove the front oil gallery plug only if service is required.
- If the front oil gallery plug is removed, a NEW oil gallery plug must be installed.

10. Remove the engine block front oil gallery plug.





Engine Block Cleaning and Inspection

Tools Required

- *J 8087* Cylinder Bore Gage
- *J 42385-100* Head/Main Bolt Thread Repair Kit

1. Clean the following areas:

Notice: Do not use a caustic solution to clean the aluminum engine block.

Important: When cleaning the engine block in a thermal type oven, do not exceed 450°F (232°C).

   - The engine block in the solvent, to remove all sludge, dirt, or debris

     Refer to *Cleanliness and Care*.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

   - Dry the block with compressed air.
   - The gasket surfaces

     Refer to *Replacing Engine Gaskets*.
   - The coolant passages
   - The oil galleries
   - The main bearing caps
   - The engine block cylinder head bolt holes for threadlocking material

     Thread repair driver tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Inspect the following areas:
   - The cylinder walls for excessive scratches, gouging, or ring ridge
   - The cylinder bores for excessive ring ridge at the top of the cylinder
   - The coolant jacket for cracks
   - The valve lifter bores for excessive scoring or wear
   - The crankshaft bearing webs for cracks
   - The gasket sealing surfaces for excessive scratches or gouging

     Refer to *Replacing Engine Gaskets*.
   - The oil galleries for restrictions
   - All threaded bolt holes for damage
3. Measure the following areas:
   - The cylinder bores for taper
   - The cylinder bores for excessive ring ridge at the top of the cylinder

Measuring the Cylinder for Taper, Out-of-Round, and Oversize

1. Adjust the micrometer to a dimension slightly smaller than the bore size.

   Adjust the micrometer to 96.0 mm (3.78 in) for 4.8 liter engines.

Adjust the micrometer to 101.62 mm (4.0 in) for 6.0 liter engines.

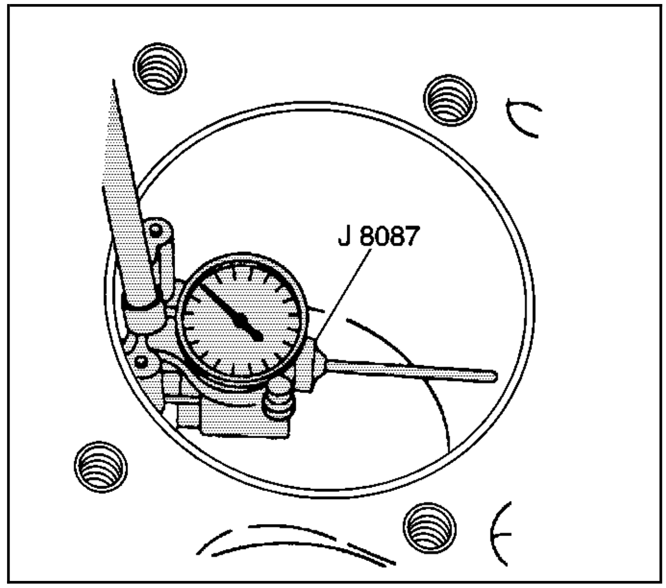
2. Insert the *J 8087* into the micrometer and zero the *J 8087* dial.
3. Using a *J 8087*, measure the cylinder bore for taper, out-of-round, and oversize.

   Slide the *J 8087* up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center, and bottom of the bore.

   A 4.8L cylinder bore that measures 96.000–96.018 mm (3.779–3.78 in) may be honed and serviced with a standard size piston.

   A 6.0 L cylinder bore that measures 101.618–101.636 mm (4.0007–4.0014 in) may be honed and serviced with a standard size piston.

   A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston.

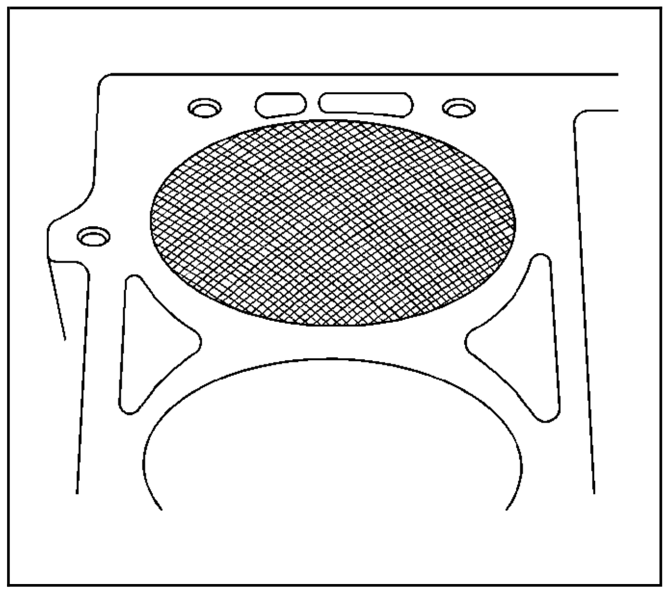


Cylinder Boring and Honing

Boring Procedure

Important: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available for the 4.8/6.0 liter engines.

1. Measure all pistons with a micrometer to determine the cylinder bore diameter.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block removing any dirt or burrs. If you do not inspect the cylinder block, the boring bar may be improperly positioned, tilted, and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.



Honing Procedure

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with

fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.

2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly inspect the cylinder bore for fit with the selected piston.

   All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100 grit stone.

4. Perform final cylinder honing with a 240 grit stone and obtain a 45 degree cross hatch pattern.

   A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.

5. When honing to eliminate taper in the cylinder, make full strokes the complete length of the bore.

   Repeatedly observe the measurement at the top, the middle, and the bottom of the bore.

6. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.

7. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.

8. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.

9. After final honing and before the piston is inspected for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.

10. Perform final measurements of the piston and the cylinder bore.

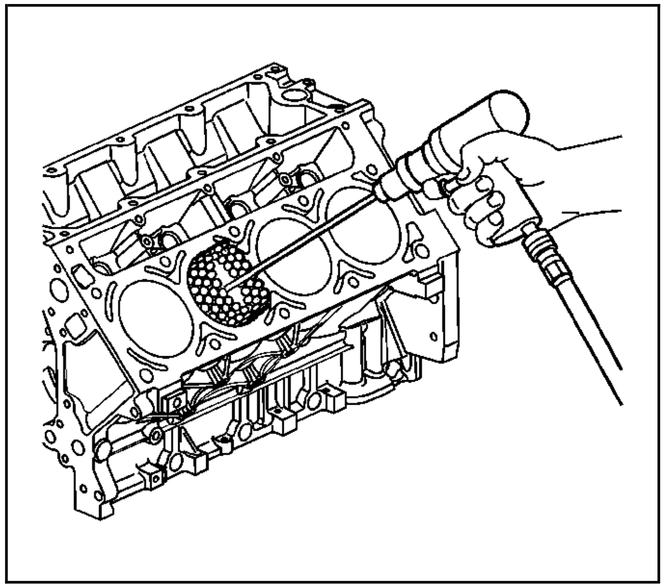
11. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.

12. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure

Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240 grit stone of silicone carbide or equivalent material when preforming the deglazing procedure.

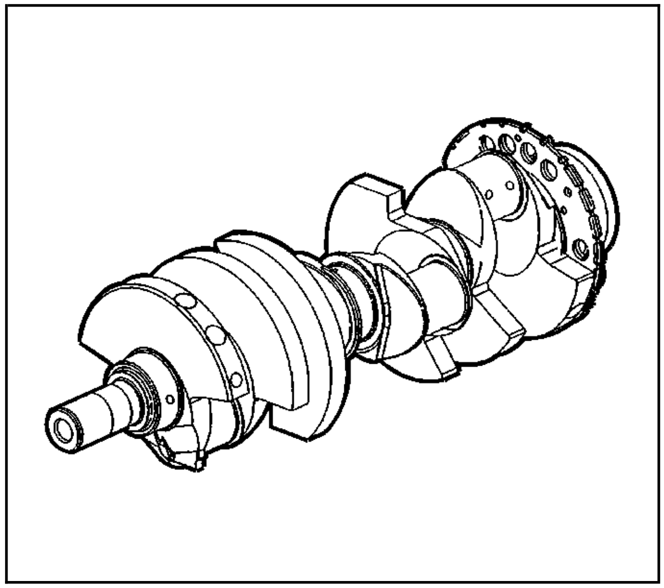
A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.



Crankshaft and Bearings Cleaning and Inspection

Tools Required

- *J 6125-1B* Slide Hammer
- *J 7872* Magnetic Base Dial Indicator Set
- *J 41818* Crankshaft Bearing Cap Remover
- *J 43690* Rod Bearing Checking Tool
- *J 43690-100* Rod Bearing Checking Tool – Adapter Kit
- *J 45059* Angle Meter



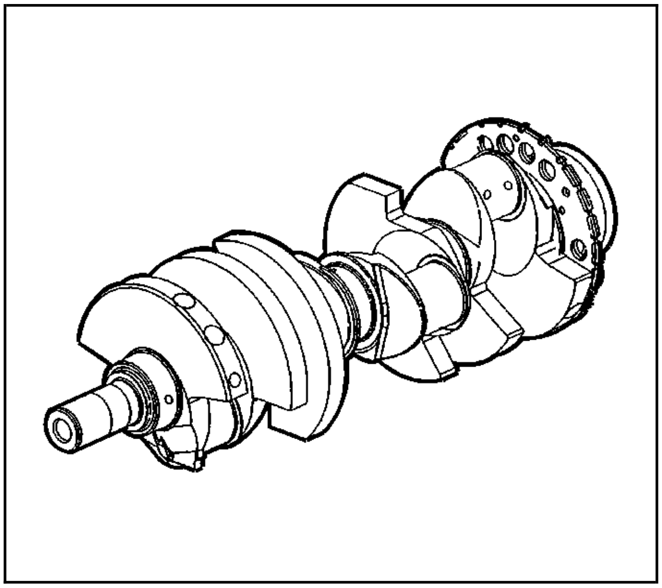
Cleaning Procedure

Important: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may effect On-Board Diagnostics (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the crankshaft with compressed air.

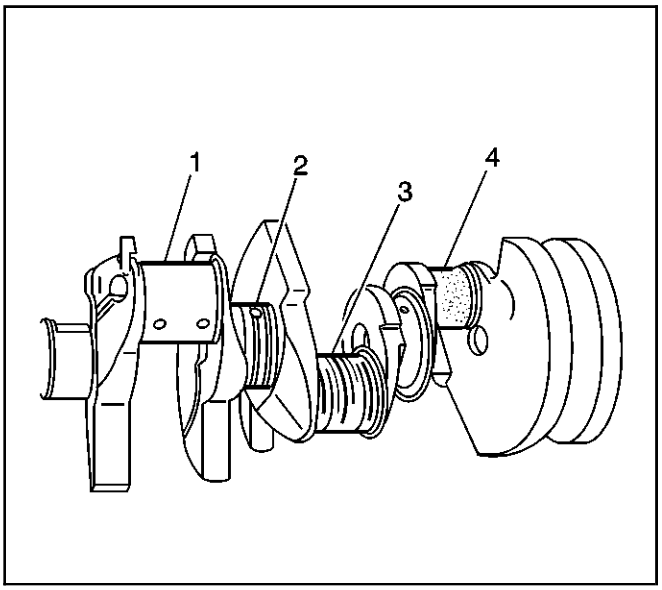


Inspection Procedure

Important: The reluctor ring teeth should not have imperfections on the rising or falling edges.

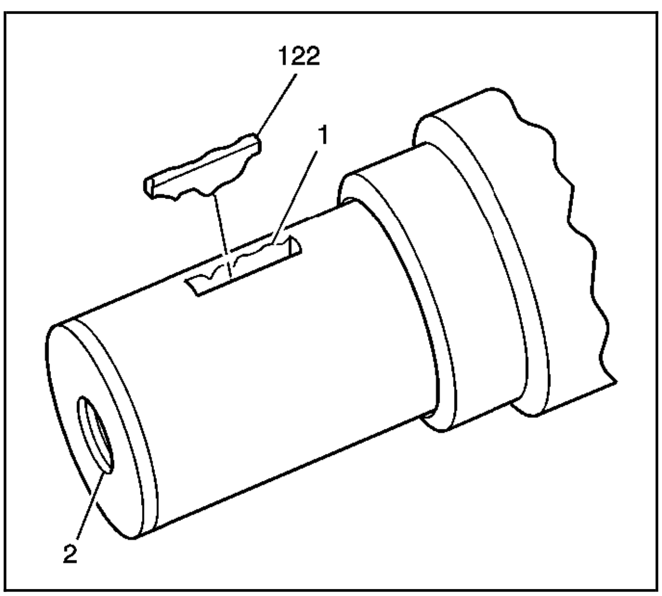
Imperfections of the reluctor ring teeth may effect OBD II system performance.

1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the crankshaft position reluctor ring lobes for damage.



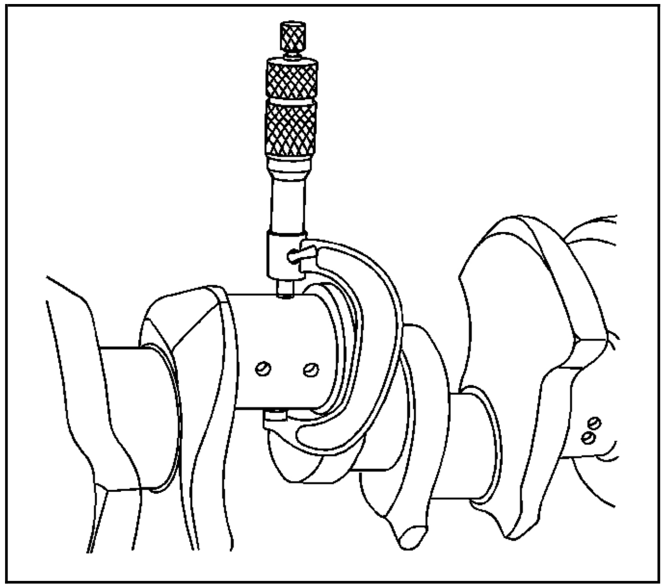
3. Inspect the crankshaft journals for wear (1).

   Journals should be smooth with no signs of scoring, wear, or damage.
4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded bearing material (4).



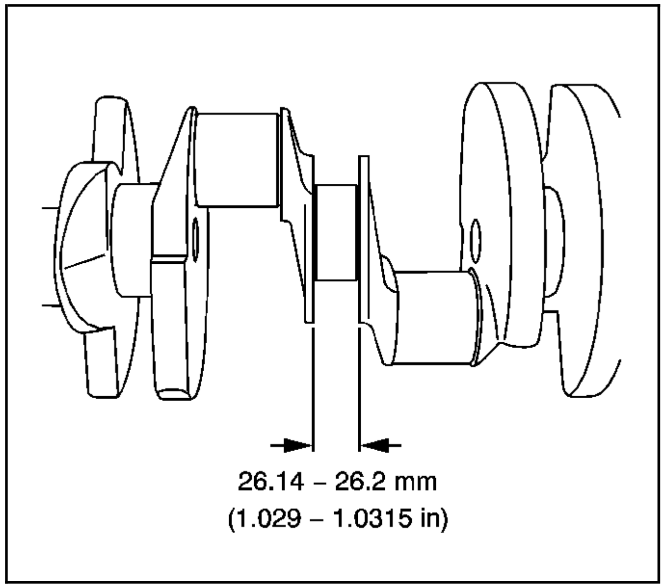
7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

8. Measure the crankpins for the out-of-round.
9. Measure the crankpins for taper.



10. Measure the crankshaft thrust wall width.

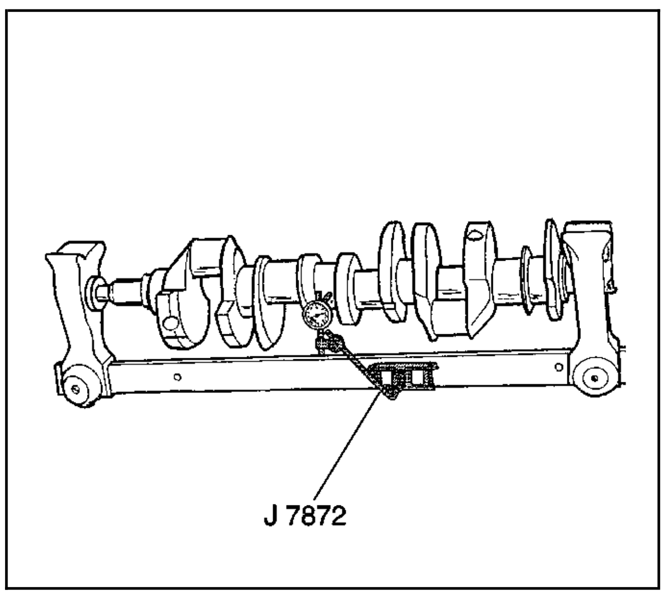
    A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.

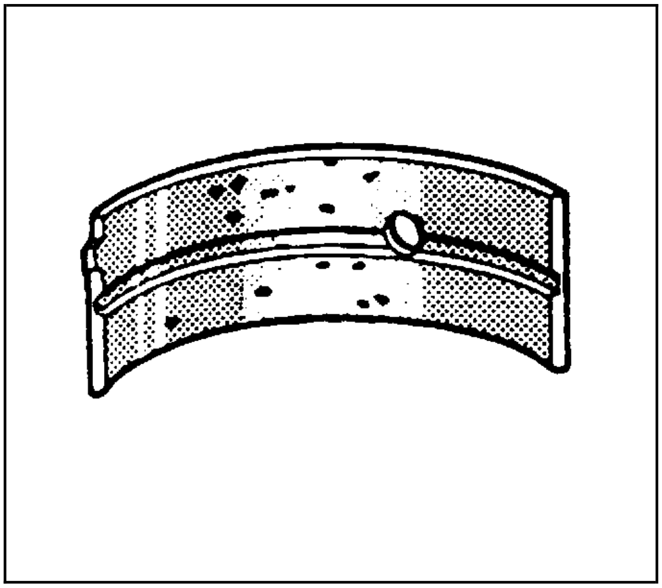


11. Measure the crankshaft runout.

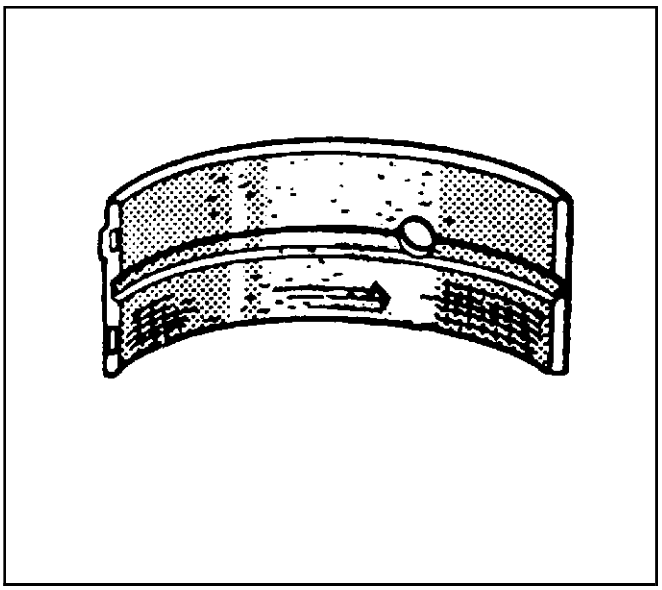
    Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.
12. Use the *J 7872* in order to measure the crankshaft runout at the front and rear intermediate journals.
13. Use the *J 7872* in order to measure the runout of the crankshaft rear flange.
14. Use the *J 7872* in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

    If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.

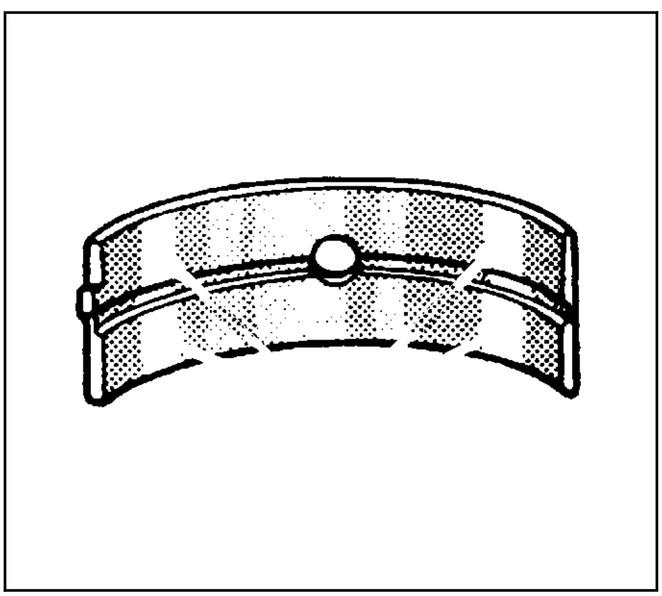




15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



16. Inspect the crankshaft bearings for excessive scoring or discoloration.
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



18. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

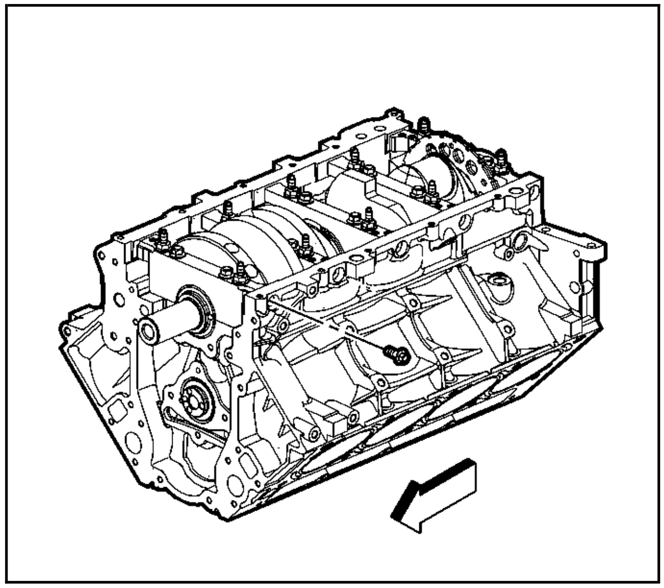
    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Measuring Main Bearing Clearance – Gaging Plastic Method

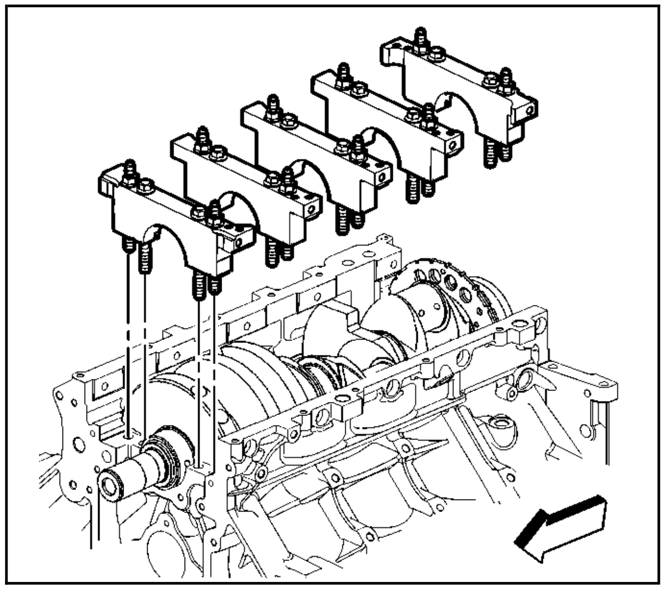
Important:

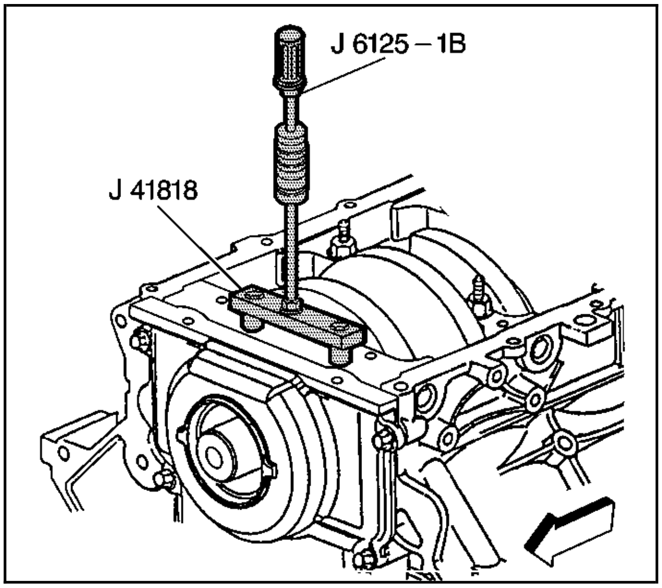
- The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.
- Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.
- The crankshaft bearing clearances are critical. Excessive bearing clearance may effect crankshaft position sensor signals and may effect On-Board Diagnostics (OBD) II system operation.
- Remove the bearing cap side bolts prior to cap removal.

1. Remove the bearing cap M8 side bolts.



2. Remove the bearing cap M10 bolts and studs.



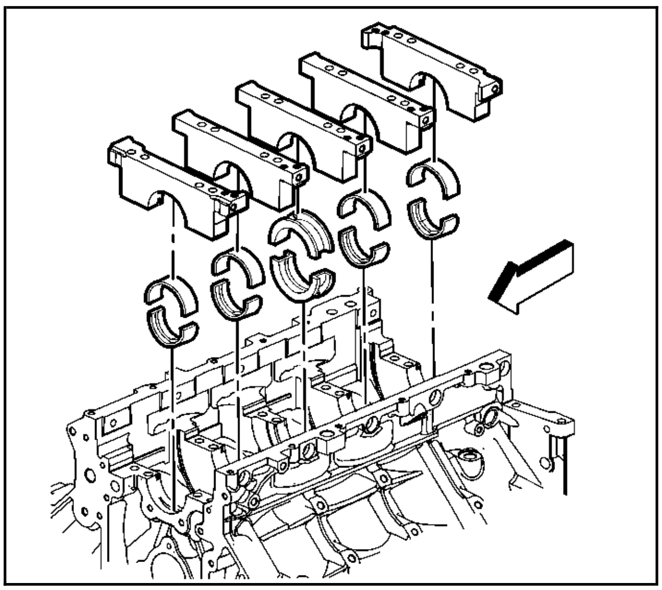


Notice: Refer to *Fastener Notice* in Cautions and Notices.

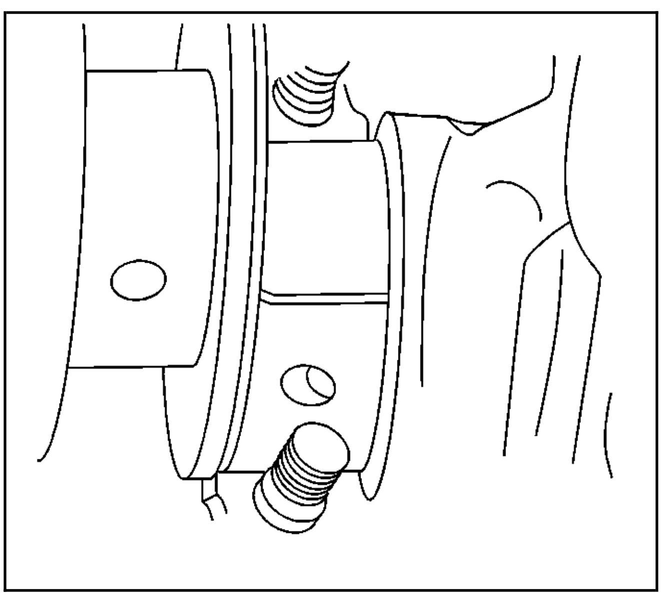
3. Install the *J 41818* to the bearing cap.

   Tighten

   Tighten the *J 41818* bolts to 11 N·m (100 lb in).
4. Install the *J 6125-1B* to the *J 41818* in order to remove the bearing cap.



5. Remove the bearing cap and lower bearing.



6. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of crankshaft bearing journal.

7. Install the bearing, bearing cap, bolts and bolt/studs.

Tighten

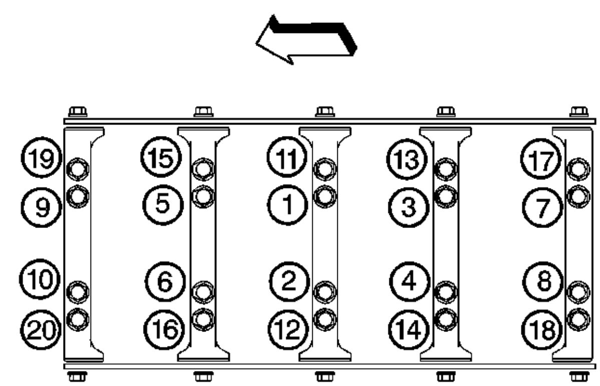
7.1. Tighten the inner bolts (1–10) a first pass in sequence to 20 N·m (15 lb ft).

7.2. Tighten the inner bolts (1–10) a final pass in sequence to 80 degrees using the *J 45059*.

7.3. Tighten the outer bolt/studs (11–20) a first pass in sequence to 20 N·m (15 lb ft).

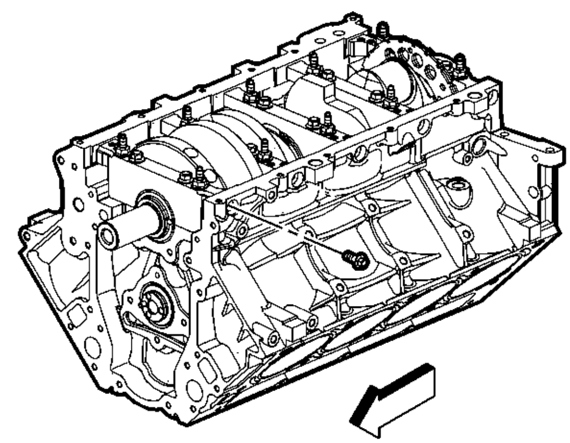
7.4. Tighten the outer bolt/studs (11–20) a final pass in sequence to 53 degrees using the *J 45059*.

7.5. Tighten the side cap bolts to 25 N·m (18 lb ft).
Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.

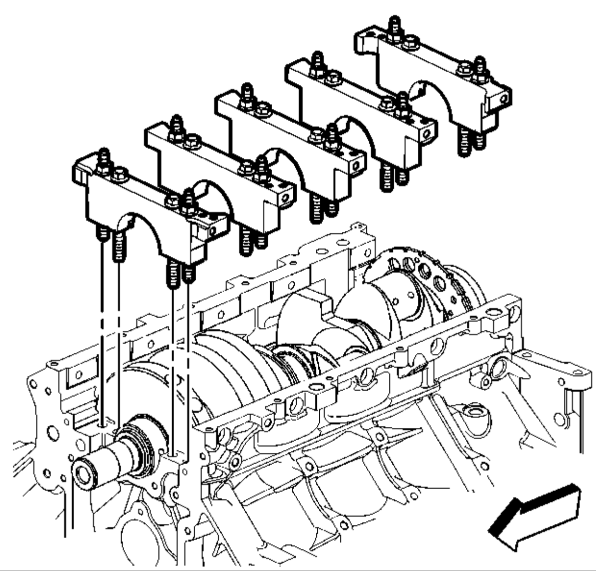


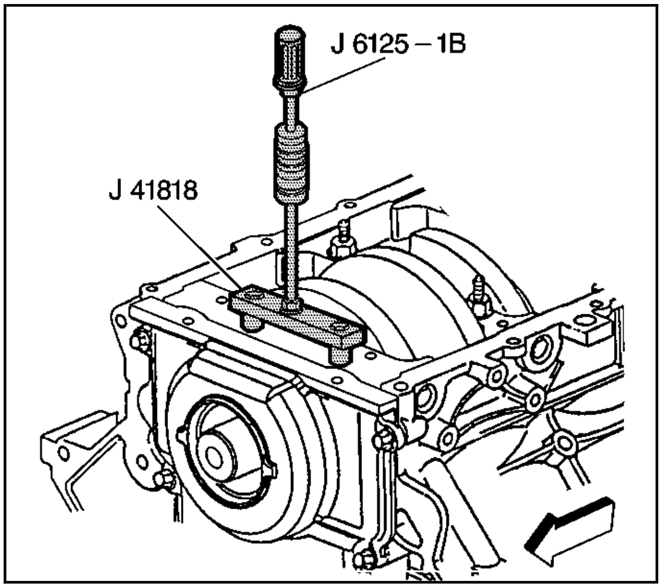
Important: Remove the bearing cap side bolts prior to cap removal.

8. Remove the bearing cap M8 side bolts.

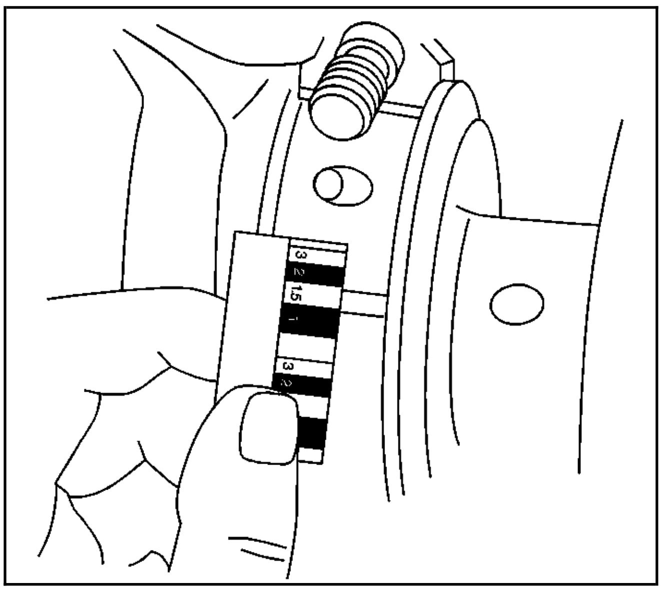


9. Remove the bearing cap bolts and bolt/studs.

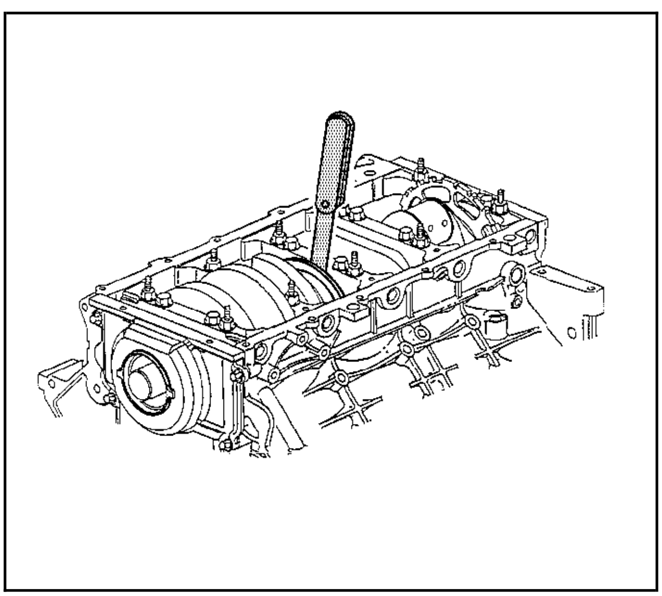




10. Use the *J 41818* and the *J 6125-1B* in order to remove the bearing cap.



11. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.
    - If the gaging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
    - If the bearing clearance is greater than 0.065 mm (0.0025 in), select and install an undersized bearing set, and measure the clearance with gaging plastic.
    - If clearance cannot be brought to specifications, replace the crankshaft or grind the crankshaft for use with the next undersized bearing.



12. Measure the crankshaft end play.
    12.1. Thrust the crankshaft forward or rearward.
    12.2. Insert a feeler gage between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.
    The proper crankshaft end play clearance is 0.04–0.2 mm (0.0015–0.0078 in).
    12.3. If the bearing clearance is not within specifications:
    - Inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.
    - Replace the thrust bearings and measure the end play.

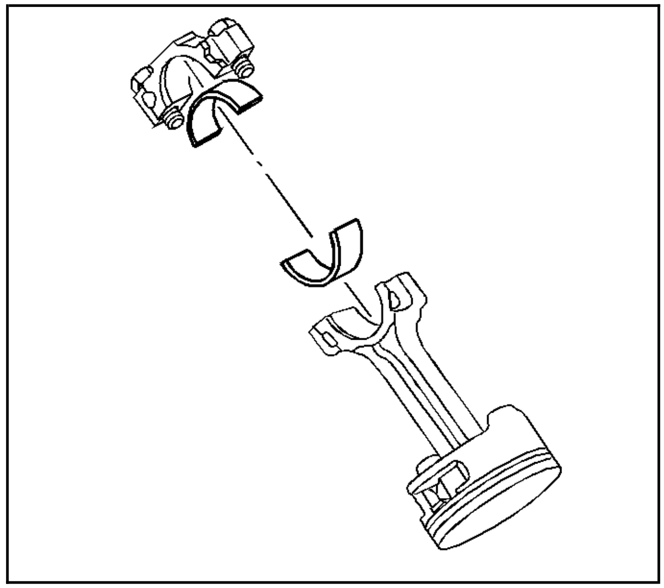
- If the correct measurements cannot be obtained, repair the crankshaft thrust surfaces or replace the crankshaft.

Measuring Connecting Rod Bearing Clearance – Gaging Plastic Method

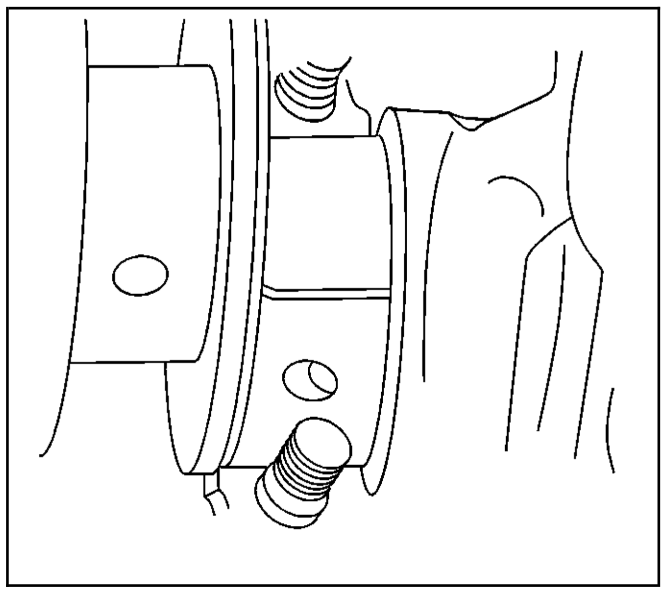
Important:

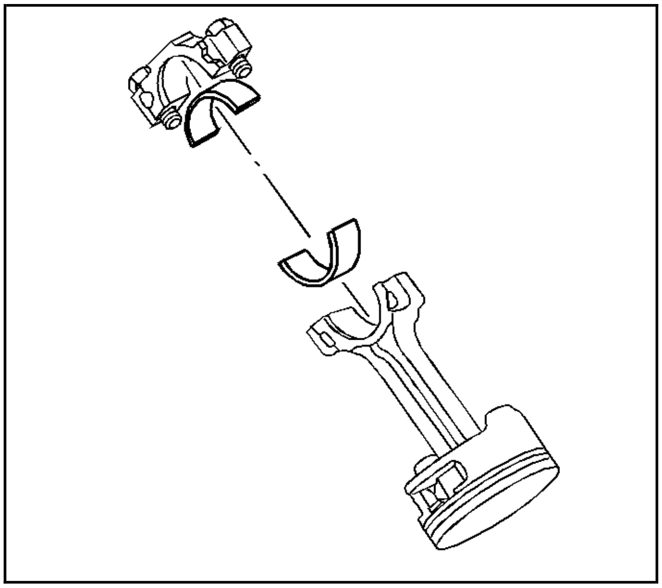
- Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required.
- Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.

1. Remove the bearing cap, bearing half and bolts.



2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.





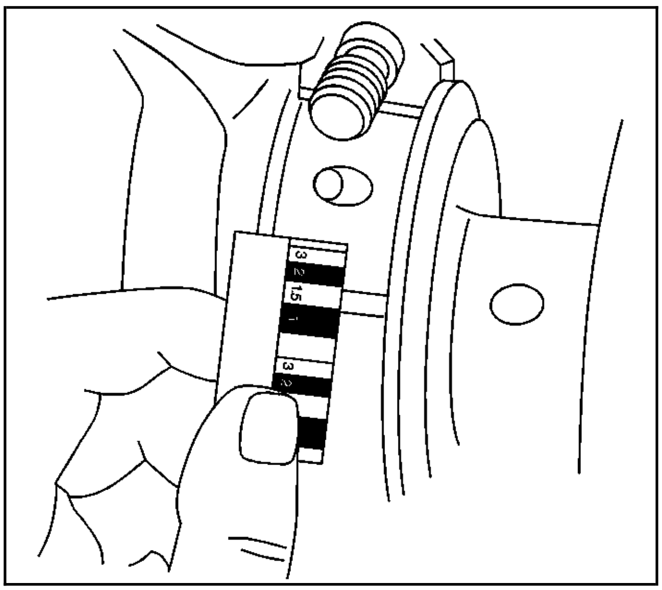
3. Install the bearing cap, bearing, and bolts.

   Tighten

   3.1. Tighten the connecting rod bolts first pass to 20 N·m (15 lb ft).

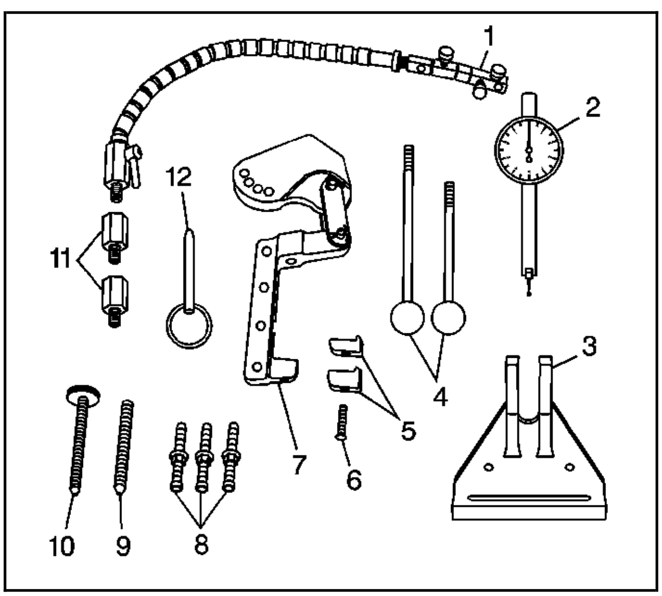
   3.2. Tighten the connecting rod bolts a final pass to 75 degrees using the *J 45059*. Refer to *Piston, Connecting Rod, and Bearing Installation*.

4. Remove the bearing cap, bearing, and bolts.



5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.

   The connecting rod bearing clearance should be 0.023–0.076 mm (0.0009–0.003 in).



Measuring Connecting Rod Bearing Clearance – Using J 43690/J 43690-100

J 43690 and *J 43690-100* have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

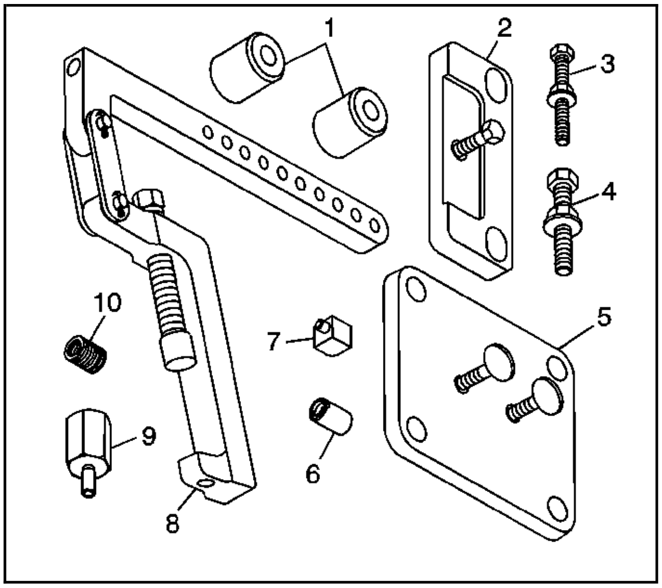
J 43690 Rod Bearing Checking Tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)

- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

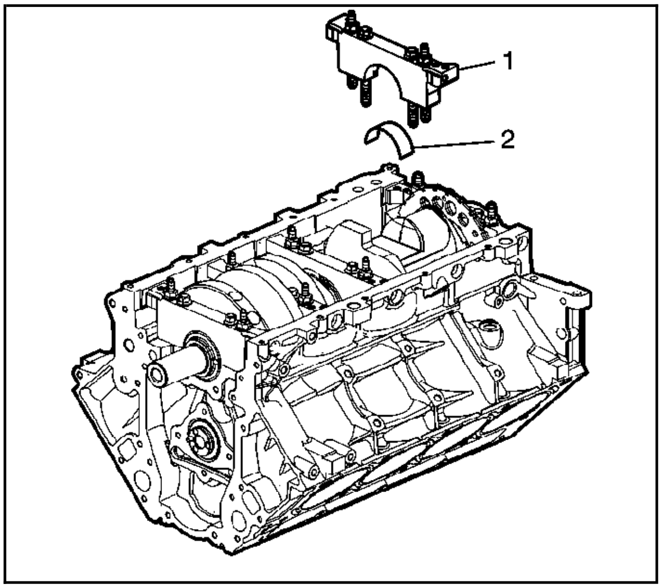
J 43690-100 Rod Bearing Checking Tool – Adapter Kit

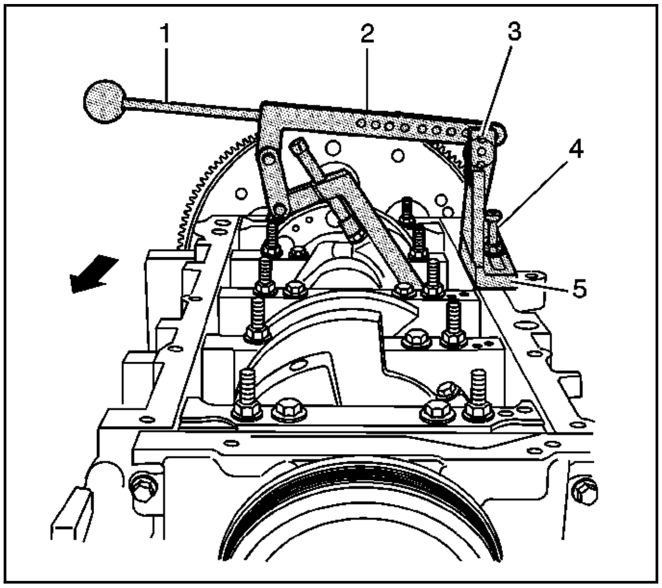
- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)



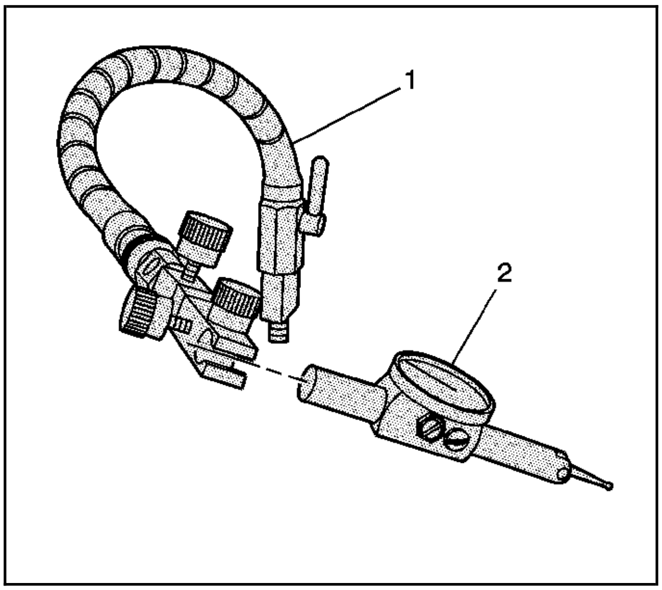
Important: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to *Fastener Tightening Specifications*.



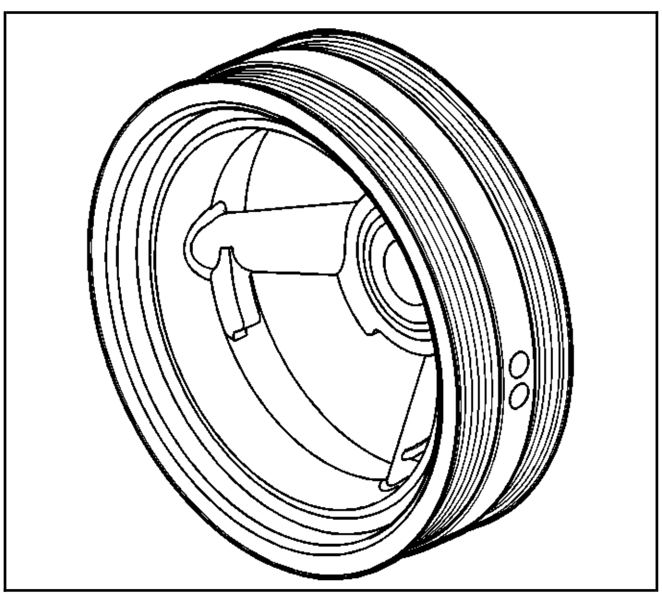


6. Install the following:
   6.1. J 43690-2 (5)
   6.2. J 43690-3 (4)
   6.3. J 43690-101 (2)
   6.4. 280310 (3)
   6.5. J 43690-5 (1)



7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

   A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components as required.



Crankshaft Balancer Cleaning and Inspection

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:
   - Worn, grooved, or damaged hub seal surface

     A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

     Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

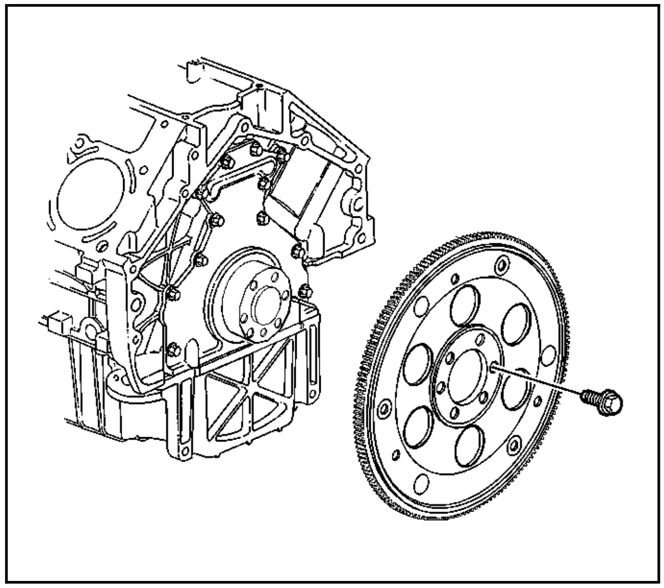
Important: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves

  The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

  Minor imperfections may be removed with a fine file.
- Worn, chunking or deteriorated rubber between the hub and pulley

Engine Flywheel Cleaning and Inspection

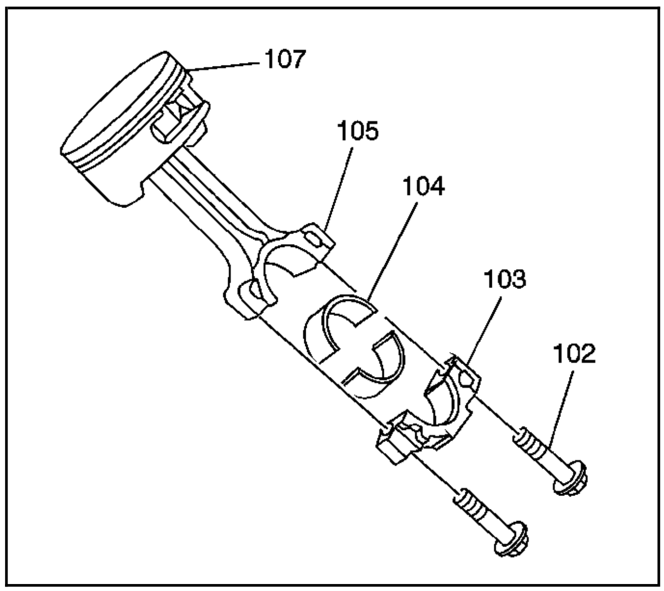


1. Clean the flywheel in solvent.
2. Dry the flywheel with compressed air.
3. Inspect the automatic transmission flywheel for the following conditions:
   - Damaged ring gear teeth
   - Stress cracks around the flywheel-to-crankshaft bolt hole locations

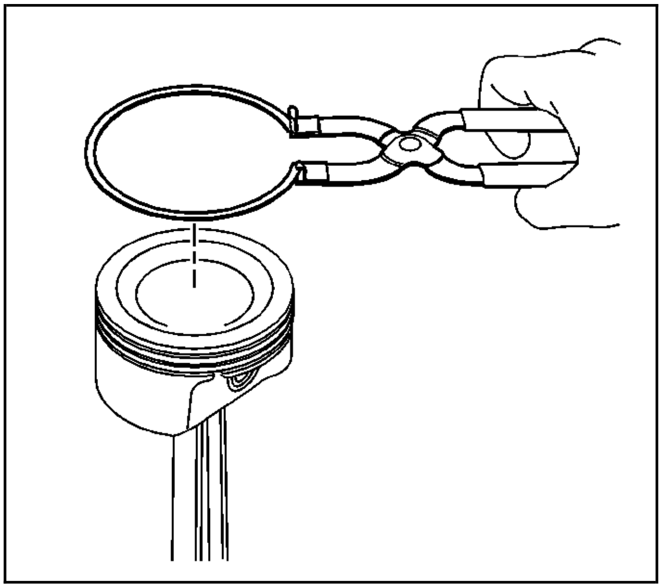
Important: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.

   - Welded areas that retain the ring gear onto the flywheel for cracking

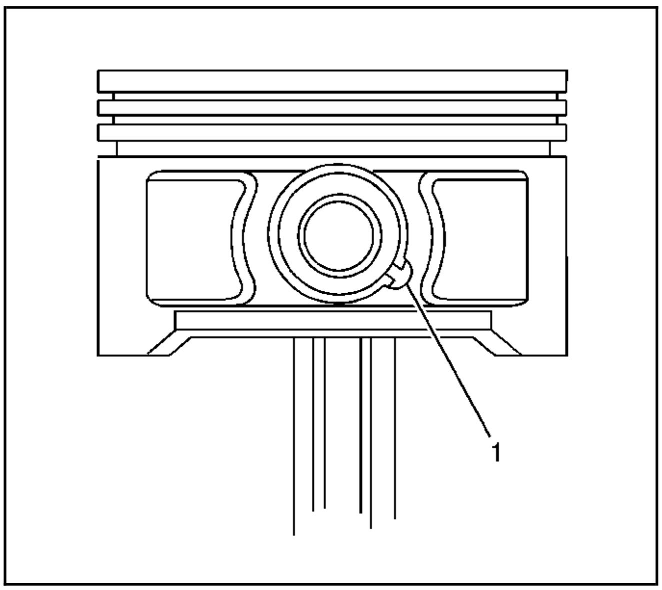
Piston and Connecting Rod Disassemble



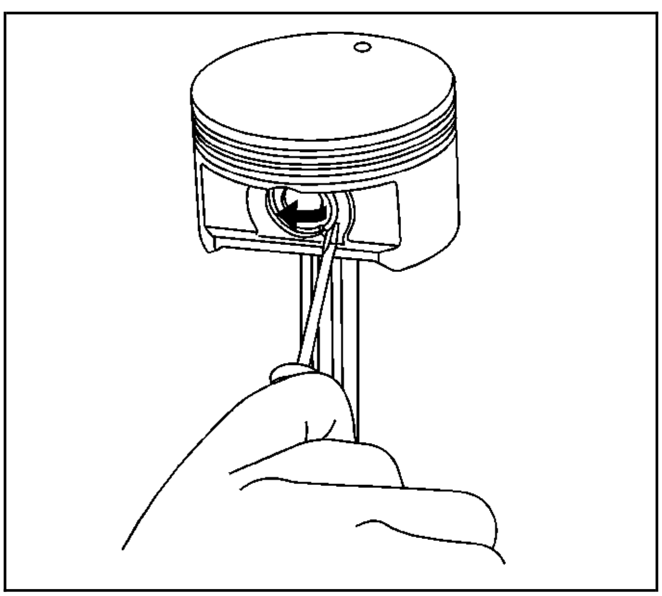
1. Remove the connecting rod bearings (104) from the rod (105) and cap (103).



2. Using piston ring pliers, remove the piston rings from the piston.



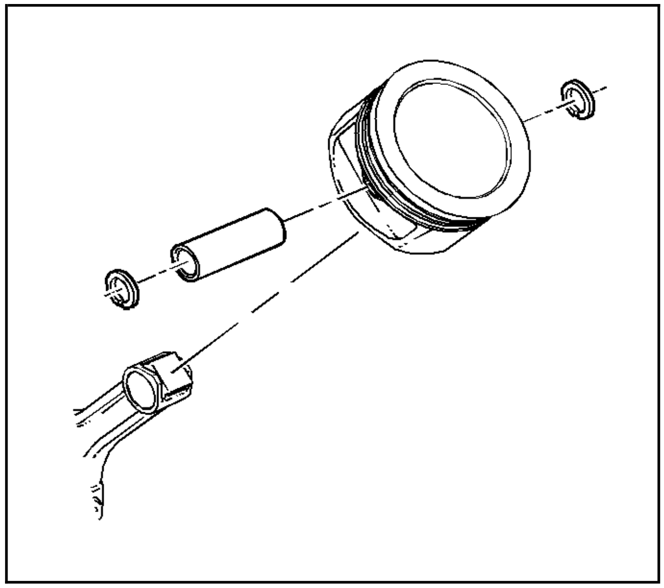
3. Rotate the piston pin retaining clips until the ring end gap is positioned in the cutout area (1) of the pin bore.



4. Remove the clips starting in the cutout area of the pin bore.

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

   Mark, sort, or organize the piston and the matching piston pin.



Piston, Connecting Rod, and Bearings Cleaning and Inspection

Piston, Pin, and Piston Rings

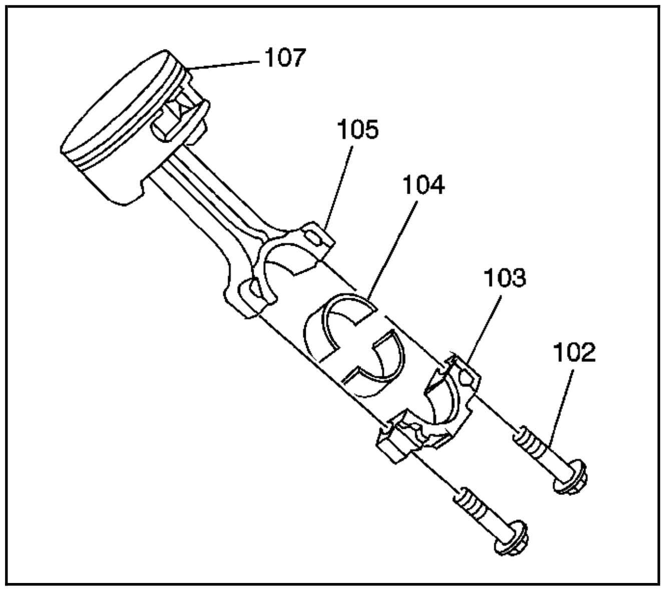
Important:

- Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.
- Do not wire brush any part of the piston.
- Measurement of the components should be taken with the components at normal room temperature.

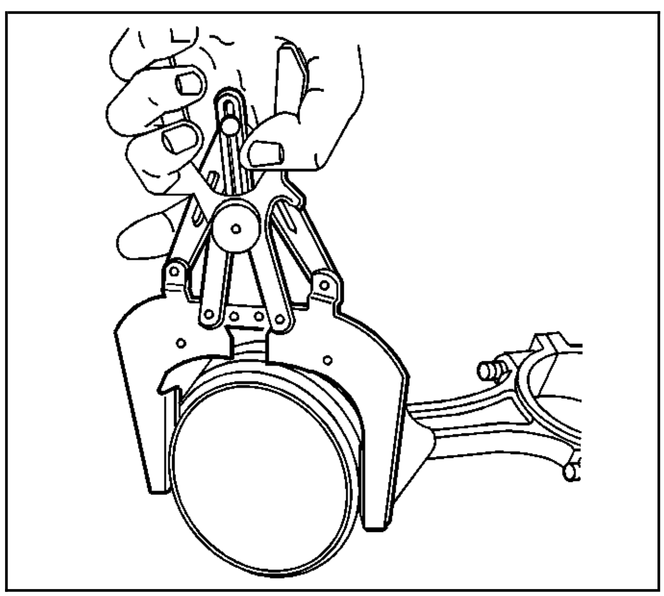
1. Clean the varnish and carbon from the piston (107) using cleaning solvent.

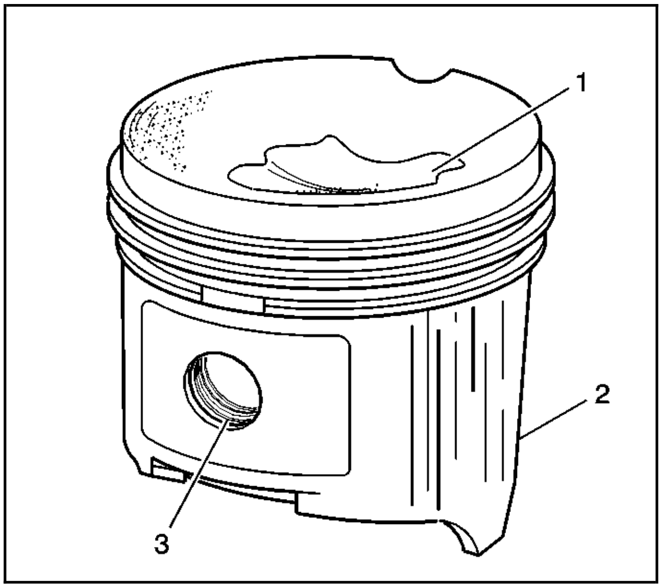
Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.

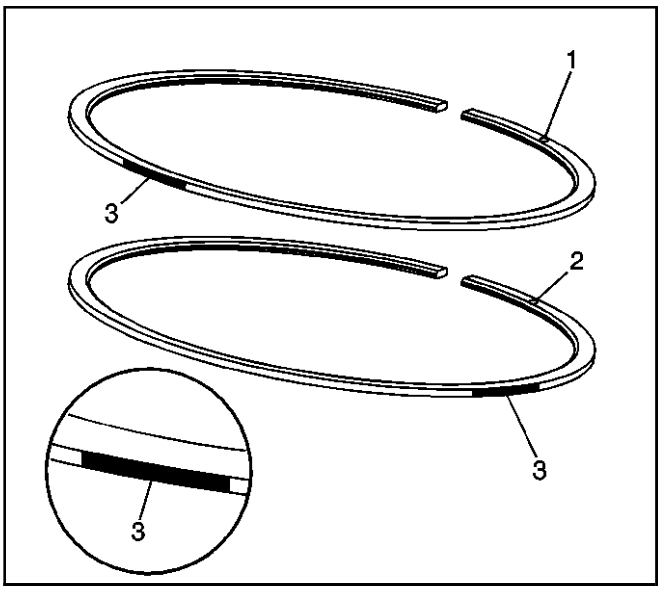


3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

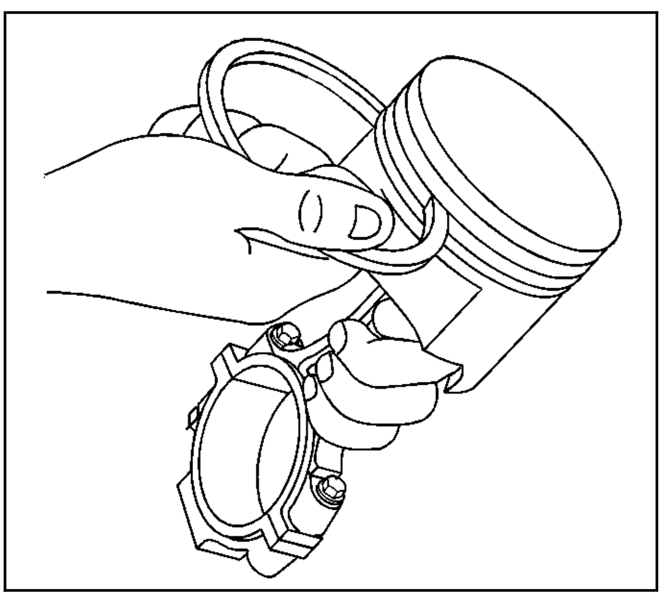




5. Inspect the piston for the following conditions:
   - Cracks in the piston ring lands, the piston skirt, or pin bosses
   - Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind—MINOR imperfections may be removed from the piston with a fine file.
   - Scuffed or damaged skirts (2)
   - Eroded areas at the top of the piston (1)
   - Scoring to the full-floating design piston pin bore (3) or piston pin



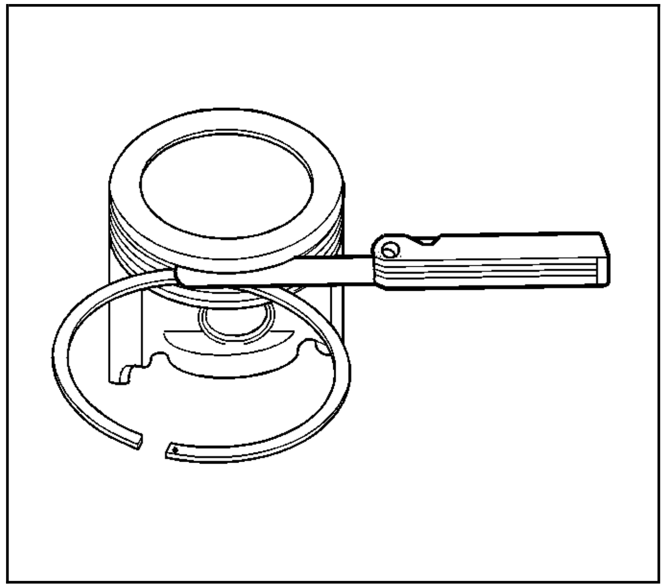
6. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



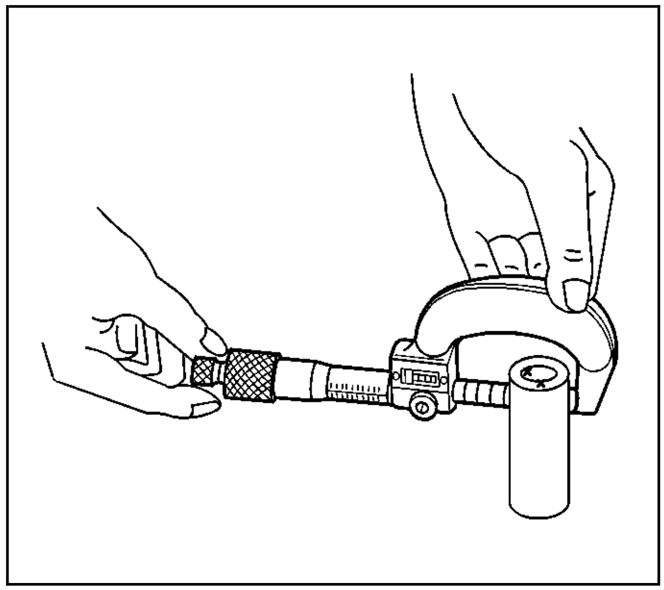
7. Insert the edge of the piston ring into the piston ring groove.

   Roll the piston ring completely around the piston. If binding is caused by distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings as required.

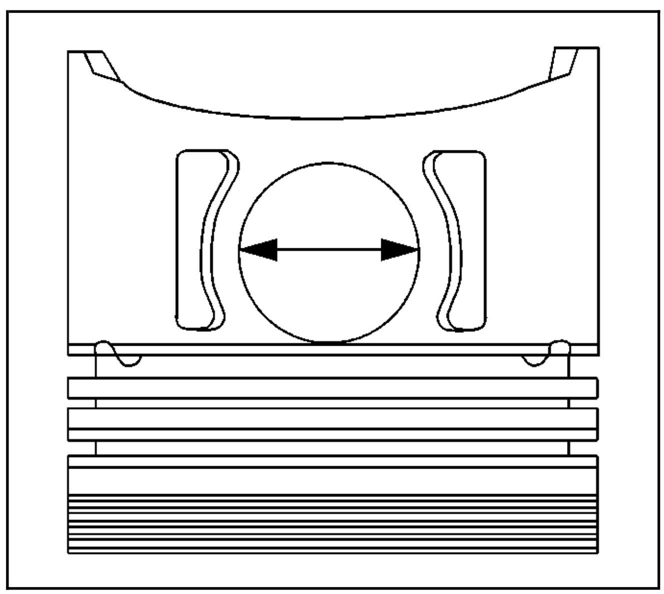
8. Measure the piston ring side clearance with a feeler gage. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston, pin, and connecting rod assembly. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U).*

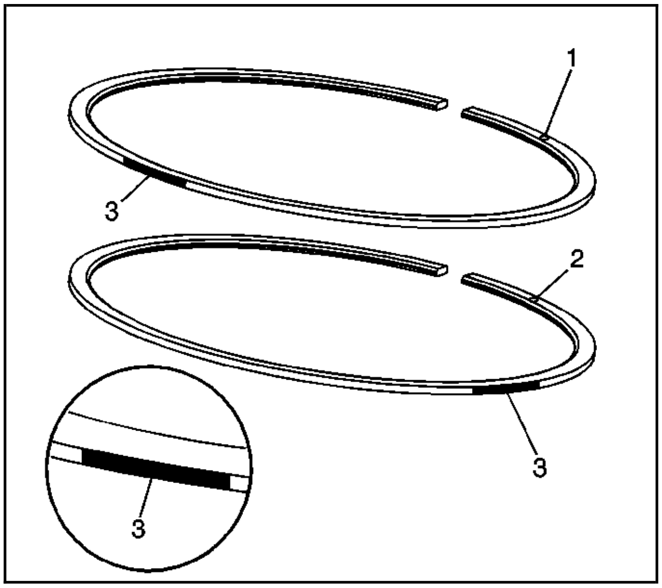


9. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).



10. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
11. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.



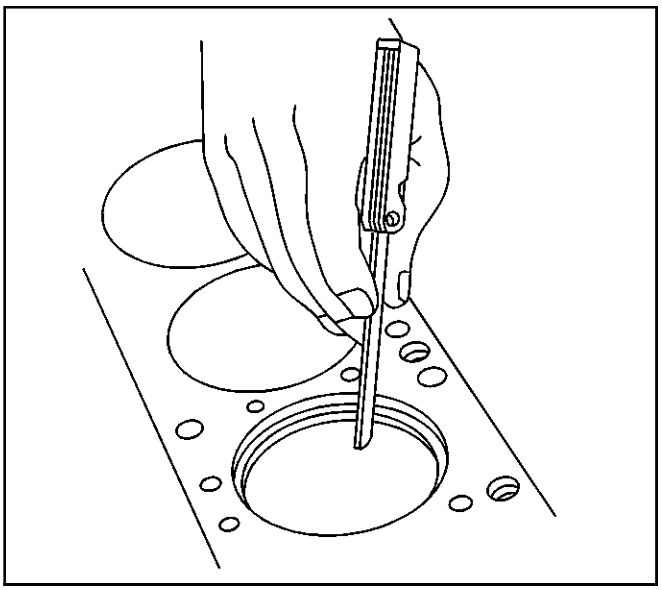


Measuring Piston Ring End Gap

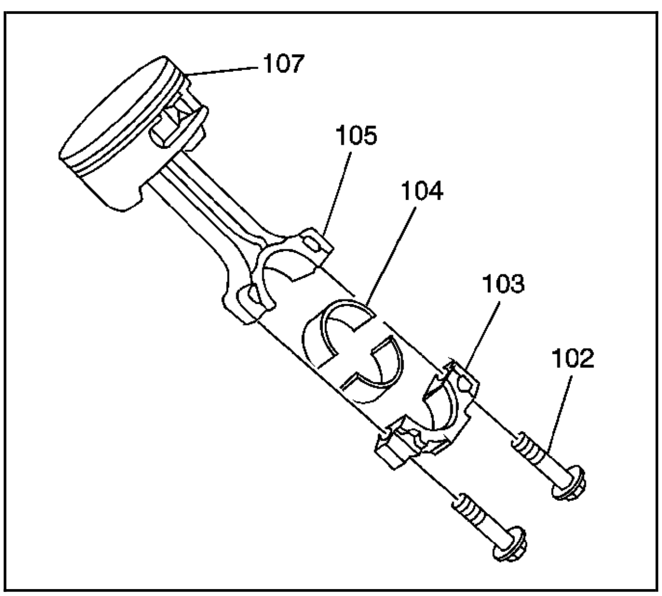
Important:

- Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.
- Measure the piston ring in the cylinder in which it will be used.

1. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



2. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area.
3. Insert a feeler gage and measure the piston ring end gap. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)* .



Connecting Rod and Bearings

Important:

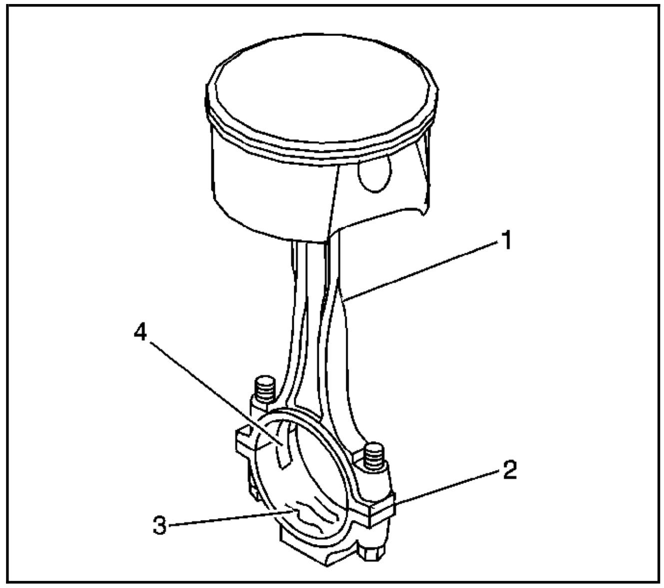
- The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the connecting rod as an assembly.
- Do not attempt to repair the bolt hole threads of the connecting rod.

1. Clean the connecting rod (105) and cap (103) in solvent.

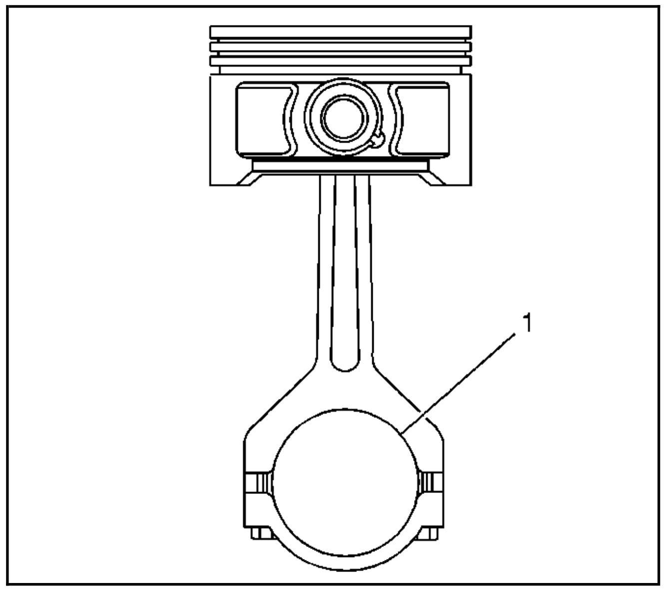
Caution:* . *Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.

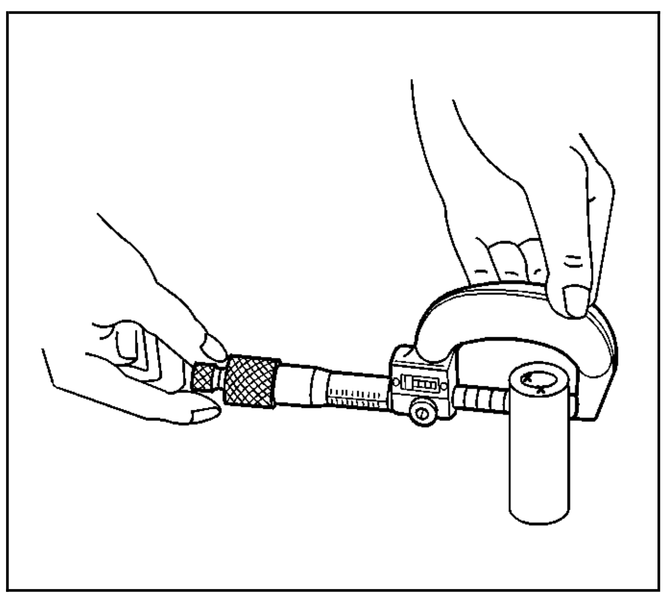
3. Inspect the connecting rod for the following conditions:
   - Twisting (1)
   - Proper fit of the connecting rod and cap mating surfaces (2)
   - Nicks or gouges in the bearing bore (3)
   - Damage to the bearing locating slots (4)

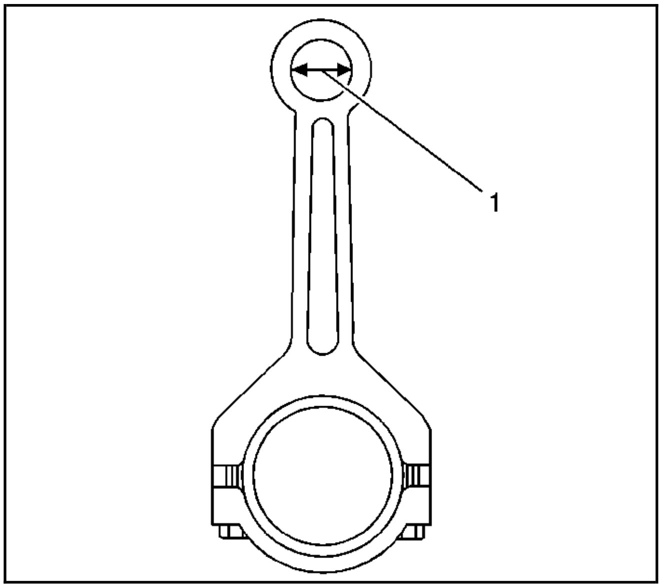


4. Measure the connecting rod bearing bore (1) for an out-of-round condition. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.

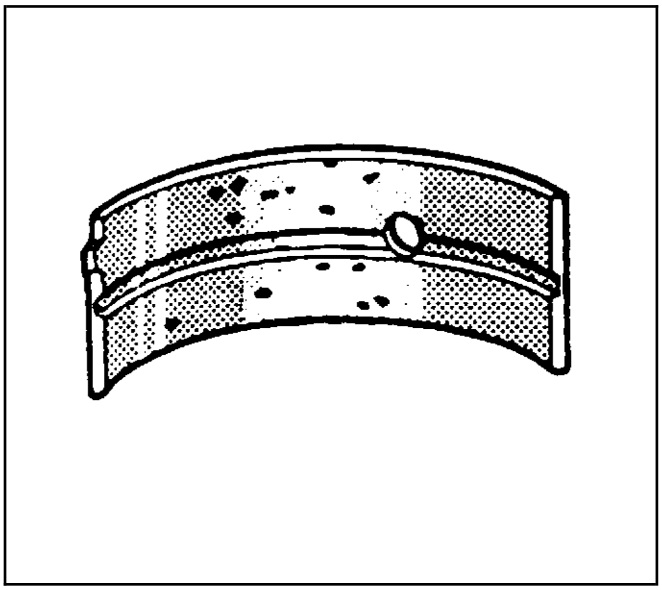


5. To determine full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

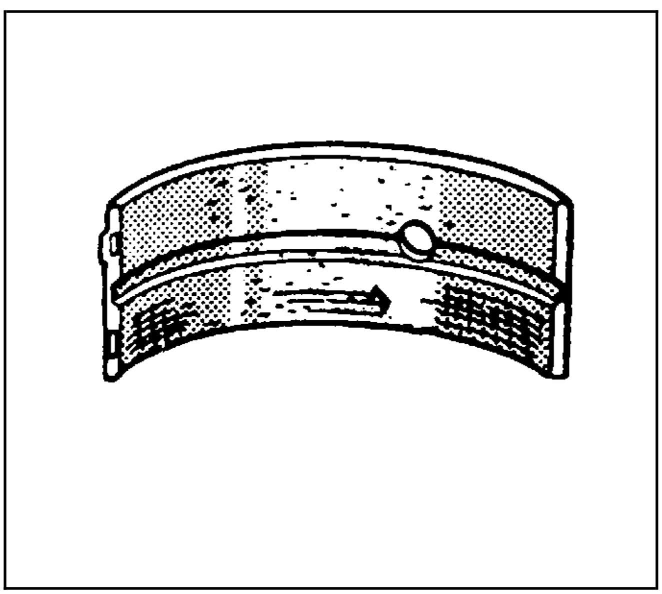




6. To determine the full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) inside diameter (ID).
7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine pin-to-bore clearance. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.

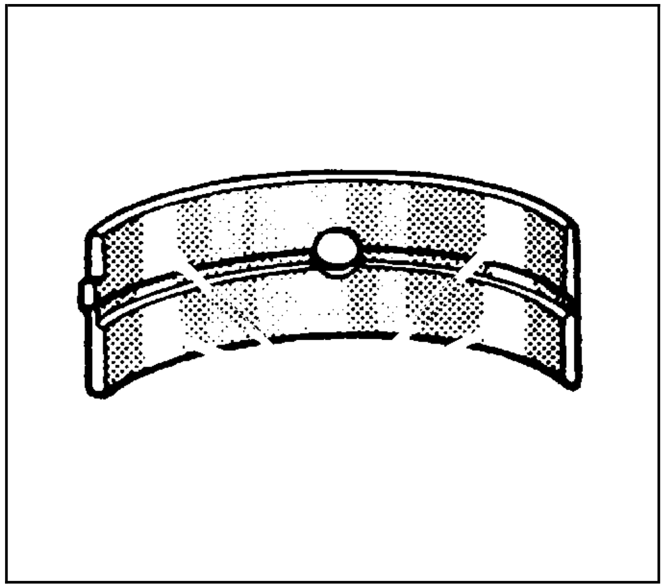


8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.



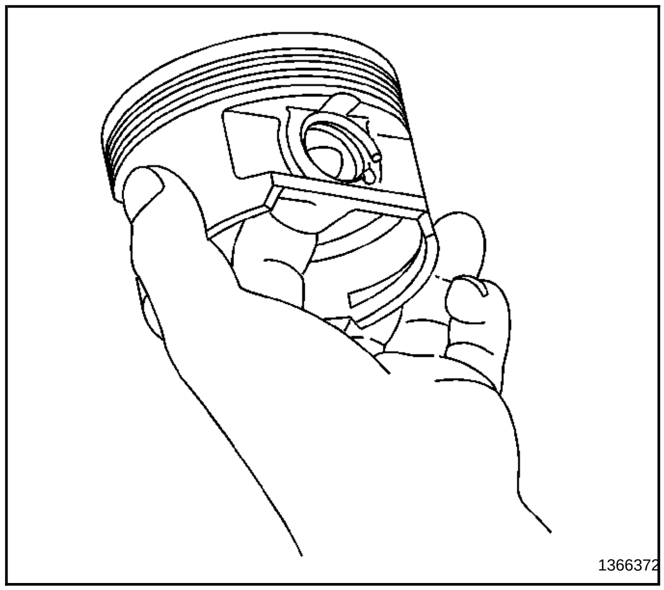
9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.

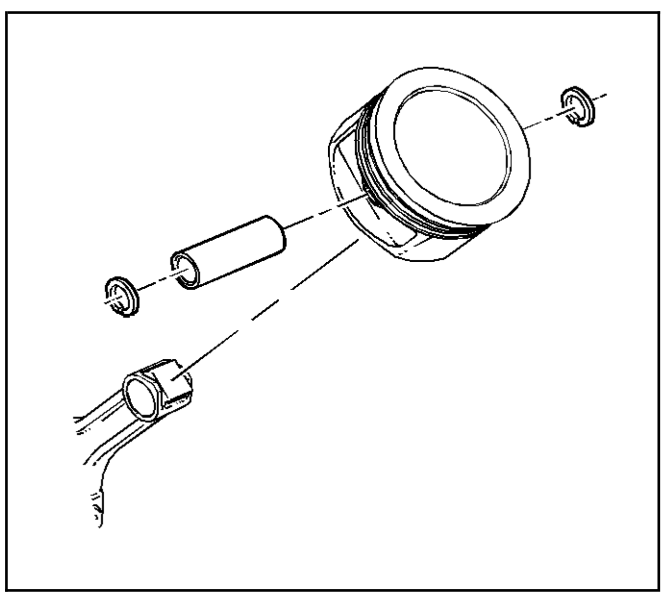


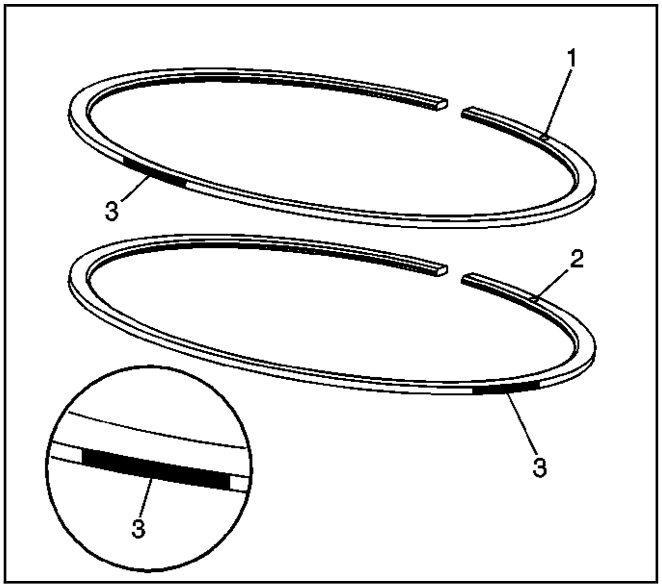
Piston and Connecting Rod Assemble

1. Install the retaining clip. The clip should be seated in the groove of the pin bore.



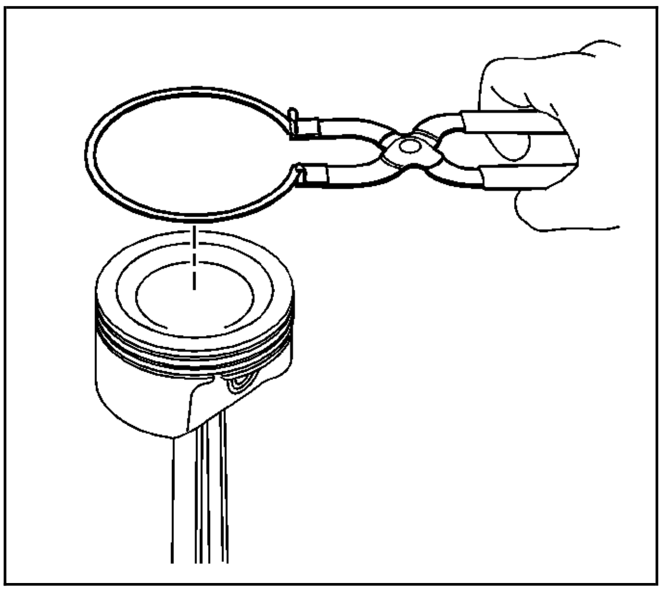
2. Install the piston pin to the piston and connecting rod.
3. Install the retaining clip. The clip should be seated in the groove of the pin bore.



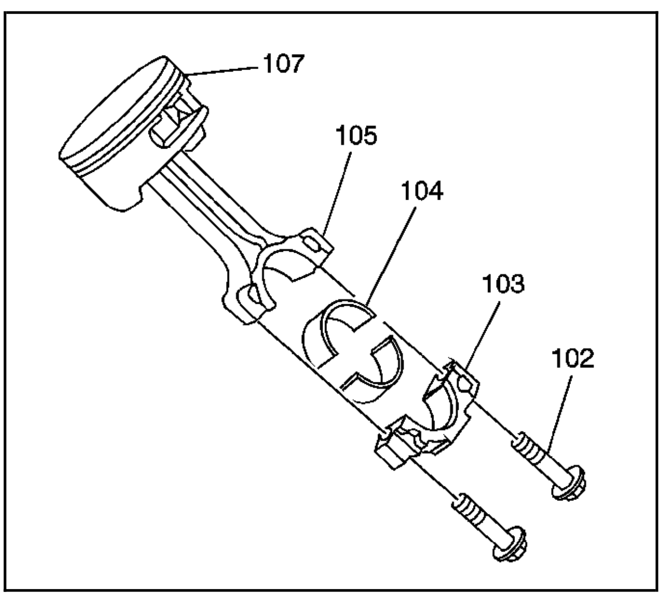


Important: When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

4. Identify the compression and oil control rings for proper installation. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



5. Using piston ring pliers, install the piston rings onto the piston.
6. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
7. Position the compression ring end gaps 180 degrees opposite each other.



8. Install the connecting rod bearings (104) to the rod (105) and cap (103).

Camshaft Bearing Removal

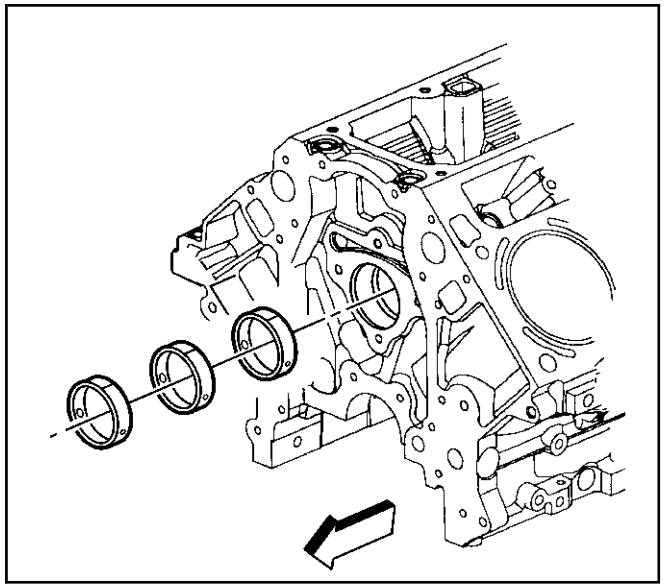
Tools Required

J 33049 Camshaft Bearing Service Set

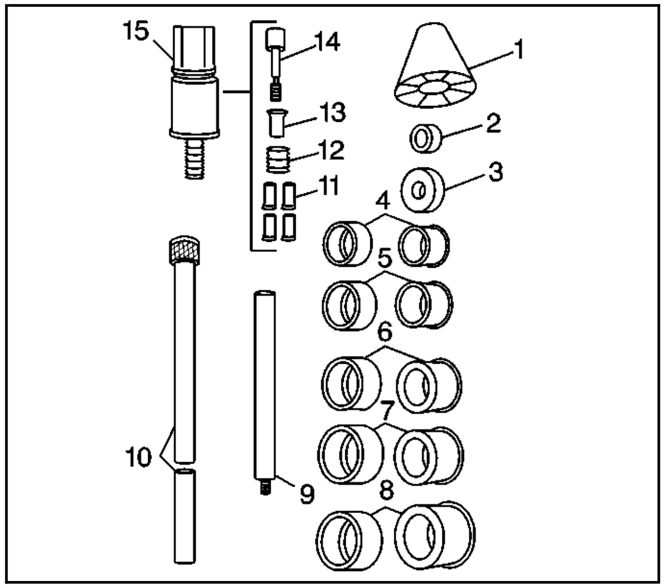
Important: A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores.

   Refer to *Camshaft and Bearings Cleaning and Inspection*.
2. Repair or replace the components as required.



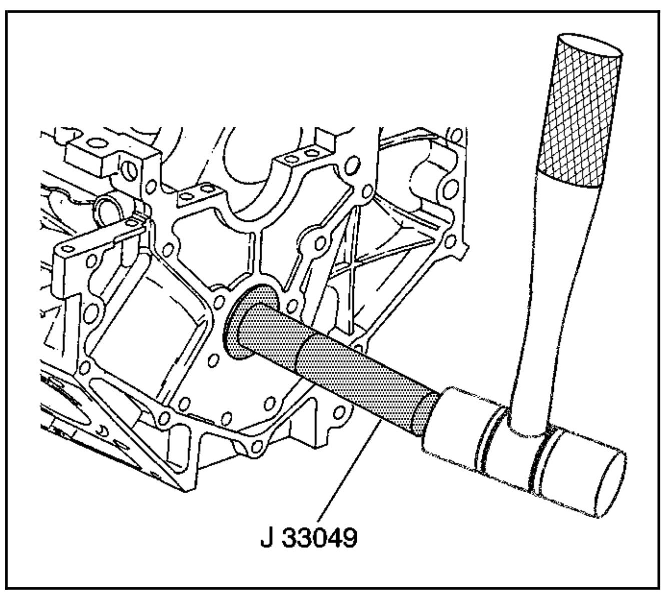
3. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*.
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing to align the tool.

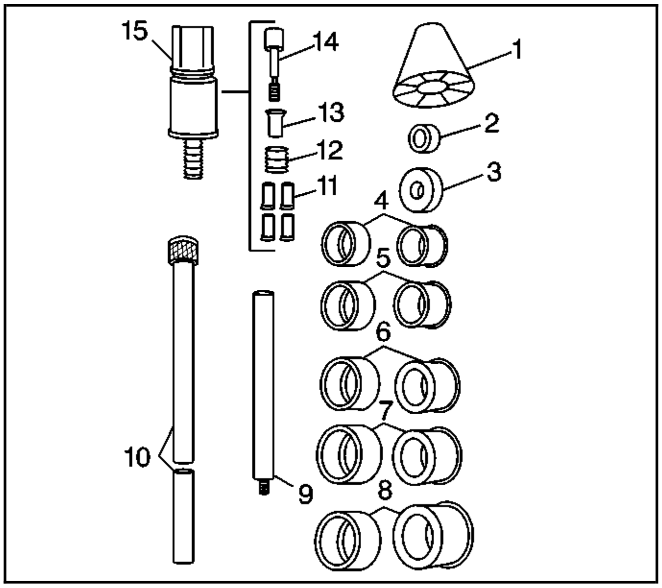


8. Drive the bearing from the block bore.

Important: To remove the front camshaft bearing, operate the tool from the rear of the block using the guide cone in the rear camshaft bearing bore.

9. Repeat the above procedures to remove the remaining bearings.

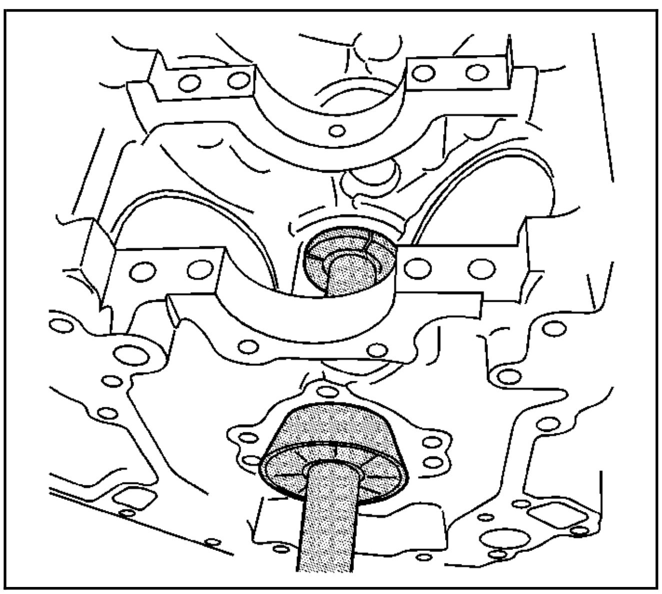




Tool Usage Information

Bearing, Expander, and Expander Driver Information

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4–8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).
- Expander bearing driver number one inside diameter is 28.575–37.465 mm (1.125–1.475 in) and is used with the expander assembly and the small washer.
- Expander bearing driver number two inside diameter is 37.465–43.18 mm (1.475–1.7 in) and is used with number one expanding driver and the small washer.
- Expander bearing driver number three inside diameter is 43.18–48.895 mm (1.7–1.925 in) and is used with number two expanding driver and the large washer.
- Expander bearing driver number four inside diameter is 48.895–54.61 mm (1.925–2.15 in) and is used with number three expanding driver and the large washer.
- Expander bearing driver number five inside diameter is 54.61–60.325 mm (2.150–2.375 in) and is used with number four expanding driver and the large washer.
- Expander bearing driver number six inside diameter is 60.325–68.326 mm (2.375–2.69 in) and is used with number five expanding driver and the large washer.



Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

Important: To install or remove the expanding driver, always push on or pull from the ends.

Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

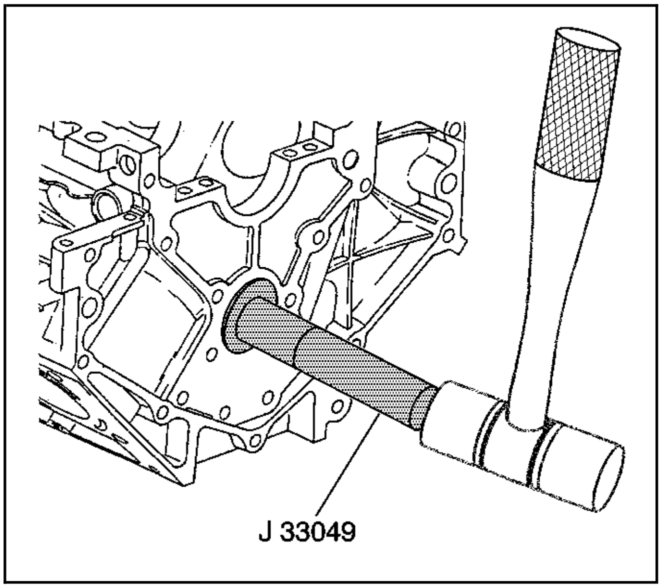
2. Place the expanding driver onto the expander assembly.
3. Check to insure that the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. Place the guide cone over the driving bar, with the small end of the cone facing the driver assembly.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

   It may be necessary to install the driver bar extension for removal of the inner bearings.
7. Insert the tool into a inner camshaft bearing and tighten until snug.

   Operate the tool from the front or rear of the engine block.

On some engine blocks the nut on the expander assembly is inaccessible except from either end. In this case you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.
11. For the two end bearings, front and rear, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.



Camshaft and Bearings Cleaning and Inspection

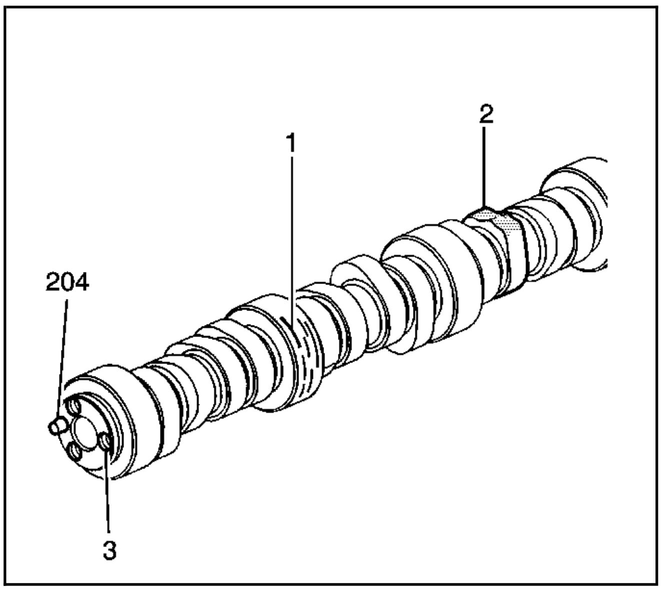
Tools Required

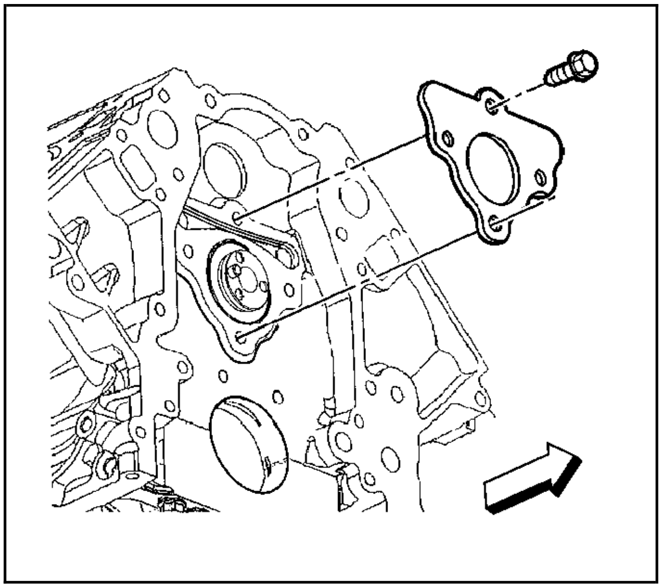
- *J 7872* Magnetic Base Dial Indicator Set
- *J 8520* Cam Lobe Lift Indicator

1. Clean the components in solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

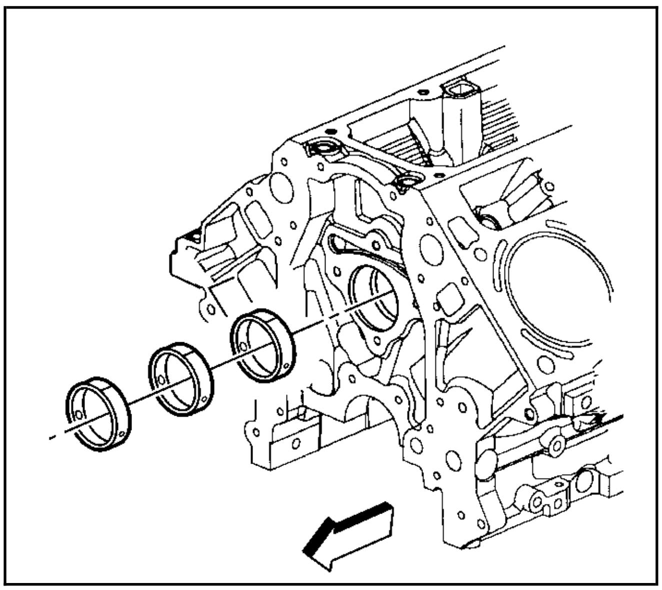
2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the threaded bolt holes (3) in the front of the camshaft for damaged threads or debris.
6. Inspect the camshaft sprocket pin (204) for damage.
7. Inspect the camshaft position reluctor ring for nicks or damage.





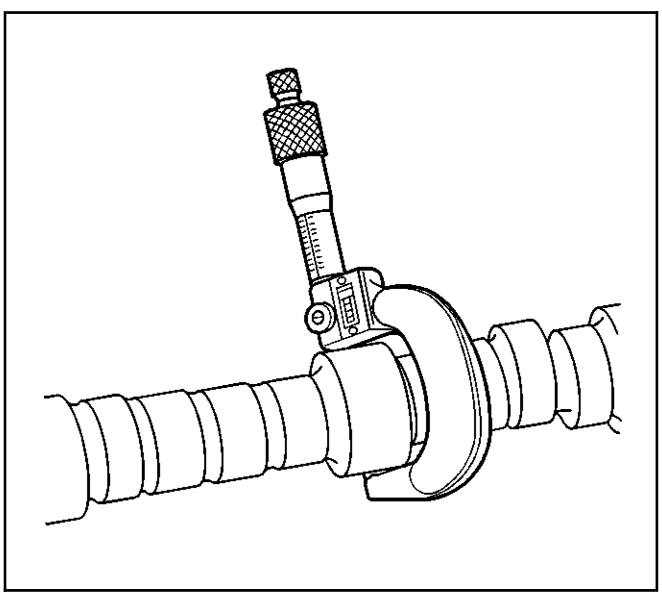
8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

   If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.



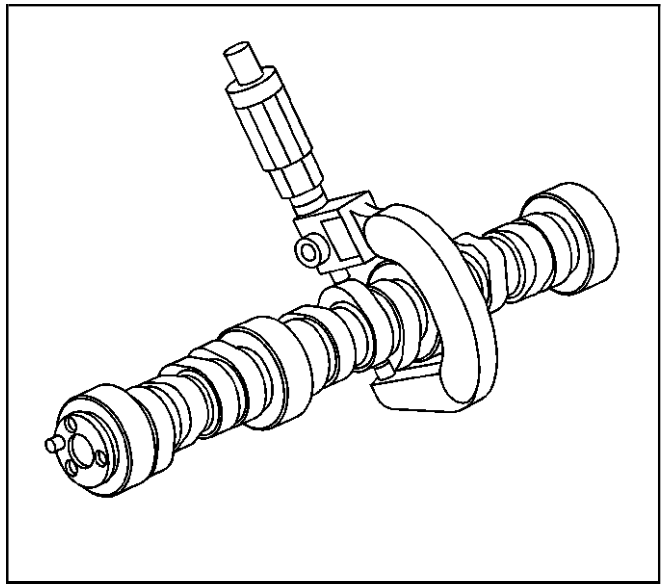
9. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
10. Inspect the camshaft bearings for excessive wear or scoring.

    Bearings with excessive scoring or wear must be replaced.

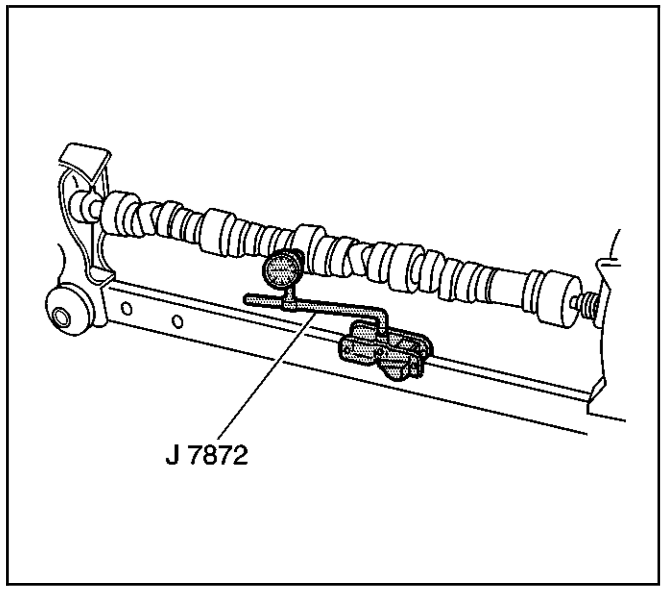


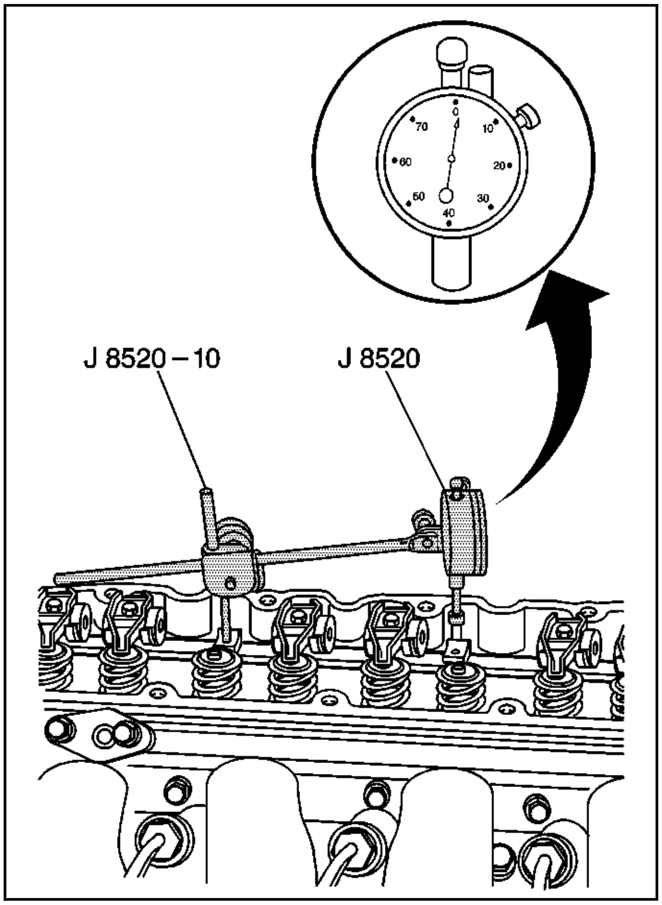
11. Measure the camshaft journals for wear and out-of-round with a micrometer.
    - If the camshaft bearing journals are more than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
    - If the camshaft bearing journal diameter is less that 54.99 mm (2.164 in), replace the camshaft.

12. Measure the camshaft lobes for wear with a micrometer.
    - A 4.8/5.3L camshaft with an intake lobe that measures 46.169 mm (1.817 in) or less must be replaced.
    - A 4.8/5.3L camshaft with an exhaust lobe that measures 46.199 mm (1.818 in) or less must be replaced.
    - A 6.0L camshaft with an intake lobe that measures 46.31 mm (1.823 in) or less must be replaced.
    - A 6.0L camshaft with an exhaust lobe that measures 46.48 mm (1.83 in) or less must be replaced.



13. Measure the camshaft runout.
    13.1. Mount the camshaft in wooden V blocks or between centers on a fixture.
    13.2. Check the runout of the intermediate camshaft bearing journals using the *J 7872*.
    13.3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

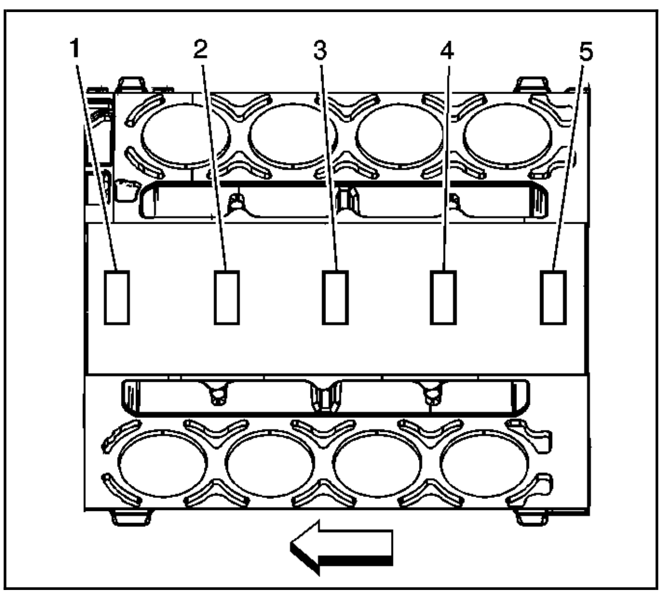




Measuring Camshaft Lobe Lift

Important: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

1. Measure camshaft lobe lift using *J 8520*.
2. Remove the valve rocker arms and bolts
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the *J 8520* and position onto the stud.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise until the dial indicator obtains its highest and lowest readings.
8. Compare the total lift shown to specifications:
   - The proper lobe lift for 4.8/5.3L intake lobes is 6.82 mm (0.268 in).
   - The proper lobe lift for 4.8/5.3L exhaust lobes is 6.96 mm (0.274 in).
   - The proper lobe lift for 6.0L intake lobes is 6.96 mm (0.274 in).
   - The proper lobe lift for 6.0L exhaust lobes is 7.13 mm (0.281 in).



Camshaft Bearing Installation

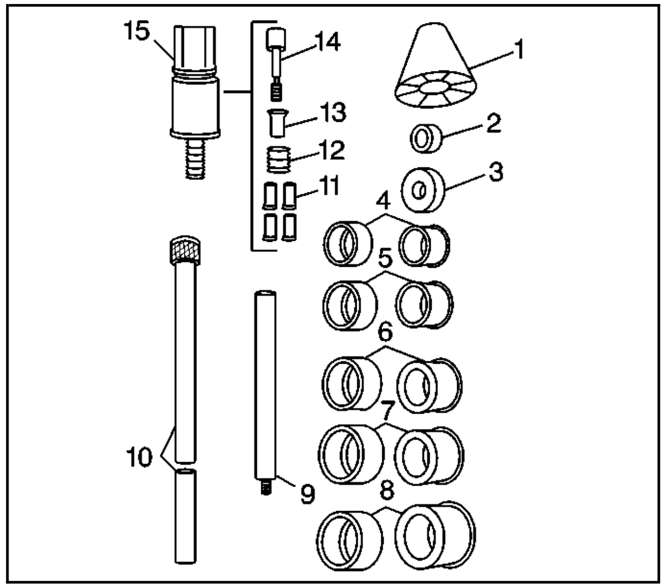
Tools Required

J 33049 Camshaft Bearing Service Set

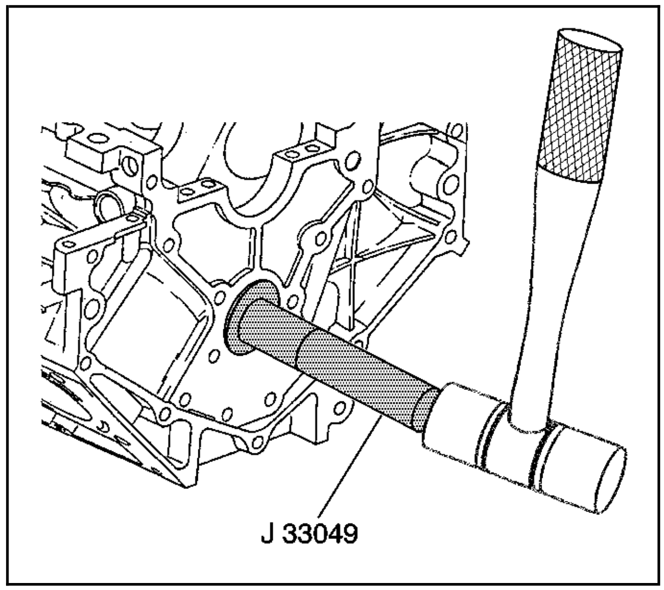
Important: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Positions 1 and 5 are the largest diameter bores. Position 3 is the smallest diameter bore. Positions 2 and 4 are the intermediate size bores. The inside diameter (ID) for all camshaft bearings is the same size.

1. Measure the engine block camshaft bearing bores (1–5) to identify the correct OD size bearing for each position. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.

2. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*. Refer to *Camshaft Bearing Removal*.
3. Assemble the tool.



4. Insert the tool through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone into the front camshaft bearing to align the tool.
7. Drive the bearing into the block bore.
8. Repeat the above procedures to install the remaining bearings.

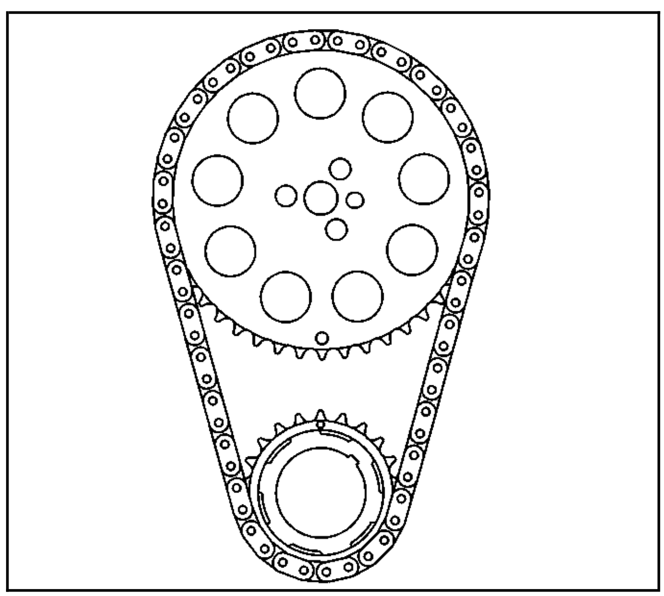


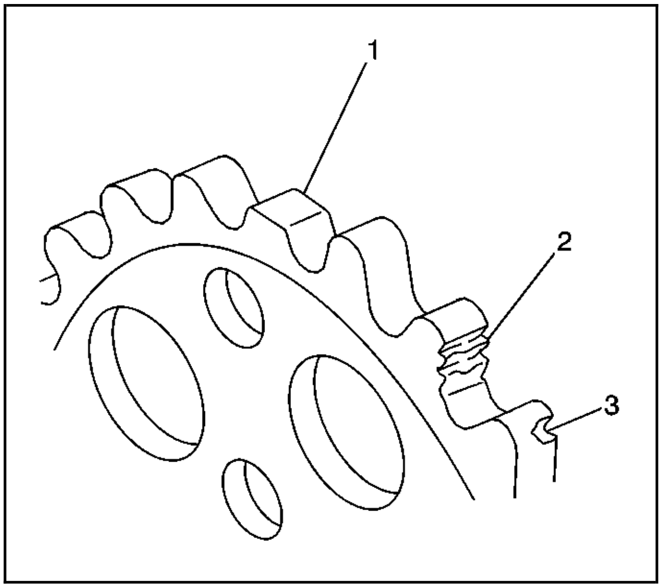
Timing Chain and Sprockets Cleaning and Inspection

1. Clean the components with cleaning solvent.

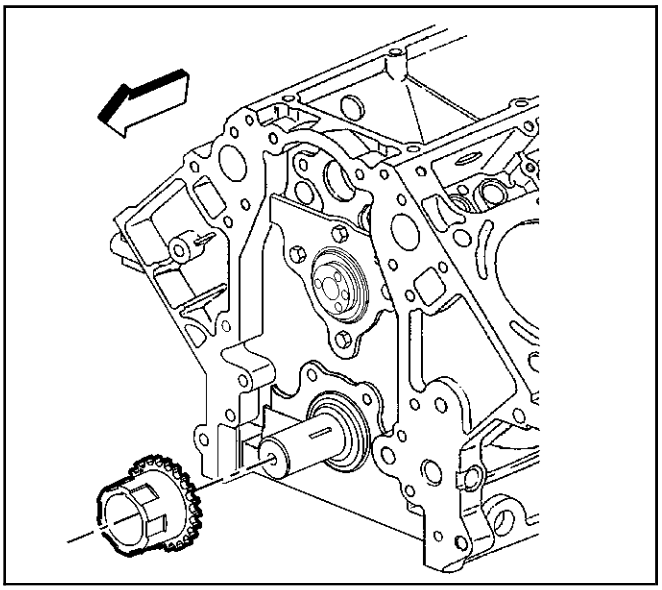
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.

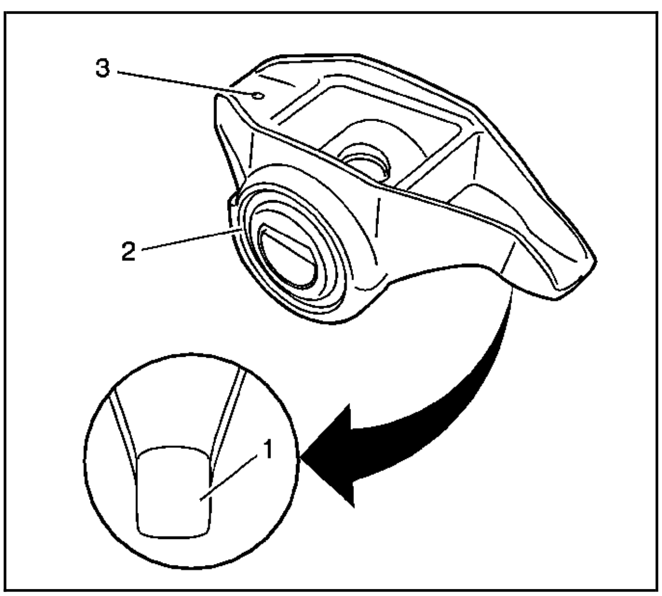




4. Inspect the camshaft and crankshaft sprockets for:
   - Worn teeth (1)
   - Damaged teeth (2)
   - Chipped teeth (3)
   - Worn valleys between the sprocket teeth



5. Inspect the crankshaft sprocket keyway for wear.
6. Inspect the crankshaft sprocket oil pump drive splines for wear.



Valve Rocker Arm and Push Rods Cleaning and Inspection

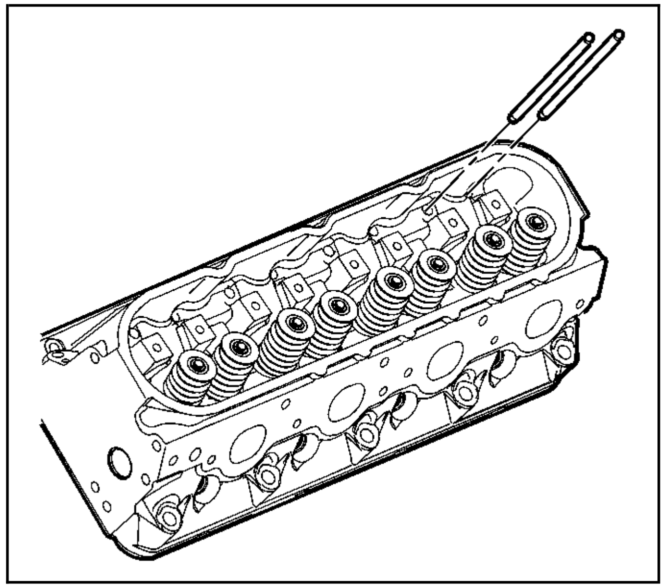
Important: Parts that are to be used again must be marked, sorted or organized for assembly.

1. Mark, sort, or organize the components for assembly. Refer to *Separating Parts*.
2. Clean the components with cleaning solvent.

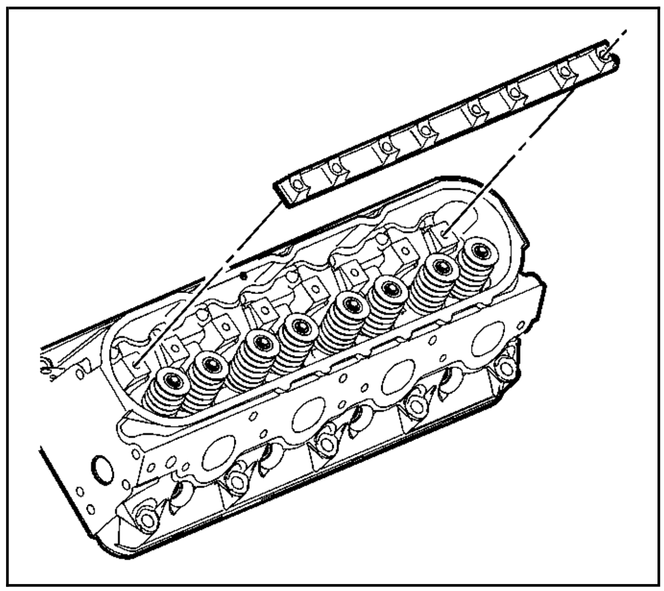
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

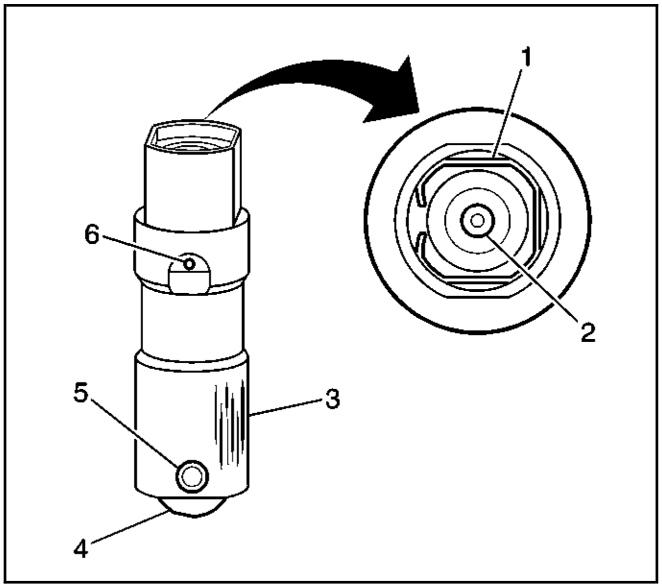
3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.

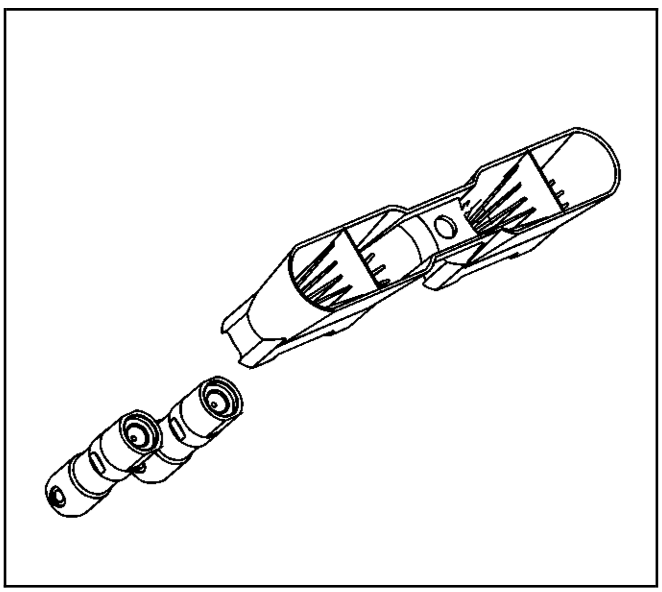
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.
6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.



9. Inspect the pivot supports for cracks, wear, or other damage.







Valve Lifters and Guides Cleaning and Inspection

Important: Components that are to be used again must be marked, sorted or organized for assembly.

1. Mark, sort, or organize the components for assembly. Refer to *Separating Parts*.
2. Clean the components in cleaning solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the components with compressed air.
4. Inspect the valve lifters for the following conditions:
   - Bent or broken clip (1)
   - Worn pushrod socket (2)
   - Scuffed or worn sides (3)

     If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.
   - Flat spots on the roller (4)
   - Loose or damaged pin (5)
   - Plugged oil hole (6)
   - Worn or damaged roller bearing

     The roller should rotate freely with no binding or roughness.
5. Inspect the valve lifter guides for the following conditions:
   - For cracks or damage
   - Excessive wear in the lifter mounting bores

Cylinder Head Disassemble

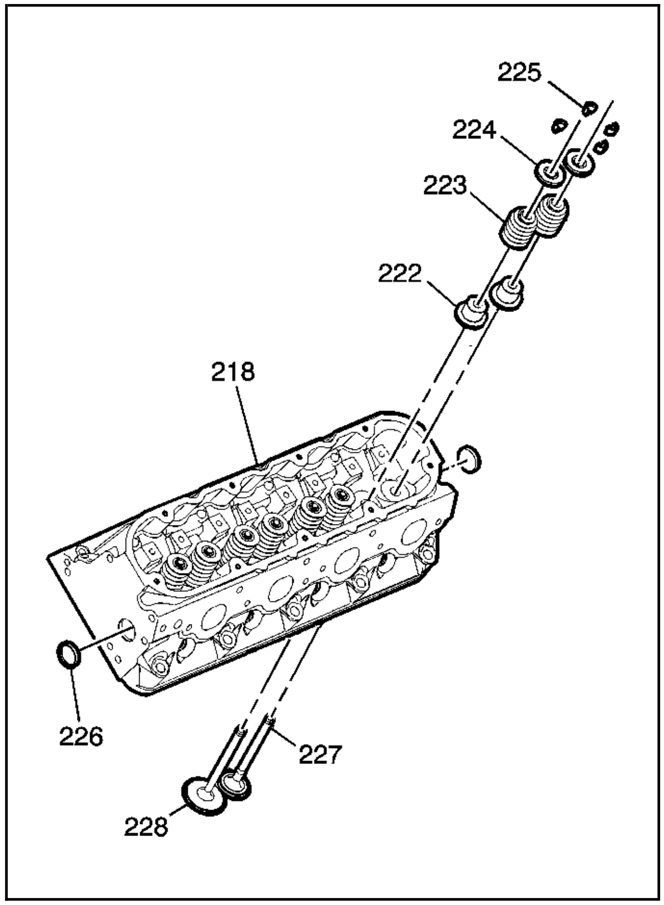
Tools Required

J 8062 Valve Spring Compressor – Head Off

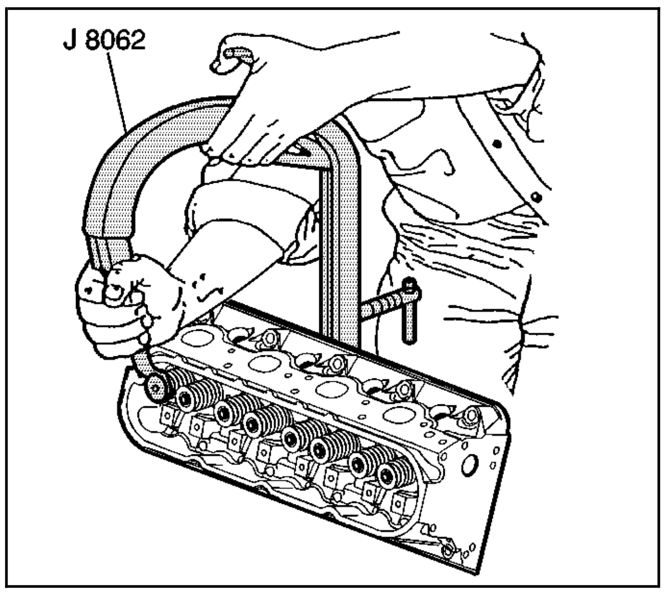
Important:

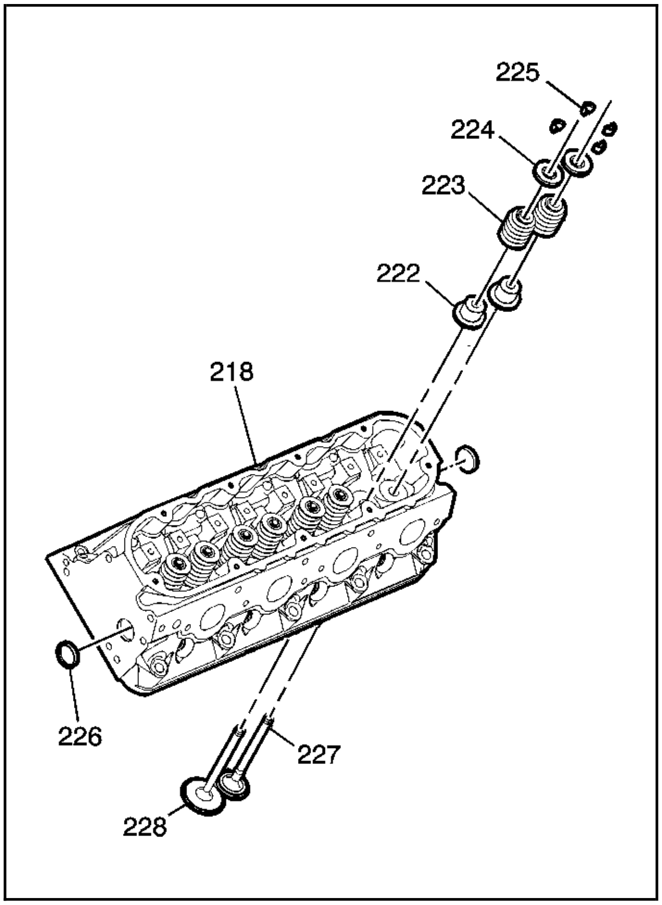
- Remove the spark plugs from the cylinder head with the components at room temperature.
- Mark, organize, or sort the cylinder head components for assembly. Return the components to their original location during assembly.
- Do not remove the cylinder head expansion plugs (226) unless service is required.

1. Remove the spark plugs from the cylinder heads.

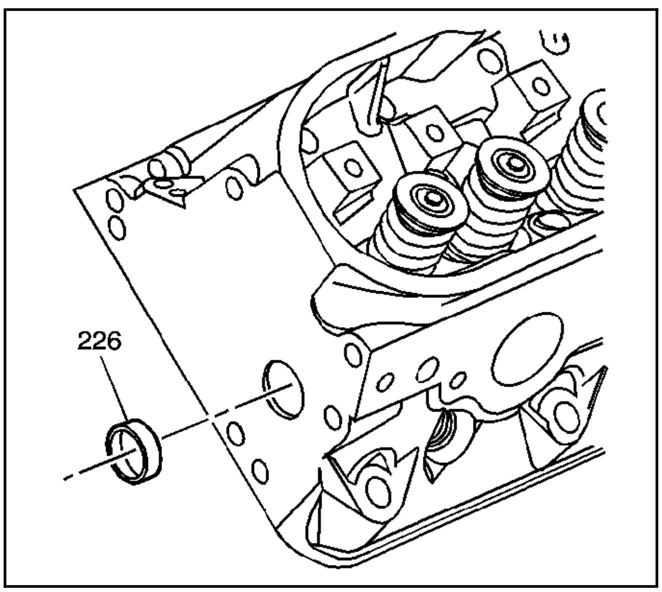


2. Use the *J 8062* in order to compress the valve spring.



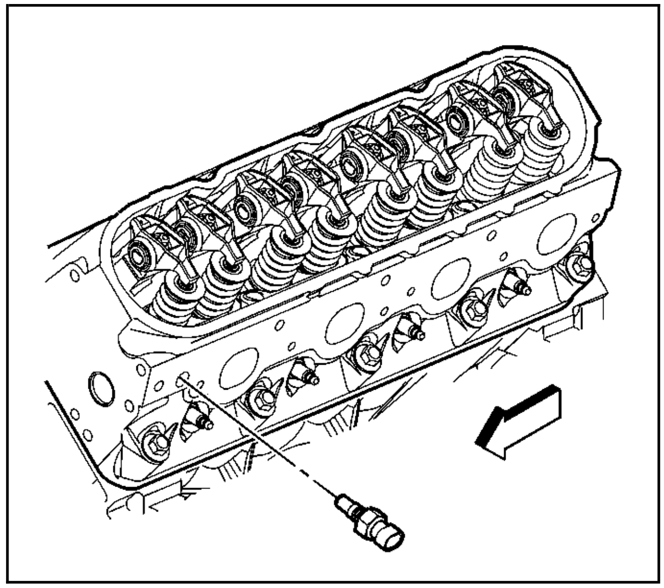


3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (227 and 228).
7. Remove the valve stem oil seal (222). Refer to *Separating Parts*.

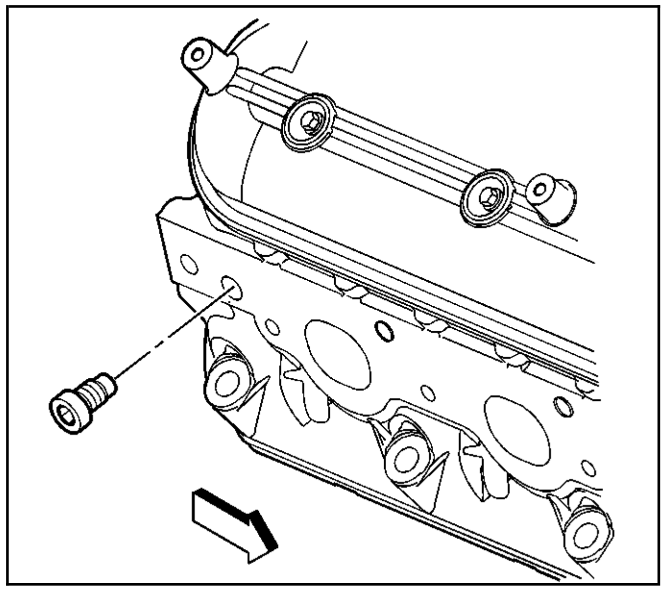


8. Remove the cylinder head expansion plugs (226), if required.

9. Remove the coolant sensor from the left cylinder head.



10. Remove the coolant plug from the right cylinder head.



Cylinder Head Cleaning and Inspection

Tools Required

- *J 8089* Carbon Removal Brush
- *J 9666* Valve Spring Tester

Important: When cleaning a cylinder head in a thermal type oven, do not exceed 204°C (400°F).

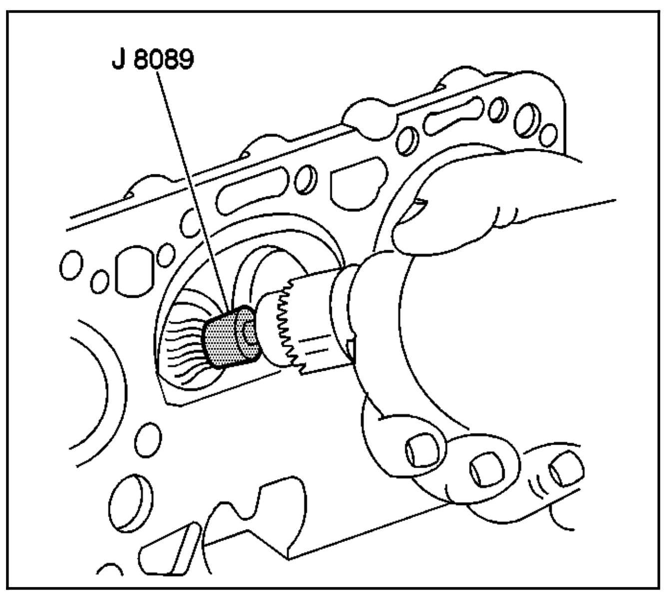
1. Clean the following components:

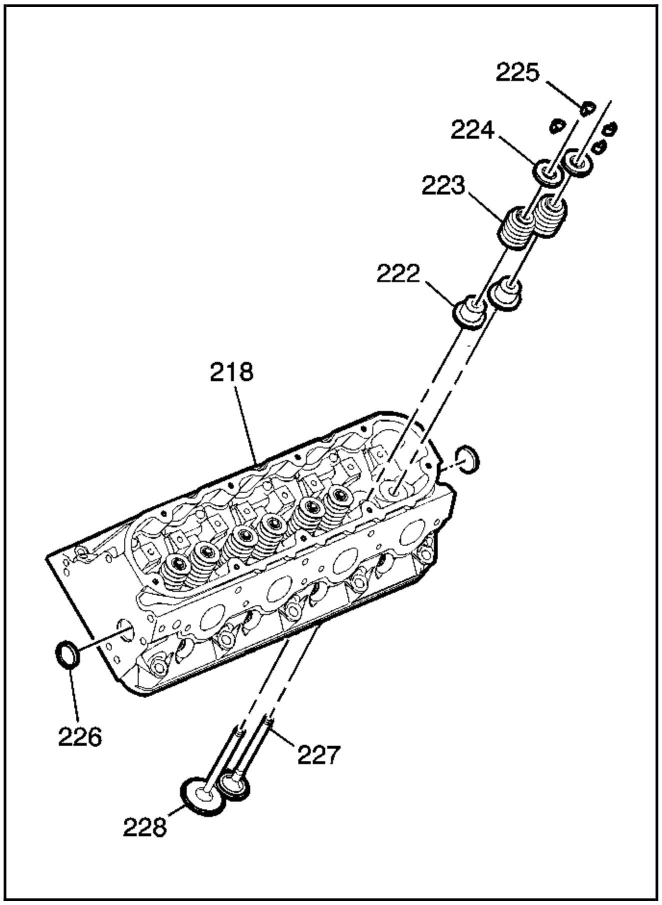
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Important: Be careful not to scuff the chamber.

- Use the *J 8089* in order to remove the carbon from the combustion chambers.
- Gasket surfaces

  Refer to *Replacing Engine Gaskets*.
- Valve stems and heads on a buffing wheel

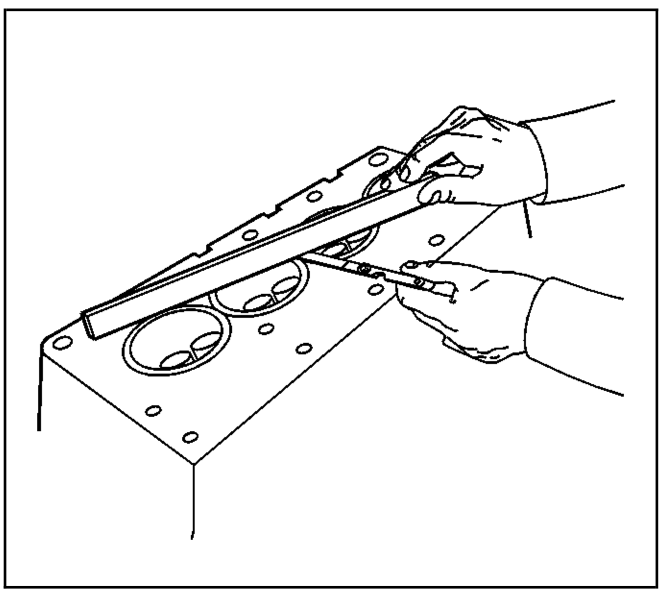




- Bolt hole threads

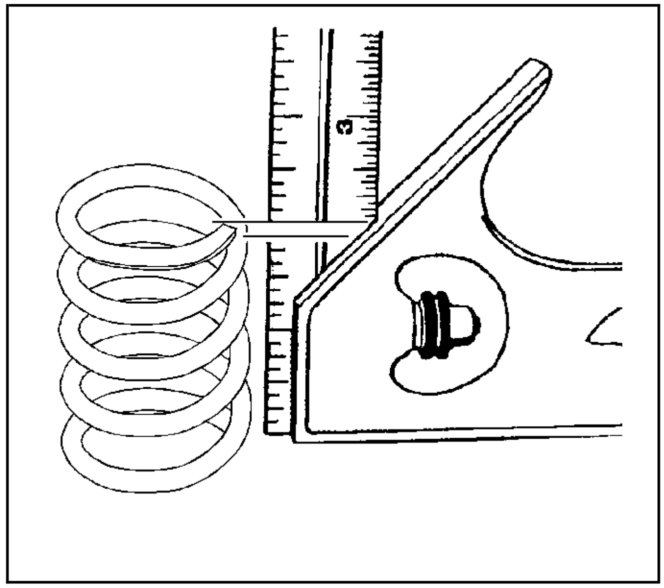
  Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the following components:
   2.1. The cylinder head (218) for cracks in the exhaust ports and combustion chambers
   2.2. The cylinder head for external cracks in the water chambers
   2.3. The gasket surfaces for excessive scratches or gouging
   Refer to *Replacing Engine Gaskets*.
   2.4. The bolt hole threads for debris or damaged threads
   Refer to *Thread Repair* or *Thread Repair Specifications*.



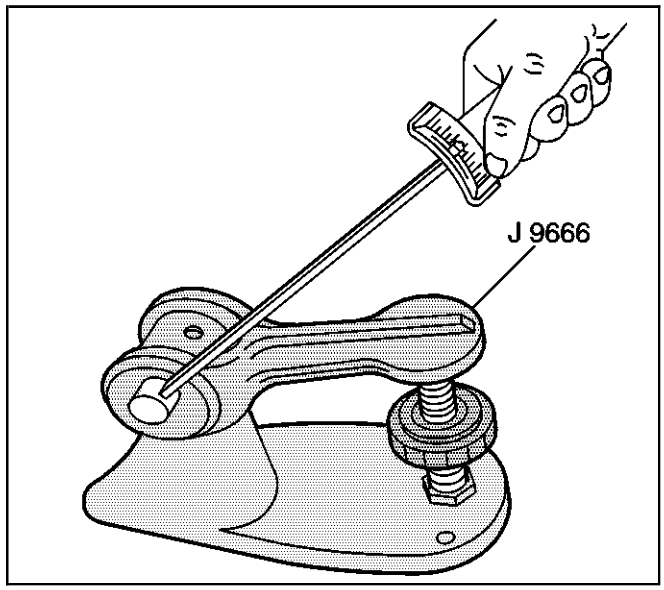
3. Inspect the cylinder head for warpage. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.

4. Inspect the valve springs for squareness.



5. Use the *J 9666* in order to measure the valve spring tension.

   Replace the spring if the spring tension is less than 310 N (70 lb) at 45.75 mm (1.80 in).



Valve Guide Reaming/Valve and Seat Grinding

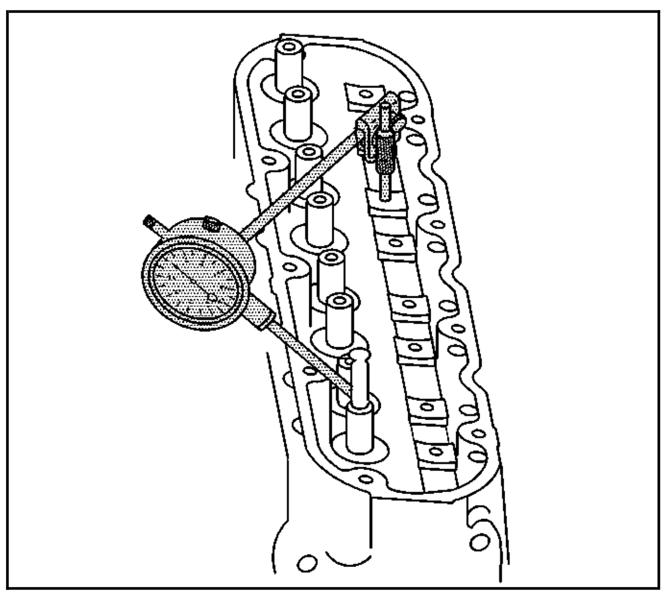
Tools Required

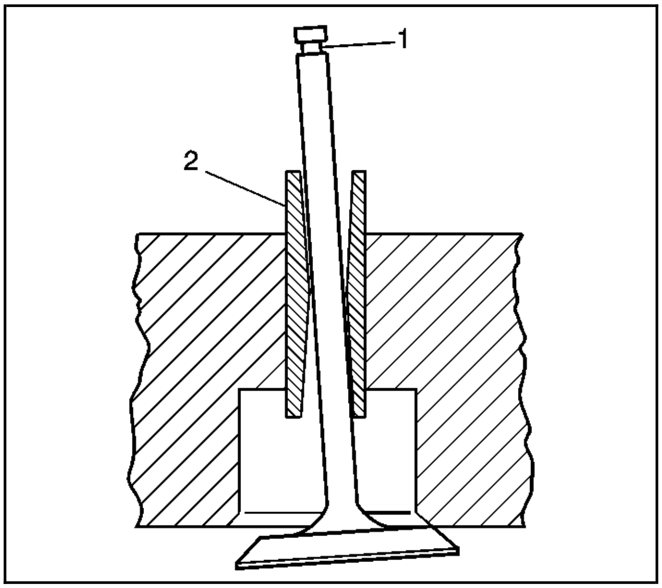
J 37378-1 Valve Guide Reamer

Valve Guide Reaming

Important:

- Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive engine oil consumption.
- Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

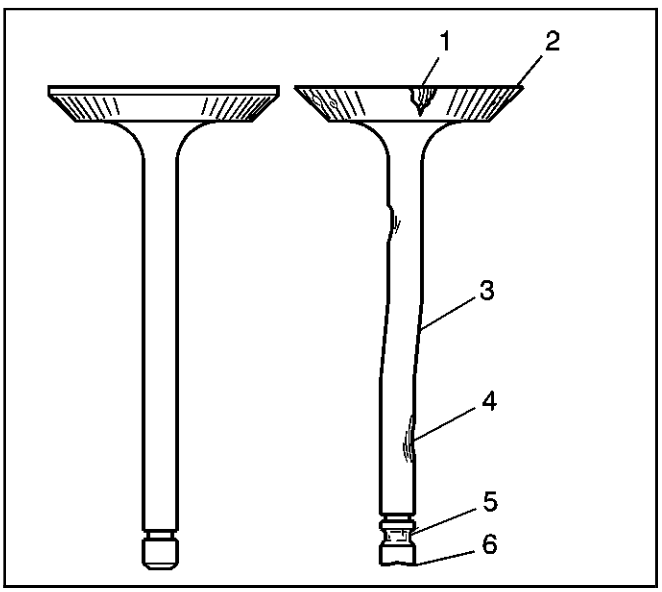




1. Measure the valve stem-to-guide clearance using a dial indicator. Position the tip of the dial indicator at the top of the valve guide.

   Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gage to measure the guide bore.
2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the components replaced.

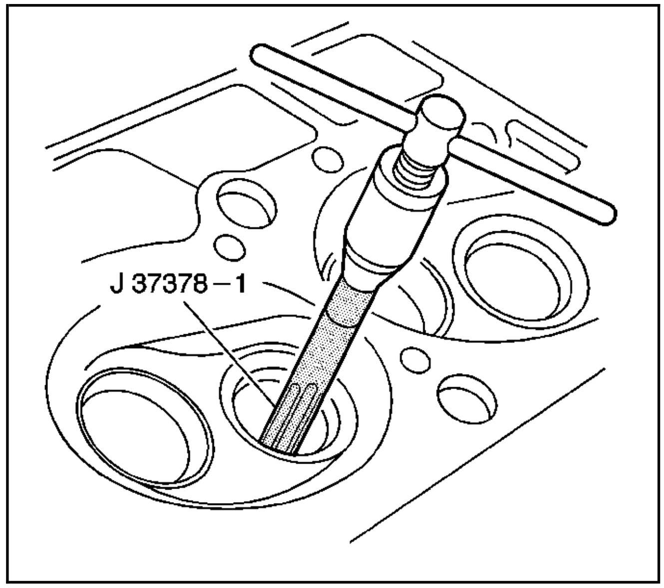
   Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.



3. Inspect the valve stems for excessive scoring, wear, or warpage.
   - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
   - A valve guide that is worn and has excessive stem-to-guide clearance should be reamed and valves with oversize stems installed.
4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

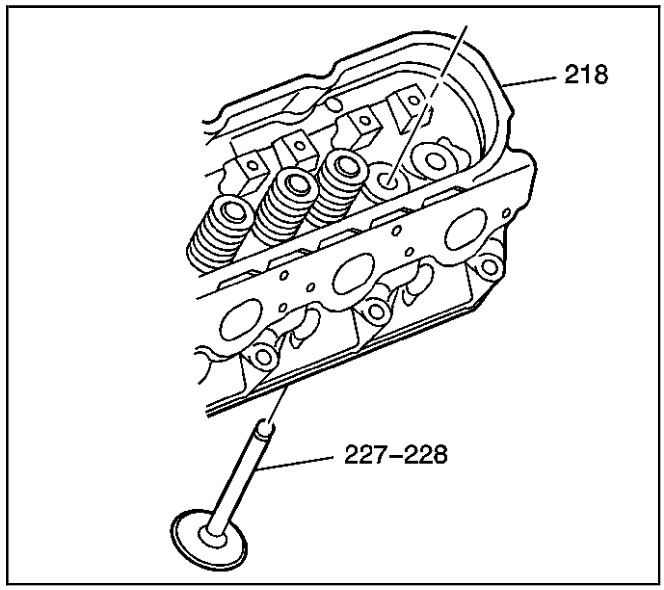
   If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the valve guide must be reamed oversize and a valve with oversize stem installed.

5. Ream the valve guide using the *J 37378-1*.
6. Clean the guide bore of all metal shavings and debris.



7. Install the valve (227–228), with oversize stem, into the cylinder head (218).
8. Inspect the valve for the proper fit.

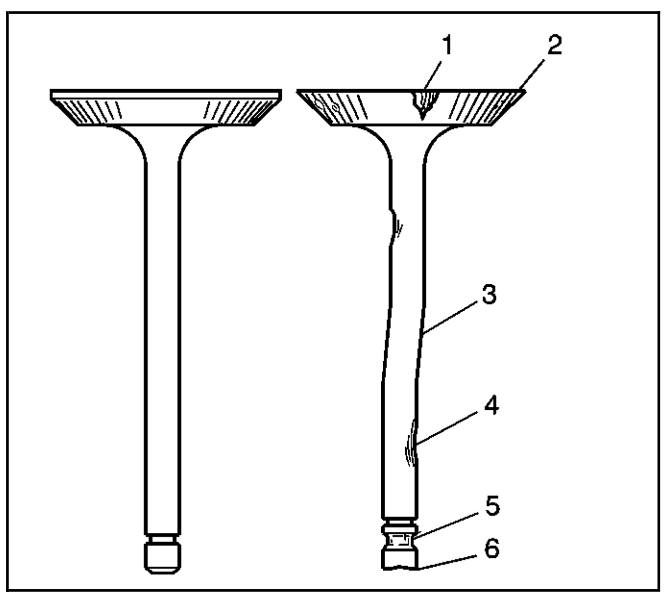
   Move the valve back and forth in the guide. The valve should move freely with no resistance or drag.

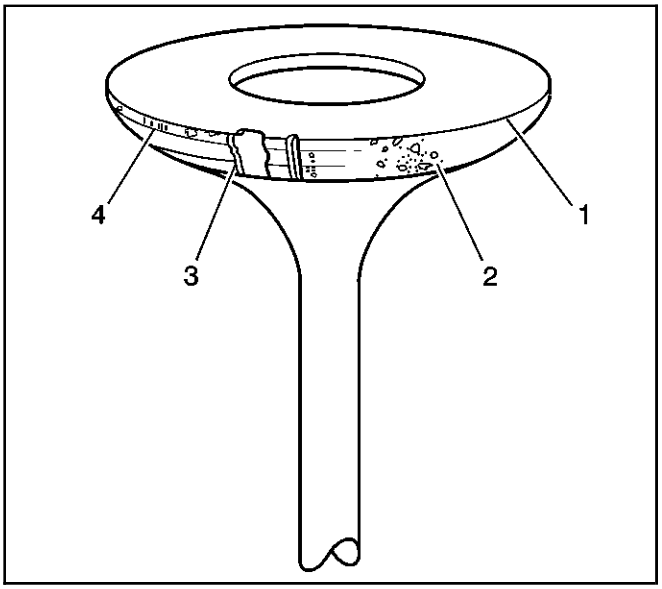


Valve and Seat Grinding

Important:

- Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of equipment are available for grinding valve seats.
- Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.
- The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.



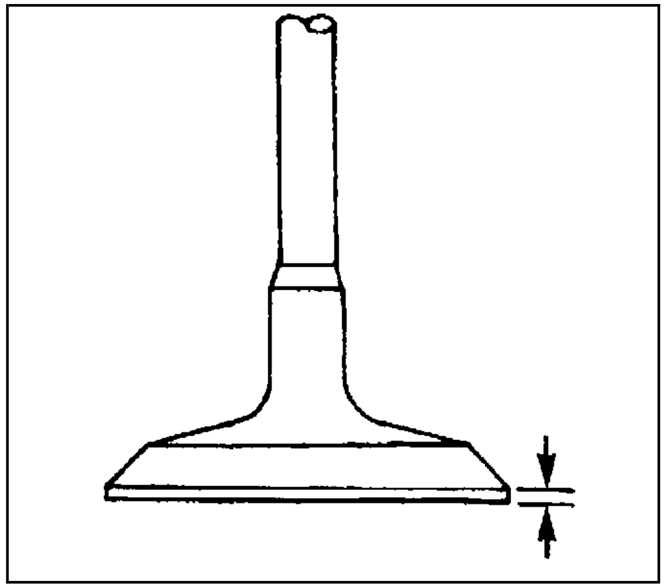


- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.
- Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment should be carefully followed to obtain the proper results.
- DO NOT reface intake valves. Intake valves with excessive wear or damage MUST be replaced.

1. Inspect the valve for the following conditions:
   - Burnt or eroded areas (1)
   - A worn margin (2)
   - A bent stem (3)
   - A worn or scored stem (4)
   - A worn key groove (5)
   - A worn stem tip (6)
2. Inspect the valve face for the following conditions:
   - Worn or no margin (1 or 4)
   - Pitted surfaces (2)
   - Burnt or eroded areas (3)

3. Inspect the valve margin.

   The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.
4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring to obtain the proper spring installed height. Refer to *Cylinder Head Disassemble*.

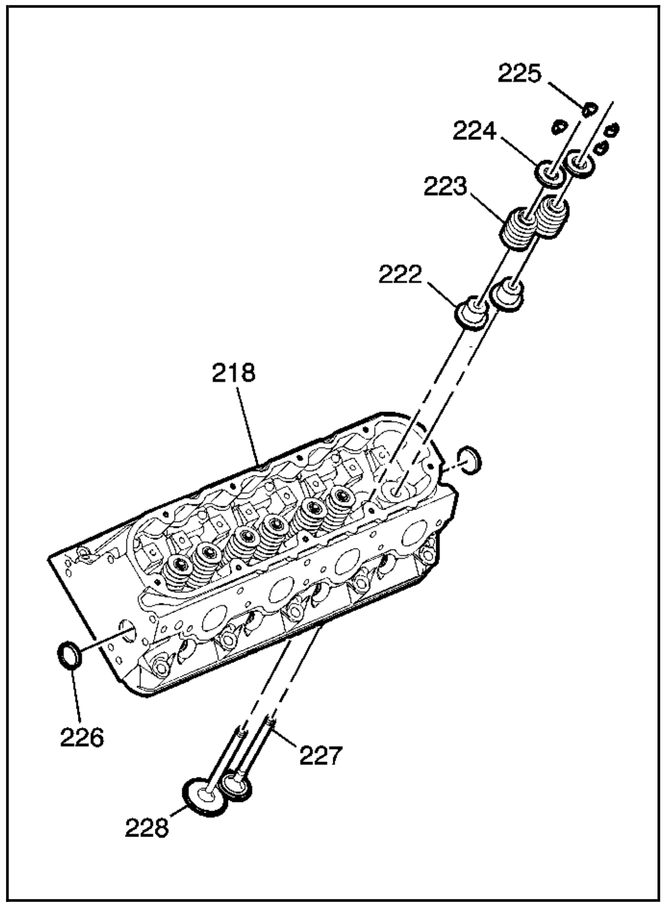


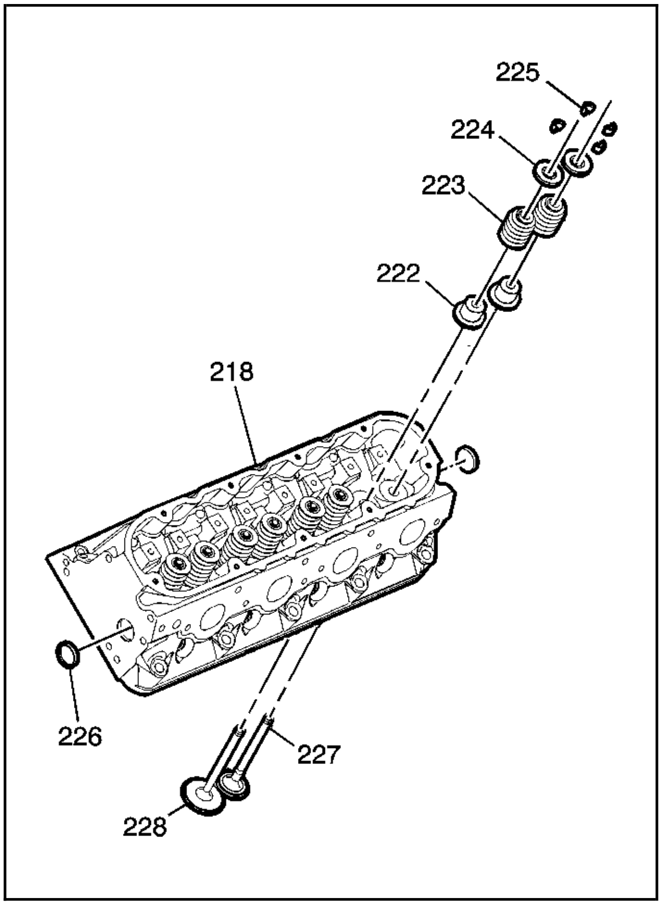
7. Inspect for a loose valve seat in the cylinder head (218). The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

   The valve guide must be clean for the seat grinding tool to obtain proper results.
9. Grind the valve seat.

   The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.
10. Inspect the valve seats.
    - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
    - If the valve seat has been ground, it may be necessary to shim the valve spring to attain the proper spring installed height.

      Refer to *Cylinder Head Disassemble*.





Cylinder Head Assemble

Tools Required

J 8062 Valve Spring Compressor – Head Off

1. Clean the cylinder head valve spring shim area.

Important: When using the valves and related components again, install the parts to their original location.

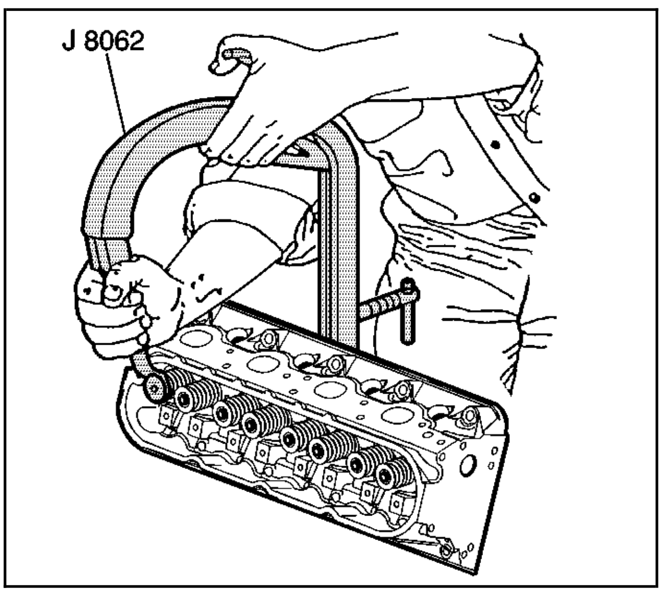
2. Install the valves (227 and 228) into the proper port.

   Refer to *Separating Parts*.

Important: The valve stem oil seal alignment and position on the valve guide is critical.

An improperly installed valve stem oil seal may lead to excessive oil consumption, increased vehicle emissions, or component damage.

3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).



6. Compress the valve spring using the *J 8062*.
7. Install the valve stem keys.
   - 7.1. Use grease to hold the keys in place and remove the *J 8062*.
   - 7.2. Ensure the keys seat properly in the groove of the valve stem.
   - 7.3. Tap the end to the valve stem with a plastic faced hammer to seat the keys, if necessary.

8. Measure the valve spring installed height using a ruler.

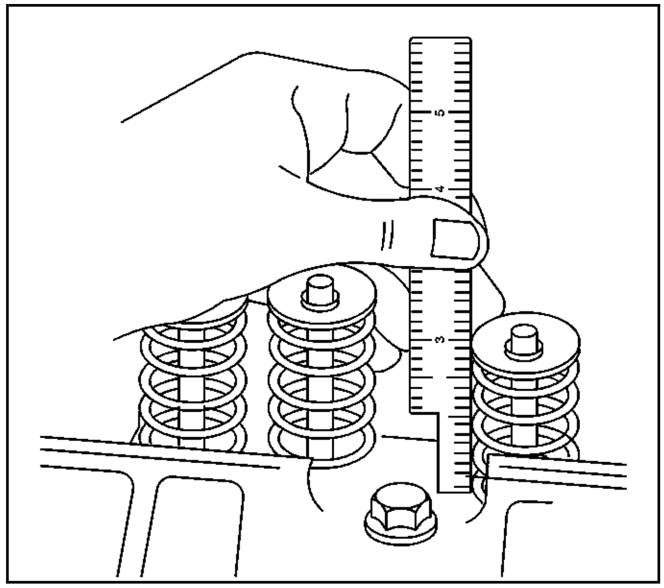
   Measure from the base of the valve spring to the top of the valve spring.

   Specification

   - If the installed height exceeds 46.25 mm (1.82 in), install a valve spring shim of approximately 0.5 mm (0.02 in) thick.
   - Do not shim the valve spring to obtain less than the specified height.

     Do not assemble the components without a spring shim on the cylinder head.

9. Install the remaining valves, springs, and other components.



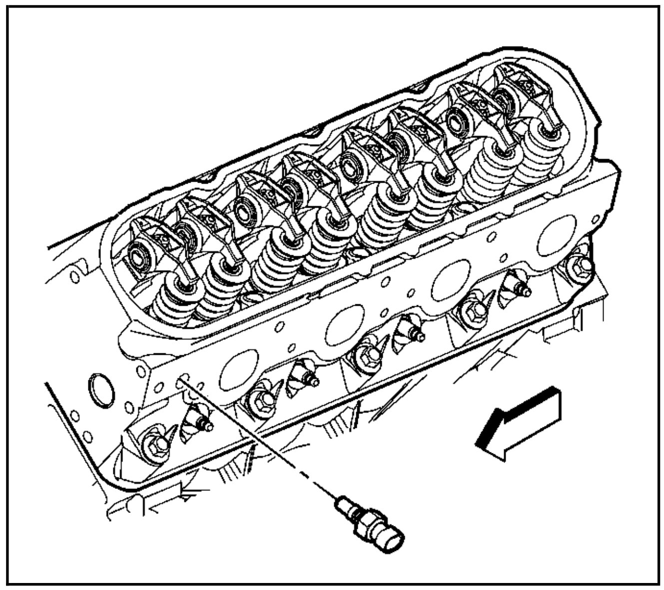
10. Install sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the coolant sensor.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

11. Install the coolant sensor into the left cylinder head.

    Tighten

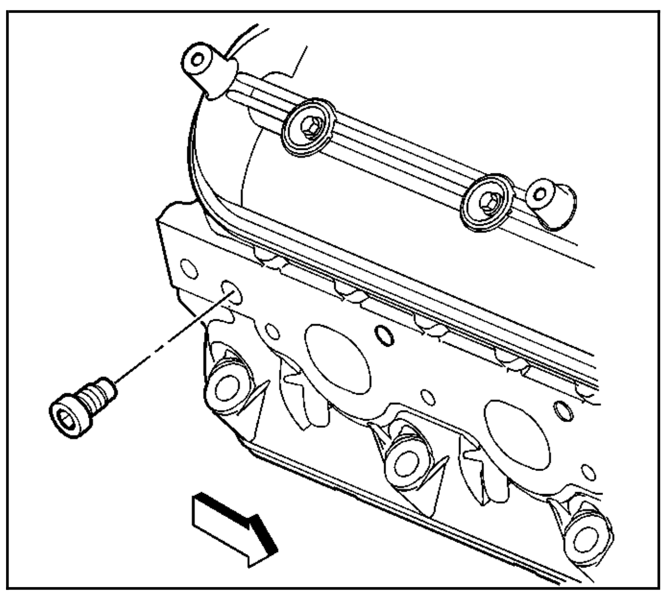
    Tighten the coolant sensor to 20 N·m (15 lb ft).

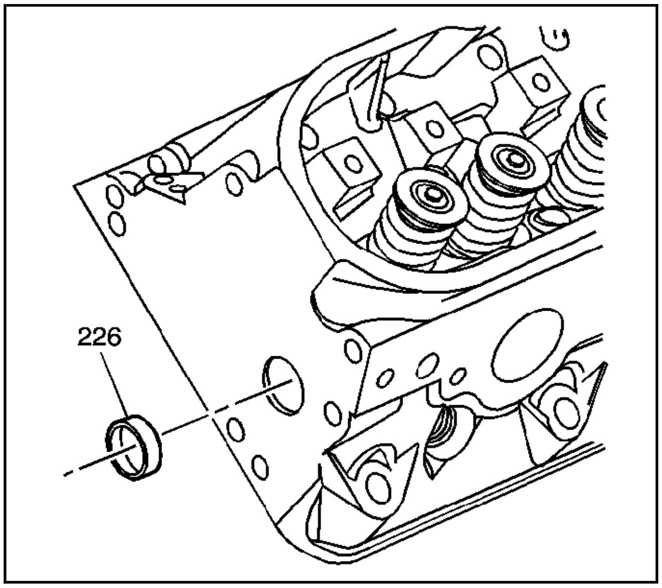


12. Install the coolant plug to the right cylinder head.

    Tighten

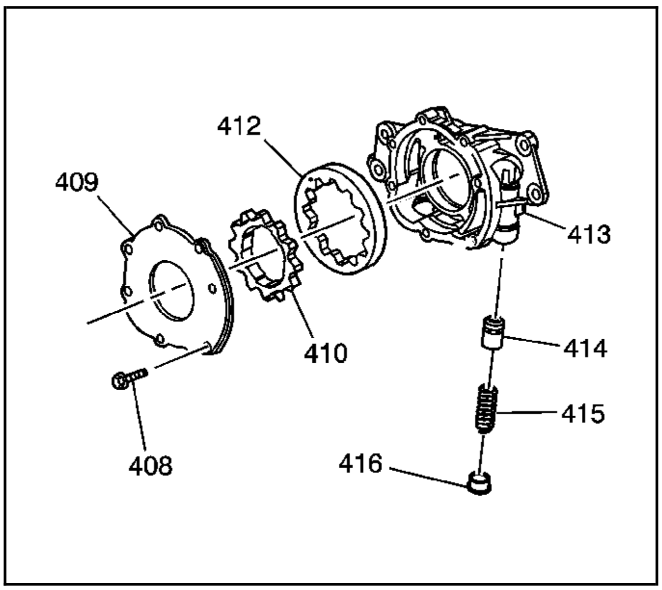
    Tighten the coolant plug to 20 N·m (15 lb ft).





13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the sides of the cylinder head expansion plugs (226).
14. Install the expansion plugs into the cylinder head.

    A properly installed plug should be installed 2.5 mm (0.1 in) below the end face of the head.



Oil Pump Disassemble

Important: The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts (408).
2. Remove the oil pump cover (409).

Important: Mark or identify the gears for assembly. Refer to *Separating Parts*.

3. Remove the drive gear (410).
4. Remove the driven gear (412).
5. Remove the pressure regulator valve plug (416).
6. Remove the pressure regulator valve spring (415).
7. Remove the pressure regulator valve (414).
8. Inspect the oil pump components. Refer to *Oil Pump Cleaning and Inspection*.

Oil Pump Cleaning and Inspection

Important:

- The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.
- The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.

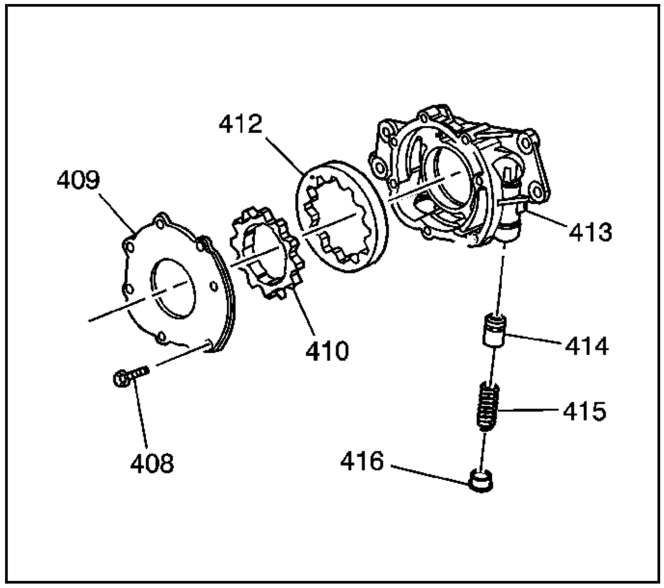
1. Clean the parts in solvent.

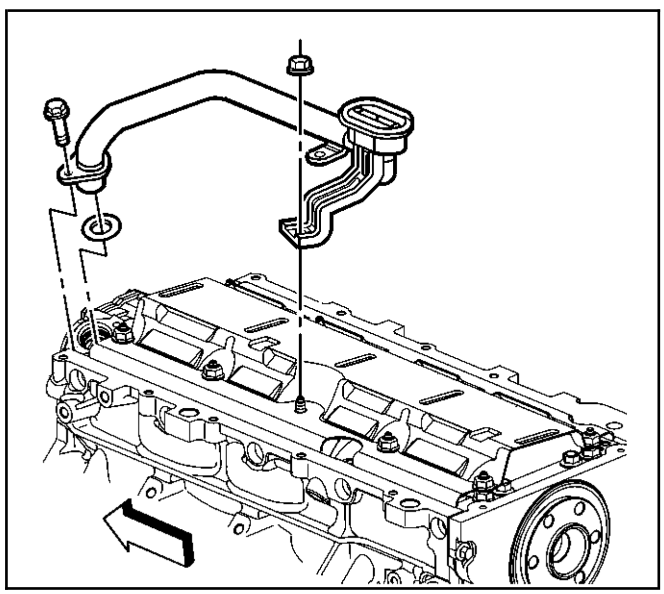
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

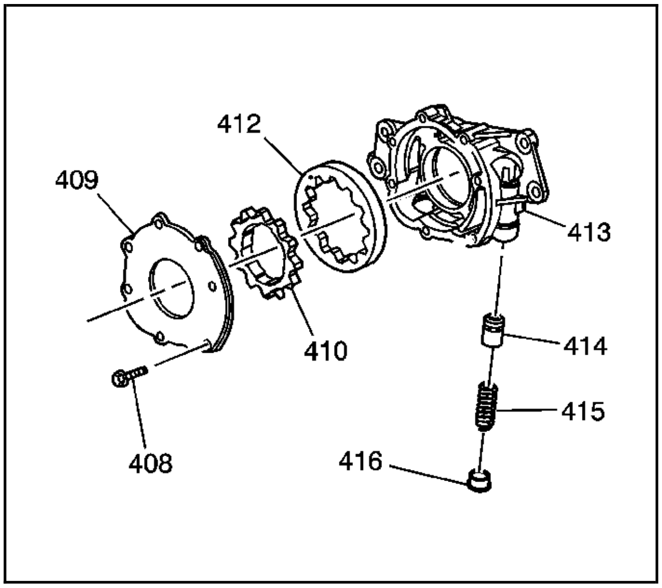
2. Dry the parts with compressed air.
3. Inspect the oil pump housing (413) and the cover (409) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the regulator valve plug (416) and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
8. Inspect the drive gear (410) and driven gear (412) for chipping, galling or wear.

   Minor burrs or imperfections on the gears may be removed with a fine oil stone.
9. Inspect the drive gear splines for excessive wear.
10. Inspect the pressure regulator valve (414) and bore for scoring or wear.

    The valve must move freely in the bore with no restrictions.
11. Inspect the oil pump screen for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.







Oil Pump Assemble

Important: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

1. Install the driven gear (412) into the pump housing (413).

   Install the driven gear with the orientation mark facing the pump cover.
2. Install the drive gear (410) into the pump housing.
3. Install the oil pump cover (409).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

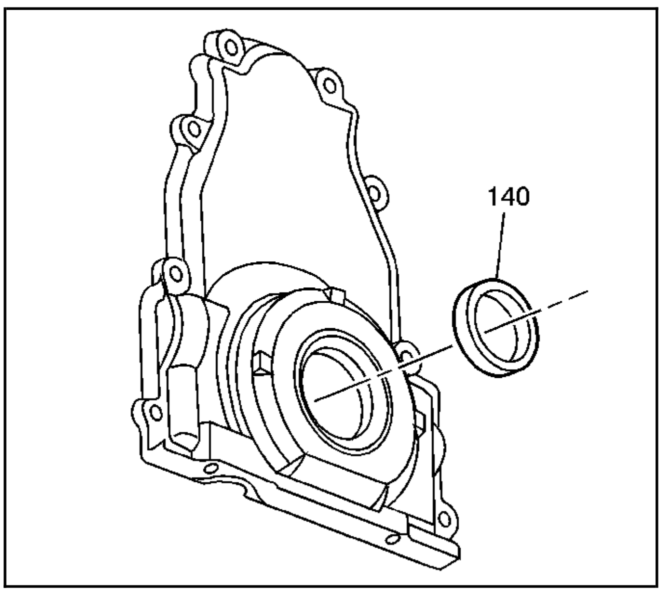
4. Install the pump cover bolts (408).

   Tighten

   Tighten the oil pump cover bolts to 12 N·m (106 lb in).
5. Install the regulator valve (414).
6. Install a NEW regulator valve spring (415).
7. Install the pressure regulator valve plug (416).

   Tighten

   Tighten the pressure regulator valve plug to 12 N·m (106 lb in).
8. Inspect the oil pump for smooth operation by rotating the drive gear.



Engine Front Cover Cleaning and Inspection

Important:

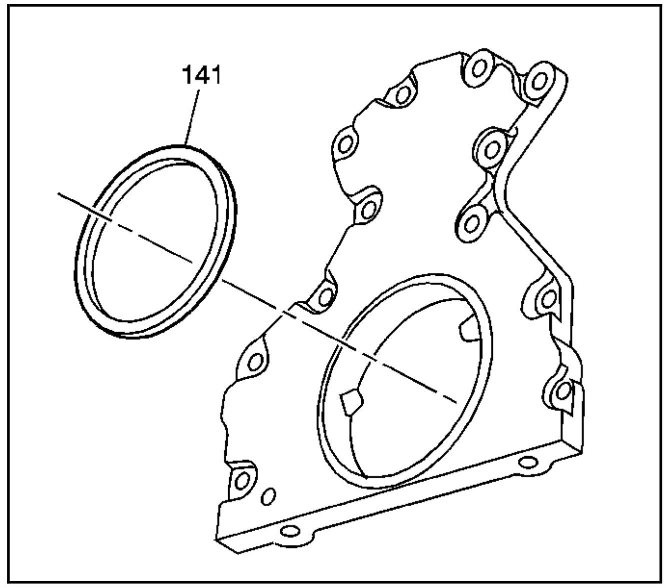
- Do not use the crankshaft oil seal again. Install a NEW crankshaft oil seal during assembly.
- Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (140) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to *Replacing Engine Gaskets*.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

Engine Rear Cover Cleaning and Inspection



Important:

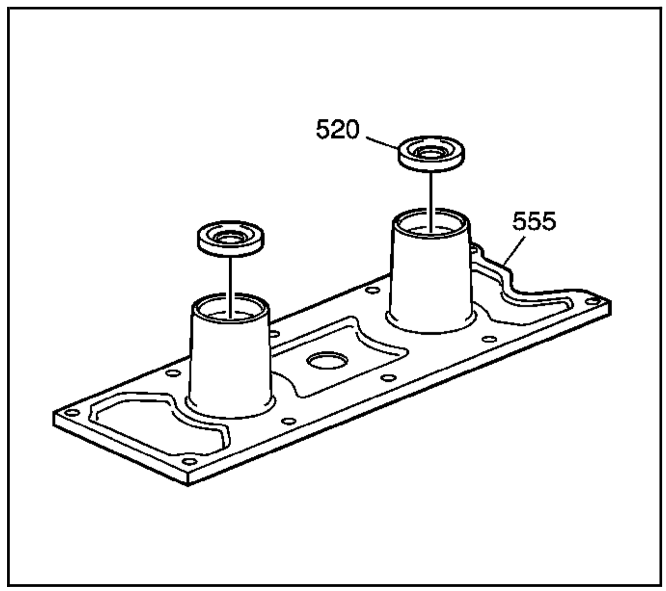
- Do not use the crankshaft oil seal again. Install a NEW crankshaft oil seal during assembly.
- Do not use the rear cover-to-engine block gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (141) from the rear cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to *Replacing Engine Gaskets*.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

Engine Valley Cover Cleaning and Inspection



Important:

- Do not use the valley cover knock sensor oil seals again. Install NEW oil seals during assembly.
- Do not use the valley cover gasket again. Install a NEW gasket during assembly.

1. Remove the knock sensor oil seals (520) from the valley cover (555).
2. Clean the valley cover in solvent.

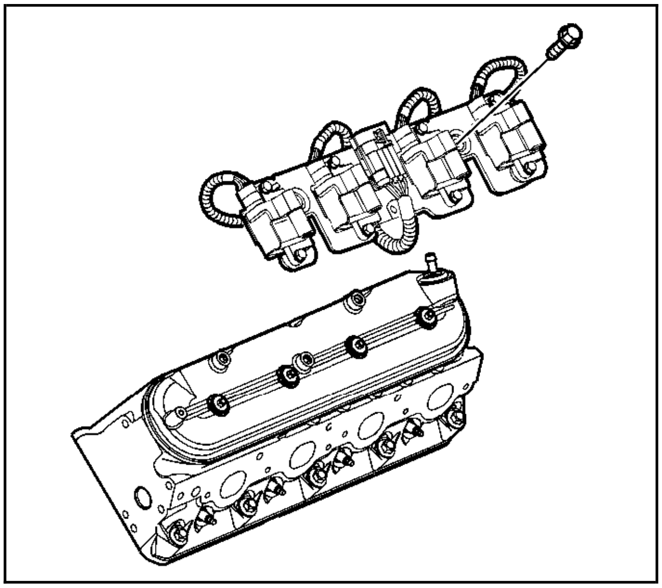
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the valley cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging. Refer to *Replacing Engine Gaskets*.
5. Inspect the valley cover oil seal bores for excessive scratches or gouging.

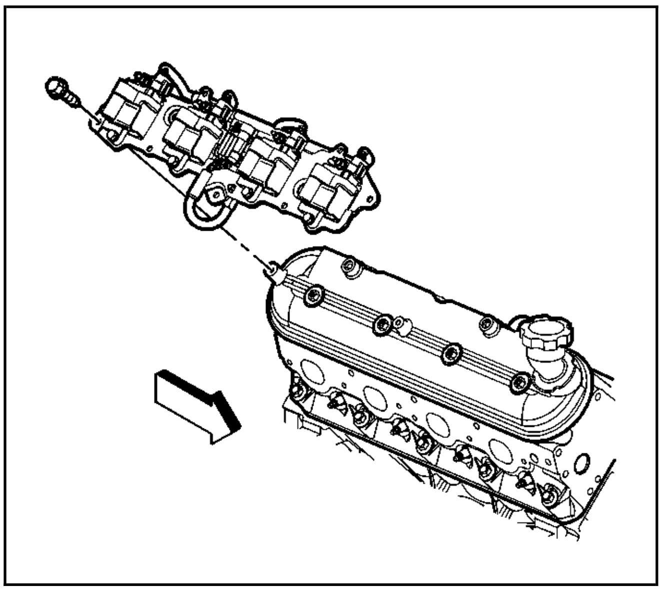
Valve Rocker Arm Cover Cleaning and Inspection

Important:

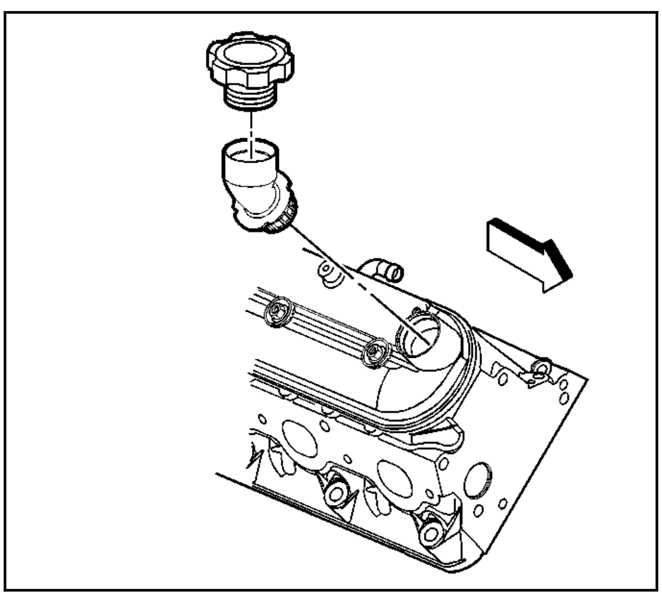
- Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.
- Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.
- Do not remove the oil fill tube or crankcase vent valve grommet from the covers unless service is required.
- If the oil fill tube or crankcase vent valve grommet have been removed from the rocker arm covers, install a NEW tube or grommet during assembly.



1. Remove the ignition coil and bracket assembly, bolts, and wire harness from the left cover, if required.

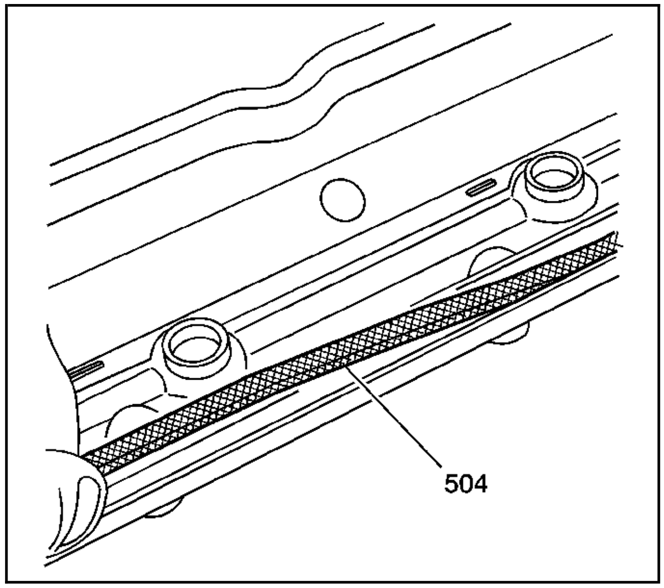


2. Remove the ignition coil and bracket assembly, bolts, and wire harness from the right cover, if required.



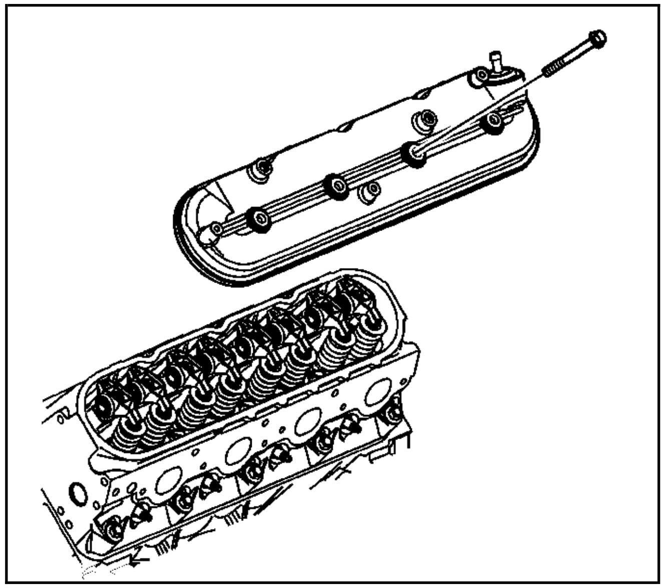
3. Inspect the tube for a loose fit or damage.
4. Remove the oil fill cap and tube from the right cover, if required.

5. Remove the gaskets (504) from the covers.
6. Remove the cover mounting bolts, with grommets.
   Cover mounting bolts and grommets that are not damaged may be used again during assembly.
7. Clean the covers in solvent.



Caution: Refer to Safety Glasses Caution in Cautions and Notices.

8. Dry the covers with compressed air.
9. Inspect the ventilation system passages for restrictions.
10. Inspect the gasket grooves for damage.
11. Inspect the coil bracket threaded bolt holes for damage or debris.

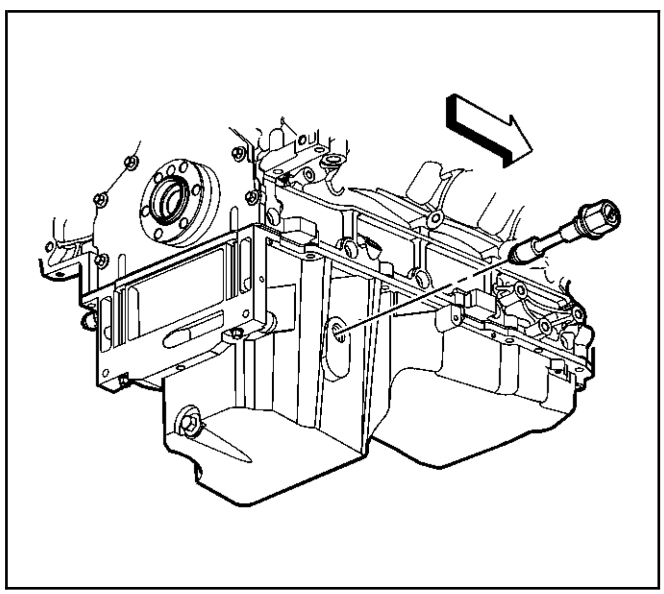


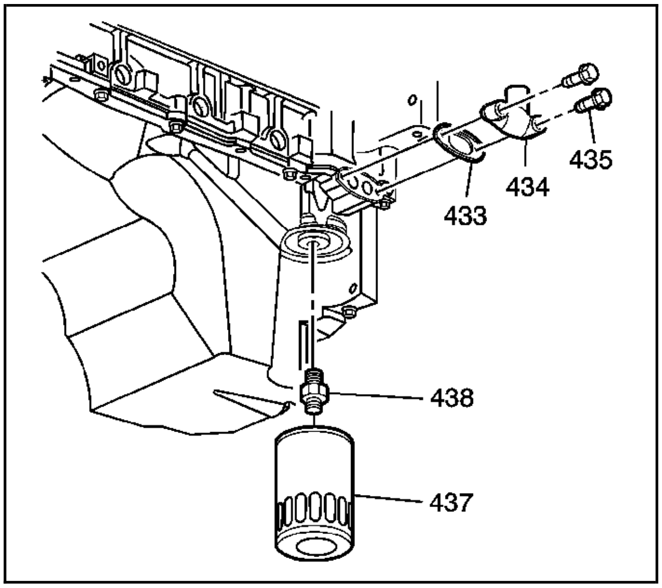
Oil Pan Cleaning and Inspection

Important:

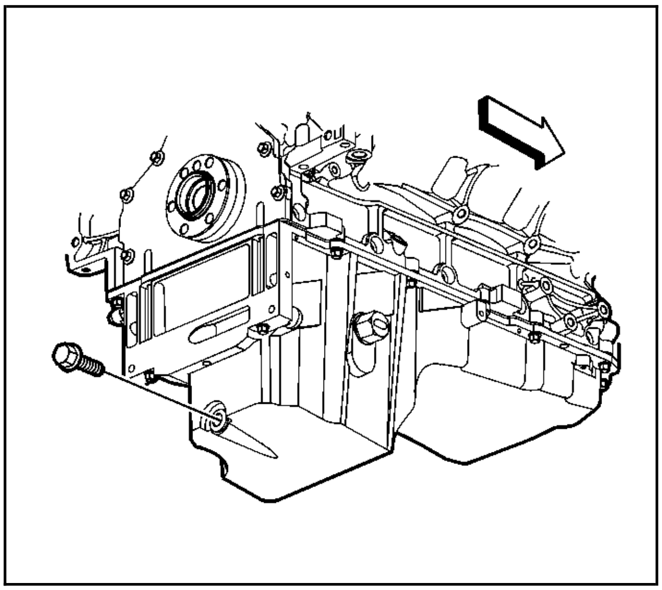
- Do not use the oil pan cover gasket again. Install a NEW cover gasket during assembly.
- Do not use the oil pan to engine block gasket again. Install a NEW gasket during assembly.
- When installing a NEW oil pan gasket, it is not necessary to install the rivets that retain the NEW gasket to the pan.

1. Remove the oil level sensor from the pan.

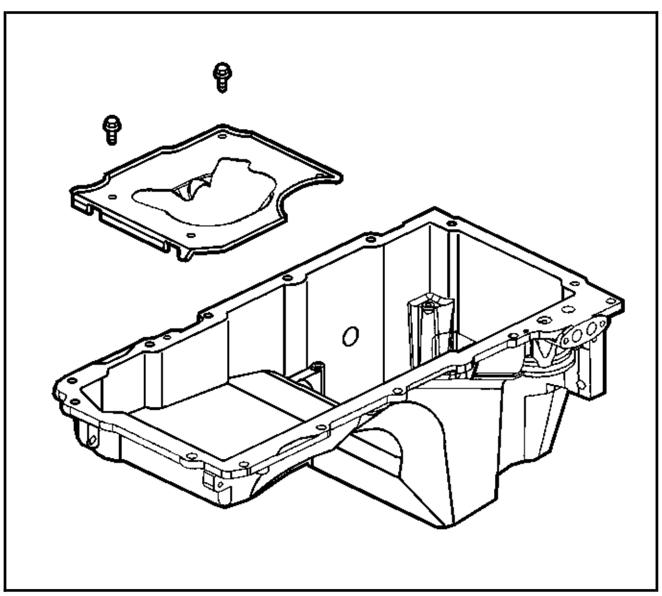




2. Remove the oil pan cover (434), gasket (433), and bolts (435), if required.



3. Remove the oil pan drain plug and O-ring seal.

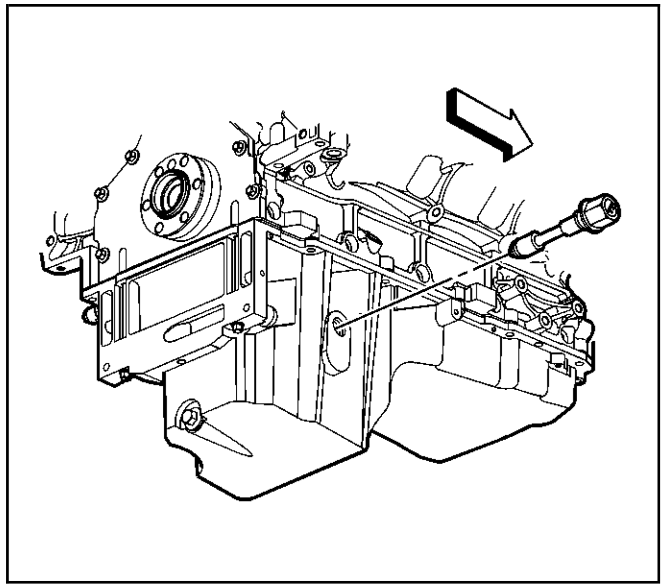


4. Remove the oil pan baffle and bolts.
5. Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.
6. Clean the oil pan gasket surfaces. Refer to *Replacing Engine Gaskets*.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

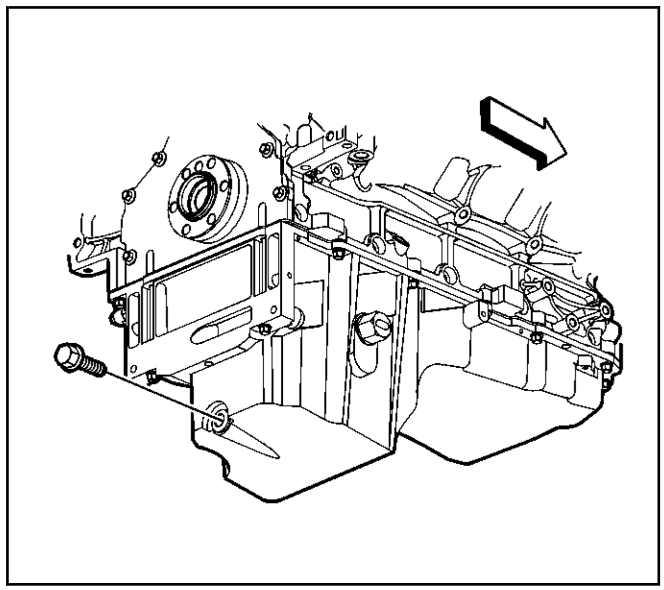
7. Dry the oil pan with compressed air.
8. Inspect the gasket sealing surfaces for excessive scratches or gouging. Refer to *Replacing Engine Gaskets*.

9. Inspect the oil level sensor seal surface and threads for damage.



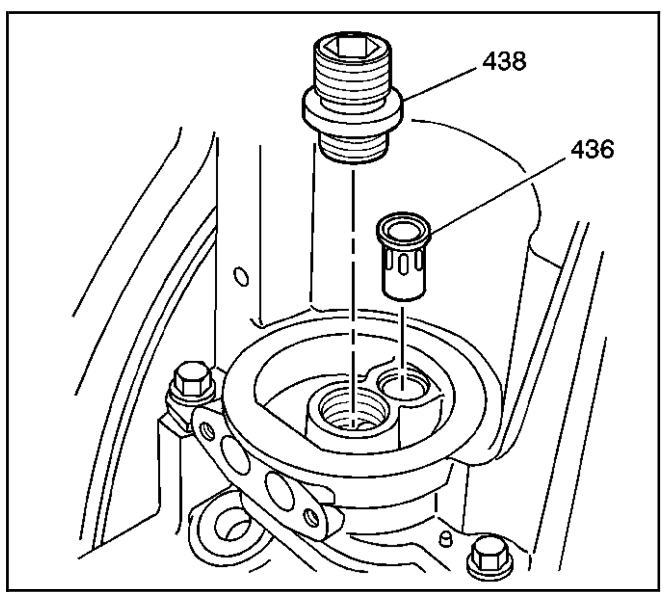
10. Inspect the oil pan drain plug and threaded drain hole for damaged threads.

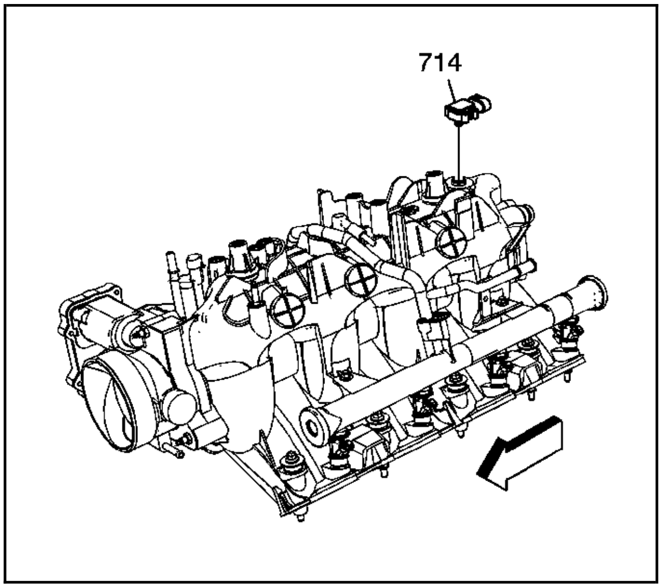
    The drain plug O-ring seal may be used again if not cut or damaged.



11. Inspect the oil filter sealing surface for scratches or gouging.
12. Inspect the oil filter fitting (438) for a loose fit or damaged threads.
13. Inspect the oil passages for restrictions.
14. Inspect the oil filter bypass valve (436) for proper operation.

    Lightly depress the bypass valve. The valve spring should seat the valve to the proper position.



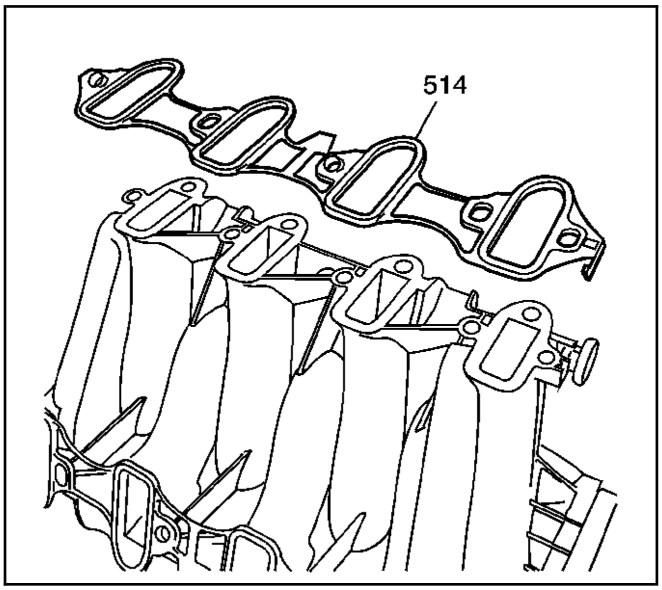


Intake Manifold Cleaning and Inspection

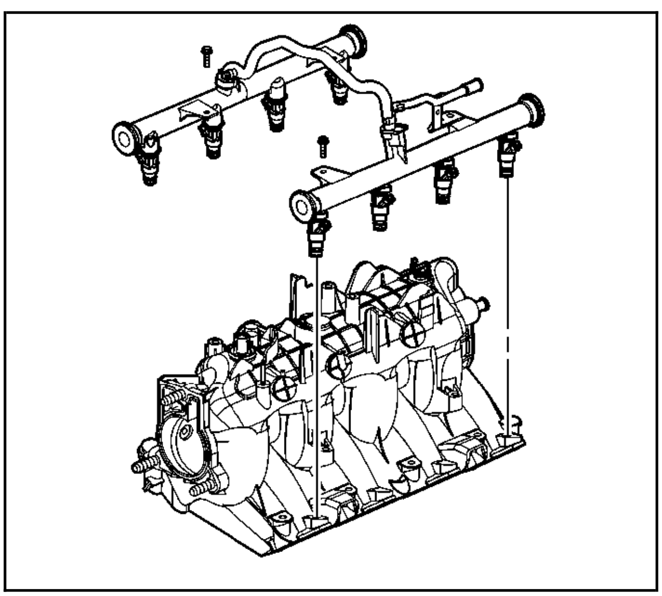
Cleaning Procedure

Important: Do not use the intake manifold-to-cylinder head sealing gaskets again.

1. Remove the manifold absolute pressure (MAP) sensor (714) from the rear of the intake. The MAP sensor is to be reinstalled upon completion of the cleaning and inspection procedures.
2. Inspect the sealing grommet on the MAP sensor. The grommet should not be torn or damaged.

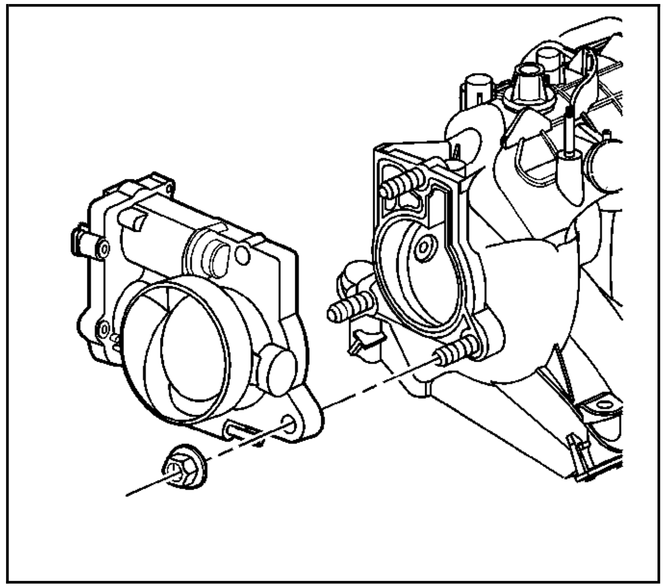


3. Remove and discard the intake manifold-to-cylinder head gaskets (514).



4. Remove the fuel rail with injectors. Refer to *Fuel Rail and Injectors Removal*.

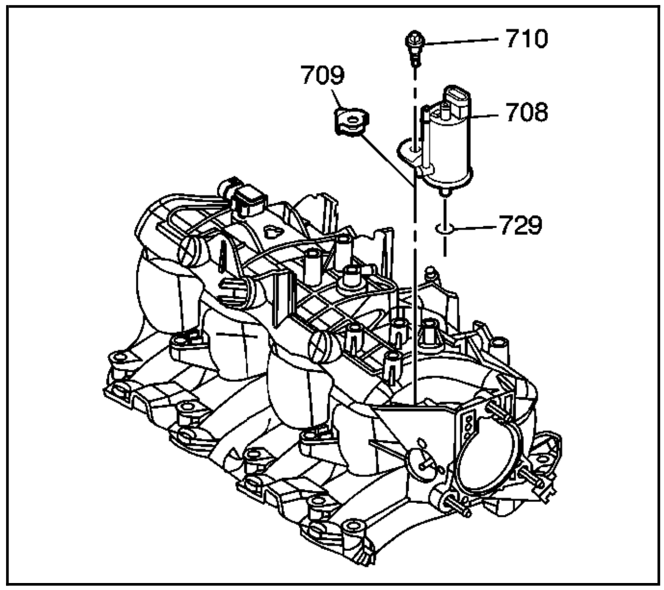
5. Remove the throttle body and gasket. Refer to *Throttle Body Removal*.



6. Remove the evaporative emissions (EVAP) purge solenoid (708), bolt (710), and isolator (709).
7. Clean the intake manifold in solvent.
   - Clean the intake manifold gasket surfaces.
   - Clean the intake manifold internal passages.

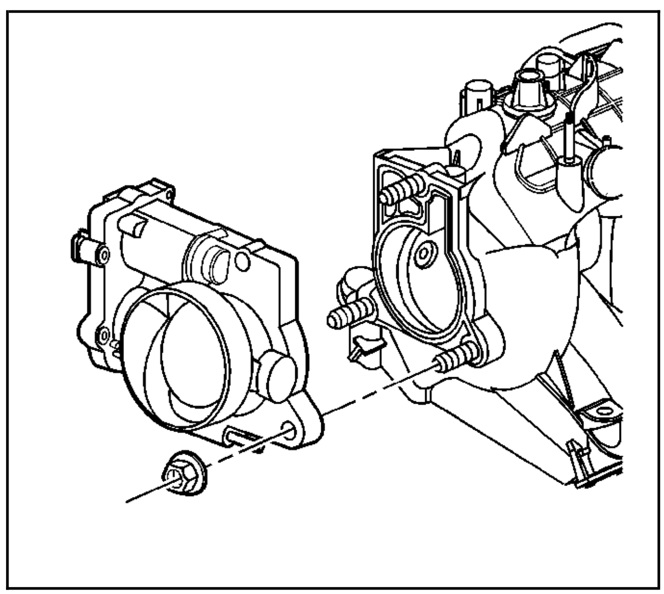
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

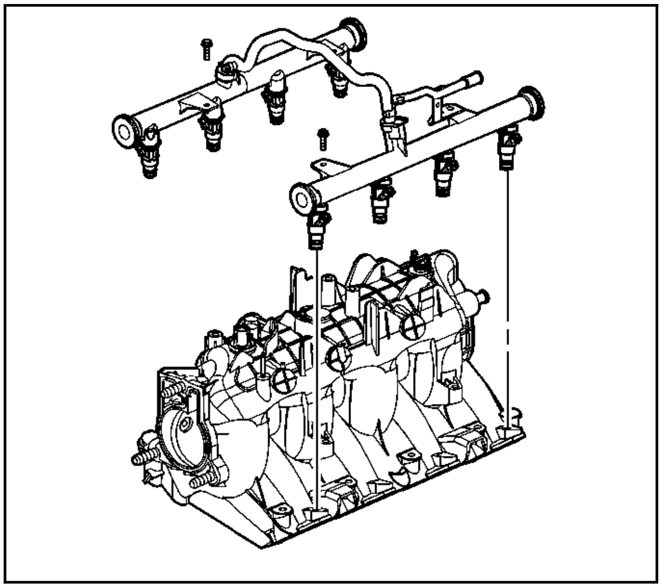
8. Dry the intake manifold with compressed air.



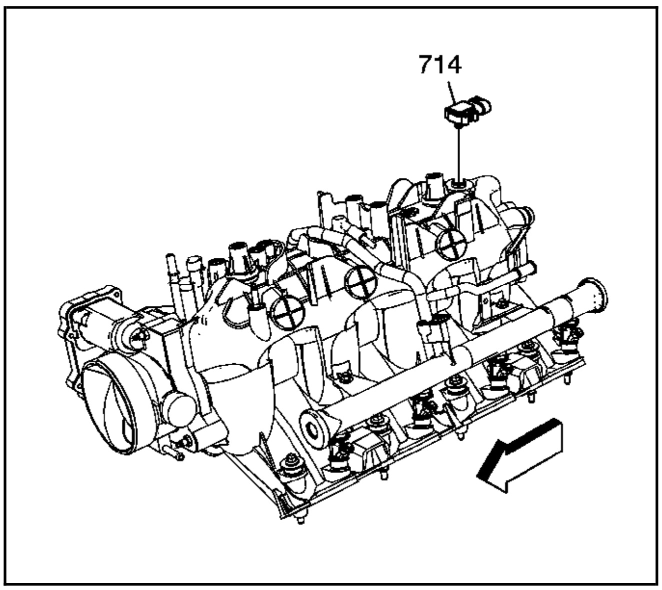
Inspection Procedure

1. Inspect the throttle body studs and threaded inserts for looseness or damaged threads.
2. Inspect the wire harness stud and threaded insert for looseness or damaged threads.



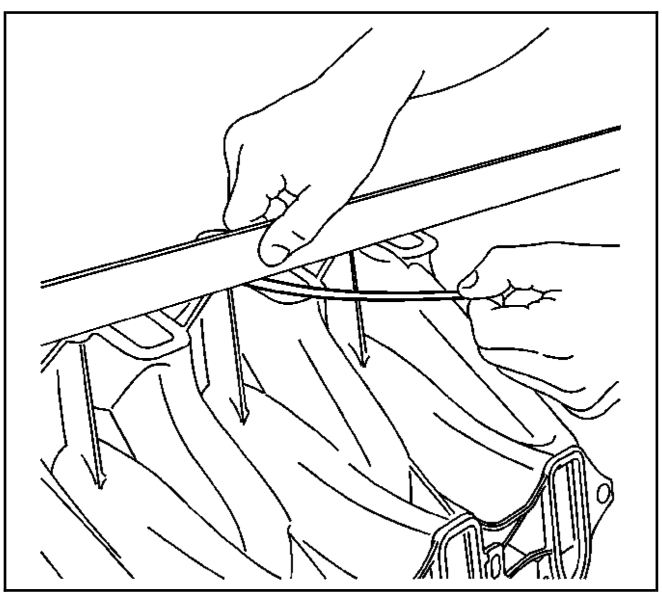


3. Inspect the fuel rail bolt inserts for looseness or damaged threads.
4. Inspect the intake manifold vacuum passages for debris or restrictions.



5. Inspect for damaged or broken vacuum fittings, damaged MAP sensor (714) mounting bore, or broken MAP sensor retaining tabs.
6. Inspect the composite intake manifold assembly for cracks or other damage.

   Inspect the areas between the intake runners.
7. Inspect all the gasket sealing surfaces for damage.



8. Inspect the fuel injector bores for excessive scoring or damage.
9. Inspect the intake manifold cylinder head deck for warpage.
   9.1. Locate a straight edge across the intake manifold cylinder head deck surface.

   Position the straight edge across a minimum of two runner port openings.
   9.2. Insert a feeler gage between the intake manifold and the straight edge.

   A intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

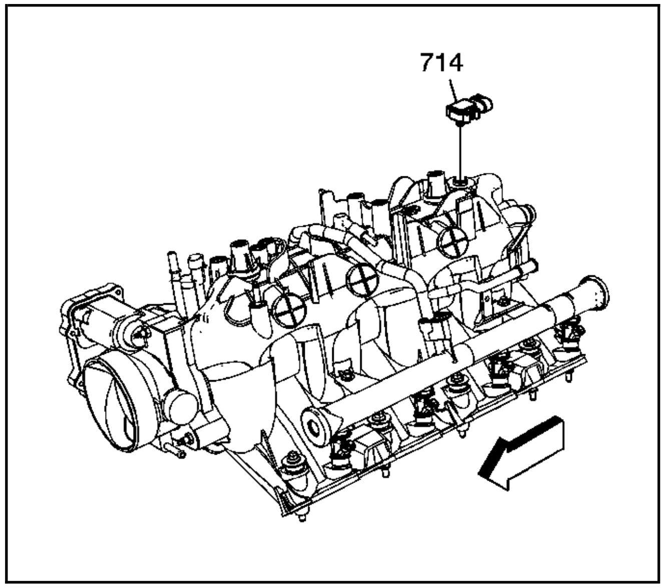
10. Install the MAP sensor (714).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

11. Install the EVAP solenoid, bolt, and isolator.

    Tighten

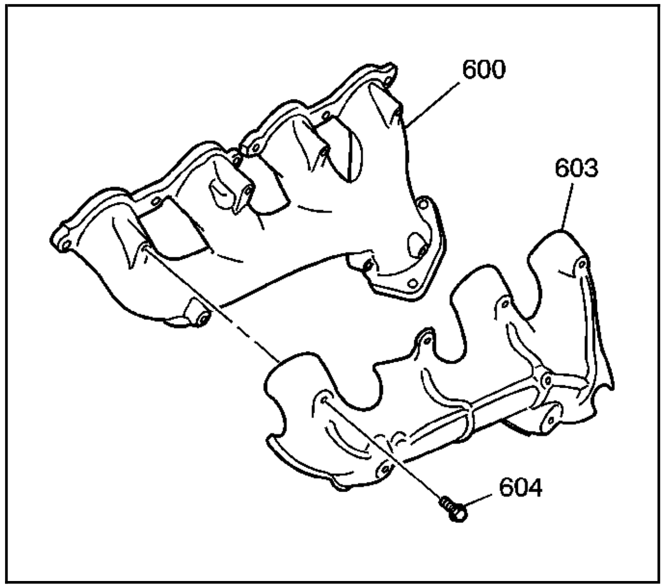
    Tighten the EVAP solenoid bolt to 10 N·m (89 lb in).



Exhaust Manifold Cleaning and Inspection

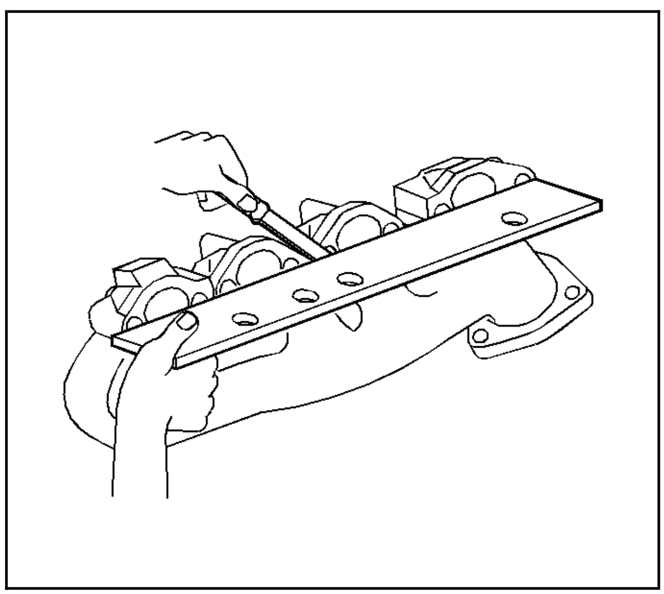
Important: Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.

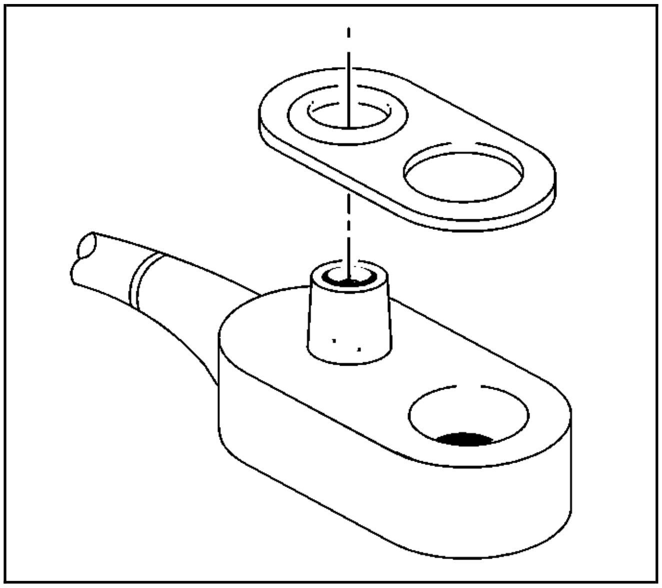
1. Clean the exhaust manifold (600) and heat shield (603) in solvent.
2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose or damaged heat shield (603).
5. Inspect the take down studs for damaged threads.



6. Use a straight edge and a feeler gage and measure the exhaust manifold cylinder head deck for warpage.

   An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the two front or two rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

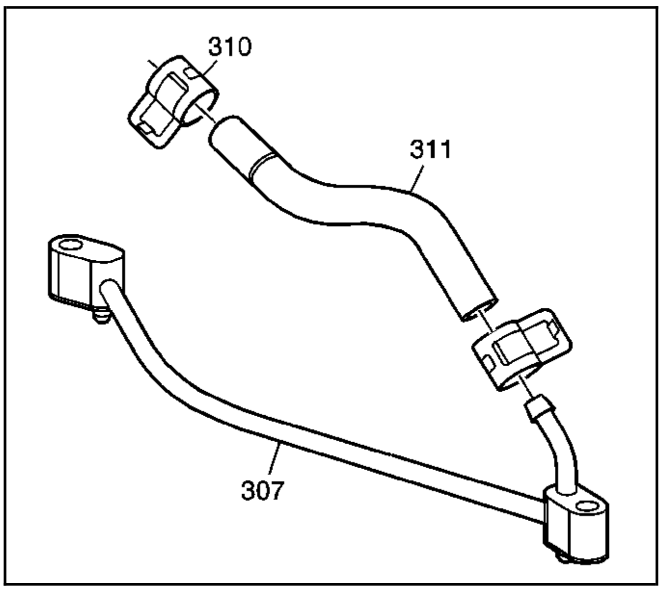




Coolant Air Bleed Pipe Cleaning and Inspection

Important: Do not use the engine coolant air bleed pipe and cover gaskets again. Upon installation of the pipe and covers, install NEW gaskets.

1. Remove the sealing gaskets from the pipe.
2. Remove the sealing gaskets from the covers.

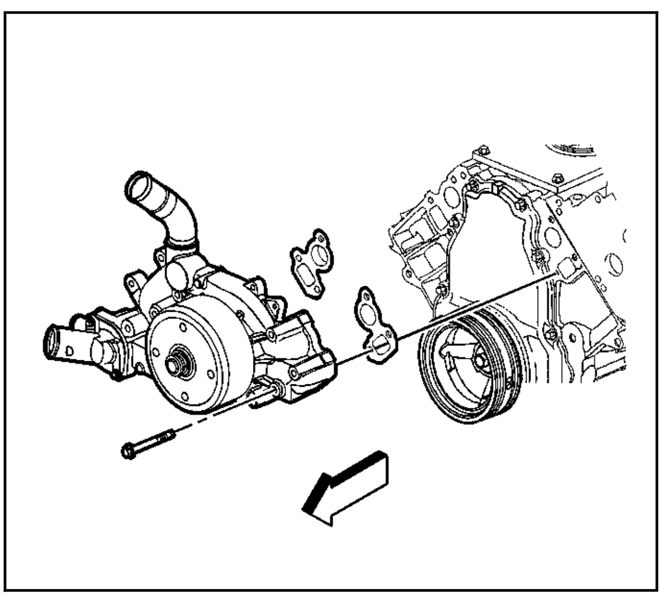


3. Clean the pipe (307), hose (311), and covers in solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

4. Dry the pipe and covers with compressed air.
5. Inspect the pipe and covers for damage or restrictions.
6. Inspect the gasket and hose sealing surfaces for damage.
7. Inspect the hose (311) for restrictions, cracking or wear.

   The hose may be used again if it is not damaged.

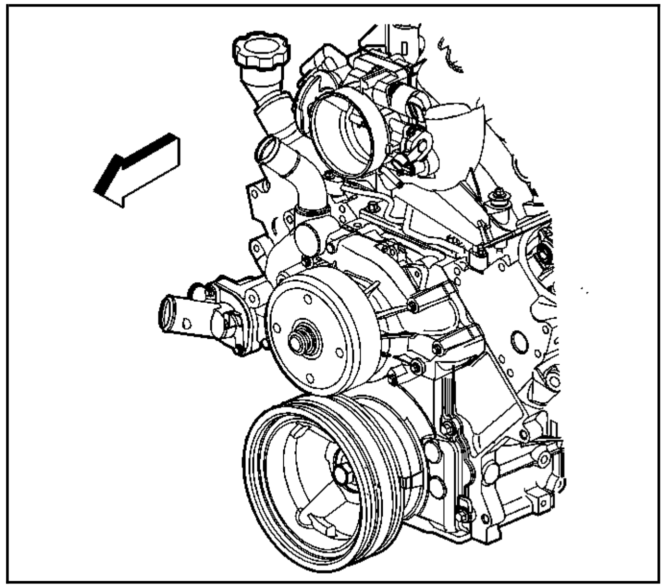


Water Pump Cleaning and Inspection

1. Remove the old gasket from the water pump sealing surfaces. Refer to *Replacing Engine Gaskets*.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
   - Gasket and hose sealing surfaces for excessive scratches or gouging
   - Restrictions within the internal coolant passages
   - Excessive side-to-side play in the pulley shaft
   - Leakage at the water outlet housing or rear cover gasket
   - Leakage at the water pump vent hole

A stain around the vent hole is acceptable. If leakage, dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.

4. Inspect the water pump pulley for wear or damage in the belt tracking area.



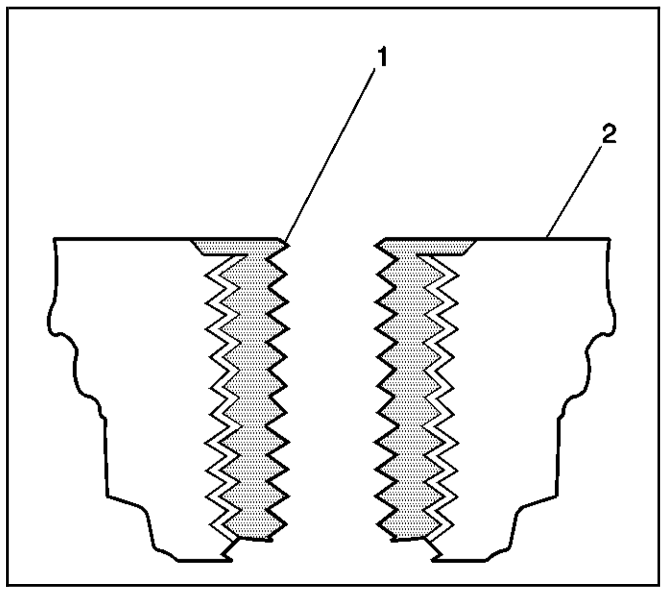
Thread Repair

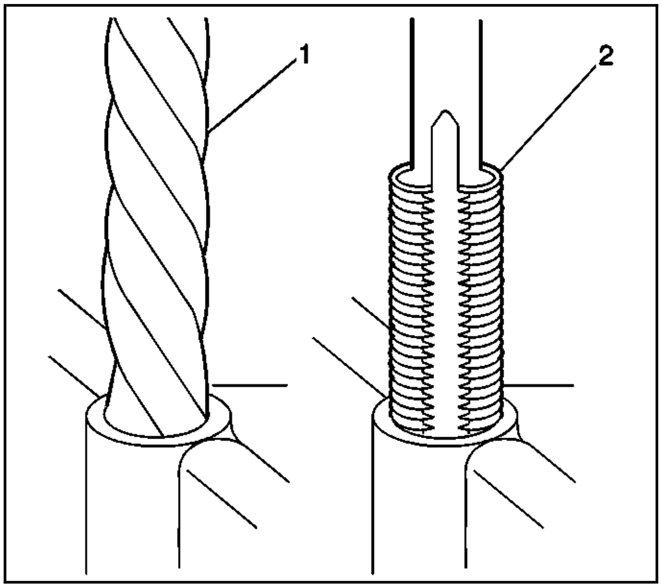
Tools Required

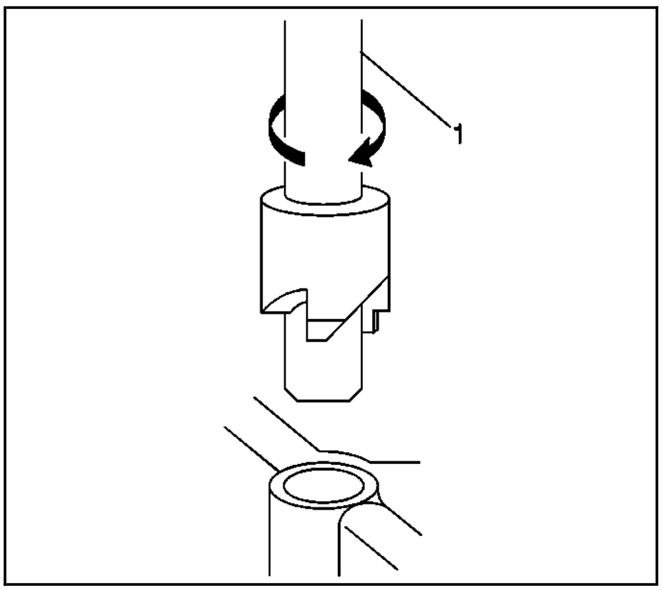
- *J 42385-100* Head/Main Bolt Thread Repair Kit
- *J 42385-200* Common Thread Repair Kit
- *J 42385-300* Fixtures and Hardware Kit

General Thread Repair

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.







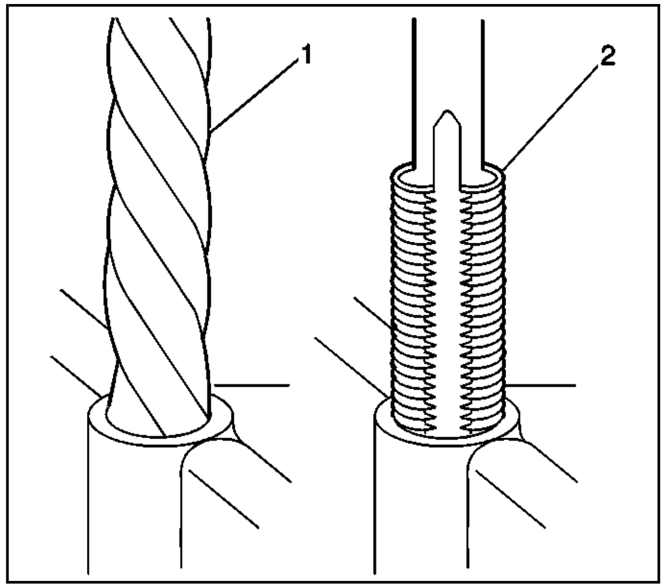
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Important:

- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent is recommended when performing the drilling, counterboring, and tapping procedures.
- Driver oil MUST be used on the installer driver tool.
- The tool kits are designed for use with either a suitable tap wrench or drill motor.

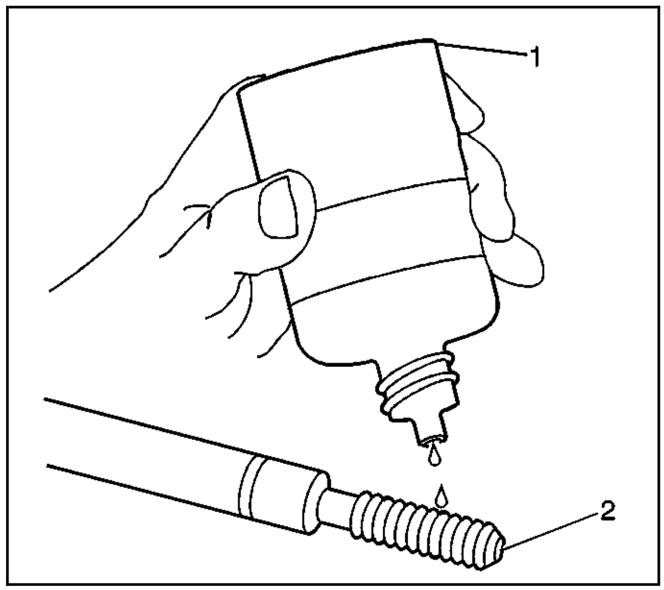
1. Drill out the threads of the damaged hole (1).
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.
3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

5. Using a tap wrench (2), tap the threads of the drilled hole.
   - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
   - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
   - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

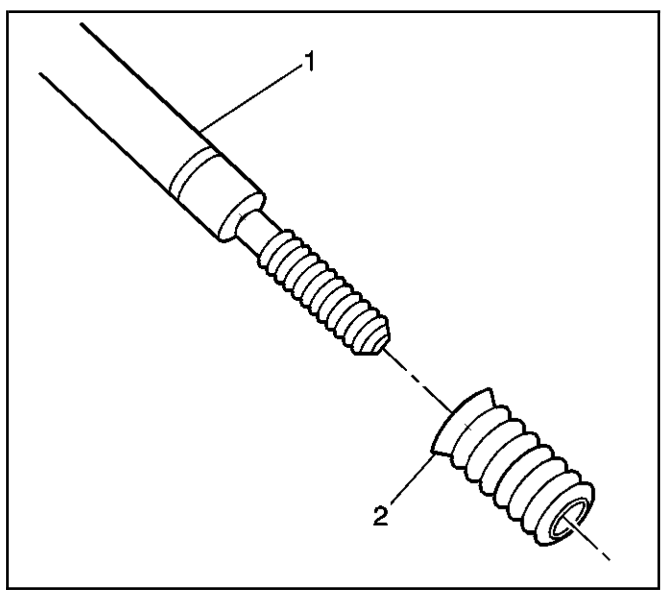


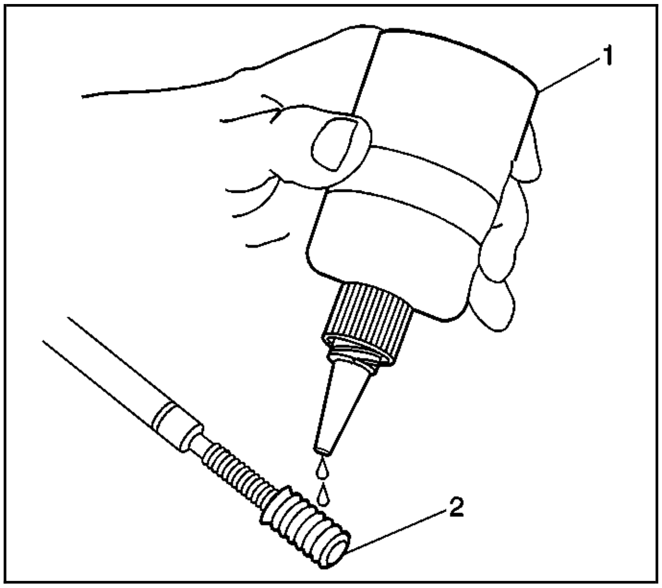
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

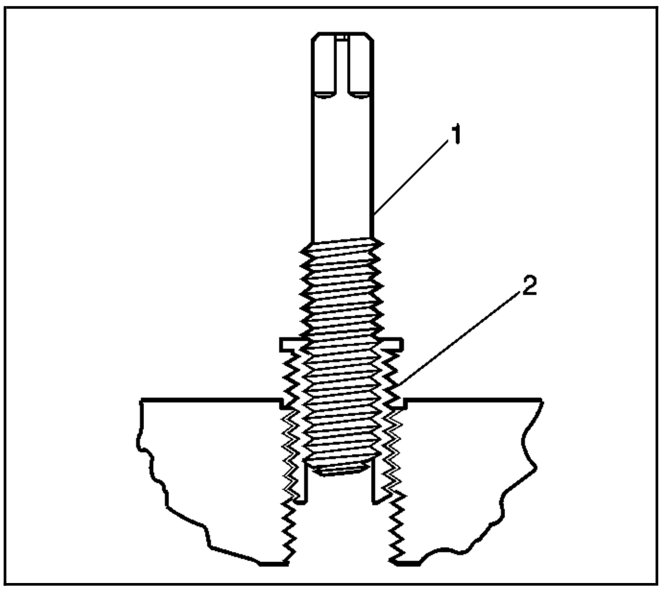


10. Install the insert (2) onto the driver tool (1).





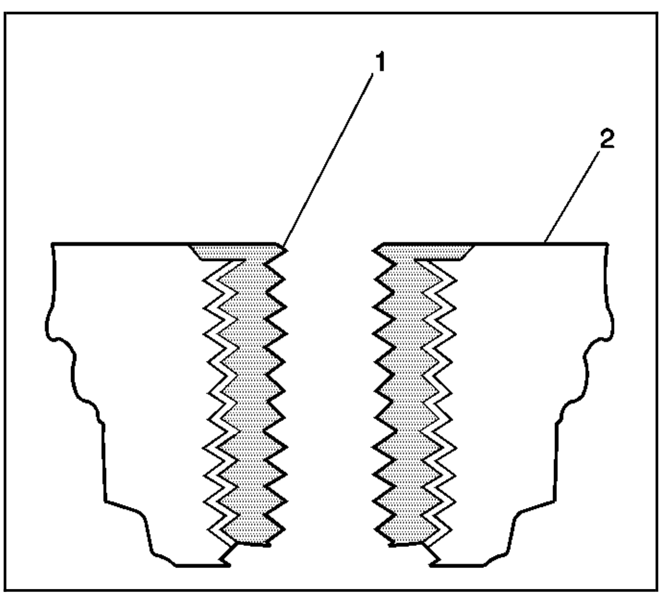
11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).



12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

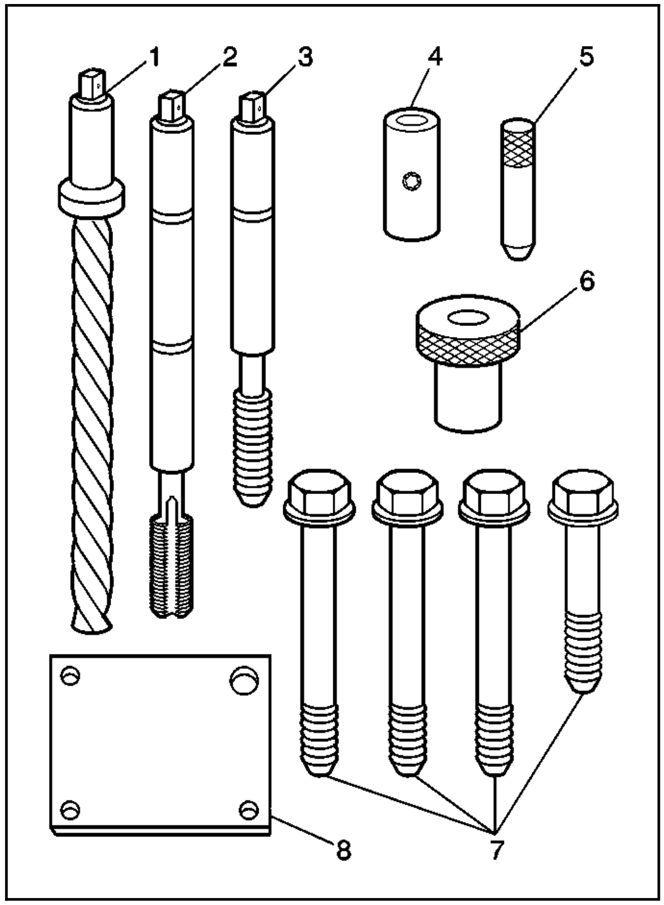
    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.



13. Inspect the insert for proper installation into the hole.

    A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

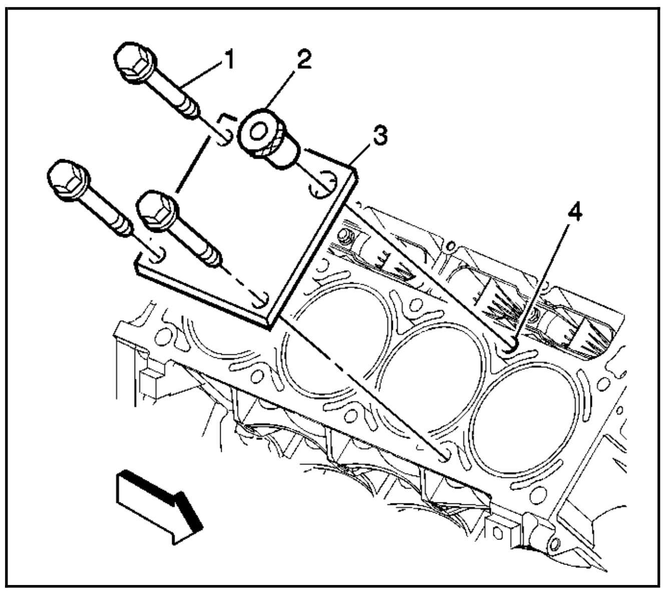


1. The cylinder head bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The sleeve (4)
   - The alignment pin (5)
   - The bushing (6)
   - The bolts (7)
   - The fixture plate (8)

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

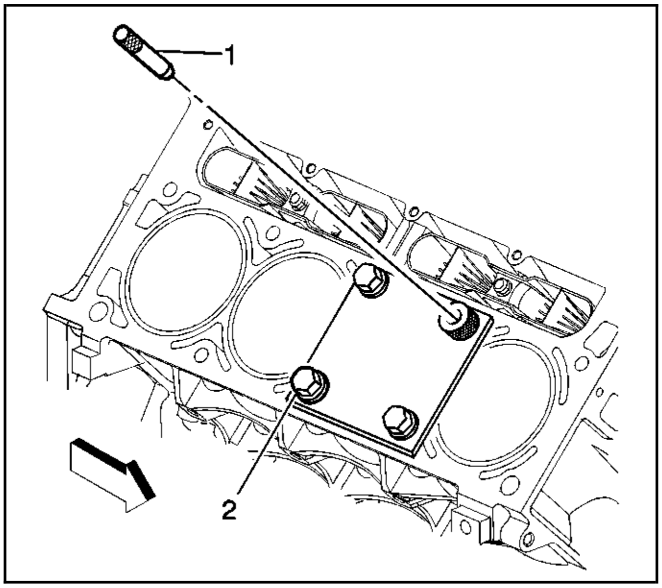
Important:

- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent is recommended when performing the drilling and tapping procedures.
- Driver oil MUST be used on the installer driver tool.
- The tool kits are designed for use with either a suitable tap wrench or drill motor.

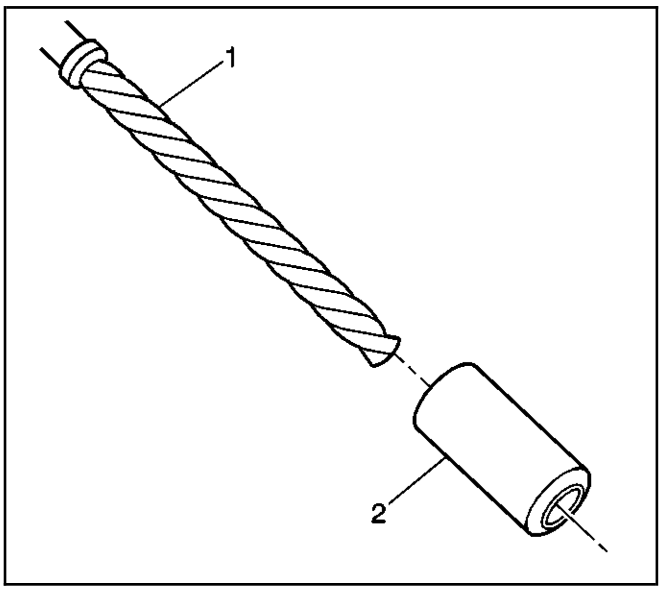


2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

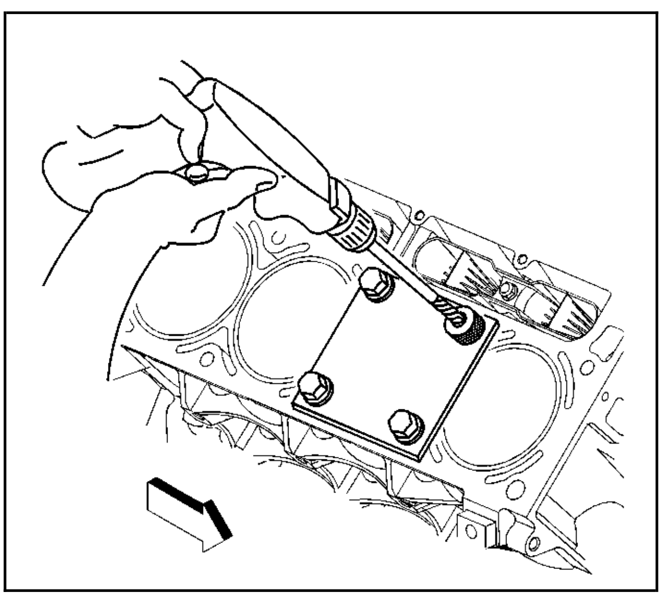
   Position the fixture plate and bushing over the hole that is to be repaired (4).



3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.



6. Install the sleeve (2) onto the drill (1).

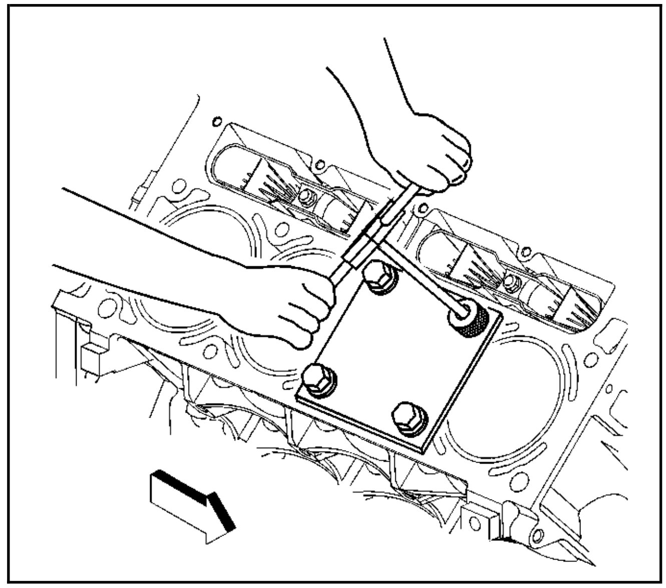


Important: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

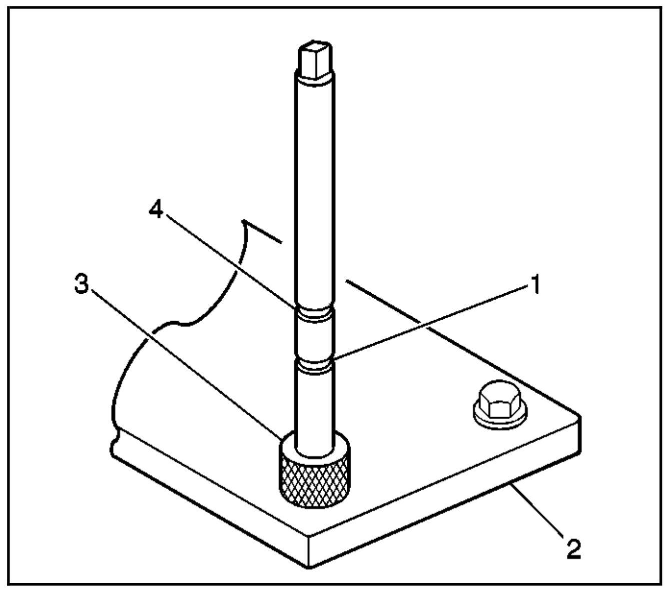
7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.
8. Using compressed air, clean out any chips.

9. Using a tap wrench, tap the threads of the drilled hole.

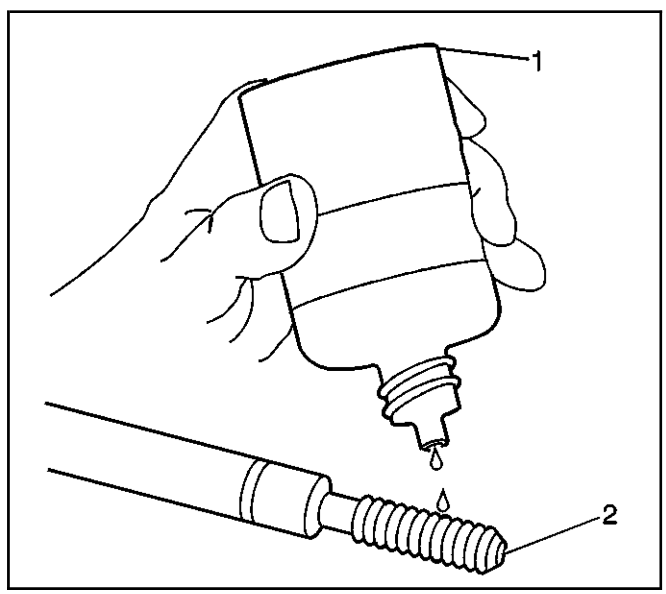


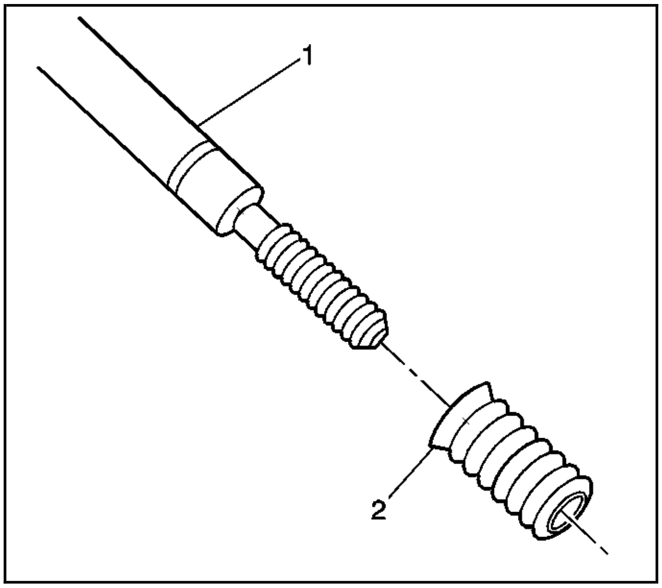
10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (1) on the tap aligns with the top of the drill bushing (3).
11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.



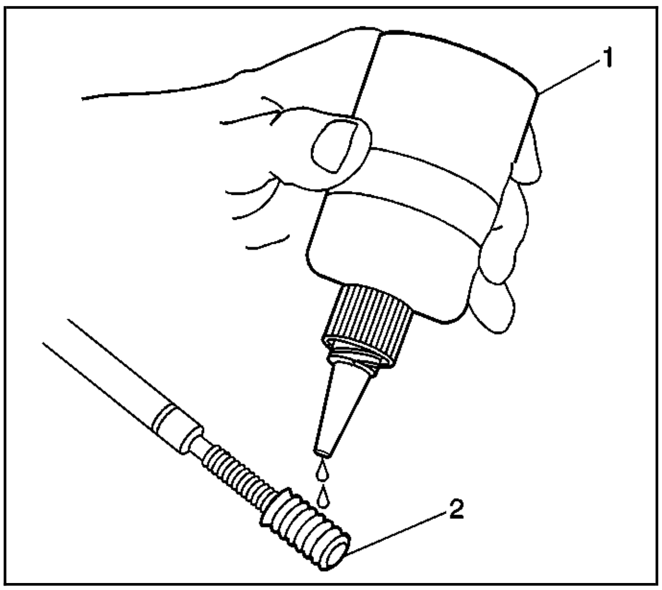
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

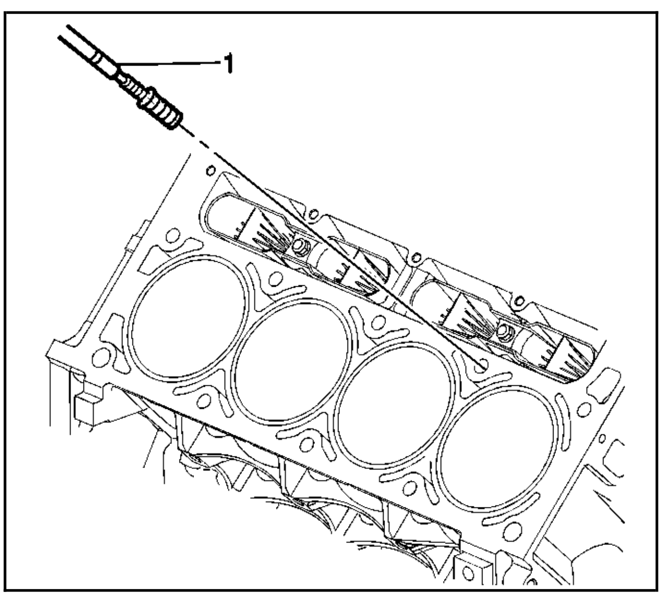




16. Install the insert (2) onto the driver tool (1).



17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).



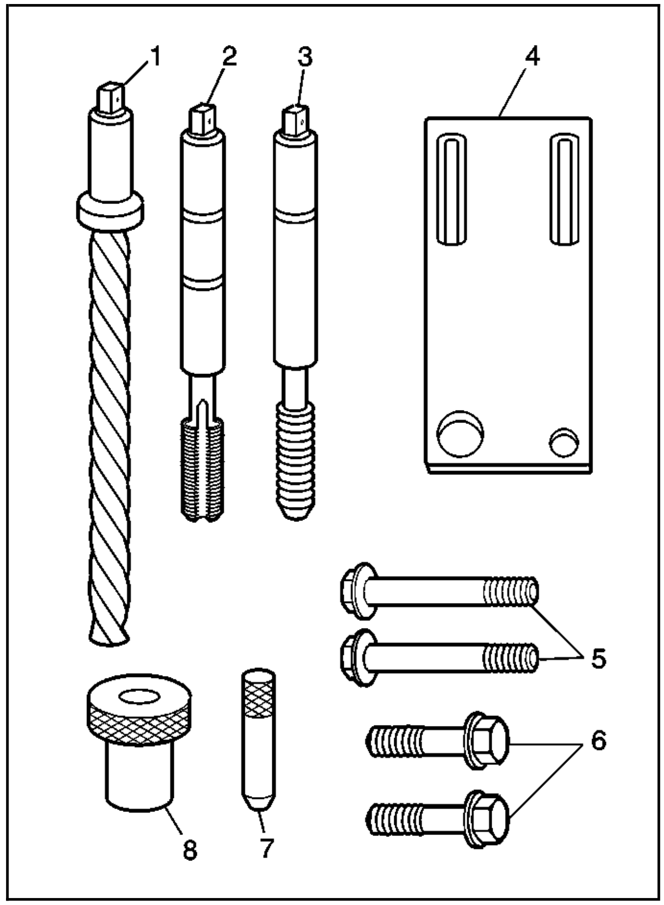
18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

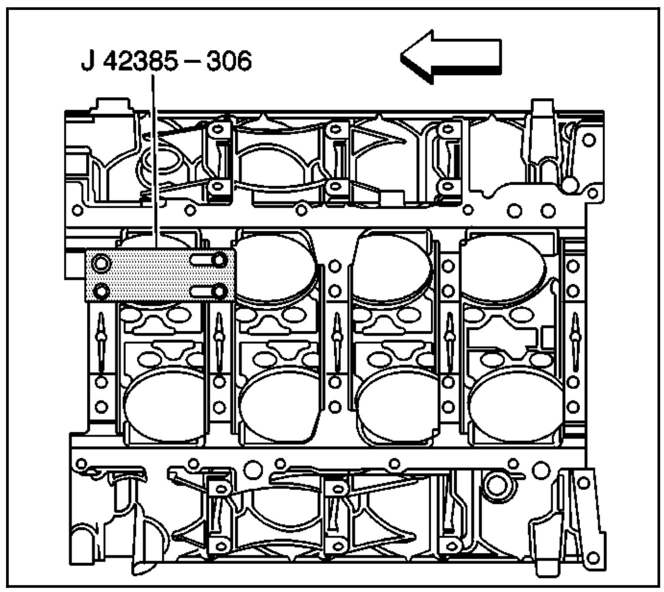
Main Cap Bolt Hole Thread Repair

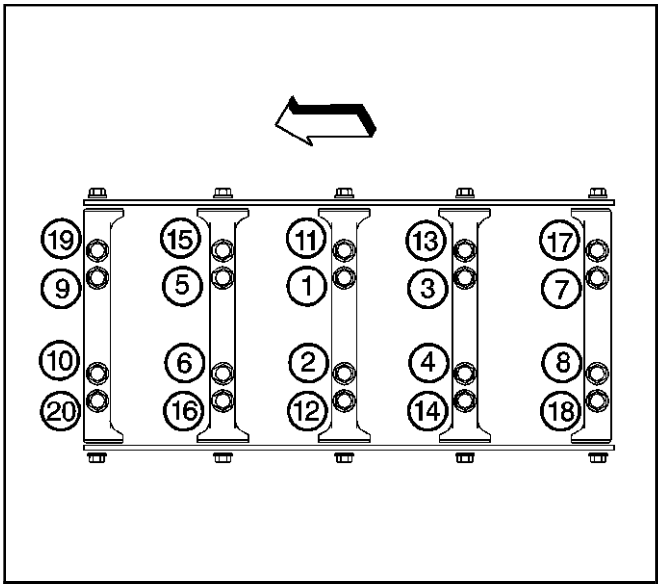
1. The main cap bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The fixture plate (4)
   - The long bolts (5)
   - The short bolts (6)
   - The alignment pin (7)
   - The bushing (8)



2. Install the fixture plate, bolt, and bushing, onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.
3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

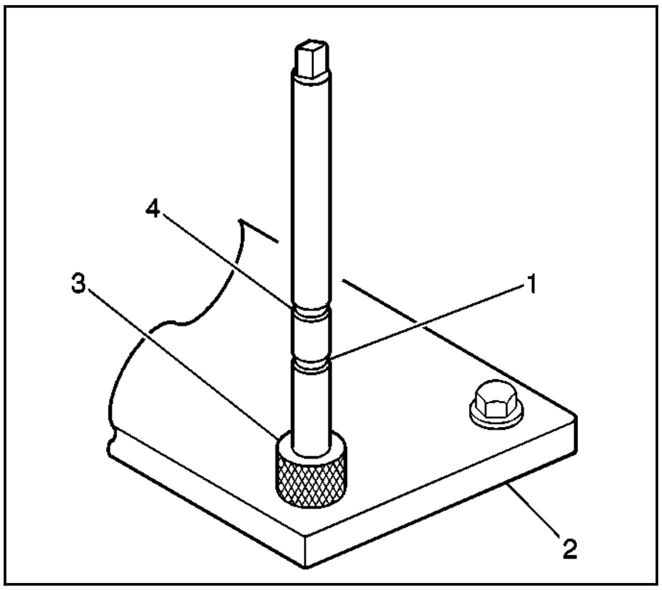




4. Drill out the damaged hole.

   The outer bolt hole locations 11–20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

   Drill until the stop collar of the drill bit or the sleeve contacts the bushing.
5. Using compressed air, clean out any chips.

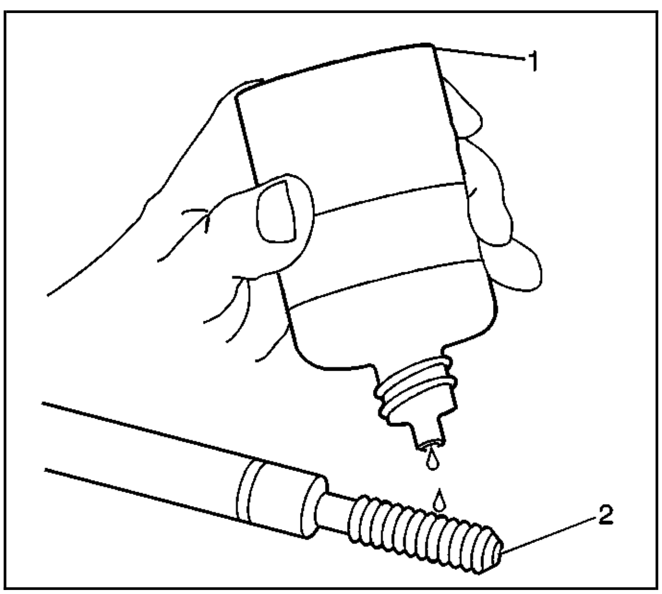


6. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

   For the deeper main cap holes 1–10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

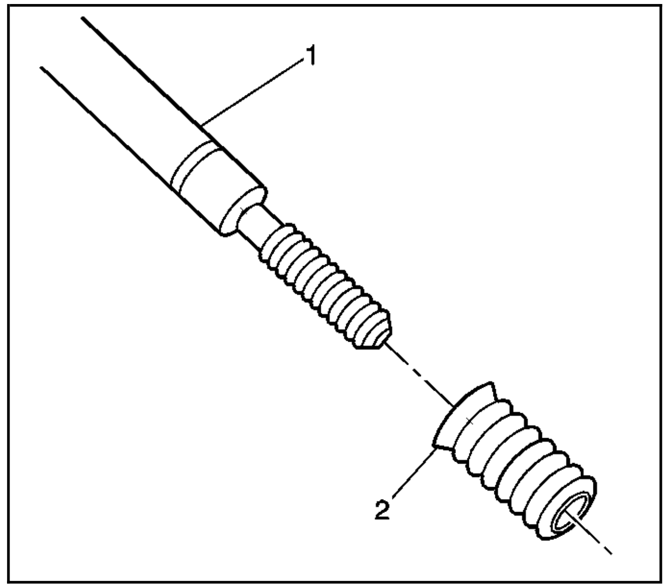
   For the shallower main cap holes 11–20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).
7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463) or equivalent into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.



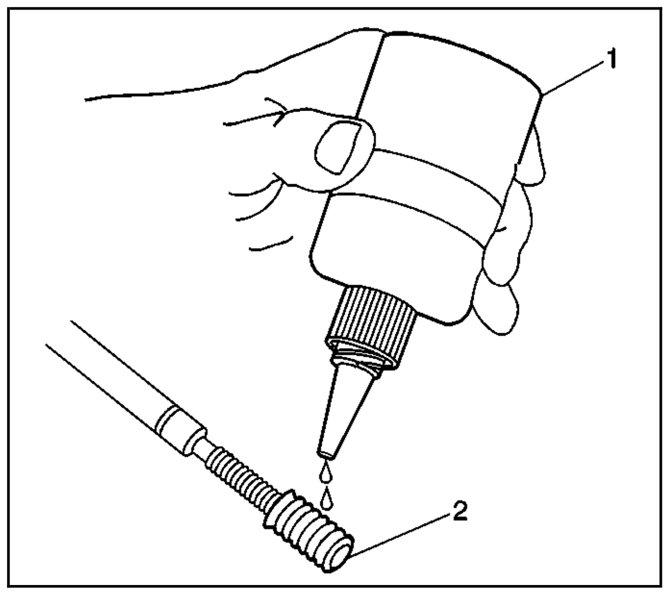
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

10. Lubricate the threads of the installer tool (2) with the driver oil (1).

11. Install the insert (2) onto the driver tool (1).



12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

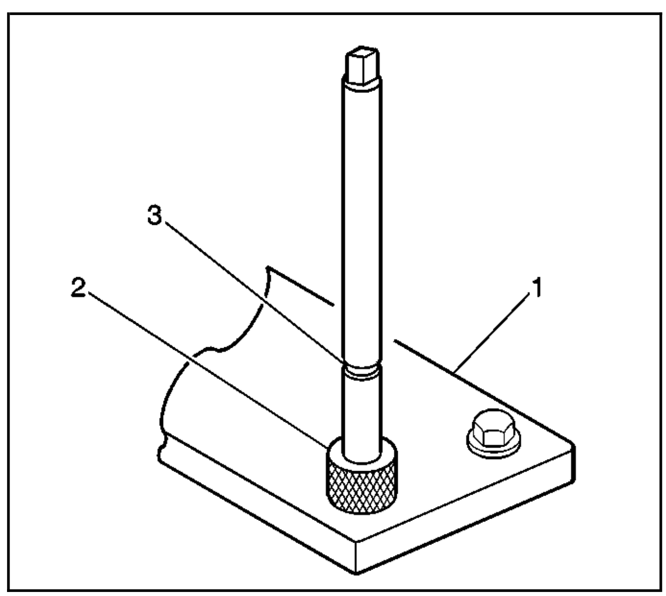


Important: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.



Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all the components. Refer to *Cleanliness and Care*.
- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to *Separating Parts*.
- During assembly, lubricate all the moving parts with clean engine oil. This will provide initial lubrication when the engine is first started.

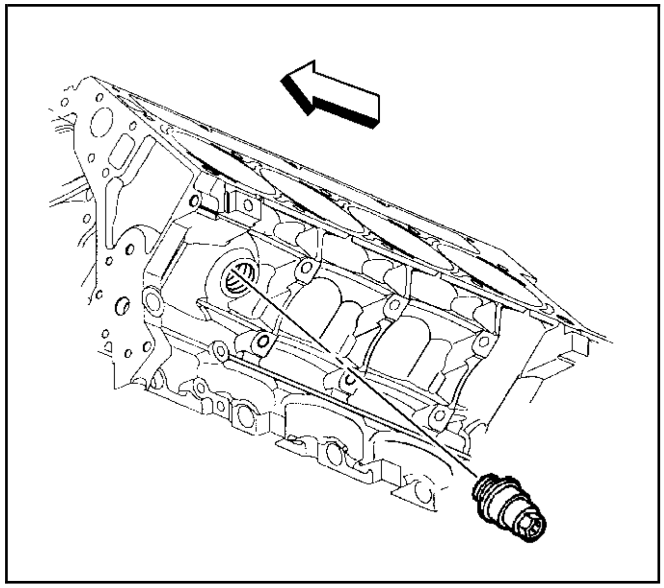
Engine Block Plug Installation

Tools Required

J 41712 Oil Pressure Switch Socket or equivalent

Important:

- Engine block plug, oil gallery and coolant, sealing washers may be used again if not bent, scored or otherwise damaged.
- Apply the proper amount and type of sealant to the sealing washer as recommended in the service procedure.



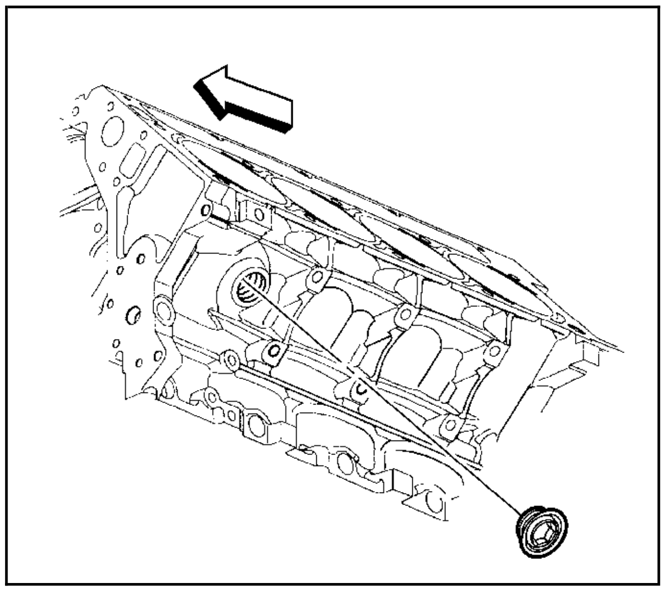
1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer, if applicable. Refer to *Sealers, Adhesives, and Lubricants*.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the engine block coolant heater to the engine block, if applicable.

   Tighten

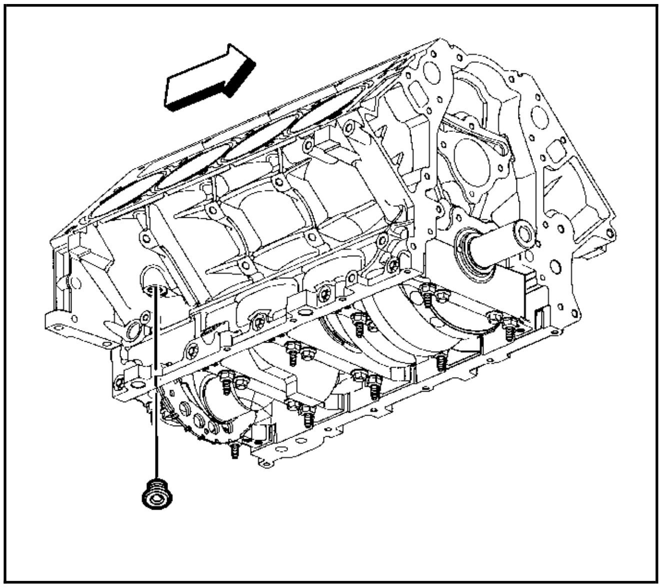
   Tighten the block coolant heater to 40 N·m (30 lb ft).



3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front coolant drain plug sealing washer, if applicable.
4. Install the engine block left front coolant drain plug, if applicable.

   Tighten

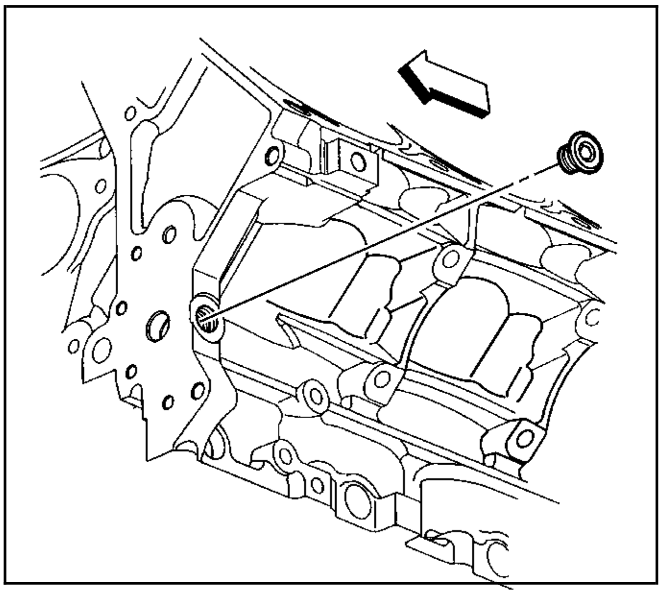
   Tighten the block left front coolant drain plug to 60 N·m (44 lb ft).



5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block right rear coolant drain plug sealing washer.
6. Install the engine block right rear coolant drain plug.

   Tighten

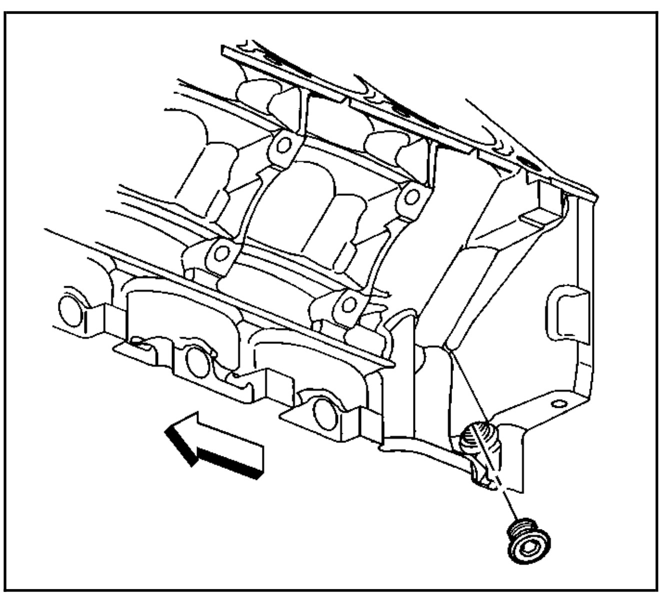
   Tighten the block right rear coolant drain plug to 60 N·m (44 lb ft).



7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer.
8. Install the engine block left front oil gallery plug.

   Tighten

   Tighten the block left front oil gallery plug to 60 N·m (44 lb ft).

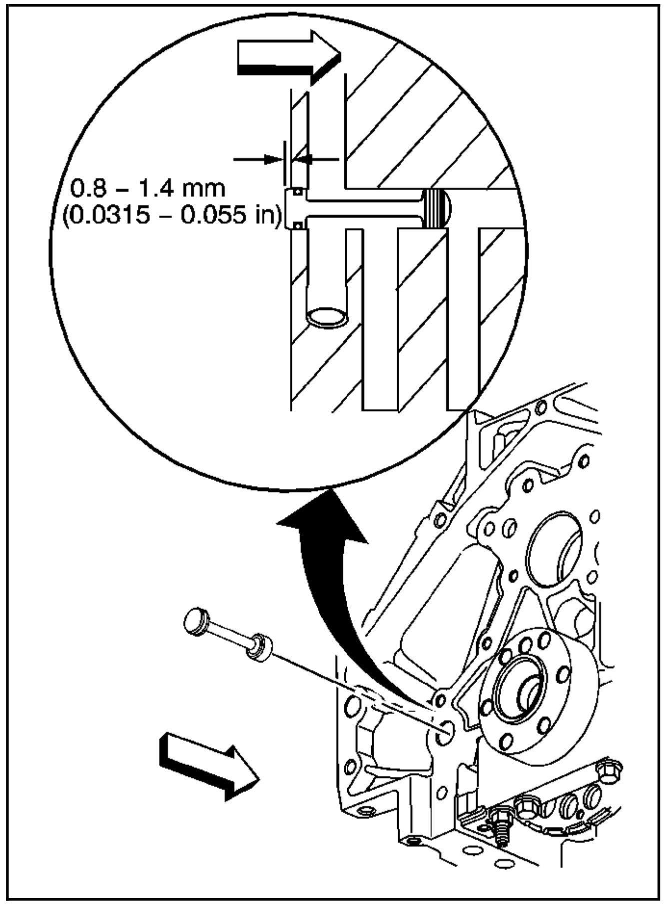


9. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer.
10. Install the engine block left rear oil gallery plug.

    Tighten

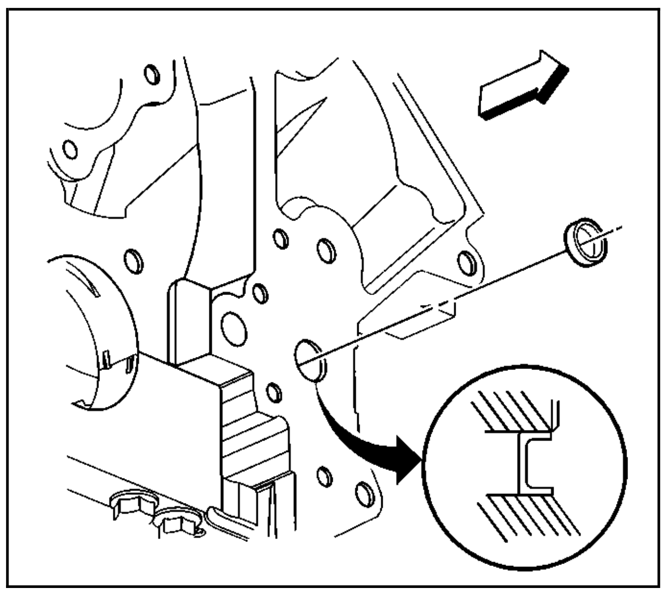
    Tighten the block left rear oil gallery plug to 60 N·m (44 lb ft).

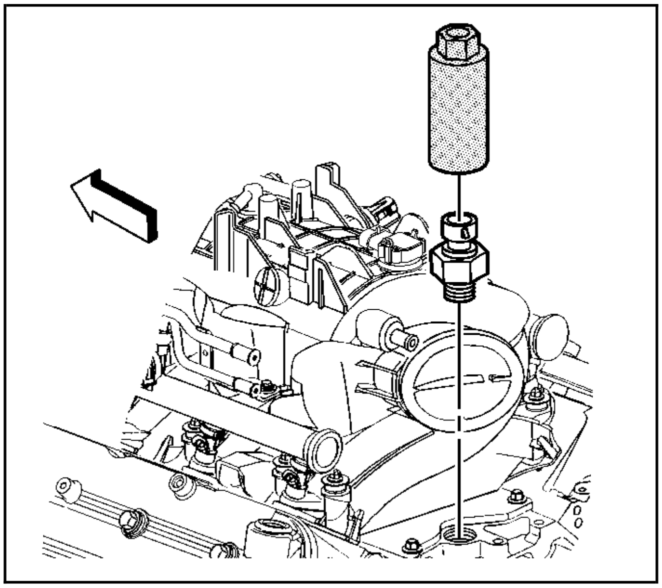
11. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be used again.
12. Lubricate the O-ring seal with clean engine oil.
13. Install the block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8–1.4 mm (0.0315–0.055 in) beyond the rear face of the block.



Important: The engine block front oil gallery plug should not be removed unless service is required.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug.
15. Install a NEW engine block front oil gallery plug, if required. Install the front oil gallery plug into the oil gallery bore 2.2–2.8 mm (0.0086–0.011 in) below flush.

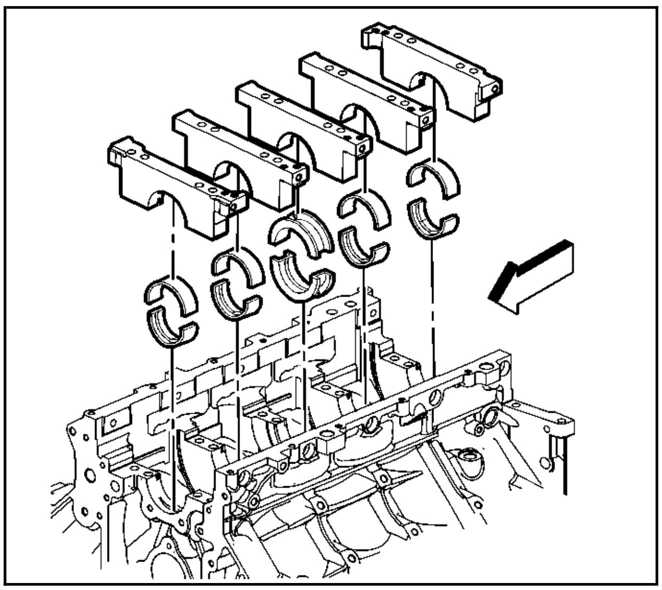




16. Apply sealant to the threads of the oil pressure sensor.
17. Use the *J 41712* or equivalent in order to install the oil pressure sensor.

    Tighten

    Tighten the oil pressure sensor to 20 N·m (15 lb ft).



Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter

Important:

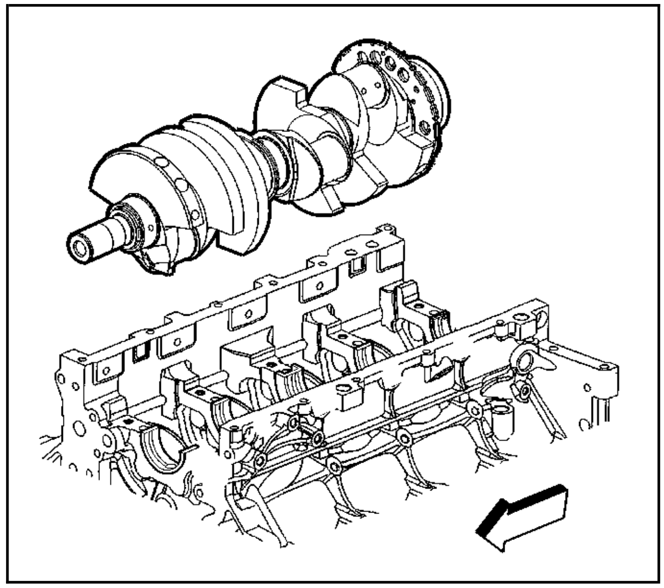
- Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may effect crankshaft position sensor signals and/or On-Board Diagnostics (OBD) II system performance.
- Crankshaft bearing caps must be installed to the proper location and direction.
- When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
- Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.
- To prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.

  The crankshaft bearing cap M8 side bolts have a sealant patch applied to the bolt flange.

1. Install the crankshaft thrust bearings to the engine block and center bearing cap.
2. Install the remaining crankshaft bearings to the engine block and bearing caps.
3. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

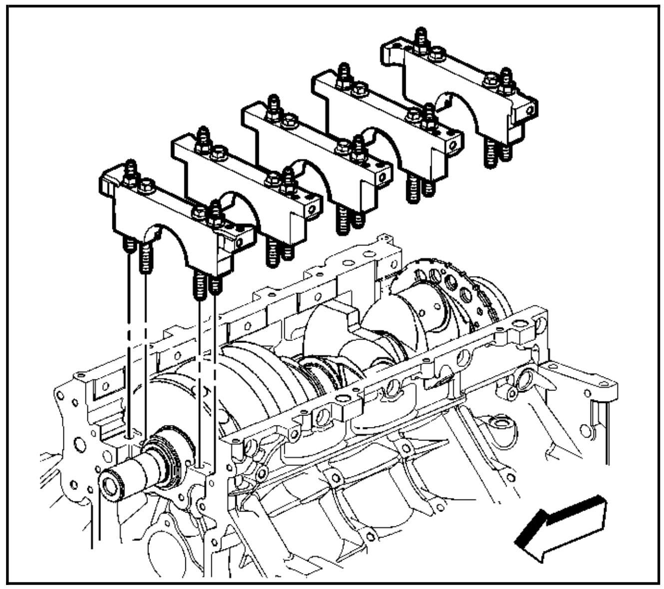
Notice: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

4. Install the crankshaft.

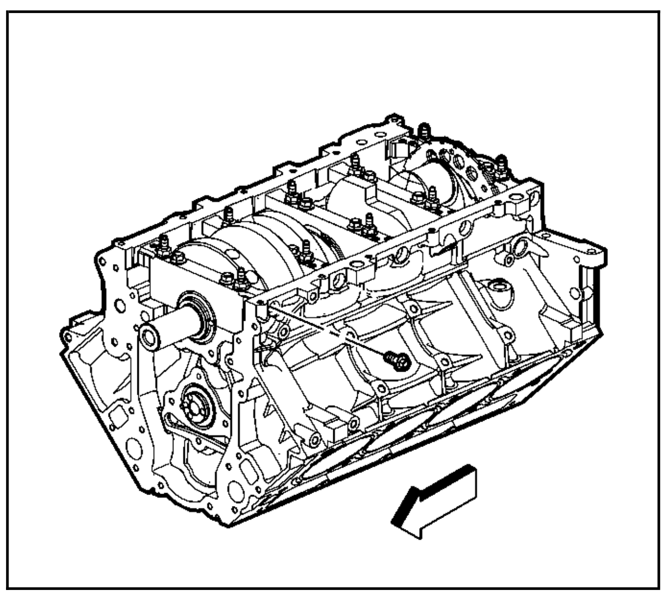


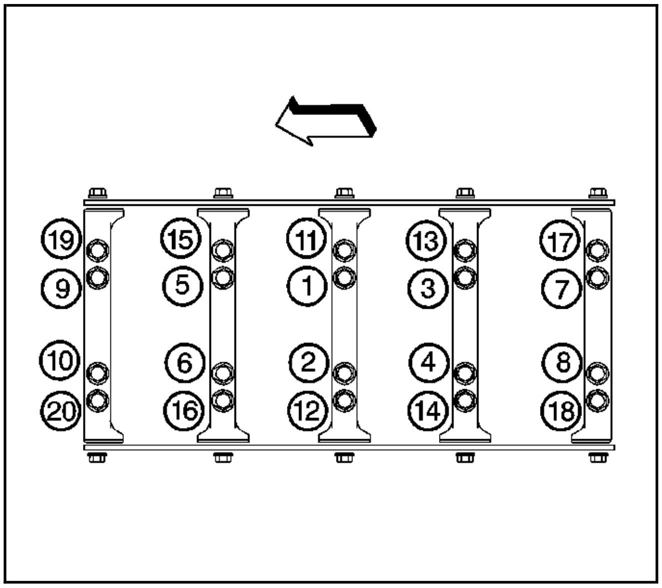
Important: The bearing caps must be installed in the proper location and direction.

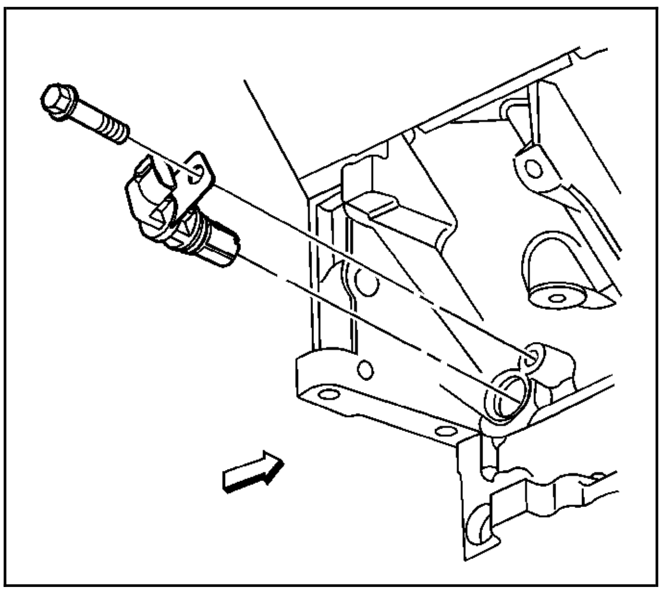
5. Install the crankshaft bearing caps, with bearings, into the engine block.
6. Start the M10 bolts and bolt/studs.
7. Tap the bearing caps into place with a plastic-face hammer.



8. Install the NEW M8 bearing cap side bolts.







Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Tighten the bearing cap bolts and studs.

   Tighten

   Tighten the inner M10 bearing cap bolts first pass in sequence to 20 N·m (15 lb ft).

Important: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward direction.

10. Using a plastic faced hammer, tap the crankshaft rearward then forward to align the thrust bearings.

    Tighten

    10.1. Tighten the inner M10 bolts final pass in sequence 80 degrees using the *J 45059*.

    10.2. Tighten the outer M10 bolts/studs first pass in sequence to 20 N·m (15 lb ft).

    10.3. Tighten the outer M10 bolts/studs final pass in sequence 51 degrees using the *J 45059*.

    10.4. Tighten the bearing cap side M8 bolts to 25 N·m (18 lb ft).

    Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.

11. Install the crankshaft position sensor.

    11.1. Inspect the crankshaft position sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used.

    11.2. Coat the O-ring seal with clean engine oil.

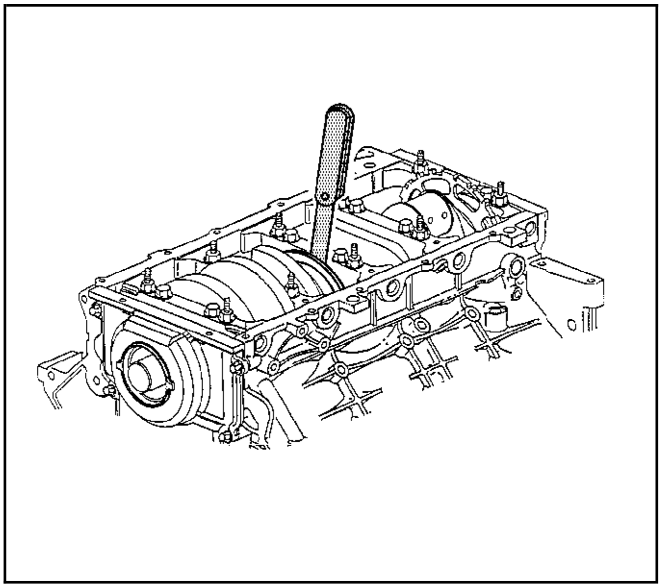
    11.3. Install the sensor. Align the notch in the sensor retaining bracket with the bolt hole in the block.

    11.4. Install the sensor bolt.

    Tighten

    Tighten the crankshaft position sensor bolt to 25 N·m (18 lb ft).

12. Measure the crankshaft end play.
    12.1. Thrust the crankshaft forward or rearward.
    12.2. Insert a feeler gage between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.
    The proper crankshaft end play clearance is 0.04–0.2 mm (0.0015–0.0078 in).
    12.3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal.
    Minor imperfections may be removed with a fine stone.



Piston, Connecting Rod, and Bearing Installation

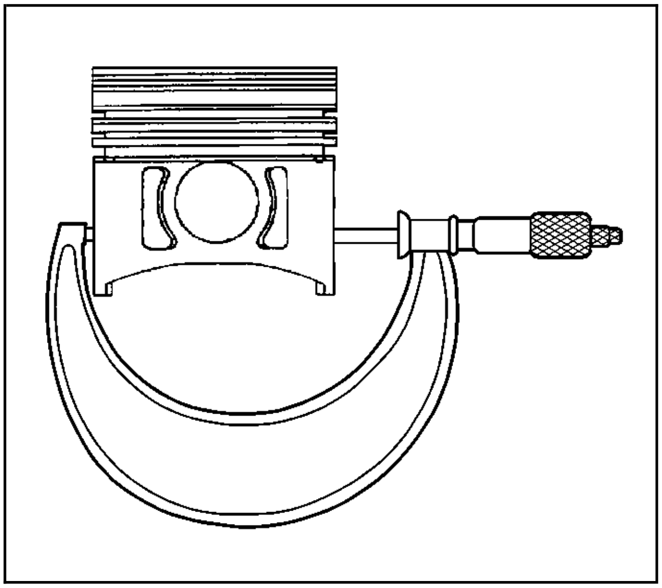
Tools Required

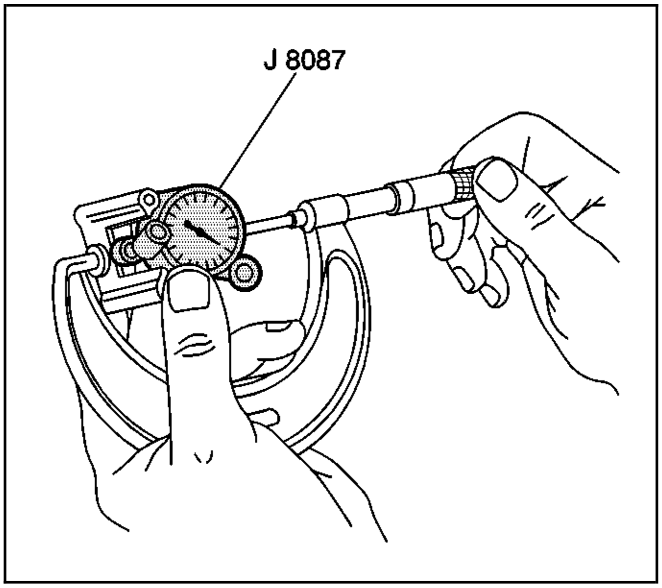
- *J 8037* Piston Ring Compressor
- *J 8087* Cylinder Bore Gage
- *J 41556* Connecting Rod Guide
- *J 45059* Angle Meter

Piston Selection

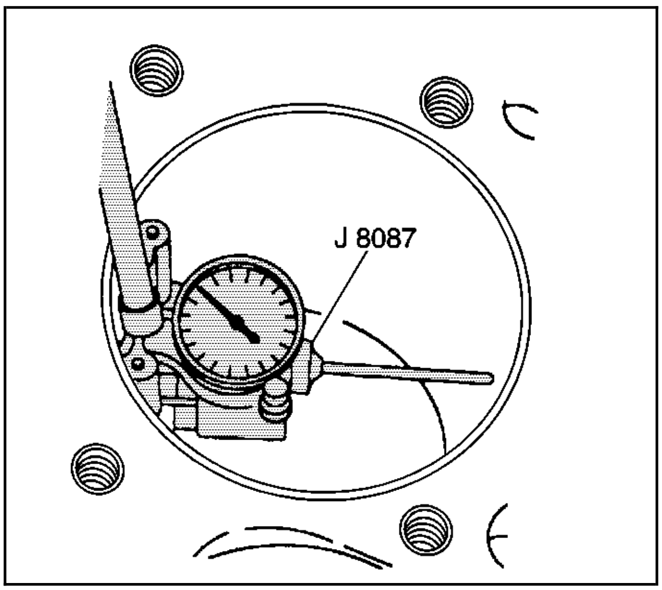
Important: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed, if after inspection, is within specifications.

1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.
2. Record the piston OD.

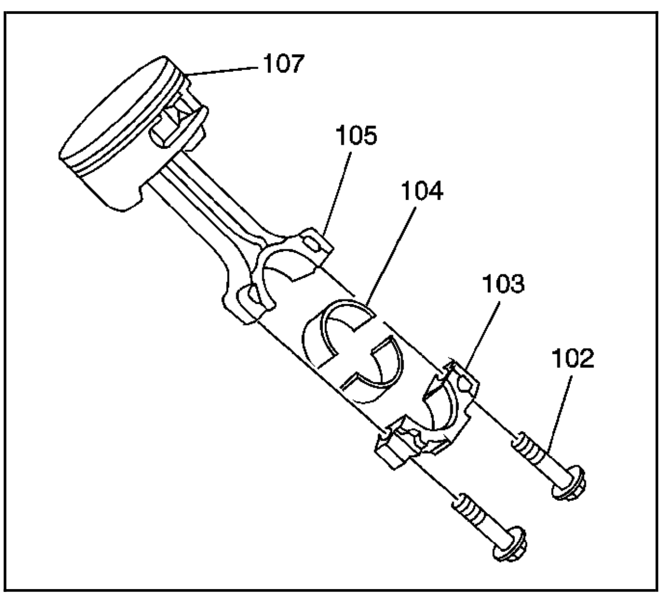




3. Adjust the micrometer to the recorded piston OD.
4. Insert the *J 8087* into the micrometer and zero the gage dial.



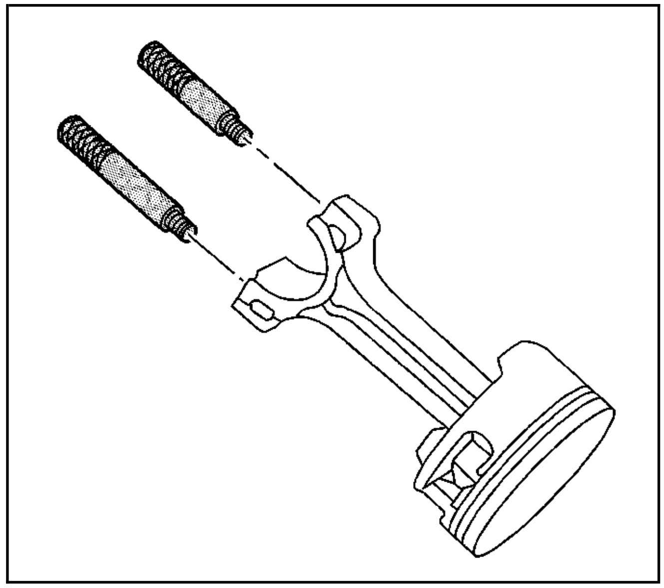
5. Using the *J 8087*, measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID to determine the piston-to-bore clearance. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.
8. If the proper clearance cannot be obtained, select another piston, pin, and connecting rod assembly and again measure the clearances. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.



Piston, Pin, and Connecting Rod Installation

1. Lightly lubricate the following components with clean engine oil:
   - Piston (107)
   - Piston rings
   - Cylinder bore
   - Bearings (104) and bearing surfaces
2. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
3. Position the compression ring end gaps 180 degrees opposite each other.

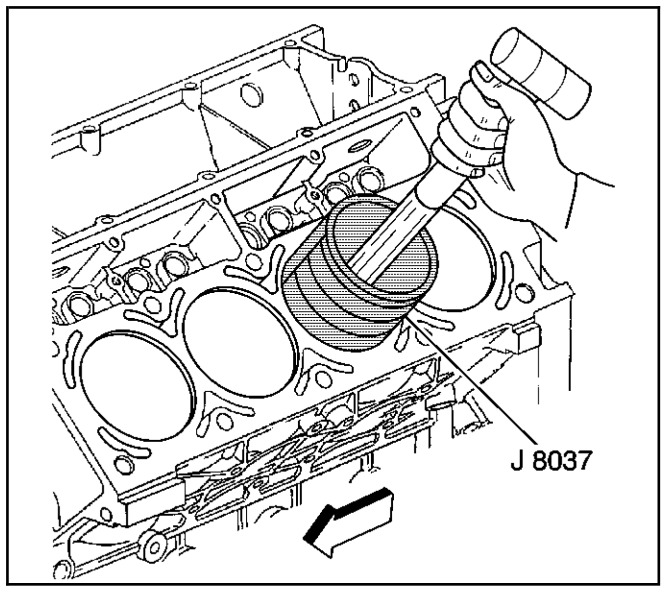
4. Install the *J 41556* to the connecting rod.



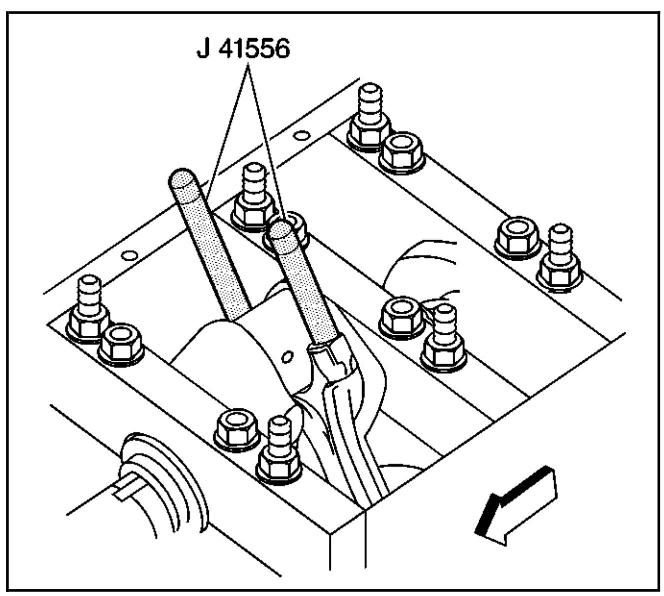
5. Install the *J 8037* onto the piston and compress the piston rings.

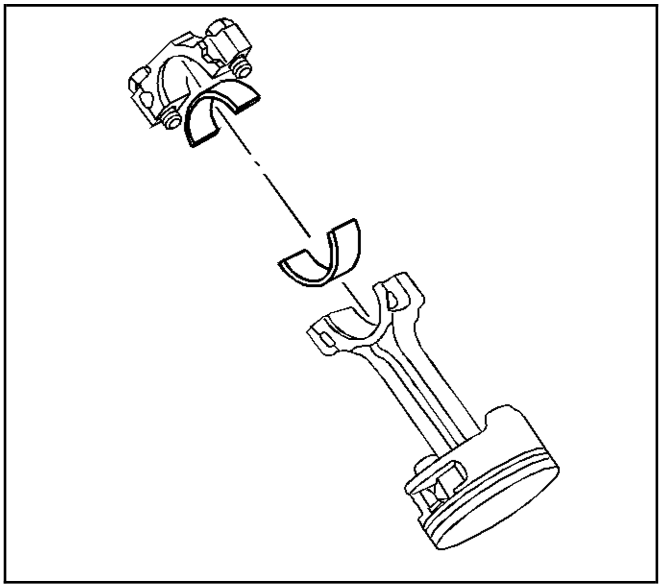
Important: The piston alignment mark MUST face the front of the engine block.

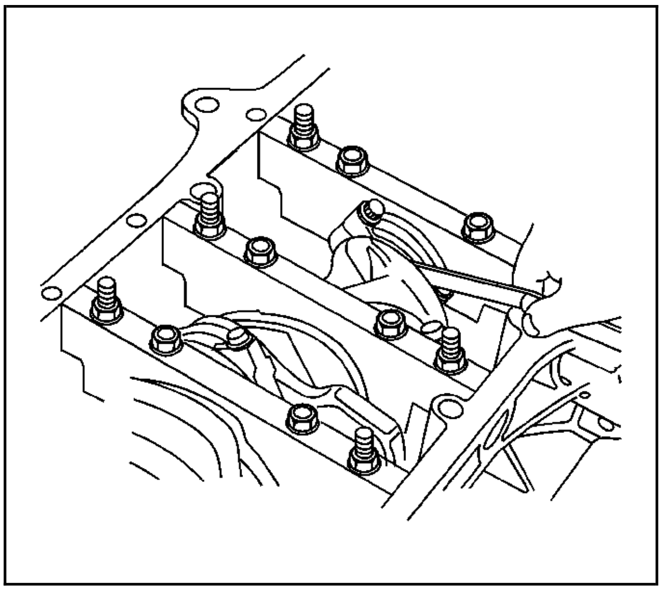
6. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all the piston rings have entered the cylinder bore.



7. Use the *J 41556* to guide the connecting rod onto the crankshaft journal.
8. Remove the *J 41556* from the connecting rod.







Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

Important: The connecting rod and cap must be assembled with the mating surfaces properly aligned.

9. Install the bearing cap, bearing half, and bolts.

   Tighten

   9.1. Tighten the bolts first pass to 20 N·m (15 lb ft).

   9.2. Tighten the bolts final pass to 75 degrees using the *J 45059*.

10. Measure the connecting rods for the proper side clearance. Refer to *Engine Mechanical Specifications (LR4 VIN V)* or *Engine Mechanical Specifications (LQ4 VIN U)*.

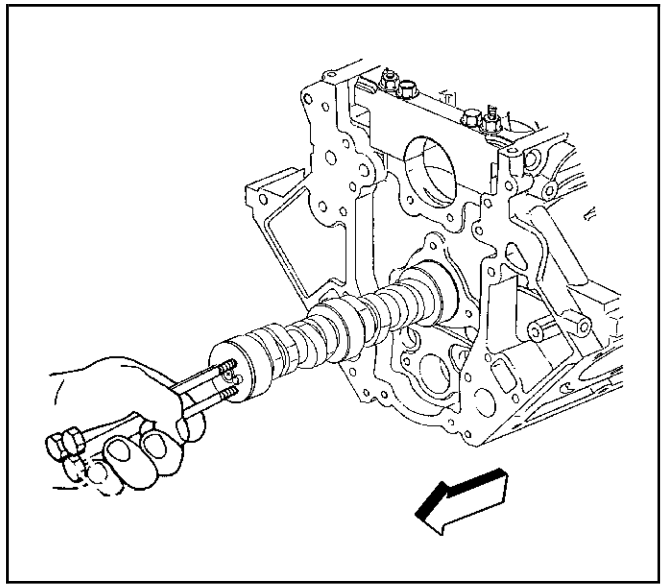
Camshaft Installation

Important: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install 3 M8 – 1.25 x 100 mm (M8 – 1.25 x 4.0 in) bolts into the camshaft front bolt holes.

Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the 3 bolts from the front of the camshaft.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

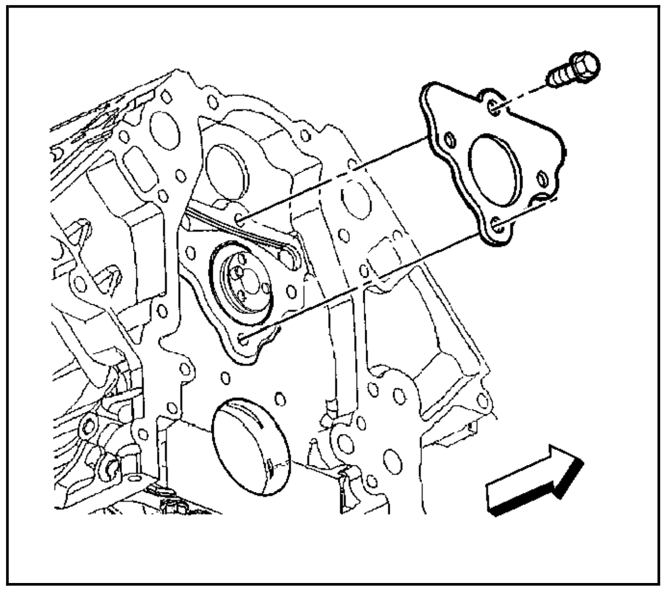
Important:

- Install the retainer plate with the sealing gasket facing the engine block.
- The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer and the bolts.

   Tighten

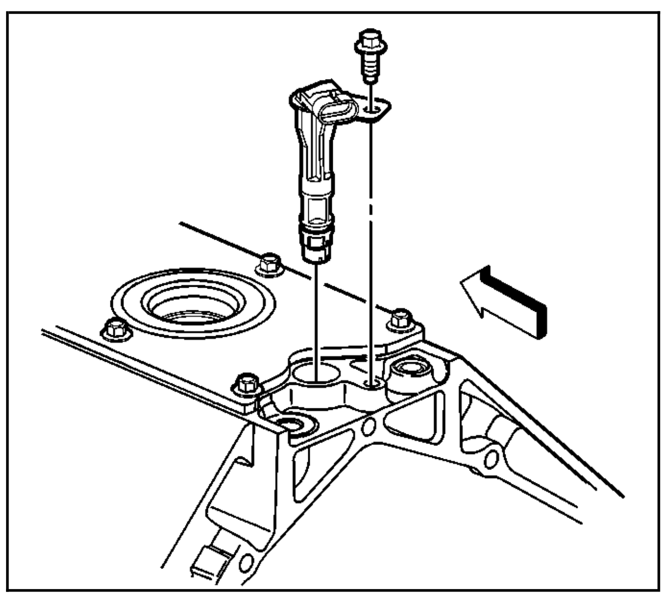
   Tighten the camshaft retainer bolts to 25 N·m (18 lb ft).
6. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used again.
7. Lubricate the O-ring seal with clean engine oil.



8. Install the camshaft position sensor and bolt.

   Tighten

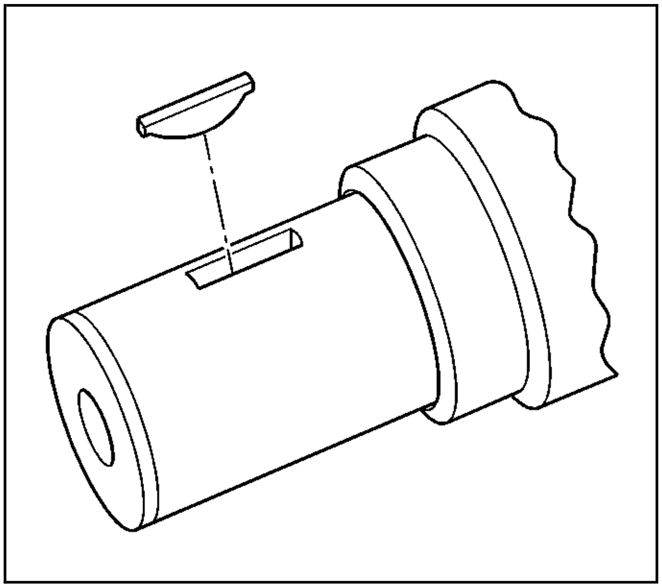
   Tighten the camshaft position sensor bolt to 25 N·m (18 lb ft).



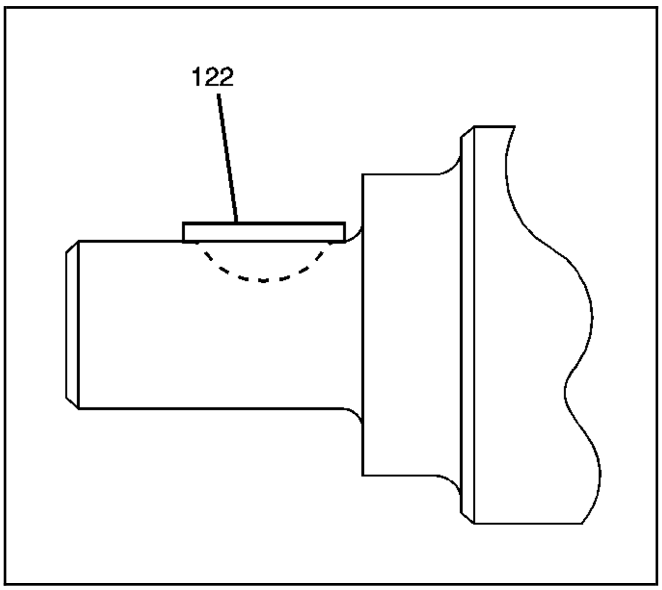
Timing Chain and Sprockets Installation

Tools Required

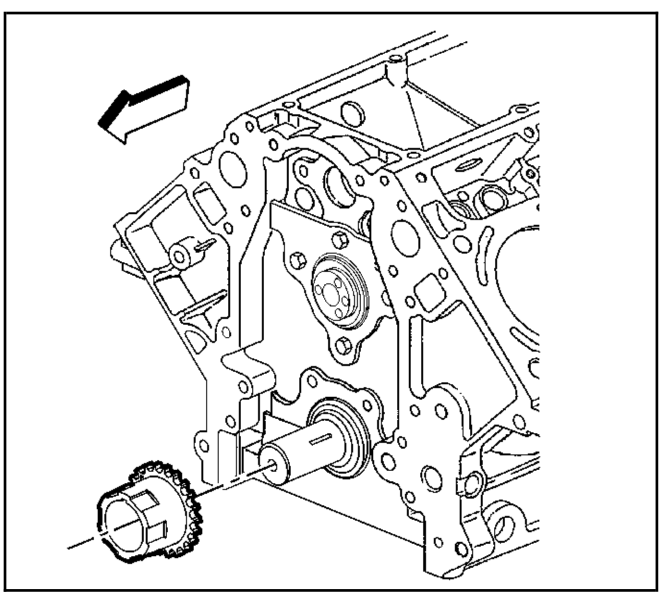
J 41665 Crankshaft Balancer and Sprocket Installer



1. Install the key into the crankshaft keyway, if previously removed.



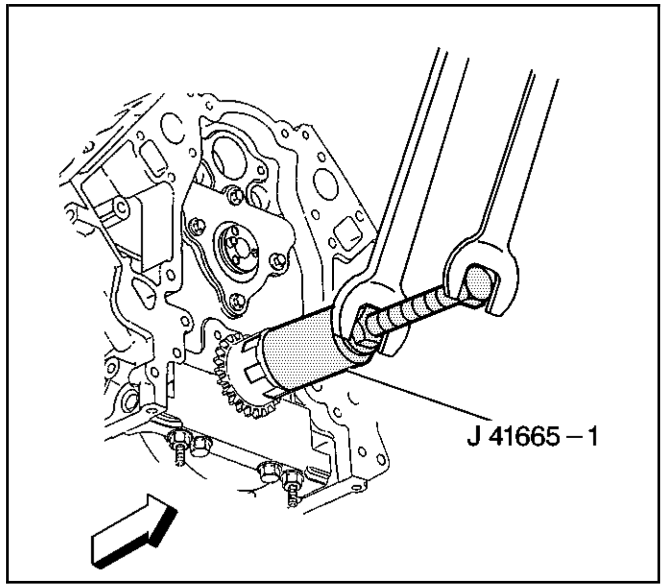
2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.



3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

4. Use the *J 41665* in order to install the crankshaft sprocket.

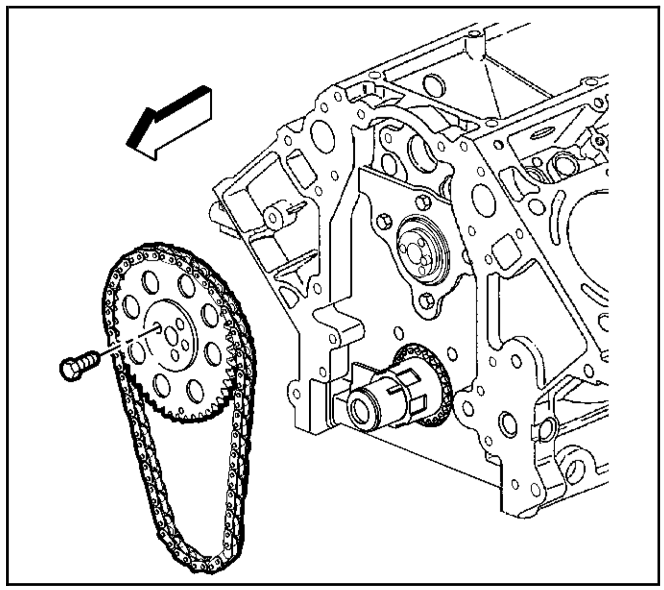
   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.



Important:
- Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.

  Locate the camshaft sprocket alignment mark in the 6 o'clock position.

6. Install the camshaft sprocket and timing chain.



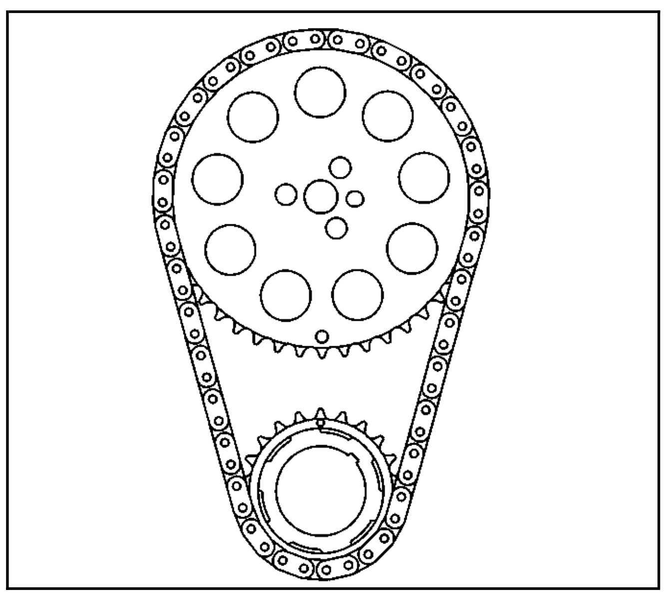
7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

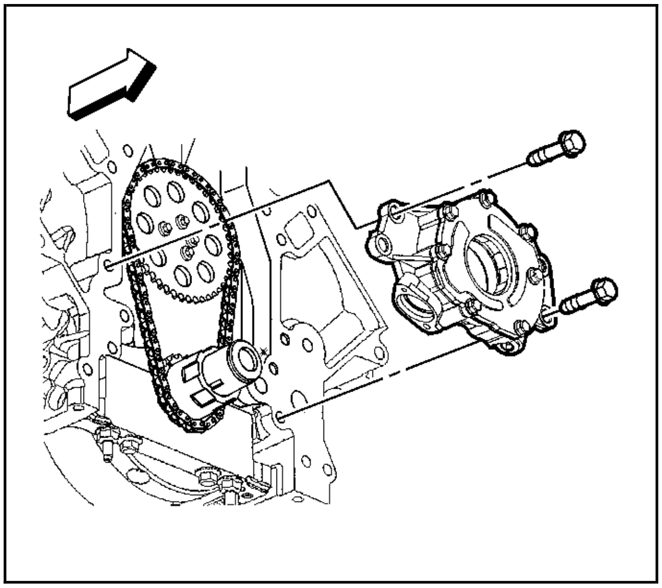
Notice: Refer to *Fastener Notice* in Cautions and Notices.

8. Install the camshaft sprocket bolts.

   Tighten

   Tighten the camshaft sprocket bolts to 35 N·m (26 lb ft).





Oil Pump, Pump Screen and Deflector Installation

Important: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

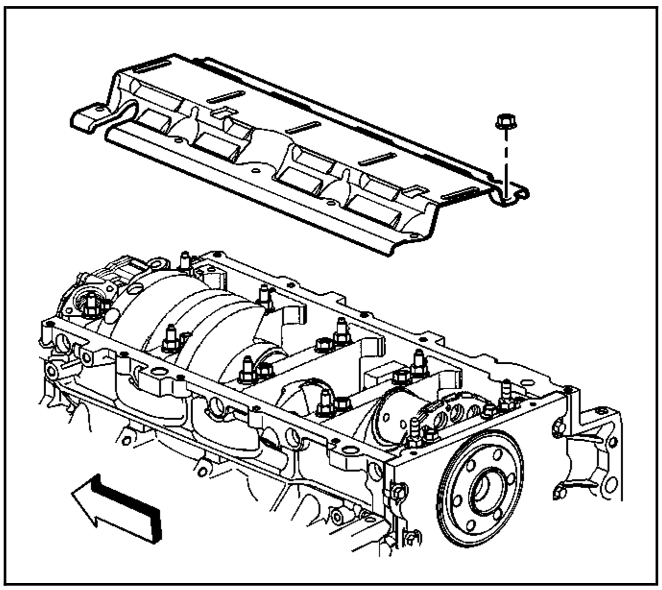
1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

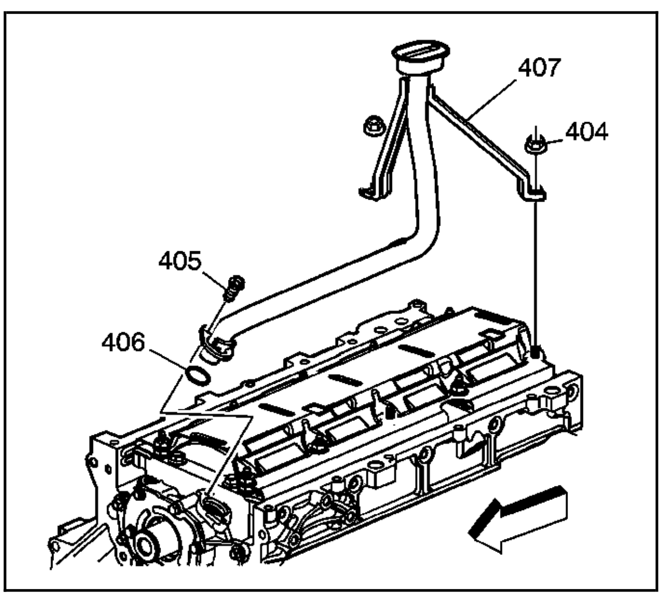
3. Install the oil pump bolts.

   Tighten

   Tighten the oil pump bolts to 25 N·m (18 lb ft).



4. Install the crankshaft oil deflector.



5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

Important:

- Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.
- Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.

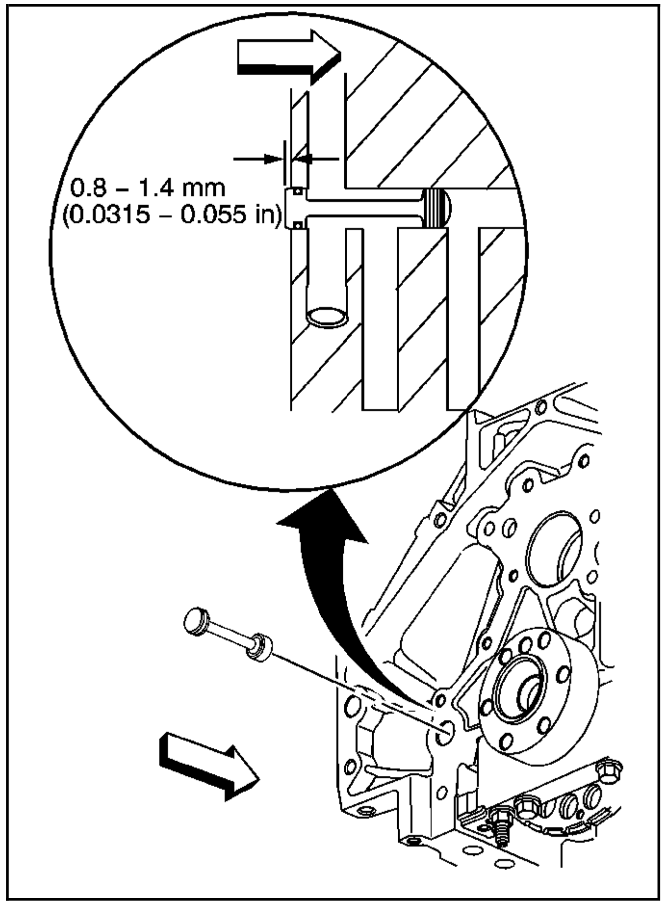
7. Install the oil pump screen (407).
8. Install the oil pump screen bolt (405) and the deflector nuts (404).

   Tighten

   8.1. Tighten the oil pump screen bolt (405) to 12 N·m (106 lb in).

8.2. Tighten the crankshaft oil deflector nuts (404) to 25 N·m (18 lb ft).

Engine Rear Cover Installation



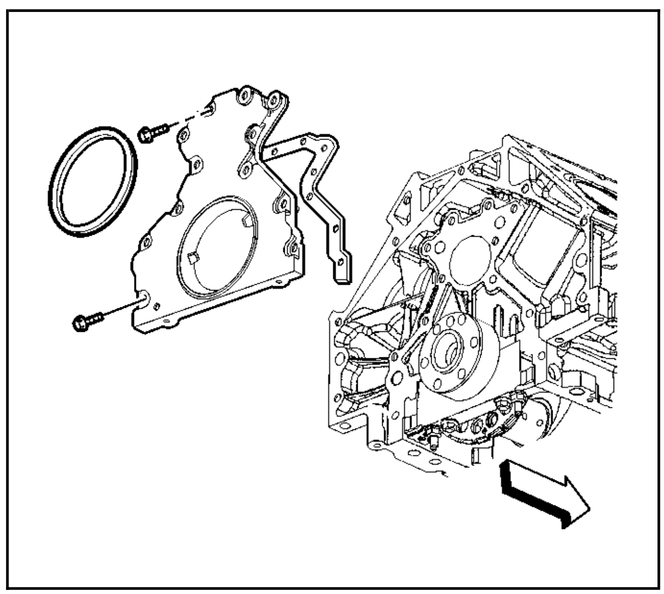
Tools Required

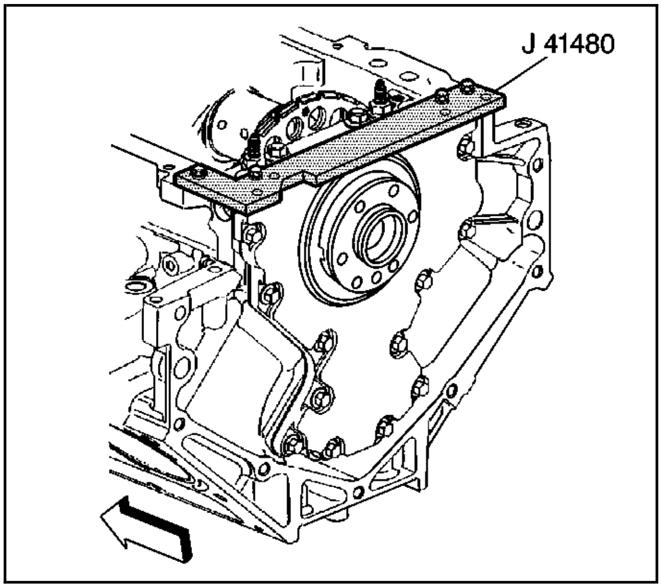
- *J 41480* Front and Rear Cover Alignment – Oil Pan Surface
- *J 41476* Front and Rear Cover Alignment Tool – Crankshaft Oil Seal Area

Important:

- Do not use the crankshaft rear oil seal or the engine rear cover gasket again.
- Do not apply any type sealant to the rear cover gasket, unless specified.
- The special tools in this procedure are used to properly align the engine rear cover at the oil pan surface and to center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned. Install the rear cover without the crankshaft oil seal.
  - The crankshaft rear oil seal MUST be centered in relation to the crankshaft.
  - The oil pan sealing surface at the rear cover and engine block MUST be aligned within specifications.
  - An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.

1. Inspect the rear oil gallery plug for proper installation.
2. Install the rear cover gasket, rear cover and bolts.
3. Tighten the bolts finger tight. Do not overtighten.





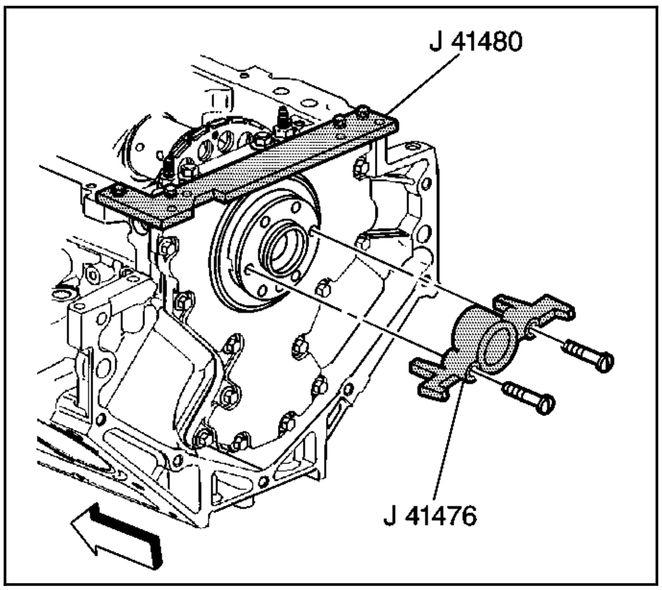
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Start the *J 41480* tool-to-rear cover bolts. Do not tighten the bolts at this time.

4. Install the *J 41480* and bolts.

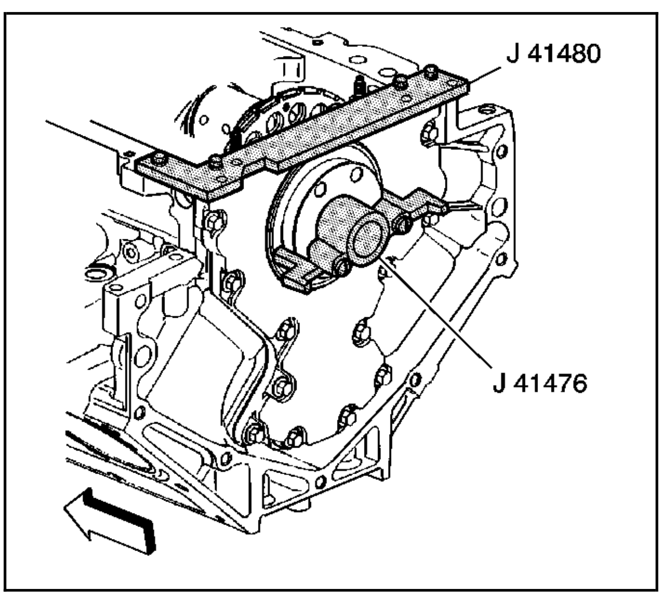
   Tighten

   Tighten the tool-to-engine block bolts to 25 N·m (18 lb ft).



Important: To properly align the rear cover, the *J 41476* must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.



Important: The tapered legs of the alignment tool must enter the rear cover oil seal bore.

6. Install the *J 41476* and bolts onto the rear of the crankshaft.

   Tighten

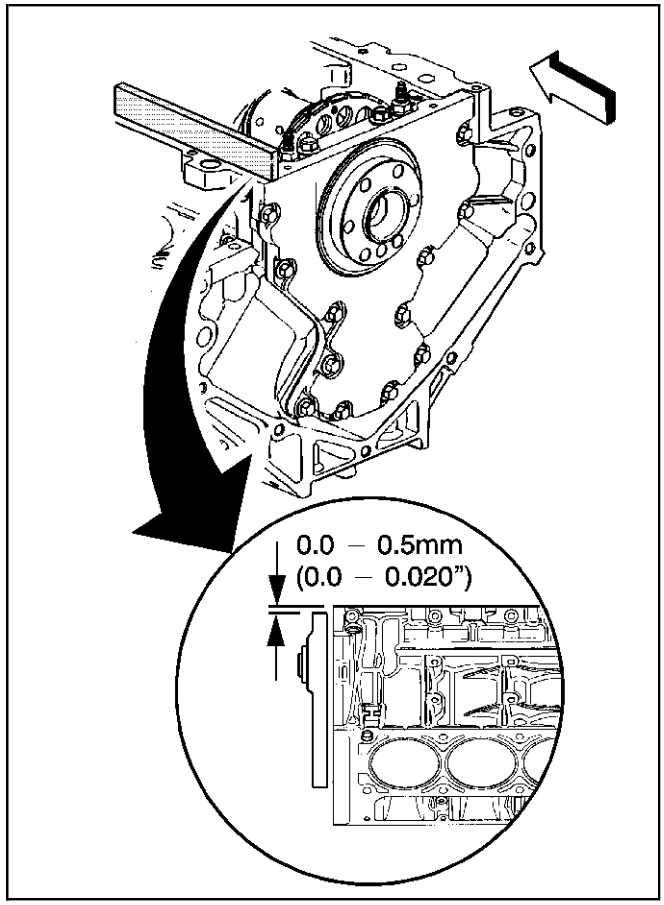
   6.1. Tighten the tool mounting bolts until snug. Do not overtighten.

   6.2. Tighten the *J 41480* tool-to-rear cover bolts evenly to 12 N·m (106 lb in).

   6.3. Tighten the rear cover bolts to 25 N·m (18 lb ft).

7. Remove the tools.

8. Measure the rear cover-to-engine block oil pan surface for flatness.
    8.1. Place a straight edge onto the engine block and rear cover oil pan sealing surfaces. Avoid contact with the portion of the gasket that protrudes into the oil pan surface.
    8.2. Insert a feeler gage between the rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
10. If the correct rear cover-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear cover.



Crankshaft Rear Oil Seal Installation

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer

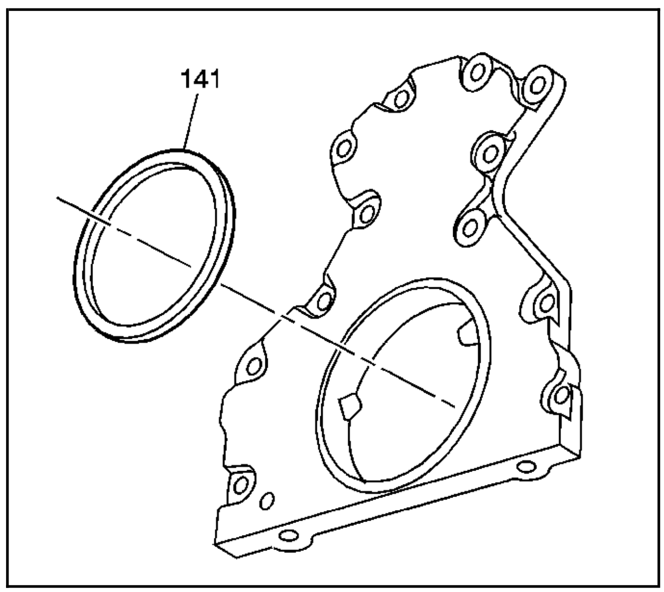
Important:

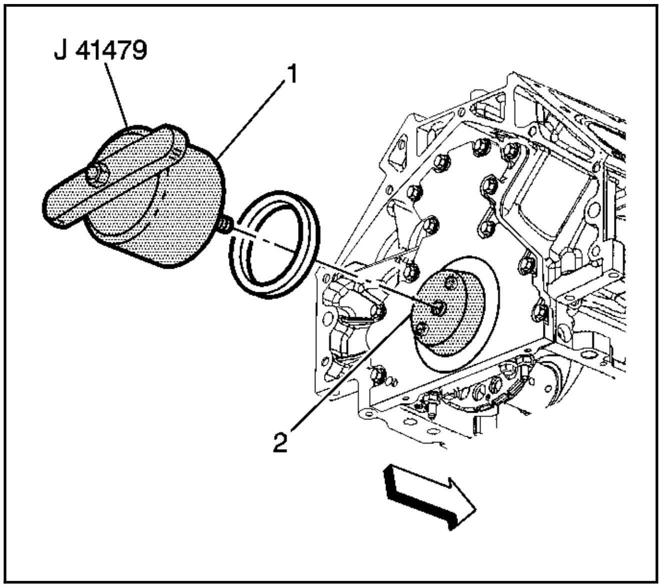
- Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.
- Do not use the crankshaft rear oil seal again.

1. Lubricate the outside diameter (OD) of the oil seal (141) with clean engine oil.

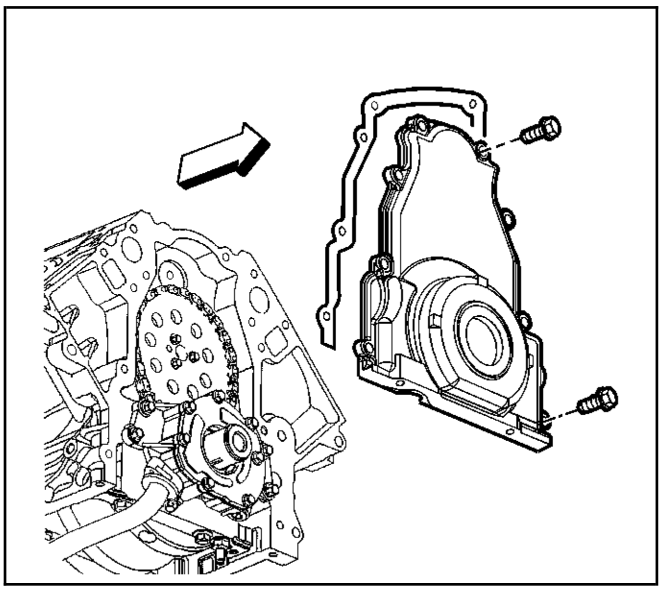
   DO NOT allow oil or other lubricants to contact the seal surface.
2. Lubricate the rear cover oil seal bore with clean engine oil.

   DO NOT allow oil or other lubricants to contact the crankshaft surface.





3. Install the *J 41479* cone (2) and bolts onto the rear of the crankshaft.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the *J 41479* threaded rod into the tapered cone until the tool (1) contacts the oil seal.
7. Align the oil seal onto the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the tool.



Engine Front Cover Installation

Tools Required

- *J 41480* Front and Rear Cover Alignment – Oil Pan Surface
- *J 41476* Front and Rear Cover Alignment Tool – Crankshaft Oil Seal Area

Important:

- Do not use the crankshaft oil seal or the engine front cover gasket again.
- Do not apply any type sealant to the front cover gasket, unless specified.
- The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.
  - All gasket surfaces should be free of oil or other foreign material during assembly.

  The crankshaft front oil seal MUST be centered in relation to the crankshaft.
  - The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.
  - An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.

1. Install the front cover gasket, cover, and bolts onto the engine.
2. Tighten the cover bolts finger tight. Do not overtighten.

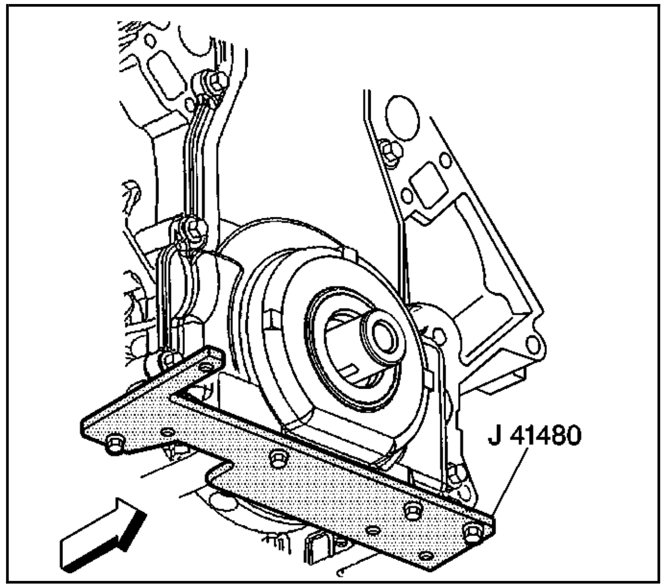
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

3. Install the *J 41480*.

   Tighten

   Tighten the tool-to-engine block bolts to 25 N·m (18 lb ft).



Important: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

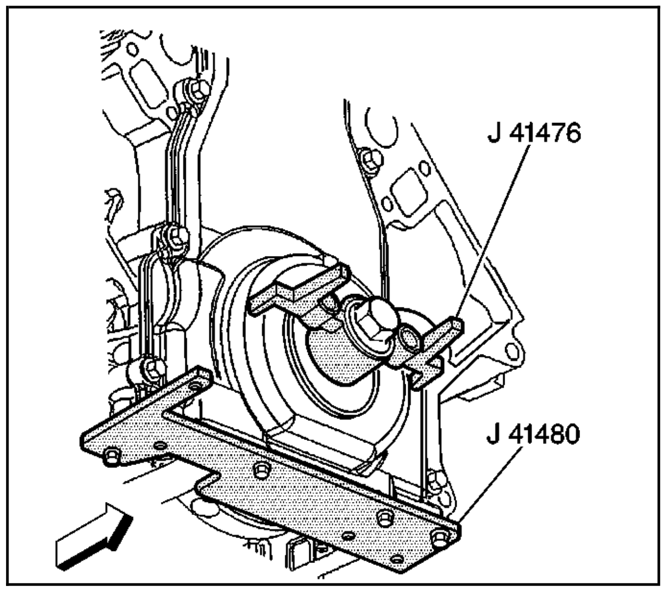
4. Install the *J 41476*.
5. Install the crankshaft balancer bolt.

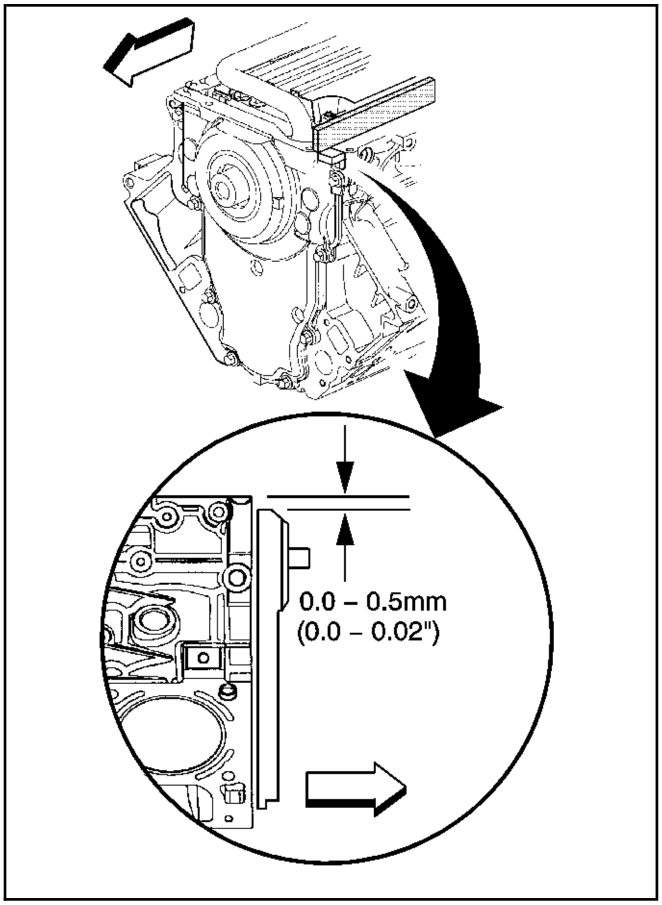
   Tighten

   5.1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.

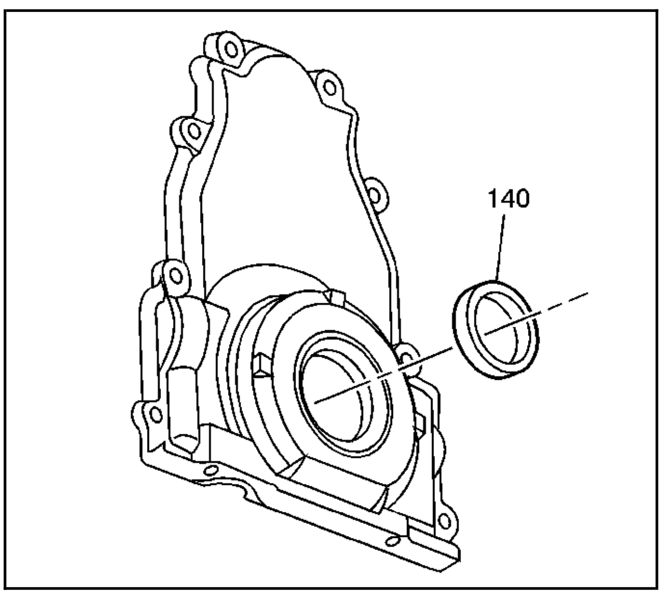
   5.2. Tighten the *J 41480*.

   5.3. Tighten the engine front cover bolts to 25 N·m (18 lb ft).
6. Remove the tools.





7. Measure the oil pan surface flatness, front cover-to-engine block.
   7.1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.
   Avoid contact with the portion of the gasket that protrudes into the oil pan surface.
   7.2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no more than 0.5 mm (0.02 in) below flush.
8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.



Crankshaft Front Oil Seal Installation

Tools Required

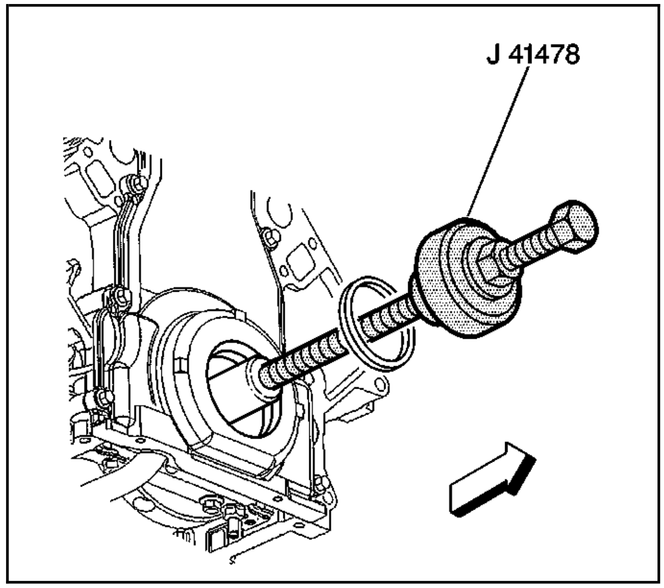
J 41478 Crankshaft Front Oil Seal Installer

Important:

- Do not lubricate the oil seal sealing surface.
- Do not use the crankshaft front oil seal again.

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

3. Install the crankshaft front oil seal onto the *J 41478* guide.
4. Install the *J 41478* threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft.
5. Use the *J 41478* in order to install the oil seal into the cover bore.
   5.1. Use a wrench and hold the hex on the installer bolt.
   5.2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
   5.3. Remove the tool.
   5.4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.



Oil Pan Installation

Important:

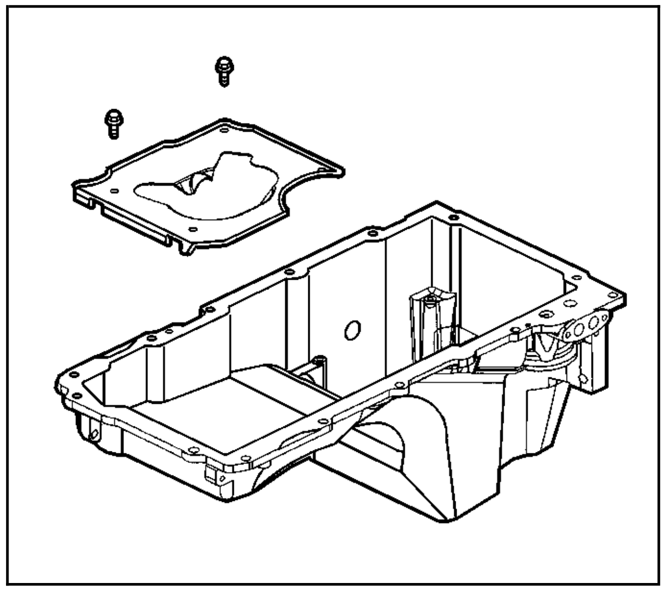
- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.
- Do not use the oil pan gasket again.
- It is not necessary to rivet the NEW gasket to the oil pan.
- It is not necessary to remove the oil level sensor prior to oil pan installation.

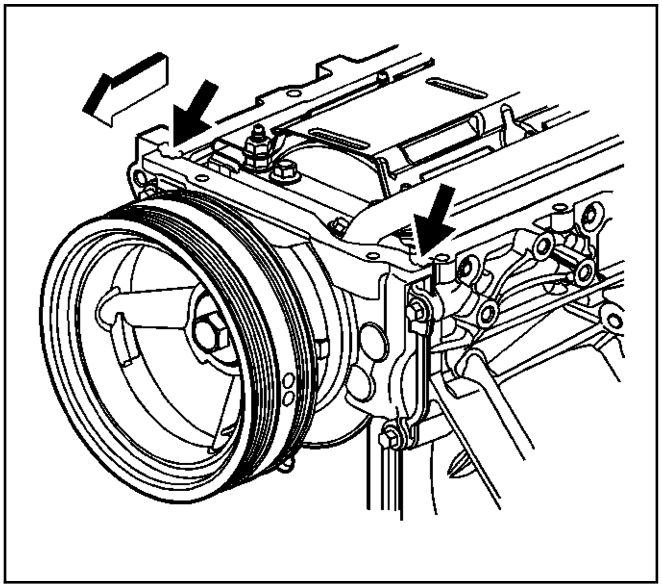
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the oil pan baffle and bolts, if previously removed.

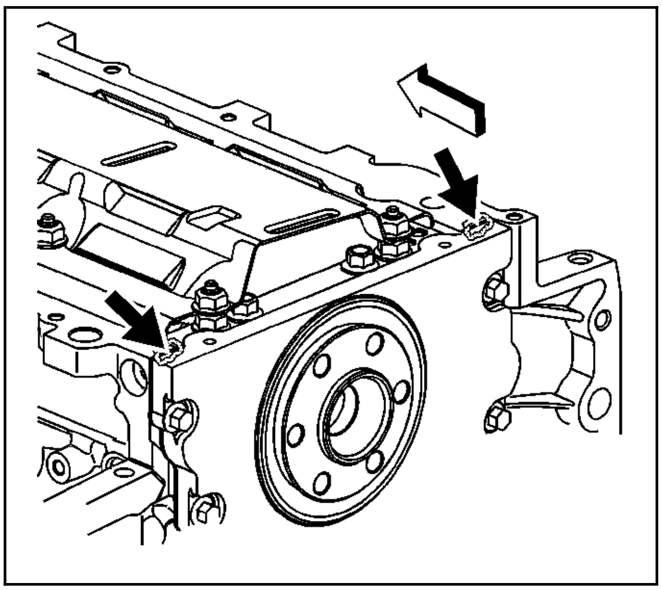
   Tighten

   Tighten the oil pan baffle bolts to 12 N·m (106 lb in).

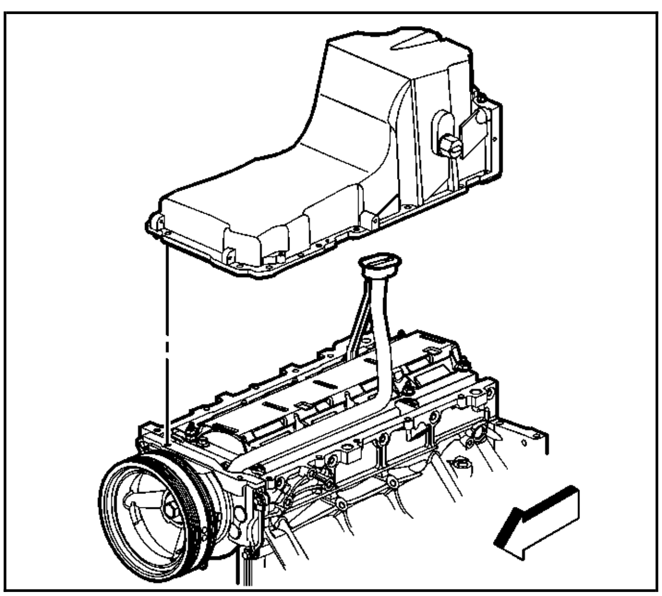




2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to *Sealers, Adhesives, and Lubricants*.



3. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrude into the oil pan surface.



Important: Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

4. Pre-assemble the oil pan gasket to the pan.
   4.1. Install the gasket onto the oil pan.
   4.2. Install the oil pan bolts to the pan and through the gasket.
5. Install the oil pan, gasket and bolts to the engine block.
6. Tighten bolts finger tight. Do not overtighten.
7. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

8. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.

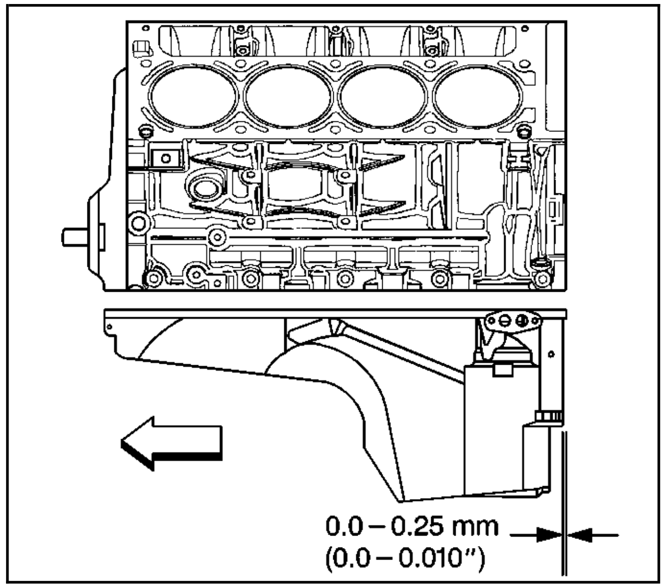
   Tighten

   8.1. Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N·m (18 lb ft).

   8.2. Tighten the oil pan-to-rear cover bolts to 12 N·m (106 lb in).

9. Measure the oil pan-to-engine block alignment.

   9.1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.



Important: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

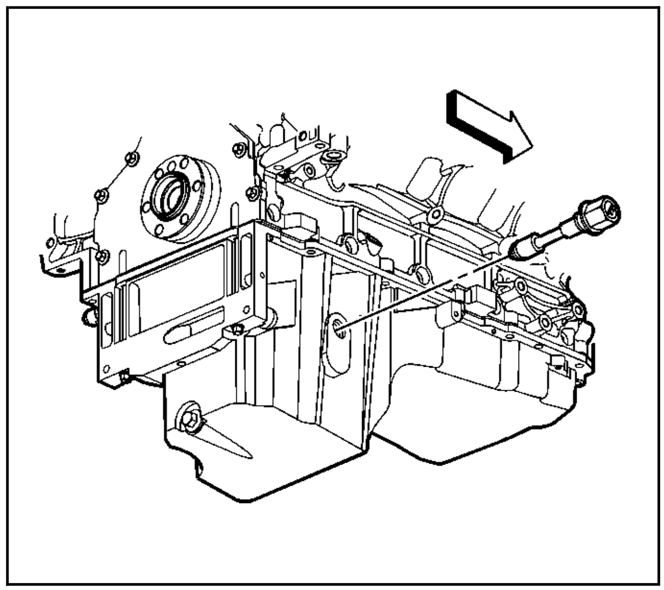
   9.2. Insert a feeler gage between the straight edge and the oil pan transmission housing mounting surface and check to make sure that there is no more than a 0.25 mm (0.01 in) gap between the pan and straight edge.

   9.3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

10. Install the oil level sensor.

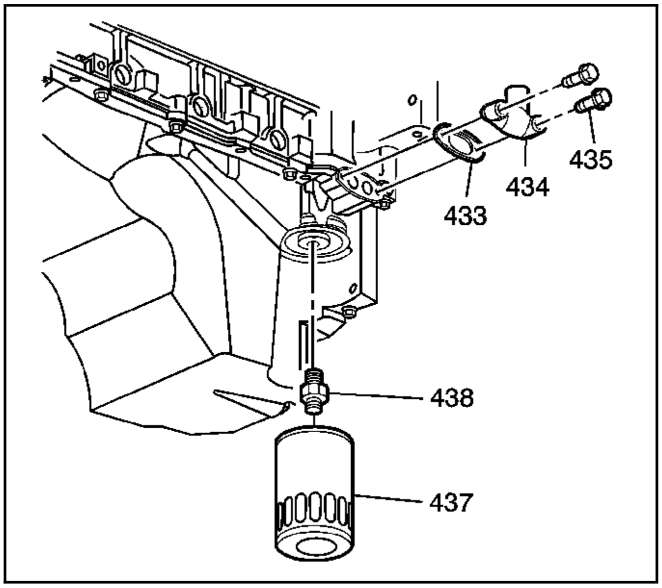
    Tighten

    Tighten the oil level sensor to 13 N·m (115 lb in).



Oil Filter, Adapter, Pan Cover Installation

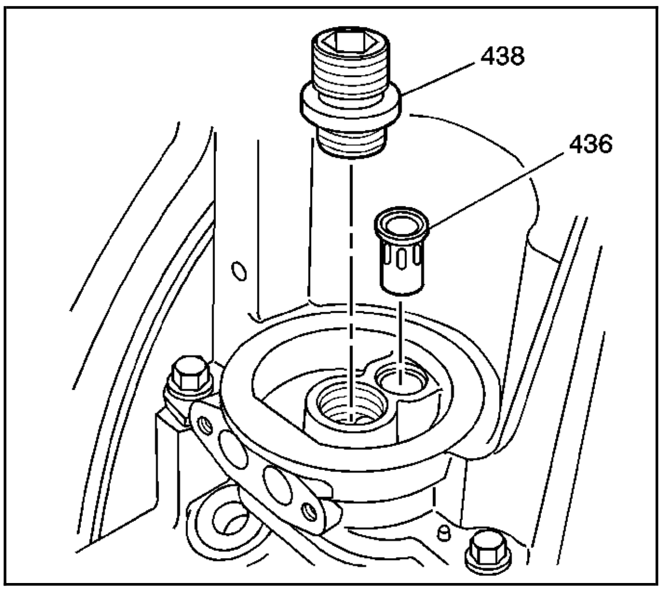
Notice: Refer to *Fastener Notice* in Cautions and Notices.



1. Install the oil pan cover (434), bolts (435), and a NEW oil pan cover gasket (433).

   Tighten

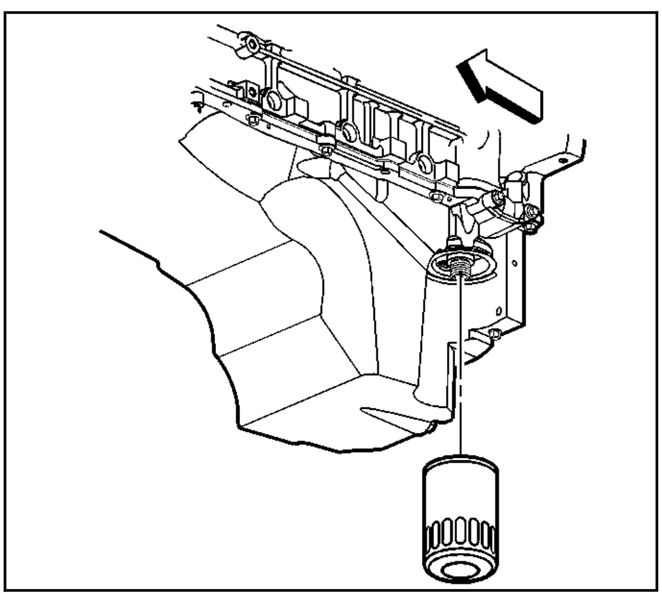
   Tighten the oil pan cover bolts to 12 N·m (106 lb in).



2. Install a new oil filter bypass valve (436) into the oil pan, if required.
3. Install the oil filter fitting (438).

   Tighten

   Tighten the oil filter fitting to 55 N·m (40 lb ft).



4. Lubricate the oil filter seal with clean engine oil.
5. Install the oil filter.

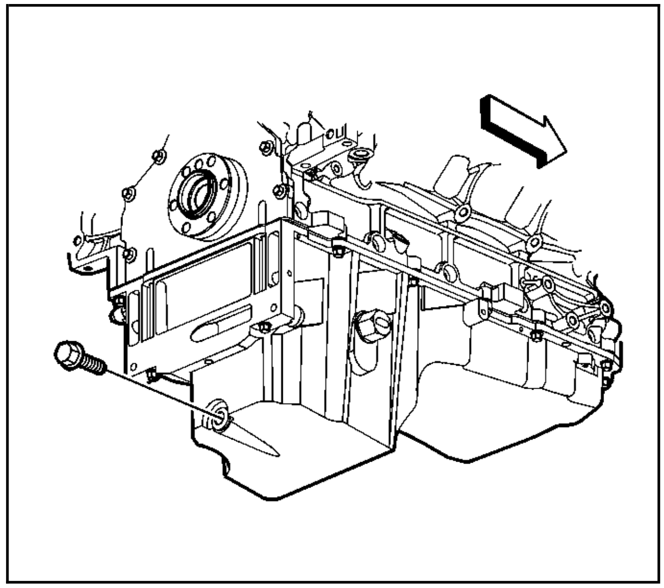
   Tighten

   Tighten the oil filter to 30 N·m (22 lb ft).

6. Install the oil pan drain plug.

   Tighten

   Tighten the oil pan drain plug to 25 N·m (18 lb ft).



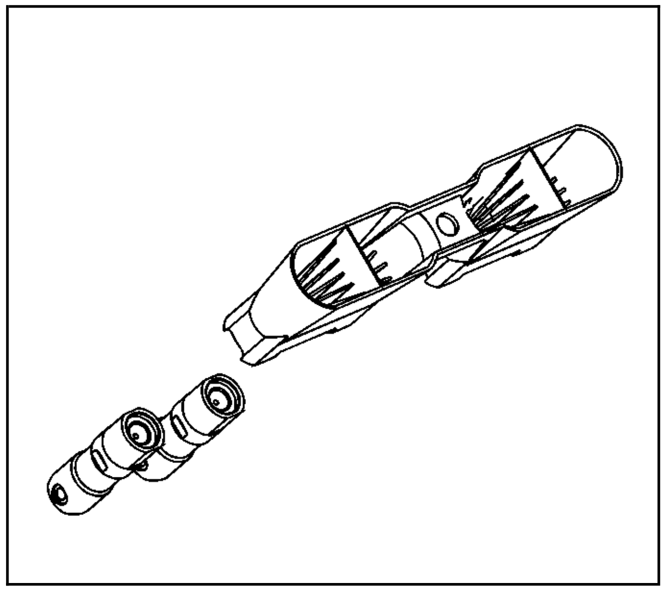
Valve Lifter Installation

mportant:

- When using the valve lifters again, install the lifters to their original locations.
- If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the valve lifters and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides.

   Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.



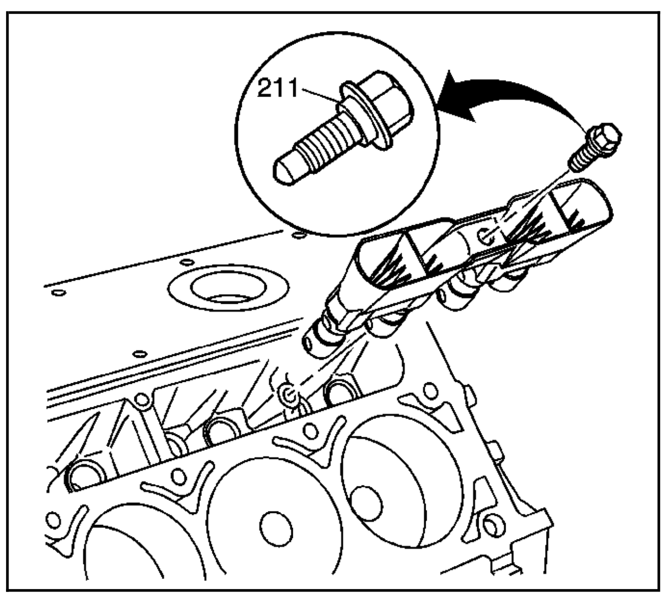
3. Install the valve lifters and guide assembly to the engine block.

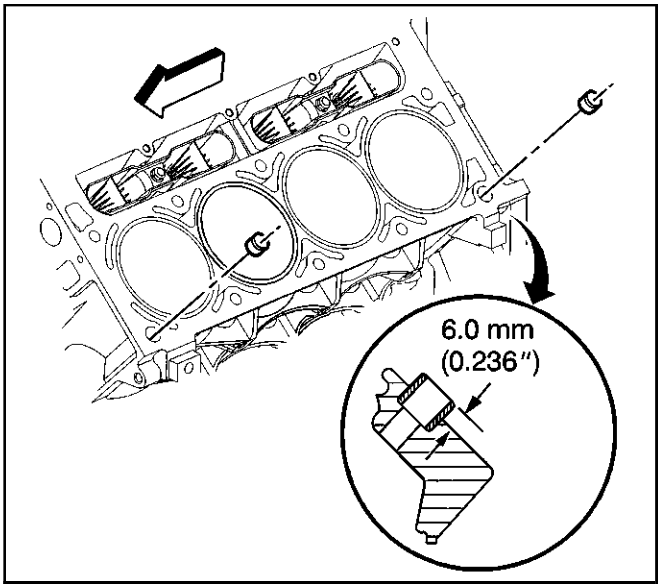
Notice: Refer to *Fastener Notice* in Cautions and Notices.

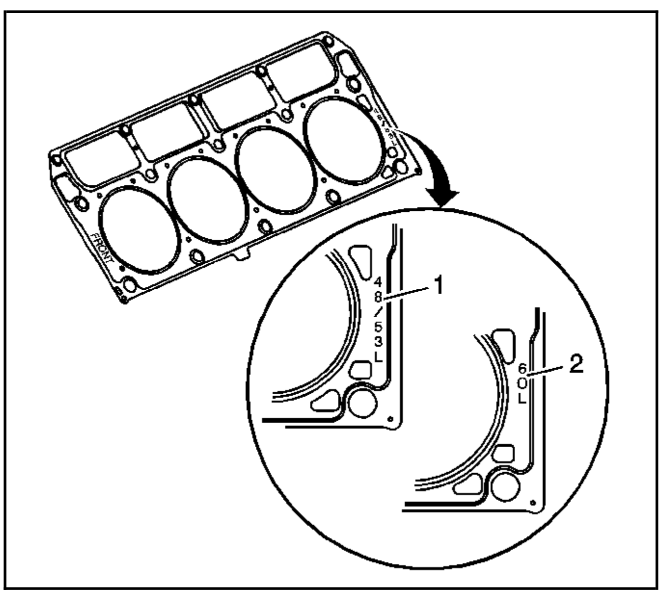
4. Install the valve lifter guide bolt (211).

   Tighten

   Tighten the valve lifter guide bolt to 12 N·m (106 lb in).







Cylinder Head Installation - Left

Tools Required

- *J 42385-100* Head/Main Bolt Thread Repair Kit
- *J 45059* Angle Meter

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Notice: SIO-ID = 96999 LMD = 13-aug-1996 Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

Important:

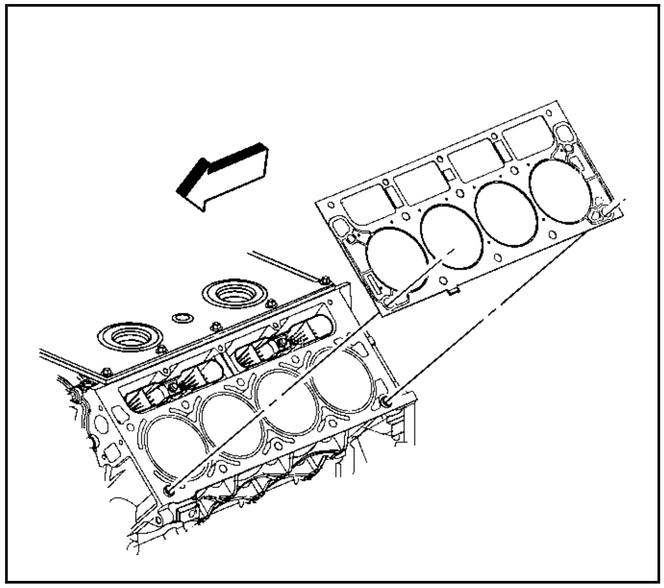
- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type sealant on the cylinder head gasket, unless specified.

1. Clean the engine block cylinder head bolt holes, if required.

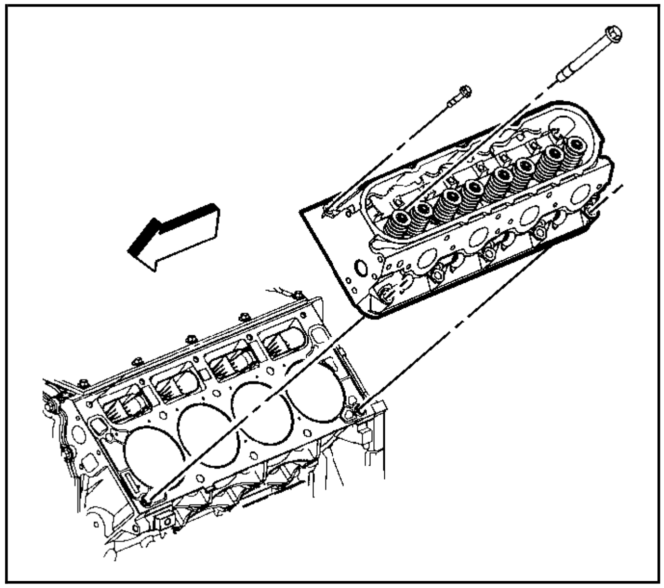
   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.
2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation.
5. Inspect the displacement markings (1) on the gasket, for proper usage.

Important: When properly installed, the tab on the left cylinder head gasket will be located left of center, or closer to the front of the engine.

6. Install the NEW left cylinder head gasket onto the locating pins.



7. Install the cylinder head onto the locating pins and the gasket.
8. Install the NEW cylinder head bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Tighten the cylinder head bolts.

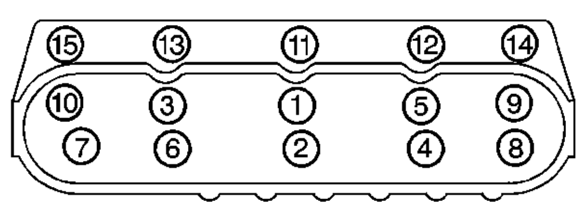
   Tighten

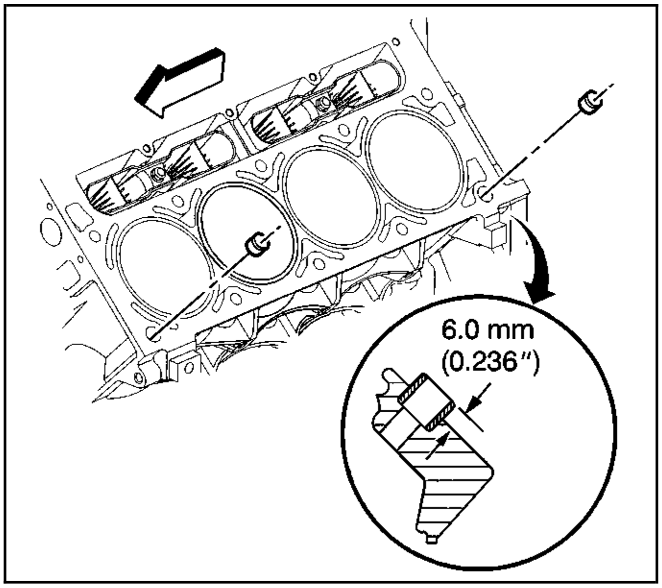
   9.1. Tighten the M11 cylinder head bolts (1–10) a first pass in sequence to 30 N·m (22 lb ft).

   9.2. Tighten the M11 cylinder head bolts (1–10) a second pass in sequence to 90 degrees using the *J 45059*.

   9.3. Tighten the M11 cylinder head bolts (1–10) a final pass in sequence to 70 degrees using the *J 45059*.

   9.4. Tighten the M8 cylinder head bolts (11–15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.





Cylinder Head Installation - Right

Tools Required

- *J 42385-100* Head/Main Bolt Thread Repair Kit
- *J 45059* Angle Meter

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

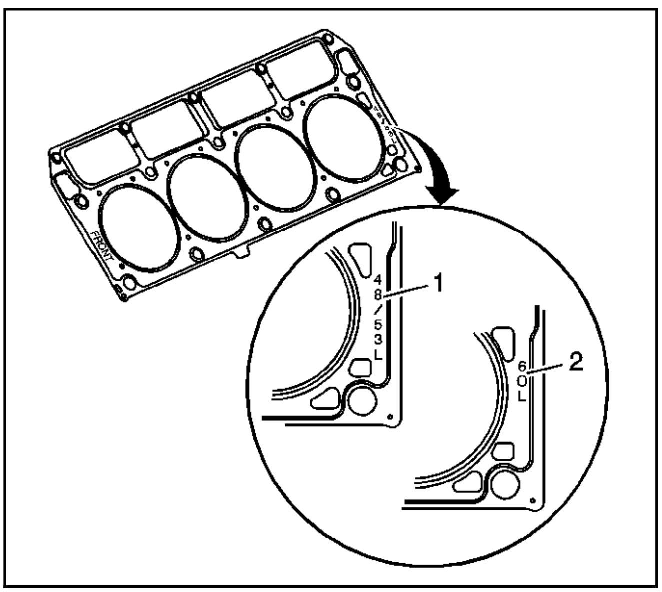
Notice: SIO-ID = 96999 LMD = 13-aug-1996 Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

Important:

- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type sealant on the cylinder head gasket, unless specified.

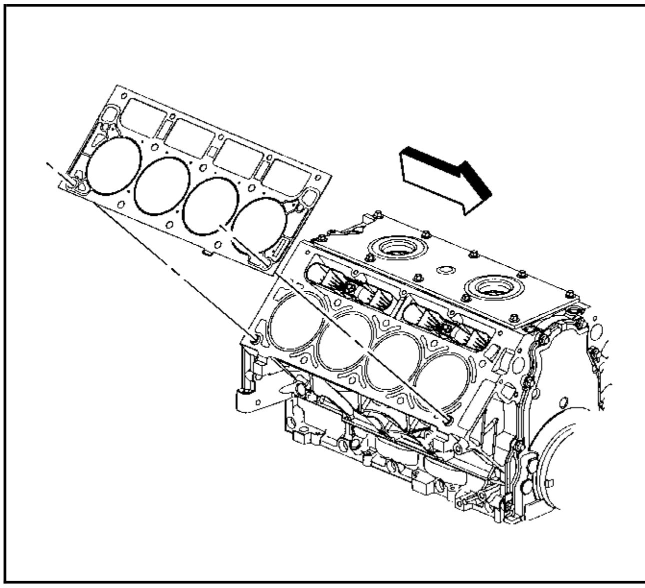
1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.
2. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation.
5. Inspect the displacement markings (1) on the gasket, for proper usage.

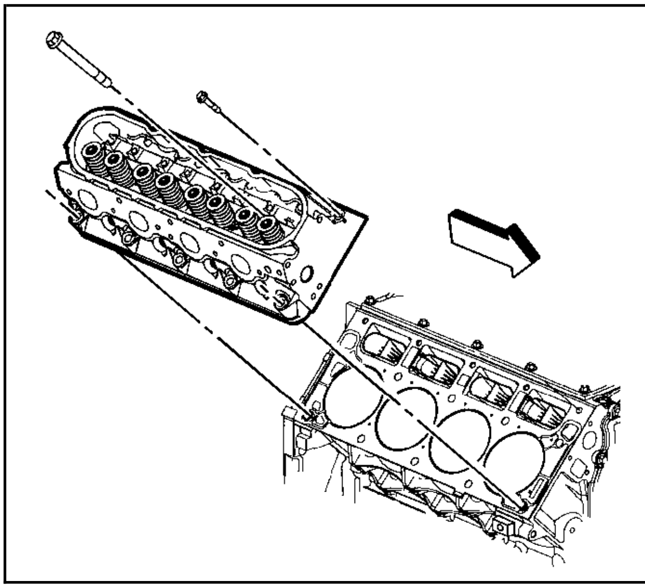


Important: When properly installed, the tab on the right cylinder head gasket will be located right of center or closer to the front of the engine.

6. Install the NEW right cylinder head gasket onto the locating pins.



7. Install the cylinder head onto the locating pins and the gasket.
8. Install the NEW cylinder head bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Tighten the cylinder head bolts.

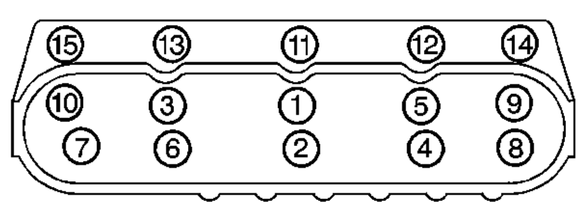
   Tighten

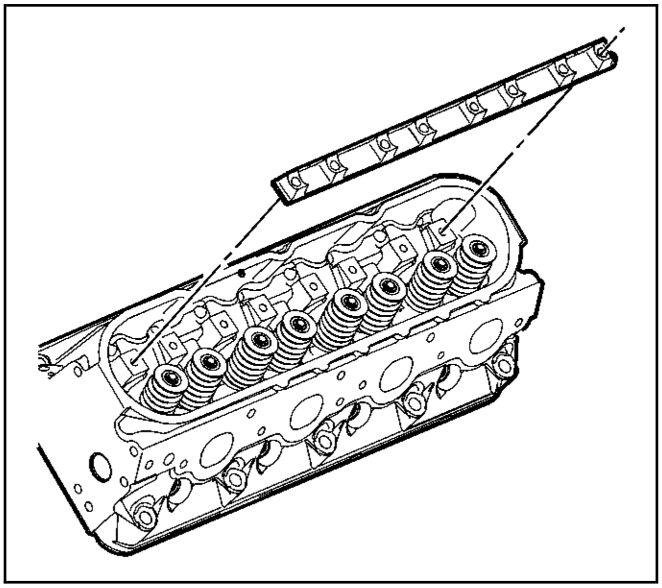
   9.1. Tighten the M11 cylinder head bolts (1–10) a first pass in sequence to 30 N·m (22 lb ft).

   9.2. Tighten the M11 cylinder head bolts (1–10) a second pass in sequence to 90 degrees using the *J 45059*.

   9.3. Tighten the M11 cylinder head bolts (1–10) a final pass in sequence to 70 degrees using the *J 45059*.

   9.4. Tighten the M8 cylinder head bolts (11–15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.





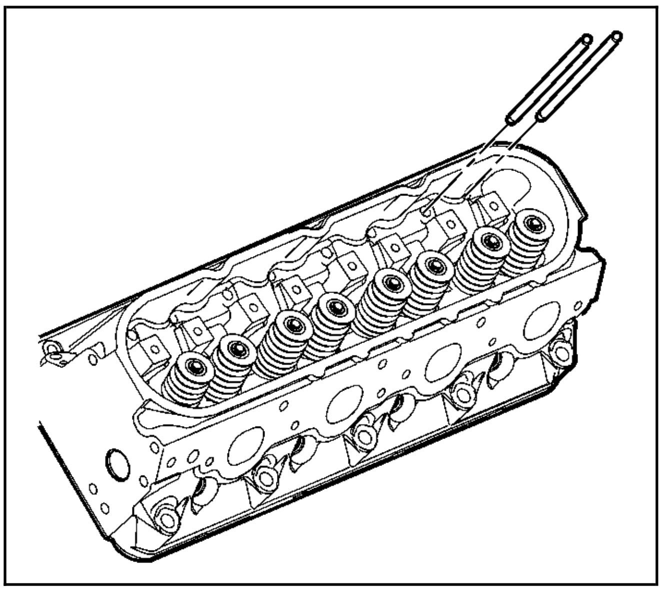
Valve Rocker Arm and Push Rod Installation

Important:

- When using the valve train components again, always install the components to the original location and position.
- Valve lash is net build, no valve adjustment is required.

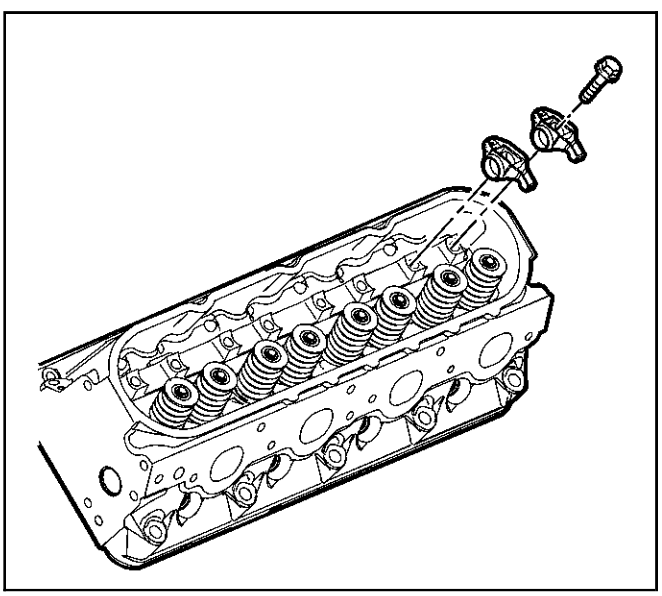
1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.

   Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.
3. Install the valve rocker arm pivot support.



Important: Ensure that the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.



Important:

- Ensure that the pushrods seat properly to the ends of the rocker arms.
- DO NOT tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.

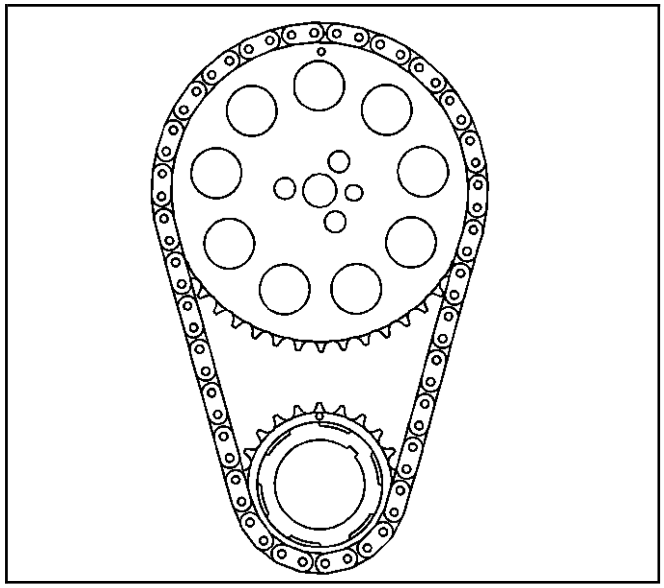
6. Rotate the crankshaft until number one piston is at top dead center of compression stroke.

   In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

   The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

   Cylinders 1, 3, 5 and 7 are left bank.

   Cylinders 2, 4, 6, and 8 are right bank.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

   Tighten

   - Tighten exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N·m (22 lb ft).
   - Tighten intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N·m (22 lb ft).

8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

   Tighten

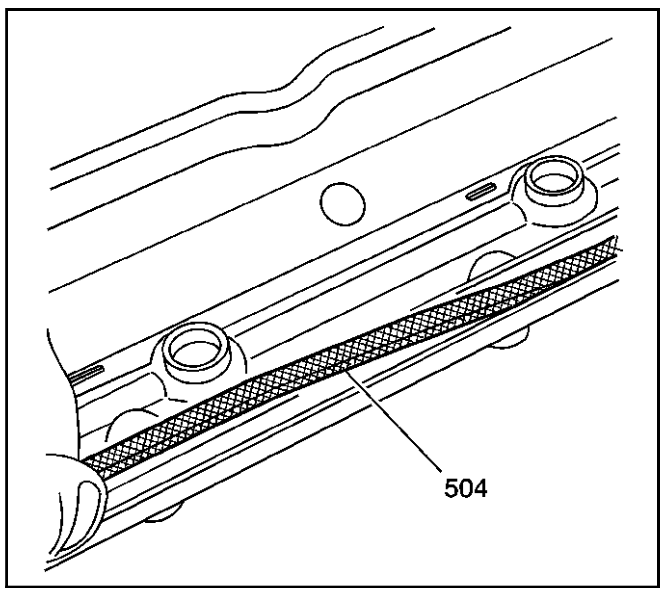
   - Tighten exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N·m (22 lb ft).
   - Tighten intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N·m (22 lb ft).

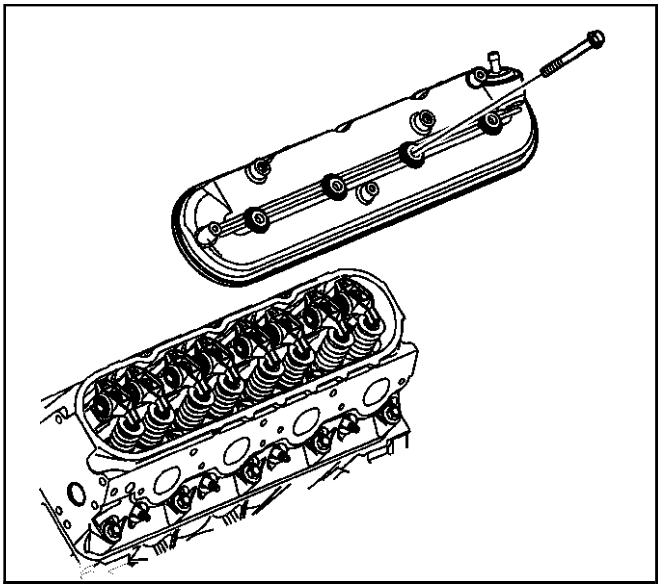
Valve Rocker Arm Cover Installation - Left

Important:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- DO NOT use the valve rocker arm cover gasket again.
- The valve rocker arm cover bolt grommets may be used again.
- If the vapor vent grommet has been removed from the valve rocker arm cover, install a NEW vapor vent gourmet during assembly.

1. Install a NEW cover gasket (504) into the left valve rocker arm cover.





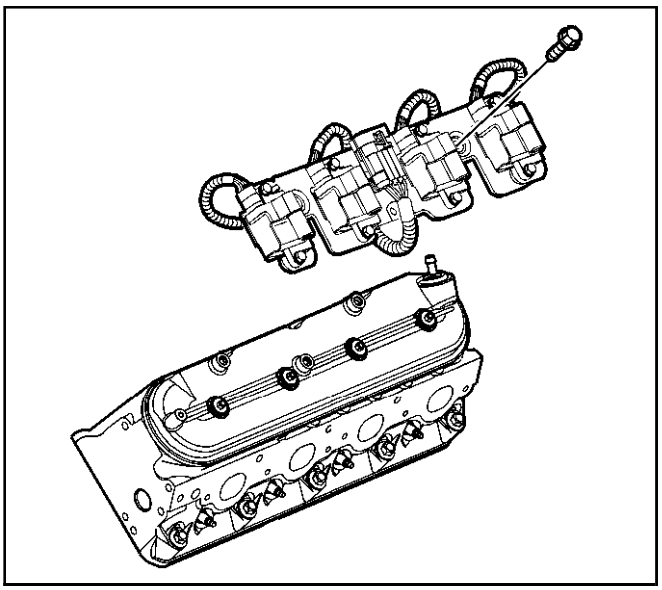
2. Install the valve rocker arm cover onto the cylinder head.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the cover bolts with grommets.

   Tighten

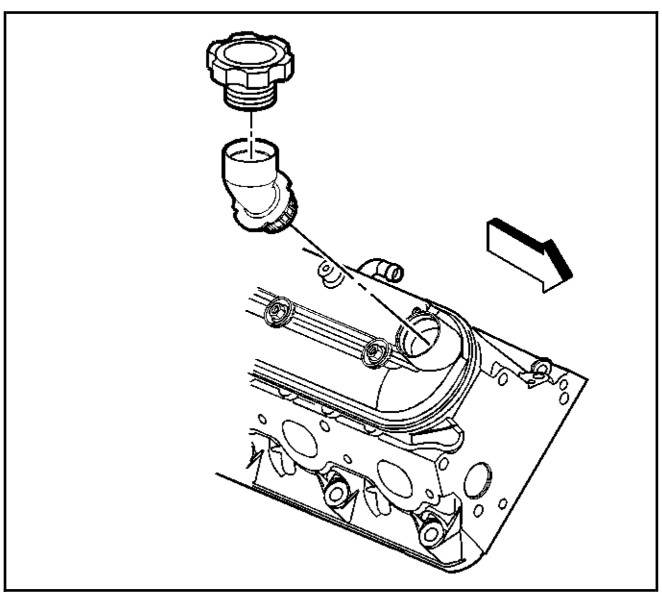
   Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).



4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
5. Install the ignition coils and bracket assembly and bolts.

   Tighten

   Tighten the ignition coil and bracket assembly bolts to 12 N·m (106 lb in).



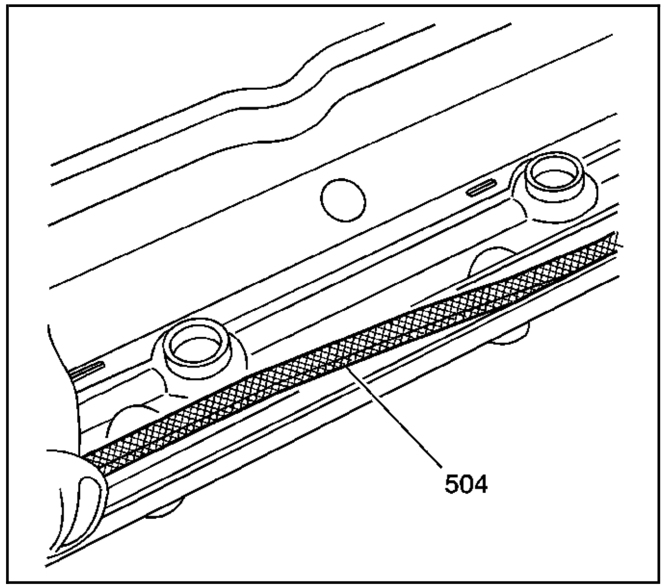
Valve Rocker Arm Cover Installation - Right

Important:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- Do not use the valve rocker arm cover gasket again.
- Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.
- The valve rocker arm cover bolt grommets may be used again.
- If the oil fill tube has been removed from the valve rocker arm cover, install a NEW oil fill tube during assembly.

1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.

2. Insert the NEW oil fill tube into the rocker arm cover and rotate the tube clockwise until locked in the proper position.
3. Install the oil fill cap into the tube and rotate clockwise until locked in the proper position.
4. Install a NEW cover gasket (504) into the right valve rocker arm cover.



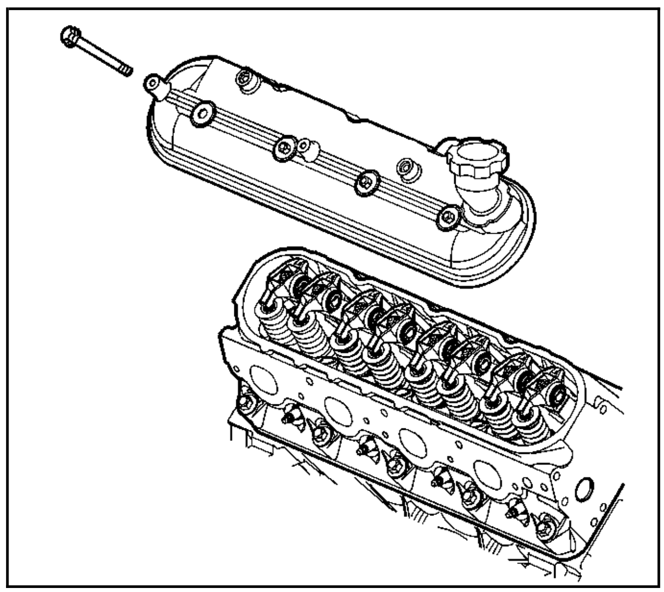
5. Install the valve rocker arm cover onto the cylinder head.

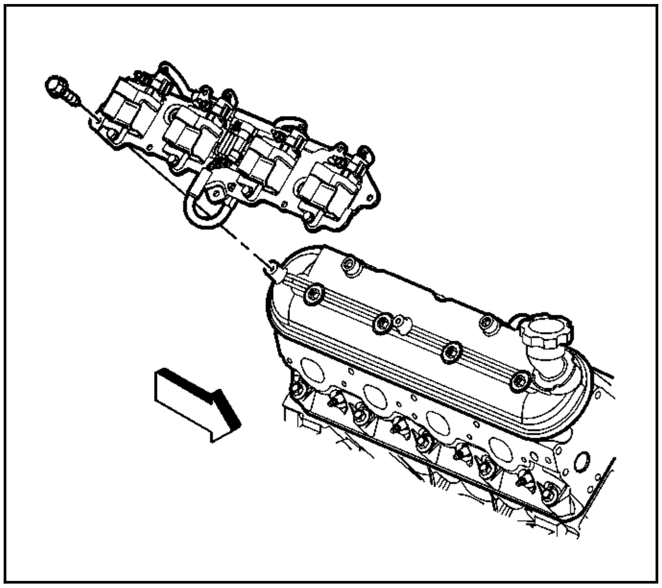
Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Install the cover bolts with grommets.

   Tighten

   Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).

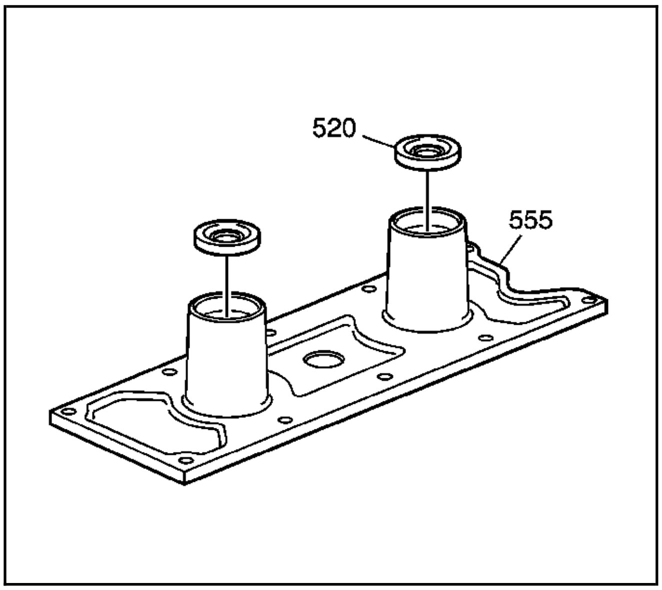




7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
8. Install the ignition coil and bracket assembly and bolts.

   Tighten

   Tighten the ignition coil and bracket assembly studs to 12 N·m (106 lb in).

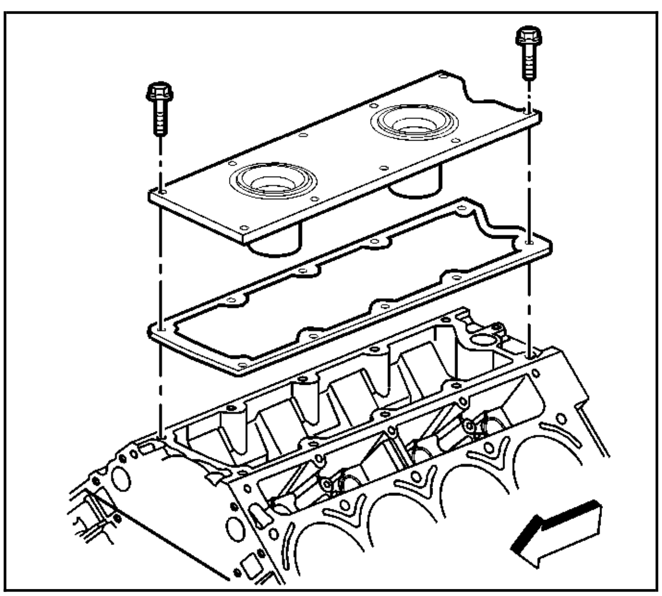


Engine Valley Cover Installation

Important: All gasket surfaces should be free of oil or other foreign material during assembly.

1. Install NEW knock sensor oil seals (520) into the valley cover (555).

   Lubricate the seal surfaces with clean engine oil.



2. Install the valley cover and NEW gasket.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the valley cover bolts.

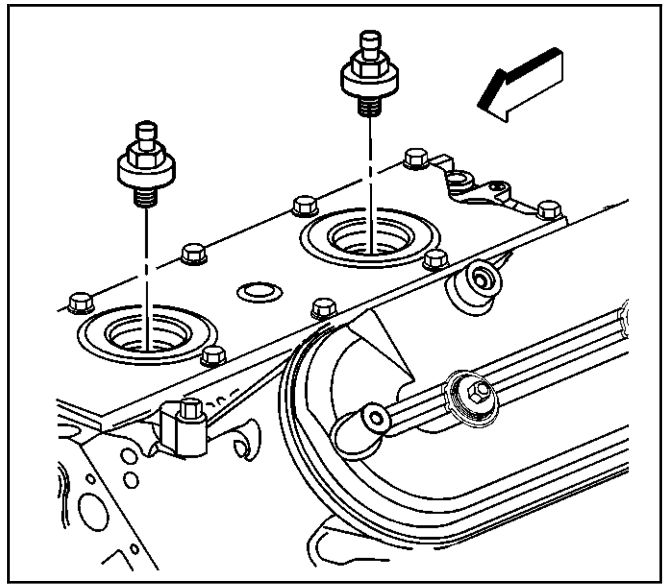
   Tighten

   Tighten the valley cover bolts to 25 N·m (18 lb ft).

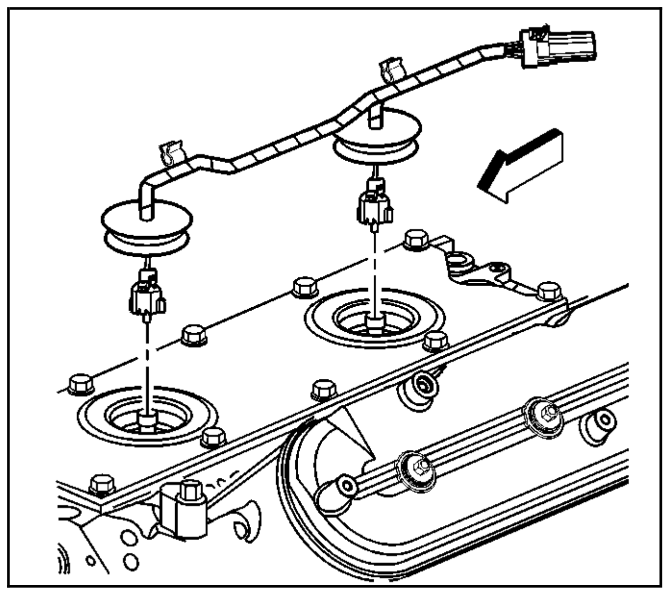
4. Install the knock sensors.

   Tighten

   Tighten the knock sensors to 20 N·m (15 lb ft).



5. Install the knock sensor wire harness.

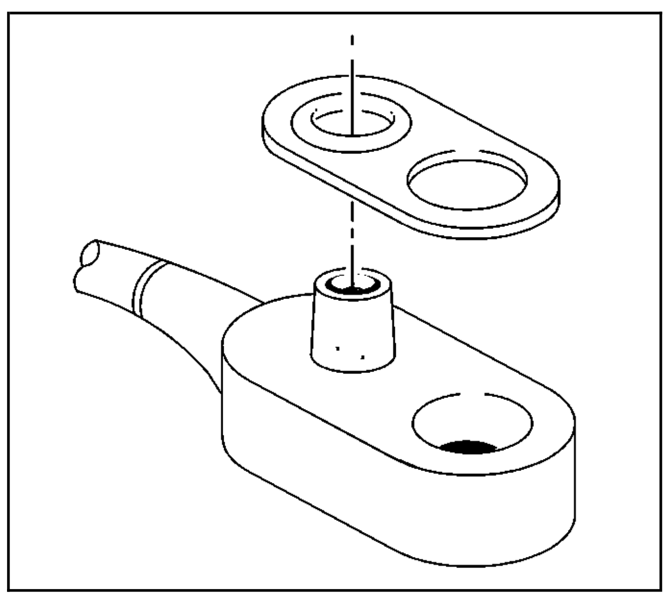


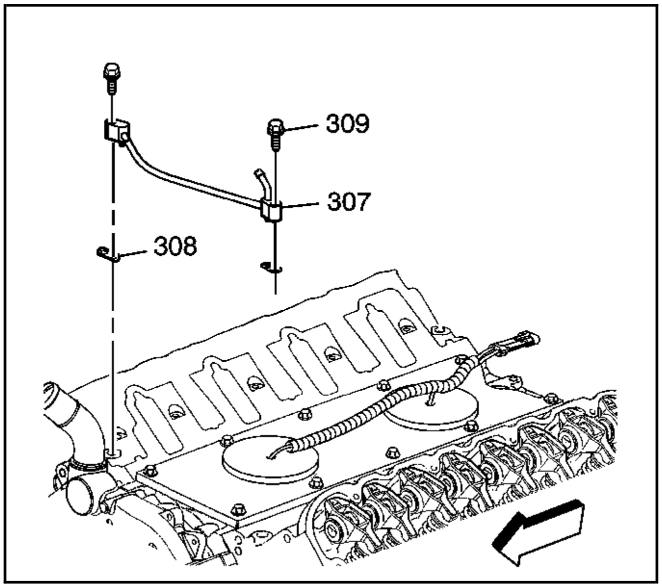
Coolant Air Bleed Pipe Installation

Important:

- Install the pipe gaskets properly onto the pipe and covers.
- Position the gasket O-ring seal onto the nipple portion of the pipe.

1. Install the gaskets onto the engine coolant air bleed pipe and covers.





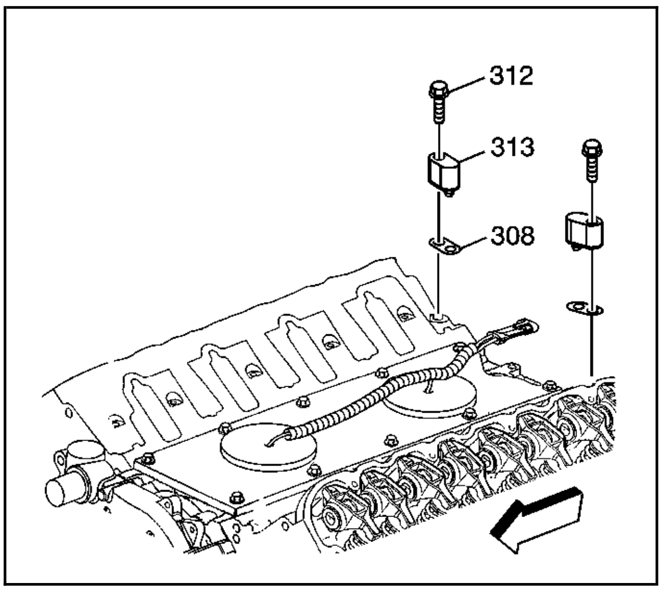
2. Install the pipe (307) and gaskets (308) onto the cylinder heads.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the pipe bolts (309).

   Tighten

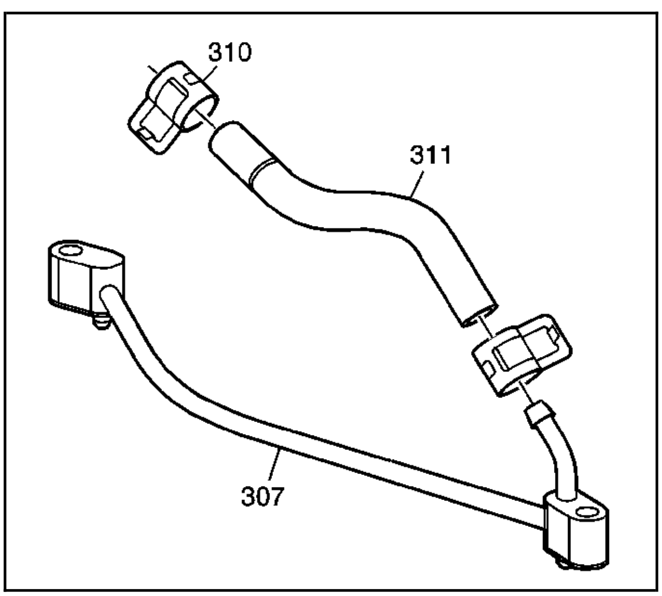
   Tighten the pipe bolts to 12 N·m (106 lb in).



4. Install the covers (313), gaskets (308), and bolts (312) onto the rear of the engine.

   Tighten

   Tighten the cover bolts to 12 N·m (106 lb in).



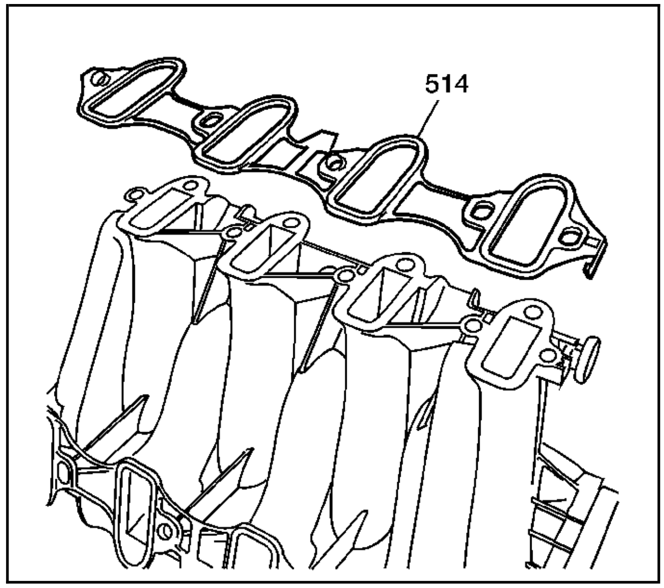
5. Install the hose (311) and clamps (310) onto the pipe (307).

Intake Manifold Installation

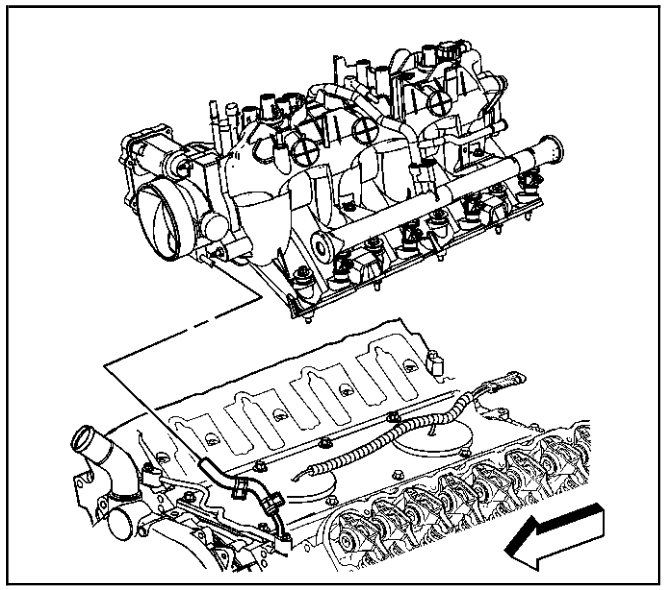
Important:

- The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.
- DO NOT use the old intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.

1. Install NEW intake manifold-to-cylinder head gaskets (514).



2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the intake manifold bolts. Refer to *Sealers, Adhesives, and Lubricants*.



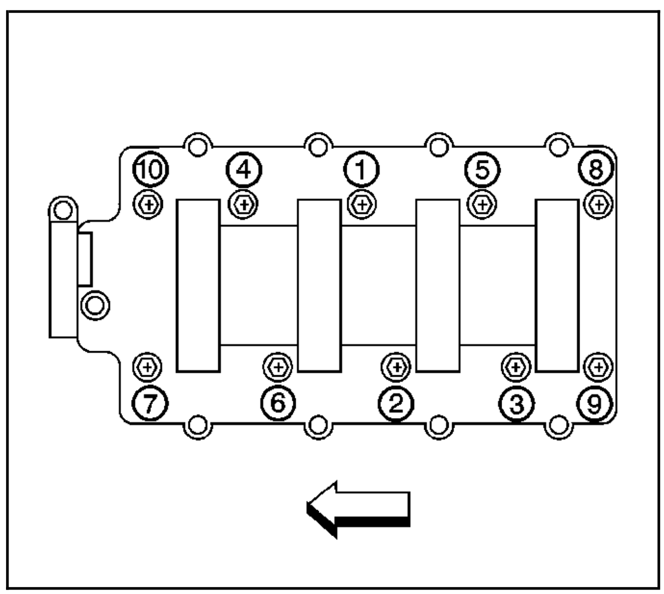
Notice: Refer to *Fastener Notice* in Cautions and Notices.

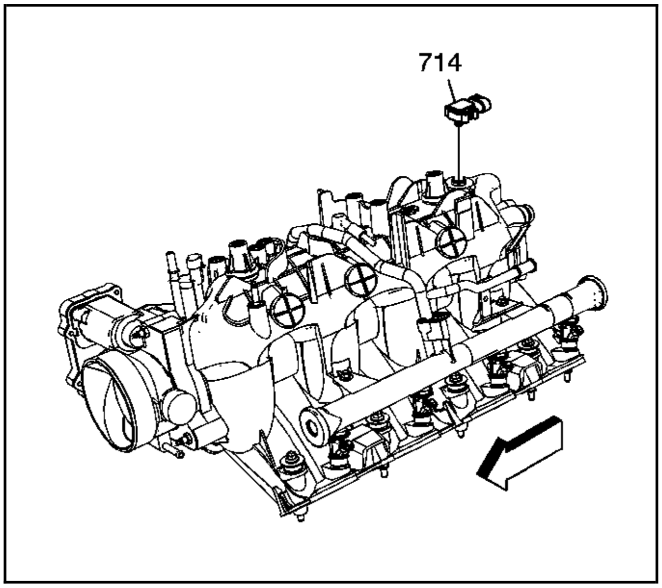
4. Install the intake manifold bolts.

   Tighten

   4.1. Tighten intake manifold bolts first pass in sequence to 5 N·m (44 lb in).

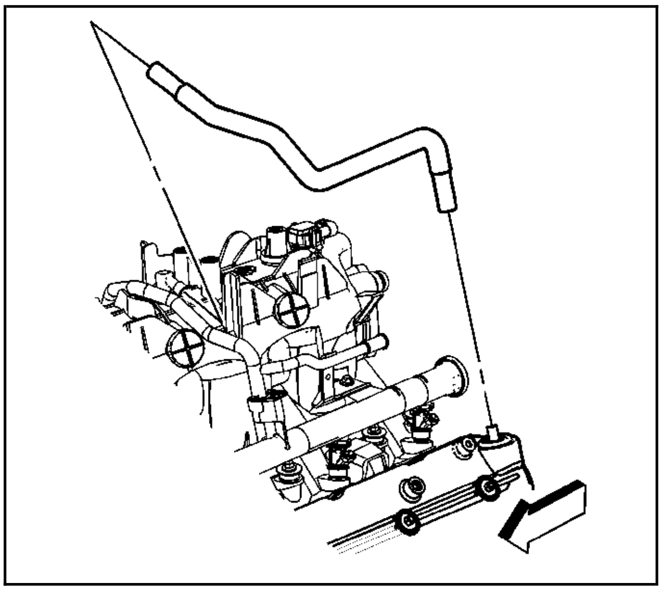
   4.2. Tighten intake manifold bolts final pass in sequence to 10 N·m (89 lb in).



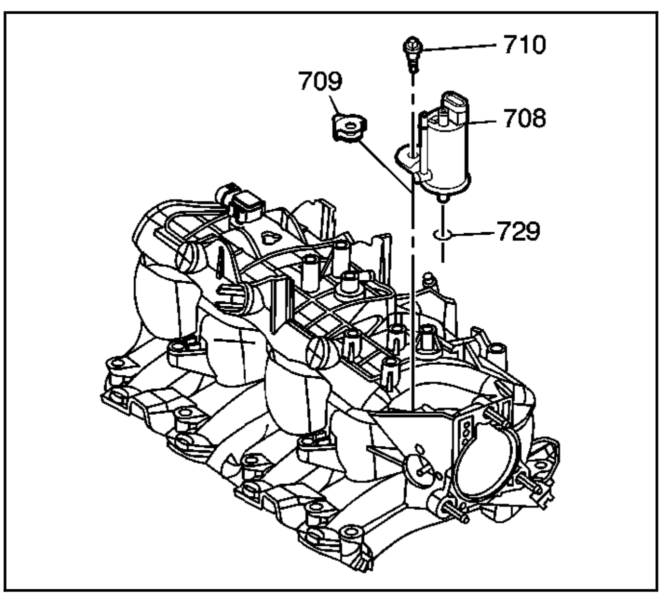


5. Install the manifold absolute pressure (MAP) sensor (714), if previously removed.

   The electrical connector end of the sensor should be facing the front of the engine.



6. Install the positive crankcase ventilation (PCV) dirty air hose.
7. Install the engine coolant air bleed hose and clamp onto the throttle body.



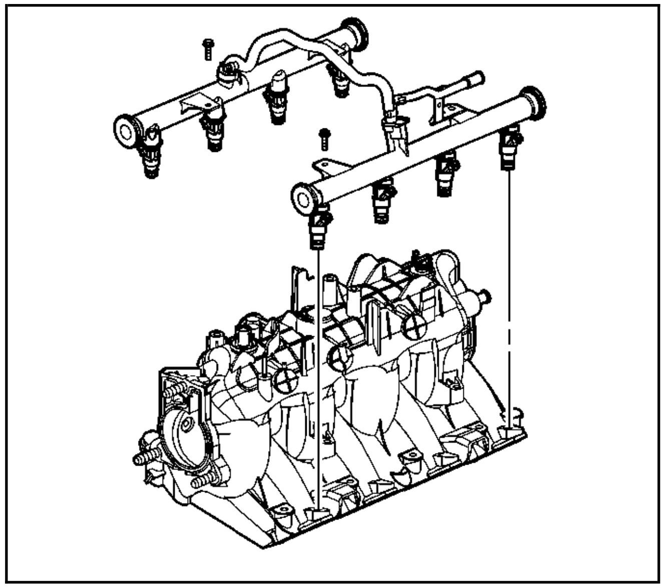
8. Install the evaporative emission (EVAP) purge solenoid (708), bolt (710), and isolator (709).

   Tighten

   Tighten the solenoid bolt to 10 N·m (89 lb in).

Fuel Rail and Injectors Installation

Caution: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.



Important: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals with clean engine oil.
2. Install the O-ring seals onto the fuel injectors.
3. Install a new O-ring seal to the right side of the crossover tube.
4. Assemble the crossover tube and bolt to the right fuel rail.
5. Install the fuel rail, with fuel injectors, into the intake manifold.

   Press evenly on both sides of the fuel rail until all of the injectors are seated in their bores.
6. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the fuel rail bolts. Refer to *Sealers, Adhesives, and Lubricants*.

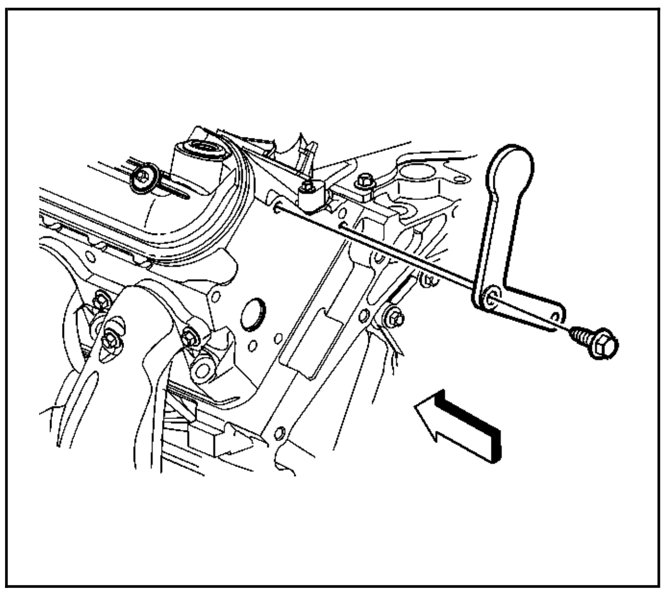
Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the fuel rail bolts.

   Tighten

   7.1. Tighten the fuel rail bolts to 10 N·m (89 lb in).

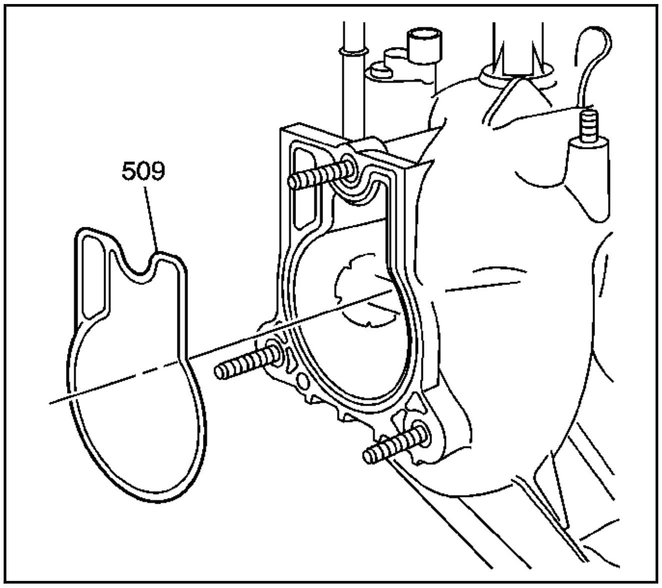
   7.2. Tighten the crossover tube right side retaining bolt to 3.8 N·m (34 lb in).
8. Install the vacuum hose to the fuel pressure regulator for the L59 engine.



9. Install the fuel rail stop bracket and bolt.

   Tighten

   Tighten the fuel rail stop bracket bolt to 50 N·m (37 lb ft).



Throttle Body Installation

Notice: Refer to *Fastener Notice* in Cautions and Notices.

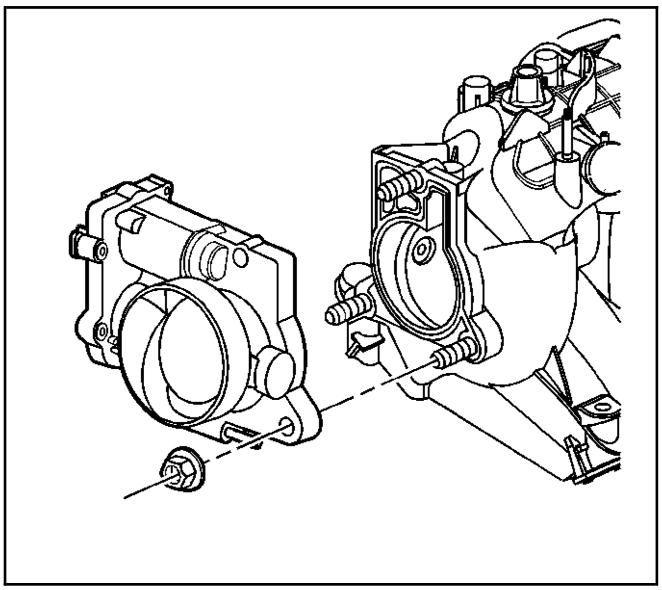
1. Install the throttle body studs, if required.

   Tighten

   Tighten the throttle body studs to 6 N·m (53 lb in).

Important: DO NOT use the throttle body gasket again. Install a NEW gasket during assembly.

2. Install the throttle body gasket (509) to the intake manifold.

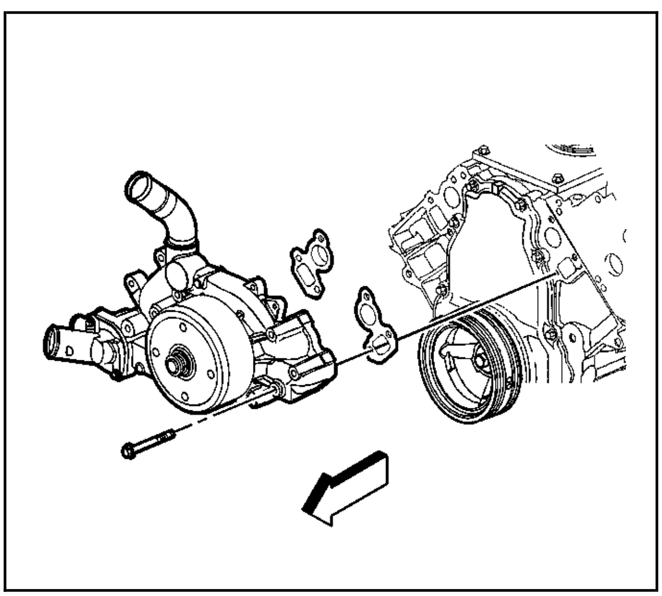


3. Install the throttle body and nuts.

   Tighten

   Tighten the throttle body nuts to 10 N·m (89 lb in).

4. Install the engine coolant air bleed hose and clamp to the throttle body.



Water Pump Installation

Notice: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

Important: All gasket surfaces to be free of oil or other foreign material during assembly.

1. Install the water pump and NEW gaskets.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

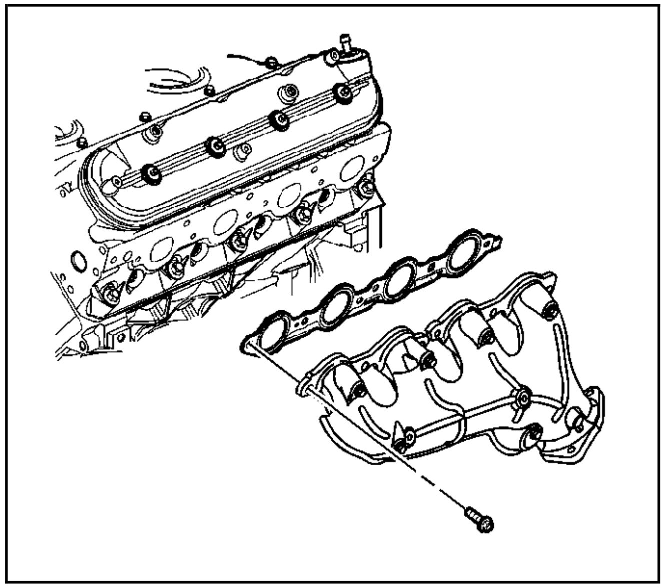
2. Install the water pump bolts.

   Tighten

2.1. Tighten the water pump bolts first pass to 15 N·m (11 lb ft).

2.2. Tighten the water pump bolts final pass to 30 N·m (22 lb ft).

Exhaust Manifold Installation - Left



Important:

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

Important: Do not apply sealant to the first three threads of the bolt.

1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to *Sealers, Adhesives, and Lubricants*.
2. Install the exhaust manifold and NEW exhaust manifold gasket.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

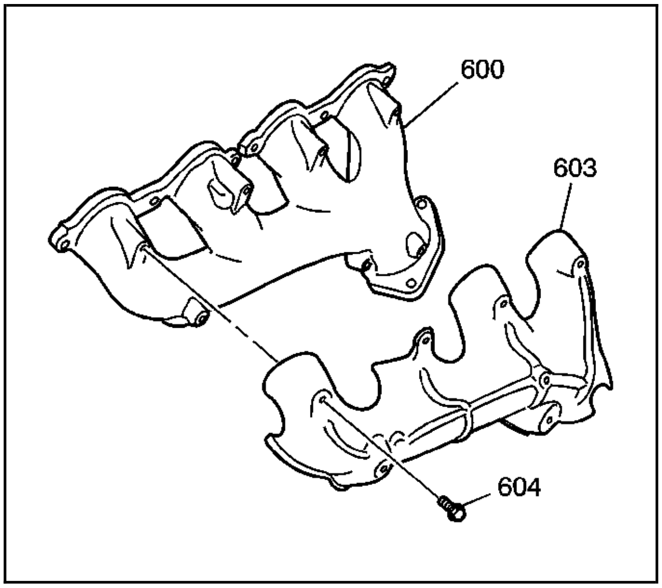
3. Install the exhaust manifold bolts.

   Tighten

   3.1. Tighten the exhaust manifold bolts a first pass to 15 N·m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

   3.2. Tighten the exhaust manifold bolts a final pass to 25 N·m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

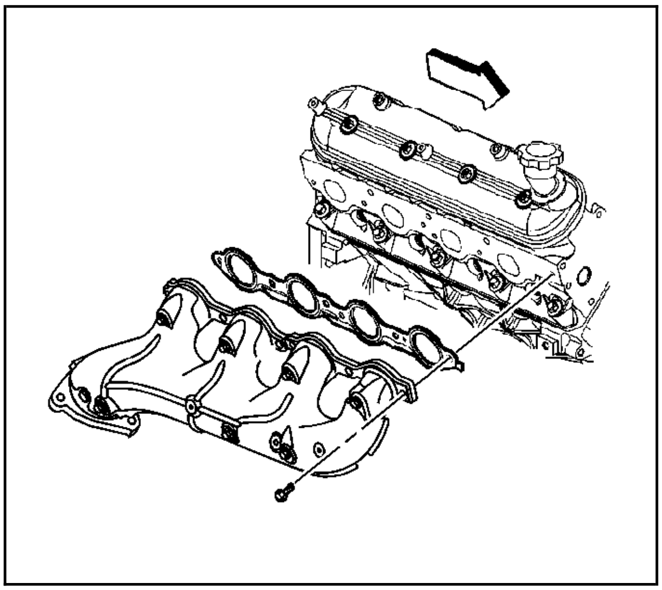
4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.



5. Install the heat shield (603) and bolts (604).

Tighten

Tighten the heat shield bolts to 9 N·m (80 lb in).



Exhaust Manifold Installation - Right

Important:

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to *Sealers, Adhesives, and Lubricants*.
2. Install the exhaust manifold gasket and exhaust manifold.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the exhaust manifold bolts.

   Tighten

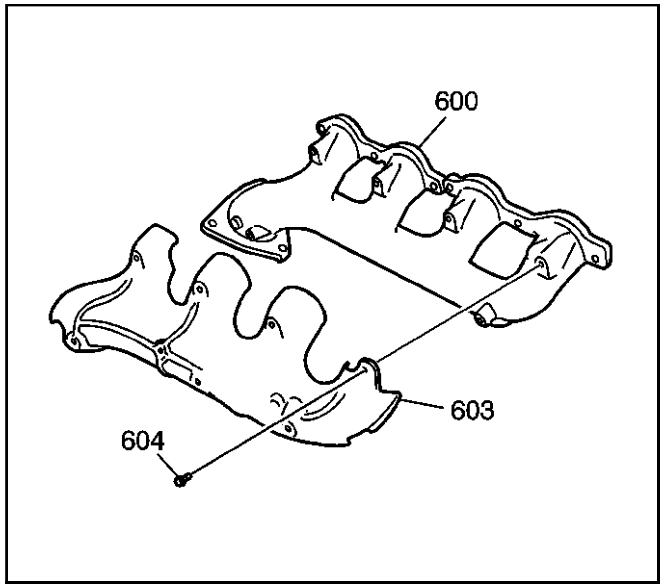
   3.1. Tighten the exhaust manifold bolts first pass to 15 N·m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

   3.2. Tighten the exhaust manifold bolts final pass to 25 N·m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the front of the right cylinder head.

5. Install the heat shield (603) and bolts (604).

   Tighten

   Tighten the heat shield bolts to 9 N·m (80 lb in).



Oil Level Indicator and Tube Installation

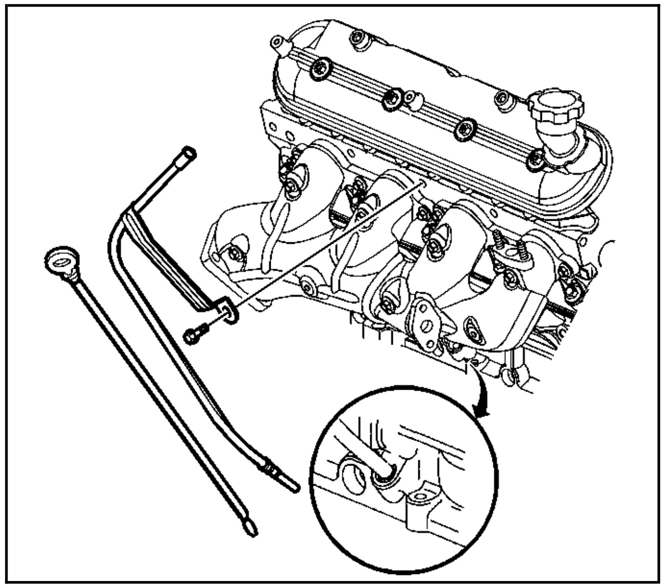
1. Inspect the O-ring seal for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be reused.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube.
4. Install the oil level indicator tube into the engine block and rotate into proper position.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the tube bolt.

   Tighten

   Tighten the oil level indicator tube bolt to 25 N·m (18 lb ft).
6. Install the oil level indicator into the tube.



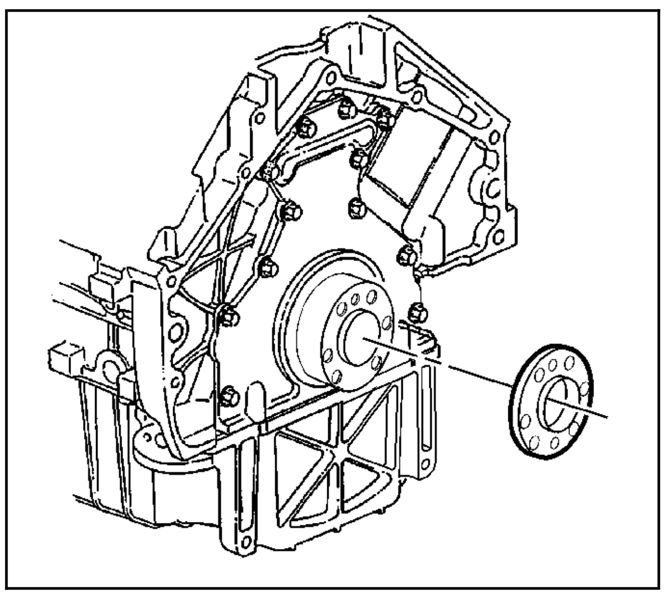
Engine Flywheel Installation

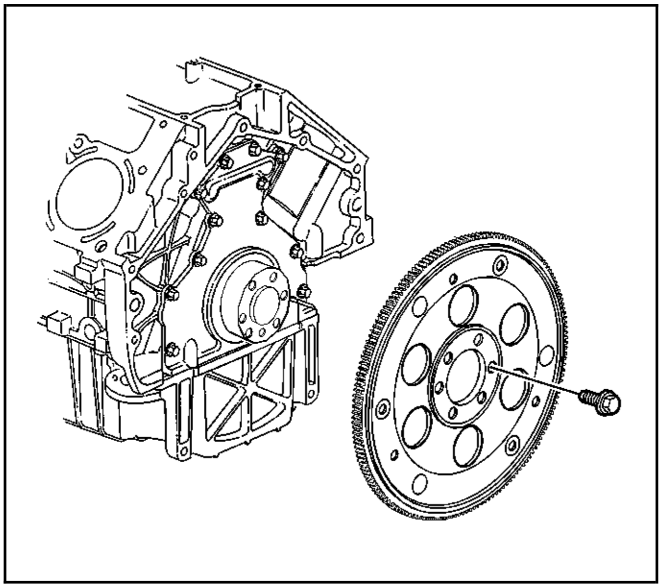
Important:

- The flywheel does not use a locating pin for alignment, and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.
- Certain applications, the 4.8L manual transmission and all 6.0L, require a spacer and longer bolts for proper flywheel position.

1. Install the spacer, if applicable, onto the rear of the crankshaft.

   A longer flywheel bolt must be used on applications using a flywheel spacer.

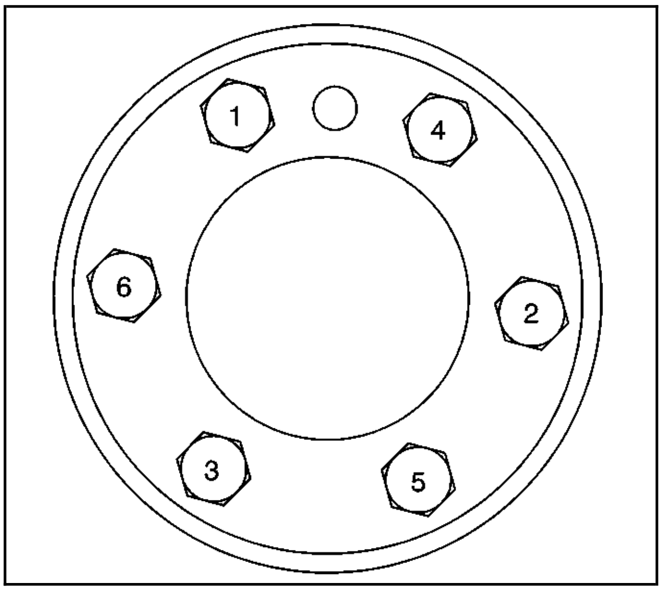




2. Install the automatic transmission engine flywheel to the crankshaft, if applicable.

Important: A longer flywheel bolt must be used on applications using a flywheel spacer.

3. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.



Notice: Refer to *Fastener Notice* in Cautions and Notices.

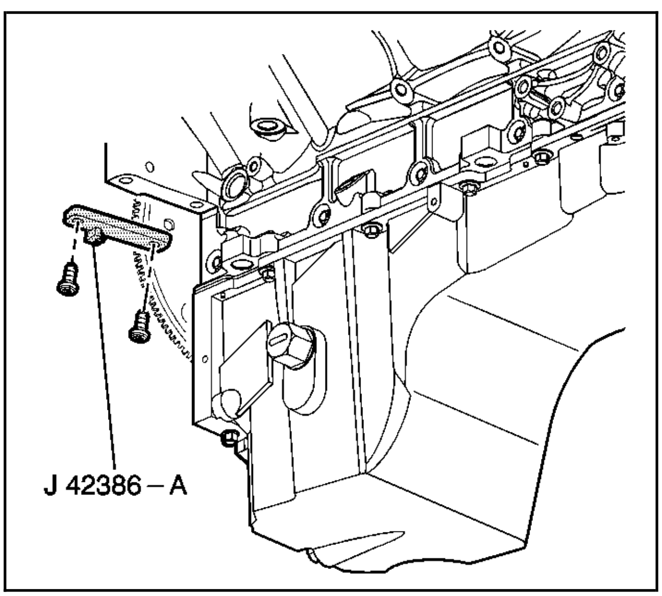
4. Install the engine flywheel bolts.

   Tighten

   4.1. Tighten the engine flywheel bolts first pass in sequence to 20 N·m (15 lb ft).

   4.2. Tighten the engine flywheel bolts second pass in sequence to 50 N·m (37 lb ft).

   4.3. Tighten the engine flywheel bolts final pass in sequence to 100 N·m (74 lb ft).



Crankshaft Balancer Installation

Tools Required

- *J 41665* Crankshaft Balancer and Sprocket Installer
- *J 42386-A* Flywheel Holding Tool
- *J 45059* Angle Meter

Important:

- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third and fourth passes tighten the new bolt to the proper torque.

- The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW crankshaft balancer bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.
- Ensure the teeth of the tool engage the engine flywheel teeth.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the *J 42386-A* and bolts.

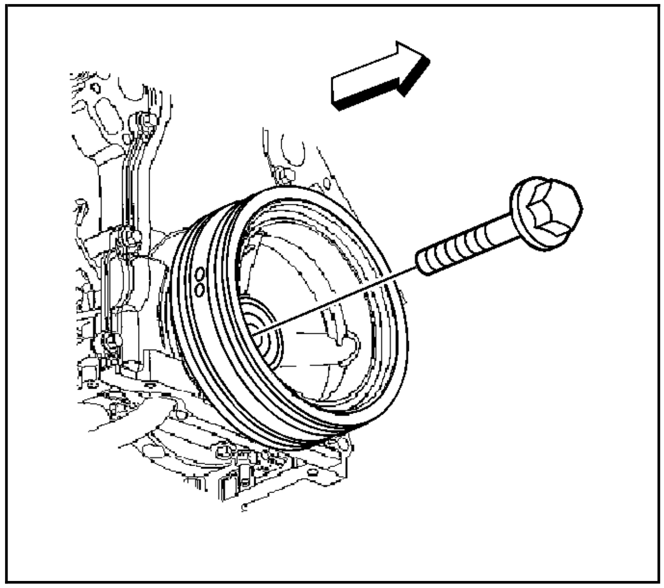
   Use one M10 – 1.5 x 120 mm and one M10 – 1.5 x 45 mm bolt for proper tool operation.

   Tighten

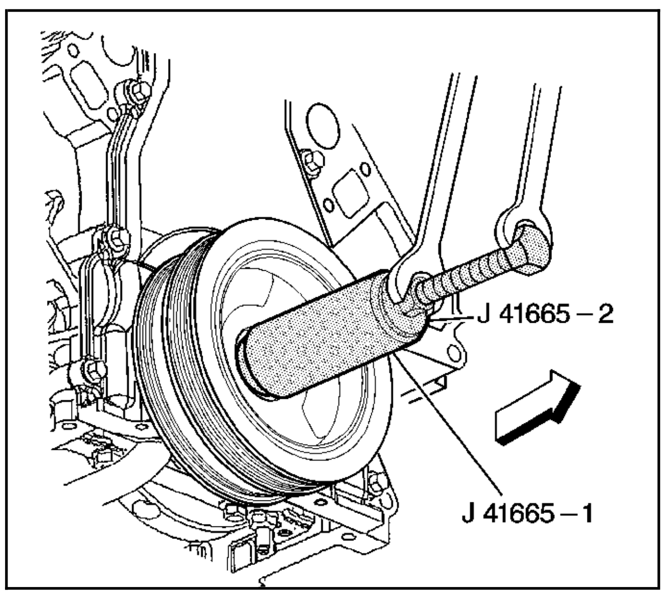
   Tighten the *J 42386-A* bolts to 50 N·m (37 lb ft).

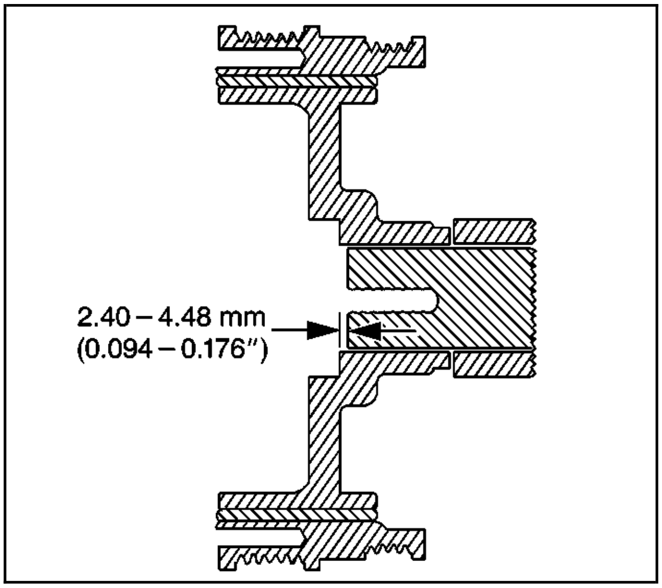
Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Install the balancer onto the end of the crankshaft.



3. Use the *J 41665* in order to install the balancer.
   3.1. Assemble the threaded rod, nut, washer and installer.
   Insert the smaller end of the installer into the front of the balancer.
   3.2. Use a wrench and hold the hex end of the threaded rod.
   3.3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto crankshaft.
   3.4. Remove the tool and reverse the installation tool.
   Position the larger end of the installer against the front of the balancer.
   3.5. Use a wrench and hold the hex end of the threaded rod.
   3.6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
   3.7. Remove the balancer installation tool.





4. Install the used crankshaft balancer bolt.

   Tighten

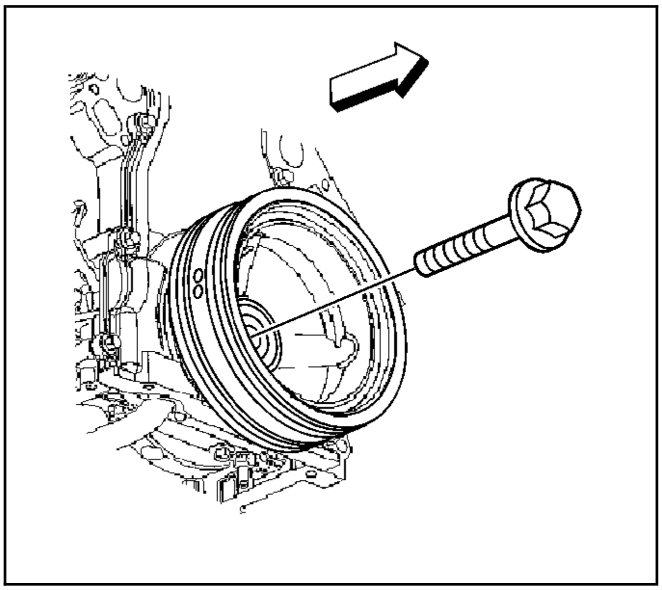
   Tighten the crankshaft balancer bolt to 330 N·m (240 lb ft).

5. Remove the used crankshaft balancer bolt.

Important: The nose of the crankshaft should be recessed 2.4–4.48 mm (0.094–0.176 in) into the balancer bore.

6. Measure for a correctly installed balancer.

   If the balancer is not installed to the proper dimensions, install the *J 41665* and repeat the installation procedure.



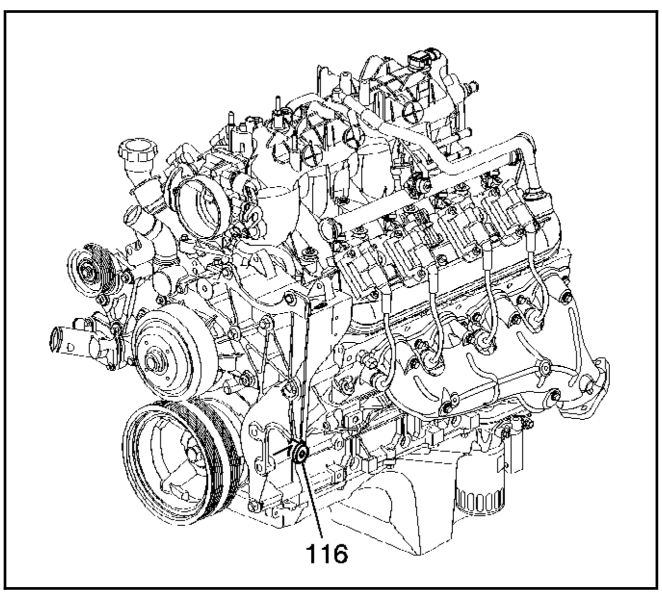
7. Install the NEW crankshaft balancer bolt.

   Tighten

   7.1. Tighten the crankshaft balancer bolt a first pass to 50 N·m (37 lb ft).

   7.2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the *J 45059*.

8. Remove the *J 42386-A*.



Engine Prelubing

Tools Required

J 45299 Engine Pre-Luber

Important: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter, fill with clean engine oil.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the oil filter.

   Tighten

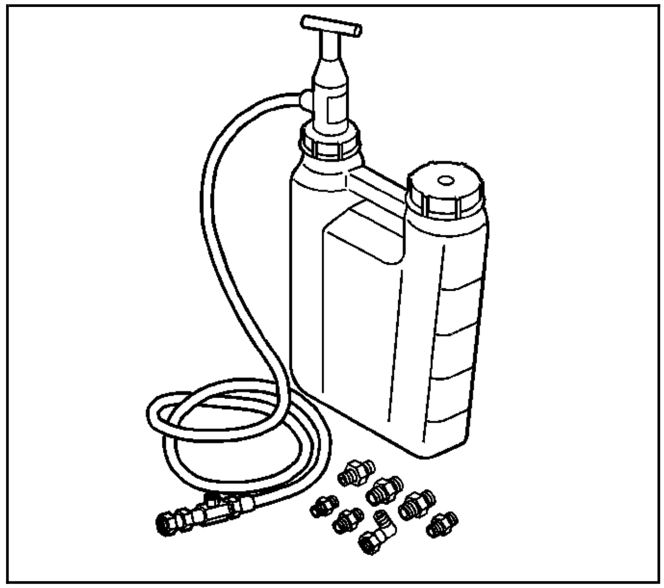
   Tighten the oil filter to 30 N·m (22 lb ft).

3. Locate the engine block left front oil gallery plug (116).

4. Install the M16 x 1.5 adapter P/N 509375.
5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the *J 45299* in order to flow a minimum of 1–1.9 liters (1–2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine.

   Tighten

   Tighten the oil gallery plug to 60 N·m (44 lb ft).
9. Top-off the engine oil to the proper level.



Description and Operation

Crankcase Ventilation System Description

A closed crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from up-stream of the throttle blade to the front of the right rocker arm cover via a formed rubber hose. To reduce the potential of oil pullover into the throttle bore area due to back flow of the ventilation system, the fitting in the right rocker arm cover is shielded from the rocker arms. From there fresh air and gases are routed through the crankcase and up to the opposite rocker arm cover where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a hose to the intake manifold.

Drive Belt System Description

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
  - The power steering pump, if belt driven
  - The generator
  - The A/C compressor, if equipped
  - The engine cooling fan, if belt driven
  - The water pump, if belt driven
  - The vacuum pump, if equipped
  - The air compressor, if equipped

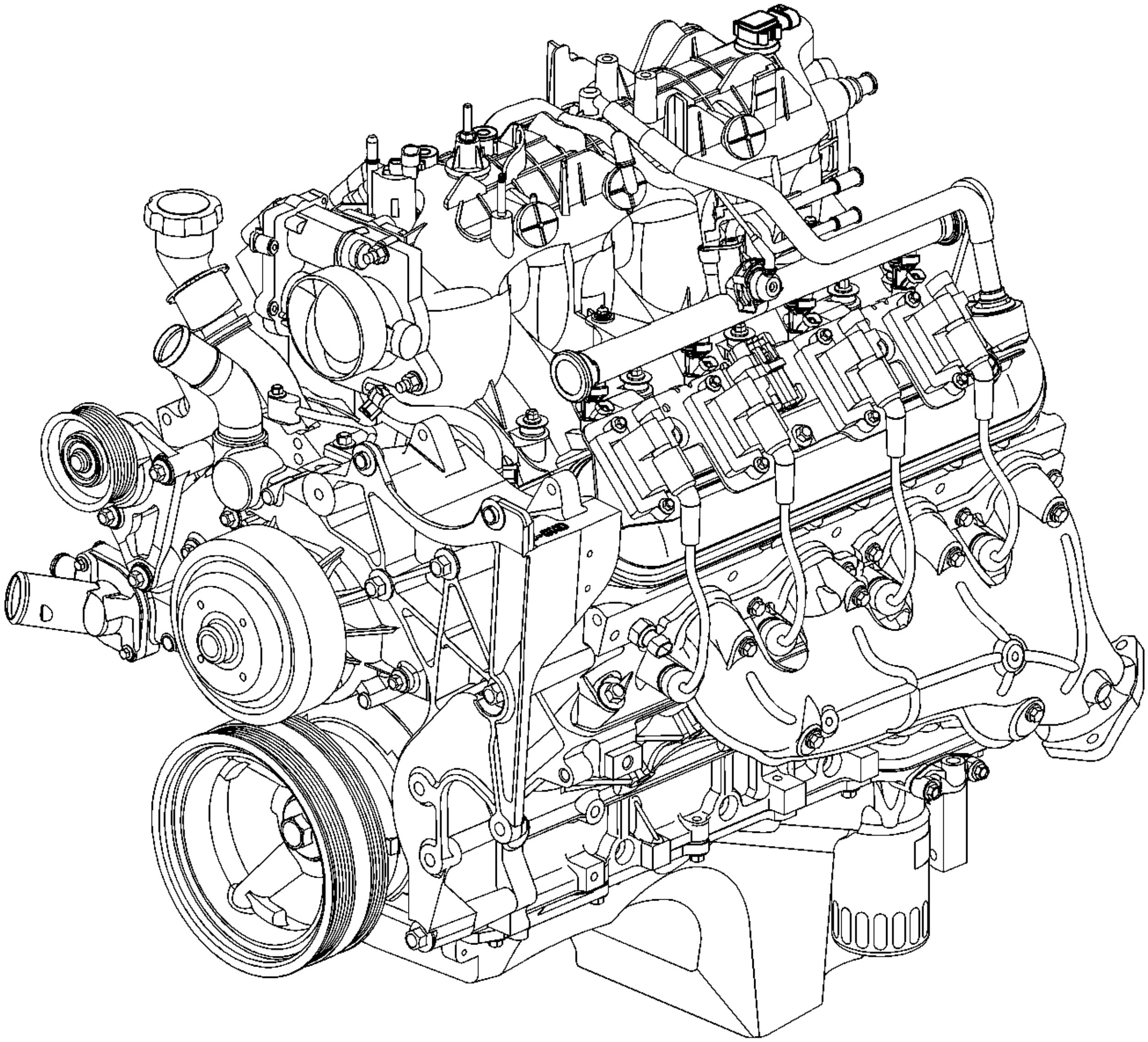
The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers — chloroprene or EPDM — and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

The 4.8, 5.3, and 6.0 Liter V8 Engines



The 4.8 and 6.0 Liter V8 engines are identified as RPO LR4 VIN V (4.8L)andRPO LQ4 VIN U (6.0L).

Camshaft and Drive System

A billet steel one piece camshaft is supported by five bearings pressed into the engine block. The camshaft has a machined camshaft sensor reluctor ring incorporated between the fourth and fifth bearing journals. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the camshaft timing chain. The splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket splines drive the oil pump driven gear. A retaining plate mounted to the front of the engine block maintains camshaft location.

Crankshaft

The crankshaft is cast nodular iron. The crankshaft is supported by five crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A crankshaft position reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately. All crankshafts will have a short rear flange, at the crankshaft rear oil seal area. Certain 4.8L manual transmissions and 6.0L applications require a spacer between the rear of the crankshaft and the flywheel for proper flywheel positioning. Longer flywheel bolts are required in applications using the spacer.

Description and Operation

Crankcase Ventilation System Description

A closed crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from up-stream of the throttle blade to the front of the right rocker arm cover via a formed rubber hose. To reduce the potential of oil pullover into the throttle bore area due to back flow of the ventilation system, the fitting in the right rocker arm cover is shielded from the rocker arms. From there fresh air and gases are routed through the crankcase and up to the opposite rocker arm cover where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a hose to the intake manifold.

Drive Belt System Description

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
  - The power steering pump, if belt driven
  - The generator
  - The A/C compressor, if equipped
  - The engine cooling fan, if belt driven
  - The water pump, if belt driven
  - The vacuum pump, if equipped
  - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers — chloroprene or EPDM — and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

Engine Component Description

- All applications use full-floating design piston pins.

Engine Mechanical Diagnostic Procedure Revisions

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Strategy Based Diagnosis* in General Information or *Diagnostic Starting Point - Engine Mechanical*

New Special Tools Required

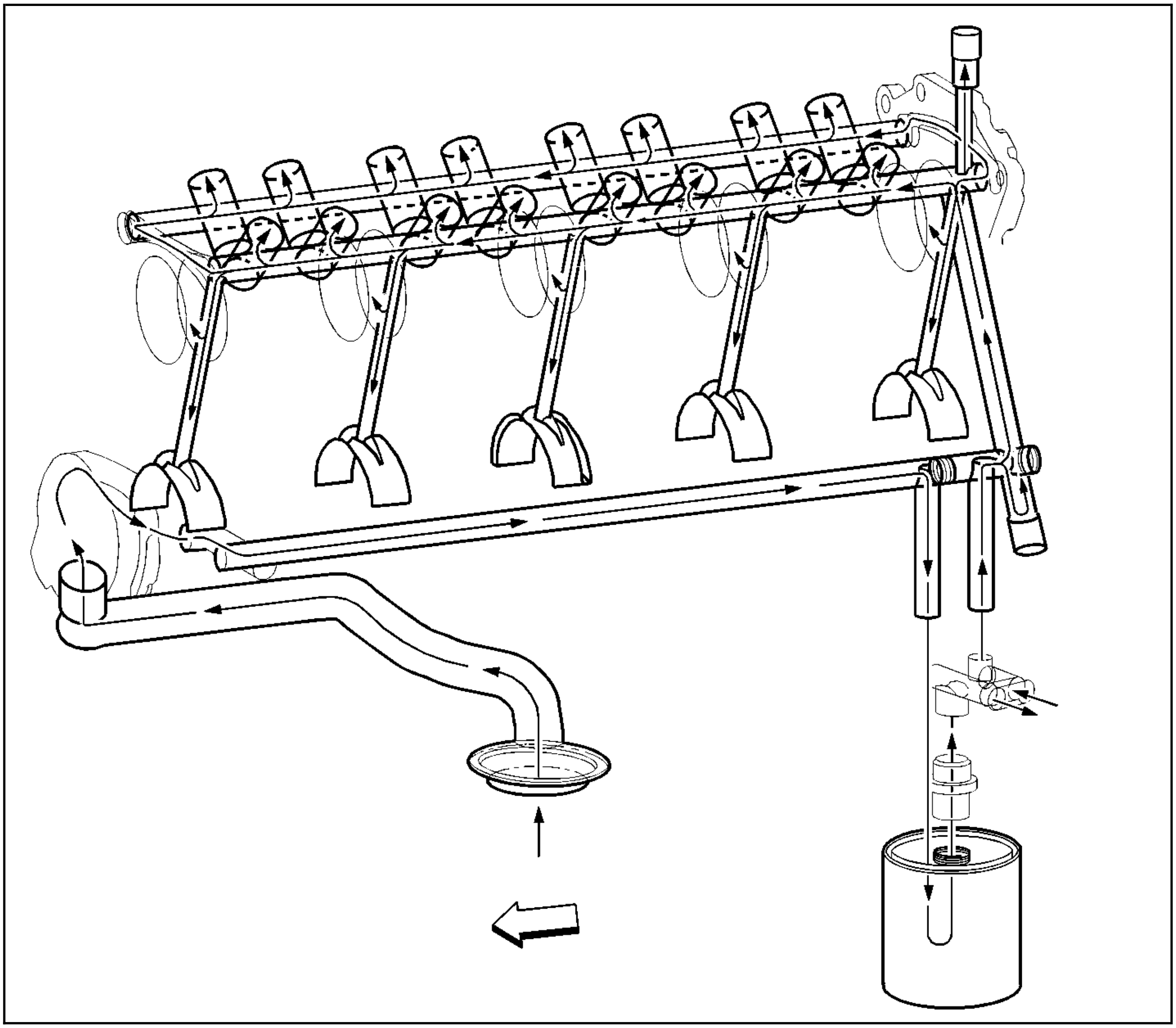
Refer to *Special Tools*.

A Component Comparison from the Previous Year

- All M11 cylinder head bolts are the same length.
- All applications use full-floating design piston pins.

Lubrication Description

Lubrication Flow Schematic



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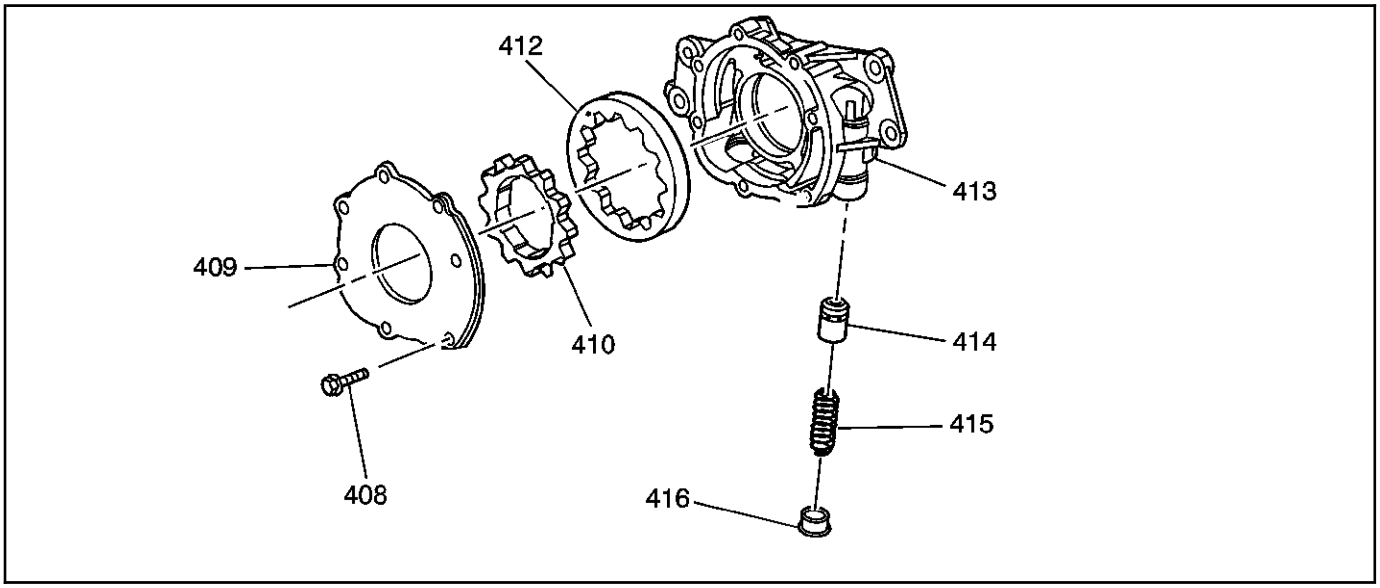
Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe.

The oil is pressurized as it passes through the pump and is sent through the engine block oil galleries. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range. Pressurized oil is directed through the lower gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan, at the oil filter boss, which will permit oil flow in the event the filter becomes restricted. At the rear of the block, oil is then directed to the upper main oil galleries which are drilled just above the camshaft assembly. From there oil is then directed to the crankshaft and camshaft bearings. Oil that has entered the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. Oil pressure and crankcase level are each monitored by individual sensors.

An external oil cooler is available on certain applications, all 6.0L. Oil is directed from the oil pump, through the lower main oil gallery to the full flow oil filter. Oil is then directed through the oil pan outlet oil gallery, located in the left rear of the oil pan, and to the external oil cooler via a hose assembly. Oil flows through the oil cooler and returns to the engine at the oil pan inlet oil gallery, located in the left rear of the oil pan. Oil is then directed to the upper main oil galleries and the remainder of the engine assembly.

Oil Pump Assembly



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Legend

- (408) Cover Bolt
- (409) Cover
- (410) Drive Gear
- (412) Driven Gear
- (413) Oil Pump
- (414) Pressure Relief Valve
- (415) Pressure Relief Valve Spring
- (416) Plug

- All applications use full-floating design piston pins.

Engine Mechanical Diagnostic Procedure Revisions

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Strategy Based Diagnosis* in General Information or *Diagnostic Starting Point*
- Engine Mechanical

New Special Tools Required

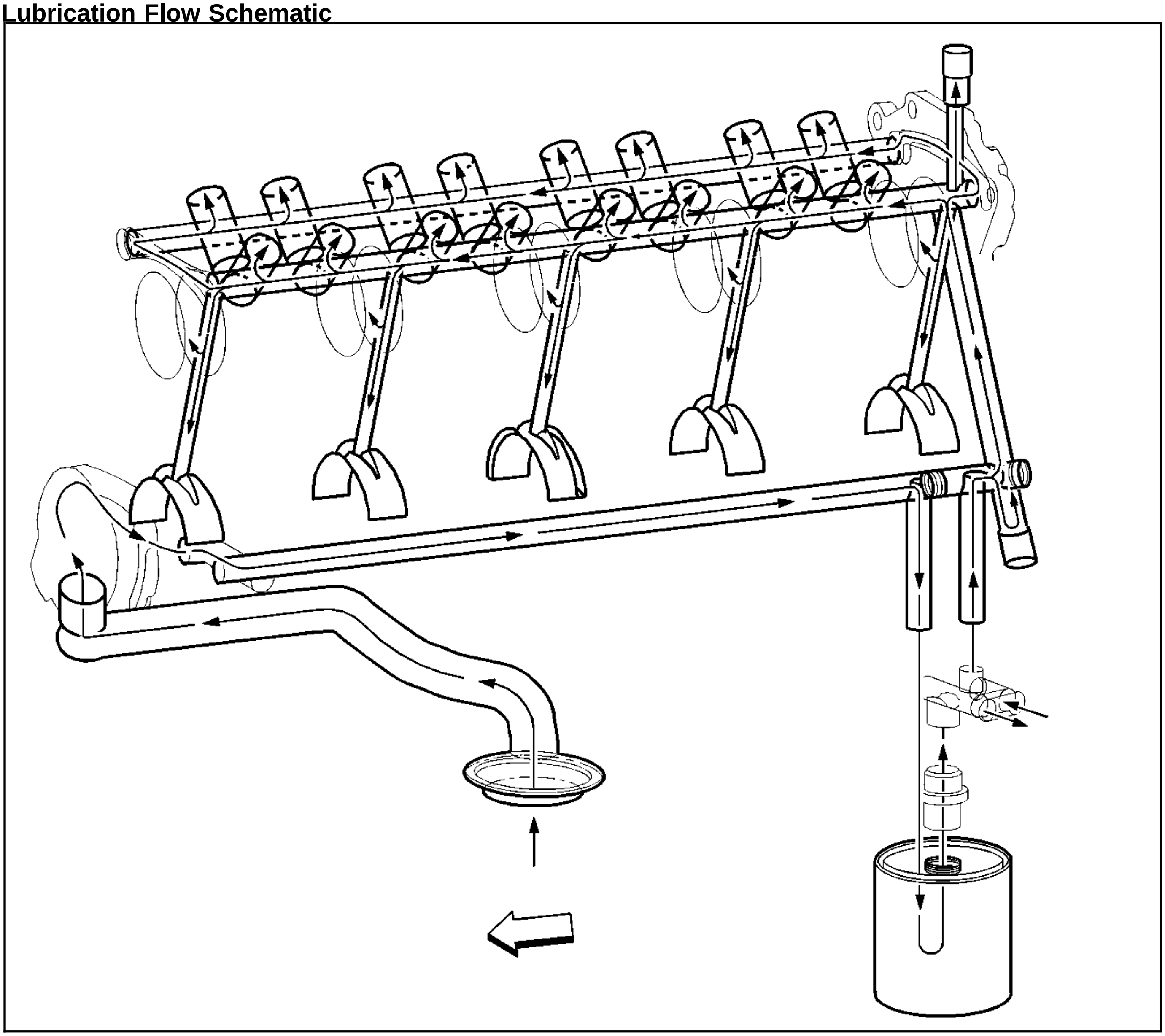
Refer to *Special Tools*.

A Component Comparison from the Previous Year

- All M11 cylinder head bolts are the same length.
- All applications use full-floating design piston pins.

Lubrication Description

Lubrication Flow Schematic



Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe.

The oil is pressurized as it passes through the pump and is sent through the engine block oil galleries. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range. Pressurized oil is directed through the

- Tighten bolts to specifications. Do not overtighten.

Use of RTV and Anaerobic Sealer

Pipe Joint Compound

Important: Three types of sealer are commonly used in engines. These are Room Temperature Vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where two non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to *Replacing Engine Gaskets*.

Notice: Refer to *Sealant Notice* in Cautions and Notices.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- RTV sealant hardens when exposed to air. This type sealer is used where two non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to *Replacing Engine Gaskets*.

Notice: Refer to *Sealant Notice* in Cautions and Notices.

- Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes.
- Assemble components while RTV is still wet, within 3 minutes. Do not wait for RTV to skin over.
- Tighten bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to *Replacing Engine Gaskets*.
- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be sealed must be clean and dry.

Notice: Refer to *Sealant Notice* in Cautions and Notices.

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

Important: Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

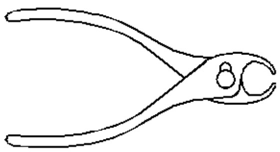
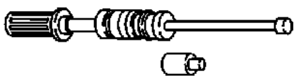
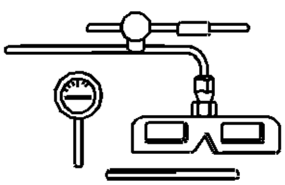
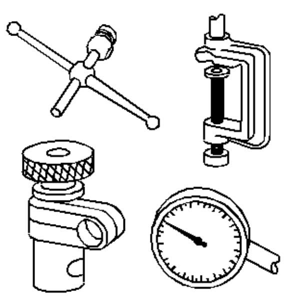
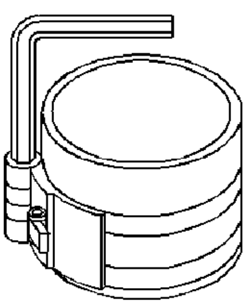
Tools and Equipment

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

Special Tools and Equipment

Illustration	Tool Number/Description
 14487	J 3049-A Valve Lifter Remover
 166875	J 6125-1B Slide Hammer
 35463	J 7872 Magnetic Base Dial Indicator Set
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Piston Ring Compressor

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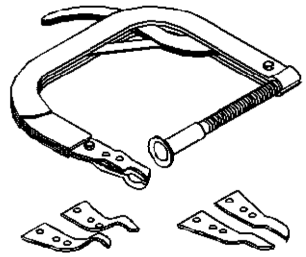
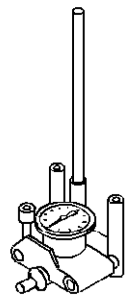
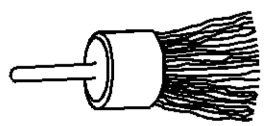
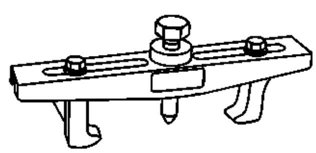
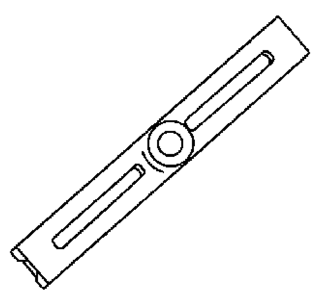
 3414	J 8062 Valve Spring Compressor – Head Off
 5110	J 8087 Cylinder Bore Gage
 4994	J 8089 Carbon Removal Brush
 216164	J 8433 Two Jaw Puller
 210221	J 8433-1 Puller Bar

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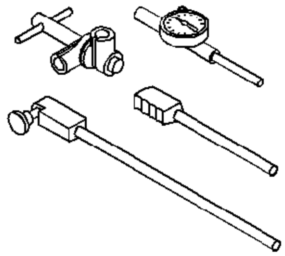
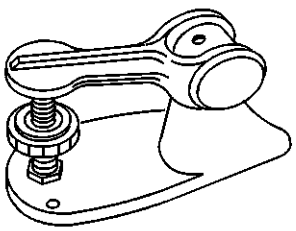
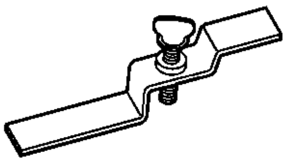
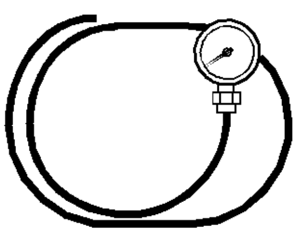
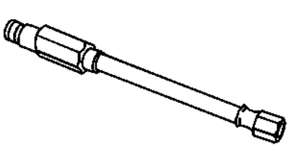
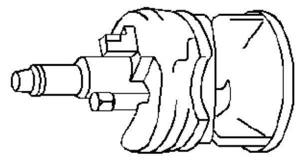
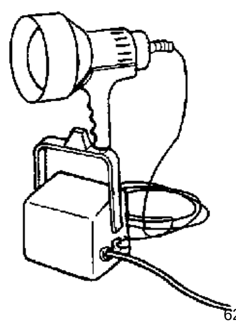
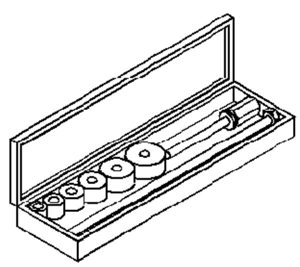
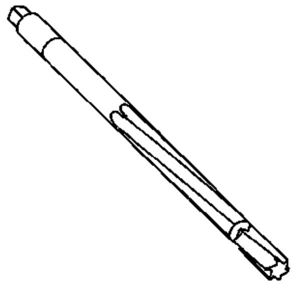
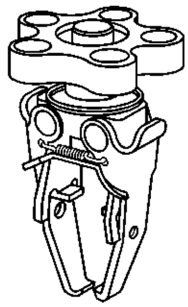
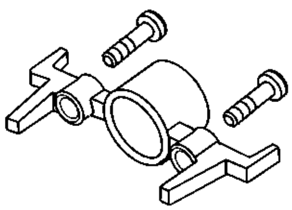
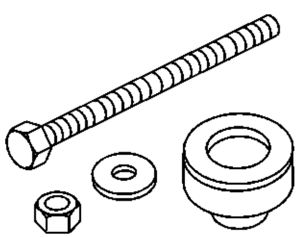
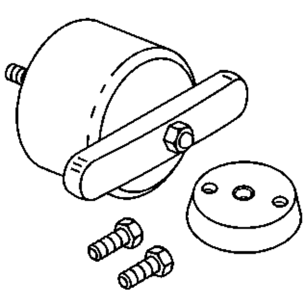
 3408	J 8520 Cam Lobe Lift Indicator
 4997	J 9666 Valve Spring Tester
 47935	J 21366 Converter Holding Strap
 29339	J 21867 Pressure Gage
 26998	J 22794 Spark Plug Port Adapter
 3412	J 24270 Cylinder Bore Ridge Reamer
 52126	J 28410 Gasket Remover
 62292	J 28428-E High-Intensity Black Light Kit
 5118	J 33049 Camshaft Bearing Service Set
 62295	J 35667-A Cylinder Head Leakdown Tester

Illustration	Tool Number/Description
 596942	J 37378-1 Valve Guide Reamer
 33658	J 38606 Valve Spring Compressor
 64207	J 41476 Front and Rear Cover Alignment Tool
 64248	J 41478 Crankshaft Front Oil Seal Installer
 64249	J 41479 Crankshaft Rear Oil Seal Installer

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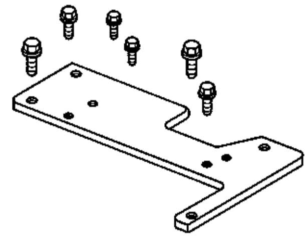
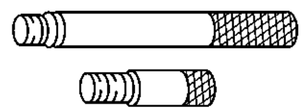
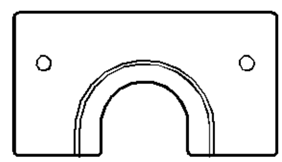
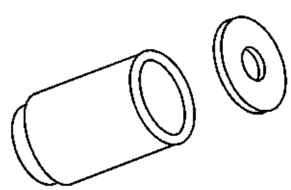
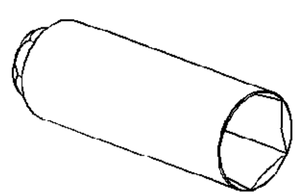
 64211	J 41480 Front and Rear Cover Alignment
 64260	J 41556 Connecting Rod Guide
 98060	J 41558 Crankshaft Sprocket Remover
 64240	J 41665 Crankshaft Balancer and Sprocket Installer
 67136	J 41712 Oil Pressure Switch Socket

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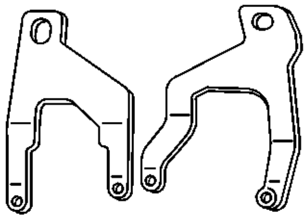
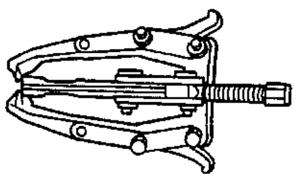
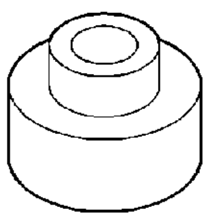
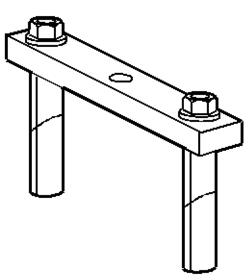
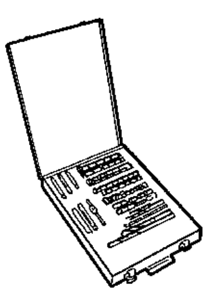
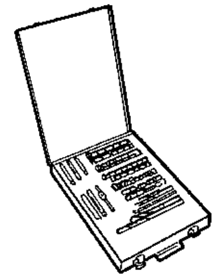
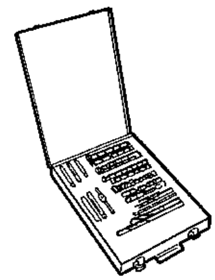
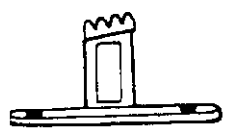
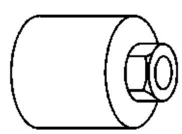
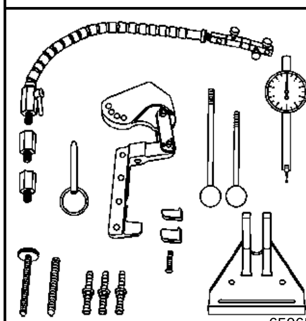
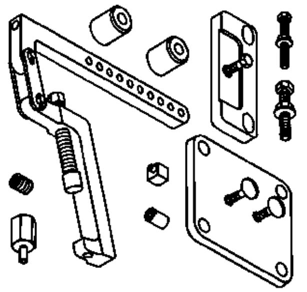
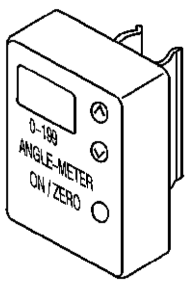
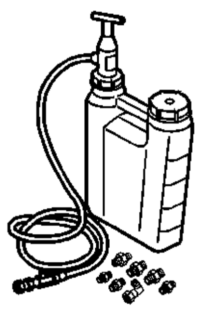
 74283	J 41798 Engine Lift Bracket
 99086	J 41816 Crankshaft Balancer Remover
 142148	J 41816-2 Crankshaft End Protector
 98072	J 41818 Crankshaft Bearing Cap Remover
 340279	J 42385-100 Head/Main Bolt Thread Repair Kit
 453049	J 42385-200 Common Thread Repair Kit
 453073	J 42385-300 Fixtures and Hardware Kit
 99089	J 42386-A Flywheel Holding Tool
 369719	J 42907 Oil Pressure Tester
 650651	J 43690 Rod Bearing Clearance Checking Tool

Illustration	Tool Number/Description
 863073	J 43690-100 Rod Bearing Checking Tool - Adapter Kit
 1197696	J 45059 Angle Meter
 852797	J 45299 Engine Preluber

Section 6

Engine 8.1L

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Engine Mechanical – 8.1L

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accessory Bracket Bolt – Left Side	50 N• m	37 lb ft
A/C Compressor Bolt	50 N• m	37 lb ft
Air Injection Pipe Bolt	25 N• m	19 lb ft
Air Injection Pipe Nut	12 N• m	106 lb in
Air Injection Pump Bolt	50 N• m	37 lb ft
Air Injection Pump Pipe Nut	12 N• m	106 lb in
Camshaft Position Sensor Bolt	12 N• m	106 lb in
Camshaft Retainer Bolt	12 N• m	106 lb in
Camshaft Sprocket Bolt	30 N• m	22 lb ft
Connecting Rod Nut	30 N• m +90 Degrees	22 lb ft +90 Degrees
Coolant Drain Hole Plug		
Left Front	60 N• m	44 lb ft
Sides	20 N• m	15 lb ft
Crankshaft Balancer Bolt	255 N• m	189 lb ft
Crankshaft Bearing Cap Bolt		
First Pass	30 N• m	22 lb ft
Final Pass	90 Degrees	
Crankshaft Bearing Cap Stud		
First Pass	30 N• m	22 lb ft
Final Pass	80 Degrees	80 Degrees
Crankshaft Oil Deflector Nut	50 N• m	37 lb ft
Crankshaft Position Sensor Bolt	12 N• m	106 lb in
Cylinder Head Bolt (In Sequence)		
First Pass	30 N• m	22 lb ft
Second Pass	30 N• m +120	22 lb ft +120 Degrees
Final Pass – Long Bolts #1, 2, 3, 6, 7, 8, 9, 10, 16,17	60 Degrees	
Final Pass – Medium Bolts #15, 18	45 Degrees	
Final Pass – Short Bolts #4, 5, 12, 13	30 Degrees	
Cylinder Head Coolant Hole Plug	23 N• m	17 lb ft
Drive Belt Tensioner Bolt	50 N• m	37 lb ft
Engine Coolant Temperature (ECT) Sensor	20 N• m	15 lb ft
Engine Coolant Temperature (ECT) Sensor	50 N• m	22 lb ft
Exhaust Manifold		
Center Bolt	35 N• m	26 lb ft
Nut	16 N•m	12 lb ft
Stud	20 N• m	15 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Exhaust Manifold Heat Shield		
Bolt	25 N·m	19 lb ft
Nut	25 N·m	19 lb ft
Flywheel Bolt		
First Pass	80 N·m	59 lb ft
Final Pass	100 N·m	74 lb ft
Flywheel Cover Bolt	12 N·m	106 lb in
Flywheel Housing		
Hex Head Bolt	67 N·m	50 lb ft
Countersunk Bolt	60 N·m	44 lb ft
Front Cover Bolt		
First Pass	6 N·m	54 lb in
Final Pass	12 N·m	106 lb in
Fuel Rail Stud	12 N·m	106 lb in
Ignition Coil Bolt	12 N·m	106 lb in
Ignition Coil Wiring Harness Bolt	12 N·m	106 lb in
Intake Manifold Bolt (In Sequence)		
First Pass	5 N·m	44 lb in
Second Pass	5 N·m	44 lb in
Third Pass	10 N·m	89 lb in
Final Pass	12 N·m	106 lb in
Knock Sensor	20 N·m	15 lb ft
Knock Sensor Heat Shield Bolt	50 N·m	37 lb ft
MAP Sensor Bolt	12 N·m	106 lb in
Oil Cooler Hose Fittings	23 N·m	17 lb ft
Oil Fill Tube Bolt	12 N·m	106 lb in
Oil Filter	38 N·m	28 lb ft
Oil Filter Fitting	66 N·m	49 lb ft
Oil Gallery Plug		
Front	30 N·m	22 lb ft
Left	30 N·m	22 lb ft
Rear	30 N·m	22 lb ft
Top	20 N·m	15 lb ft
Oil Level Indicator Tube Bracket Nut	18 N·m	13 lb ft
Oil Level Indicator Tube Bracket to Generator Bracket Bolt	12 N·m	106 lb in
Oil Level Switch	14 N·m	10 lb ft
Oil Pan Bolt		
First Pass	10 N·m	89 lb in
Final Pass	25 N·m	19 lb ft
Oil Pan Drain Plug	28 N·m	21 lb ft
Oil Pressure Gauge Sensor	30 N·m	22 lb ft
Oil Pump Bolt	75 N·m	56 lb ft
Oil Pump Cover Bolt	12 N·m	106 lb in
Oil Pump Drive Bolt	25 N·m	19 lb ft
Power Steering Pump Brace to Engine Bolt (P32)	50 N·m	37 lb ft
Power Steering Pump Bracket to Accessory Bracket Nut (P22)	65 N·m	48 lb ft
Power Steering Pump Front Bolts (P32)	50 N·m	37 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Purge Solenoid Bolt	10 N·m	89 lb in
Spark Plug	20 N·m	15 lb ft
Thermostat Housing Bolt	30 N·m	22 lb ft
Throttle Body		
Nut	10 N·m	88 lb in
Stud	12 N·m	106 lb in
Transmission Converter Bolts	12 N·m	106 lb in
Valve Lifter Guide Retainer Bolt	25 N·m	19 lb ft
Valve Rocker Arm Cover Bolt		
First Pass	6 N·m	54 lb in
Final Pass	12 N·m	106 lb in
Valve Rocker Arm Nut	25 N·m	19 lb ft
Valve Rocker Arm Stud	50 N·m	37 lb ft
Water Crossover Pipe Bolt	50 N·m	37 lb ft
Water Pump Bolt		
First Pass	25 N·m	19 lb ft
Final Pass	50 N·m	37 lb ft
Water Pump Pulley Bolt	25 N·m	19 lb ft

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	V-8	
Displacement	8.1 L	496 CID
RPO	L18	
VIN	G	
Bore	107.950 mm	4.250 in
Stroke	111.00 mm	4.370 in
Compression Ratio	9.1:1	
Firing Order	1-8-7-2-6-5-4-3	
Spark Plug Gap	1.52 mm	0.060 in
Cylinder Head		
Surface Flatness	0.050 mm	0.002 in
Maximum Cylinder Head Block Deck Resurfacing	0.3048 mm	0.012 in
Exhaust Manifold		
Surface Flatness	0.254 mm	0.010 in
Lubrication System		
Oil Capacity without Filter Change	5.7 L	6 Qts
Oil Pressure (Minimum)	34 kPa @ 1,000 RPM	5 psi @ 1,000 RPM
Oil Pressure (Maximum)	69 kPa @ 2,000 RPM	10 psi @ 2,000 RPM
Oil Filter System	Full Flow	
Oil Pump Type	Gear Driven	

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Cylinder Bore		
Diameter – Production	107.950-107.968 mm	4.2500-4.2507 in
Diameter – Service	107.940-107.990 mm	4.2496-4.2516 in
Out-of-Round Production (Maximum Minus Minimum Bore Diameter)	0.0180 mm (max.)	0.0007 in (max.)
Out-of-Round Service (Maximum Minus Minimum Bore Diameter)	0.050 mm (max.)	0.002 in (max.)
Taper Production	0.0180 mm (max.)	0.0007 in (max.)
Taper Service – Thrust Axis	0.050 mm (max.)	0.002 in (max.)
Taper Service – Pin Axis	0.050 mm (max.)	0.002 in (max.)
Engine Block (Production Specifications)		
Main Bearing Bore Diameter	74.6060-74.6220 mm	2.9372-2.9379 in
Lift Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Deck Height from Crankshaft Bore	259.875-260.125 mm	10.231-10.241 in
Head Deck Surface Flatness (entire face)	0.100mm	0.004 in
Head Deck Surface Flatness within 150 mm (6 in)	0.050mm	0.002 in
Piston		
Piston Diameter (Coated Piston)	Not Measurable	Not Measurable
Clearance Production	Interference Fit (coated piston)	Interference Fit (coated piston)
Piston Ring Compression		
Top Groove Clearance	0.031-0.074 mm	0.0012-0.0029 in
Second Groove Clearance	0.031-0.074 mm	0.0012-0.0029 in
Top Ring Production Gap	0.300-0.450 mm	0.012-0.018 in
Top Ring Service Limit Gap	0.450-0.675 mm	0.018-0.027 in
Second Ring Production Gap	0.450-0.650 mm	0.017-0.025 in
Second Ring Service Limit Gap	0.675-0.975 mm	0.026-0.039 in
Piston Ring Oil Control		
Ring Groove Clearance	0.051-0.203 mm	0.002-0.008 in
Production Gap	0.249-0.759 mm	0.0098-0.0299 in
Service Limit Gap	0.373-0.138 mm	0.015-0.045 in
Piston Pin		
Diameter	26.416-26.419 mm	1.0400-1.0401 in
Fit in Connecting Rod	0.049-0.020 mm Interference	.0019-.0007 in Interference
Crankshaft		
Crankshaft Main Journal Runout – Production	0.0380 mm (max.)	0.0015 in (max.)
Crankshaft Main Journal Runout – Service	0.0510 mm (max.)	0.0020 in (max.)
Crankshaft Journal Diameter #1, #2, #3, #4, #5	69.805-69.822 mm	2.7482-2.7489 in
Crankshaft Journal Taper Production	0.0102 mm (max.)	0.0004 in (max.)
Crankshaft Journal Out-of-Round Production	0.0102 mm (max.)	0.0004 in (max.)
Crankshaft Bearing Clearance #1, #2, #3, #4 Production	0.022-0.052 mm	0.0008-0.0020 in
Crankshaft Bearing Clearance #5 Production	0.035-0.067 mm	0.0014-0.0026 in
Crankshaft Bearing Clearance #1, #2, #3, #4 Service Limit	0.022-0.089 mm	0.0008-0.0035 in
Crankshaft Bearing Clearance #5 Service Limit	0.035-0.102 mm	0.0014-0.0040 in
Crankshaft End Play	0.127-0.279 mm	0.0050-0.0110 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Crankpin Diameter	55.854-55.870 mm	2.1990-2.1996 in
Crankpin Taper Production	0.0102 mm (max.)	0.0004 in (max.)
Crankpin Out-of-Round Production	0.0102 mm (max.)	0.0004 in (max.)
Rod Bearing Clearance Production	0.021-0.064 mm	0.0008-0.0025 in
Rod Bearing Clearance Service Limit	0.021-0.081 mm	0.0008-0.0032 in
Connecting Rod Side Clearance	0.384-0.686 mm	0.0151-0.0270 in
Camshaft		
Camshaft Runout Production	0.051 mm (max.)	0.002 in (max.)
Camshaft Runout Service	0.076 mm	0.003 in
Lobe Lift Intake	6.924-7.026 mm	0.2726-0.2766 in
Lobe Lift Exhaust	6.973-7.075 mm	0.2745-0.2785 in
Journal Diameter	49.4720-49.5220 mm	1.9477-1.9497 in
Camshaft Bearing Inside Diameter	49.4580-49.5730 mm	1.9507-1.9517 in
Valve System		
Lifter	Hydraulic, Roller Followers	
Rocker Arm Ratio	1.70:1	
Valve Lash Intake	Net Lash	
Valve Lash Exhaust	Net Lash	
Face Angle (Intake/Exhaust)	45 Degrees	
Seat Angle (Intake/Exhaust)	46 Degrees	
Seat Runout (Intake/Exhaust)	0.0500 mm (max.)	0.002 in (max.)
Seat Width Intake	0.800-1.200 mm	0.030-0.060 in
Seat Width Exhaust	1.651-2.159 mm	0.060-0.095 in
Stem Clearance Production Intake	0.025-0.074 mm	0.0010-0.0029 in
Stem Clearance Production Exhaust	0.030-0.079 mm	0.0012-0.0031 in
Stem Clearance Service Intake	0.025-0.088 mm	0.0010-0.0034 in
Stem Clearance Service Exhaust	0.030-0.091 mm	0.0012-0.0036 in
Valve Spring Pressure Closed	381-419 N @ 45.923 mm	86-94 lb @ 1.808 in
Valve Spring Pressure Open	962-1058 N @ 33.985 mm	216-236 lb @ 1.338 in
Valve Spring Installed Height	45.923-46.685 mm	1.808-1.838 in
Valve Spring Free Length	56.35 mm	2.218 in
Valve Head Diameter – Intake	55.63 mm	2.19 in
Valve Head Diameter – Exhaust	43.69 mm	1.72 in
Valve Stem Diameter – Intake	9.436-9.454 mm	0.3715-0.3722 in
Valve Stem Diameter – Exhaust	9.431-9.449 mm	0.3713-0.3720 in
Maximum Valve Spring Installed Height Shim (Service Only)	0.726 mm	0.030 in
Maximum Valve Spring Tension Shim (Service Only)	0.726 mm	0.030 in
Maximum Combined Valve Spring Installed Height and Valve Spring Tension Shim (Service Only – Shim Placed Under Valve Rotator Only)	1.524 mm	0.060 in

Service Parts Group Numbers

Application	Service Parts Group Number
Camshaft	0.519
Camshaft Sprocket	0.736
Camshaft Timing Chain	0.724
Crankshaft	0.646
Crankshaft Bearing Kit	0.096
Crankshaft Sprocket	0.728
Connecting Rod and Piston Assembly	0.629
Cylinder Head	0.269
Cylinder Head Gasket Kit	0.289
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.270
Engine Front Cover	0.206
Engine Front Cover Gasket	0.207
Intake Manifold (with Gasket)	3.265
Oil Filter	1.836
Oil Level Indicator	1.516
Oil Pan	1.426
Oil Pan Gasket	1.429
Oil Pump Cover	1.723
Oil Pump	1.652
Piston Ring Kit	0.643
Spark Plug	2.270
Valve Lifter	0.459
Themostat	1.246
Valve Pushrod	0.426
Valve Rocker Arm	0.333
Valve Rocker Arm Cover Gasket Kit	0.423
Water Pump Kit	1.069

Sealers, Adhesives, and Lubricants

Application	Type of Material	Part Number
Block Heater Threads	Sealant	12346004
Camshaft Rear Bearing Hole Plug	Sealant	12377901
Coolant Sensor (ETC) Threads	Sealant	12346004
Crankshaft Position Sensor Bolt	Thread Adhesive	12345493
Crankshaft Rear Bearing Cap	Sealant	1052942
Cylinder Head Bolt Threads	Sealant	12346004
Engine Block Coolant Drain Plugs	Sealant	12346004
Engine Block Oil Gallery Plugs	Sealant	12346004
Engine Front Cover	Sealant	12346286
Engine Oil Supplement	Lubricant	1051396
Intake Manifold Bolt Threads	Thread Adhesive	12345382
Knock Sensor Threads	Sealant	12346004
MAP Sensor Seal	Lubricant	9985770
Oil Cooler Hose Fittings	Sealant	12346004
Oil Pan Corners	Sealant	12346286
Oil Pressure Sensor Threads	Sealant	12346004
Purge Solenoid Bolt	Thread Adhesive	12345493
Valve Train Component Prelube	Lubricant	1052367
Water Pump Thread Bolts	Sealant	12346004

Diagnostic Information and Procedures

Diagnostic Starting Point – Engine Mechanical

Begin the system diagnosis by reviewing the Disassembled Views, Engine Component Description, Lubrication Description, and the Drive Belt System Description. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to *Symptoms – Engine Mechanical* in this supplement in order to identify the correct procedure for diagnosing the system and where the procedure is located.

Symptoms – Engine Mechanical

Strategy Based Diagnostics

1. Perform a Diagnostic Starting Point – Engine Controls before using the symptom tables (if applicable). Refer to *Diagnostic Starting Point – Engine Controls* in this supplement.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to *Disassembled Views, Engine Component Description, Drive Belt System Description, and Lubrication Description* in this supplement.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Strategy Based Diagnosis* in General Information in the WCC Service Manual.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds (if applicable) to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank – Crankshaft Will Not Rotate
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Crankcase Ventilation System Inspection/Description
- Drive Belt Chirping Diagnosis
- Drive Belt Squeal Diagnosis
- Drive Belt Whine Diagnosis
- Drive Belt Rumbling Diagnosis
- Drive Belt Vibration Diagnosis
- Drive Belt Falls Off Diagnosis
- Drive Belt Excessive Wear Diagnosis
- Drive Belt Tension Diagnosis

Base Engine Misfire without Internal Lower Engine Noises

Cause	Correction
Abnormalities (severe cracking, bumps, or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition).	Replace the drive belt. Refer to *Drive Belt Replacement* in this supplement.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout (A misfire code may be present without an actual misfire condition.)	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual misfire condition.)	Repair or replace the flywheel and/or balancer as required. Refer to *Engine Flywheel Replacement* or *Crankshaft Balancer Replacement* in this supplement.
Restricted exhaust system (A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters).	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads and/or throttle body as required.
Improperly installed or damaged MAP sensor (The sealing grommet of the MAP sensor should not be torn or damaged.)	Repair or replace the MAP sensor as required.
Worn or loose rocker arms	Replace the valve rocker arms as required.
Worn or bent push rods	Replace the push rods.
Sticking valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure (A lubrication system with excessive oil pressure may lead to excessivevalve lifter pump-up and loss of compression.)	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing* in this supplement. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Perform a pressure test to the cooling system. Refer to *Cooling System Leak Testing* in Engine Cooling in the WCC Service Manual. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn piston rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test* in this supplement. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.

Base Engine Misfire without Internal Lower Engine Noises (cont'd)

Cause	Correction
A damaged crankshaft reluctor wheel (A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.) • Systems with electronic communications (DIS or coil per cylinder) and SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.) • Systems with electronic communication (DIS or coil per cylinder) and SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set. • Systems with mechanical communications (high voltage switch) and SEVERE reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft reluctor wheel as required.

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.)	Replace the drive belt. Refer to *Drive Belt Replacement* in this supplement.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout (A misfire code may be present without an actual misfire condition.)	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual misfire condition.)	Repair or replace the flywheel and/or balancer as required. Refer to *Engine Flywheel Replacement* or *Crankshaft Balancer Replacement* in this supplement.
Worn piston rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test* in this supplement. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn Crankshaft Thrust Bearings (Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.)	• Check the crankshaft endplay. • Replace the crankshaft and/or bearings as required.

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms	Replace the valve rocker arms as required.
Worn or bent push rods	Replace the push rods.
Sticking valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Perform a pressure test to the cooling system. Refer to *Cooling System Leak Testing* in Engine Cooling in the WCC Service Manual. • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Repair or replace as required.
Worn piston rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to *Spark Plug Visual Diagnosis* in Engine Electrical in the WCC Service Manual. • Inspect the cylinders for a loss of compression. Refer to *Engine Compression Test* in this supplement. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train (upper engine) concern, or a low rumble/knocking may indicate a crankshaft or piston (lower engine) concern.	
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	• Drain the oil. • Install the correct viscosity oil.
High valve lifter leak down rate	Replace the valve lifters as required.
Worn crankshaft thrust bearing	• Check the crankshaft endplay. • Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train (upper engine) concern.	
Plugged oil filter	Replace the oil filter.
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing* in this supplement. • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm stud, nut or bolt. • Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Bent or damaged push rod	Inspect the following components, and replace as required: • The valve rocker arm • The valve push rod • The valve lifter
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn and/or damaged valve rotators	Replace the valve rotators as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves (Carbon on the valve stem or valve seat may cause the valve to stick.)	Inspect the following components, and repair as required: • Use GM Top Engine Cleaner, P/N 12346535, to eliminate carbon deposits (Follow manufacturer's instructions) • The valves • The valve guides

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A low rumble/knocking may indicate a crankshaft or piston (lower engine) concern.	
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing* in this supplement. • Repair or replace damaged components as required.
Worn accessory drive components (Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.)	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to *Engine Controls – 8.1L* in this supplement.
Loose torque converter bolts (automatic transmission only)	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen (An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.)	• Inspect the oil pan. • Inspect the oil pump screen. • Repair or replace as required.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation (Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.)	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

Engine Noise Under Load

Cause	Correction
Important: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A low rumble/knocking may indicate a crankshaft or piston (lower engine) concern.	
Low oil pressure	• Perform an oil pressure test. Refer to *Oil Pressure Diagnosis and Testing* in this supplement. • Repair or replace damaged components as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to *Engine Controls – 8.1L* in this supplement.
Loose torque converter bolts or improperly installed torque converter (automatic transmission only)	• Inspect the torque converter bolts and flywheel. • Verify correct installation of the torque converter. • Repair as required.
Cracked flywheel (automatic transmission)	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

Engine Will Not Crank – Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belt(s). 2 Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain	• Inspect timing chain and gears. • Repair as required.
Seized timing chain or timing gears	• Inspect timing chain and gears for foreign material. • Repair as required.
Seized camshaft	• Inspect camshaft and camshaft bearings. • Repair as required.
Bent valve in cylinder head	• Inspect valves and cylinder heads. • Repair as required.
Hydraulically locked cylinder: • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for a sticking fuel injector. 3. Inspect for broken head gasket(s). 4. Inspect for cracked engine block or cylinder head.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Material in cylinder: • Broken valve • Piston material • Foreign material	• Inspect cylinder for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

Diagnostic Information and Procedures

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of more than 0.95 liter (1 quart) of engine oil within 100 gallons of fuel used. However, during initial engine break-in periods 5 000-6 500 kilometers (3,000-4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or more per 100 gallons of fuel used. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the vehicle on a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components.
- Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
- Piston improperly installed or miss-fitted.

Oil Pressure Diagnosis and Testing

1. With the vehicle on a level surface, allow adequate drain down time (2-3 minutes) and measure for a low engine oil level.
   Add the recommended grade engine oil GM P/N 12345610 or equivalent, and fill the crankcase until the oil level measures FULL on the oil level indicator.
2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gauge or oil indicator light.
   Listen for a noisy valve train or knocking noise.
3. Inspect for the following:
   - Engine oil diluted by moisture or unburned fuel mixtures
   - Improper engine oil viscosity for the expected temperature
   - Incorrect or faulty oil pressure gauge sensor
   - Incorrect or faulty oil pressure gauge
   - Plugged oil filter
   - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gauge sensor or another engine block oil gallery plug.
5. Install an oil pressure gauge and measure the engine oil pressure.
6. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
   - Oil pump worn or dirty
   - Malfunctioning oil pump pressure relief valve
   - Oil pump screen loose, plugged, or damaged
   - Excessive bearing clearance
   - Cracked, porous or restricted oil galleries
   - Engine block oil gallery plugs missing or incorrectly installed
   - Broken valve lifters

Oil Leak Diagnosis

Step	Action	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait (15 minutes). 4. Check for drippings. Are drippings present?	Go to *Step 2*	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 3*
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 4*
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait (15 minutes). 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 5*
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 6*
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 7*

Oil Leak Diagnosis (cont'd)

Step	Action	Yes	No
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 8*
8	Use *J 28428-E* High Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	Go to *Step 9*
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to *Step 10*	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to *Step 11*	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to *Step 1*	System OK

Crankcase Ventilation System Inspection/Description

A crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. The air cleaner supplies fresh air through a filter to the crankcase. The crankcase mixes the fresh air with blow-by gases. This mixture then passes through a pipe located in the intake manifold.

The crankcase ventilation system has no serviceable components so no maintenance of the system is required.

Drive Belt Chirping Diagnosis

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt(s) or the pulley(s). It may be necessary to spray a small amount of water onto the drive belt(s) in order to duplicate the customer's concern. If spraying water onto the drive belt(s) duplicates the symptom, cleaning the belt pulleys may be the probable solution.

A loose or improper installation of a body component, suspension component, or other items on the vehicle may also cause the chirping noise.

Test Description

The number(s) below refer to the step(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period, will verify if the noise is related to the drive belt. When removing the drive belt(s) the water pump may not be operating and the engine may overheat. Also (DTCs) may set when the engine is operating with the drive belt removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it may be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.
12. Inspection of the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • It usually occurs on cold damp mornings and will subside once the vehicle reaches normal operating temperature.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to *Step 3*	Go to *Diagnostic Aids* in this supplement
3	1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to *Engine Noise Diagnosis* in this supplement	Go to *Step 4*
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Do the belt grooves have pilling?	Go to *Step 5*	Go to *Step 6*
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to *Step 15*	Go to *Step 6*
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to *Step 7*	Go to *Step 8*
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to *Step 15*	Go to *Step 8*
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to *Step 9*	Go to *Step 10*
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to *Step 15*	Go to *Step 10*
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to *Step 11*	Go to *Step 12*
11	Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to *Fastener Tightening Specifications* in this supplement. Did you complete the repair?	Go to *Step 15*	Go to *Step 12*

Drive Belt Chirping Diagnosis (cont'd)

Step	Action	Yes	No
12	Inspect for a bent pulley. Did you find the condition?	Go to *Step 13*	Go to *Step 14*
13	Replace the bent pulley. Did you complete the repair?	Go to *Step 15*	Go to *Step 14*
14	Replace the drive belt. Refer to *Drive Belt Replacement* in this supplement. Did you complete the repair?	Go to *Step 15*	Go to *Diagnostic Aids* in this supplement
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Squeal Diagnosis

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items on the vehicle may cause the squeal noise.

If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operating to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.

Test Description

The number(s) below refer to the step(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify if the squeal noise is the drive belt(s) or an accessory drive component. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. This test is to verify that an accessory drive component does not have a seized bearing. With the belt removed, test the bearings in the accessory drive components for smooth operation. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components is operate properly.
5. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
6. This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
7. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper removal and installation procedure for that pulley.
8. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle, compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt (this is unusual for a drive belt with multiple ribs). • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement, snapping the throttle, slipping on a seized pulley, or a faulty accessory drive component.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to *Step 3*	Go to *Diagnostic Aids* in this supplement
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to *Engine Noise Diagnosis* in this supplement	Go to *Step 4*
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 5*
5	Test the drive belt tensioner for proper operation. Refer to *Drive Belt Tensioner Diagnosis* in this supplement. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 6*
6	Inspect for the correct drive belt length. Refer to *Drive Belt Replacement* in this supplement. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 7*
7	Inspect for a misaligned pulley. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 8*
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to *Step 9*	Go to *Diagnostic Aids* in this supplement
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Whine Diagnosis

Diagnostic Aids

The drive belt(s) will not cause the whine noise. If the whine noise is intermittent, verify the accessory drive components by varying their loads, making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test is to verify that the noise is being caused by the drive belt(s) or the accessory drive components. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt(s) may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to *Step 3*	Go to *Diagnostic Aids* in this supplement
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to *Engine Noise Diagnosis* in this supplement	Go to *Step 4*
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to *Step 5*	Go to *Diagnostic Aids* in this supplement
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	—

Drive Belt Rumbling Diagnosis

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make a rumbling noise.

The drive belt(s) may have a condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If after replacing the drive belt(s), completing the diagnostic table, and the noise is only heard when the drive belt(s) is installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that the drive belt(s) is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. Inspecting the drive belt(s) is to ensure that it is not causing a noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.
5. Small amounts of pilling is a normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: – Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove. – The separation of the drive belt. – A damaged drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to *Step 3*	Go to *Diagnostic Aids* in this supplement
3	1. Remove the drive belt(s). Refer to *Drive Belt Replacement* in this supplement. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to *Engine Noise Diagnosis* in this supplement	Go to *Step 5*
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to *Step 7*	Go to *Step 5*
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to *Step 6*	Go to *Step 7*
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to *Drive Belt Replacement* in this supplement. Did you complete the repair?	Go to *Step 8*	Go to *Step 7*
7	Install a new drive belt. Refer to *Drive Belt Replacement* in this supplement. Did you complete the replacement?	Go to *Step 8*	—
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Diagnostic Aids* in this supplement

Drive Belt Vibration Diagnosis

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as but not limited to the A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
3. This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. The drive belt(s) may cause a vibration. While the drive belt(s) is removed this is the best time to inspect the condition of the belt.
6. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.
8. This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.
9. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known, good water pump.
10. Accessory drive component brackets that are bent, cracked, or loose may put an extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to *Step 3*	Go to *Diagnostic Aids* in this supplement
3	1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to *Engine Noise Diagnosis* in this supplement	Go to *Step 4*
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs? Did you find any of these conditions?	Go to *Step 5*	Go to *Step 6*
5	Install a new drive belt. Refer to *Drive Belt Replacement* in this supplement. Did you complete the replacement?	Go to *Step 11*	—
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to *Step 7*	Go to *Step 8*
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to *Fastener Tightening Specifications* in this supplement. Did you complete the repair?	Go to *Step 11*	—
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to *Fan Replacement (8.1L)* in this supplement. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 9*
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to *Water Pump Replacement (8.1L)* in this supplement. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 10*
10	Inspect for bent or cracked brackets. Did you correct the condition?	Go to *Step 11*	Go to *Diagnostic Aids* in this supplement
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Falls Off Diagnosis

Diagnostic Aids

If the drive belt(s) repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify that the accessory drive components are operating properly.

If the drive belt(s) is the incorrect length, the drive belt tensioner may not maintain the proper tension on the drive belt.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may have occurred to the drive belt when the drive belt fell off the pulley. The drive belt may have been damaged, which caused the drive belt to fall off. Inspect the drive belt for cuts, tears, sections of ribs missing, or damaged belt plys.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that

accessory drive component for the proper removal and installation procedure of that pulley.

5. Inspection of the pulley(s) should include inspecting for a bends, dents, or other damage that would prevent the drive belt from seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the drive belt is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
7. Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed. Missing, loose, or incorrect fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Inspect for a damaged drive belt. Did you find the condition?	Go to *Step 3*	Go to *Step 4*
3	Install a new drive belt. Refer to *Drive Belt Replacement* in this supplement. Does the drive belt continue to fall off?	Go to *Step 4*	System OK
4	Inspect for misaligned pulleys. Refer to *Drive Belt Idler Pulley Replacement* in this supplement. Did you find and repair the condition?	Go to *Step 12*	Go to *Step 5*
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to *Step 12*	Go to *Step 6*
6	Inspect for a bent or cracked bracket. Did you find and repair the condition?	Go to *Step 12*	Go to *Step 7*
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to *Step 8*	Go to *Step 9*
8	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to *Fastener Tightening Specifications* in this supplement. Does the drive belt continue to fall off?	Go to *Step 9*	System OK
9	Test the drive belt tensioner for correct operation. Refer to *Drive Belt Tensioner Diagnosis* in this supplement. Does the drive belt tensioner operate properly?	Go to *Step 11*	Go to *Step 10*
10	Replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement. Does the drive belt continue to fall off?	Go to *Step 11*	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	System OK	Go to *Diagnostic Aids* in this supplement
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 2*

Drive Belt Excessive Wear Diagnosis

Diagnostic Aids

Excessive wear on a drive belt(s) is usually caused by incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt(s) to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt(s) fall off.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The inspection is to verify the drive belt(s) is correctly installed on all of the drive belt pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt by one groove on a pulley.
3. The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on the pulleys.
4. This inspection is to verify the drive belt is not contacting any part of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt(s) should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices in this supplement. DEFINITION: Wear at the outside ribs of the drive belt due to incorrect installation of the drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms – Engine Mechanical* in this supplement
2	Inspect the drive belt for proper installation. Refer to *Drive Belt Replacement* in this supplement. Did you find the condition?	Go to *Step 5*	Go to *Step 3*
3	Inspect for the proper drive belt. Did you find this condition?	Go to *Step 5*	Go to *Step 4*
4	Inspect for the drive belt for signs of rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to *Step 6*	Go to *Diagnostic Aids* in this supplement
5	Replace the drive belt. Refer to *Drive Belt Replacement* in this supplement. Did you complete the replacement?	Go to *Step 6*	—
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	—

Drive Belt Tensioner Diagnosis

Inspection Procedure

Notice: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the drive belt tensioner through it's full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
4. If any binding is observed, replace the tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement.
5. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.

Engine Compression Test

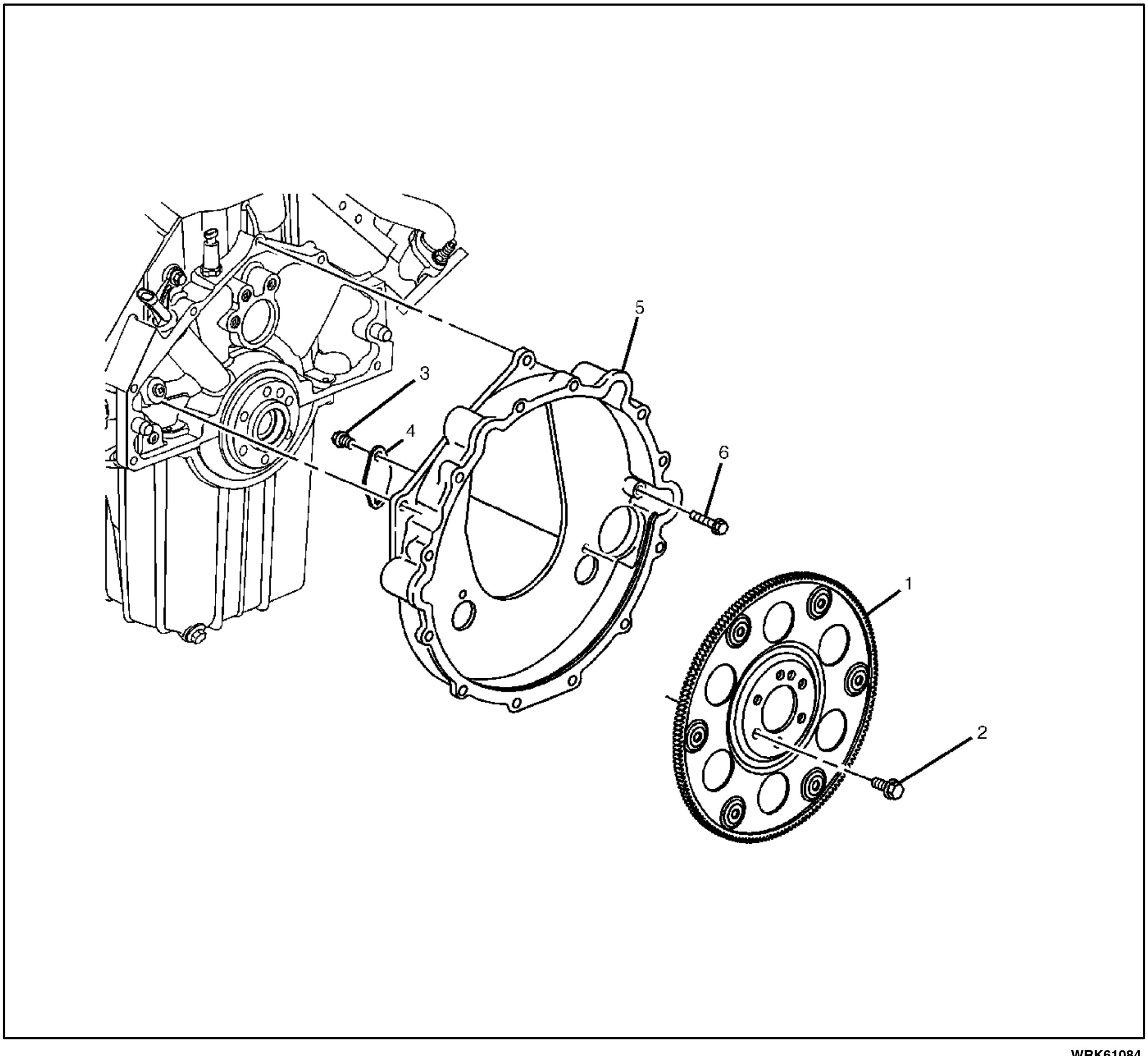
1. Disconnect the ignition coil wire harness connector at the front of the engine on the left cylinder bank and at the rear of the engine at the right cylinder bank.
2. Disconnect the fuel injector electrical harness connector at the rear of the intake manifold.
3. Remove all the spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery if the battery is not fully charged.
6. Start with the compression gauge at zero. Then crank the engine through four compression strokes (four puffs).
7. Make the compression check the same for each cylinder. Record the reading.

   The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1035 x 70% = 725) (150 x 70% = 105).
8. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
   - Normal – Compression builds up quickly and evenly to the specified compression for each cylinder.
   - Piston Rings Leaking – Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.
   - Valves Leaking – Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
   - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the two cylinders.

Component Locator

Disassembled Views

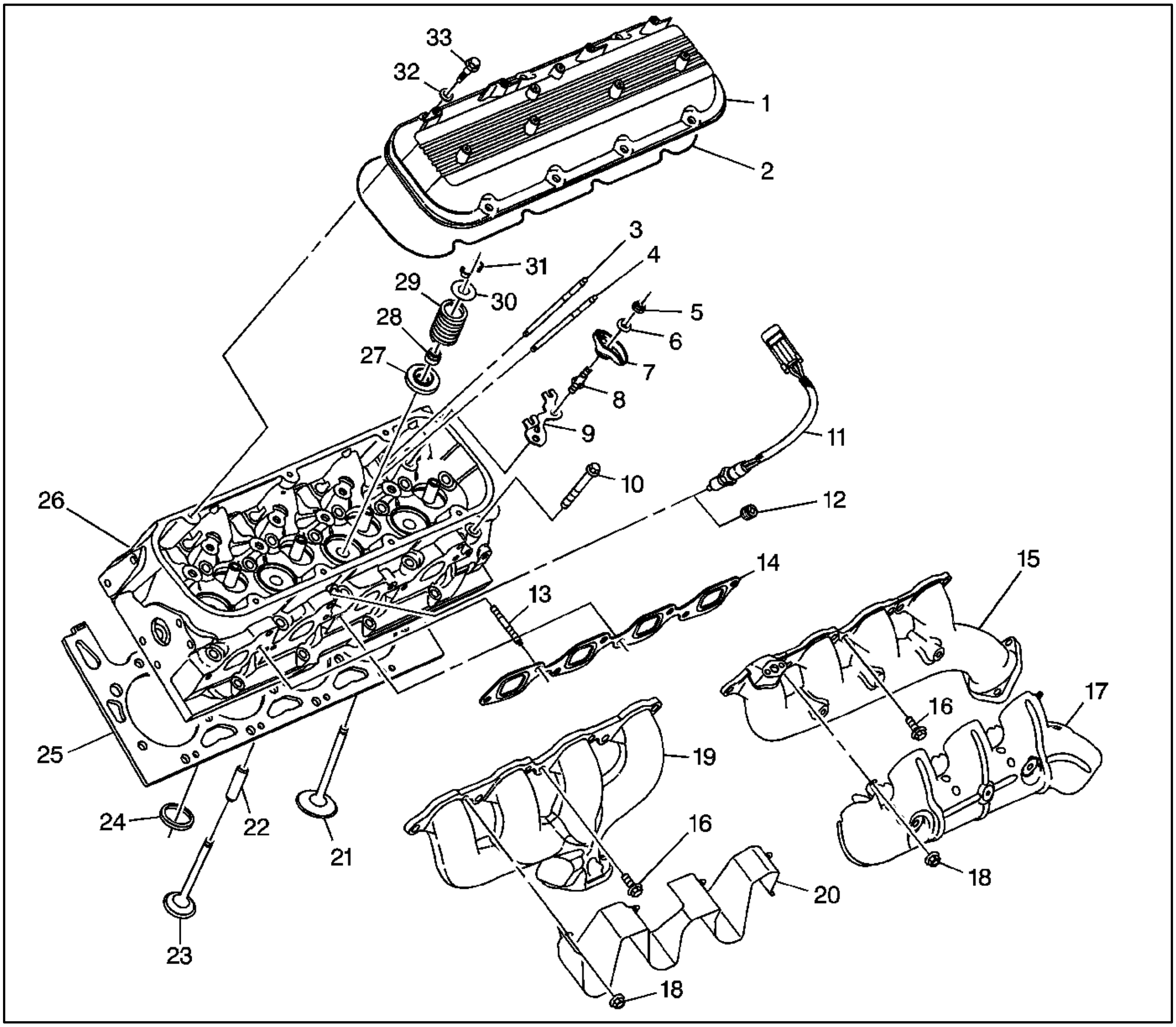
Engine Flywheel and Flywheel Housing Components



Legend

(1) Flywheel – Automatic Transmission
(2) Flywheel Bolt
(3) Transmission Converter Cover Bolt
(4) Transmission Converter Cover
(5) Flywheel Housing – Medium Duty with Automatic Transmission
(6) Flywheel Housing Adapter Bolt

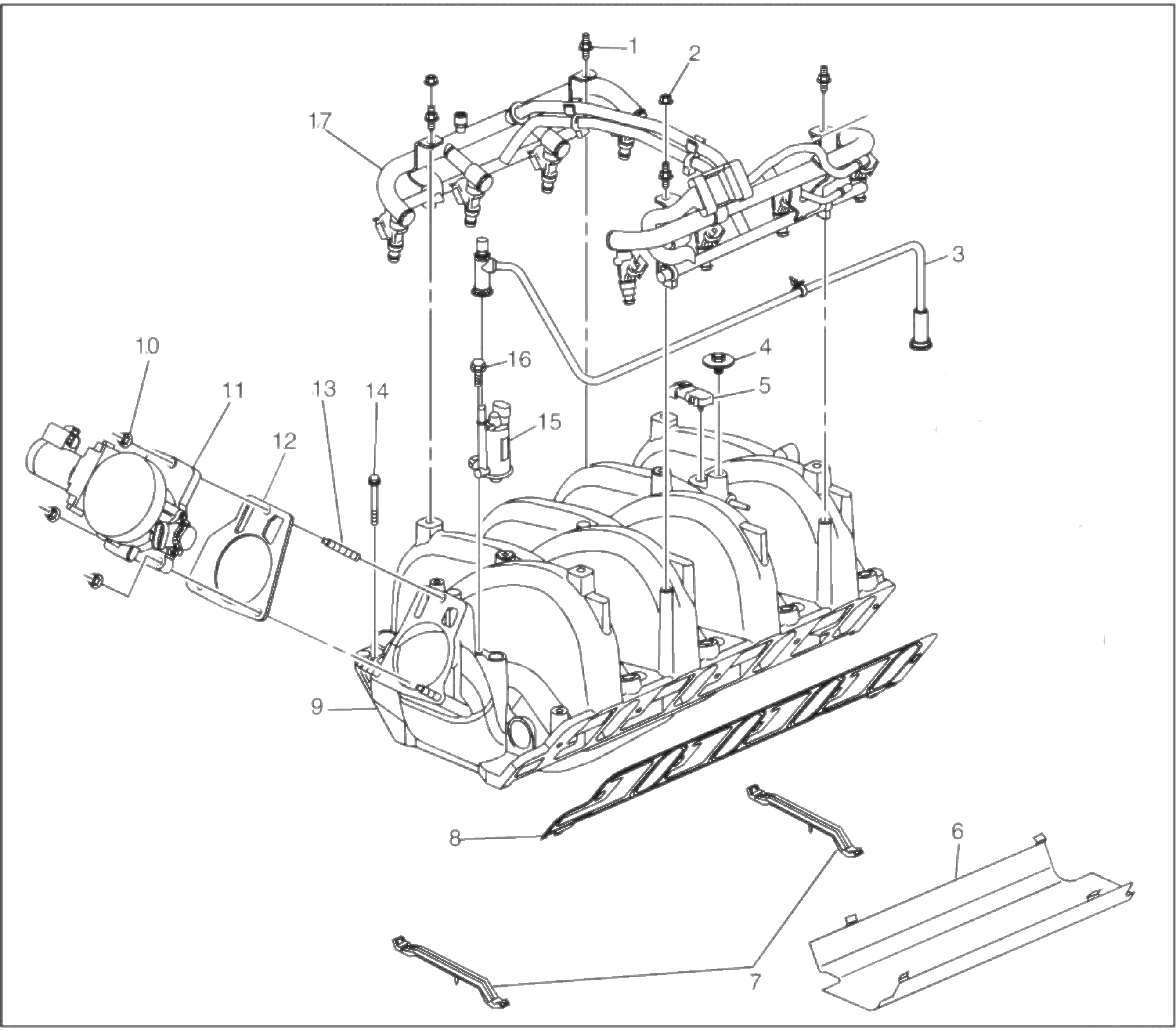
Cylinder Head and Components



Legend

(1) Valve Rocker Arm Cover
(2) Valve Rocker Arm Cover Gasket
(3) Intake Valve Push Rod
(4) Exhaust Valve Push Rod
(5) Valve Rocker Arm Nut
(6) Valve Rocker Arm Ball
(7) Valve Rocker Arm
(8) Valve Rocker Arm Stud
(9) Push Rod Guide
(10) Cylinder Head Bolt
(11) Engine Coolant Temperature (ECT) Sensor – Right Cylinder Head
(12) Coolant Hole Plug – Left Cylinder Head
(13) Exhaust Manifold Stud
(14) Exhaust Manifold Gasket
(15) Exhaust Manifold (P32)
(16) Exhaust Manifold Bolt
(17) Heat Shield (P32)
(18) Heat Shield Nut
(19) Exhaust Manifold (P22)
(20) Heat Shield (P22)
(21) Intake Valve
(22) Exhaust Valve Guide
(23) Exhaust Valve
(24) Exhaust Valve Seat
(25) Cylinder Head Gasket
(26) Cylinder Head
(27) Valve Rotator
(28) Valve Stem Oil Seal
(29) Valve Spring
(30) Valve Spring Cap
(31) Valve Keys
(32) Valve Rocker Arm Cover Bolt Gasket
(33) Valve Rocker Arm Cover Bolt

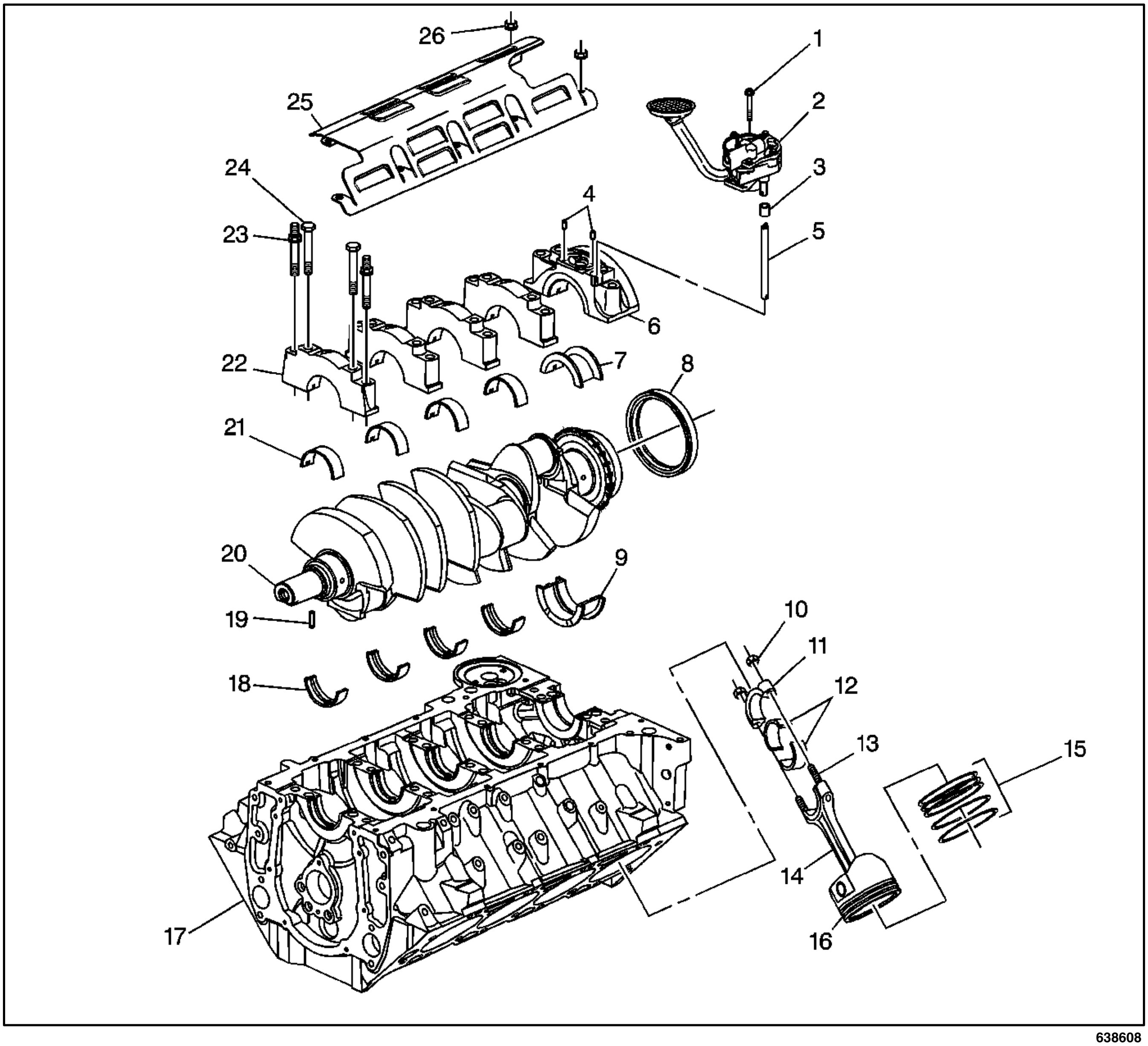
Intake Manifold and Components



Legend

(1) Fuel Rail Studs
(2) Field Rail Nuts
(3) Purge Solenoid Vacuum Hose
(4) MAP Sensor Retaining Bolt
(5) MAP Sensor
(6) Splash Shield
(7) Intake Manifold End Gaskets
(8) Intake Manifold Side Gaskets
(9) Intake Manifold
(10) Throttle Body Nuts
(11) Throttle Body
(12) Throttle Body Gasket
(13) Throttle Body Studs
(14) Intake Manifold Bolts
(15) Purge Solenoid
(16) Purge Solenoid Bolt
(17) Fuel Rail

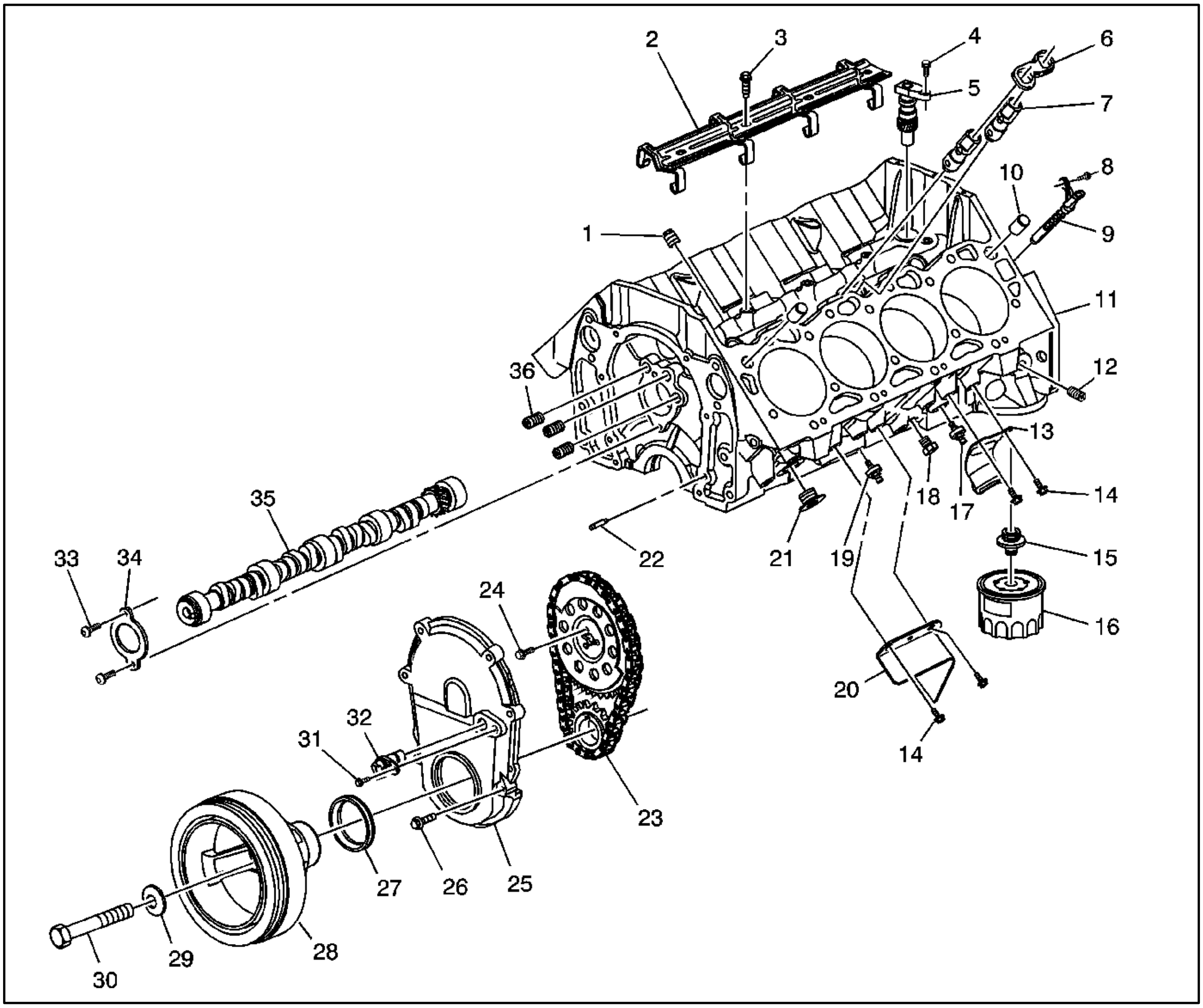
Engine Crankshaft and Components



Legend

(1) Oil Pump Bolt
(2) Oil Pump Assembly
(3) Oil Pump Driveshaft Retainer
(4) Oil Pump Locating Pins
(5) Oil Pump Driveshaft
(6) Crankshaft Thrust Bearing Cap
(7) Lower Crankshaft Thrust Bearing
(8) Rear Crankshaft Seal
(9) Upper Crankshaft Thrust Bearing
(10) Connecting Rod Nut
(11) Connecting Rod Cap
(12) Connecting Rod Bearings
(13) Connecting Rod Bolt
(14) Connecting Rod
(15) Piston Rings
(16) Piston
(17) Engine Block
(18) Crankshaft Upper Bearings
(19) Crankshaft Pin
(20) Crankshaft Assembly with Reluctor Wheels
(21) Crankshaft Lower Bearings
(22) Crankshaft Bearing Caps
(23) Crankshaft Bearing Cap Outer Studs
(24) Crankshaft Bearing Inner Bolts
(25) Crankshaft Oil Deflector
(26) Crankshaft Oil Deflector Nuts

Lower Engine Block and Components



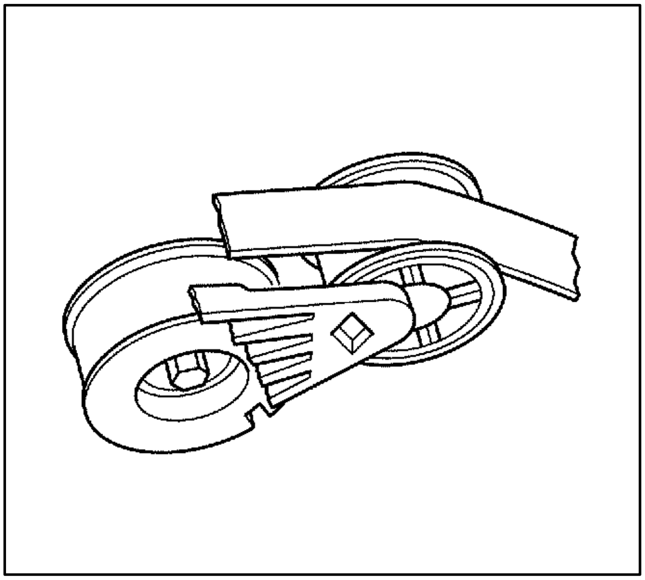
Legend

- (1) Top Oil Gallery Plug
- (2) Valve Lifter Guide Retainer
- (3) Valve Lifter Guide Retainer Bolt
- (4) Oil Pump Drive Bolt
- (5) Oil Pump Drive
- (6) Valve Lifter Guide
- (7) Valve Lifter
- (8) Crankshaft Position Sensor Bolt
- (9) Crankshaft Position Sensor
- (10) Cylinder Head Locating Pin
- (11) Engine Block
- (12) Left Oil Gallery Plug
- (13) Left Knock Sensor Shield (P32)
- (14) Left Knock Sensor Shield Bolt
- (15) Oil Filter Fitting
- (16) Oil Filter
- (17) Left Knock Sensor (P32)
- (18) Coolant Drain Plug
- (19) Left Knock Sensor (P22)
- (20) Left Knock Sensor Shield (P22)
- (21) Coolant Hole Plug (Optional Block Heater)
- (22) Front Engine Cover Locating Pin
- (23) Timing Chain and Sprockets
- (24) Camshaft Sprocket Bolt
- (25) Front Engine Cover
- (26) Front Engine Cover Bolt
- (27) Front Crankshaft Oil Seal
- (28) Crankshaft Balancer
- (29) Crankshaft Balancer Washer
- (30) Crankshaft Balancer Bolt
- (31) Camshaft Position Sensor Bolt
- (32) Camshaft Position Sensor
- (33) Camshaft Retainer Bolt
- (34) Camshaft Retainer
- (35) Camshaft
- (36) Front Oil Gallery Plug

Repair Instructions

Drive Belt Replacement

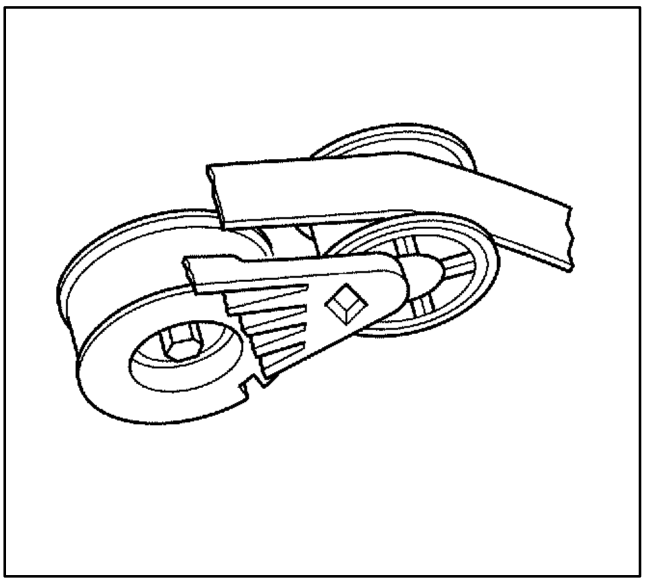
Removal Procedure



WRK61083

1. Remove the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
2. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm clockwise.
3. Remove the drive belt.
4. Slowly release the tension on the tensioner arm.

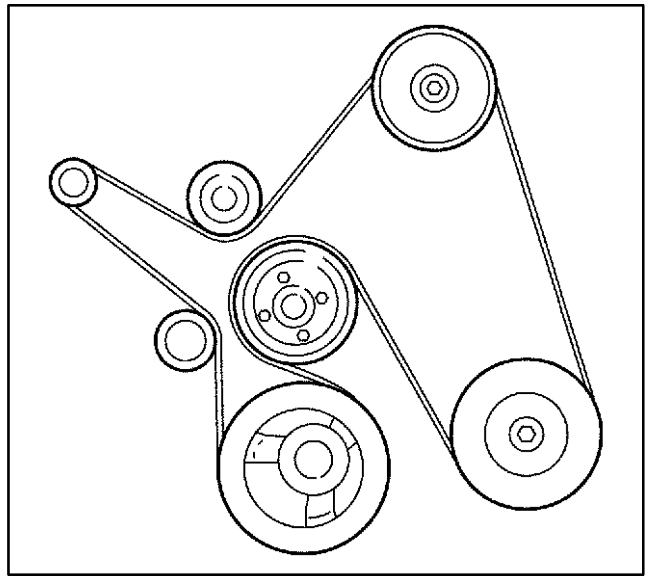
Installation Procedure



WRK61083

1. Route the belt over all the pulleys except the tensioner arm pulley.
2. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm clockwise.

3. Install the belt over the tensioner arm pulley.
4. Slowly release the tension on the tensioner arm.
5. Confirm that the belt is properly routed.
6. Install the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.

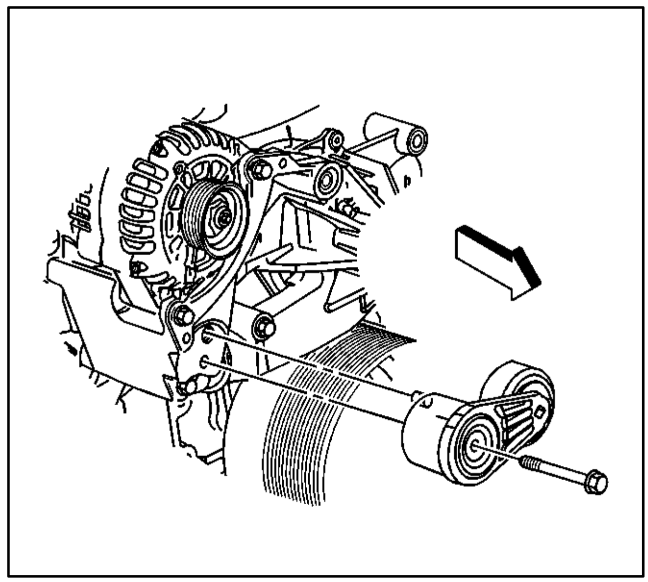


WRK61002

Drive Belt Tensioner Replacement

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
2. Remove the tensioner retaining bolt.
3. Remove the tensioner.



704632

Installation Procedure

1. Install the drive belt tensioner assembly.

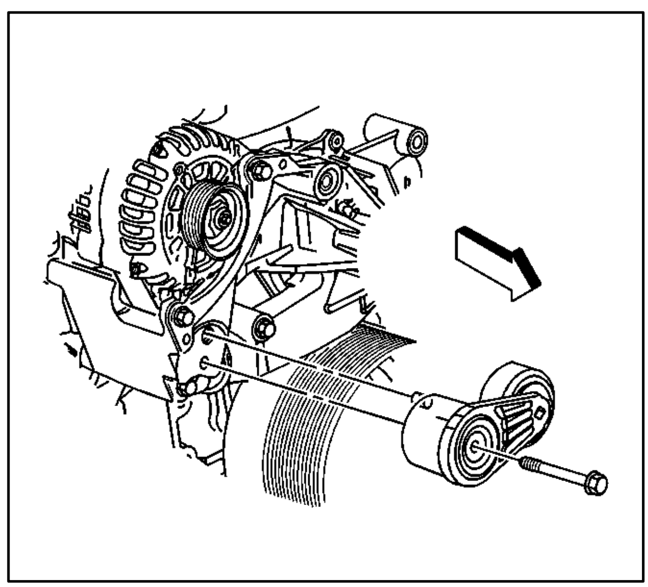
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the tensioner retaining bolt.

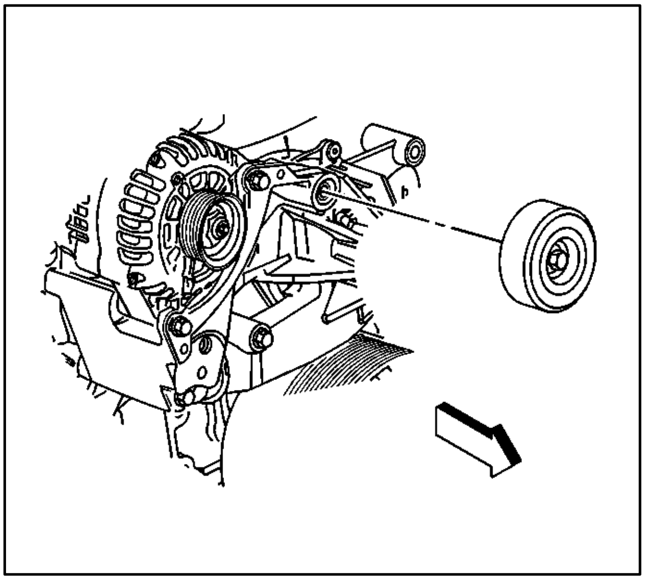
   Tighten

   Tighten the tensioner assembly bolt to 50 N·m (37 lb ft).

3. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.



704632

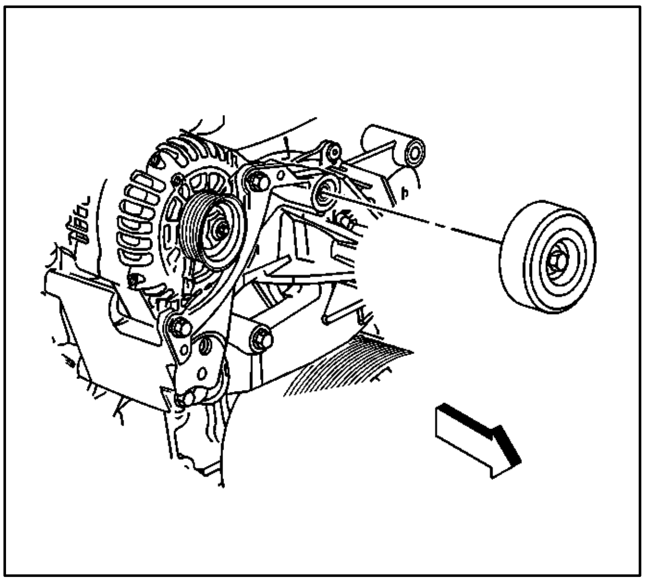


704644

Drive Belt Idler Pulley Replacement

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
2. Remove the drive belt idler pulley from the engine.



704644

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

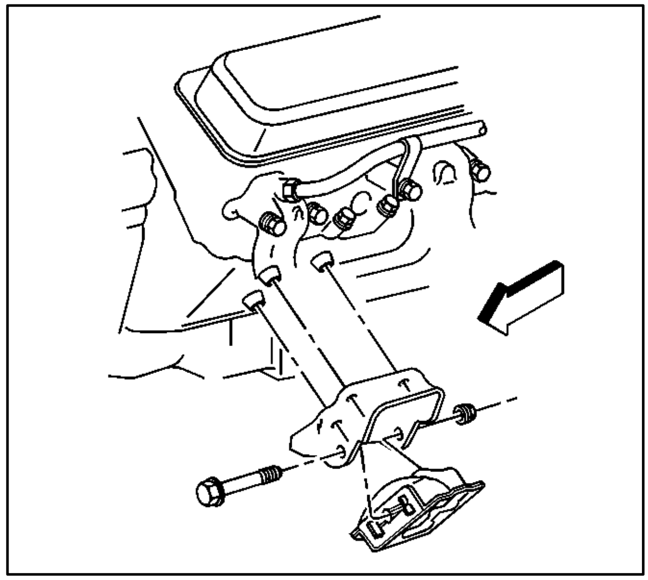
1. Install the drive belt idler pulley to the engine.

   Tighten

   Tighten the bolt to 50 N·m (37 lb ft).
2. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.

Engine Mount Inspection

Front Engine Mount



704669

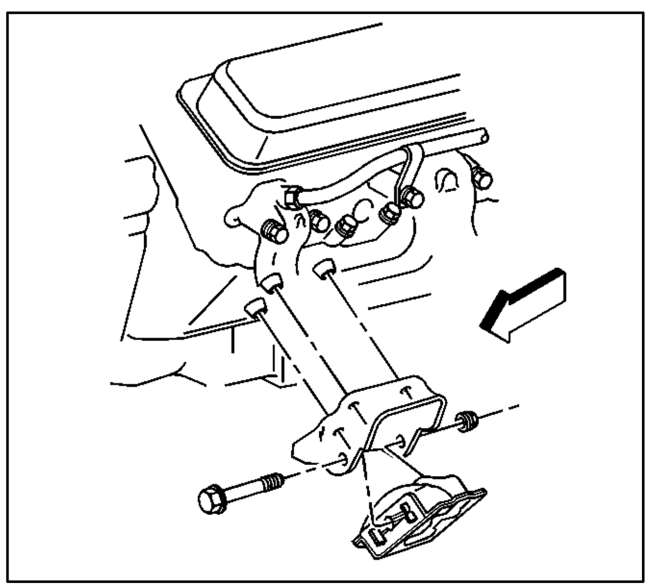
Notice: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Raise the engine in order to remove the weight from the mount and to place a slight tension on the rubber cushion.
2. Use a jack on the square tab at the rear of the engine block. Observe both mounts while raising the engine.
3. Replace the mount if any of the following conditions exist:
   - Hard rubber surface covered with heat check cracks
   - The rubber cushion separated from the metal plate of the mount
   - The rubber cushion is split through the center
4. If there is movement between a metal plate of the mount and its attaching points, lower the engine and tighten the bolts or nuts attaching the mount to the engine, the frame or the bracket.

Engine Mount Replacement – Left

Removal Procedure

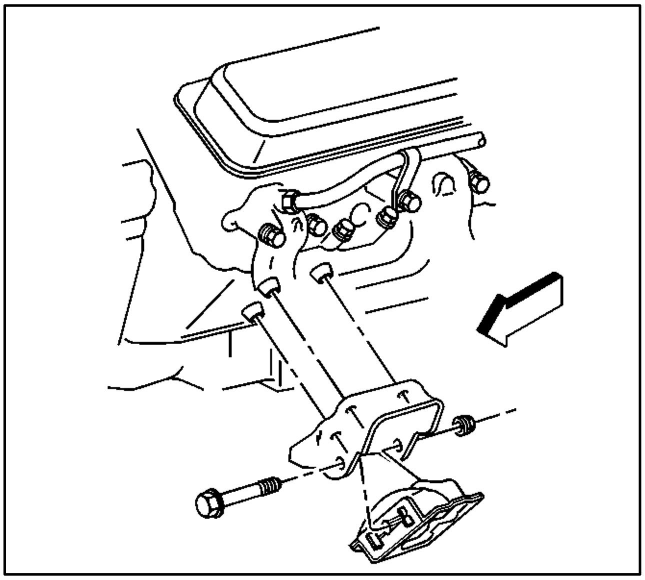


704669

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

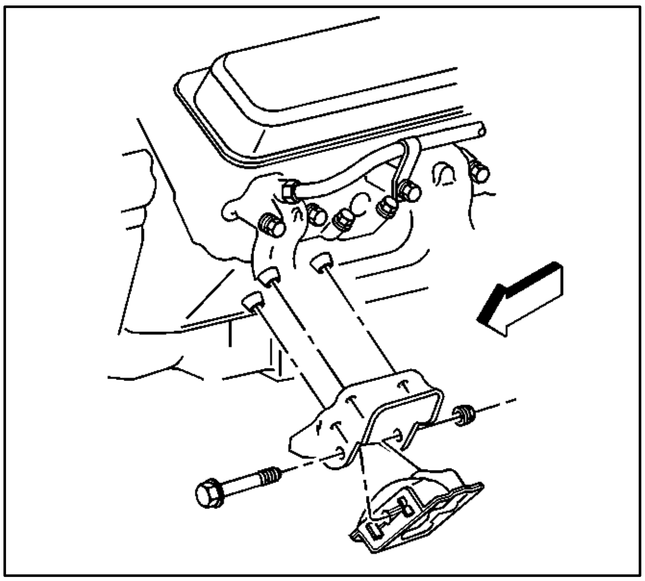
Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

2. Support the engine with a suitable jack. Do not load the engine mounts.
3. Remove the engine mount through bolt and the nut.
4. Raise the engine only enough to permit removal of the engine mount.



704669

5. Remove the engine mount assembly bolts, nuts, and washers.
6. Remove the engine mount and heat shield assembly.



704669

Installation Procedure

1. Install the engine mount and heat shield assembly.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the engine mount assembly bolts, nuts, and washers.

   Tighten

   - Tighten the bolts to 59 N·m (44 lb ft).
   - Tighten the nuts to 45 N·m (33 lb ft).

3. Lower the engine until the engine mount through bolt can be inserted.
4. Install the engine mount through the bolt and the nut.

   Tighten

   Tighten the through bolt nut to 68 N·m (50 lb ft).

5. Connect the battery negative cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.

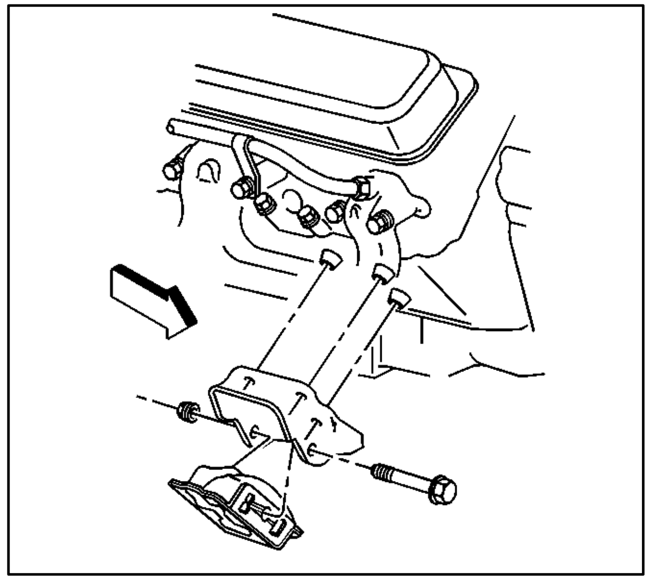
Engine Mount Replacement – Right

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

2. Support the engine with a suitable jack. Do not load the engine mounts.
3. Remove the engine mount through bolt and the nut.
4. Raise the engine only enough to permit removal of the engine mount.
5. Remove the engine mount assembly bolts, nuts, and washers.
6. Remove the engine mount and heat shield assembly.



704674

Installation Procedure

1. Install the engine mount and heat shield assembly.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

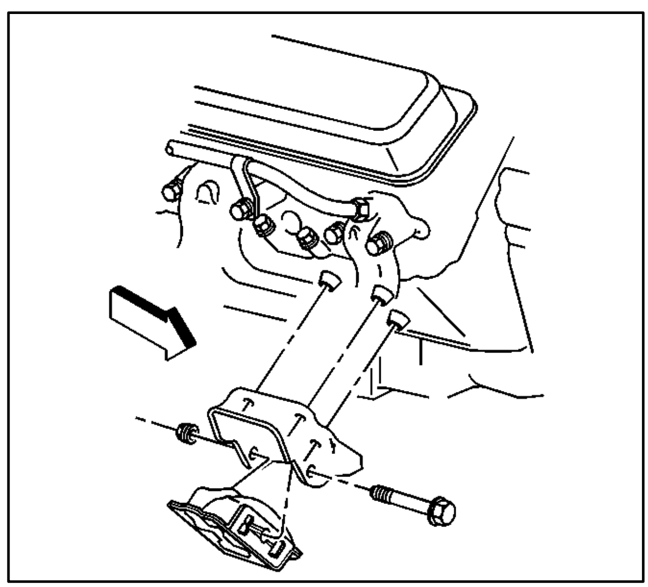
2. Install the engine mount assembly bolts, nuts, and washers.

   Tighten

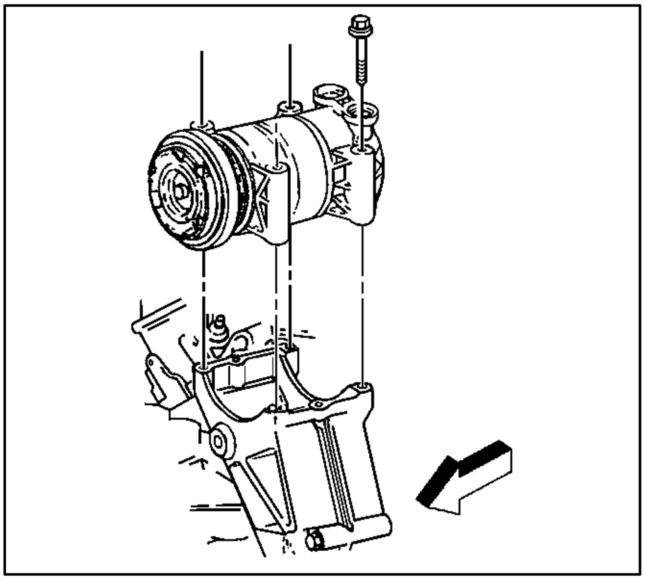
   - Tighten the bolts to 59 N·m (44 lb ft).
   - Tighten the nuts to 45 N·m (33 lb ft).
3. Lower the engine until the engine mount through bolt can be inserted.
4. Install the engine mount through bolt and the nut.

   Tighten

   Tighten the through bolt nut to 68 N·m (50 lb ft).
5. Connect the battery negative cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.



704674



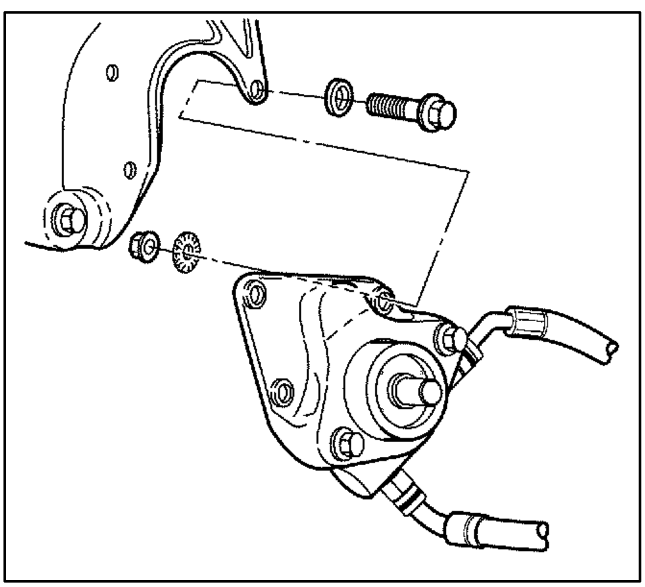
WRK61080

Accessory Bracket Replacement – Left

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

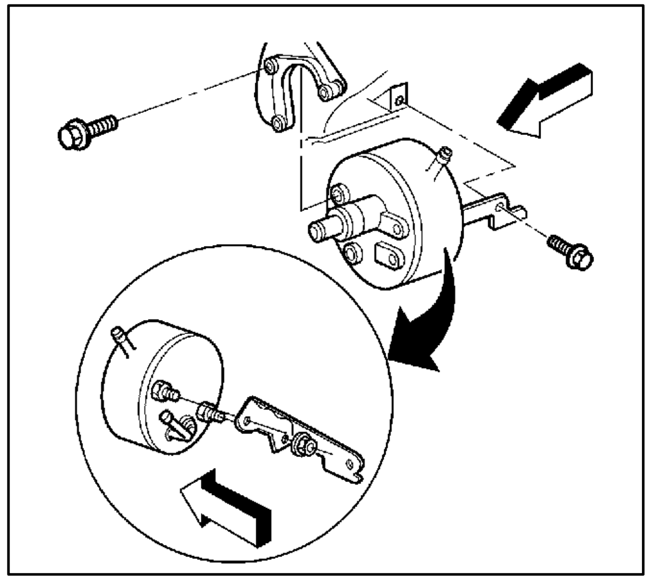
1. Disconnect the negative battery cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Drain the coolant from the radiator. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
3. Remove the air intake duct from the throttle body and the MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
4. Remove the upper radiator hose from the radiator and thermostat housing. Refer to *Radiator Hose Replacement – Inlet (8.1L)* in this supplement.
5. Remove the upper fan shroud. Refer to *Fan Shroud Replacement – Upper (8.1L)* in this supplement.
6. Remove the lower fan shroud. Refer to *Fan Shroud Replacement – Lower (8.1L)* in this supplement.
7. Remove the fan. Refer to *Fan Replacement (8.1L)* in this supplement.
8. Disconnect the electrical connector from the A/C compressor.
9. Remove the A/C compressor retaining bolts and reposition A/C compressor without disconnecting the refrigerant lines.
10. Remove the power steering pump pulley from the power steering pump. Refer to *Power Steering Pump Pulley Replacement* in this supplement for P22 models. Refer to *Power Steering Pump Replacement (7.4 L Engine)* for P32 Models.



WRK61086

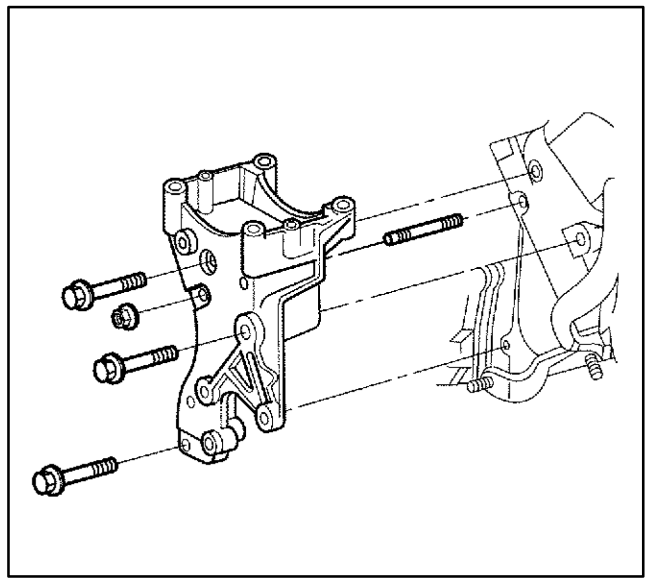
11. Remove the power steering pump without disconnecting the hydraulic lines.
    11.1. On P22 models, remove the bolts, washers, and nuts from the power steering pump bracket and the accessory bracket.

11.2. On P32 models:
    11.2.1. Remove the brace to engine bolt.
    11.2.2. Remove the power steering pump to bracket bolts.
12. Reposition the power steering pump without disconnecting the hydraulic lines.



WRK61087

13. Remove the left accessory bracket bolts and bracket from the engine.



WRK61081

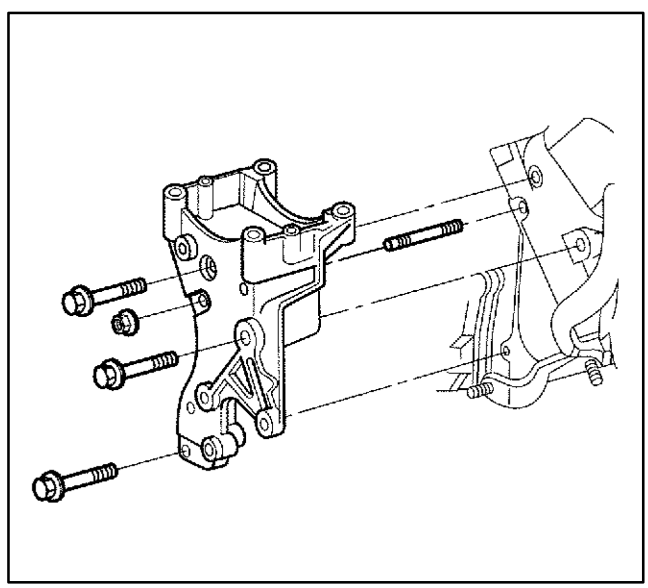
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

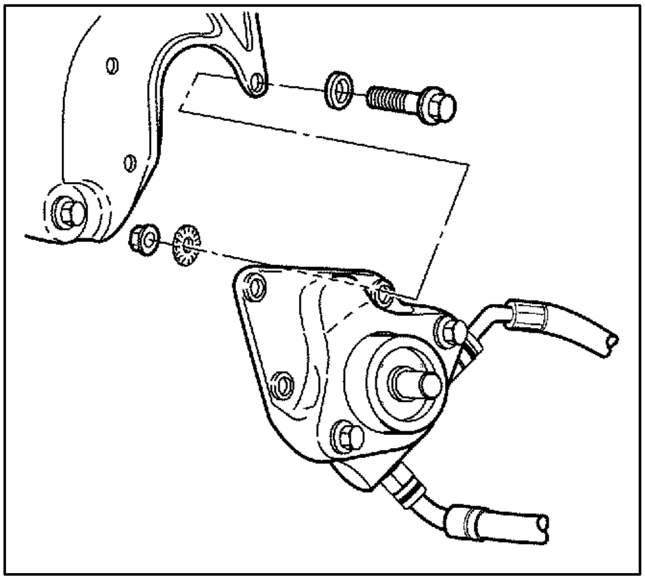
1. Install the left accessory bracket and bracket bolts to the engine.

   Tighten

   Tighten the accessory bracket bolts to 50 N·m (37 lb ft).



WRK61081

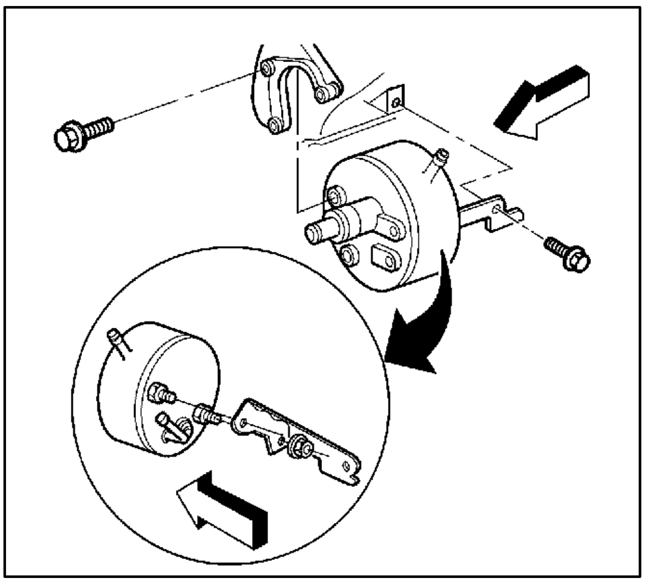


WRK61086

2. Reposition the power steering pump to the left accessory bracket.
3. Install the power steering pump.
   3.1. On P22 models, install the bolts, washers, and nuts to the power steering pump bracket and the accessory bracket.

   Tighten

   Tighten the power steering pump bracket to accessory bracket nuts to 65 N·m (48 lb ft).



WRK61087

   3.2. On P32 models, finger start the bolt securing the power steering brace to the engine, and the front pump bolts.

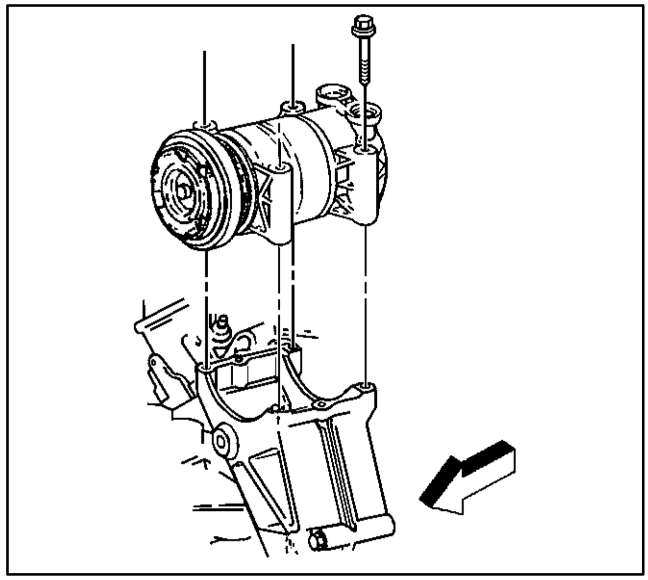
   Tighten

   Tighten the power steering front pump bolts and the power steering pump brace to engine bolt to 50 N·m (37 lb ft).
4. Install the power steering pump pulley to the power steering pump. Refer to *Power Steering Pump Pulley Replacement* in this supplement for P22 models. Refer to *Power Steering Pump Replacement (7.4 L Engine)* for P32 models.

5. Install the A/C compressor and retaining bolts to the left accessory bracket.

   Tighten

   Tighten the A/C compressor bolts to 50 N·m (37 lb ft).
6. Connect the electrical connector to the A/C compressor.
7. Install the fan. Refer to *Fan Clutch Replacement (8.1L)* in this supplement.
8. Install the lower fan shroud. Refer to *Fan Shroud Replacement – Lower (8.1L)* in this supplement.
9. Install the upper fan shroud. Refer to *Fan Shroud Replacement – Upper (8.1L)* in this supplement.
10. Install the upper radiator hose to the radiator and thermostat housing. Refer to *Radiator Hose Replacement – Inlet (8.1L)* in this supplement.
11. Install the air intake duct to the throttle body and the MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
12. Refill the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
13. Connect the negative battery cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.



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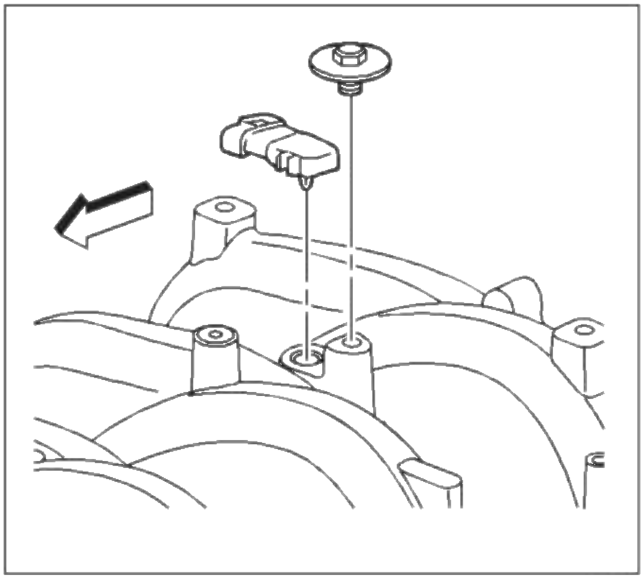
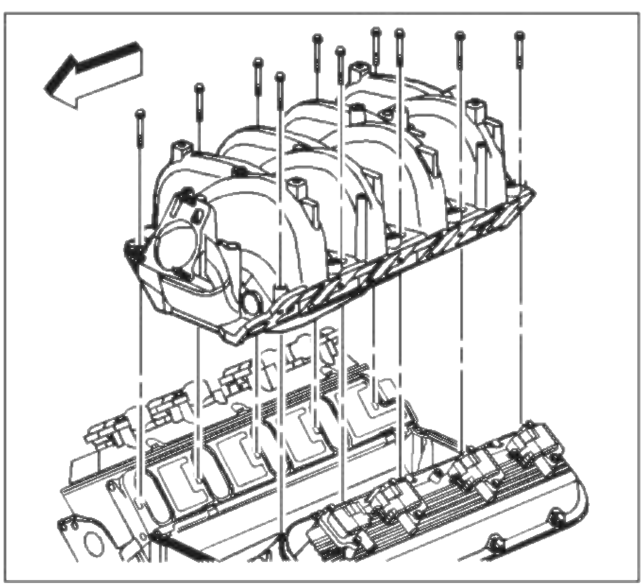


471023

Intake Manifold Replacement

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the fuel rail from the intake manifold. Refer to *Fuel Rail Assembly Replacement* in this supplement.
3. Remove the oil fill tube from the intake manifold.
4. Disconnect the electrical connectors from the throttle body.
5. Disconnect the vacuum lines from the intake manifold.
6. Remove the electrical wiring harness bolts and retainers from the intake manifold and reposition the harness.
7. Disconnect the electrical connector from the MAP sensor.
8. Remove the bolt, washer, and MAP sensor from the intake manifold.



470775

9. Remove the intake manifold bolts.
10. Remove the intake manifold from the engine.
11. Remove the intake manifold gaskets and seals from the cylinder heads and engine block.
12. Clean all sealing surfaces of oil and grease.

Installation Procedure

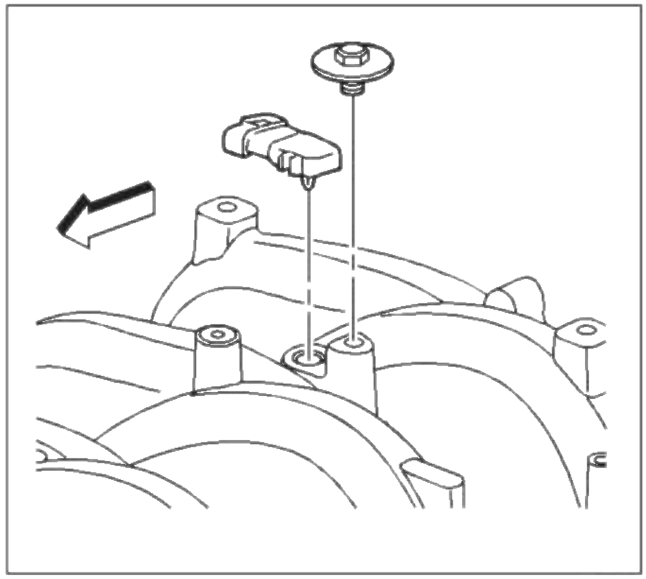
1. Install the intake manifold. Refer to *Intake Manifold Installation* in this supplement.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the MAP sensor, washer, and bolt to the intake manifold.

   Tighten
   Tighten the MAP sensor bolt to 12 N·m (106 lb in).
3. Connect the electrical connector to the MAP sensor.
4. Place the electrical wiring harness back into position and install the wiring harness retainers and bolts to the intake manifold.

   Tighten
   Tighten the wiring harness bolts to 12 N·m (106 lb in).
5. Connect the vacuum lines to the intake manifold.
6. Connect the electrical connectors to the throttle body.
7. Install the oil fill tube to the intake manifold.
8. Install the fuel rail to the intake manifold. Refer to *Fuel Rail Assembly Replacement* in this supplement.
9. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



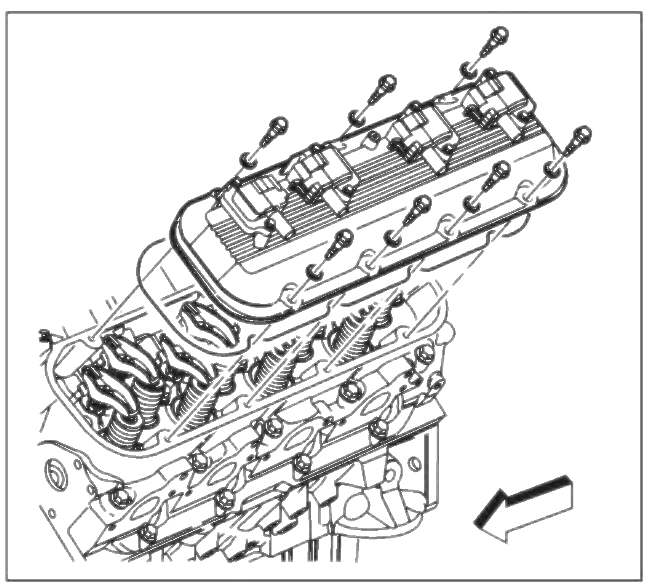
471023

Valve Rocker Arm Cover Replacement – Left

Removal Procedure

Important: Valve rocker arm cover gaskets are reusable. Replace the valve arm cover gasket only if damaged.

1. Disconnect all the spark plug wires from the spark plugs on the left bank.
2. Disconnect the electrical connectors from the left bank coils.
3. Remove the left valve cover retaining bolts.
4. Remove the left valve cover from the engine.
5. Remove the valve cover gasket.



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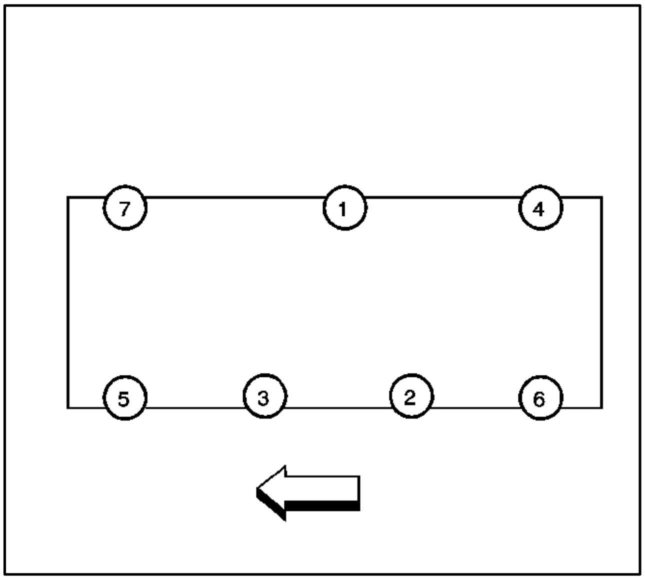


677858

Installation Procedure

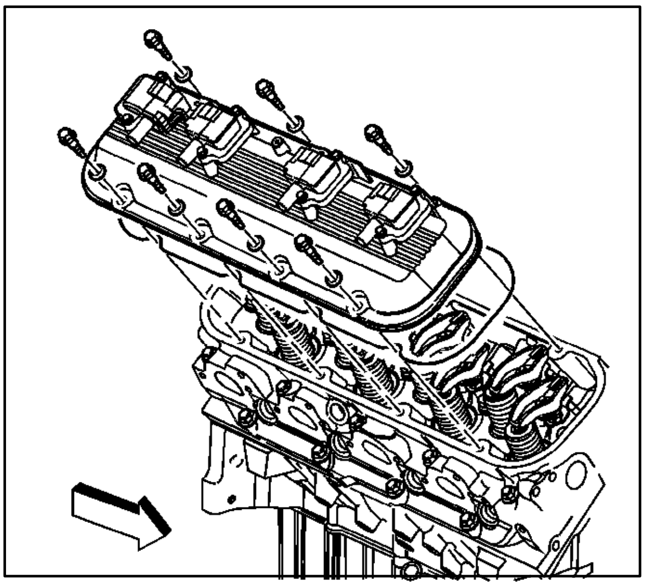
1. Install the valve cover gasket to the cylinder head.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the left valve cover to the engine.
3. Install the left valve cover retaining bolts.

   Tighten

   - Tighten the valve cover bolts to 6 N·m (54 lb in) first pass.
   - Tighten the valve cover bolts to 12 N·m (106 lb in) second pass.
4. Connect the electrical connectors to the left bank coils.
5. Connect all the spark plug wires to the spark plugs on the left bank.

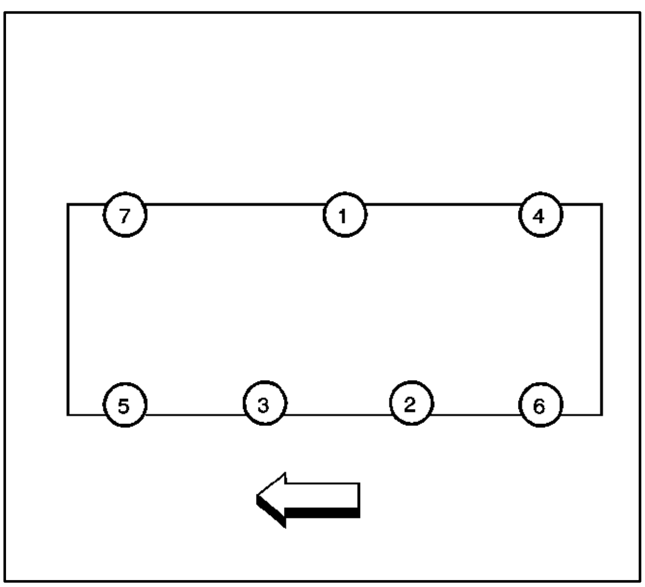

470897

Valve Rocker Arm Cover Replacement – Right

Removal Procedure

Important: Valve rocker arm cover gaskets are reusable. Replace the valve arm cover gasket only if damaged.

1. Disconnect all the spark plug wires from the spark plugs on the right bank.
2. Disconnect the electrical connectors from the right bank coils.
3. Remove the right valve cover retaining bolts.
4. Remove the right valve cover from the engine.
5. Remove the valve cover gasket.



677858

Installation Procedure

1. Install the valve cover gasket to the cylinder head.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the right valve cover to the engine.
3. Install the right valve cover retaining bolts.

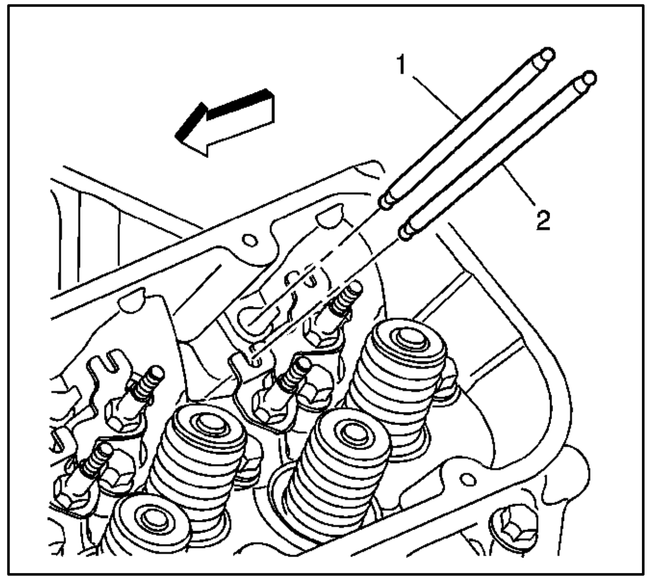
   Tighten

   - Tighten the valve cover bolts to 6 N·m (54 lb in) first pass.
   - Tighten the valve cover bolts to 12 N·m (106 lb in) second pass.
4. Connect the electrical connectors to the right bank coils.
5. Connect all the spark plug wires to the spark plugs on the right bank.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

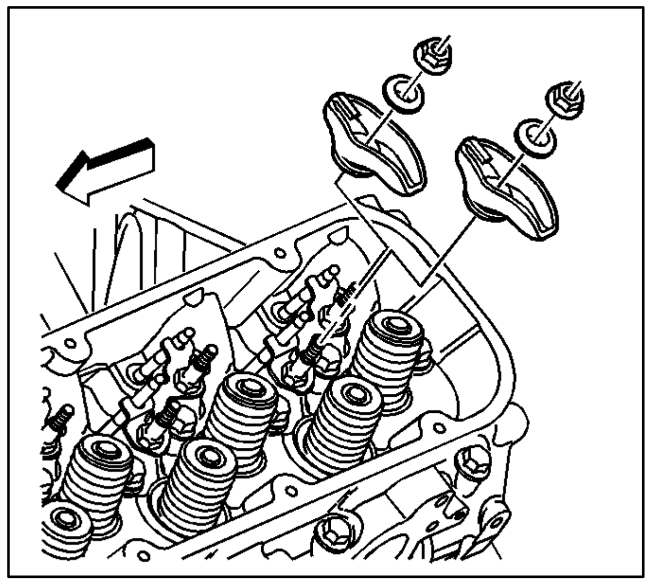
1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover Replacement – Right* in this supplement.



470903

Important: If the push rod is the only item to be replaced, loosen the valve rocker arm nut until the valve rocker arm can be rotated so the push rod can be removed.

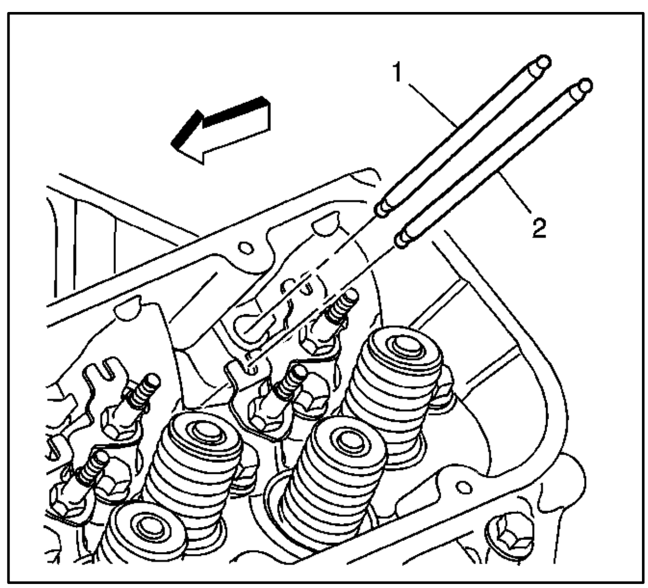
3. Remove the valve rocker arm nuts from the cylinder head.
4. Remove the valve rocker arm from the cylinder head.


470899

Important: The exhaust valve push rods (2) are longer than the intake valve push rods (1).

5. Remove the pushrod from the engine block.

Installation Procedure



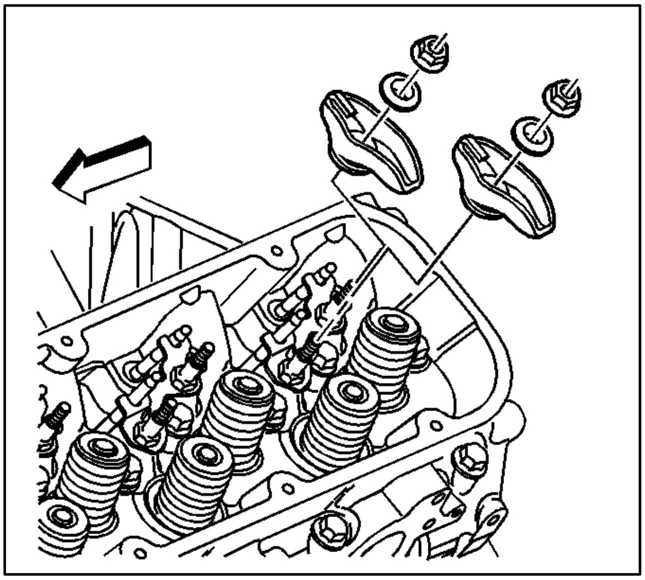
470903

Important: Make Sure that the push rod is properly seated in the valve lifter.

Important: The exhaust valve push rods (2) are longer than the intake valve push rods (1).

1. Install the push rod into the engine block.

Important: When a new valve rocker arm and balls are installed, coat the bearing surfaces with clean engine oil.



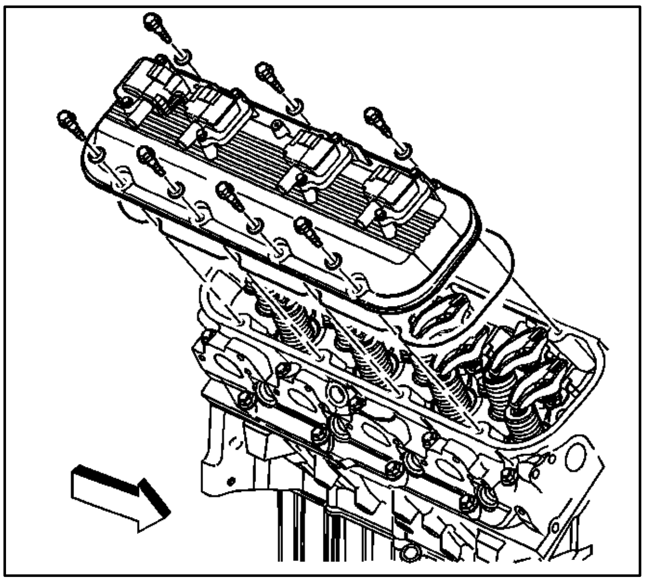
470899

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the valve rocker arm nut to the cylinder head.

   Tighten

   Slowly tighten the nuts to 25 N·m (18 lb ft).
3. Install the valve rocker arm covers to the cylinder heads. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover – Right* in this supplement.
4. Connect the battery negative to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



470897

Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- *J 5892-D* Valve Spring Compressor
- *J 22794* Spark Plug Port Adapter
- *J 43105* Valve Stem Seal Installer

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the valve rocker arm covers from the cylinder heads. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover Replacement – Right* in this supplement.
3. Rotate the crankshaft until both valves are closed before installing the compressed air into the cylinder being serviced.

Important: Rotate the cylinder being serviced to the bottom of the stroke, to ensure that the engine does not rotate when the compressed air is applied to the cylinder being serviced.

4. Remove the valve rocker arm from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
5. Remove the valve push rod from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
6. Remove the spark plugs from the cylinder head.

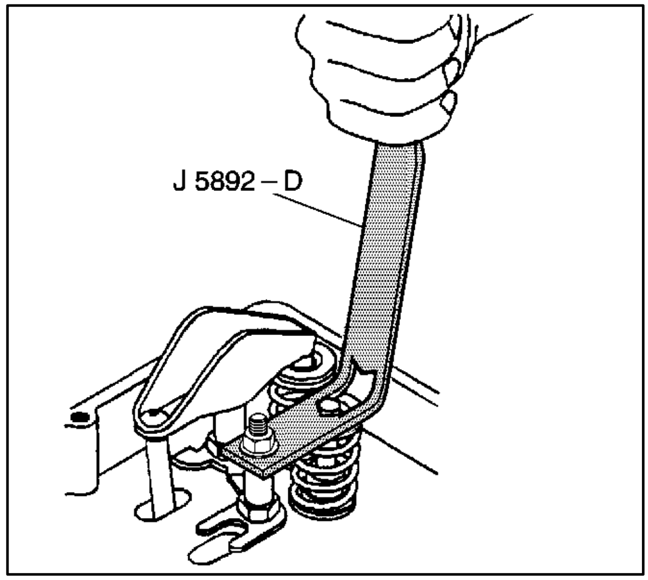
7. Remove the valve keepers as follows:
   7.1. Install the *J 22794* into the spark plug hole.
   7.2. Apply compressed air into the cylinders in order to hold the valves closed.
   7.3. Lightly tap the valve spring retainer to loosen the valve keepers.
   7.4. Install the *J 5892-D* to the cylinder head.
   7.5. Install the valve rocker arm nut.

Important: Tighten the valve rocker arm nut enough to hold *J 5892-C* in place while compressing the valve and valve spring assembly.

   7.6. Use the *J 5892-D* to compress the valve spring assembly.
   7.7. Remove the valve keepers.

Important: Do not release the compressed air from the cylinder being worked on. The valve will fall into the cylinder bore.

   7.8. Carefully release the spring tension and remove the *J 5892-D.*
   7.9. Remove the *J 5892-D* from the cylinder head.



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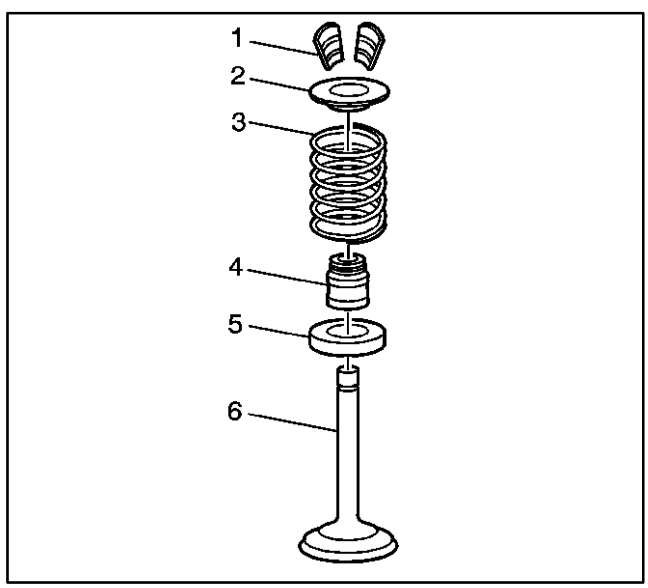
8. Remove the valve spring cap (2) and the valve spring (3) from the cylinder head.
9. Remove the valve stem oil seal from the valve guide.



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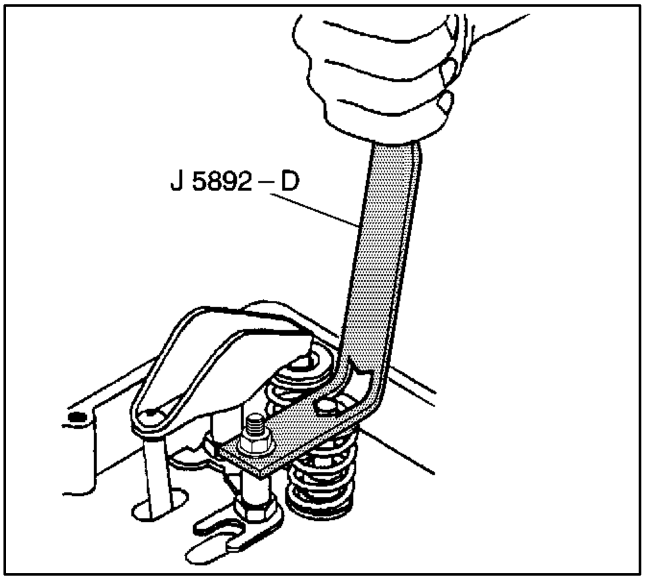

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Installation Procedure

1. Install the valve stem oil seal to the valve guide using *J 43105.*
2. Install the valve spring cap and the spring.
3. Use the *J 5892-D* to install the valve springs and keepers to the cylinder head.
4. Install the valve keepers to the valve as follows:
   4.1. With the compressed air still applied, use the *J 5892-D* to compress the valve spring assembly.
   4.2. Install the valve keepers to the valve being worked on. Apply a small amount of clean grease to hold the valve keepers in place.
   4.3. Carefully release the tension on the valve spring assembly. Make sure the valve keepers do not move while releasing the tension.
   4.4. Remove the *J 5892-D* from the valve assembly.
   4.5. Carefully release the compressed air from the cylinder being worked on.
5. Install the spark plugs to the cylinder head being serviced. Refer to *Spark Plug Replacement* in the WCC Service Manual.
6. Install the valve rocker arms to the cylinder head being serviced. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
7. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover – Left* and *Valve Rocker Arm Cover – Right* in this supplement.
8. Connect the battery negative cables to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

Valve Lifter Replacement

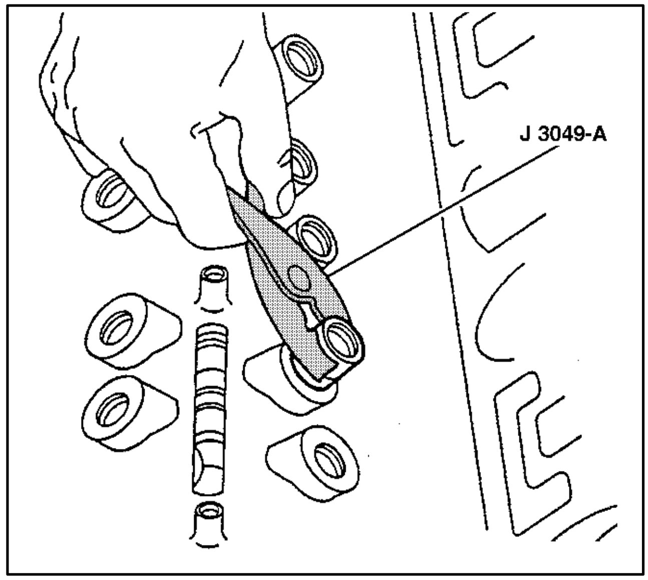
Tools Required

J 3049-A Valve Lifter Remover

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the intake manifold from the cylinder heads. Refer to *Intake Manifold Replacement* in this supplement.
3. Remove the valve rocker arm covers from the cylinder heads. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover – Right* in this supplement.
4. Remove the valve rocker arm from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
5. Remove the push rod from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
6. Remove the valve lifter guide retainer bolts and retainer.
7. Remove the valve lifter guides.
8. Remove the valve lifters one at a time. Place the valve lifters in an organizer rack in order to ensure that the valve lifters are later returned to the original bore during installation.

   A stuck valve lifter can be removed using *J 3049-A*.



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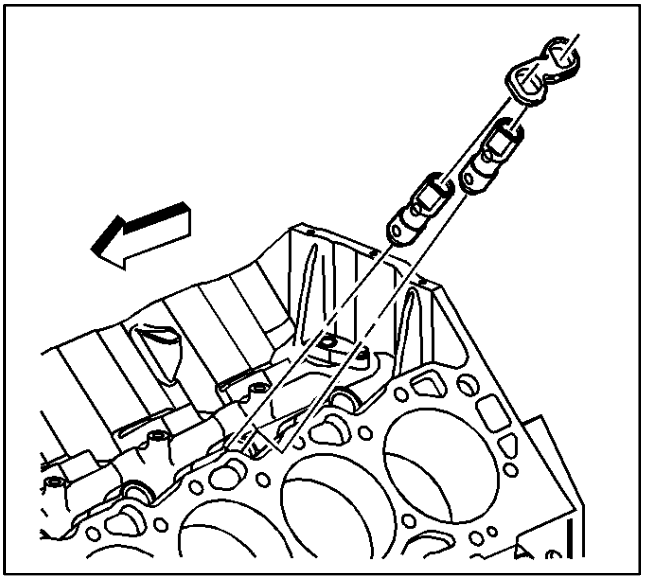

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Installation Procedure

Important: Replace the engine oil and oil filter if new valve lifters or a new camshaft is installed.

1. Install the valve lifters and guides into the engine block. Lubricate the valve lifter and the body with clean engine oil.

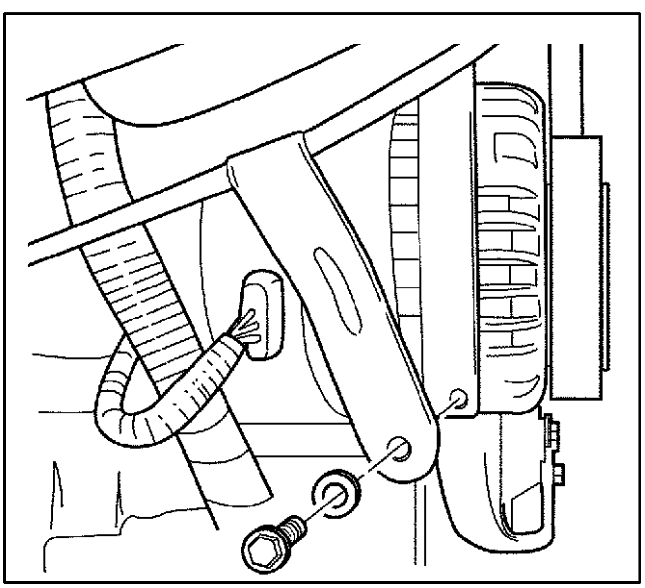
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the valve lifter guide retainer and bolts.

   Tighten

   Tighten the valve lifter guide retainer bolts to 25 N·m (19 lb ft).

3. Install the push rods into the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
4. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
5. Install the valve rocker arm covers to the cylinder heads. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover Replacement – Right* in this supplement.
6. Install the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
7. Connect the battery negative cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



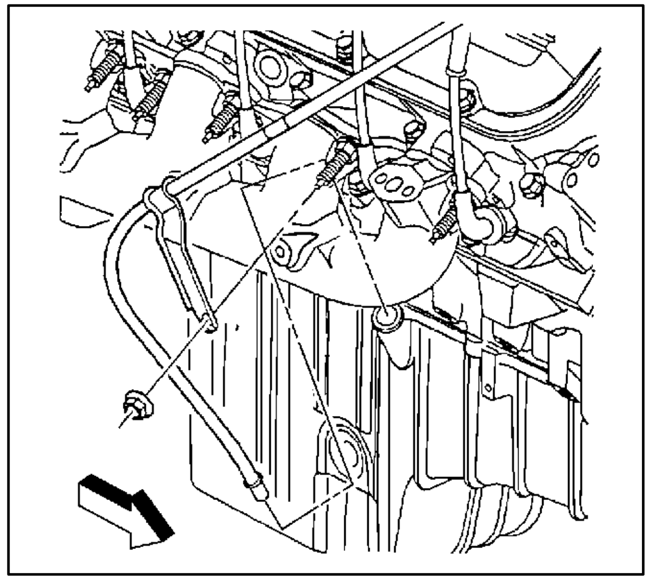
WRK61022

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the oil level indicator from the oil level indicator tube.
2. Remove the retaining bolt and washer from the tube bracket and the generator bracket.

3. Remove the retaining nut from the oil level indicator tube bracket at the exhaust manifold stud.
4. Remove the oil level indicator tube from the engine oil pan.
5. Remove the O-ring from the oil level indicator tube.



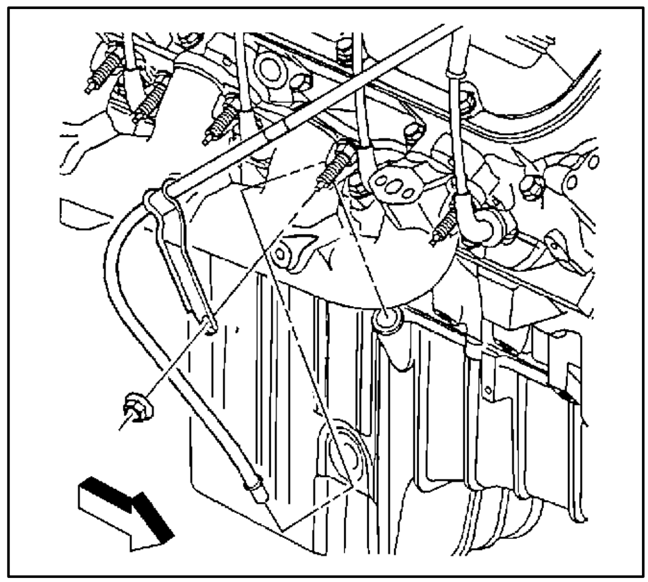
WRK61023

Installation Procedure

Important: When installing the oil level indicator tube to the engine, always use a new O-ring.

1. Install the new O-ring on the oil level indicator tube.
2. Apply clean engine oil to the oil level indicator tube O-ring.
3. Install the oil level indicator tube to the oil pan and the oil level indicator tube bracket to the exhaust manifold stud.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.



WRK61023

4. Install the oil level indicator tube bracket to exhaust manifold stud nut.

   Tighten

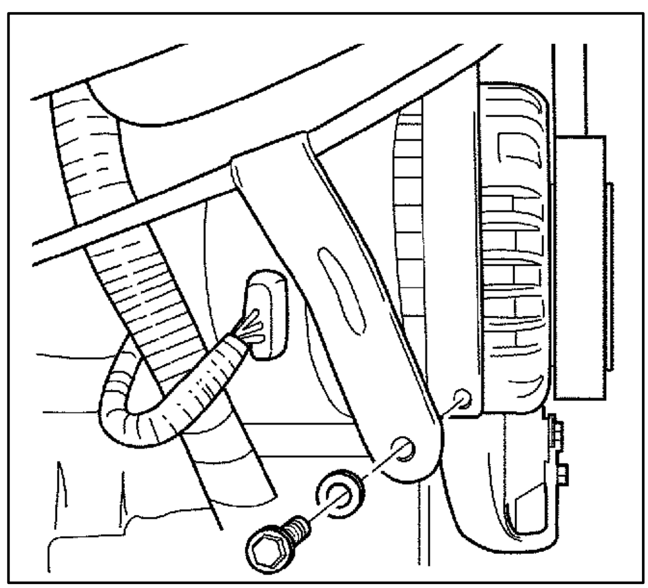
   Tighten the oil level indicator tube bracket to exhaust manifold stud nut to 25 N·m (18 lb ft).

5. Install the retaining bolt and washer to the tube bracket and the generator bracket.

   Tighten

   Tighten the tube bracket to generator bracket bolt to 12 N·m (106 lb in).

6. Install the oil level indicator into the oil level indicator tube.



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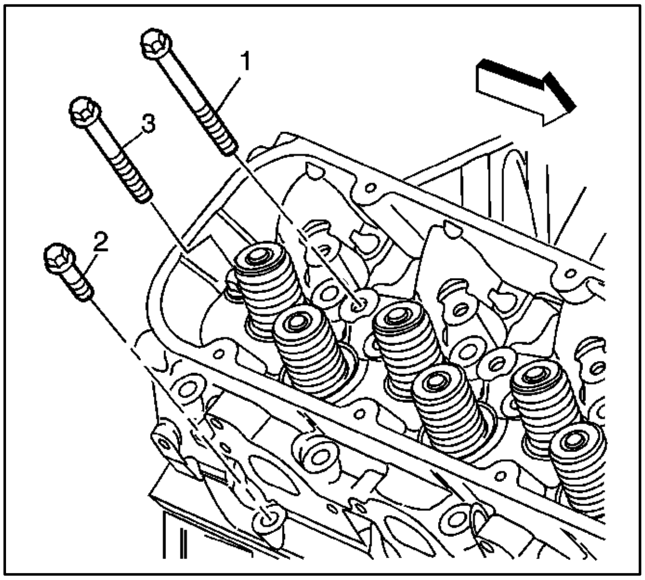

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Cylinder Head Replacement – Right

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Drain the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
4. Remove the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement* in this supplement.
5. Remove the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
6. Remove the generator bracket. Refer to *Generator Bracket Replacement* in this supplement.
7. Remove the water crossover and bypass hose. Refer to *Water Crossover Replacement (8.1L)* in this supplement.
8. Remove the valve rocker arm cover from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Right* in this supplement.
9. Remove the valve rocker arms from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
10. Remove the push rods from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
11. Remove the spark plugs from the right cylinder head. Refer to *Spark Plug Replacement* in this supplement.
12. Remove the exhaust manifold from the cylinder head. Refer to *Exhaust Manifold Replacement – Right* in this supplement.
13. Remove the cylinder head bolts (1, 2, 3) from the engine block.
14. Remove the cylinder head and gasket from the engine block.
15. Clean and inspect the sealing surfaces on the cylinder heads.
16. Discard the cylinder head bolts.

Installation Procedure

Important: Do not use sealer on the composition gaskets, and make sure that the punch code on the cylinder head gasket is facing up.

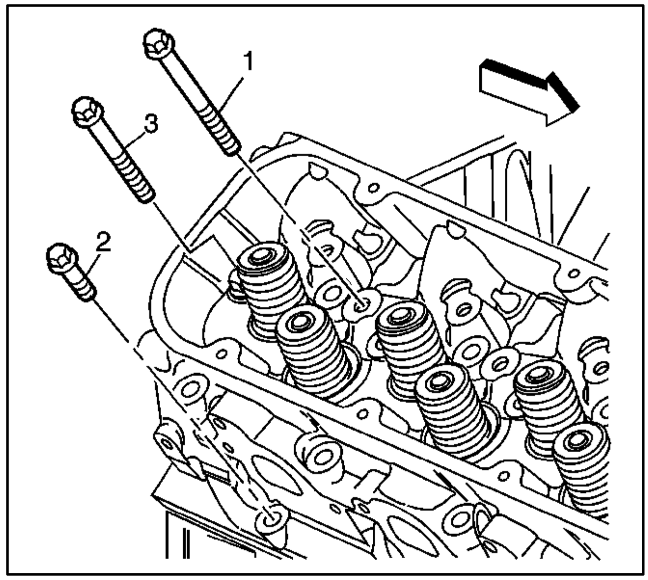
1. Install the cylinder head gasket to the engine block.
2. Install the cylinder head to the engine block.

Important: Make sure that that the threads on the cylinder head bolts are clean as well as the threaded holes in the engine block

Important: Make sure the bolts (1, 2, 3) are installed in the proper location. Installing the bolts in the wrong location could result in damage to the cylinder head.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the new cylinder head bolts. Sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the new cylinder head bolts.



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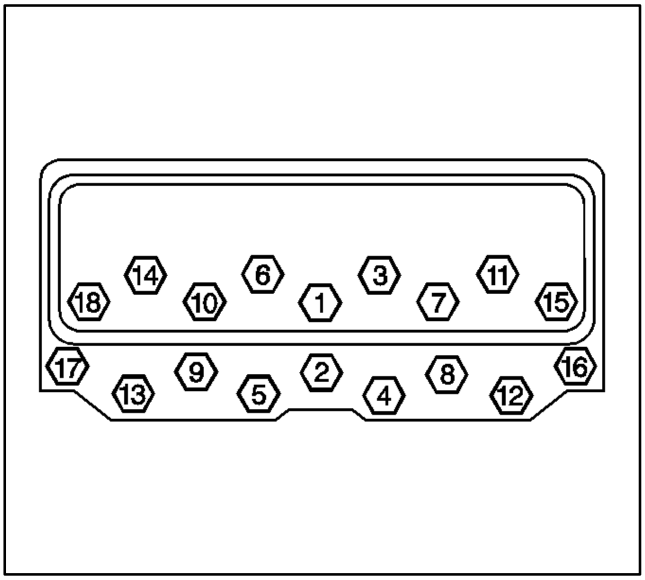

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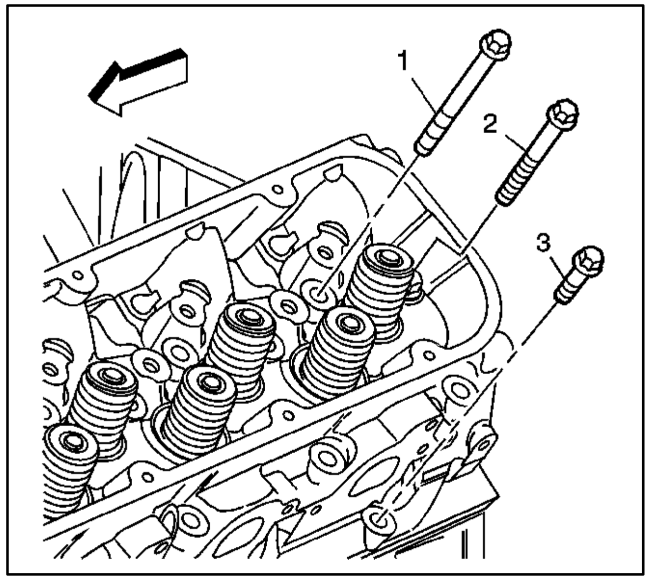
Tighten

- Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).
- Retighten the bolts in a second pass in sequence to 30 N·m (22 lb ft). Then an additional 120 degrees using the *J 36630-A.*
- Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18) an additional 60 degrees and bolts (4, 5, 12, 13) an additional 30 degrees in a final pass using the *J 36630-A.*

4. Install the exhaust manifold to the cylinder head. Refer to *Exhaust Manifold Installation – Right* in this supplement.
5. Install the spark plugs to the right cylinder head. Refer to *Spark Plug Replacement* in this supplement.
6. Install the push rods to the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
7. Install the rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
8. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Right* in this supplement.
9. Install the water crossover and bypass hose. Refer to *Water Crossover Replacement* in this supplement.
10. Install the generator bracket. Refer to *Generator Bracket Replacement* in this supplement.
11. Install the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
12. Install the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement* in this supplement.
13. Fill the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
14. Install the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
15. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

Cylinder Head Replacement – Left

Removal Procedure



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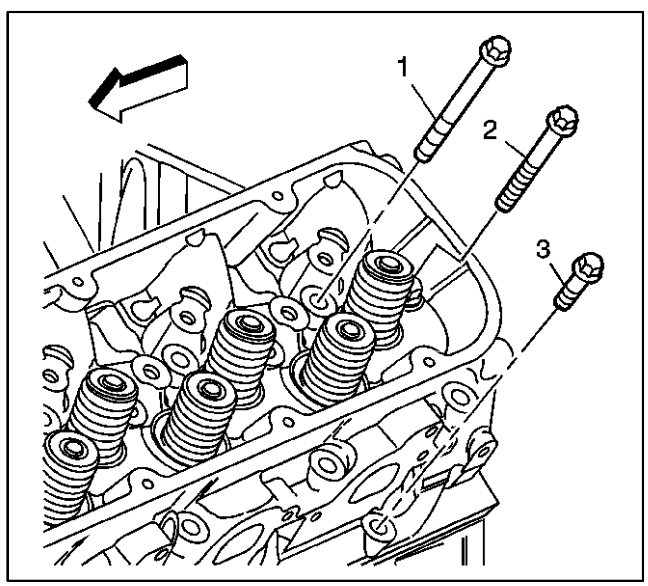
1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Drain the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
4. Remove the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
5. Remove the left side accessory bracket. Refer to *Accessory Bracket Replacement – Left* in this supplement.
6. Remove the water crossover and bypass hose. Refer to *Water Crossover Replacement* in this supplement.
7. Remove the valve rocker arm cover from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Left* in this supplement.
8. Remove the valve rocker arms from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
9. Remove the push rods from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
10. Remove the spark plugs from the left cylinder head. Refer to *Spark Plug Replacement* in this supplement.
11. Remove the exhaust manifold from the cylinder head. Refer to *Exhaust Manifold Removal – Left* in this supplement.
12. Remove the cylinder head bolts (1, 2, 3) from the engine block.
13. Remove the cylinder head and gasket from the engine block.
14. Clean and inspect the sealing surfaces on the cylinder heads.
15. Discard the cylinder head bolts.

Installation Procedure



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Important: Do not use sealer on the composition gaskets, and make sure that the punch code on the cylinder head gasket is facing up.

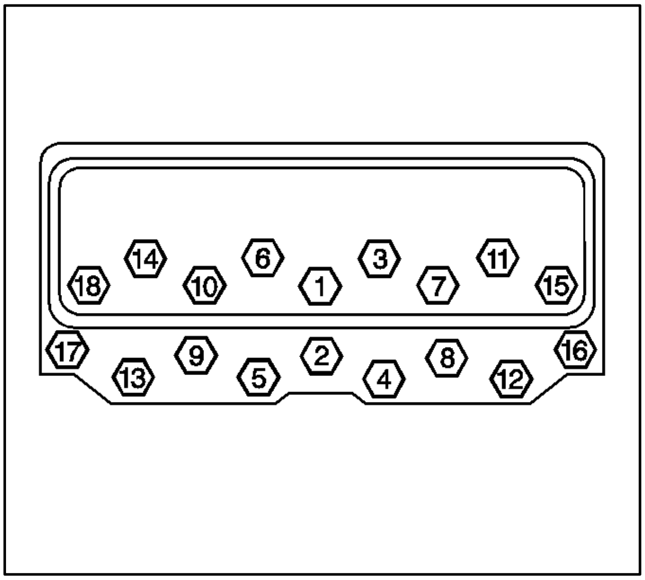
1. Install the cylinder head gasket to the engine block.
2. Install the cylinder head to the engine block.

Important: Make sure that that the threads on the cylinder head bolts are clean as well as the threaded holes in the engine block.

Important: Make sure the bolts (1, 2, 3) are installed in the proper location. Installing the bolts in the wrong location could result in damage to the cylinder head.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install new cylinder head bolts. Sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the new cylinder head bolts.



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Tighten

- Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).
- Retighten the bolts in a second pass in sequence to 30 N·m (22 lb ft). Then an additional 120 degrees using the *J 36630-A.*
- Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18) an additional 60 degrees and bolts (4, 5, 12, 13) an additional 30 degrees in a final pass using the *J 36630-A.*

4. Install the exhaust manifold to the cylinder head. Refer to *Exhaust Manifold Installation – Left* in this supplement.
5. Install the spark plugs to the left cylinder head. Refer to *Spark Plug Replacement* in this supplement.
6. Install the push rods to the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
7. Install the rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
8. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Left* in this supplement.
9. Install the water crossover and bypass hose. Refer to *Water Crossover Replacement* in this supplement.
10. Install the left side accessory bracket. Refer to *Accessory Bracket Replacement – Left* in this supplement.
11. Install the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
12. Fill the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
13. Install the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
14. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

Crankshaft Balancer Replacement

Tools Required

- *J 38416* Three Jaw Puller
- *J 42845* Crankshaft Balancer Installer
- *J 42846* Crankshaft Protector Button
- *J 42847* Flywheel Holding Tool

Removal Procedure

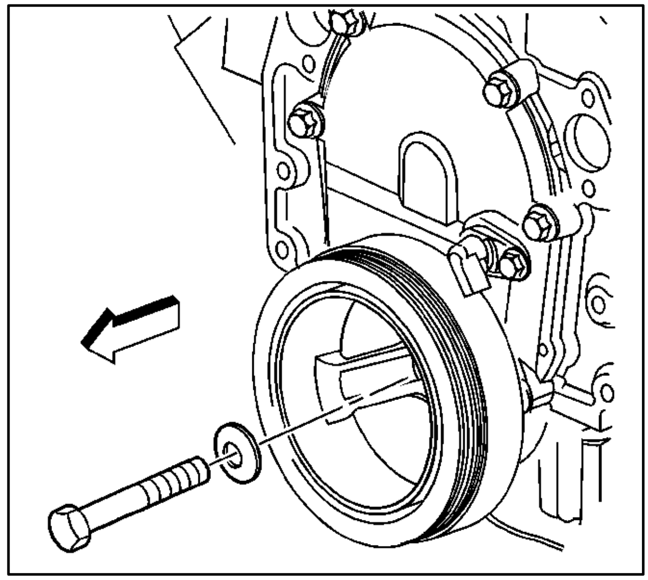
1. Remove the lower fan shroud. Refer to *Fan Shroud Replacement – Lower (8.1L)* in this supplement.
2. Remove the drive belt from the engine. Refer to *Drive Belt Replacement* in this supplement.
3. Remove the starter from the engine. Refer to *Starter Motor Replacement* in this supplement.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.

4. Install *J 42847* to the starter bolt holes.

   Tighten
   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).
5. Remove the crankshaft balancer bolt and washer from the crankshaft.



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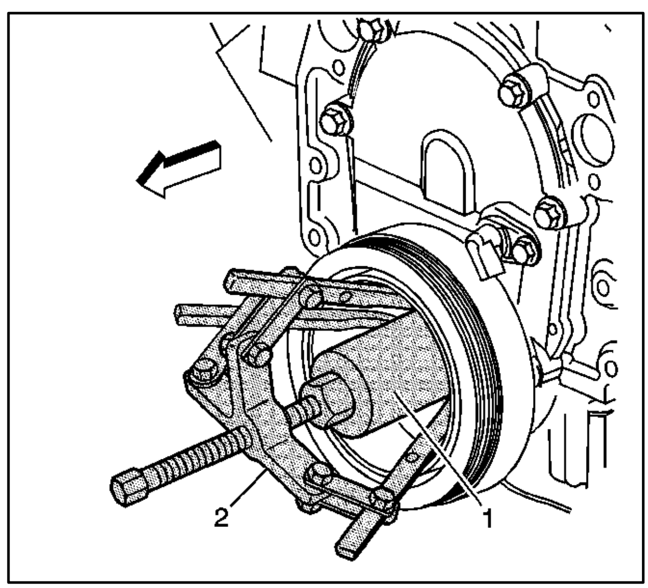
6. Install the *J 42846* onto the end of the crankshaft.
7. Install the *J 38416* to remove the crankshaft balancer.
8. Tighten the center screw of the *J 38416* until the crankshaft balancer is clear of the crankshaft nose.
9. Remove the *J 38416*.
10. Remove the crankshaft balancer.
11. Remove the *J 42846* from the end of the crankshaft.



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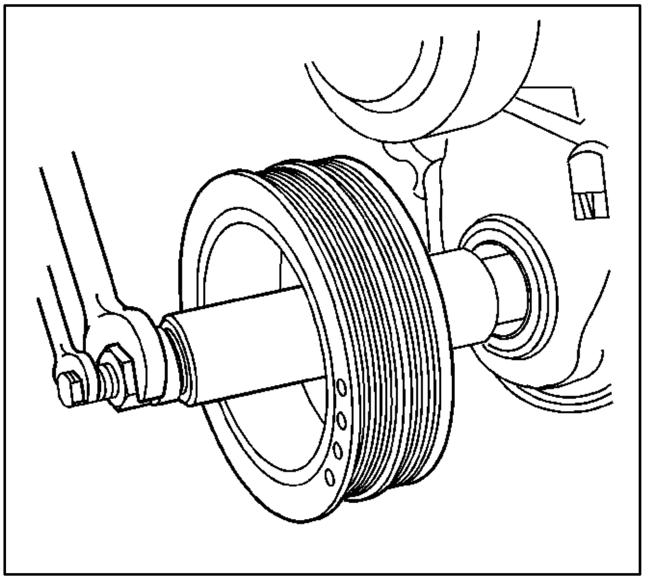

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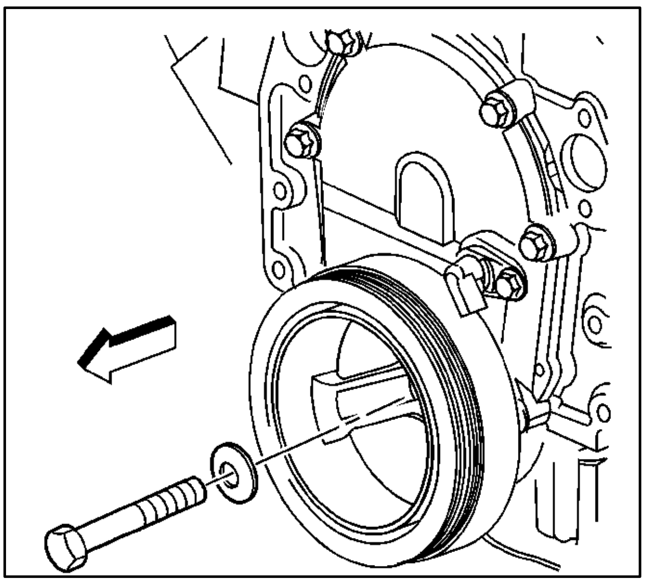
Installation Procedure

Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation. Apply grease or clean engine oil to the inside of the crankshaft balancer or the end of the crankshaft, to prevent galling during assembly.

1. Install the crankshaft balancer onto the end of the crankshaft.
2. Install *J 42845* to the crankshaft balancer.

Notice: The crankshaft balancer must be completely seated against the crankshaft sprocket. Failure to correctly install the crankshaft balancer may allow the crankshaft balancer to come loose, causing engine damage.

3. Tighten the *J 42845* until the crankshaft balancer is completely seated against the crankshaft sprocket.
4. Remove the *J 42845* from the crankshaft.



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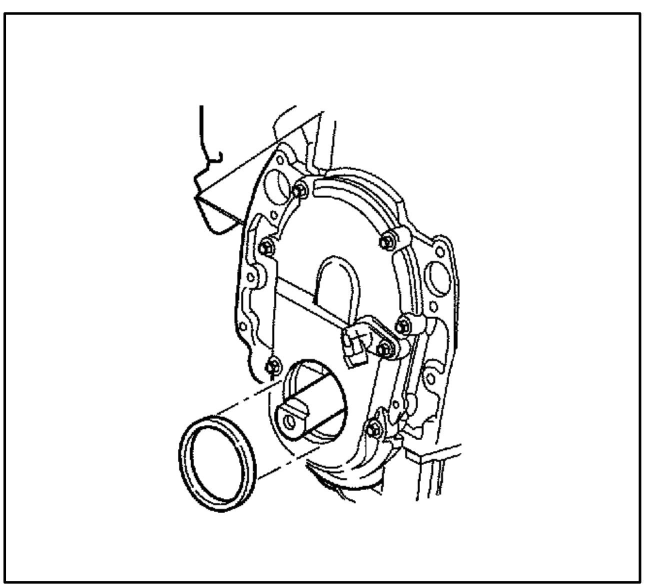
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

5. Install the crankshaft washer and bolt.

   Tighten

   Tighten the crankshaft balancer bolt to 255 N·m (189 lb ft).
6. Remove the *J 42847*.
7. Install the starter to the engine. Refer to *Starter Motor Replacement* in this supplement.
8. Install the drive belt to the engine. Refer to *Drive Belt Replacement* in this supplement.
9. Install the lower fan shroud. Refer to *Fan Shroud Replacement – Lower (8.1L)* in this supplement.



WRK61030

Crankshaft Front Cover Oil Seal Replacement

Tools Required

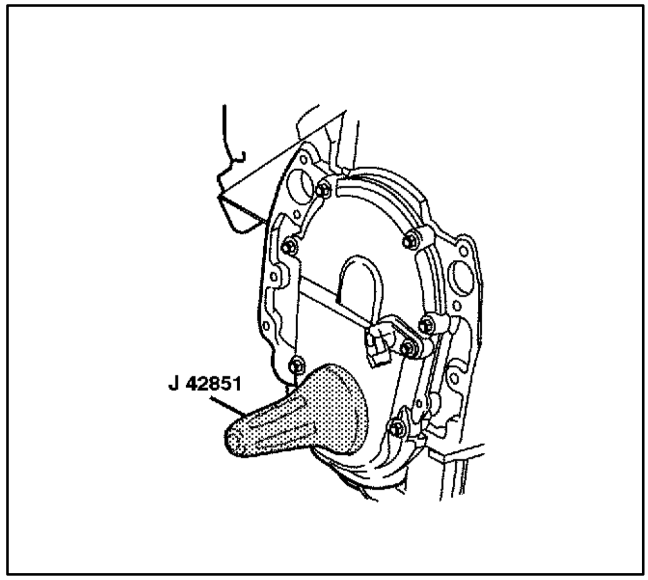
J 42851 Front Cover Oil Seal Installer

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
3. Remove the crankshaft front cover oil seal from the engine front cover.

Installation Procedure

1. Coat the crankshaft front cover oil seal with clean engine oil.
2. Use the J 42851 to install the crankshaft front cover oil seal to the engine front cover.
3. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
4. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



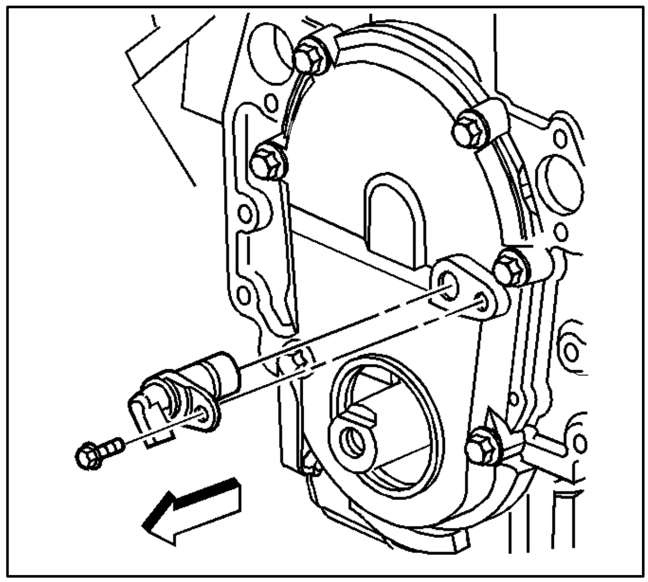
WRK61082

Engine Front Cover Replacement

Removal Procedure

Important: The engine front cover gasket is reusable. Replace only if gasket is damaged.

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
3. Remove the camshaft position sensor bolt.
4. Remove the camshaft position sensor.
5. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.
6. Remove the water pump from the engine block. Refer to *Water Pump Replacement (8.1L)* in this supplement.



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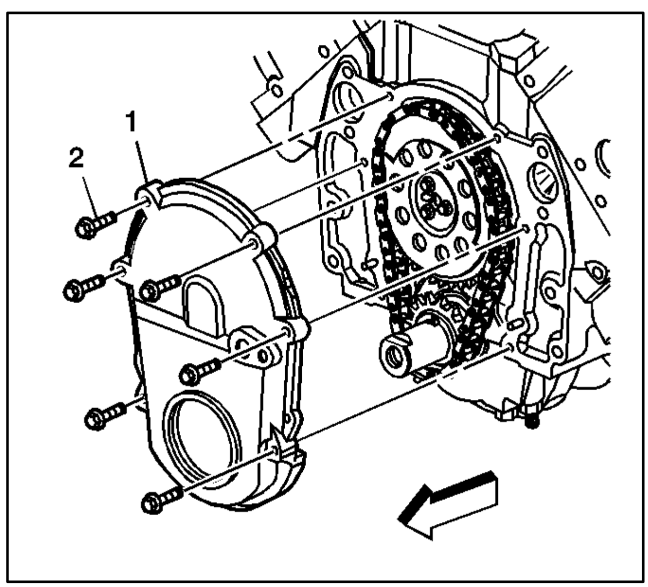
7. Remove the engine front cover mounting bolts (2).
8. Remove the engine front cover (1) and gasket from the engine block.



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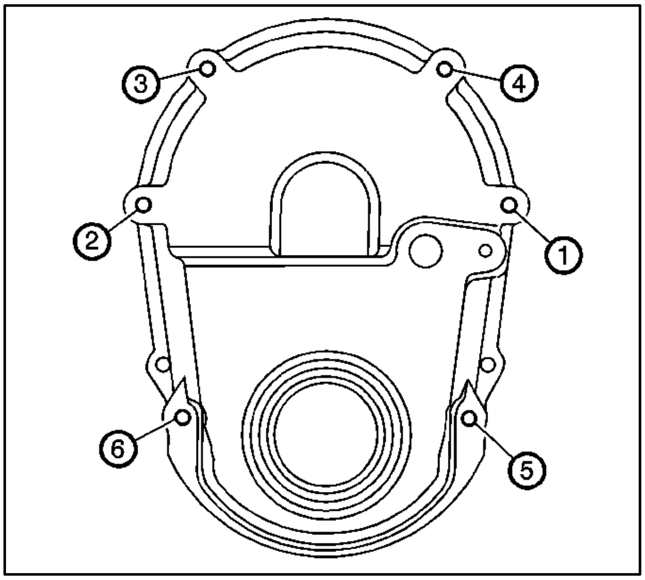

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Installation Procedure

Important: The engine front cover gasket is reusable. Replace only if gasket is damaged.

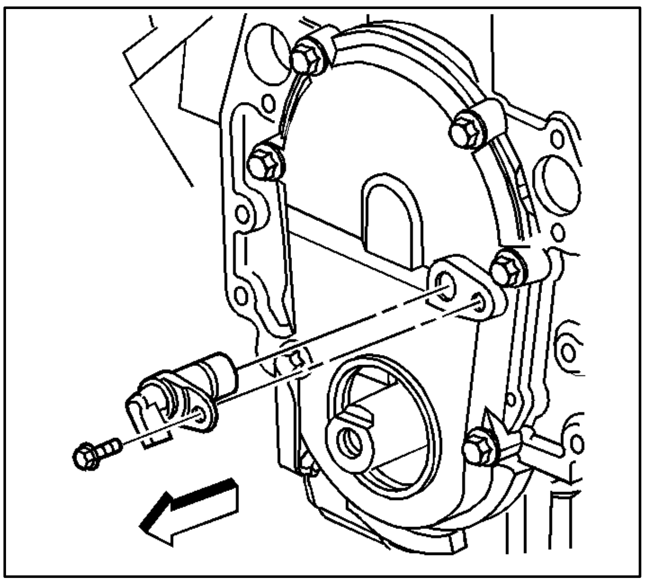
1. Install the engine front cover gasket to the front cover.
2. Install the engine front cover and gasket to the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the engine front cover bolts.

   Tighten

   - Tighten the engine front cover bolts in sequence to 6 N·m (54 lb in) in the first pass.
   - Tighten the engine front cover bolts in sequence to 12 N·m (106 lb in).



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4. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.
5. Apply a light film of clean engine oil to the camshaft position sensor O-ring.
6. Install the camshaft position sensor.
7. Install the camshaft position sensor bolt.

   Tighten

   Tighten the camshaft position sensor bolt to 12 N·m (106 lb in).
8. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
9. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

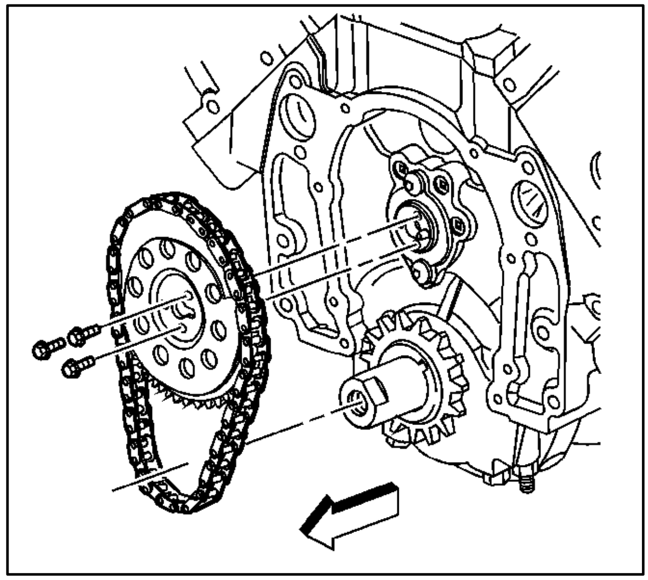
Timing Chain and Sprockets Replacement

Tools Required

- *J 22102* Crankshaft Oil Seal and Sprocket Installer
- *J 38416-B* Three Jaw Puller
- *J 42846* Crankshaft Protector Button

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
3. Remove the engine front cover. Refer to *Engine Front Cover Replacement* in this supplement.
4. Align the timing marks on the camshaft and crankshaft gears.
5. Remove the camshaft sprocket retaining bolts.
6. Remove the timing chain and camshaft sprocket.



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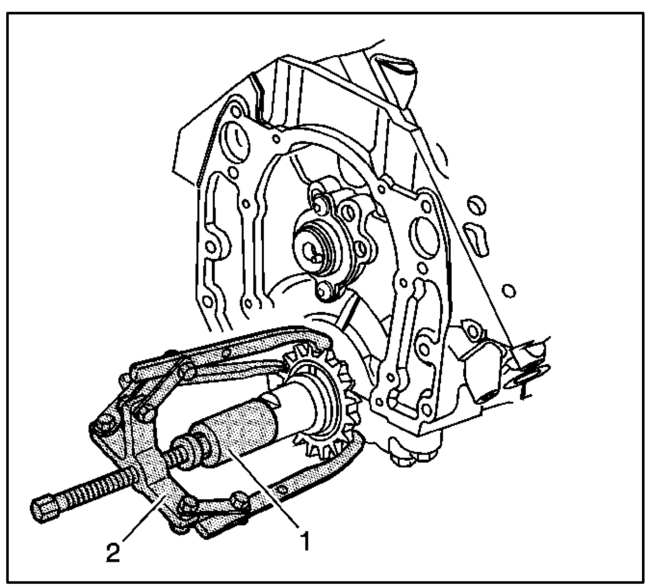
7. Install the *J 42846* onto the end of the crankshaft.
8. Use the *J 38416-B* to remove the crankshaft sprocket.



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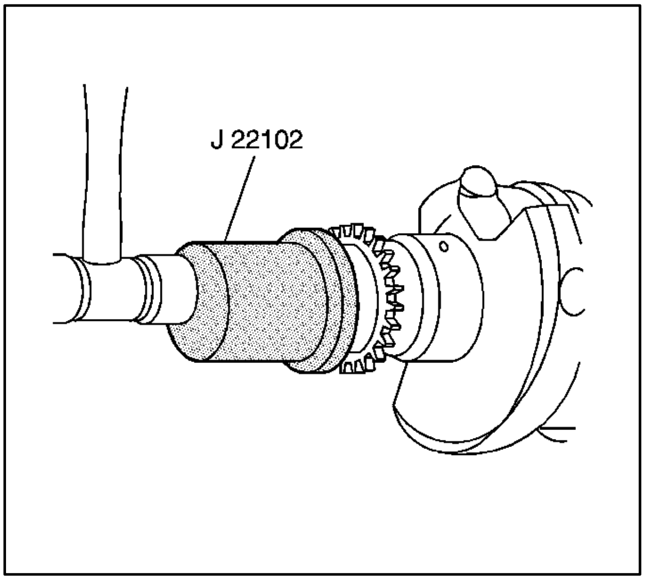

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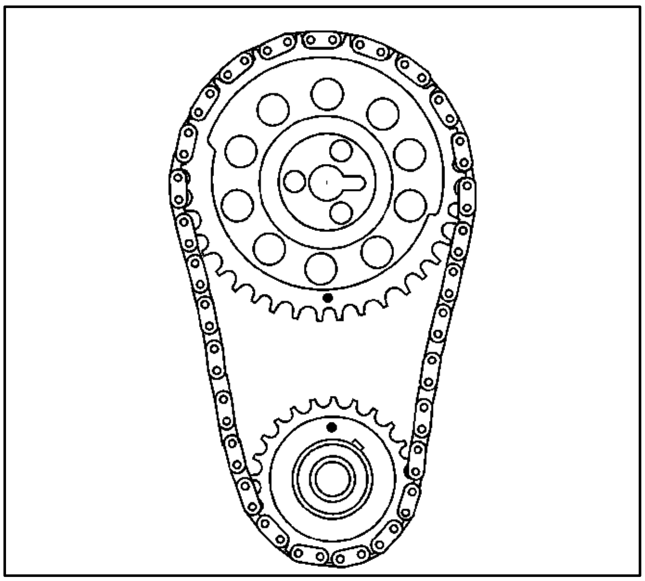
Installation Procedure

Important: Ensure the following conditions exist:

- The camshaft and the crankshaft timing marks are aligned.
- The camshaft dowel pin and camshaft sprocket holes are properly aligned.
- The gears and the chain mesh properly.

1. Use the *J 22102* to install the crankshaft sprocket.



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Important: Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may dislodge the rear camshaft plug and/or damage the camshaft.

2. Install the timing chain and sprocket to the camshaft.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the camshaft sprocket bolts.

   Tighten

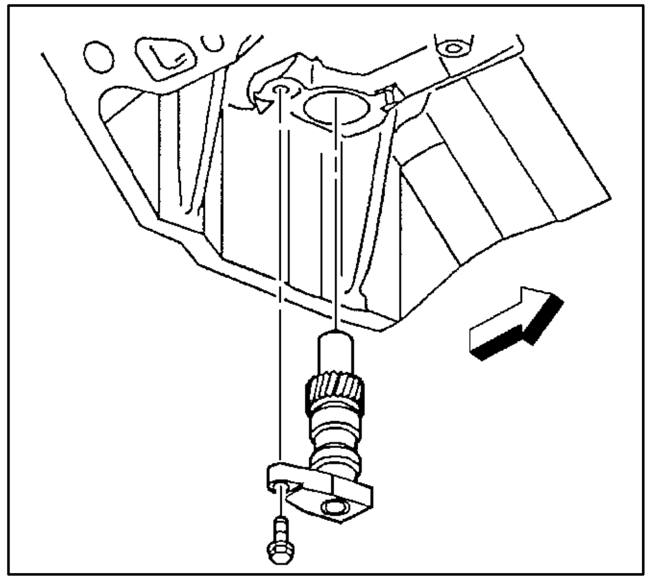
   - Tighten the three camshaft sprocket bolts to 30 N·m (22 lb ft).
   - Tighten the three camshaft sprocket bolts in a second pass to 30 N·m (22 lb ft).

4. Install the engine front cover. Refer to *Engine Front Cover Replacement* in this supplement.
5. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
6. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in this supplement.

Oil Pump Drive Replacement

Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
3. Remove the intake splash shield.
4. Remove the oil pump drive bolt.
5. Remove the oil pump drive.



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Installation Procedure

1. Apply grease to the oil pump drive gear for ease of assembly.

Important: Correct alignment of the oil pump drive and oil pump drive shaft is critical. Make sure both components mate correctly, or engine damage may occur.

2. Line up the oil pump drive, making sure that the oil pump drive is fully sealed in the engine block.

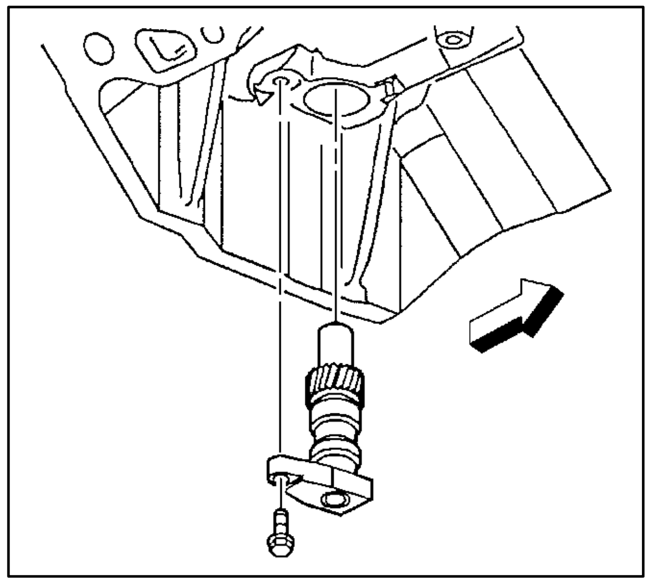
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the oil pump drive bolt.

   Tighten

   TIghten the oil pump drive bolt to 25 N·m (18 lb ft).

4. Install the intake splash shield.
5. Install the intake manifold. Refer to *Intake Manifold Replacement* in this supplement.
6. Connect the negative battery cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.



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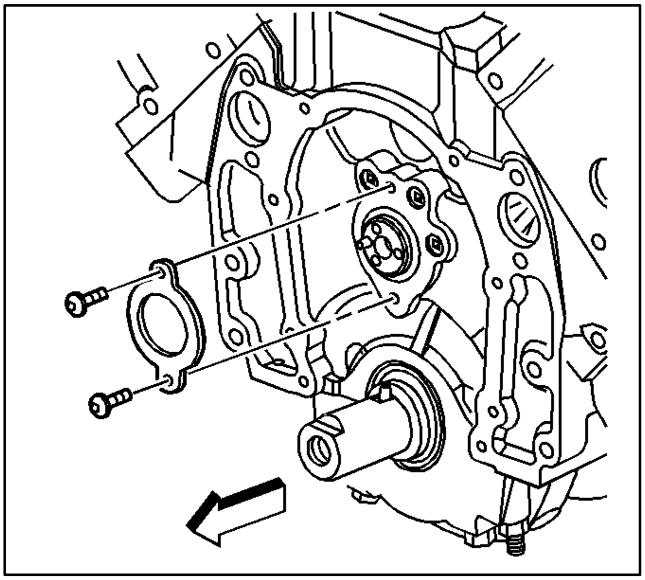

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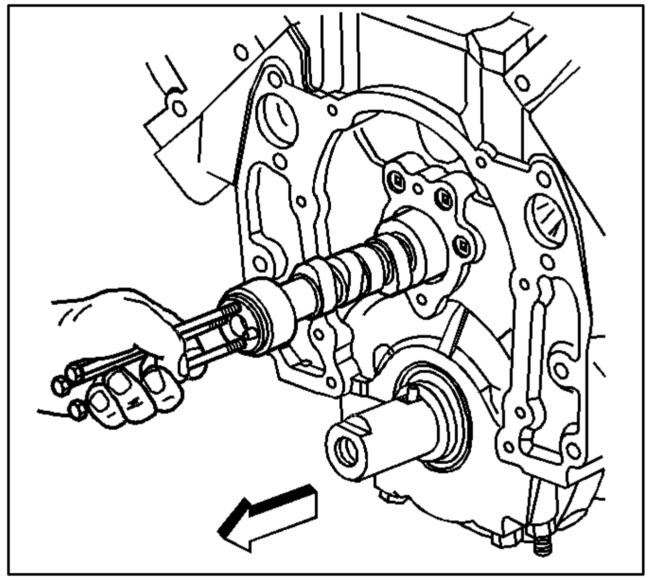
Camshaft Replacement

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Remove the drive belts. Refer to *Drive Belt Replacement* in this supplement.
4. Remove the air conditioning condenser. Refer to *Condenser Replacement* in this supplement.
5. Remove the radiator assembly from the vehicle. Refer to *Radiator Replacement (8.1 L)* in this supplement.
6. Remove the intake manifold from the engine block. Refer to *Intake Manifold Replacement* in this supplement.
7. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover Replacement – Right* in this supplement.
8. Remove the valve rocker arms from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
9. Remove the valve push rods from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
10. Remove the valve lifters from the engine block. Refer to *Valve Lifter Replacement* in this supplement.
11. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
12. Remove the water pump from the engine block. Refer to *Water Pump Replacement (8.1 L)* in this supplement.
13. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Replacement* in this supplement.
14. Remove the timing chain and sprockets from the engine block. Refer to *Timing Chain and Sprockets Replacement* in this supplement.
15. Remove the camshaft retainer bolt and retainer from the engine block.
16. Install three 8 – 1.25 x 100 mm long bolts into the camshaft threaded bolt holes. Use these bolts as a handle for the camshaft removal.

Important: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

17. Pull the camshaft from the engine block. Use care as not to damage the camshaft bearings.
18. Remove the three 8 – 1.25 x 100 mm bolts from the camshaft.



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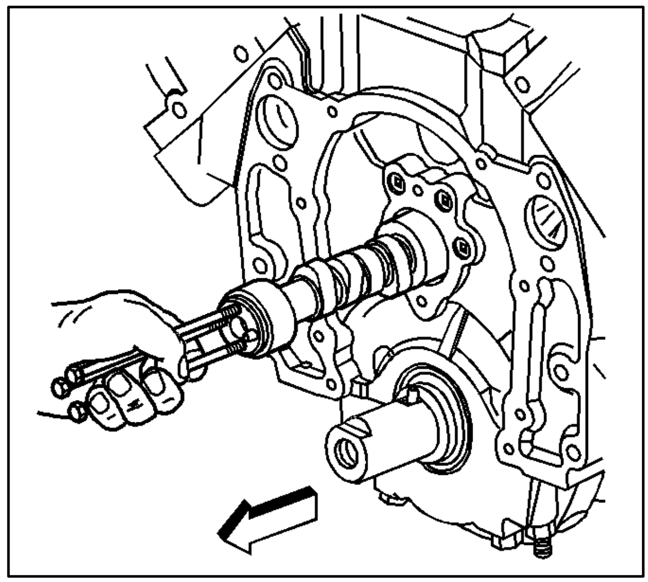
Installation Procedure

1. Install the three 8 – 1.25 x 100mm long bolts into the camshaft threaded bolt holes. Use these bolts as a handle to install the camshaft in the engine block.
2. Coat the camshaft lobes, camshaft bearing journals and camshaft bearings with engine oil supplement GM P/N 1052367 before installing the camshaft into the cylinder block.
3. Install the camshaft into the engine block.

Important: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

4. Remove the three 8 – 1.25 x 100 mm bolts from the camshaft.



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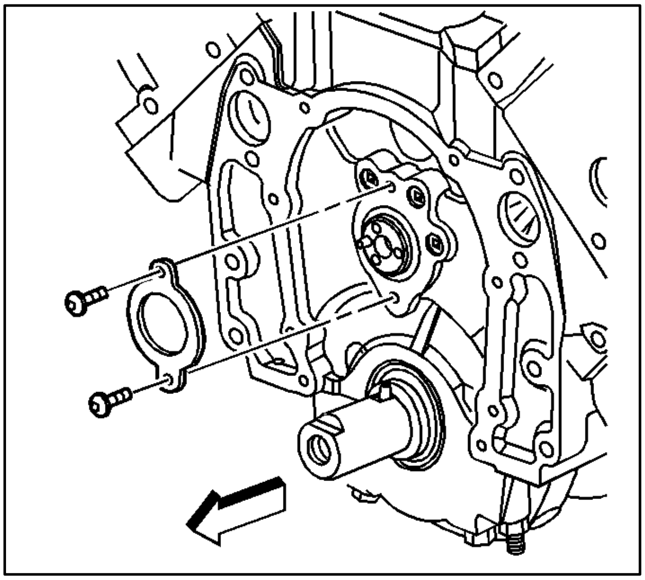

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Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. install the camshaft retainer and bolts in the engine block.

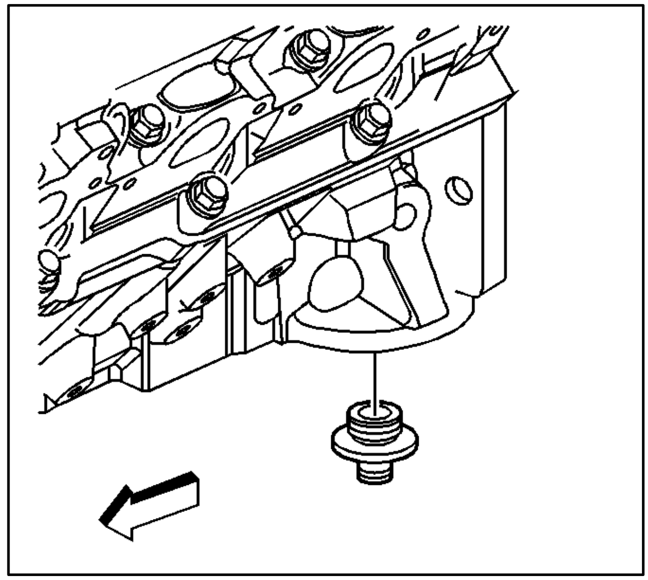
   Tighten

   Tighten the bolts to 12 N·m (106 lb in).
6. Install the timing chain and camshaft sprocket to the camshaft. Refer to *Timing Chain and Sprockets Replacement* in this supplement.
7. Install the engine front cover to the engine block. Refer to *Engine Front Cover Replacement* in this supplement.
8. Install the water pump to the engine block. Refer to *Water Pump Replacement* in this supplement.
9. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement* in this supplement.
10. Install the valve lifters to the engine block. Refer to *Valve Lifter Replacement* in this supplement.
11. Install the push rods into the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
12. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement* in this supplement.
13. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement – Left* and *Valve Rocker Arm Cover Replacement – Right* in this supplement.
14. Install the intake manifold to the engine block. Refer to *Intake Manifold Replacement* in this supplement.
15. Install the radiator in the vehicle. Refer to *Radiator Replacement 8.1L* in this supplement.
16. Install the air conditioning condenser to the vehicle. Refer to *Condenser Replacement* in this supplement.
17. Install the drive belt on the drive pulleys. Refer to *Drive Belt Replacement* in this supplement.
18. install the air intake duct. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
19. Connect the battery negative cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.

Oil Filter Bypass Valve Replacement

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
2. Remove the oil filter from the engine block. Refer to *Engine Oil and Oil Filter Replacement* in this supplement.
3. Remove the oil filter fittings from the engine block using a hex wrench.



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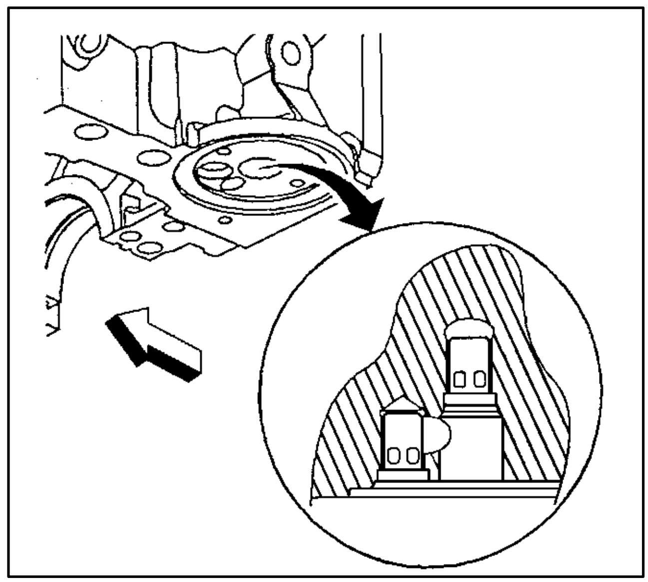
4. Remove the oil filter bypass valves. Unstake the tangs on the oil bypass valves and remove with long nose pliers.
5. Discard the oil bypass valves.



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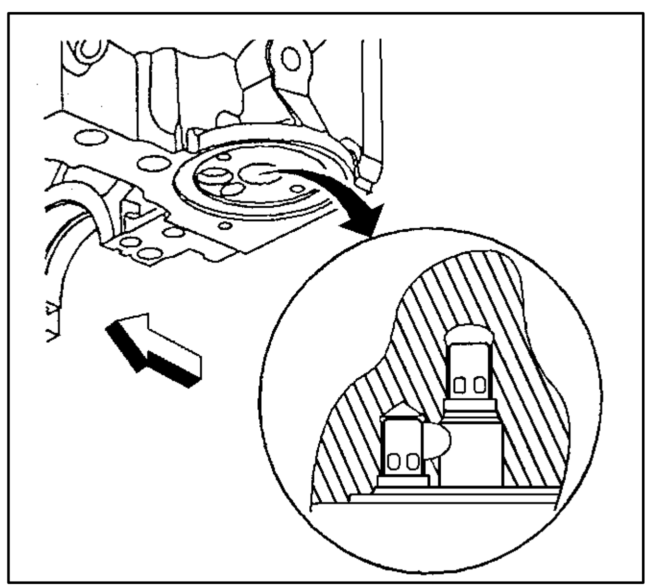
Installation Procedure

1. Install the new bypass valves. Stake the tangs on the oil bypass valves.



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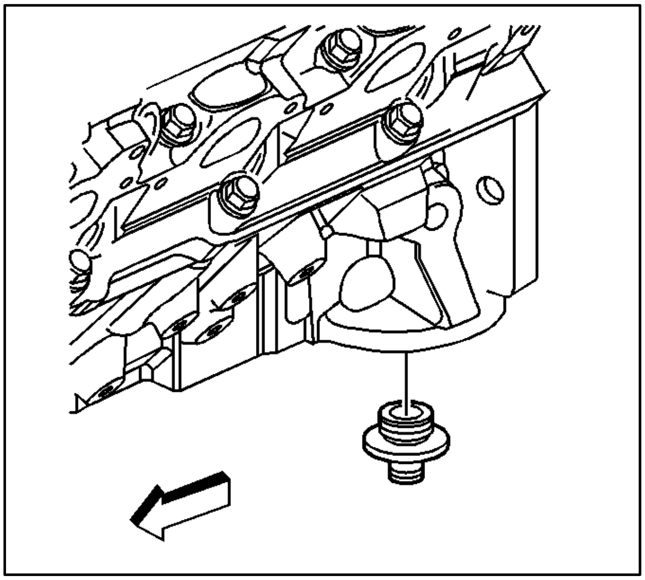

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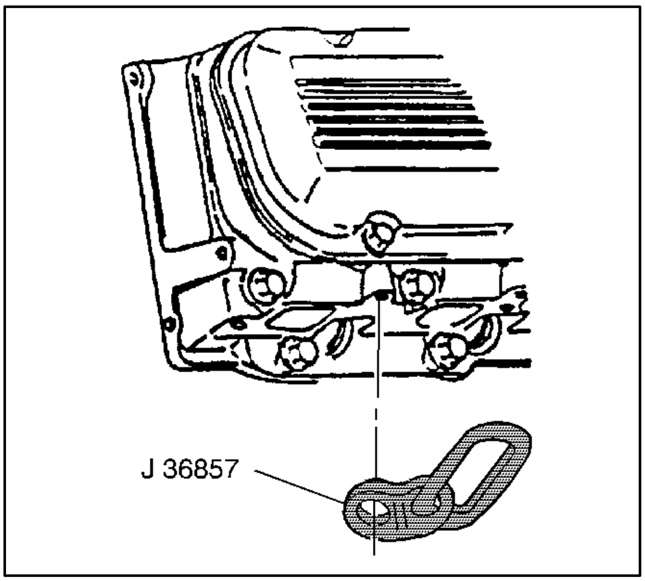
2. Install the oil filter fitting.

   Tighten

   Tighten the oil filter fitting to 66 N·m (49 lb ft).
3. Install the oil filter to the adapter. Refer to *Engine Oil and Oil Filter Replacement* in this supplement.
4. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in this supplement.



66457

Oil Pan Replacement

Tools Required

J 36857 Engine Lift Bracket

Removal Procedure

Notice: Do not raise the engine by the crankshaft balancer to perform this service procedure. Damage to the crankshaft balancer or the crankshaft may occur.

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the oil level indicator and tube from the engine. Refer to *Oil Level Indicator and Tube Replacement* in this supplement.
3. Drain the crankcase. Refer to *Engine Oil and Oil Filter Replacement* in this supplement.
4. Remove the oil cooler lines from the retaining bracket. Refer to *Engine Oil Cooler Line Replacement (8.1L*) in this supplement.
5. Remove the upper fan shroud. Refer to *Fan Shroud Replacement – Upper (8.1L)* in this supplement.
6. Unclip and reposition the starter electrical wiring harness.

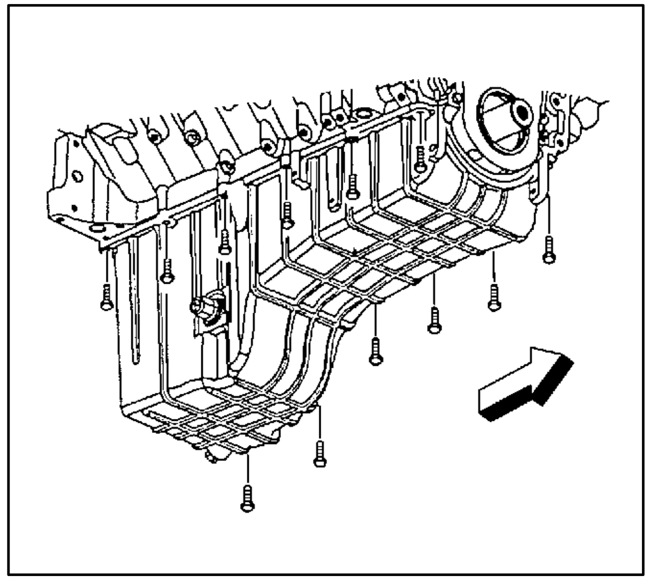
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

7. Attach *J 36857* to the rear of the right cylinder head and to the front of the left cylinder head.
8. Install the attaching bolt and washer. Use P/N 9428217 with P/N 15650963.

   Tighten

   Tighten the lifting bracket bolts to 40 N·m (30 lb ft).

9. Remove the front engine mount through bolts. Refer to *Engine Mount Replacement – Left* and *Engine Mount Replacement – Right* in this supplement.
10. Raise engine with a suitable lifting device.
11. Remove the oil pan bolts from the engine block.



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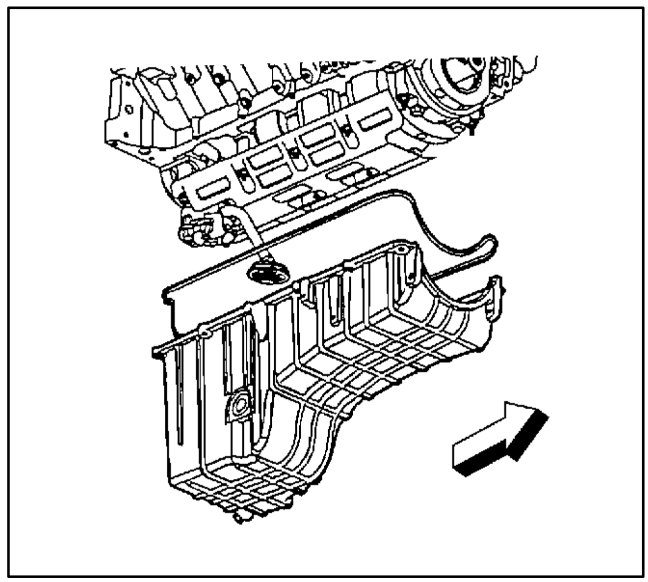
12. Remove the oil pan from the vehicle.
13. Remove the oil pan gasket from the engine block.
14. Remove the oil from the sealing surfaces.



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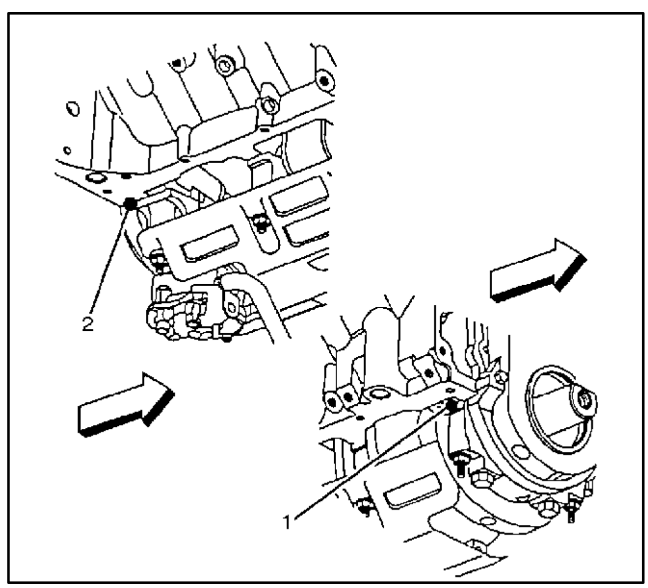
Installation Procedure

Important: The oil pan must be installed within five minutes of the sealer being applied or sealer will begin to cure, causing an inadequate seal.

1. Apply sealant GM P/N 12346286 to the side of the front (1) and rear (2) crankshaft bearing caps, on both the left and right side (four locations total).



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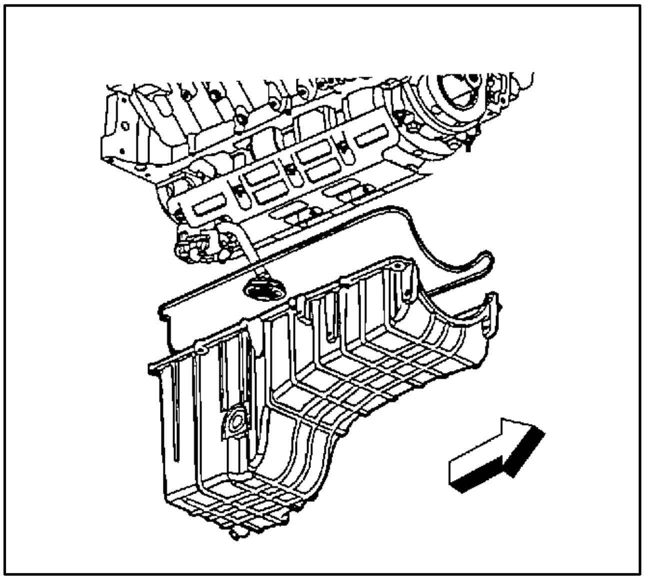

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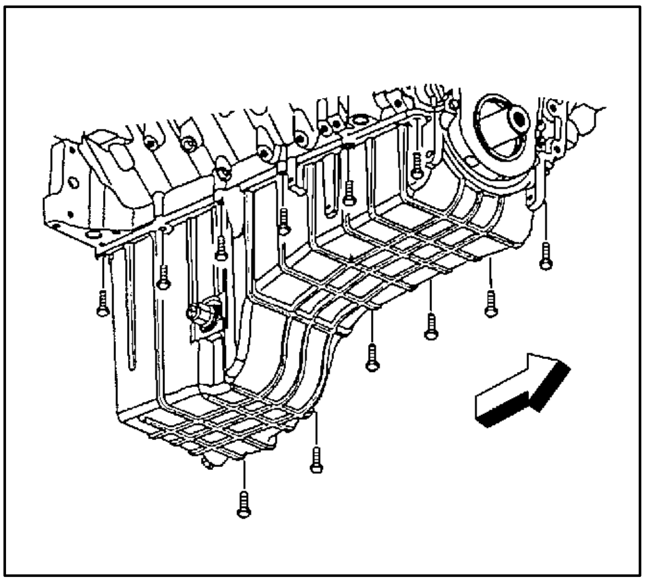
Important: the oil pan gasket is reusable. Replace only if the gasket is damaged.

2. Install the oil pan gasket into the oil pan groove.
3. Install the oil pan gasket and oil pan to the engine block.



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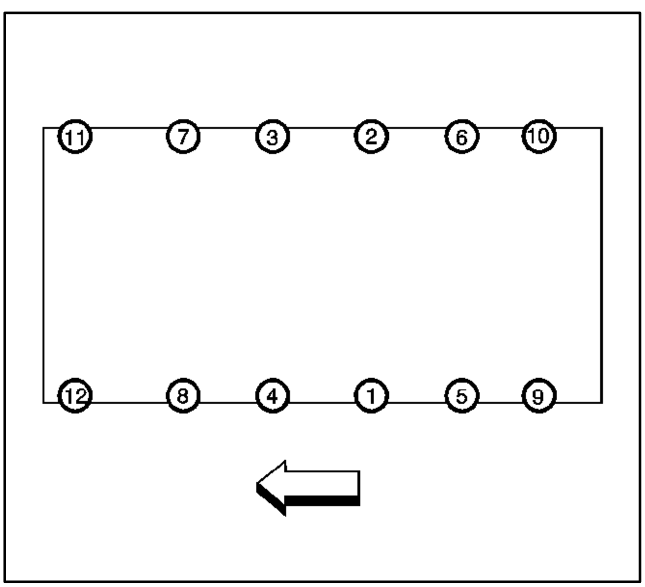
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the oil pan bolts to the oil pan and engine block.



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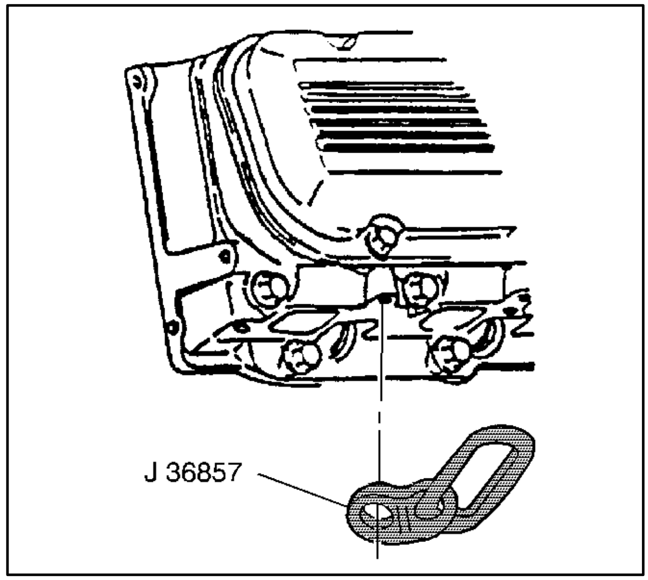
Tighten

Tighten the oil pan bolts in sequence to 25 N·m (18 lb ft).

5. Lower the engine back into position.
6. Install the front engine mount through bolts. Refer to *Engine Mount Replacement – Left and Engine Mount – Right* in this supplement.

7. Remove the attaching bolt, washer, and the *J 36857* from the rear of the right cylinder head and from the front of the left cylinder head.
8. Clip the starter electrical wiring harness back into the wire clip.
9. Install the upper fan shroud. Refer to *Fan Shroud Replacement – Upper (8.1L)* in this supplement.
10. Install the oil cooler lines to the retaining bracket. Refer to *Engine Oil Cooler Line Replacement (8.1L)* in this supplement.
11. Install the oil level indicator and tube to the engine. Refer to *Oil Level Indicator and Tube Replacement* in this supplement.
12. Connect the negative battery cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



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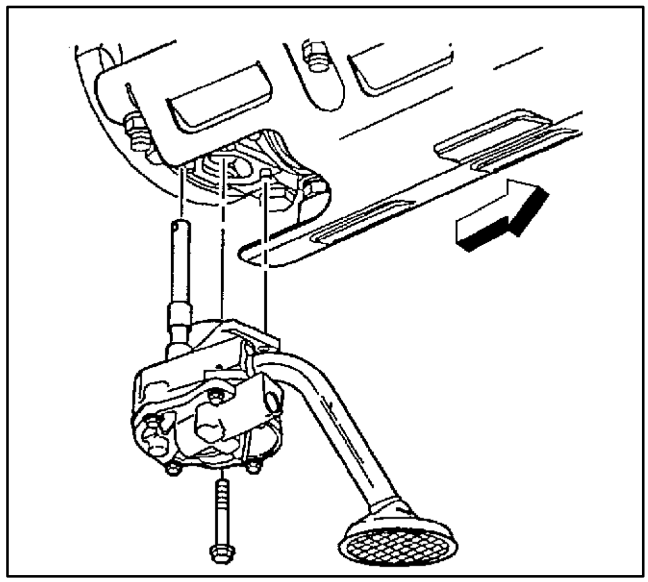
Oil Pump Replacement

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Drain the crankcase. Refer to *Engine Oil and Oil Filter Replacement* in this supplement.
3. Remove the oil pan from the engine block. Refer to *Oil Pan Replacement* in this supplement.
4. Remove the oil pump retaining bolt that attaches the oil pump to the rear crankshaft bearing cap.
5. Remove the oil pump, driveshaft, and retainer from he rear crankshaft bearing cap.
6. Separate the oil pump, driveshaft and retainer.
7. Discard the driveshaft retainer.



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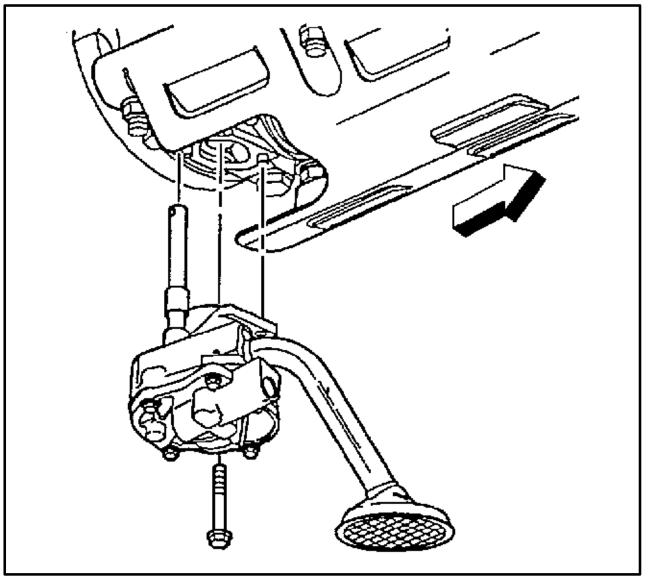

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Installation Procedure

Important: When installing the oil pump, always replace the retainer between the oil pump and the shaft.

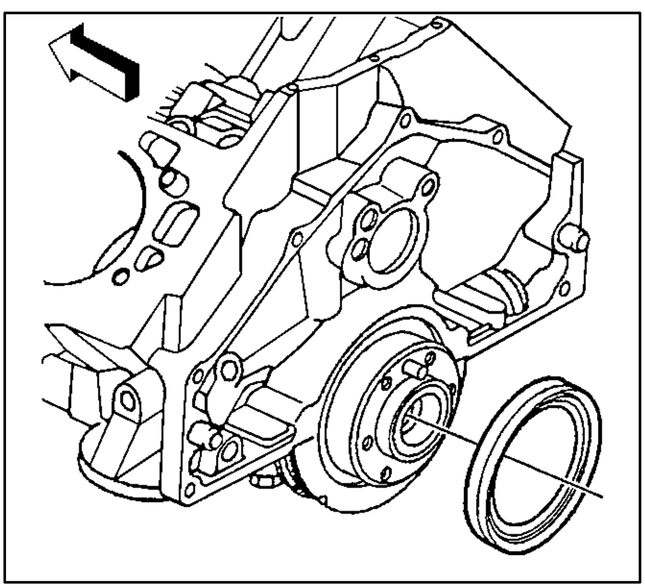
1. Assemble the oil pump, drive shaft and a NEW retainer.
2. Install the oil pump assembly. Position the oil pump onto the locating pins.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the oil pump mounting bolt to the rear crankshaft bearing cap.

   Tighten

   Tighten the bolt to 75 N·m (56 lb ft.)
4. Install the oil pan to the engine block. Refer to *Oil Pan Replacement* in this supplement.
5. Connect the battery negative cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



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Crankshaft Rear Oil Seal Replacement

Tools Required

- *J 43320* Crankshaft Rear Seal Puller
- *J 42849* Crankshaft Rear Seal Installer

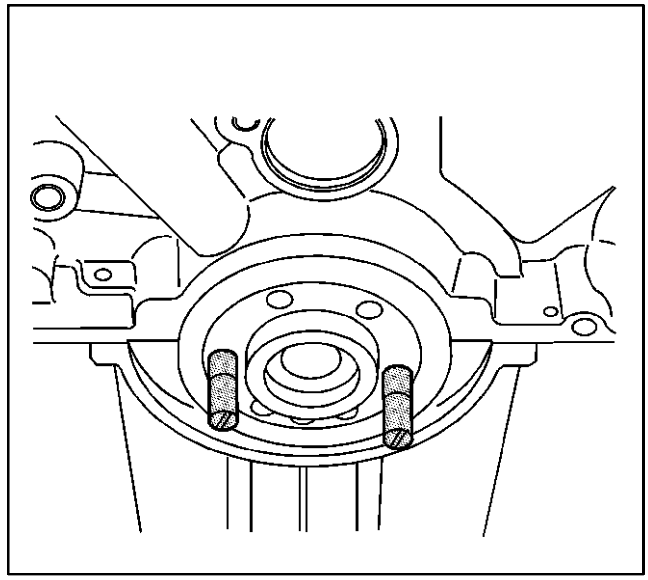
Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.

Notice: Do not remove or attempt to repair the Allison LCT1000 automatic transmission without calling Workhorse Technical Assistance.

3. Remove the transmission from the vehicle.
4. Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Replacement* in this supplement.

5. Install the *J 43320* guide pins into the crankshaft.



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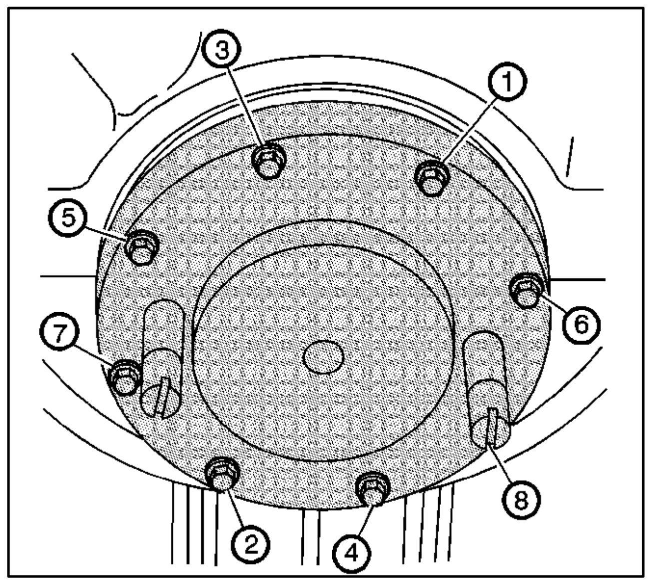
6. Install the *J 43320* over the guide pins.
7. Using a suitable drill, insert eight of the self-drilling sheet metal screws (screws provided with special tool kit) into the rear crankshaft seal, using a criss-cross pattern.



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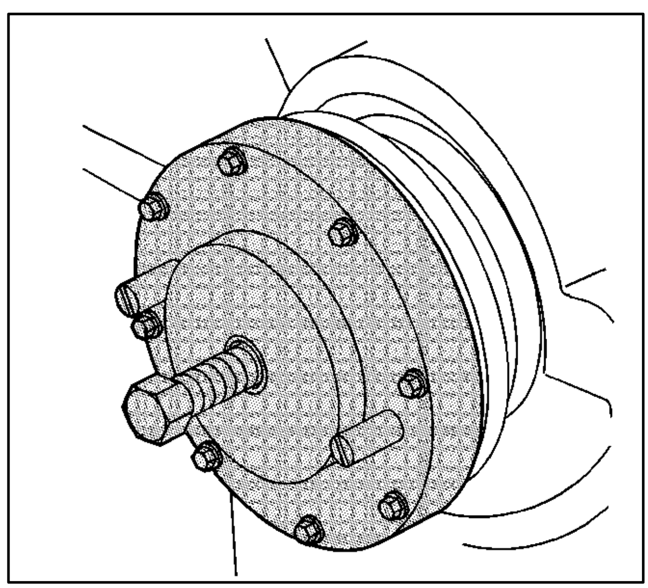
8. Thread the center bolt of *J 43320* into the crankshaft to remove the seal.
9. Remove the *J 43320* guide pins from the crankshaft.



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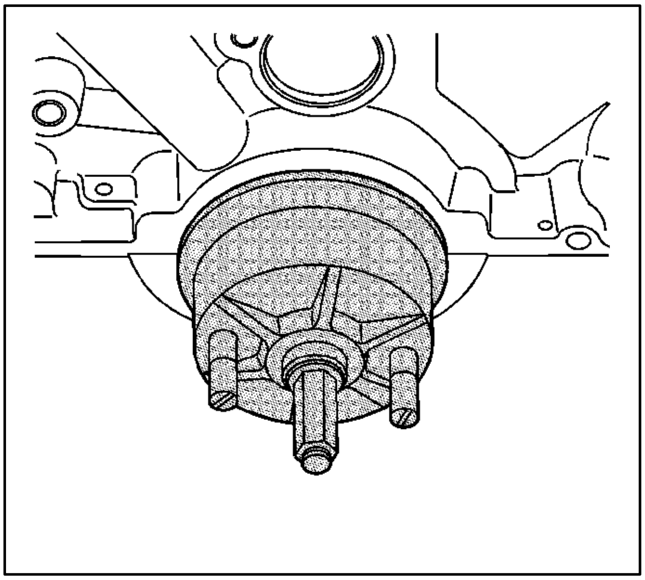

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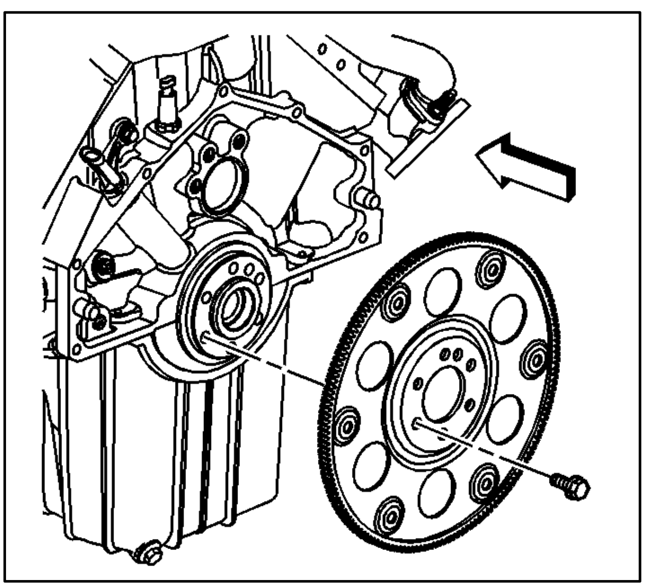
Installation Procedure

1. Make sure the crankshaft is free of grit, loose rust and burrs. Correct as needed.
2. Apply a very light film of oil onto the crankshaft sealing surface. DO NOT apply oil to the sealing surface of the engine block.
3. Install the seal on the *J 42849.*
4. Position *J 42849* against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Rotate the center nut until the *J 42829 bottoms.*
7. Remove the *J 42829.*
8. Install the flywheel to the crankshaft. Refer to *Engine Flywheel Replacement* in this supplement.
9. Install the transmission to the vehicle.
10. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
11. Connect the battery negative cable to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



470572

Engine Flywheel Replacement (Automatic Transmission)

Removal Procedure

1. Disconnect the battery negative cables from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.

Notice: Do not remove or attempt to repair the Allison LCT1000 automatic transmission without calling Workhorse Technical Assistance.

3. Remove the transmission from the vehicle.
4. Remove the engine flywheel bolts.
5. Remove the engine flywheel.

Installation Procedure

Important: Make sure the automatic transmission flywheel is installed correctly. “Engine Side” is stamped on the flywheel to assist with installation.

1. Install the inner engine flywheel retainer.
2. Install the engine flywheel.

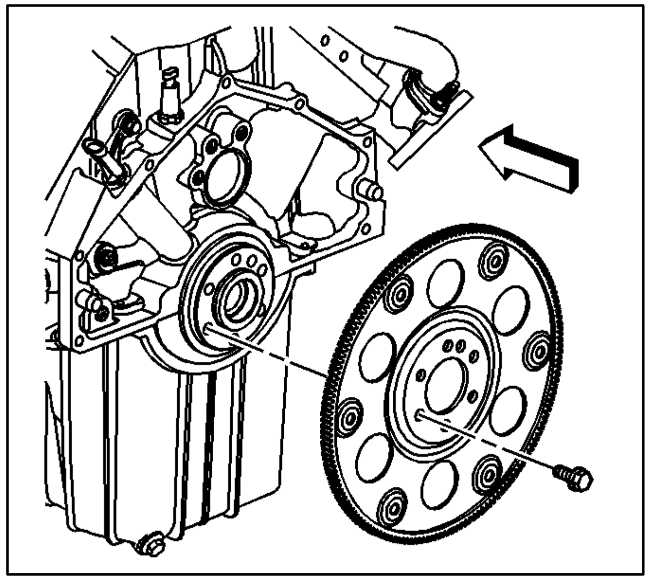
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

3. Install the engine flywheel bolts.

   Tighten

   - Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the first pass.
   - Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for final pass.

4. Install the automatic transmission.
5. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
6. Connect the battery negative cables to the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.



470572

Engine Replacement

Tools Required

J 36857 Engine Lift Brackets

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable Replacement* in the WCC Service Manual.
2. Remove the air intake duct from the throttle body. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Remove the ignition coils from the valve rocker arms covers. Refer to *Ignition Coil(s) Replacement* in this supplement.
4. Disconnect the fuel supply lines from the fuel rail. Refer to *Fuel Rail Assembly Replacement* in this supplement.
5. Drain the cooling system. Refer to *Draining and Filling Cooling System* in the WCC Service Manual.
6. Discharge the A/C system. Refer to *Refrigerant Recovery and Recharging* in the WCC Service Manual.
7. Remove the air conditioning compressor from the engine block. Refer to *Compressor Replacement* in this supplement.
8. Remove the fan assembly. Refer to *Fan Replacement (8.1L)* in this supplement.
9. Remove the radiator from the vehicle. Refer to *Radiator Replacement (8.1L)* in this supplement.
10. Disconnect the electrical connectors on the throttle body actuator control. Refer to *Throttle Actuator Control (TAC) Module Replacement* in this supplement.
11. Disconnect the vacuum lines from the engine, as required.
12. Remove the generator from the generator mounting bracket. Refer to *Generator Replacement* in this supplement.
13. Remove the engine electrical harness and tie out of the way.
14. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
15. Remove the hoses from the power steering pump. Refer to *Power Steering Hydraulic Hoses Replacement – Pressure,* and *Power Steering Hydraulic Hoses Replacement – Return* in this supplement.
16. Remove the ground strap from the engine block.
17. Remove the starter motor from the engine block. Refer to *Starter Motor Replacement* in this supplement.

Notice: Do not remove or attempt to repair the Allison LCT1000 automatic transmission without calling Workhorse Technical Assistance.

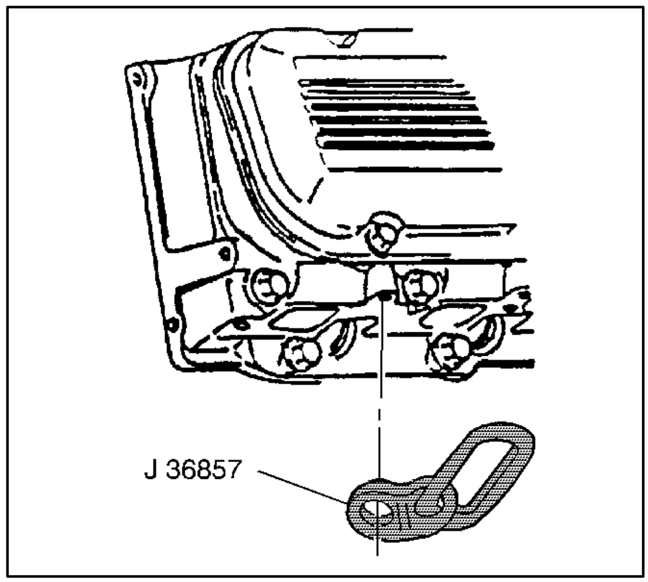
20. Remove the bolts from the torque convertor to the flywheel. Refer to *Engine Flywheel Replacement* in this supplement.
21. Remove the exhaust pipes from the exhaust manifolds. Refer to *Exhaust Pipe Replacement (Front) (8.1L)* in this supplement.
22. Remove the bolts from the transmission to the engine block.
23. Remove the engine auxiliary oil cooler lines from the engine block. Refer to *Engine Oil Cooler Lines Replacement (8.1L)* in this supplement.
24. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
25. Support the transmission with a suitable jack.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

26. Attach *J 36857* to the rear of the right cylinder head and to the front of the left cylinder head.
27. Install the attaching bolt and washer. Use P/N 9428217 with P/N 15650963.

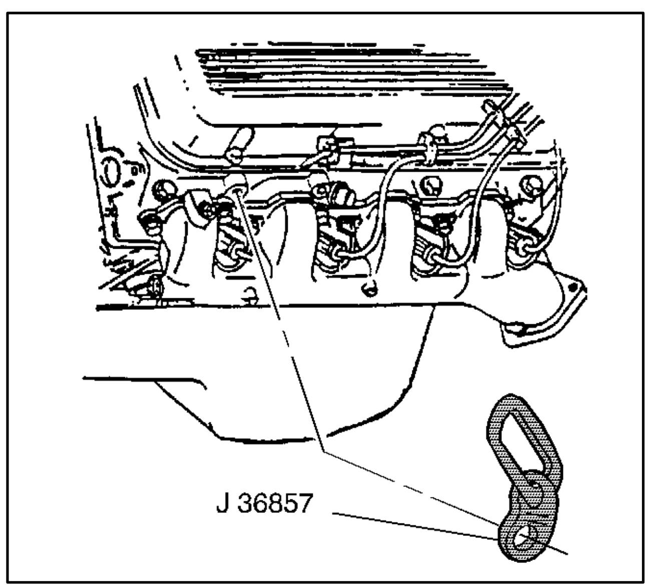
    Tighten

    Tighten the lift bracket bolts to 40 N·m (30 lb ft).
28. Remove the front engine mount through bolts. Refer to *Engine Mount Replacement – Left* and *Engine Mount Replacement – Right* in this supplement.
29. Remove the engine with a suitable lifting device.
30. Remove the generator mounting bracket from the engine block. Refer to *Generator Bracket Replacement* in this supplement.



66457

31. Remove the air conditioning compressor/power steering pump mounting bracket from the cylinder head. Refer to *Accessory Bracket Replacement – Left* in this supplement.
32. Remove the lift bracket bolts, washers, and *J 36857* from the cylinder heads.



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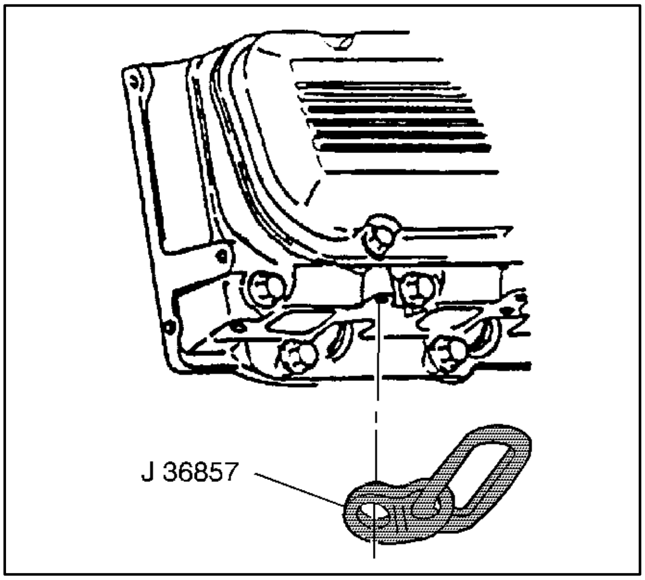
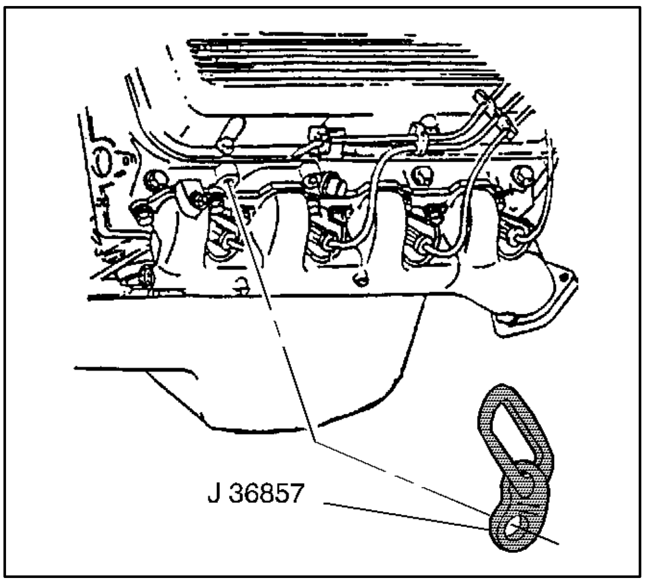


66457

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Attach *J 36857* to the rear of the right cylinder head.
   Install the attaching bolt and washer. Use P/N 9428217 with P/N 15650963.
   Tighten
   Tighten the lift bracket bolts to 40 N·m (30 lb ft).



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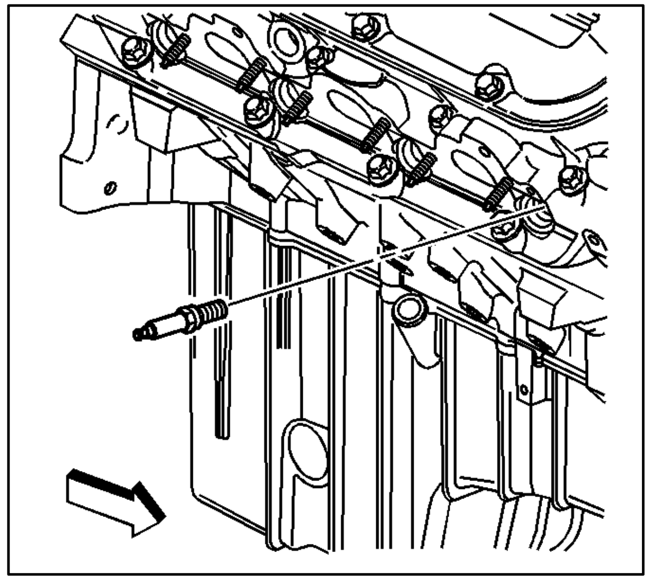
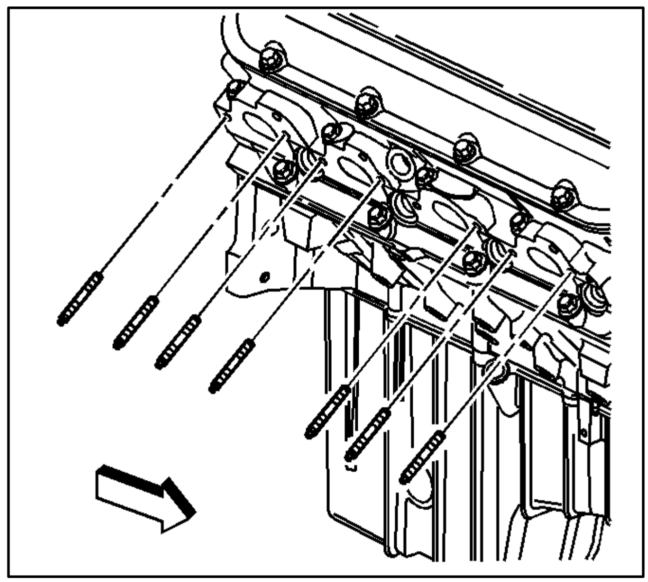
2. Attach *J 36857* to the front of the left cylinder head.
   Install the attaching bolt and washer. Use P/N 9428217 with P/N 15650963.
   Tighten
   Tighten the lift bracket bolts to 40 N·m (30 lb ft).
3. Install the engine into the vehicle.
4. Install the engine mount through bolts. Refer to *Engine Mount Replacement – Left* and *Engine Mount Replacement – Right* in this supplement.
5. Remove the engine lift bracket bolts, washers, and *J 36857* from the cylinder heads.
6. Install the air conditioning compressor/power steering pump mounting bracket to the engine block. Refer to *Accessory Bracket Replacement – Left* in this supplement.
7. Install the generator mounting bracket. Refer to *Generator Bracket Replacement* in this supplement.
8. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
9. Install the bolts from the transmission to the engine block.
10. Install the ground strap to the engine block.
11. Install the hoses to the power steering pump. Refer to *Power Steering Hydraulic Hoses Replacement – Pressure*, and *Power Steering Hydraulic Hoses Replacement – Return* in this supplement.
12. Install the torque converter bolts to the flywheel. Refer to *Engine Flywheel Replacement* in this supplement.
13. Install the starter motor to the engine block. Refer to *Starter Motor Replacement* in this supplement.

13. Remove the right spark plugs.



470727

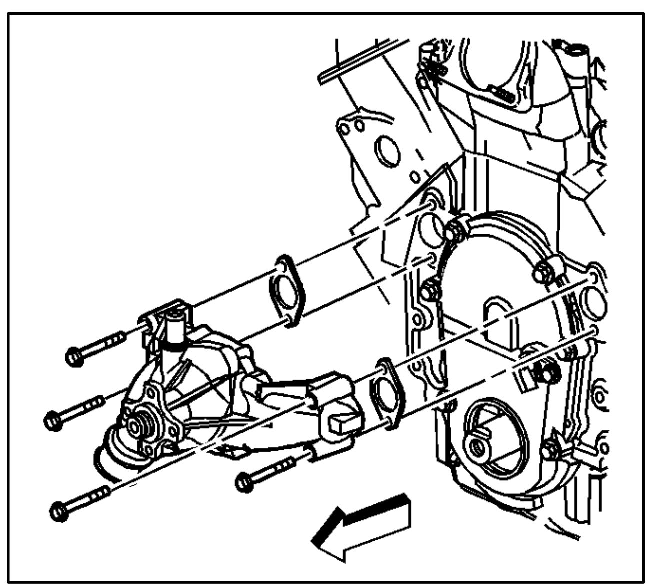
14. Remove the exhaust manifold studs, if necessary.



470723

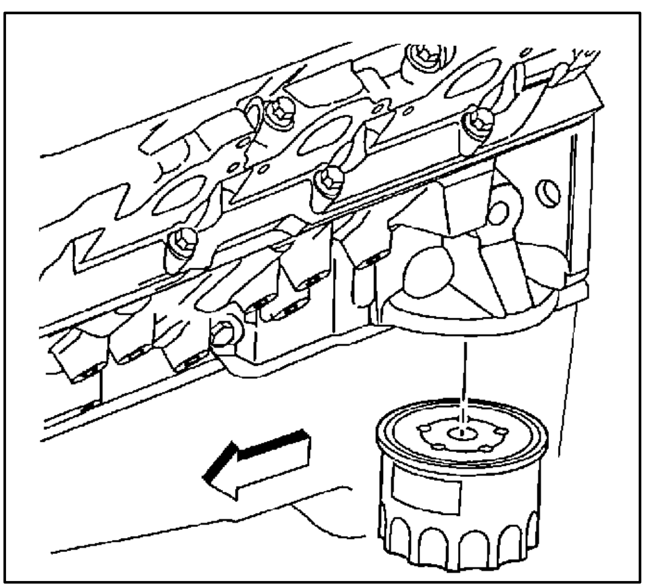
Water Pump Removal

1. Remove the water pump bolts.
2. Remove the water pump.
3. Remove the water pump gaskets.



470792

- Add engine oil supplement P/N 1052367 or equivalent to the engine oil.
- Remove the fuel pump fuse and disconnect the coil harness connectors, then crank until oil pressure is present.
- Crank the engine several times. Listen for any unusual noises or evidence that any of the parts are binding.
- Start the engine and listen for unusual noises.
- Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure. If necessary install an oil pressure gauge and measure the oil pressure.
- Run the engine and about 1000 RPM until the engine has reached normal operating temperature.
- Inspect for oil and or coolant leaks while the engine is running.
- Stop engine and perform a final inspection for the proper engine oil and coolant levels.
- The final step is to perform the CKP System Variation Learn Procedure. Refer to *CKP System Variation Learn Procedure*



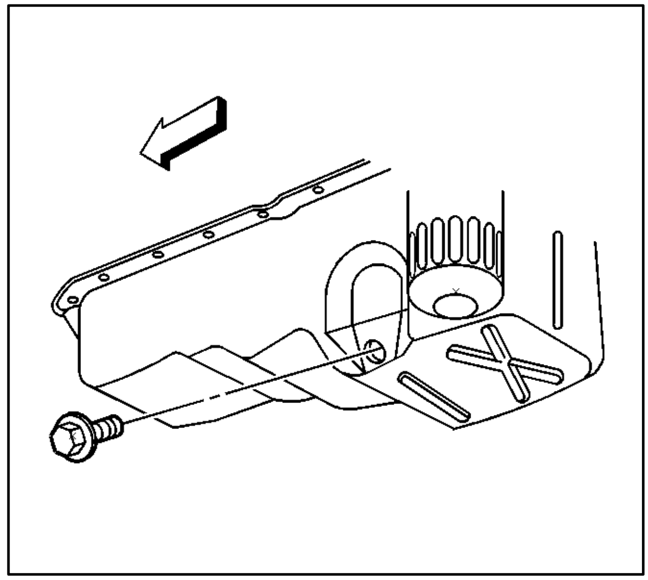
WRK61063

Engine Oil and Oil Filter Replacement

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
2. Remove the oil filter from the engine block. Clean the oil filter mounting surfaces.

3. Remove the oil pan drain plug and drain the engine oil. Clean the oil pan plug and mounting surface.



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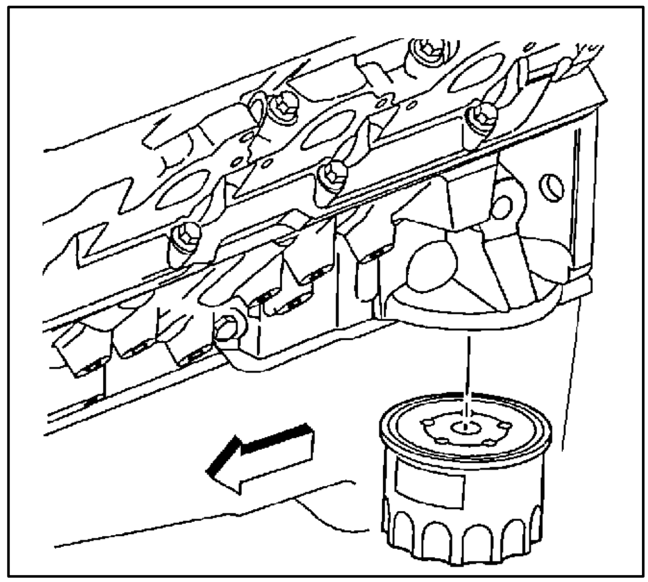
Installation Procedure

1. Install the oil filter to the engine block. Tighten the oil filter per the oil filter manufacturer's instruction printed on the oil filter box



WRK61063

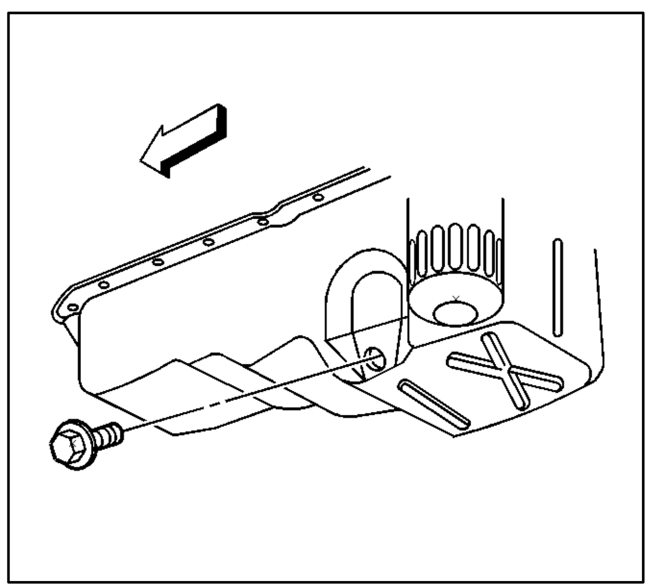
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the drain plug to the oil pan.

   Tighten

   Tighten the drain plug to 28 N·m (21 lb ft).

3. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
4. Fill the crankcase with oil. Refer to *Fluid and Lubricant Recommendations* in this supplement.



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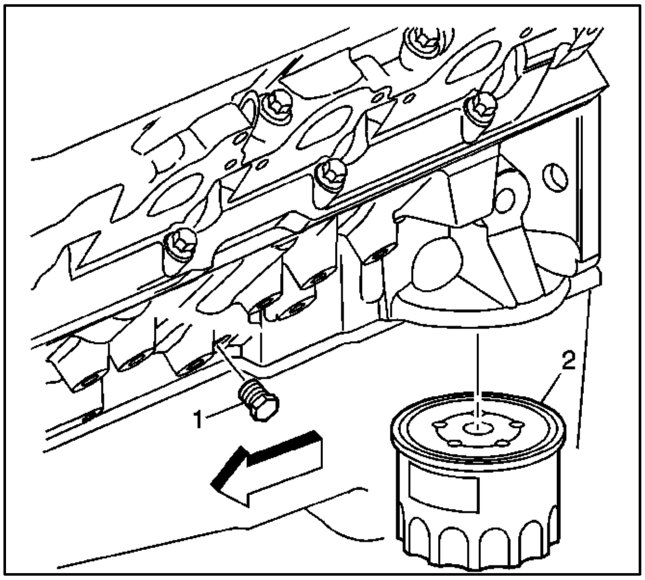
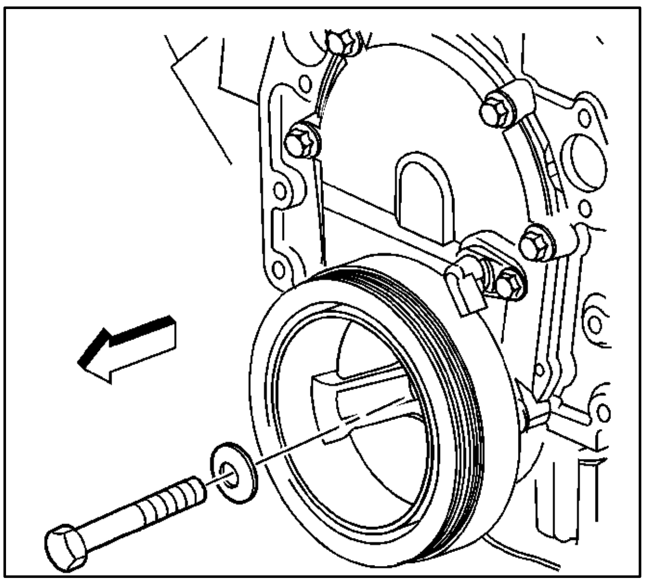


470515

Draining Fluids and Oil Filter Removal

1. Remove the oil pan drain plug.
2. Drain the engine oil.
3. Remove the oil filter (2).
4. Remove the left engine coolant drain hole plug (1) and the right engine coolant drain hole plug.
5. Drain the engine coolant.


470799

Crankshaft Balancer Removal

Tools Required

- *J 38416* Three Jaw Puller
- *J 42846* Crankshaft Protector Button
- *J 42847* Flywheel Holding Tool

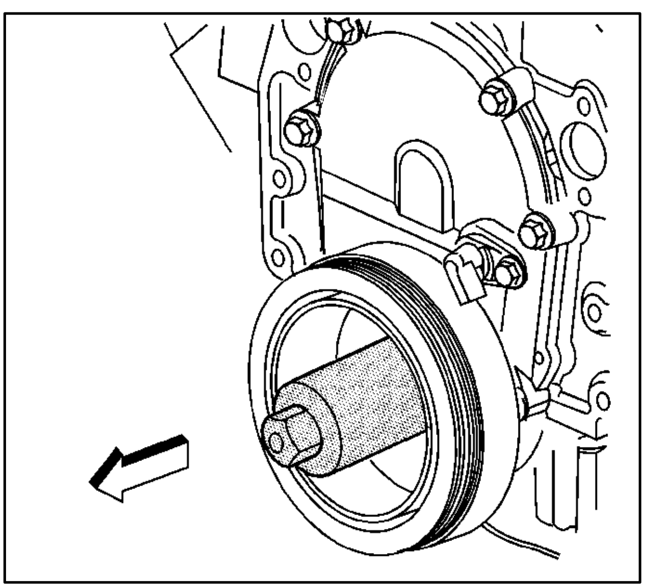
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.

1. Install the *J 42847* to the starter bolt holes.

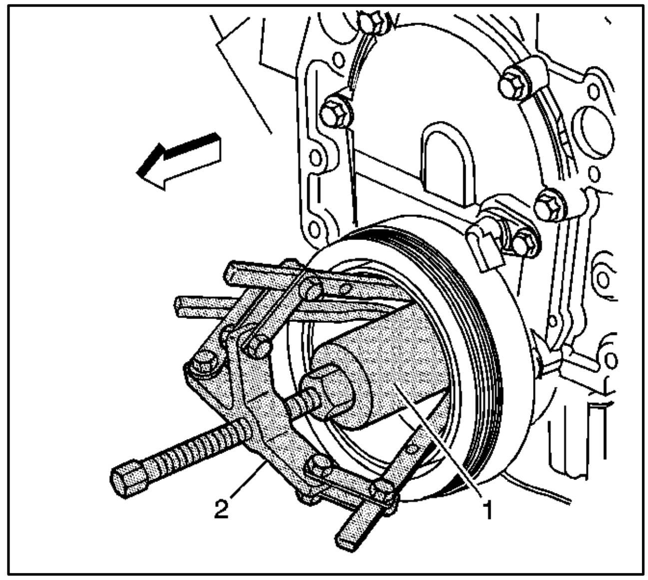
   Tighten

   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).
2. Remove the crankshaft balancer bolt and washer.


640013

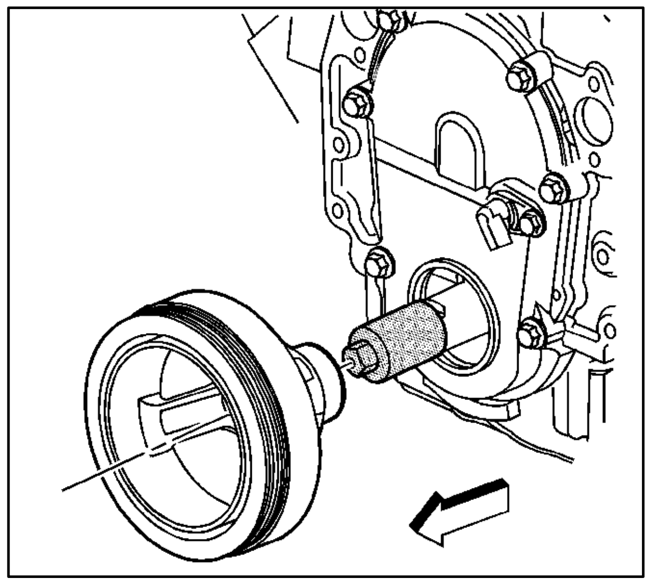
3. Install the *J 42846* onto the end of the crankshaft.

4. Install the *J 38416* (2) in order to remove the crankshaft balancer. Place the legs of the *J 38416* into the recesses cast into the backside of the balancer inner hub.
5. Tighten the center screw of the *J 38416* until the crankshaft balancer is clear of the crankshaft nose.



640014

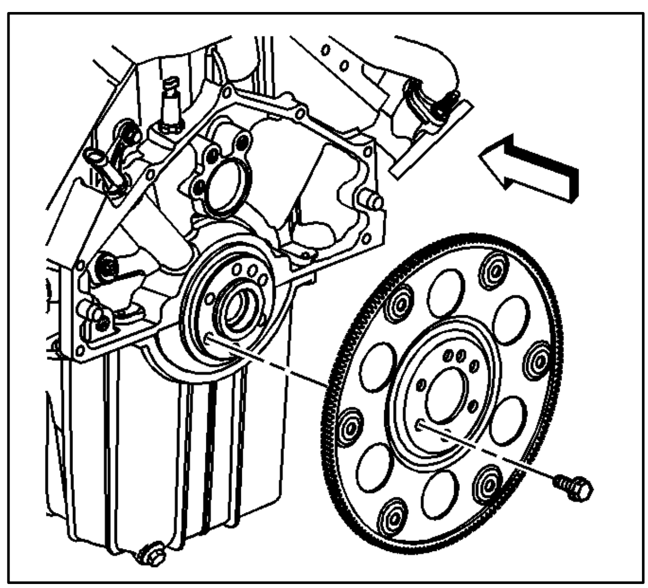
6. Remove the *J 38416.*
7. Remove the crankshaft balancer.
8. Remove the *J 42846* from the end of the crankshaft.
9. Remove the *J 42847.*



640015

Engine Flywheel Removal

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.



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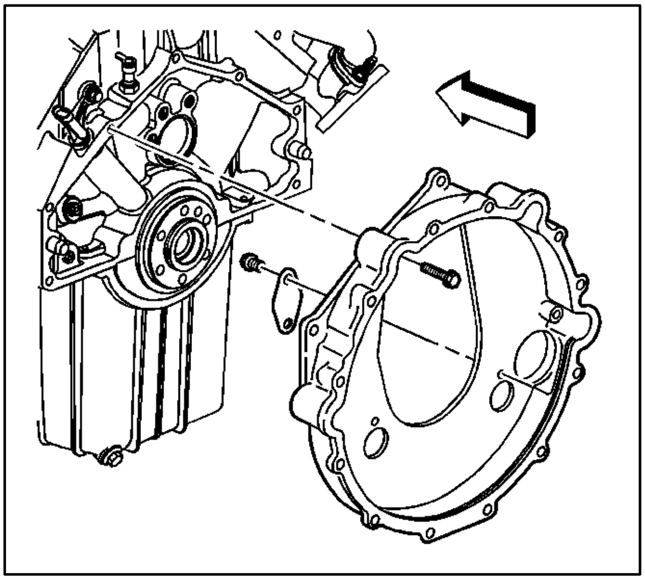
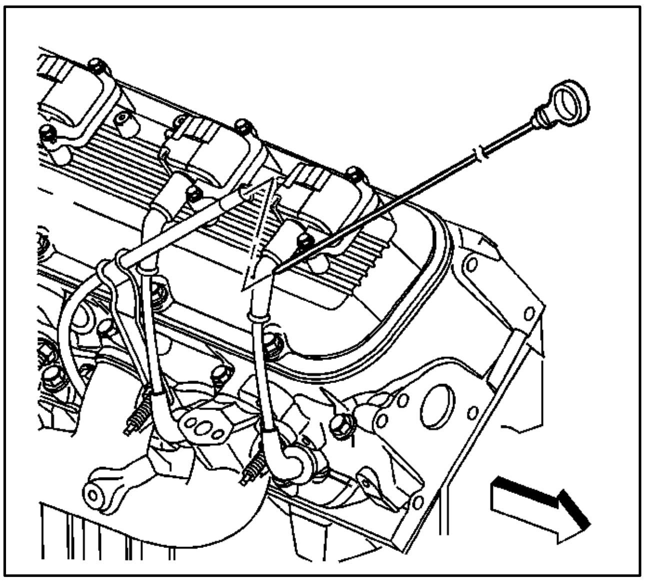

470599

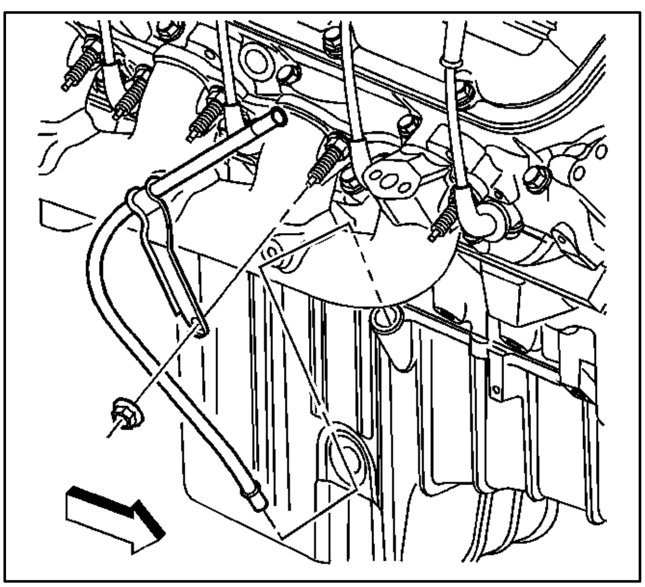
Engine Flywheel Housing Removal

1. Remove the engine flywheel housing bolts.
2. Remove the engine flywheel housing.
3. Remove the transmission converter cover bolt.
4. Remove the transmission converter cover.


470627

Oil Level Indicator and Tube Removal

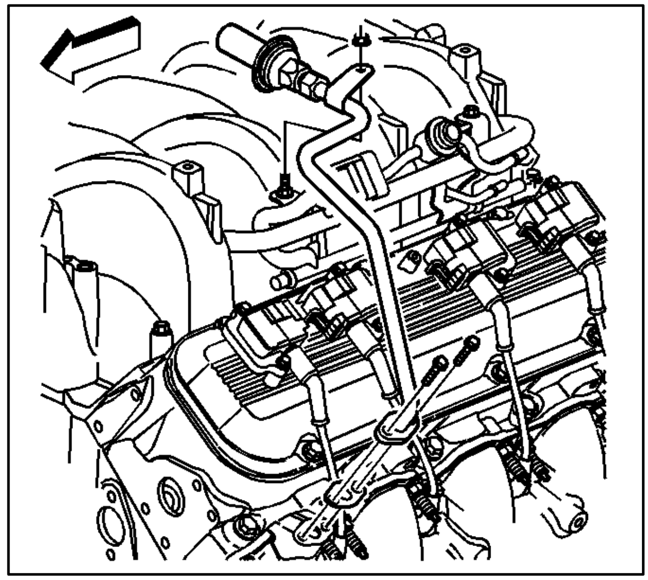
1. Remove the oil level indicator from the oil level indicator tube.


470630

2. Remove the oil level indicator tube bracket nut from the exhaust manifold stud.
3. Remove the oil level indicator tube bracket from the exhaust manifold stud.
4. Remove the oil level indicator tube from the oil pan.
5. Remove the O-ring seal from the oil level indicator tube.

Exhaust Manifold Removal – Left

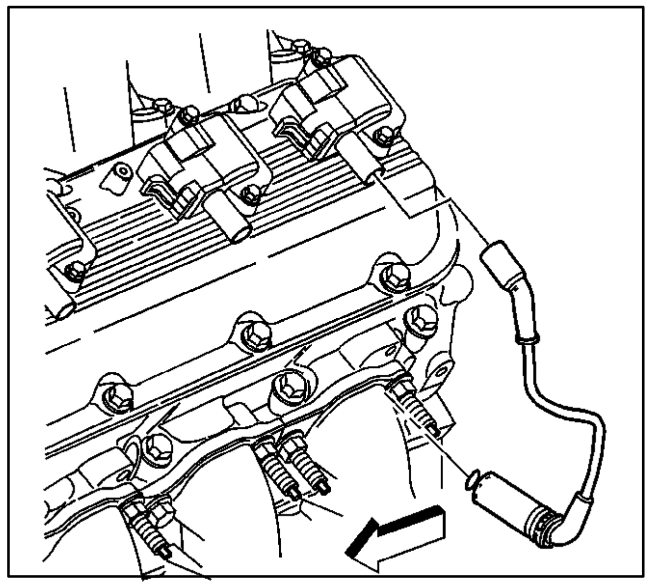
1. Remove the secondary air injection pipe nut from the fuel injection fuel rail stud (if applicable).
2. Remove the secondary air injection pipe bolts from the left exhaust manifold (if applicable).
3. Disconnect the secondary air injection pipe from the secondary air injection pump pipe (if applicable).
4. Remove the secondary air injection pipe (if applicable).



470641

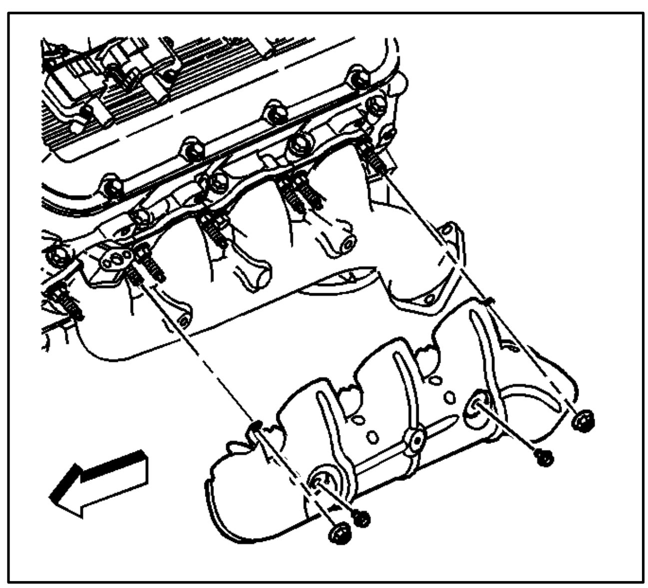
Important: Twist the spark plug tool boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

5. Remove the left spark plug wires from the spark plugs and ignition coils.



470666

6. Remove the left exhaust manifold heat shield bolts and nuts.
7. Remove the left exhaust manifold head shield.



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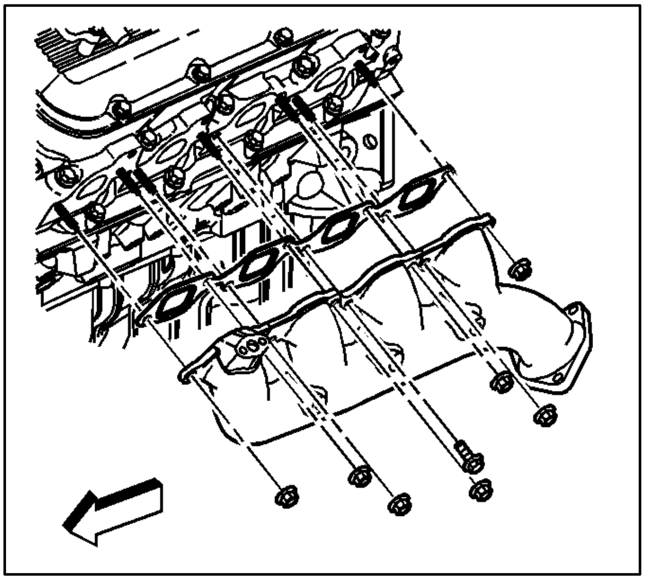
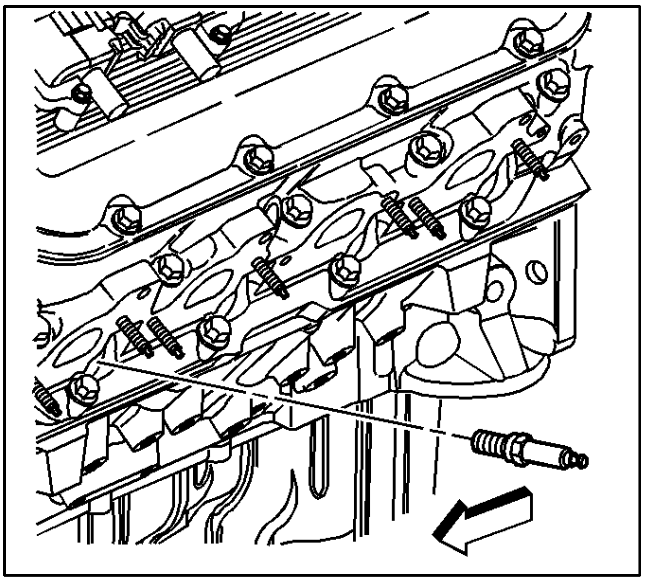


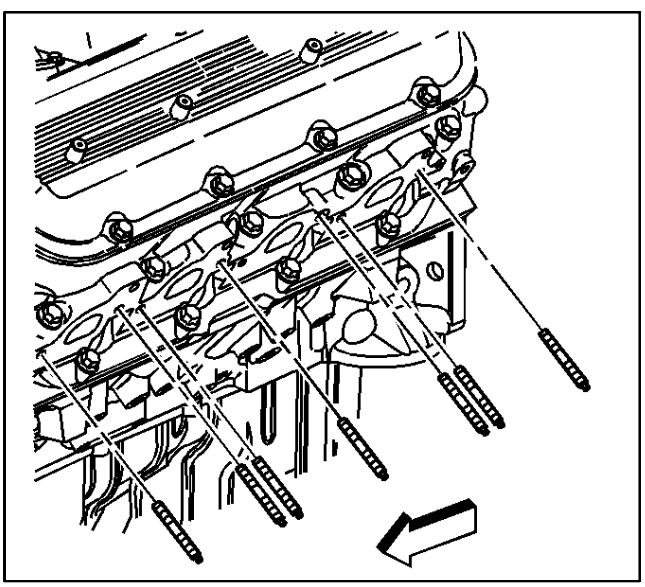
470679

8. Remove the left exhaust manifold nuts and center bolt.
9. Remove the left exhaust manifold.
10. Remove the left exhaust manifold gasket.



470690

11. Remove the left spark plugs.

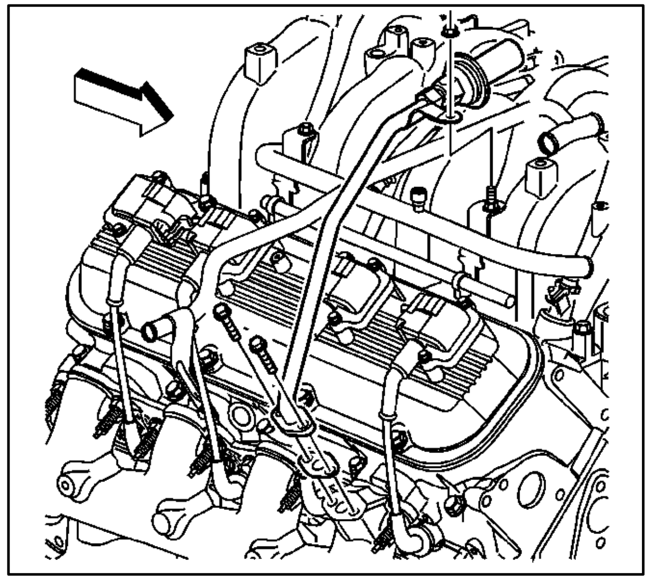


470683

12. Remove the exhaust manifold studs, if necessary.

Exhaust Manifold Removal – Right

1. Remove the secondary air injection pipe nut from the fuel injection fuel rail stud (if applicable).
2. Remove the secondary air injection pipe bolts from the right exhaust manifold (if applicable).
3. Disconnect the secondary air injection pipe from the secondary air injection pump pipe (if applicable).
4. Remove the secondary air injection pipe (if applicable).



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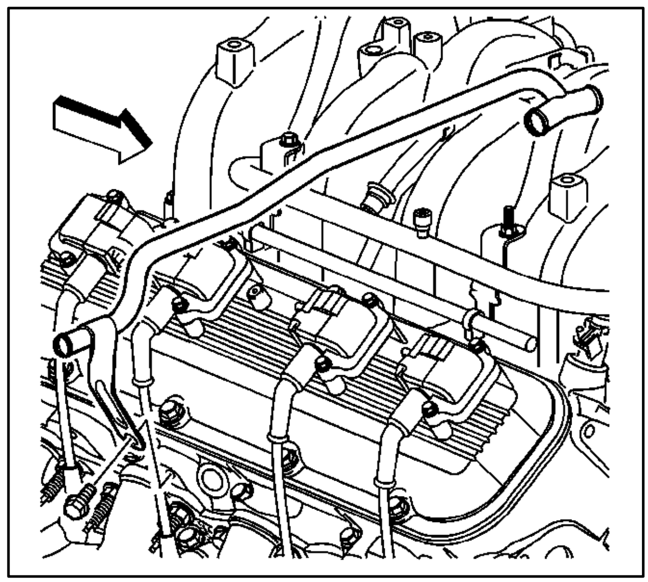
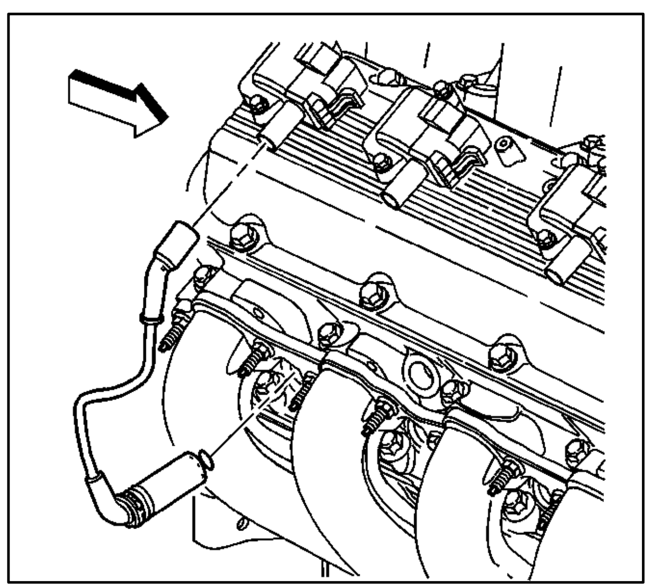
5. Remove the secondary air injection pump pipe bolt from the right cylinder head (if applicable).
6. Remove the secondary air injection pump pipe (if applicable).



470646

Important: Twist the spark plug tool boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

7. Remove the right spark plug wires from the spark plugs and ignition coils.



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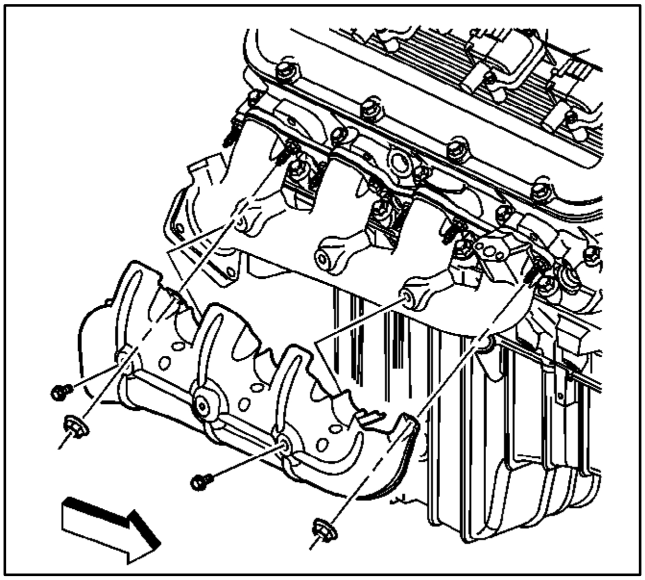
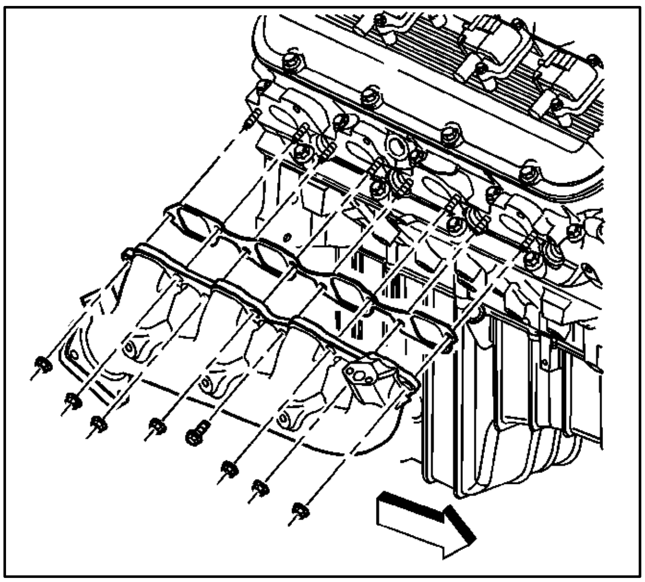
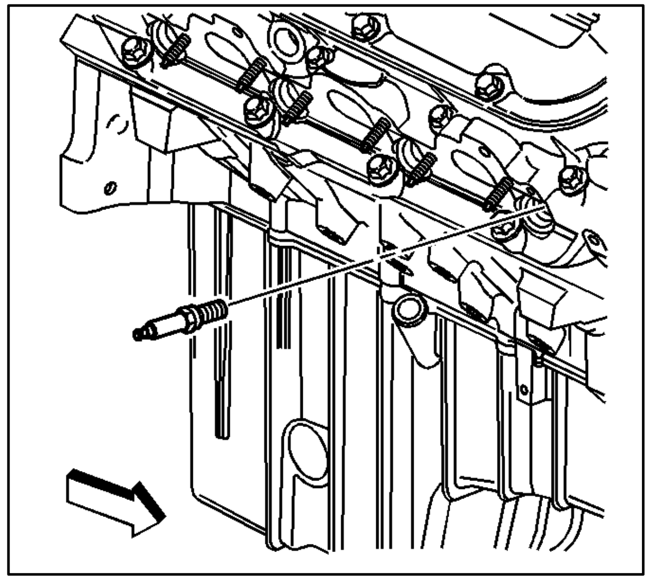


8. Remove the right exhaust manifold heat shield bolts and nuts.
9. Remove the right exhaust manifold heat shield.



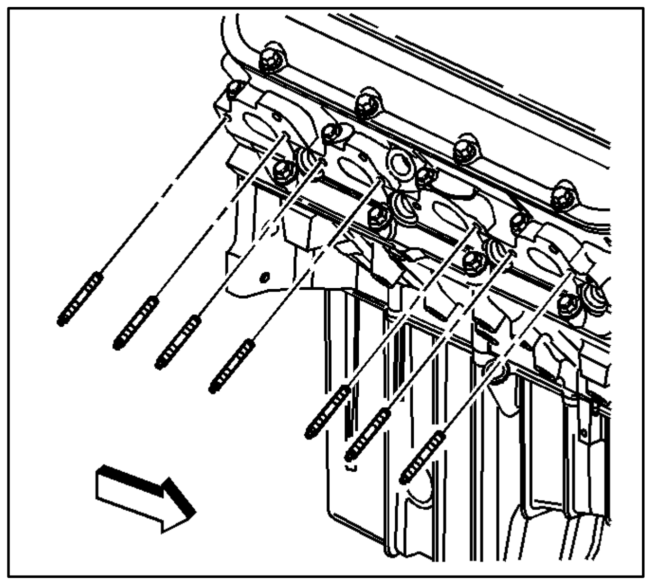
10. Remove the right exhaust manifold nuts and center bolt.
11. Remove the right exhaust manifold.
12. Remove the right exhaust manifold gaskets.

13. Remove the right spark plugs.



470727

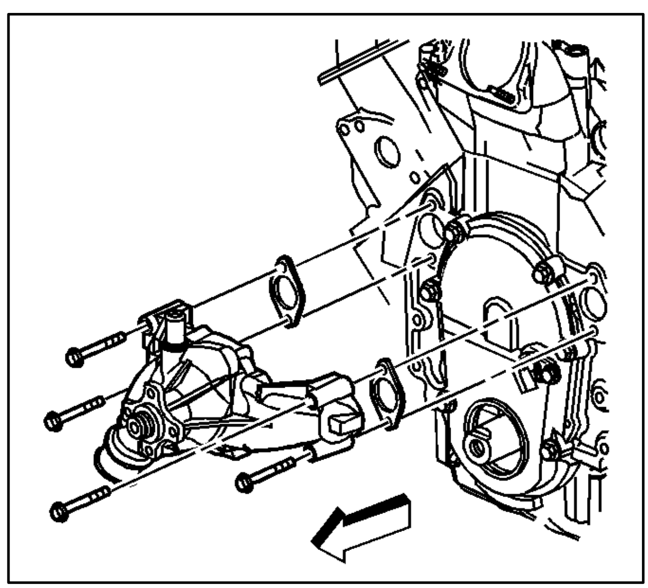
14. Remove the exhaust manifold studs, if necessary.



470723

Water Pump Removal

1. Remove the water pump bolts.
2. Remove the water pump.
3. Remove the water pump gaskets.



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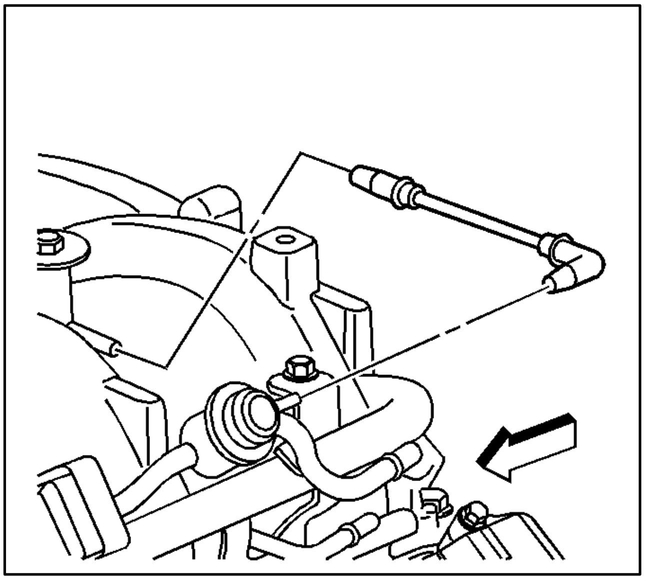
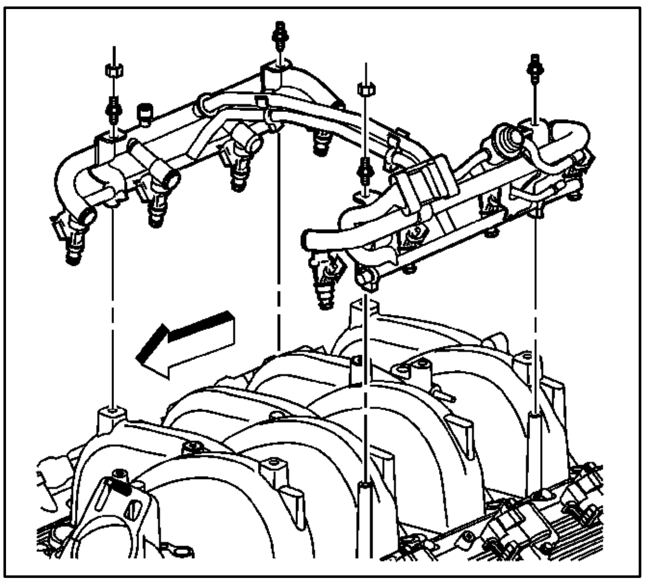


470770

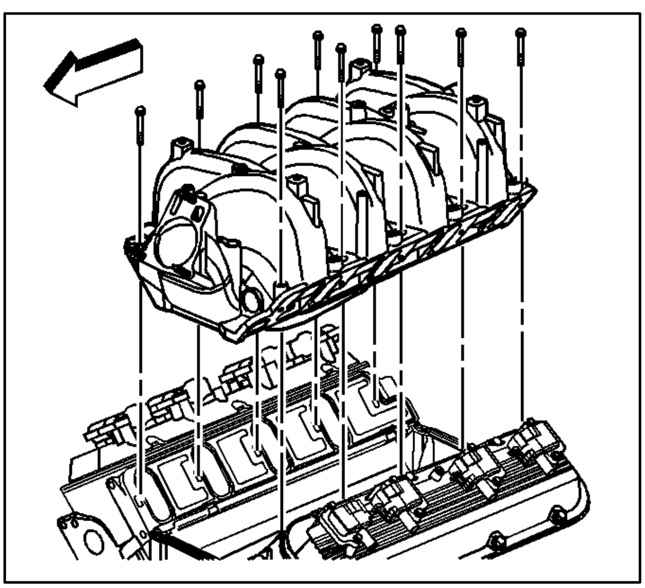
Intake Manifold Removal

1. Remove the fuel pressure regulator vacuum hose.



470774

2. Remove the fuel injection fuel rail bolts and/or studs.
3. Remove the fuel injection fuel rail.



470775

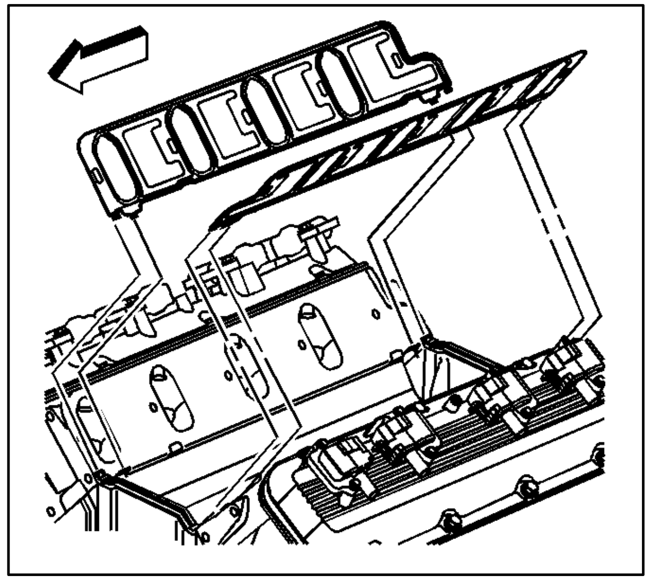
4. Remove the intake manifold bolts.

Important: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

5. Remove the intake manifold.

Important: The intake manifold gaskets are not reusable.

6. Remove and discard the intake manifold side gaskets.



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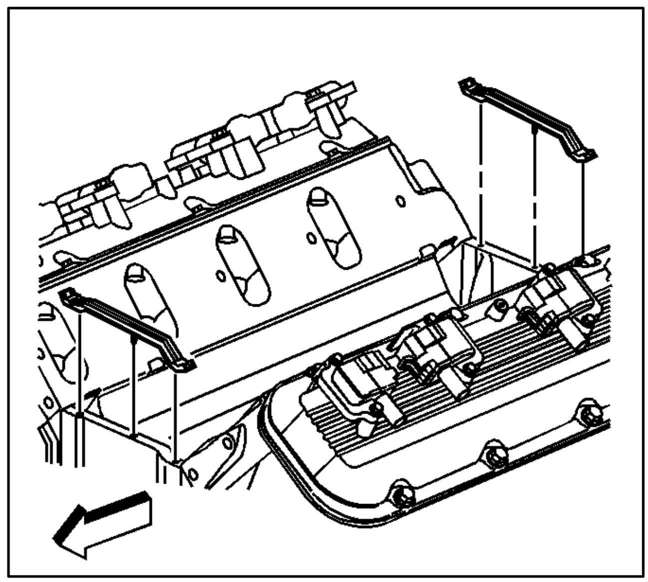
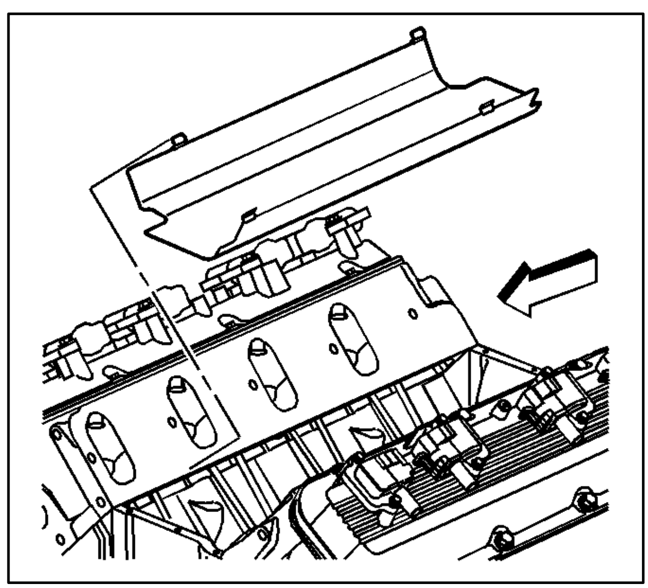
7. Remove and discard the lower intake manifold end seals.



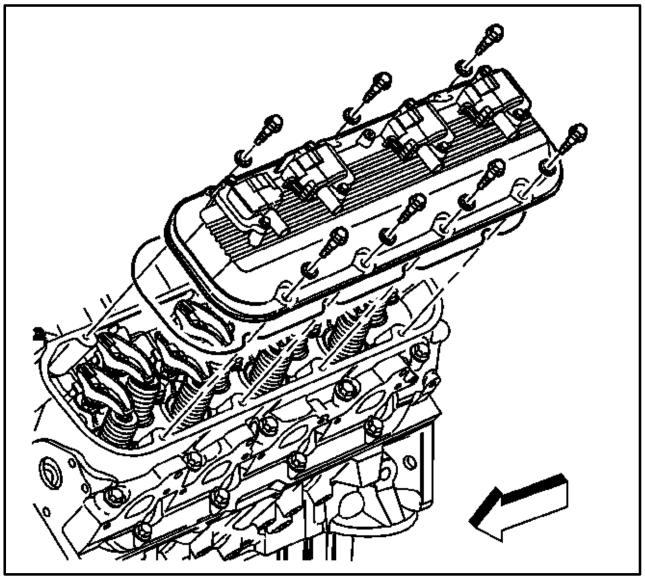
470783

Important: The splash shield is secured using a snap-in fit. Do not distort the splash shield. The splash shield is reusable.

8. Remove the splash shield.



470786



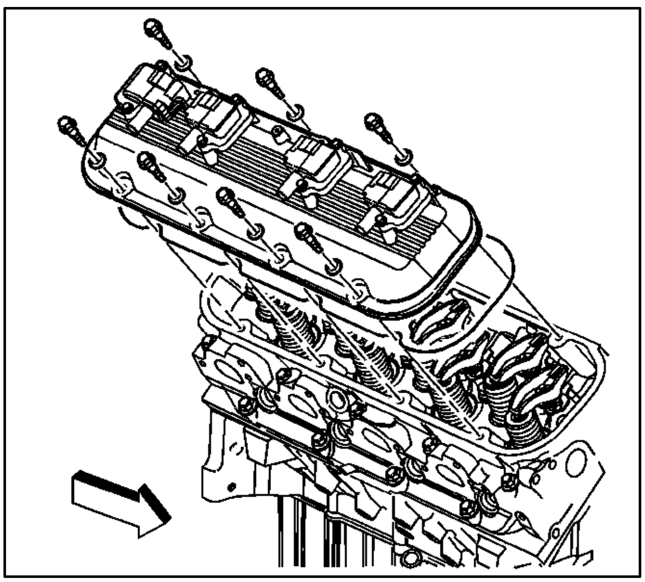
470890

Valve Rocker Arm Cover Removal – Left

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.

Important: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

3. Replace the valve rocker arm cover gasket if it is cut or damaged.



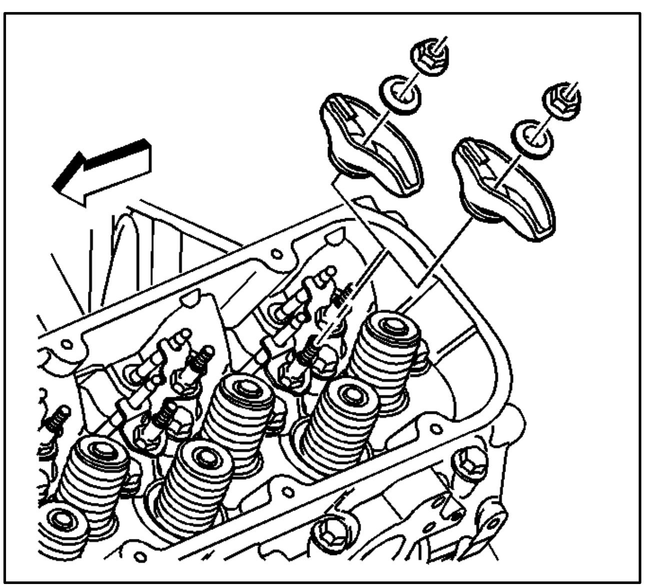
470897

Valve Rocker Arm Cover Removal – Right

1. Remove the valve rocker arm cover belts.
2. Remove the valve rocker arm cover.

Important: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

3. Replace the valve rocker arm cover gasket if it is cut or damaged.



470899

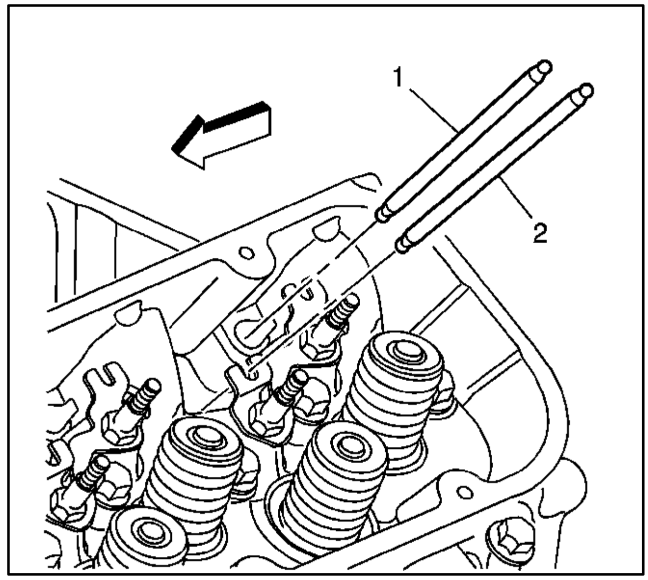
Valve Rocker Arm and Push Rod Removal

Important: Mark, organize and sort the cylinder head components. Return the components to their original location during reassembly. Make an organizer rack from a piece of wood.

1. Remove the valve rocker arm nuts, the valve rocker arm balls and the valve rocker arms.

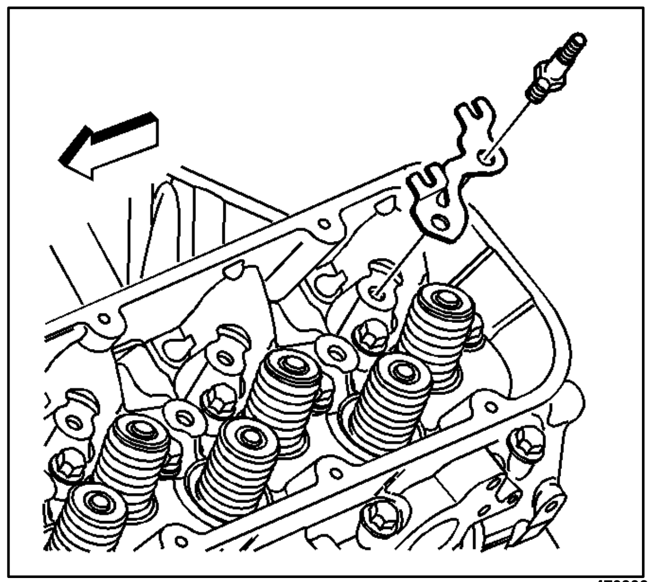
Important: The exhaust valve push rods (2) are longer than the intake valve push rods (1).

2. Remove the valve push rods.



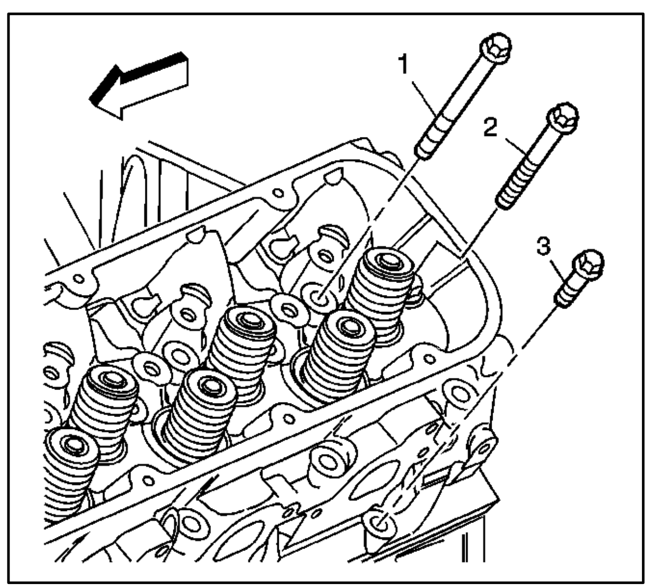
470903

3. Remove the valve rocker arms studs and push rod guides.

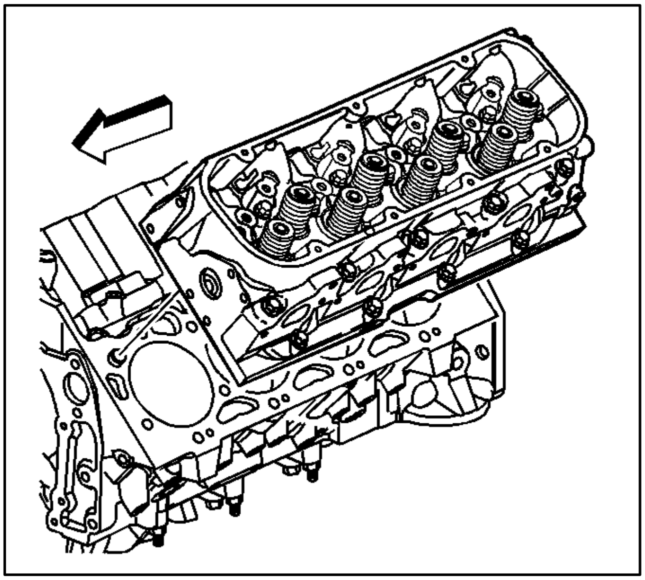

470906

Cylinder Head Removal – Left

1. Remove and discard the eighteen cylinder head bolts (1, 2, 3).



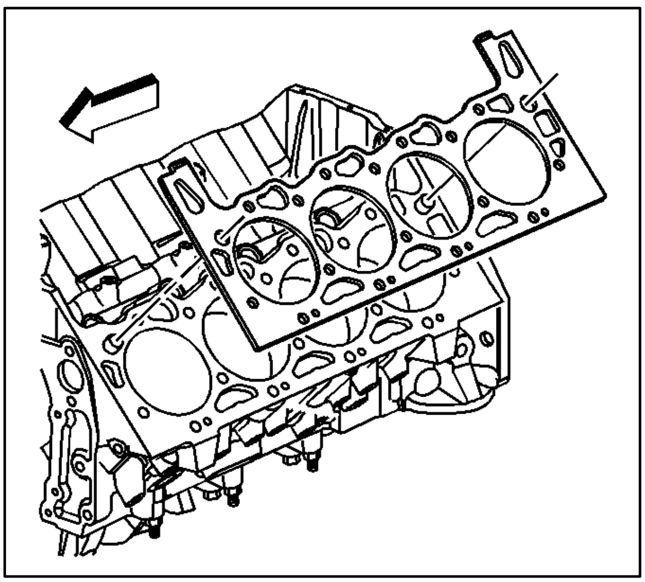
470914



470916

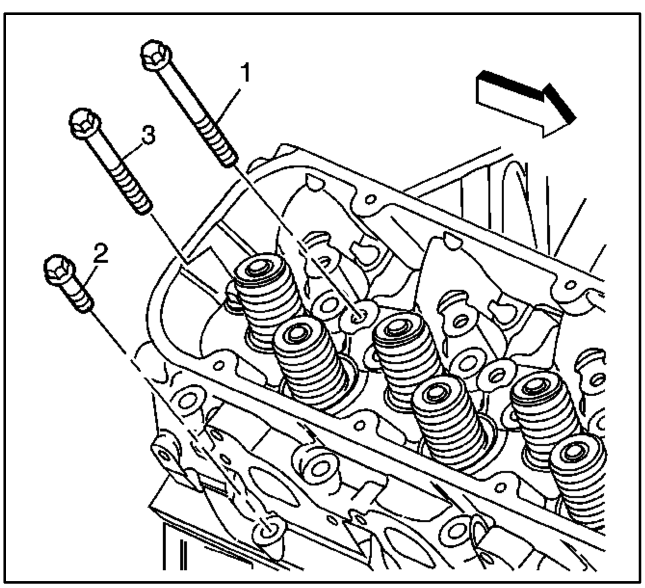
Important: Place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head.



470974

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.



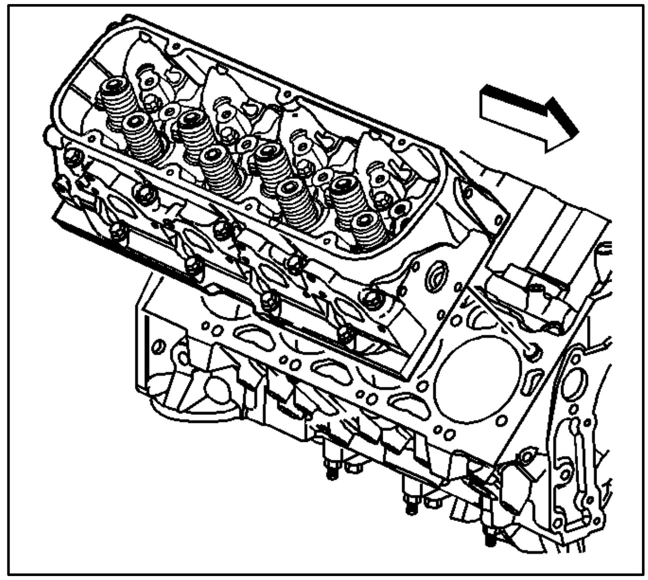
470989

Cylinder Head Removal – Right

1. Remove and discard the eighteen cylinder head bolts (1, 2, 3).

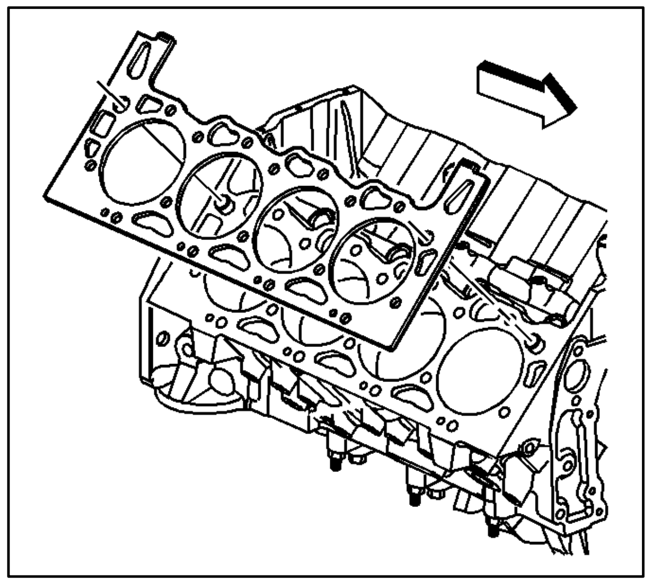
Important: Place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head.



470991

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.



470992

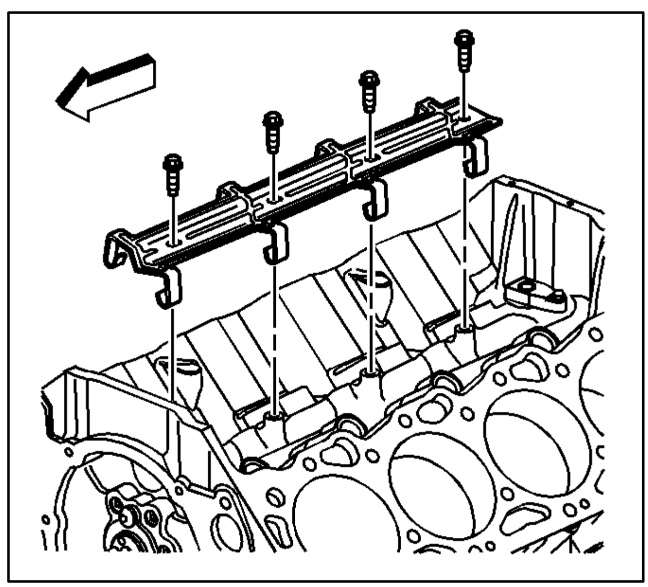
Valve Lifter Removal

Tools Required

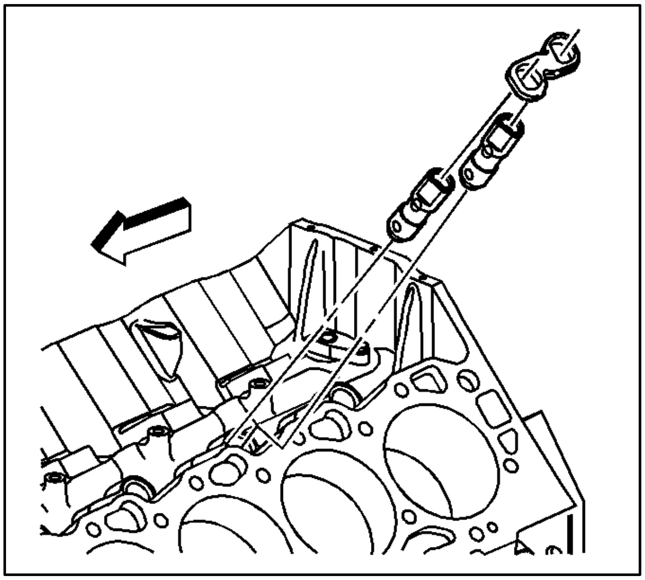
J 3049-A Valve Lifter Remover

Important: Mark, sort, or organize the valve lifters and guides for return to their original location during assembly.

1. Remove the valve lifter guide retainer bolts and retainer.



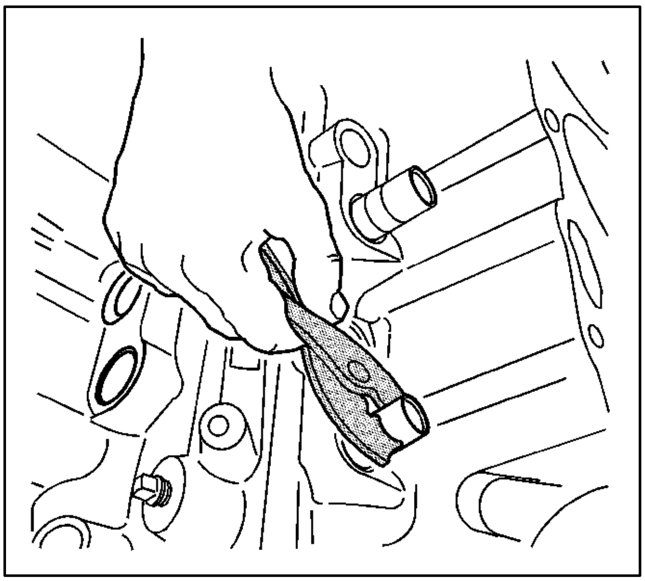
470994


470996

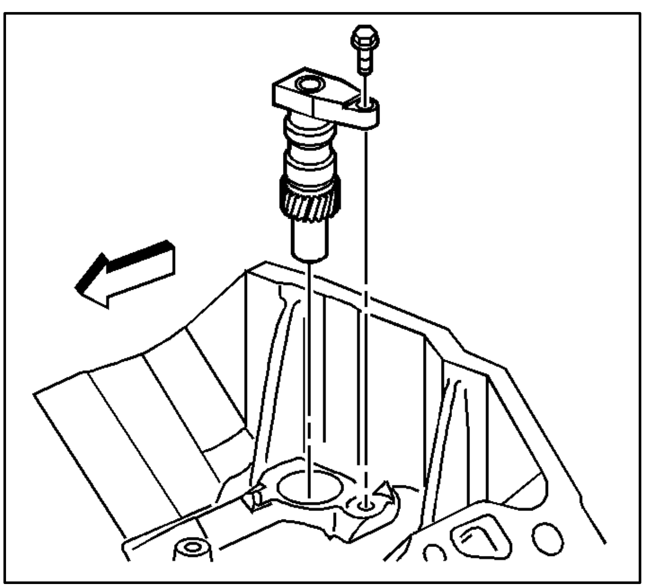
2. Remove the valve lifter guides.

Important: Place the valve lifters in the organizer rack or tag them in a way to ensure they can be returned to the valve lifter bore from which they were removed.

3. Remove the valve lifters.


719128

4. Some valve lifters may be stuck in their bore due to gum or varnish deposits. These valve lifters can be removed using *J 3049-A.*

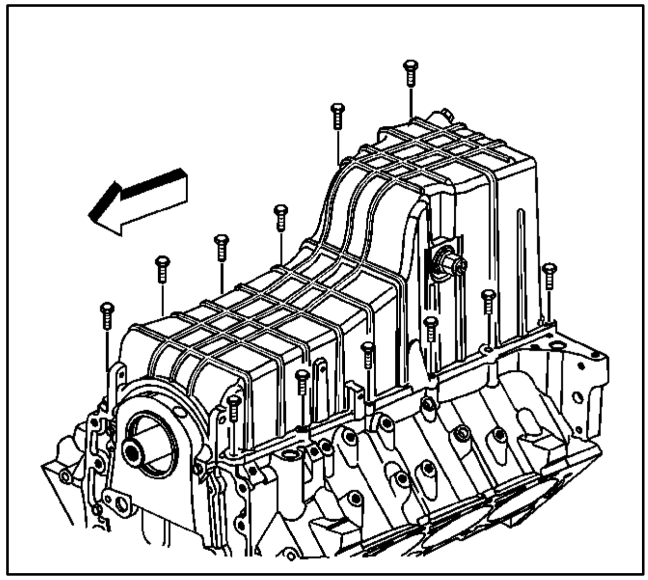

470910

Oil Pump Removal

1. Remove the oil pump drive bolt.
2. Remove the oil pump drive.

Oil Pan Removal

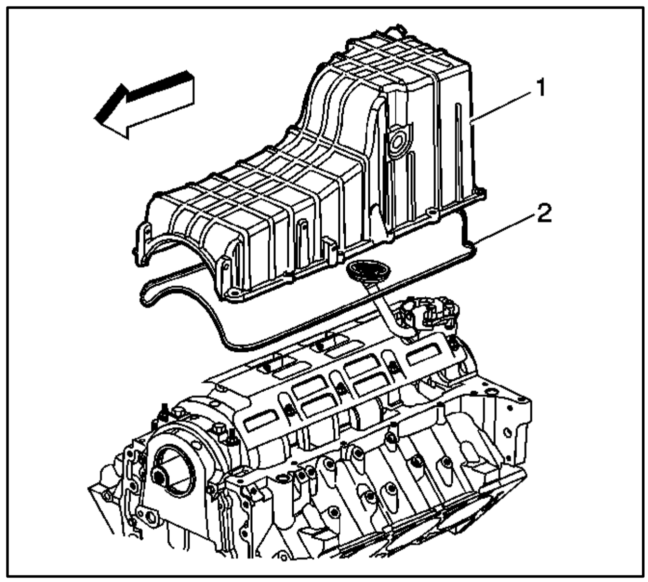
1. Remove the oil level switch from the oil pan, if equipped.
2. Remove the oil pan bolts.



635648

Important: The oil pan gasket is reusable if not cut or damaged.

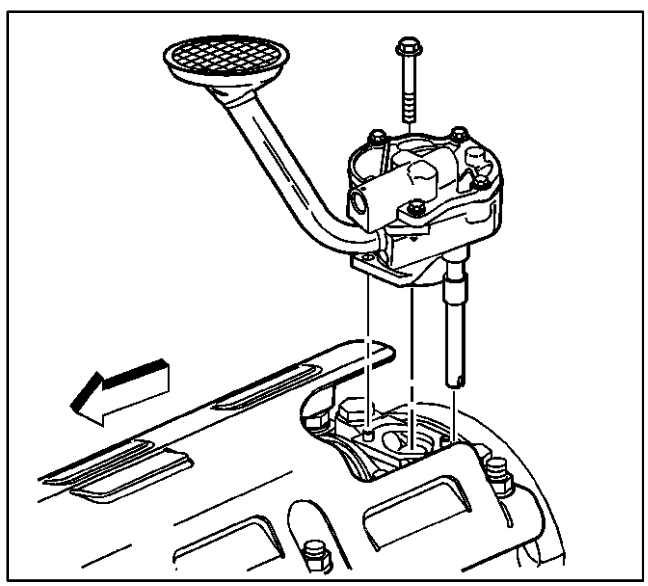
3. Remove the oil pan (1) and the captured oil pan gasket (2).



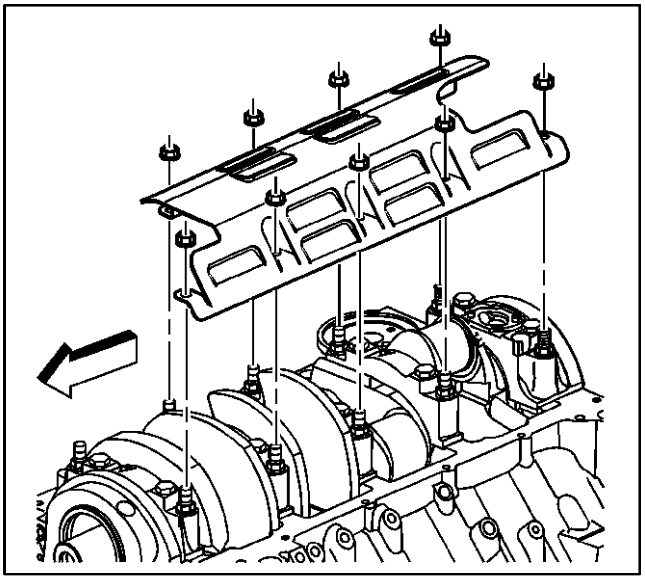
635654

Oil Pump, Pump Screen and Deflector Removal

1. Remove the bolt that attaches the oil pump to the rear crankshaft bearing cap.
2. Remove the oil pump, driveshaft and retainer from the rear crankshaft bearing cap.
3. Separate the oil pump, driveshaft and retainer.
4. Discard the driveshaft retainer.

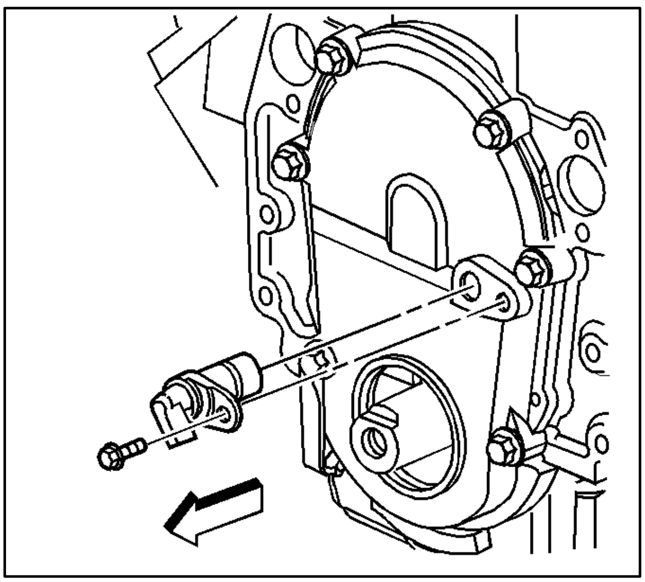


635701



635703

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

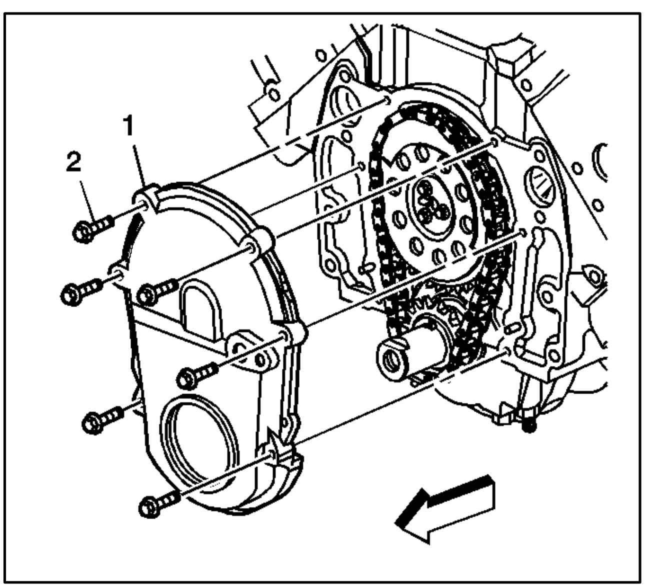


470803

Engine Front Cover Removal

Notice: This component initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing self-tapping bolt(s) can lead to the damage and unnecessary replacement of the self-tapping bolt(s) and/or the component the self-tapping bolt(s) is threaded into.

1. Remove the camshaft position sensor bolt.
2. Remove the camshaft position sensor.
3. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.



470805

4. Remove the engine front cover bolts.
5. Remove the engine front cover.

Important: The engine front cover gasket is reusable.

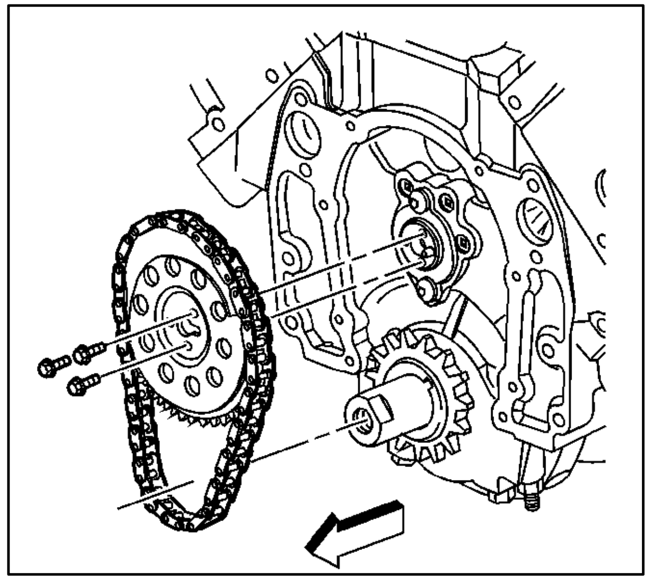
6. Remove the engine front cover gasket.
7. Remove the crankshaft front oil seal from the engine front cover.

Timing Chain and Sprockets Removal

Tools Required

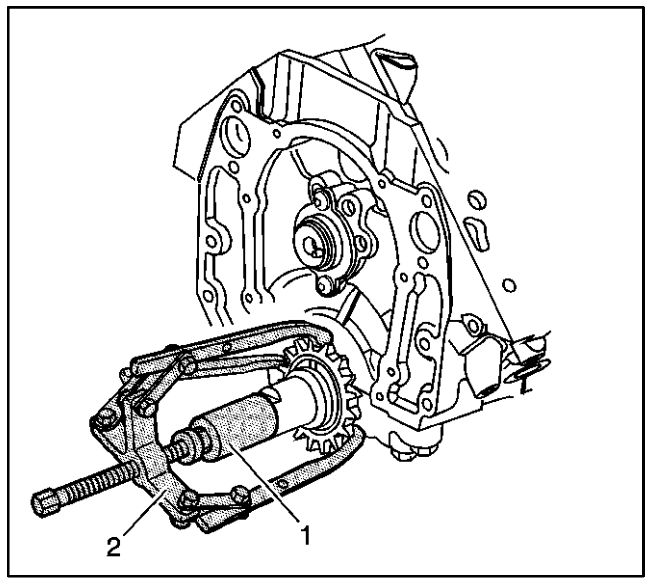
J 42846 Crankshaft Protector Button

1. Measure the camshaft timing chain free play. If the chain can be moved back and forth in excess of 16mm (0.625 in), make a note that the camshaft timing chain and the sprockets must be replaced during assembly.
2. Remove the camshaft sprocket bolts.
3. Remove the camshaft sprocket and the camshaft timing chain.



470814

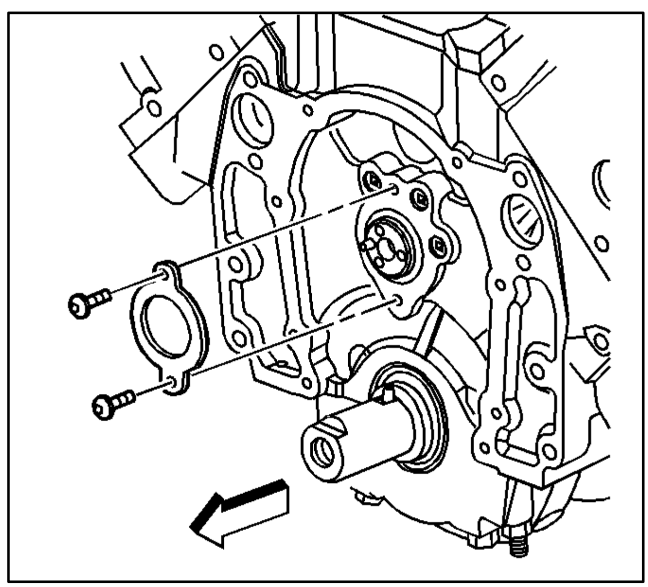
4. Install the *J 42846* into the end of the crankshaft.
5. Remove the crankshaft sprocket using a suitable three jaw puller.



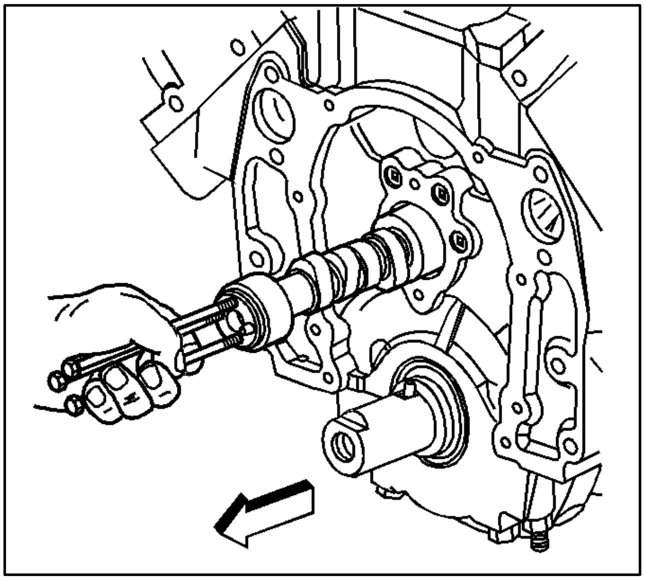
639535

Camshaft Removal

1. Remove the camshaft retainer bolts.
2. Remove the camshaft retainer.



470998

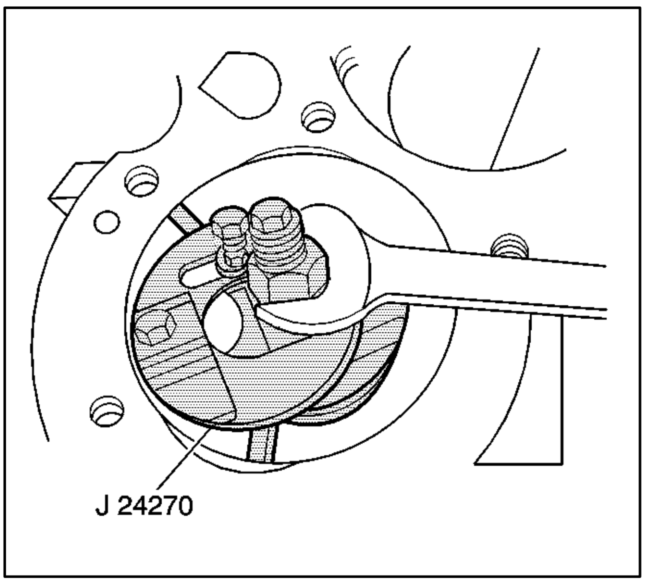


471002

3. Install three 8 – 1.25 x 100 mm bolts in the camshaft front bolt holes.

Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

4. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
5. Remove the bolts from the front of the camshaft.



11497

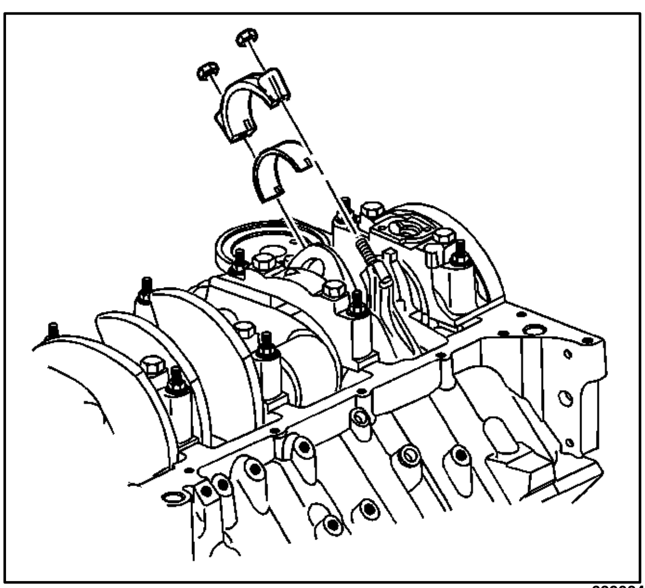
Piston, Connecting Rod, and Bearing Removal

Tools Required

- *J 24270* Ridge Reamer
- *J 42846* Crankshaft Protector Button

Important: Do not remove the excessive material from the cylinder bore. Excessive removal of material may require cylinder boring to the next oversize.

1. Remove the cylinder bore ridge as necessary.
   1.1. Install the *J 42846* onto the front of the crankshaft in order to turn crankshaft.
   1.2. Rotate the crankshaft until the piston is at the bottom of the stroke (BDC).
   1.3. Place a cloth on top of the piston.
   1.4. Perform the cutting operation with a *J 24270*. Refer to the manufacturer's instructions before using the *J 24270.*
   1.5. Remove the *J 24270.*
   1.6. Rotate the crankshaft until the piston is at top dead center (TDC).
   1.7. Remove the cloth and the cuttings.
   1.8. Repeat the procedure for each piston.



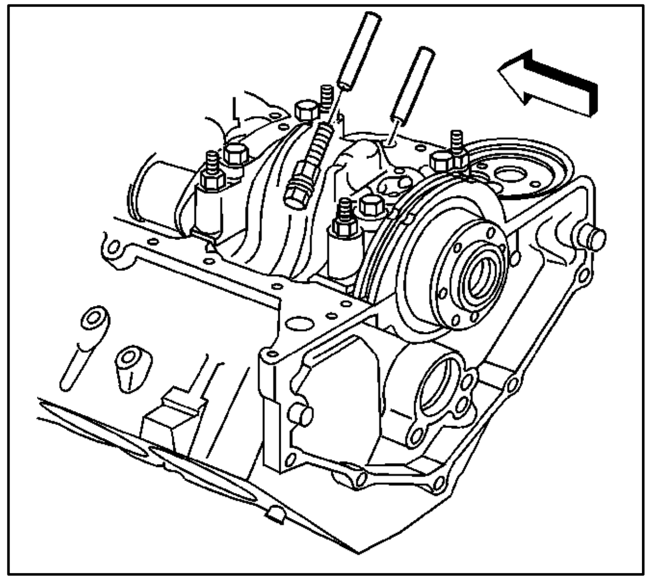
639084

Important: Place the matching marks or numbers on the connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

Important: When connecting rod bearings are removed, NEW bearings must be installed.

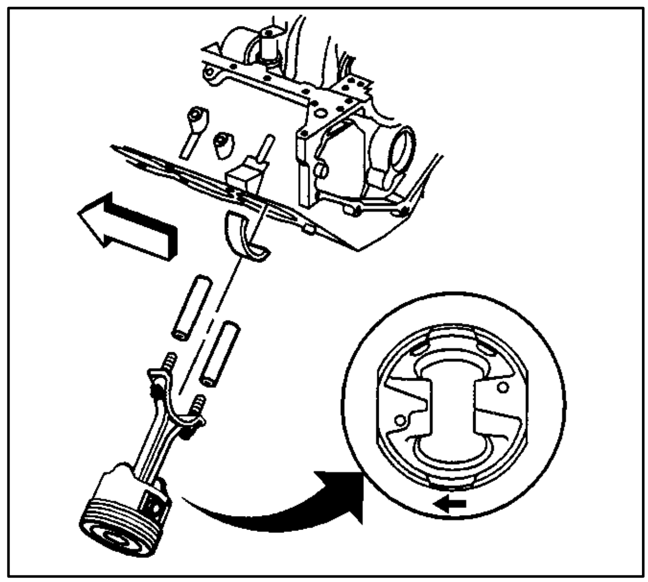
2. Remove the connecting rod nuts.
3. Remove the connecting rod cap and the lower connecting rod bearing.

4. Install rubber fuel line onto the connecting rod bolts to prevent contact with the crankshaft.



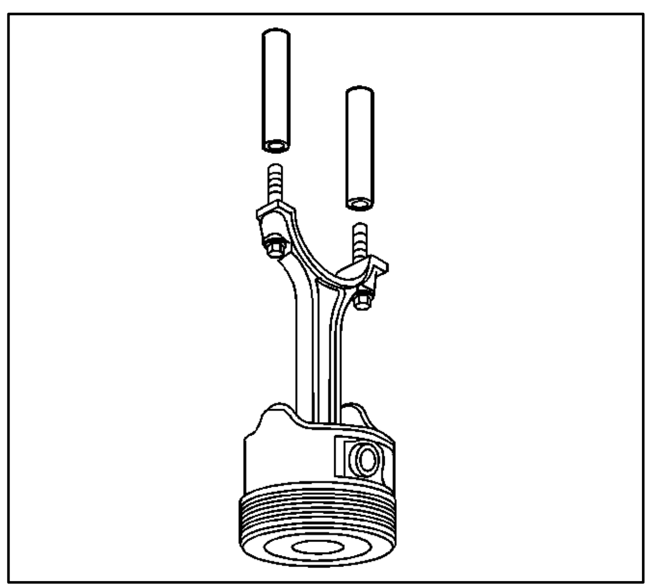
639533

5. Remove the piston, connecting rod and upper connecting rod bearing rod out of the top of the engine block.



639536

6. Remove the rubber fuel line from the connecting rod bolts.
7. Remove the remaining piston and connecting rod assemblies.
8. Remove the *J 42846* from the front of the crankshaft.

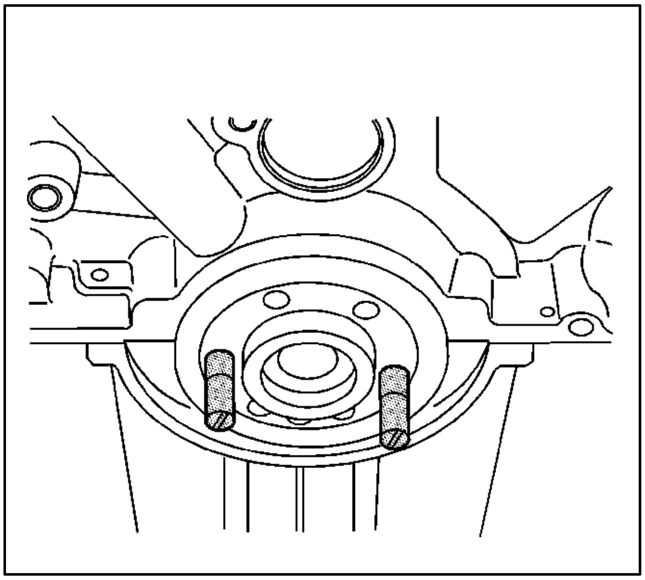


639532

Crankshaft Rear Oil Seal Removal

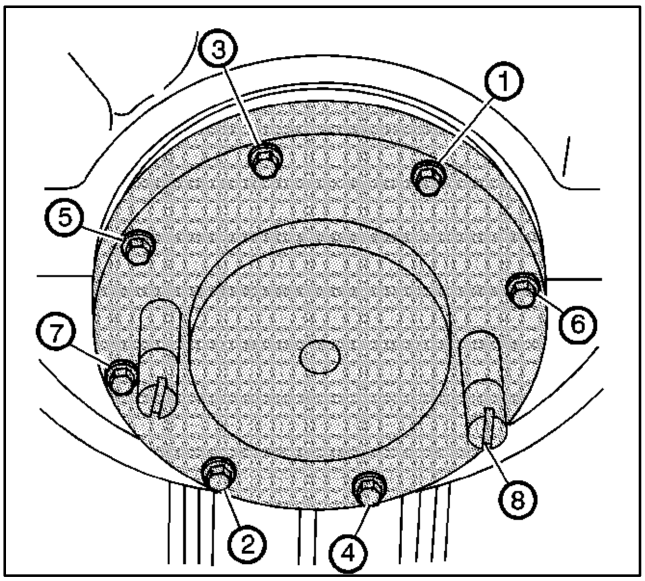
Tools Required

J 43320 Crankshaft Rear Seal Puller



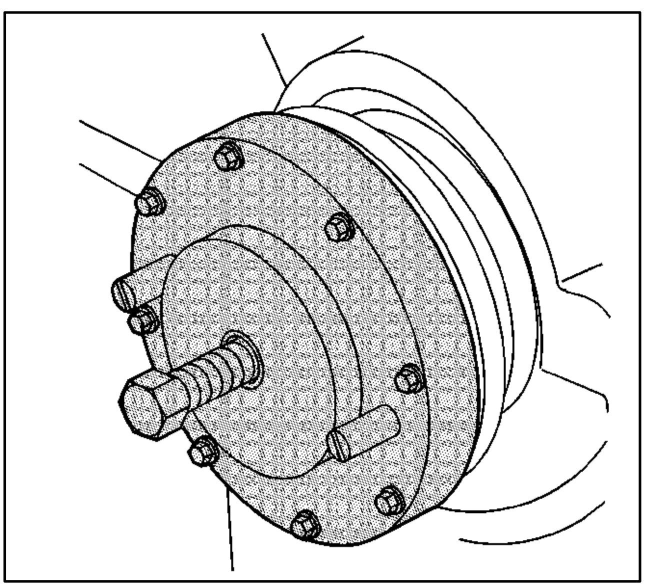
655276

1. Install the *J 43320* guide pins into the crankshaft.



655278

2. Install the *J 43320* over the guide pins.
3. Using a suitable drill, insert eight of the self-drilling sheet metal screws into the rear crankshaft seal, using a criss-cross pattern. The self drilling screws are included with the *J 43320*.



655279

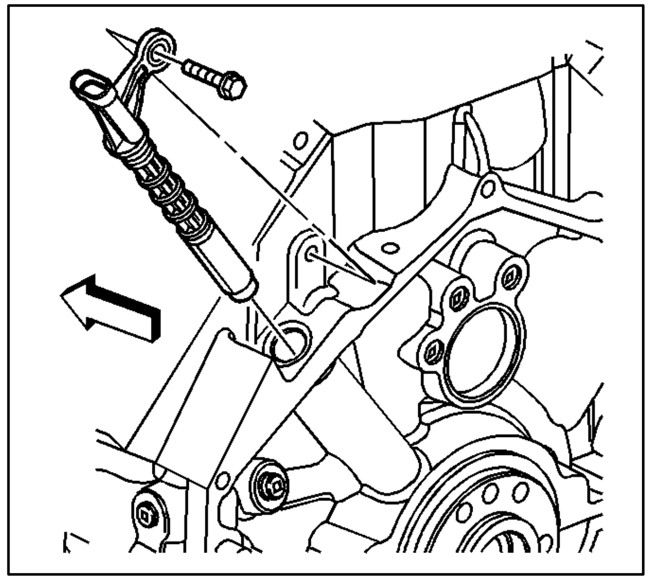
4. Thread the center bolt of *J 43320* into the crankshaft to remove the seal.
5. Remove the *J 43320* guide pins from the crankshaft.

Crankshaft and Bearings Removal

Important: The crankshaft position sensor is designed to contact the reluctor wheel of the crankshaft. Wear may be noticeable on the end of the sensor.

Important: Care must be taken when removing the crankshaft position sensor. Twist the sensor to break the O-ring seals loose. When removing the sensor, pull the sensor straight out of the engine block at the same angle the sensor was installed. Failure to be careful may result in sensor damage.

1. Remove the crankshaft position sensor bolt.
2. Apply penetrating oil to the crankshaft position sensor-to-engine block mating surface. Allow the penetrating oil to soak for several minutes, to help loosen the O-ring from the engine block.
3. Remove the crankshaft position sensor.

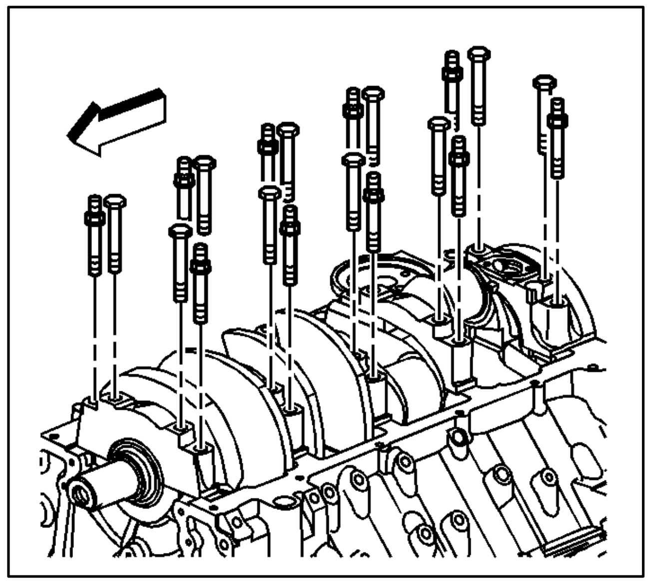


470801

4. Inspect both crankshaft position sensor O-rings for cuts, cracks, tears or damage. Replace the O-rings as needed.

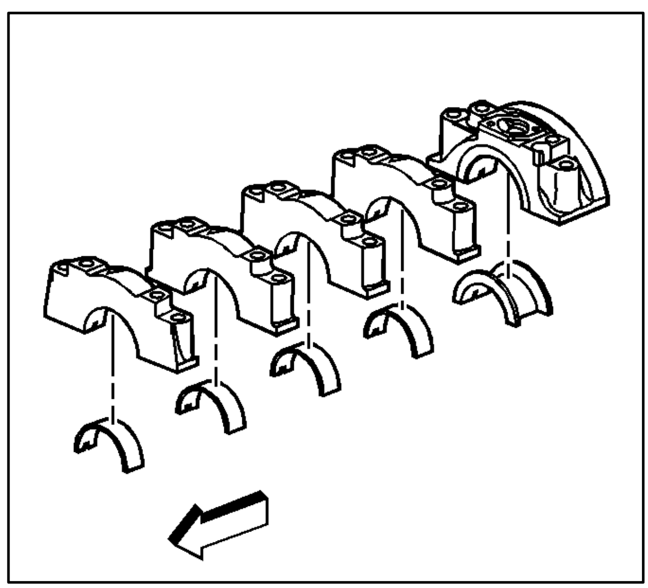
Important: Crankshaft bearing caps are machined with the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. Crankshaft bearing caps must be installed in their original locations.

5. Remove the crankshaft bearing cap bolts and studs.

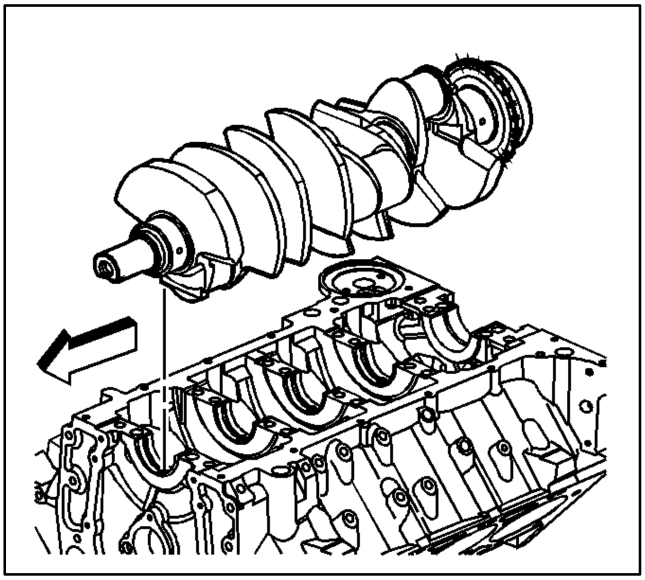


471055

6. Remove the crankshaft bearing caps.
7. Remove the crankshaft lower bearings from the crankshaft bearing caps.



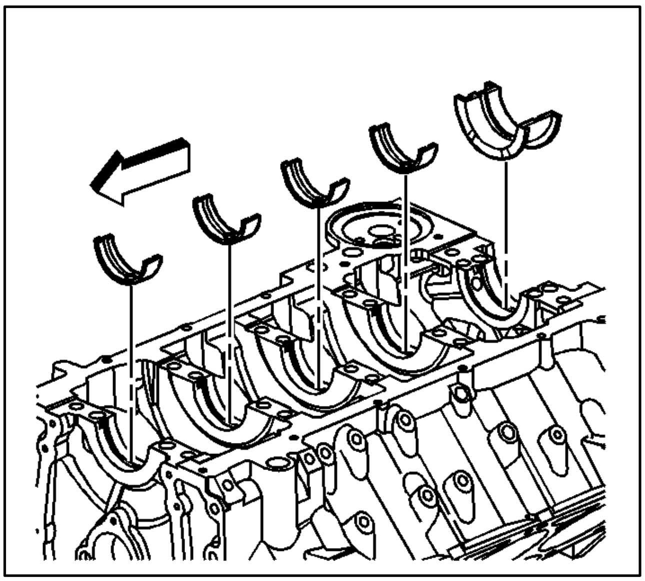
471044



471047

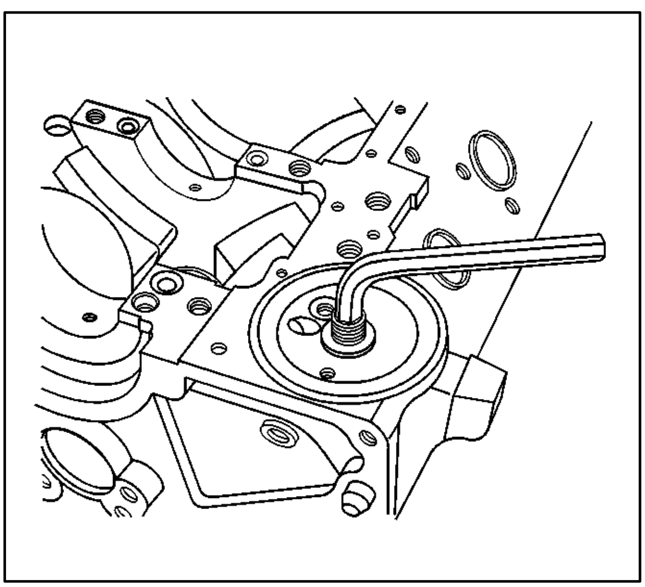
Important: Care should be taken when removing the crankshaft so that the crankshaft position sensor reluctor ring is not damaged.

8. Remove the crankshaft.



471041

9. Remove the crankshaft upper bearings from the engine block.

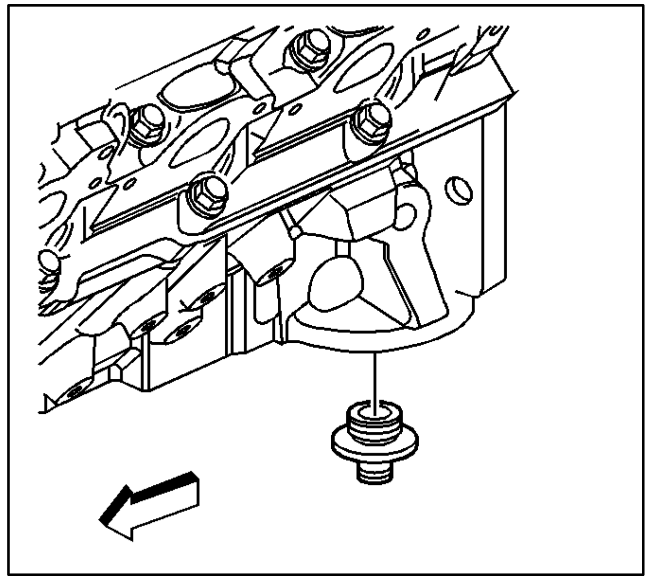


452375

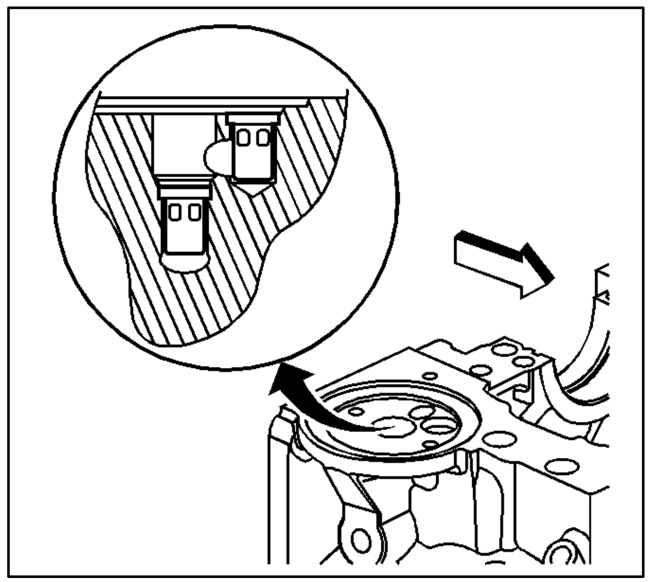
Oil Filter Adapter Removal

1. Loosen the oil filter fitting, using a hex wrench.

2. Remove the oil filter fitting.
3. Inspect the oil filter fitting, replace if necessary.


471026

4. Remove the oil bypass valves (if required). Unstake the tangs on the oil bypass valves and remove with long nose pliers.
5. Discard the oil bypass valves, if removed.

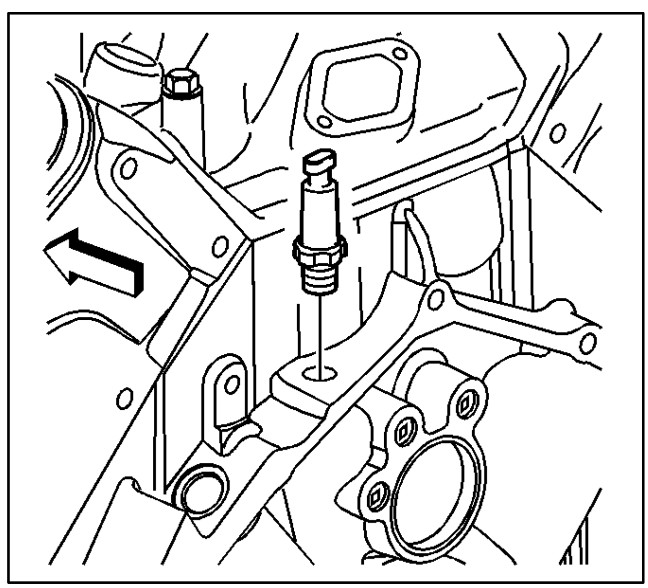

471143

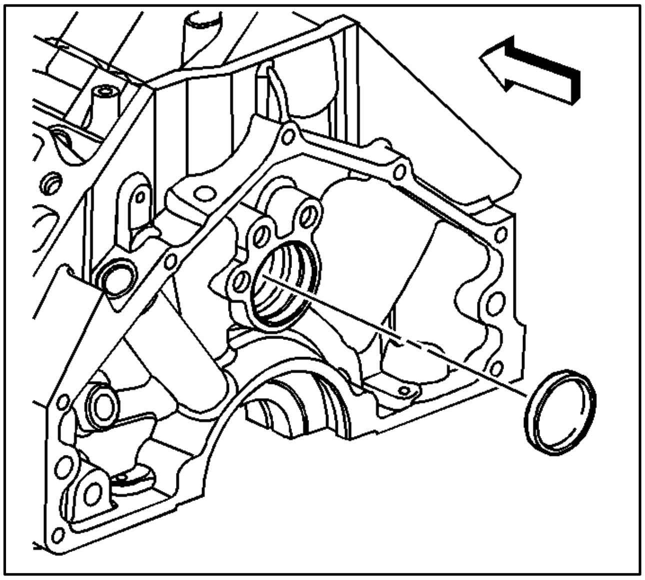
Engine Block Plug Removal

Tools Required

J 41712 Oil Pressure Sending Unit Socket

1. Remove the oil pressure switch using *J 41712.*

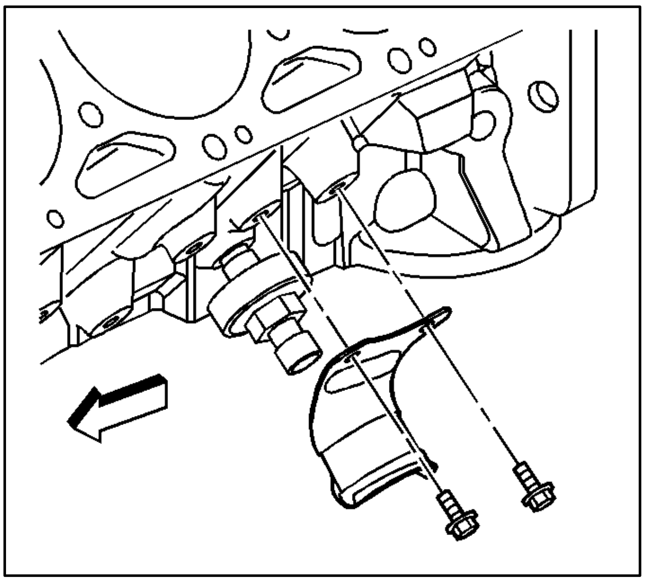

471089


471118

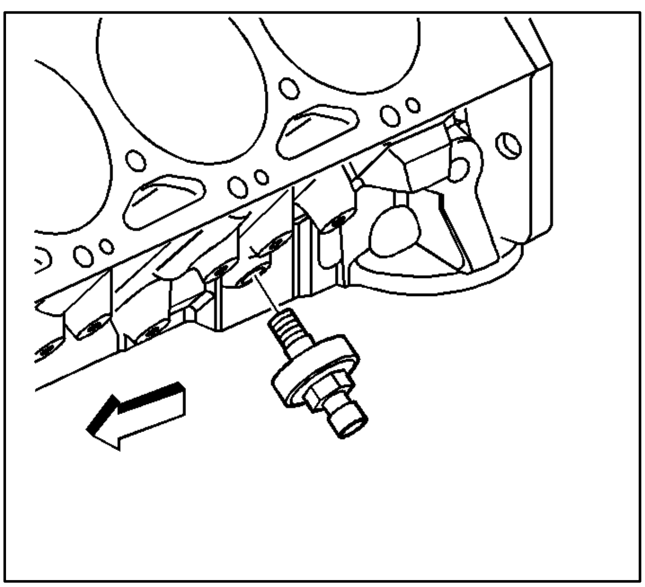
2. Remove the camshaft rear bearing hole plug:
   2.1. Obtain a suitable self-threading screw.
   2.2. Drill a hold into the plug.
   2.3. Install the self-threading screw.
   2.4. Pull on the plug until it has left the bore.

Important: Use care not to damage the camshaft bearings.

   2.5. An alternate method to remove the plug would be to insert a long shaft or bar through the front of the engine and drive the plug from the bore.

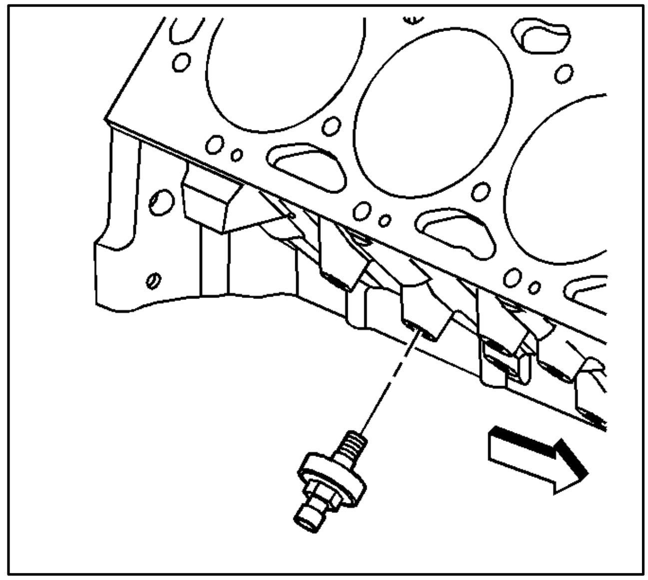

471100

3. Remove the left side knock sensor bolts.
4. Remove the left side knock sensor shield.


471081

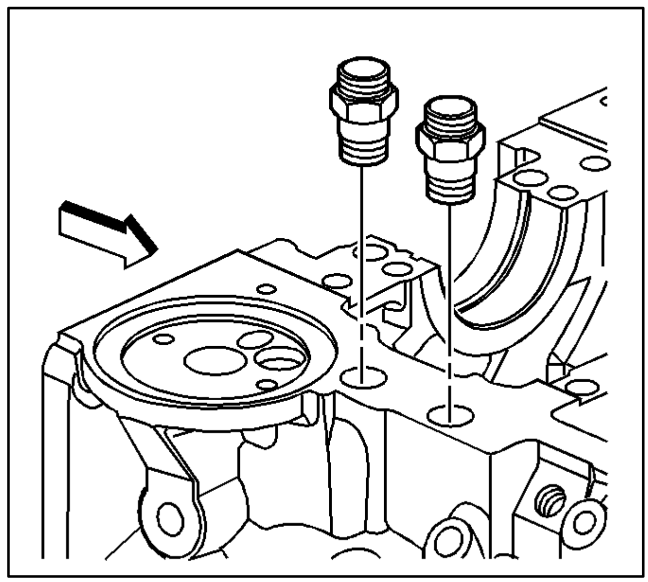
5. Remove the left side knock sensor.

6. Remove the right side knock sensor.



471076

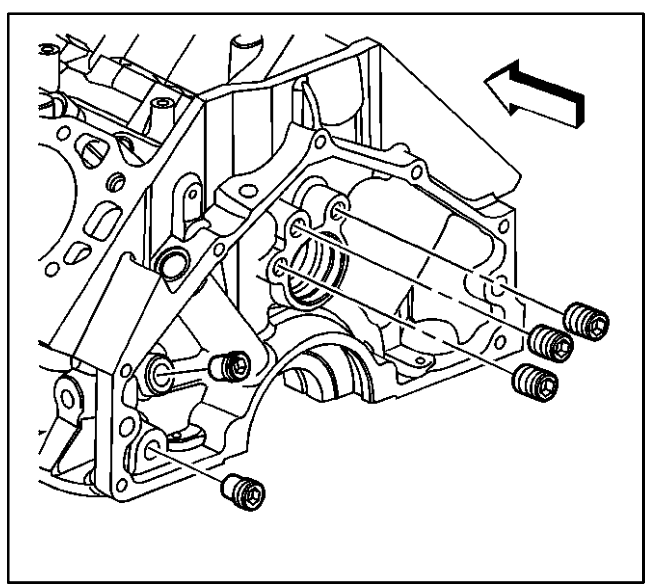
7. Remove the engine block oil cooler hose fittings.



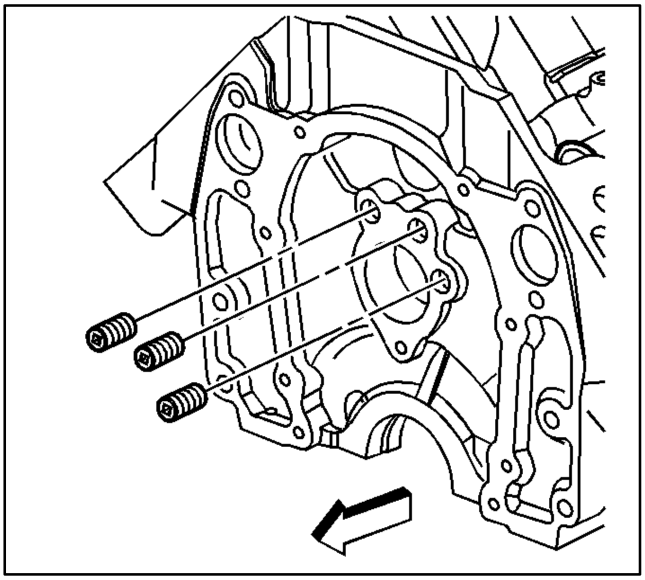
471126

Important: Cylinder block oil gallery plugs with a square drive are English taper threads. Plugs with a hex drive are Metric Straight Threads. Ensure the correct plugs are used during reassembly.

8. Remove the rear oil gallery plugs.

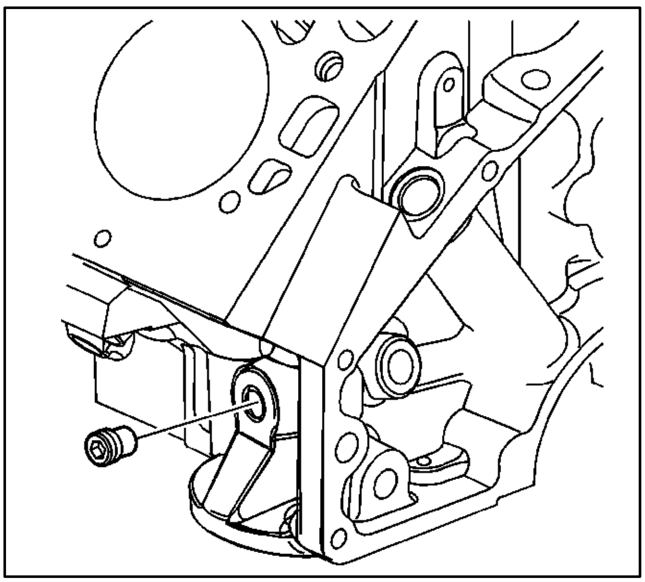


471134



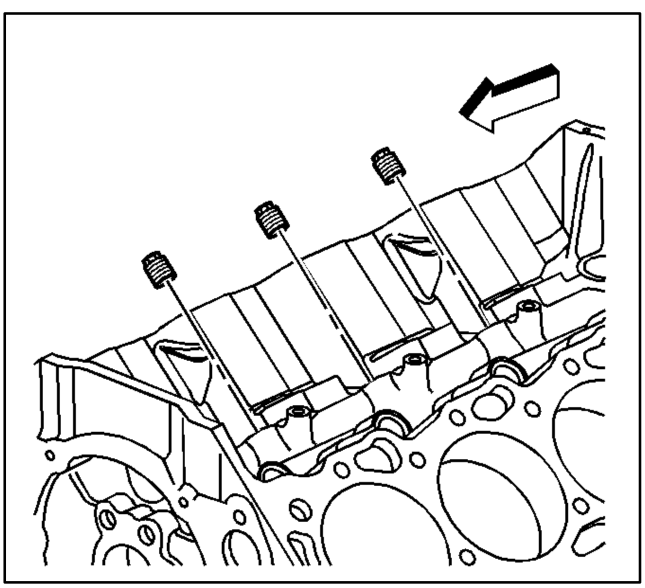
471133

9. Remove the front oil gallery plugs.



471138

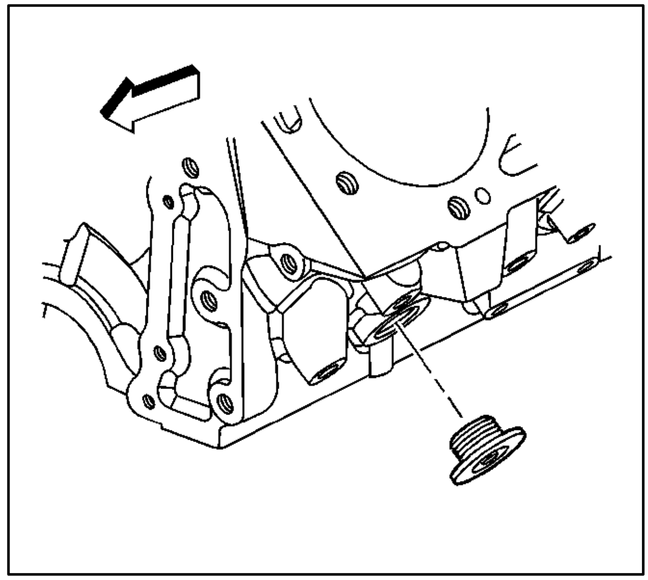
10. Remove the left side oil gallery plugs.



471137

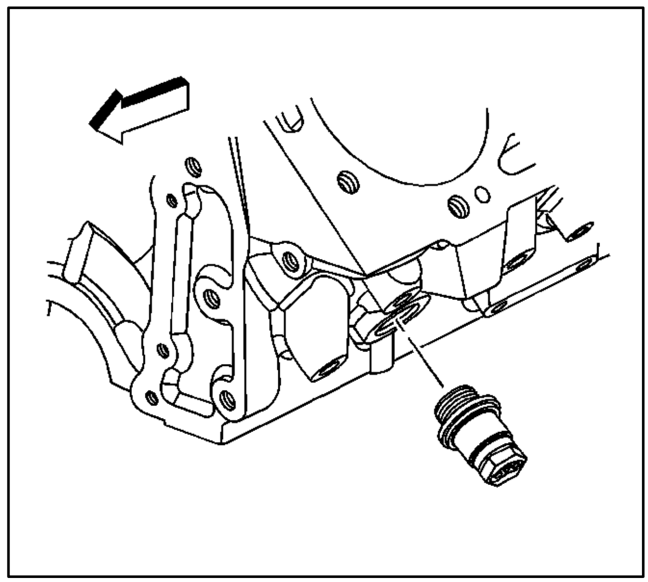
11. Remove the top oil gallery plugs.

12. Remove the engine coolant hole plug.



635657

13. Remove the engine block heater, if equipped.



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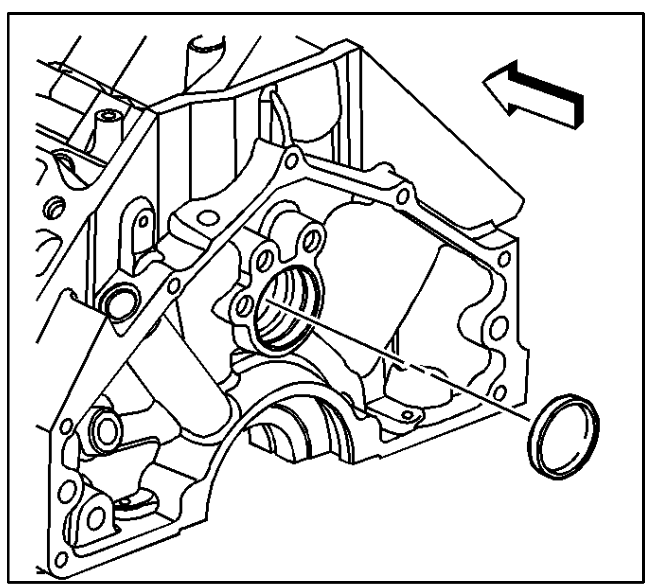
Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Remover/Installer

1. Remove the rear camshaft plug, if not previously removed.
   Insert a long bar through the front of the engine and drive the plug out of the rear bore.



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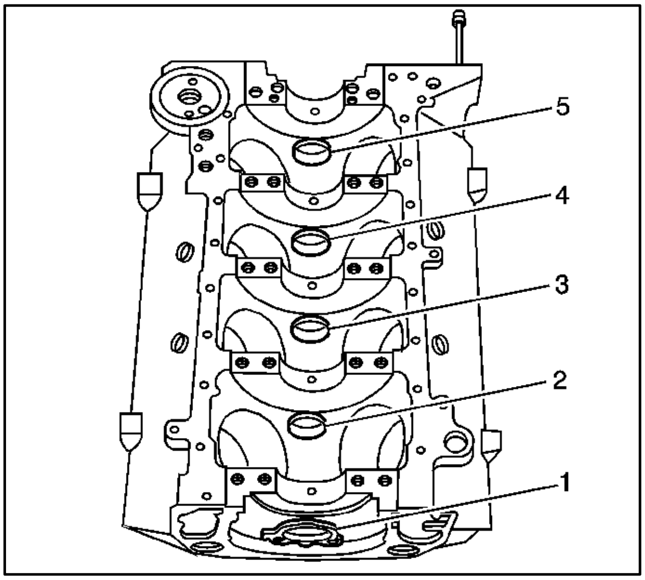

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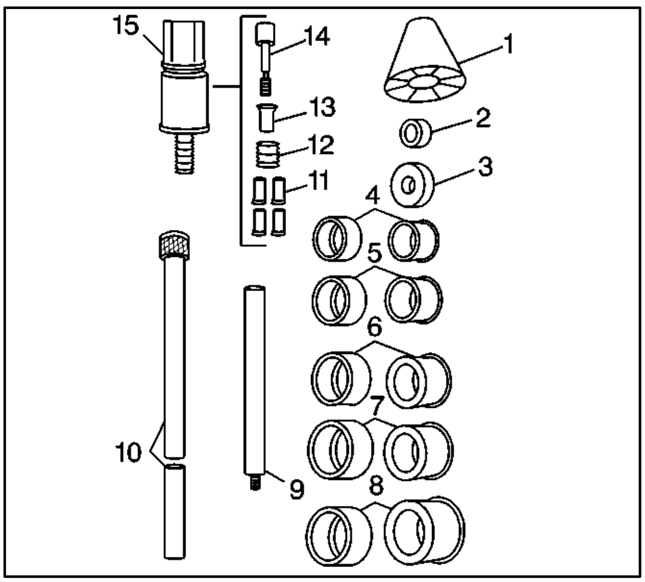
Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block bearing bore.

2. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores (positions 1-5).



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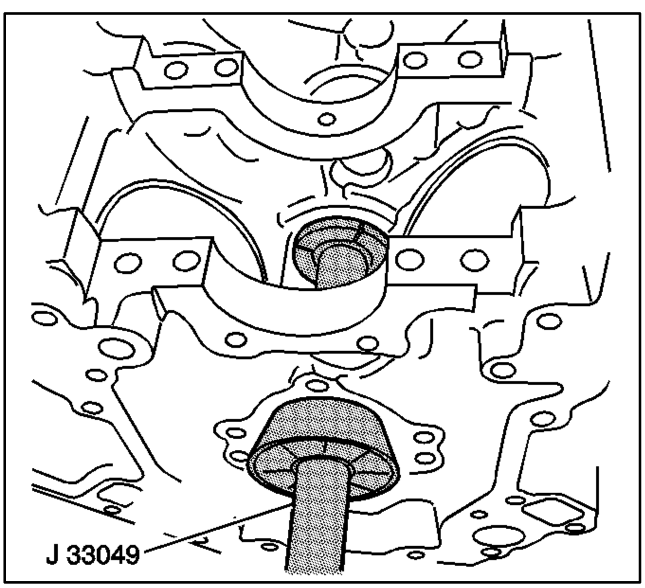
3. Select the expanding driver (4-8) and washer (2 or 3) from the *J 33049.*
4. Assemble the *J 33049.*



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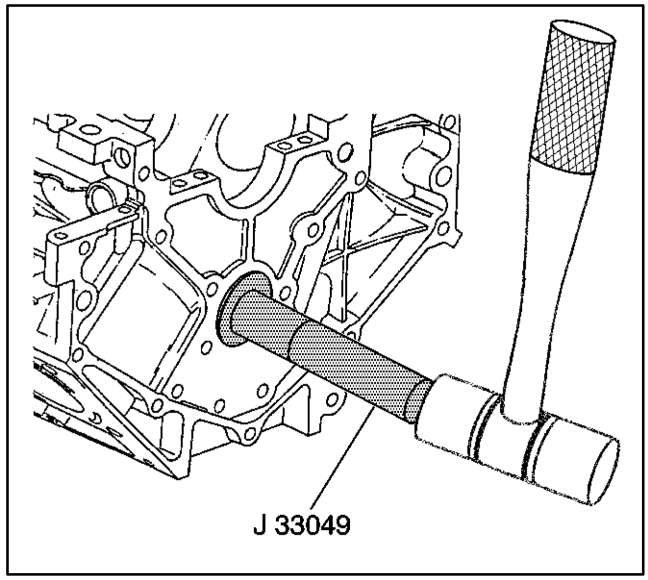
Important: Remove the inner bearings (positions 2, 3, and 4) first. The outer bearings (positions 1 and 5) serve as a guide for the *J 33049*.

5. Insert the *J 33049* through the front of the engine block and into the bearing.
6. Tighten the expander assembly nut (15) until snug.
7. Push the guide cone (1) into the front camshaft bearing (position 1) to align the *J 33049.*
8. Drive the inner bearings (positions 2, 3, and 4) from their block bores.

9. Assemble the *J 33049* handle (10), expanding driver (4-8), and washer (2 or 3).
10. Insert the *J 33049* into the outer camshaft bearings (position 1 or 5).
11. Drive the outer bearings (position 1 or 5) from the bore.



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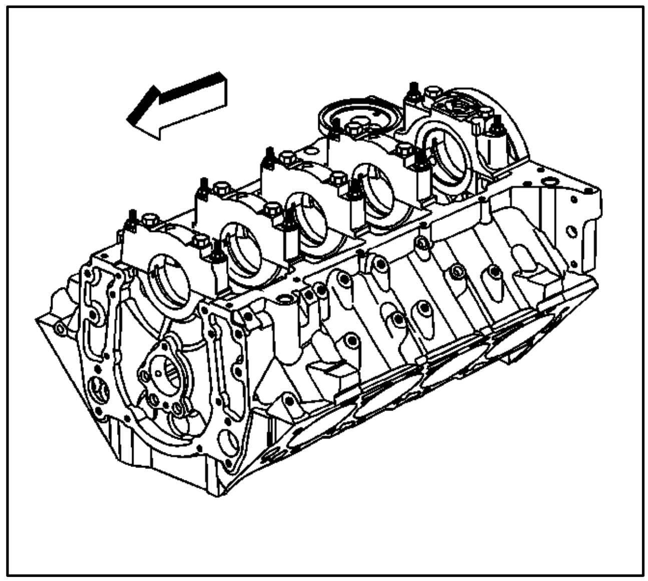
Engine Block Cleaning and Inspection

1. Boil the cylinder block in caustic solution.
2. Flush the cylinder block with clean water or steam.
3. Clean the following areas:
   - All gasket surfaces. Refer to *Replacing Engine Gaskets* in this supplement.
   - Cylinder bores, remove excessive cylinder ring ridge as required.
   - Main bearing caps.
   - Oil galleries, remove all sludge or restrictions.
   - Scale deposits from the coolant passages.
   - All dirt or debris from threaded bolt holes.

Caution: Wear safety glasses in order to avoid eye damage.

4. Dry the block with compressed air.
5. Lubricate the cylinder bores with clean engine oil to prevent rusting.
6. Inspect the engine block for the following conditions:
   - Gasket surfaces for deep gouges or other damage.
   - Crankshaft bearing bores for wear.
     - The surfaces where the crankshaft bearings contact the crankshaft baring bore must be smooth.
     - All crankshaft bearing bores must be round and uniform in inside diameter (ID) at all the bearing supports.
     - If a crankshaft bearing cap is damaged and requires replacement, refer to *Crankshaft and Bearings Cleaning and Inspection* in this supplement.
   - Camshaft bearing bores for wear or damage.
   - Valve lifter bores for scuffing or wear.
   - Engine block for cracks or other damage.
   - Cylinder walls for scoring or gouges.



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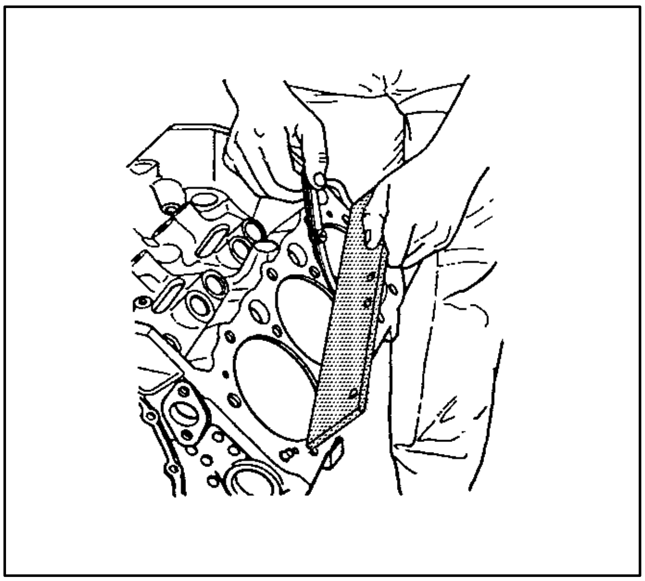
- Coolant jackets for cracks.
- Crankshaft bearing webs for cracks.
- Engine mount bosses for damage.
- The oil passages for restrictions.



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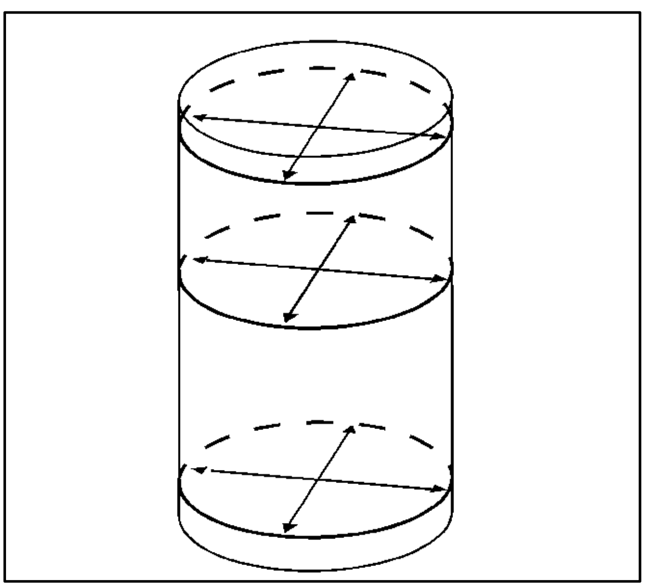
7. Inspect the engine block cylinder head deck for flatness using a straight edge and a feeler gauge.
   The surface must be flat within 0.100 mm (0.004 in).



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8. Use a bore gauge and measure the cylinder bore for taper, out-of-round and oversize. Slide the bore gauge up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center and bottom of the bore. A cylinder bore that measures 107.940 – 107.990 mm (4.249 – 4.251 in) may be honed and serviced with a standard size piston/connecting rod assembly. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston/connecting rod assembly.

Cylinder Boring and Honing

Cylinder Boring Procedure

Important: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.

To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston/connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications, the cylinder must be resized to accept a new, oversized piston.

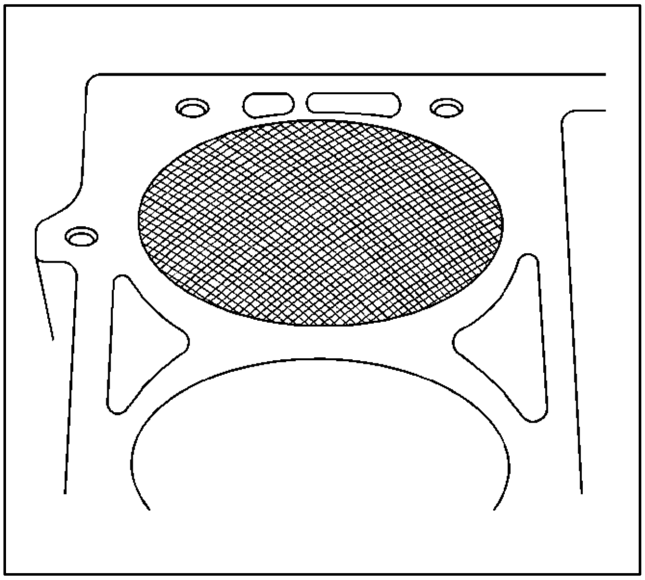
Important: If you do not check the cylinder block, the boring bar may be tilted, this may result in incorrect rebored cylinder wall to crankshaft angle.

1. Before you use any type of boring bar, clean the top of the cylinder block in order to remove any dirt or burrs.
2. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
3. When you rebore cylinders, make sure all crankshaft bearing caps are in place.
   - Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly.
   - The crankshaft must be removed prior to cylinder boring.
4. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between pistons, rings, and cylinder bores).

Cylinder Honing Procedure

Important: Always remove all bearings and components from engine block before cleaning, boring or honing the engine block.

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
   - Use only clean, sharp stones of the proper grade for the amount of material you remove.
   - Dull, dirty stones cut unevenly and generate excessive heat.
   - Do not hone to a final grade with a coarse or medium-grade stone.



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- Leave sufficient metal so that all stone marks may be removed with fine grade stones.
- The re-honed surfaced finish should be 0.25 – 0.50 micrometer (10 – 20 microinch).
- Perform final honing with a fine-grade stone and hone the cylinder in a cross hatch pattern at 20 to 30 degrees to obtain the proper clearance.

2. During the honing operation, thoroughly clean the cylinder bore.
   - Repeatedly check the cylinder bore for fit with the selected oversized piston.
   - All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.
3. To eliminate taper in the cylinder, when honing, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle, and the bottom of the bore.
   - The finish marks should be clean but not sharp.
   - The finish marks should be free from embedded particles and torn or folded metal.
4. When finished, the reconditioned cylinder bores should have less than or meet the specific out-of-round or taper requirements.
5. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent.
   - 5.1. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores.
     - Abrasive material may cause premature wear of new piston rings and cylinder bores.
     - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
   - 5.2. After washing the cylinder bore, dry the bore with a clean shop towel.
6. Perform final measurements of the cylinder bore.
7. Permanently mark the piston for the specific cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- *J 7872* Magnetic Base Dial Indicator
- *J 36660-A* Electronic Torque Angle Meter

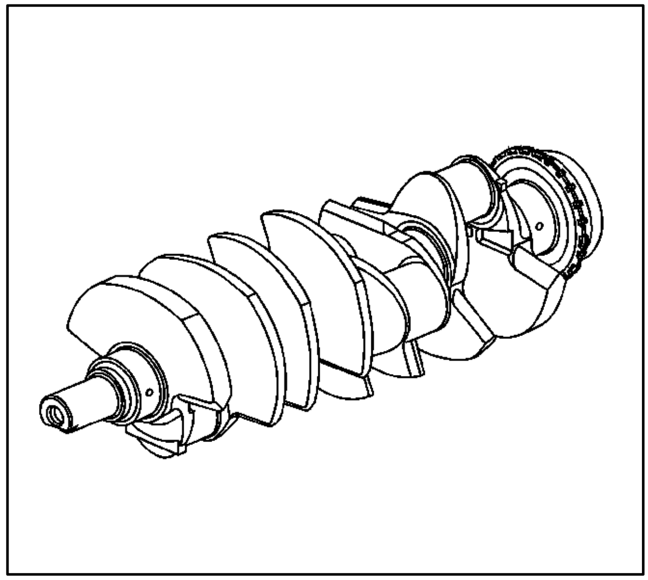
Crankshaft Inspection

Important: Use care when handling the crankshaft. Avoid damage to the bearing surfaces.

1. Clean the crankshaft in solvent. Remove all sludge or restrictions from the oil passages.

Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the crankshaft and bearings with compressed air.



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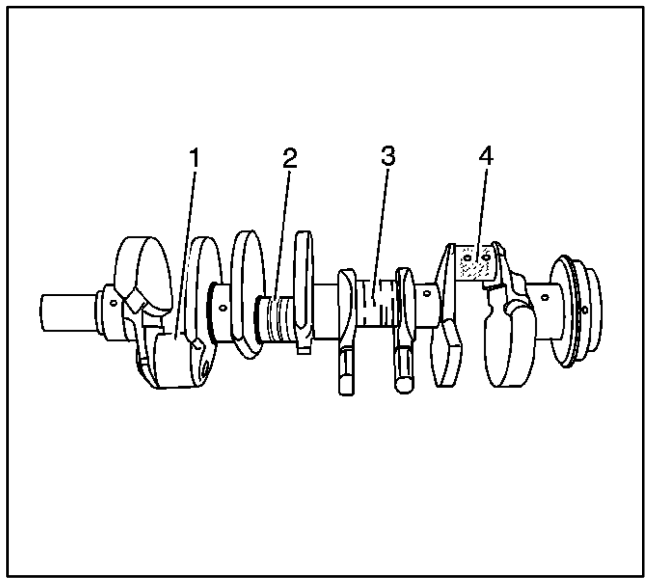
3. Inspect the crankshaft for the following conditions:
   - Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
   - Deep grooves (2).
   - Scratches or uneven wear (3).
   - Pitted surfaces (4).
   - Wear or damage to the thrust journal surfaces.
   - Scoring or damage to the rear seal surface.
   - Restrictions to oil passages.
   - Damage to threaded bolt holes.



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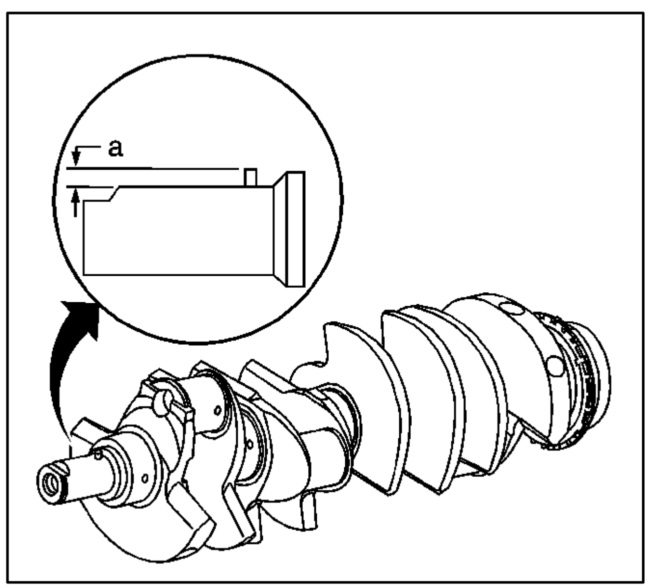
Important: The crankshaft pin is a pressed-in roll pin. The pin only needs to be removed from the crankshaft if the pin is damaged.

4. Inspect the crankshaft pin for damage.
   - Measure for proper installed height (a).
   - Proper crankshaft pin installed height is 2.00 to 2.25 mm (0.078 to 0.088 in).
   - Replace the crankshaft pin if it is damaged.



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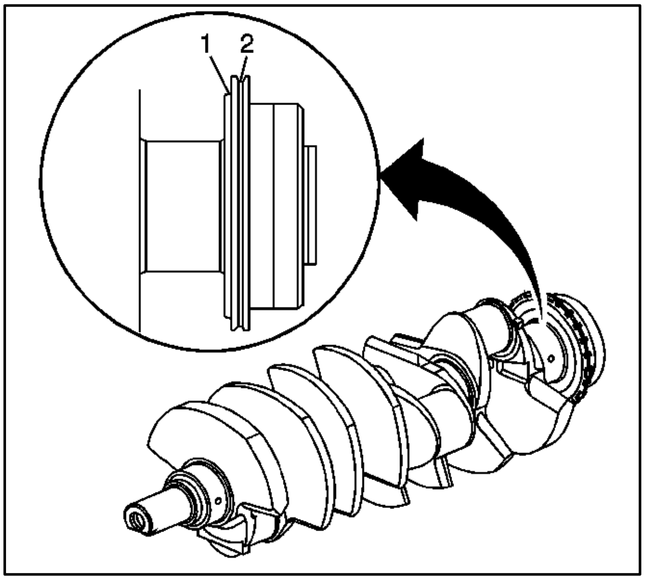

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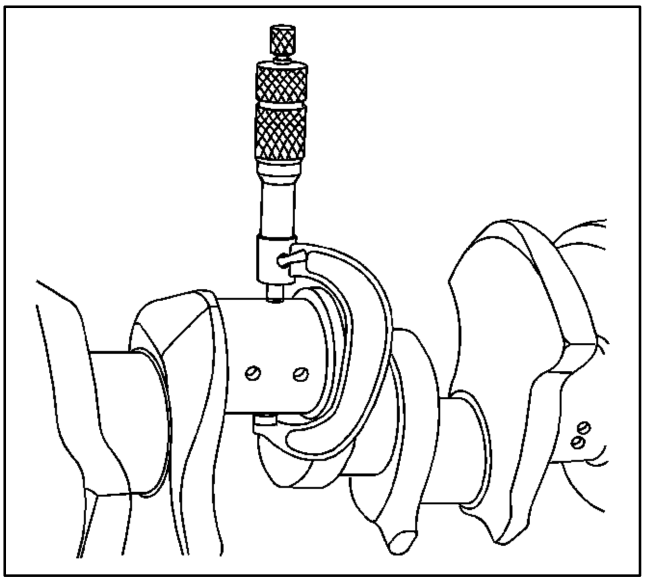
Important: Do NOT attempt to remove the crankshaft reluctor wheels. If the reluctor wheels are damaged and/or removed, the crankshaft must be replaced.

5. Inspect the reluctor wheels for cracked, bent or broken teeth.
   - Measure between the crankshaft shoulder and the front reluctor wheel (1).
   - Measure between the front and rear reluctor wheels (2).
   - The maximum allowable gap is 0.15 mm (0.006 in).



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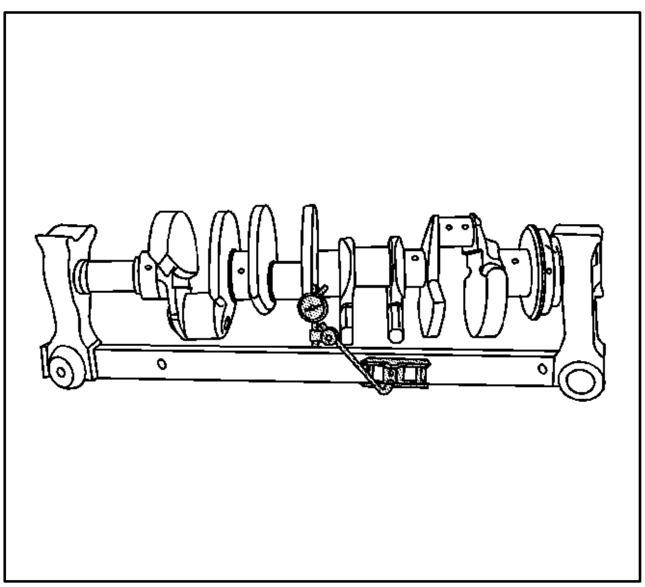
6. Measure the crankshaft main journals and the crankpins for out-of-round and taper.



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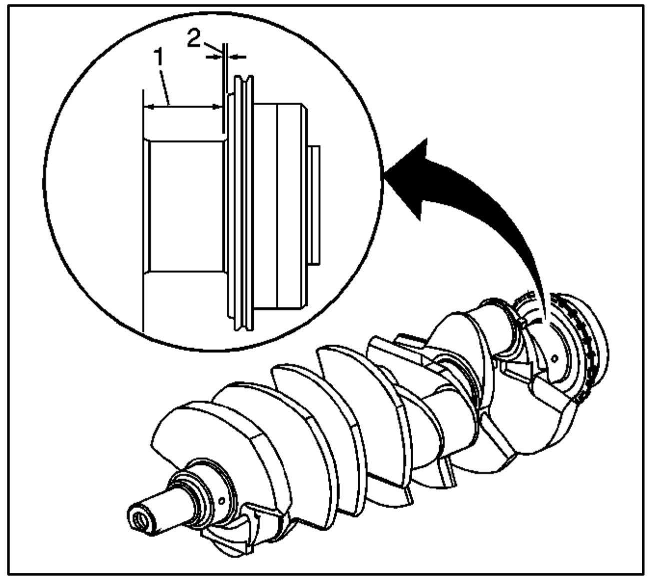
7. Using a suitable fixture, support the crankshaft.
   - 7.1. Measure the crankshaft runout using *J 7872*.
   - 7.2. Crankshaft runout should not exceed 0.051 mm (0.002 in).

8. Inspect the crankshaft thrust wall surface for wear (1) and/or excessive runout (2). Refer to *Engine Mechanical Specifications* in this supplement.



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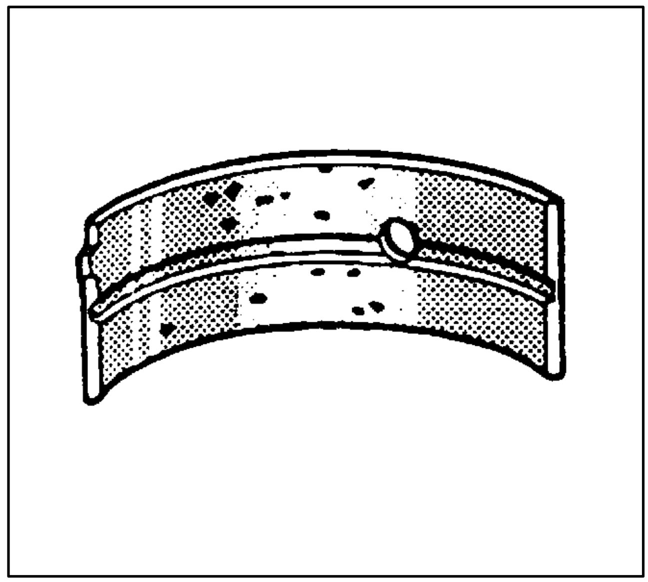
Crankshaft and Connecting Rod Bearing Inspection

Important: The crankshaft and connecting rod bearings should be inspected only to determine what kind of damage or failure has occurred. Always install NEW bearings once the bearings have been removed.

1. Inspect the bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.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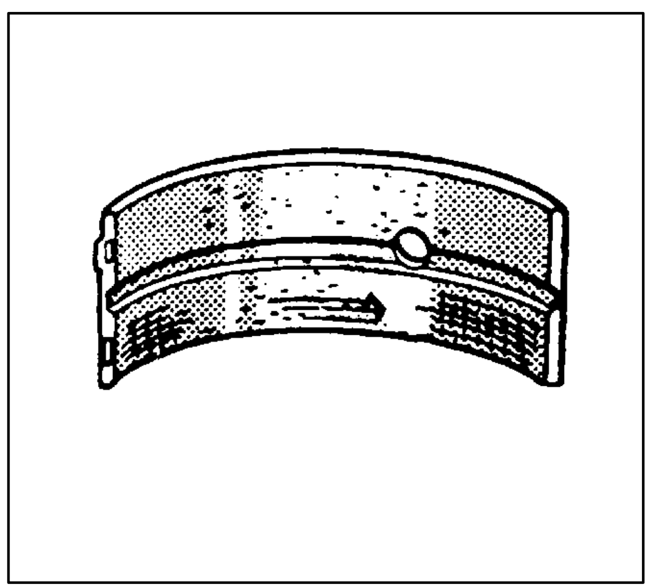
2. Inspect the bearings for excessive scoring or discoloration.
3. Inspect the bearings for dirt or debris embedded into the bearing material.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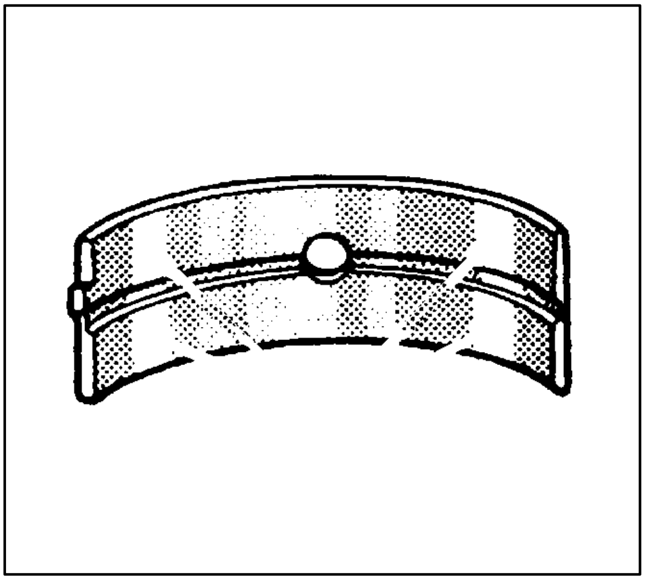

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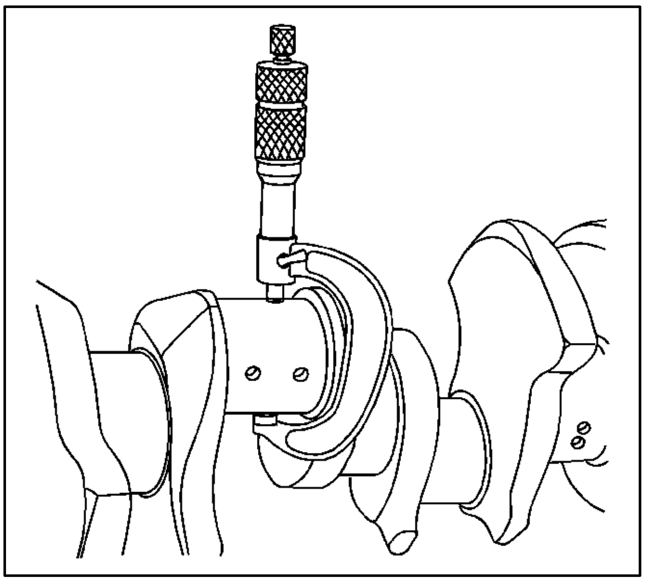
4. Inspect the bearings for improper seating indicated by bright, polished sections of the bearings.



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Crankshaft and Connecting Rod Bearing Clearance Measurement

The crankshaft and connecting rod bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, undersize bearings will be required. The service bearings are available in both the undersize and standard size.

The selective fitting of the bearings is necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use on-half of a standard bearing with one-half of an undersize bearing.

In order to determine the correct replacement bearing size, the bearing clearance must be measured accurately. The micrometer method is preferred because it is more accurate. The plastic gauge method should only be used if the micrometer method is not available.

Micrometer Method for Crankshaft Bearings

Tools Required

J 36660-A Electronic Torque Angle Meter

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankshaft main journal diameter with a micrometer in several places along the length approximately 90 degrees apart, (minimum of 4 places), and average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications* in this supplement.

3. Install the NEW crankshaft bearings into the crankshaft baring caps and the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

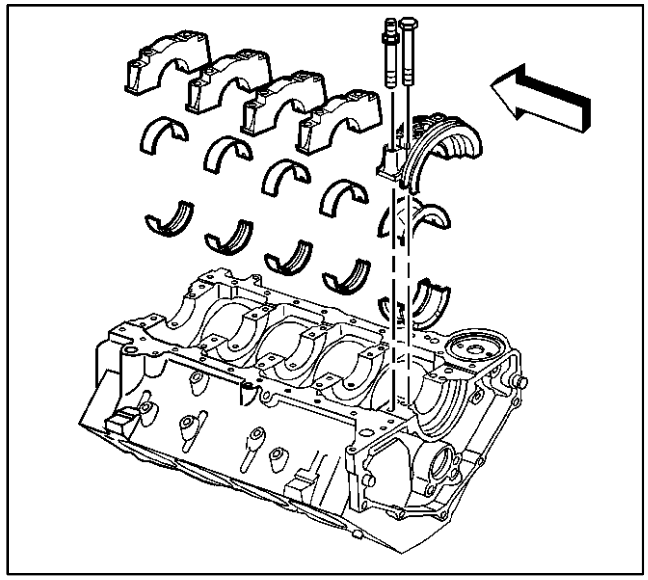
Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap studs.

4 Install the crankshaft bearings caps and the crankshaft bearing cap bolts and studs.

   Tighten

   - Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).
   - Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).
   - Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.
   - Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.

5. Measure the crankshaft bearing inside diameter (ID) using an inside micrometer. Measure at a minimum of four places and average the measurements.
6. In order to determine the crankshaft bearing clearance, subtract the crankshaft journal diameter from the crankshaft bearing ID.
7. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications* in this supplement.
8. If the crankshaft bearing clearances exceeds specifications, install undersize crankshaft bearings to achieve the correct clearance.
9. Measure the new crankshaft bearing inside diameter (ID) using an inside micrometer.
10. Replace or repair the crankshaft if the proper clearances cannot be obtained with available crankshaft bearings.



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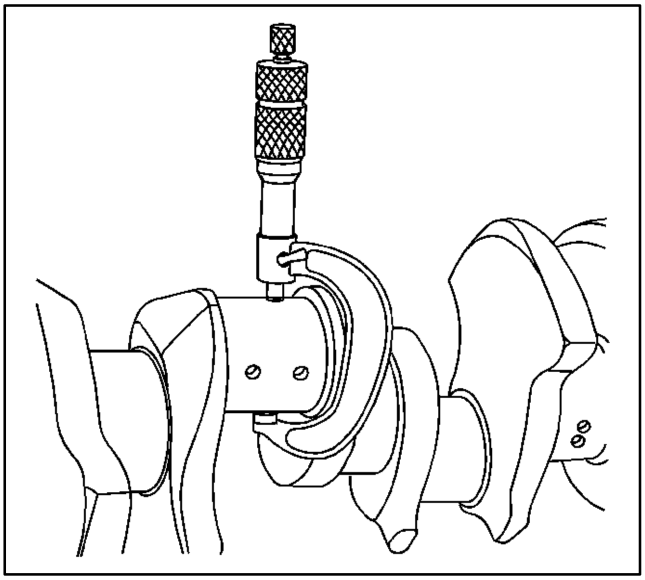

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Micrometer Method for Connecting Rod Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankpin diameter with a micrometer in several places along the length, approximately 90 degrees apart (minimum of 4 places), and average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications* in this supplement.
3. Install the NEW connecting rod bearings into the connecting rod cap and the connecting rod.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: Use the original connecting rod nuts for clearance measurement. During final assembly new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original (used) nuts.

   Tighten

   Tighten the connecting rod nuts to 30 N·m (22 lb ft). Tighten the connecting rod nuts an additional 90 degrees.
5. Measure the connecting rod bearing inside diameter (ID) using an inside micrometer.
6. Compare the connecting rod bearing clearance specifications. Refer to *Engine Mechanical Specifications* in this supplement.
7. If the connecting rod bearing clearances exceed specifications, install undersize connecting rod bearings to achieve the correct clearance.
8. A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it will be necessary to replace or repair the crankshaft or connecting rods.

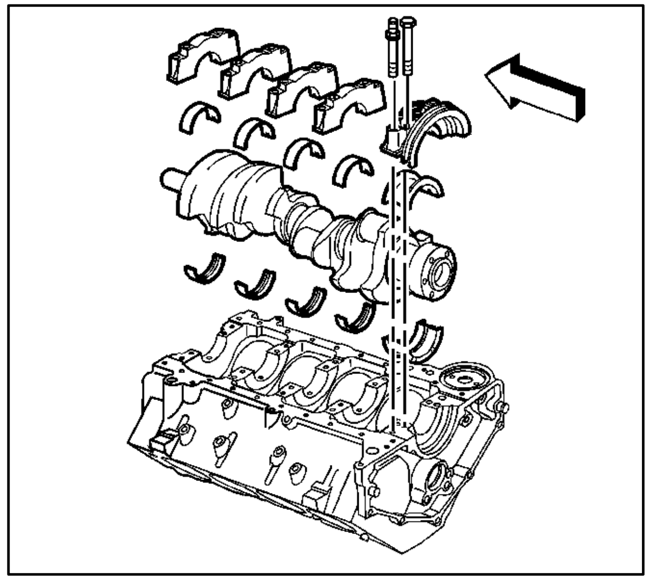
Plastic Gauge Method for Crankshaft Bearings

Tools Required

J 36660-A Electronic Torque Angle Meter

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the crankshaft and the new crankshaft bearings into the block, making sure not to damage the reluctor rings of the crankshaft.



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2. Install the gauging plastic the full width of the crankshaft journal.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

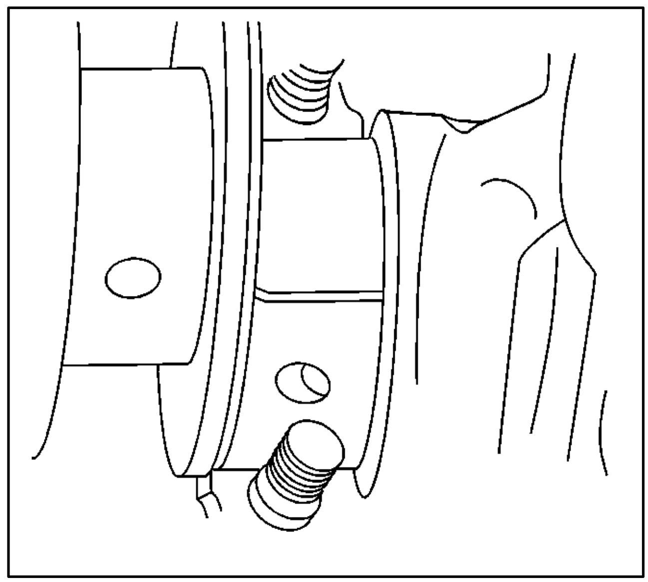
Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap studs. The crankshaft journal and the crankshaft bearing surface must be free from oil to obtain a correct measurement. Do not allow the crankshaft to rotate while performing the measurement, or an incorrect measurement will be obtained.

3. Install the crankshaft bearing caps and the crankshaft bearing cap bolts and studs.

   Tighten

   - Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).
   - Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).
   - Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.
   - Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.

4. Remove the crankshaft bearing cap bolts and the crankshaft bearing caps. The gauging plastic may adhere to either the crankshaft journal or the crankshaft bearing surfaces.



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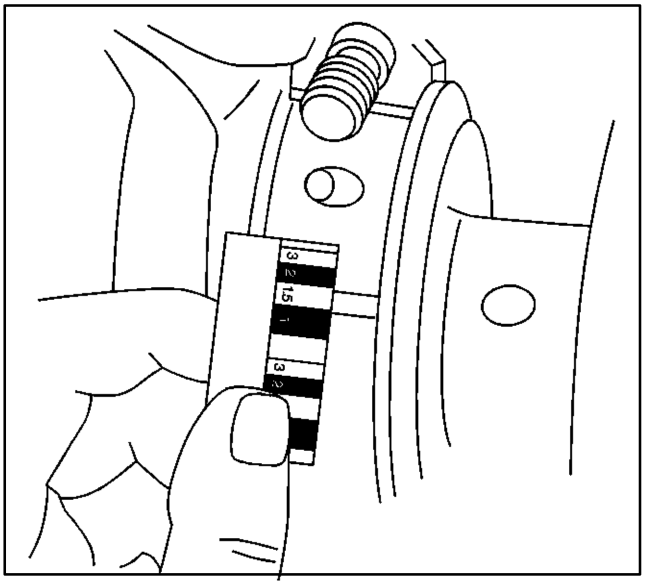

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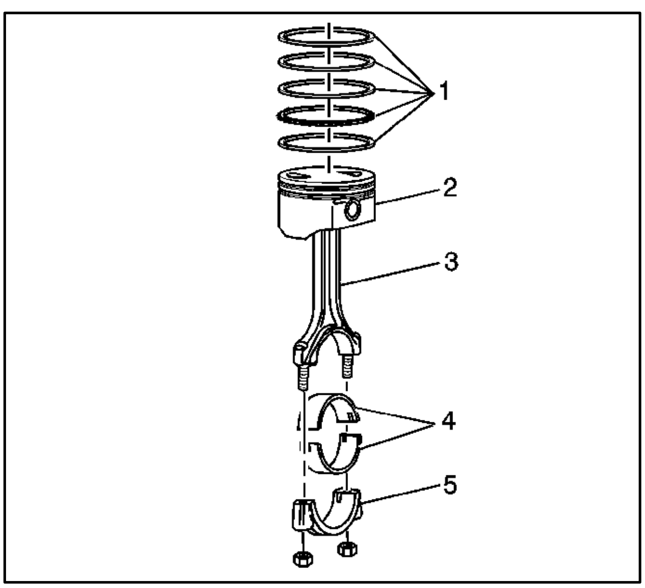
5. On the edge of the gauging plastic envelope there is a graduated scale. Without removing the gauging plastic, measure the compressed width at the widest point.
6. If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft journal.
   - Normally the crankshaft journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round (0.0254 mm (0.001 in) maximum) crankshaft journal, be sure to fit to the maximum diameter of the crankshaft journal.
   - If the crankshaft bearing is fitted to the minimum diameter and the crankshaft journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft journal will result in rapid crankshaft bearing failure.
7. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications* in this supplement.
8. If the crankshaft bearing clearances exceeds specifications, install undersize crankshaft bearings to achieve the correct clearance.
9. Measure the new crankshaft bearing inside diameter (ID) using the same method.
10. Replace or repair the crankshaft if the proper clearances cannot be obtained with available crankshaft bearings.
11. Remove the flattened gauging plastic.
12. Measure the remaining crankshaft journals.



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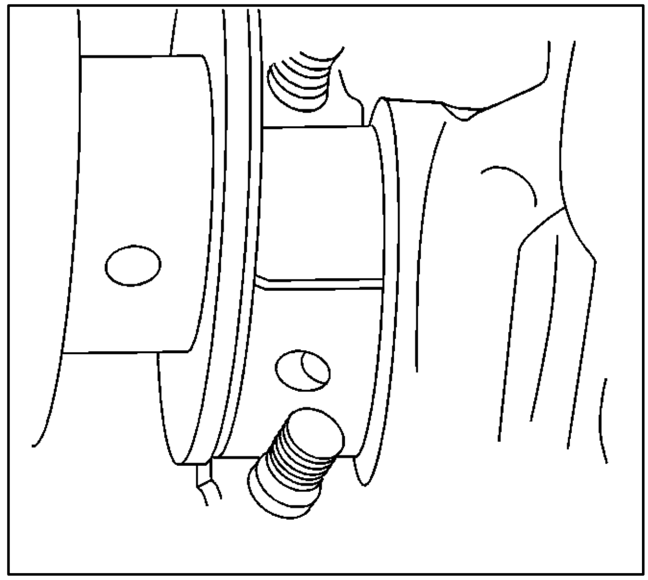
Plastic Gauge Method for Connecting Rod Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the connecting rod bearings into the connecting rod and the connecting rod cap.
2. Using rubber fuel line over the connecting rod bolts, install the piston and connecting rod assembly onto the crankpin journal.

3. Install the gauging plastic the full width of the crankpin journal.



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Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

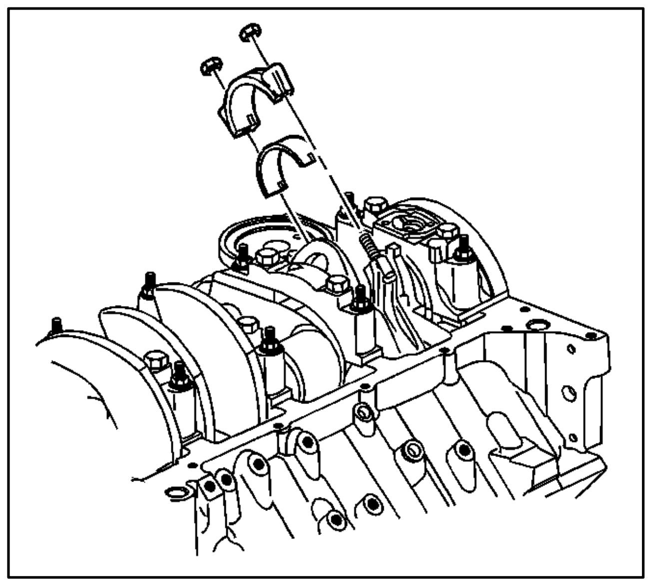
Important: Use the original connecting rod nuts for clearance measurement. During final assembly, new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original (used) nuts.

   Tighten

   Tighten the connecting rod nuts to 30 N·m (22 lb ft). Tighten the connecting rod nuts an additional 90 degrees.

5. Remove the connecting rod nuts and cap. The gauging plastic may adhere to either the crankpin journal or the connecting rod bearing surface.



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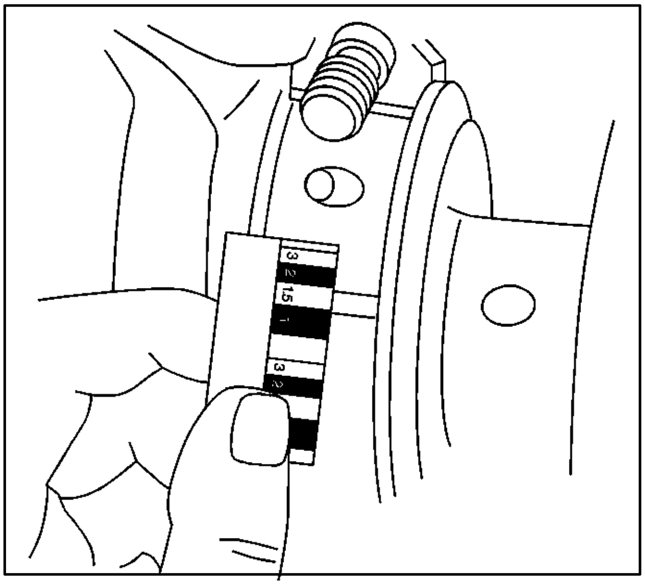

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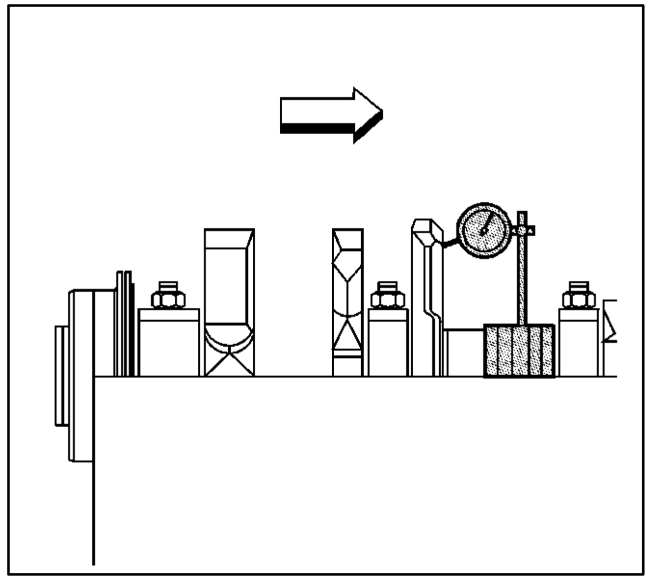
6. On the edge of the gauging plastic envelope there is a graduated scale. Without removing the gauging plastic, measure the compressed width at the widest point.

   If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankpin journal.
7. Normally the crankpin journals wear evenly and are not out-of-round. However, if a connecting rod bearing is being fitted to an out-of-round (0.0254 mm (0.001 in) maximum) crankpin journal, be sure to fit to the maximum diameter of the crankpin journal. If the connecting rod bearing is fitted to the minimum diameter and the crankpin journal is excessively out-of-round, the interference between the connecting rod bearing and the crankpin journal will result in rapid connecting rod bearing failure.
8. Compare the connecting rod bearing clearance to the specifications. Refer to *Engine Mechanical Specifications* in this supplement.
9. If the connecting rod bearing clearances exceed specifications, install undersize connecting rod bearings to achieve the correct clearance.
10. A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it will be necessary to replace or repair the crankshaft or connecting rods.
11. Remove the flattened gauging plastic.
12. Measure the remaining crankpin journals.

Measuring Crankshaft End Play

Tools Required

J 7872 Magnetic Base Dial Indicator



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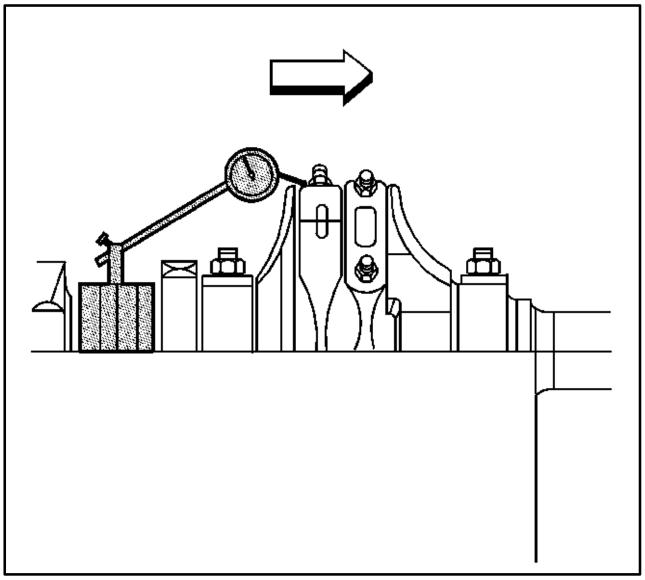
Important: In order to properly measure the crankshaft end play, the crankshaft, bearings, bearing caps and fasteners must be installed into the engine block and the bolts tightened to specifications. Refer to *Crankshaft and Bearings Installation* in this supplement.

1. Install the *J 7872* or equivalent to the cylinder block, with the dial indicator plunger against one of the counterweights of the crankshaft.
2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward and read the endplay measurement on the dial indicator. An optional method is to insert a feeler gauge between the crankshaft and bearing surface and measure the clearance. Refer to *Engine Mechanical Specifications* in this supplement.
4. If the correct end play cannot be obtained, inspect for the following conditions:
   - Verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications* in this supplement.
   - Inspect the crankshaft thrust wall surface for wear and/or excessive runout. Refer to *Engine Mechanical Specifications* in this supplement.
5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition(s) could cause a lack of clearance at the bearing:
   - Burrs on the crankshaft bearing cap.
   - Foreign matter between the crankshaft bearing and the block or the crankshaft bearing cap.
   - A faulty crankshaft bearing.



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Measuring Connecting Rod Side Clearance

Tools Required

J 7872 Magnetic Base Dial Indicator

Important: In order to properly measure the connecting rod side clearance, the piston/connecting rod assembly and bearings must be installed into the engine block and the connecting rod nuts tightened to specifications. Refer to *Piston, Connecting Rod and Bearing Installation* in this supplement.

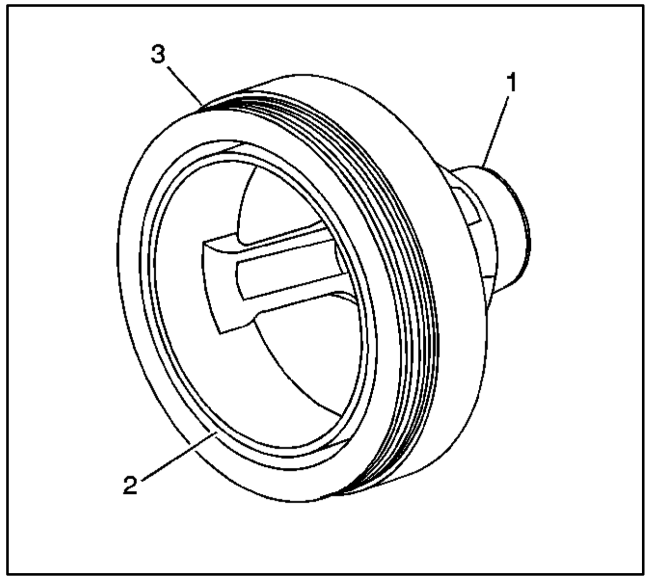
1. Install the *J 7872* or equivalent to the cylinder block, with the dial indicator plunger against the side of the pair of connecting rods.
2. With the connecting rods pushed forward, zero the dial indicator. Firmly move the pair of connecting rods side to side and read the measurement on the dial indicator. An optional method is to insert a feeler gauge between the connecting rod caps and measure the connecting rod side clearance. Refer to *Engine Mechanical Specifications* in this supplement.

Crankshaft Balancer Cleaning and Inspection

1. Clean the crankshaft balancer in solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
   - Damaged belt grooves (3).
   - Debris in the belt grooves (3).
   - Worn, grooved, or damaged hub seal surface (1).
     – Minor imperfections on the hub seal surface may be removed with a polishing compound or fine grade of emery cloth.
     – A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
   - Worn, chunking or deteriorated rubber between the hub and pulley (2).
4. Repair or replace the crankshaft balancer as necessary.



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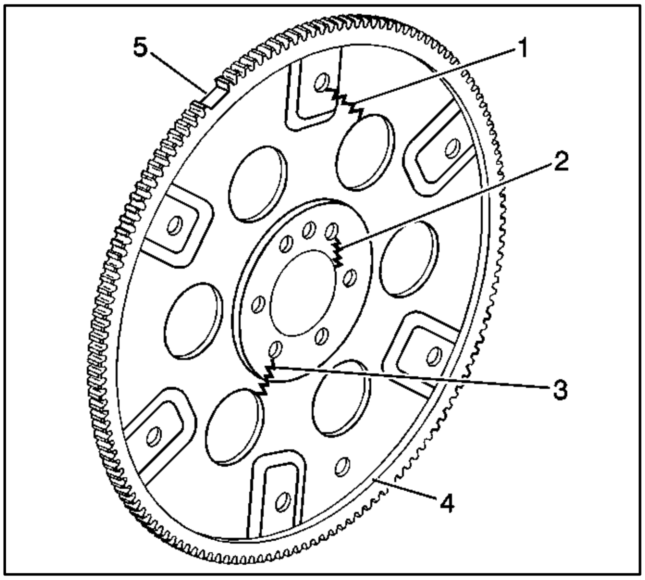

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Engine Flywheel Cleaning and Inspection

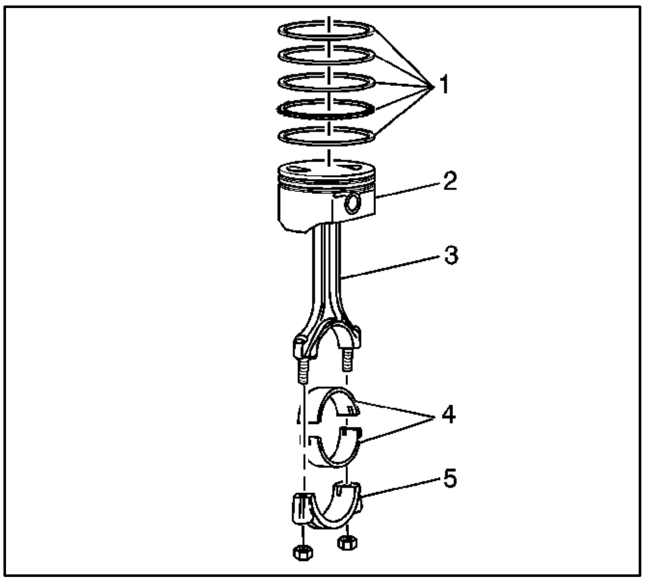
1. Clean the engine flywheel in solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 3).

Important: Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.

- Cracks at welded areas that retain the ring gear onto the engine flywheel (4).
- Damaged or missing ring gear teeth (5).



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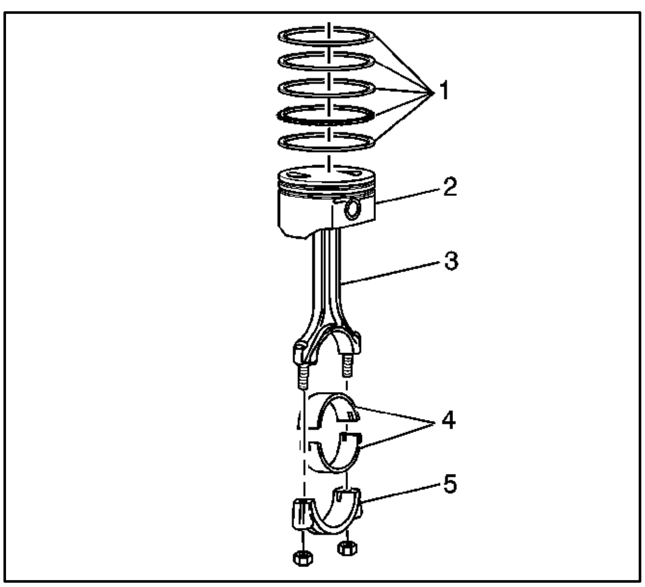
Piston and Connecting Rod Disassemble

Important: The piston and connecting rod are only serviced as an assembly. If a new piston or connecting rod is required, a complete piston/connecting rod assembly must be used.

Important: New connecting rod nuts must be used when the pistons are reinstalled in the engine.

Remove the piston rings (1) from the piston (2).



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Piston, Connecting Rod, and Bearings Cleaning and Inspection

Important: The piston diameter can NOT be measured due to the piston coating. Do NOT measure the piston diameter.

Important: Measurement of all components should be taken with the components at room temperature.

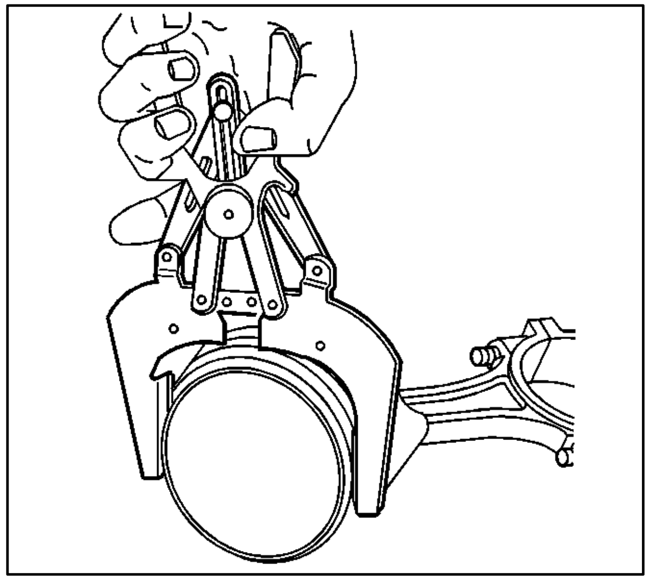
Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston (2), connecting rod (3) and connecting rod cap (5) in solvent.

Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.



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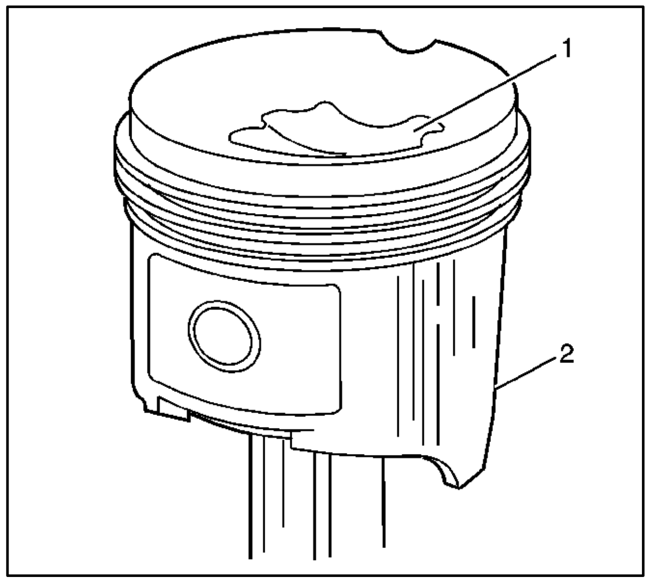
5. Inspect the piston for the following conditions:
   - Eroded areas (1) on the top of the piston.
   - Scuffed or damaged skirt (2).
   - Cracks in the piston ring lands, the piston skirt, or the pin bosses.
   - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind.
6. Inspect the piston pin for scoring, wear or other damage.



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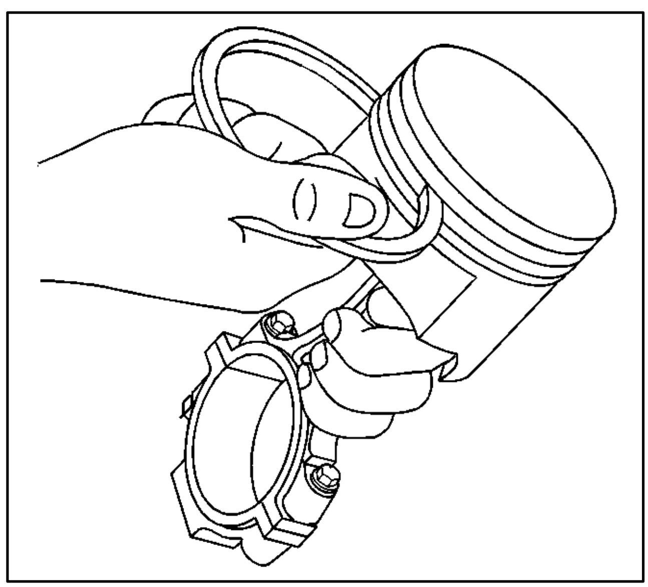
7. Measure the piston ring-to-piston ring groove side clearance. Refer to *Engine Mechanical Specifications* in this supplement.
   7.1. Insert the edge of the piston ring into the piston ring groove.
   Roll the piston ring completely around the piston.
   7.2. If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
   7.3. If binding is caused by a distorted piston ring, replace the piston ring.



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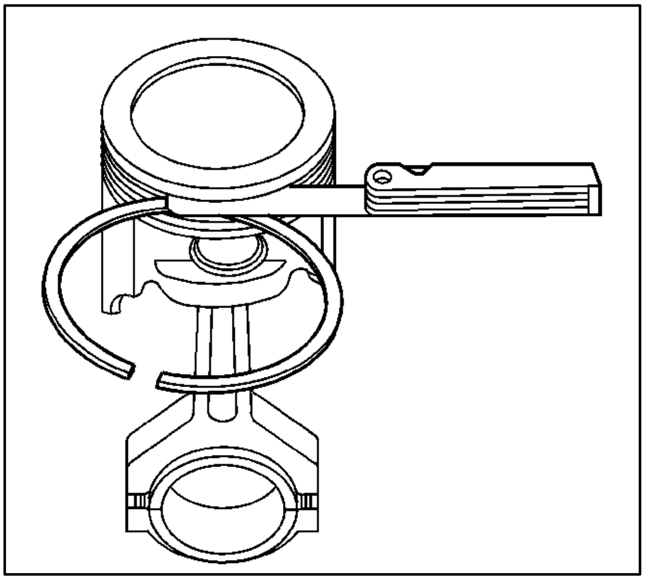

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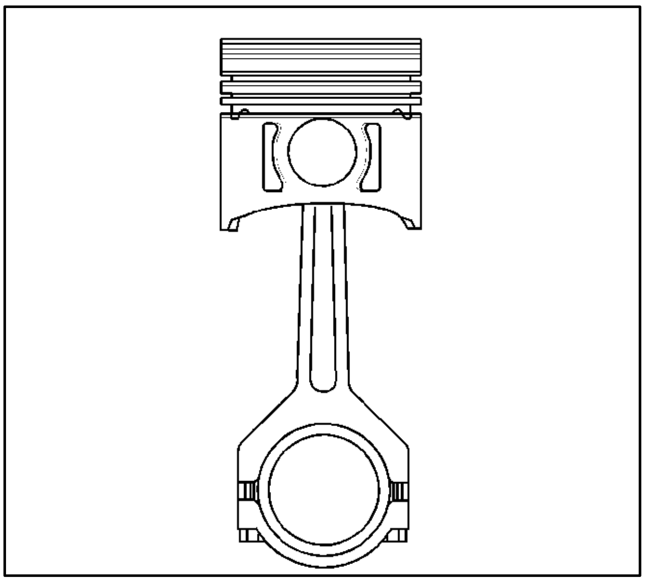
8. Measure the piston ring side clearance with a feeler gauge.
9. If the side clearance is too small, try another piston ring set. Refer to *Engine Mechanical Specifications* in this supplement.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.



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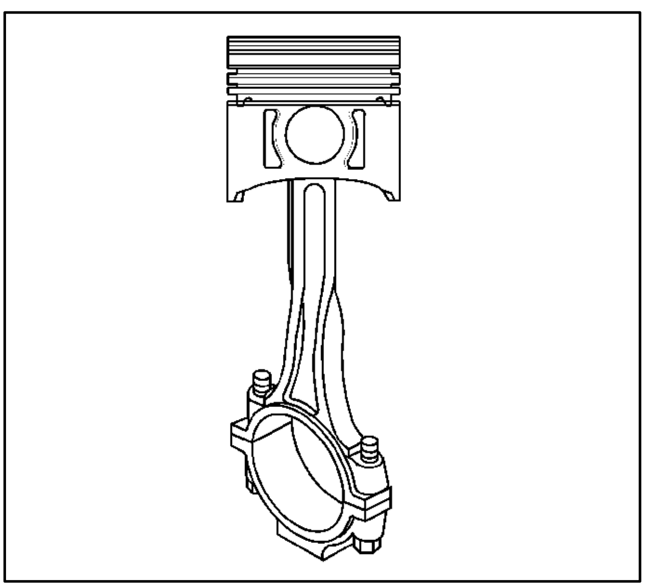
11. Inspect the connecting rod for an out-of-round bearing bore.



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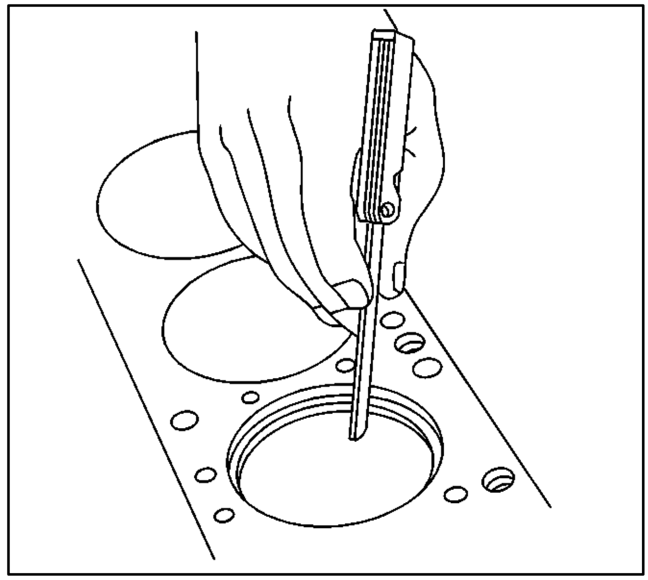
12. Inspect the connecting rod for twisting.
13. Inspect the connecting rod for damage to the connecting rod bolt threads.

Important: Fit each compression ring to the cylinder in which it will be used.

14. Measure the piston compression ring end gap.
    14.1. Place the compression ring in to the cylinder bore.
    14.2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.
    The ring must be square to the cylinder wall.
    14.3. Use a feeler gauge in order to measure the end gap.
    14.4. Select another size ring set if the end gap exceeds specifications.



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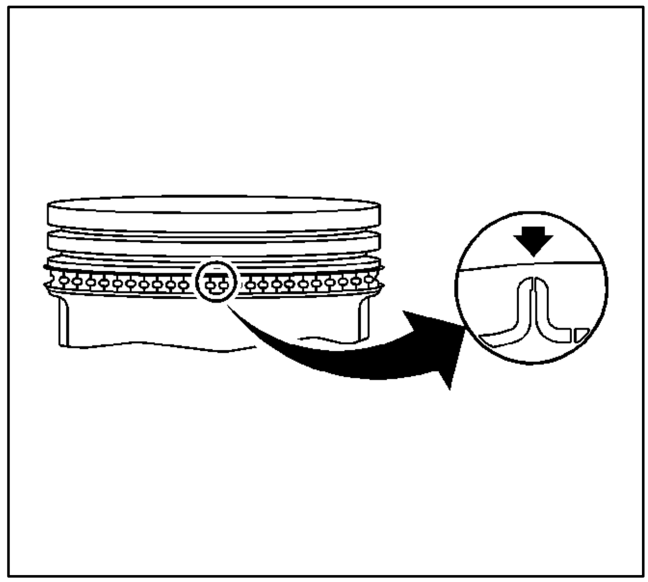
Piston and Connecting Rod Assemble

Notice: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the lower oil control piston ring spacer onto the piston.



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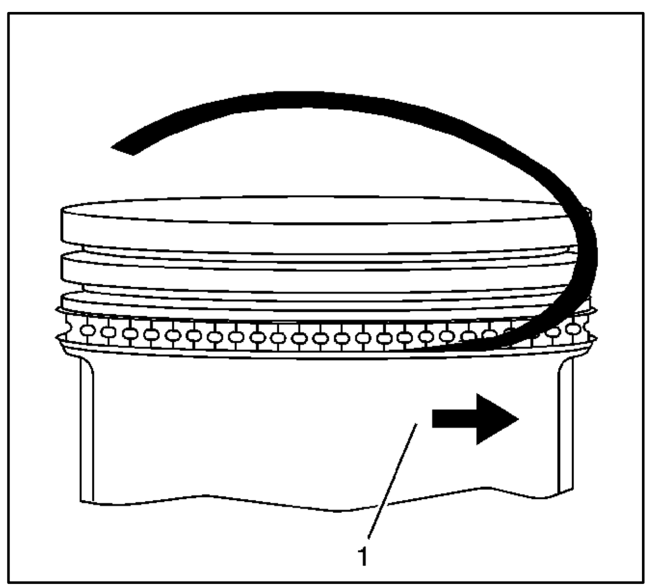
2. Install the lower oil control piston ring onto the piston (1).



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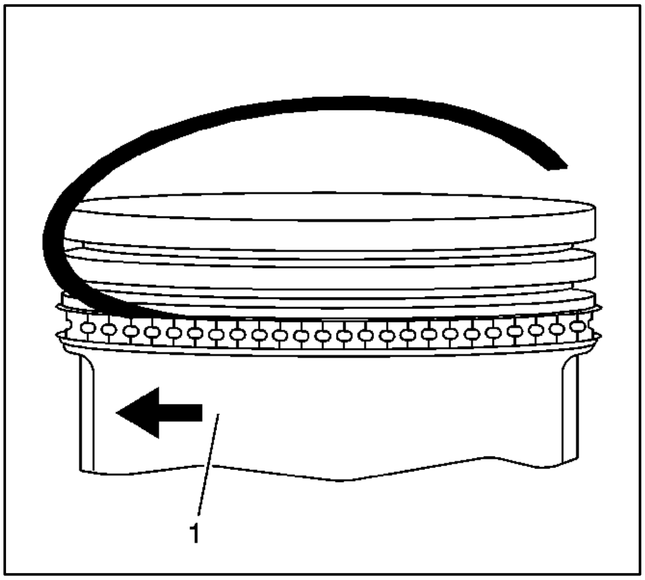

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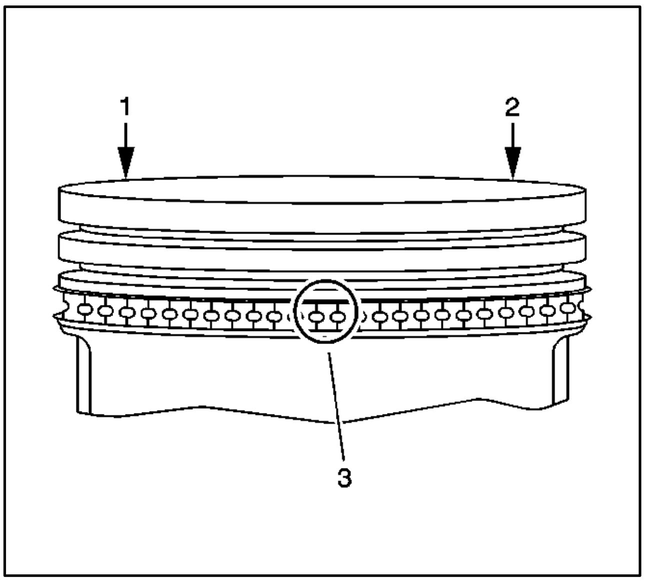
3. Install the upper oil control piston ring onto the piston (1).



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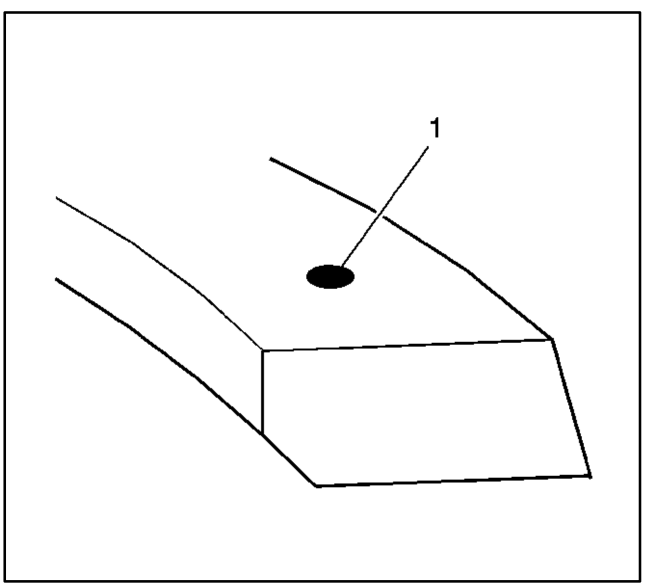
4. Space the oil control piston ring end gaps a minimum of 90 degrees apart (1, 2, 3).



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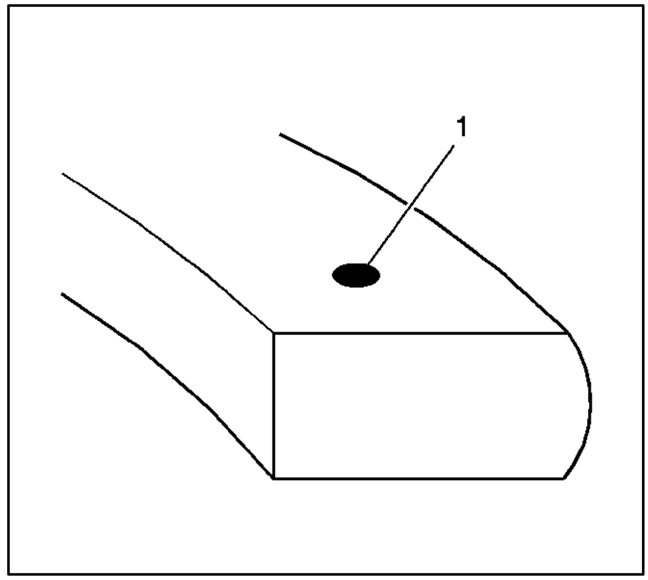
5. Install the lower compression piston ring onto the piston (1). The mark on the side of the piston ring should face the top of the piston.

6. Install the upper compression piston ring onto the piston. The mark (1) on the side of the piston ring should face the top of the piston.
7. Space the compression piston ring end gaps 120 degrees apart.



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Camshaft and Bearings Cleaning and Inspection

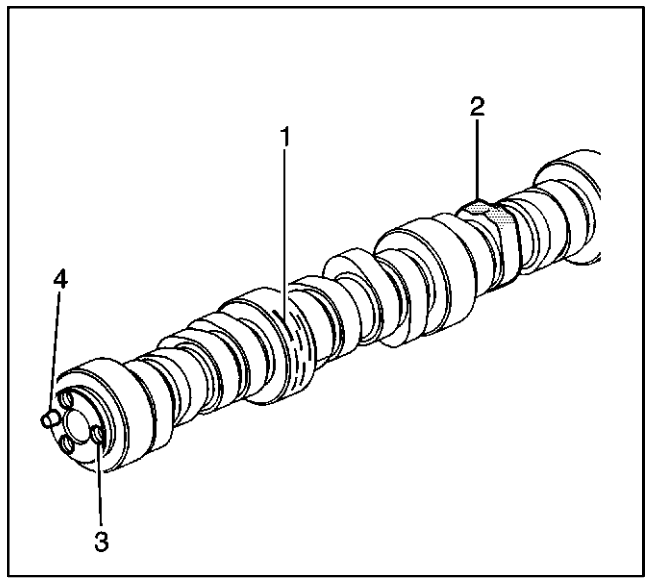
Tools Required

J 7872 Magnetic Base Dial Indicator

1. Clean the camshaft in solvent.

Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.
4. Inspect the camshaft for the following conditions:
   - Camshaft bearing journals (1) that are:
     – Worn
     – Scored
     – Damaged
   - Worn camshaft lobes (2).
   - Damaged sprocket bolt threads (3).
   - Damaged sprocket pin (4).



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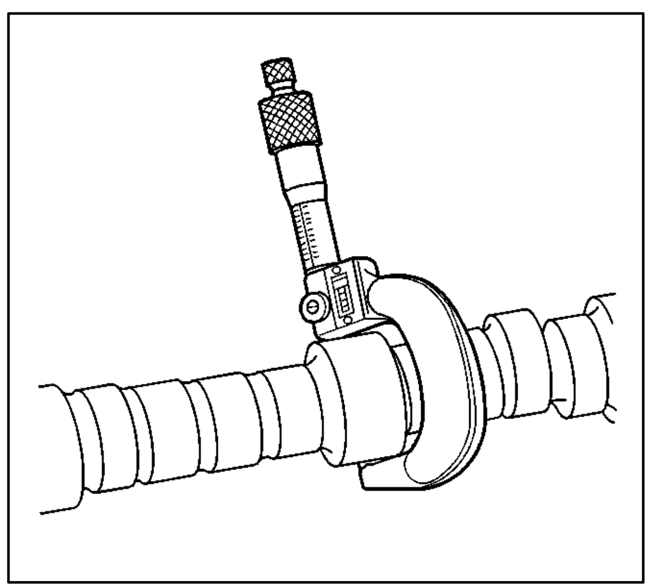
5. Measure the camshaft journals with a micrometer. Refer to *Engine Mechanical Specifications* in this supplement.
6. Measure for excessive camshaft runout using *J 7872*.
   6.1. Mount the camshaft in a suitable fixture.
   6.2. Use the *J 7872* in order to measure for a bent camshaft. Refer to *Engine Mechanical Specifications* in this supplement.
7. Replace the camshaft if runout exceeds specifications.



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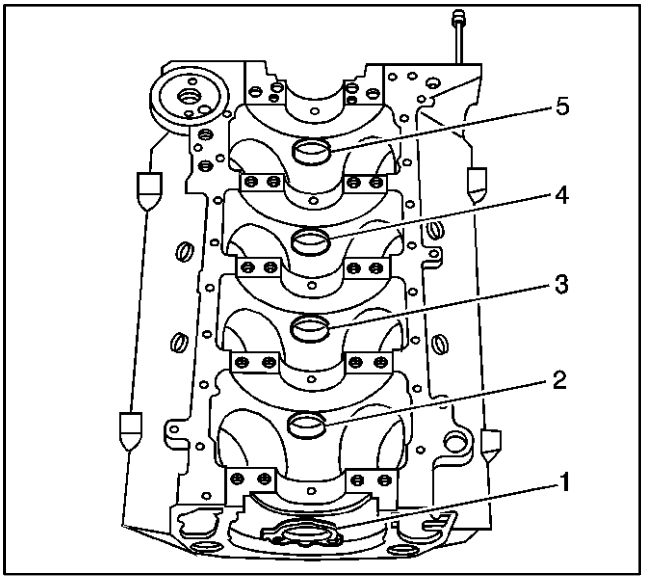

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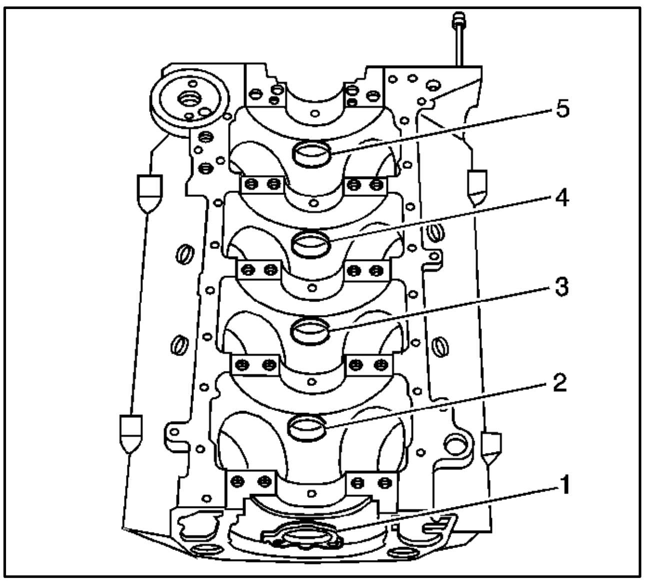
8. Inspect the camshaft bearings (1-5) for serviceability.
9. Replace the camshaft bearings if necessary. Refer to *Camshaft Bearing Removal* and *Camshaft Bearing Installation* in this supplement.



639523

Camshaft Bearing Installation

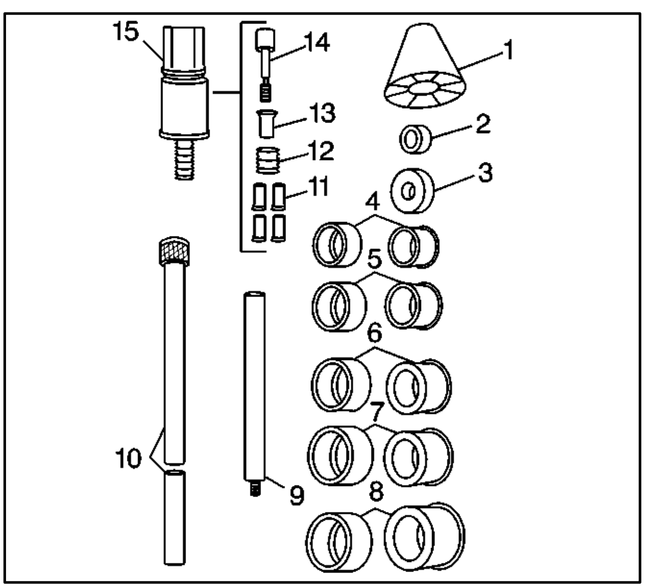
Tools Required

J 33049 Camshaft Bearing Remover/Installer

Important: The outer camshaft bearings (positions 1 and 5) must be installed first. These bearings serve as guides for the tool and help center the inner bearings during the installation process.

Ensure the correct camshaft bearing fits into the proper bore. The camshaft bearing bores may vary in size.

Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.



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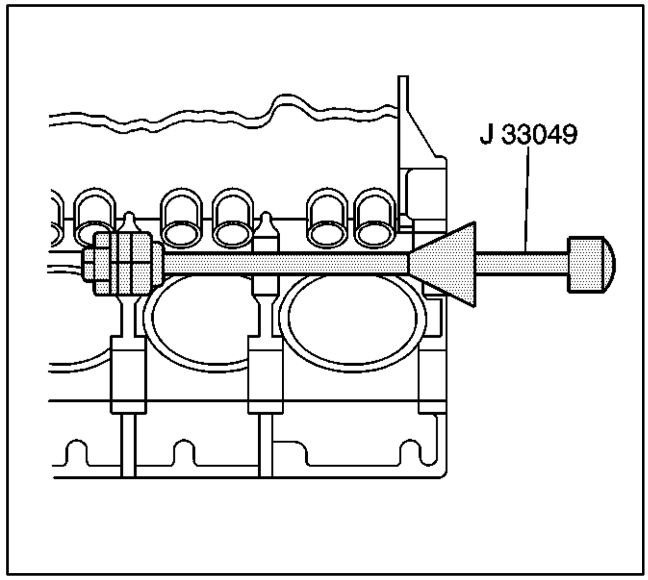
1. Assemble the tool handle (10), expanding driver (4 – 8), and the washer (2 or 3).

2. Insert the *J 33049* tool into the engine block end camshaft bearings (positions 1 or 5).

Notice: Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

Important: An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

3. Drive the end bearings (positions 1 and 5) into the bore.



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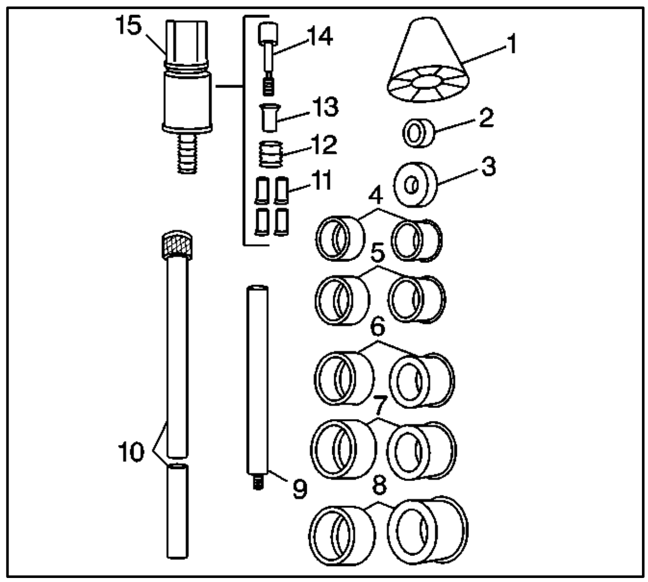
4. Select the expanding driver (4 – 8) and washer (2 or 3) from the *J 33049*.
5. Assemble the tool.



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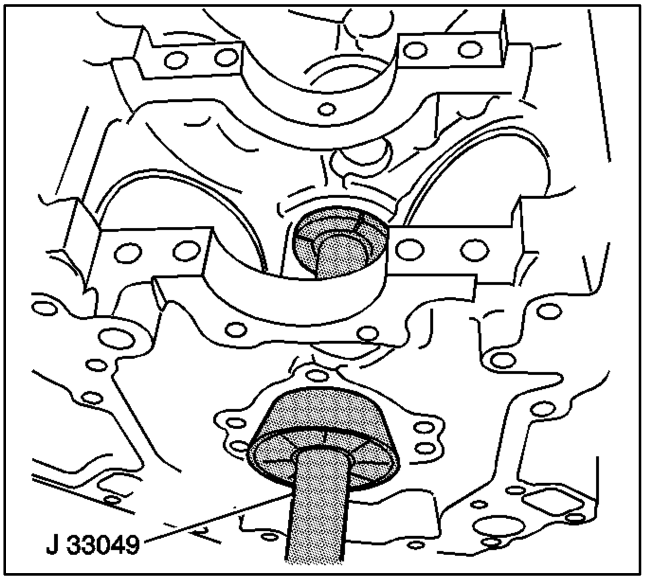

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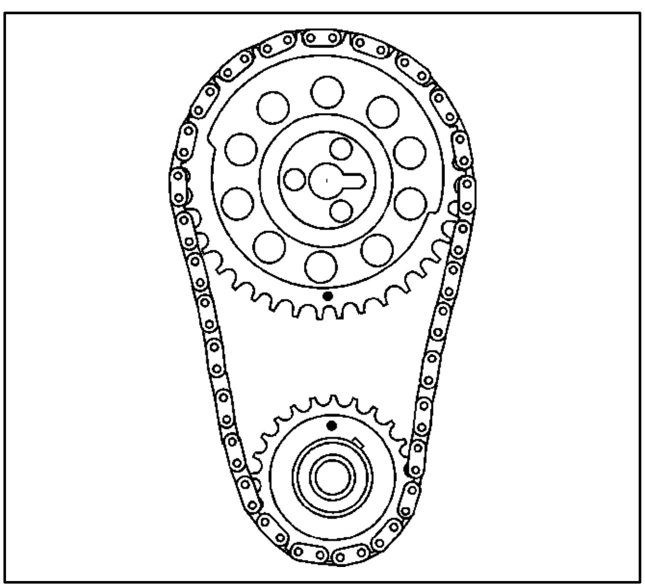
6. Insert the *J 33049* tool through the front of the engine block and to the inner bearing bores (positions 2, 3, and 4).
7. Install the bearing on to the expanding driver (4 – 8).
8. Tighten the expander assembly nut until the tool is snug in the bearing.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

9. Align the oil lubrication hole in the bearing with the oil galleries in the engine block.
10. Push the guide cone into the front camshaft bearing bore to align the tool.
11. Drive the bearing into the bore.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Timing Chain and Sprockets Cleaning and Inspection

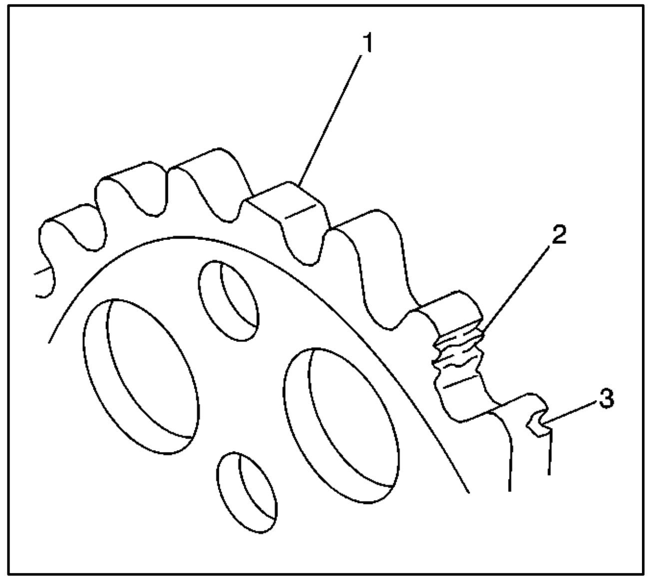
1. Clean the camshaft timing components in solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.

Important: If the sprocket(s) must be replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

4. Inspect the camshaft and crankshaft sprockets for the following conditions:
   - Worn teeth (1).
   - Damaged teeth (2).
   - Chipped teeth (3).
   - Uneven wear on one edge of the teeth.
   - Worn valleys between the sprocket teeth.
   - Crankshaft sprocket keyway for wear.



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Valve Rocker Arm and Push Rods Cleaning and Inspection

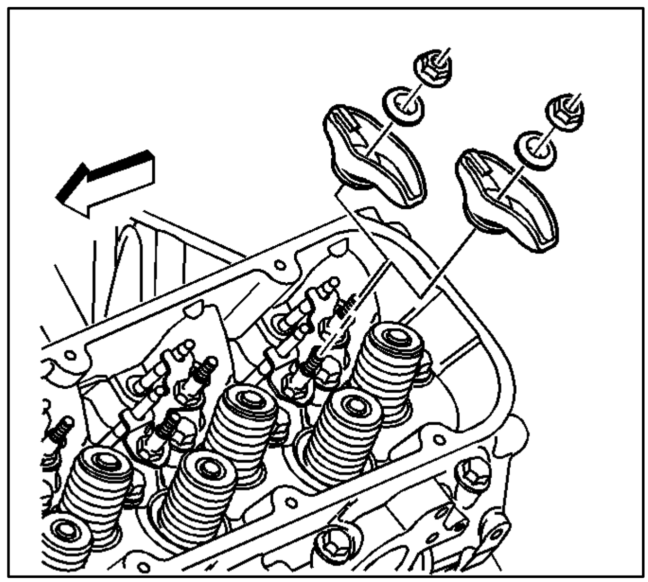
Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

1. Clean the components with cleaning solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the components with compressed air.
3. Inspect the valve rocker arms for wear or scoring in the ball area.
4. Inspect the valve rocker arm push rod sockets and valve stem tip mating surfaces.
5. Inspect the valve rocker arm ball for wear or scoring.

   These surfaces should be smooth with no scoring or exceptional wear.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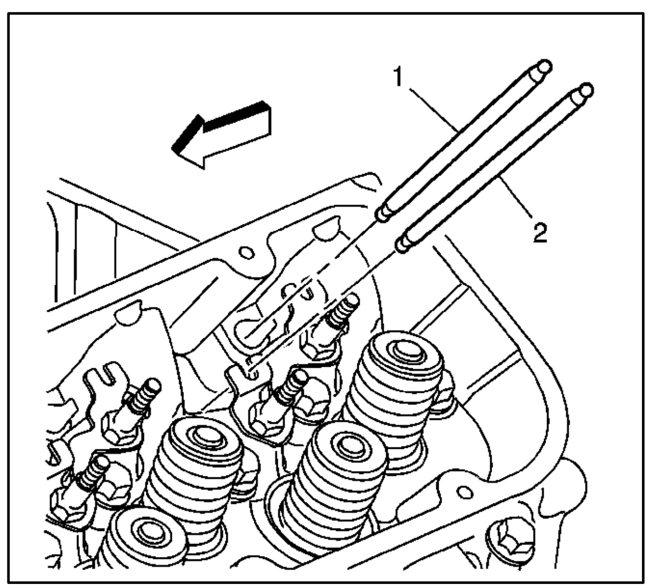
6. Inspect the push rods (1, 2) for worn or scored ends.

   These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the push rods for bends. Roll the push rods on a flat surface to determine if the push rod is bent. If it rolls smoothly, it is OK. If the push rod does not roll smoothly, replace the push rod.
8. Inspect the push rod oil passages for restrictions.
   - Clean out the push rod tube with compressed air.
   - Inspect by looking through the push rod tube for obstructions. A clear push rod will allow light through.
   - Replace push rod(s) that cannot be cleaned out.



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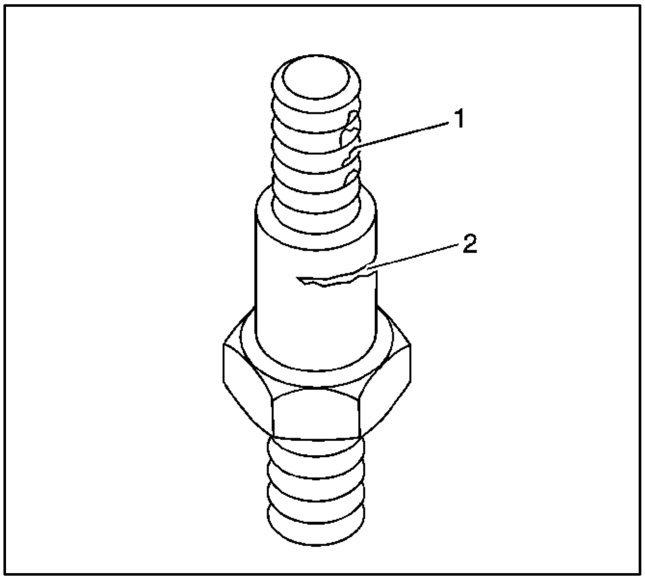

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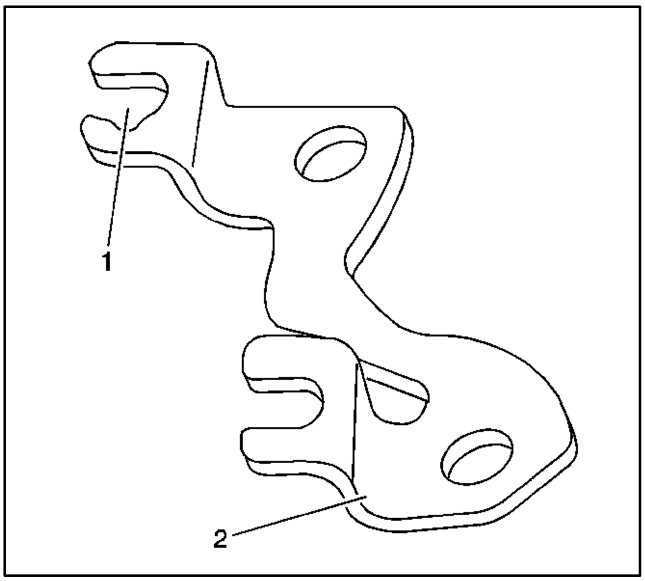
Important: A light contact mark on the rocker am stud is normal. A noticeable groove in the rocker arm stud is excessive wear and the rocker arm stud should be replaced.

9. Inspect the rocker arm studs for the following conditions:
   - Damaged threads (1).
   - Excessive wear or damage made from contact between the rocker arm and rocker arm stud (2).
10. Valve rocker arm studs with excessive wear and/or damage must be replaced.



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11. Inspect the push rod guides for the following conditions:
    - Wear between the push rod and the push rod guide (1).
    - Bent push rod guide (2).
    - Cracks.
12. Push rod guides with excessive wear and/or damage must be replaced.

Valve Lifters and Guides Cleaning and Inspection

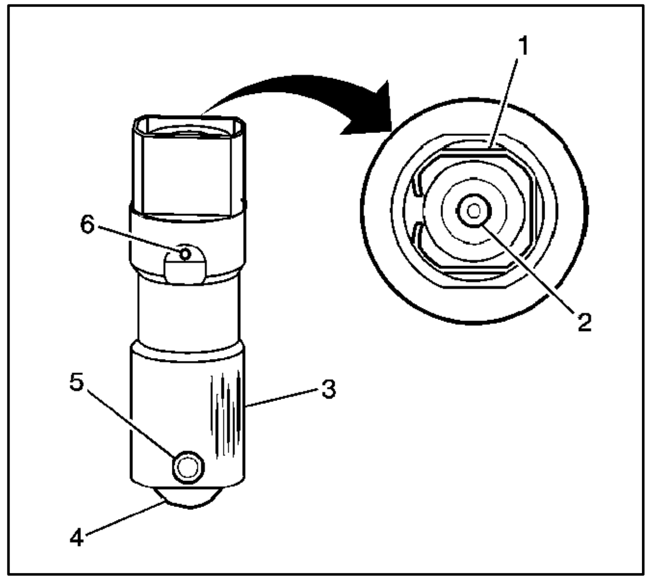
Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

Important: Disassembly of the valve lifter(s) is not recommended.

1. Clean the components in cleaning solvent.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following:
   - A damaged, mispositioned or broken clip (1).
   - A scored or worn pushrod socket (2).
   - A severely scuffed or worn lifter body (3). If the valve lifter body shows scuffing or wear, inspect the engine block valve lifter bores for wear or damage.
   - Flat spots on the roller (4).
   - A loose pin (5).
   - A plugged oil hole (6).
4. If flat spots are found on the lifter(s), inspect the corresponding lobe on the camshaft for damage.



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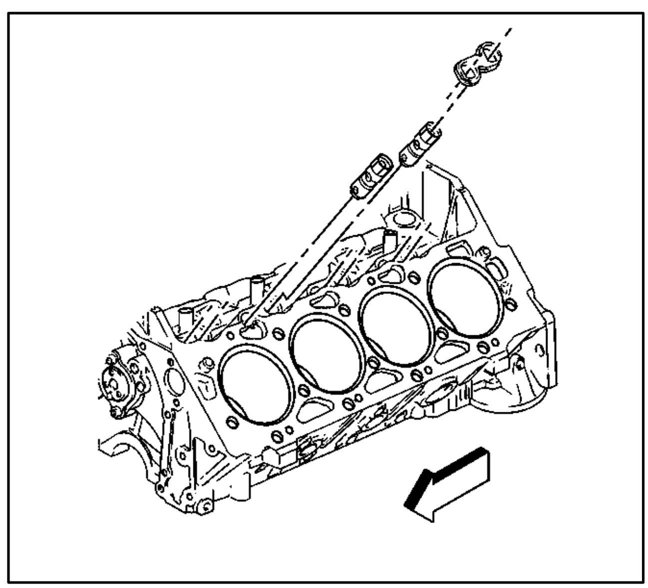
5. Inspect the valve lifter guides for the following:
   - Excessive guide slot side wear.
   - Cracks or damage.



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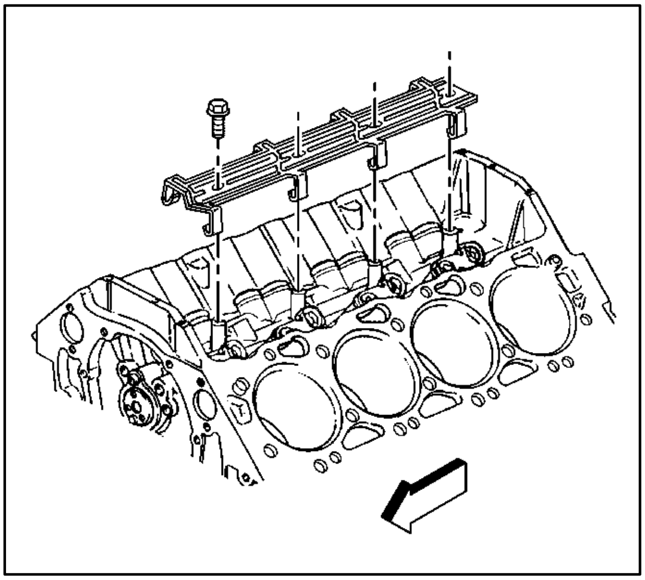

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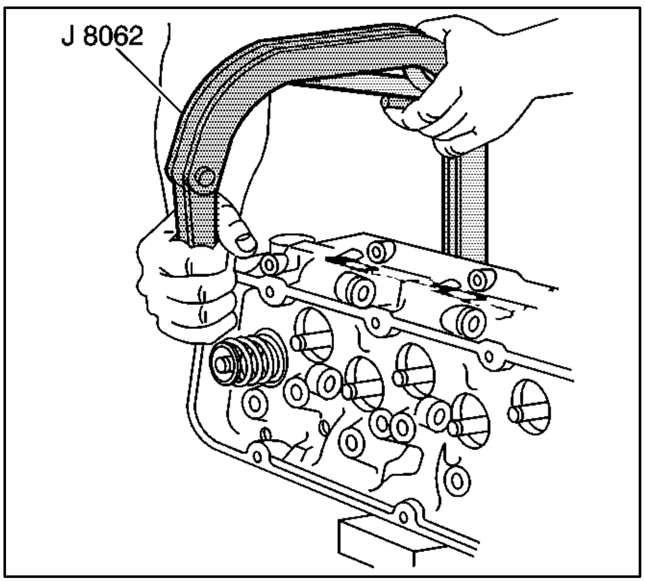
6. Inspect the valve lifter guide retainer for the following:
   - Wear, damage, or stress cracking in the leg areas.
   - Wear or damage around the retainer bolt holes.



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Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

Caution: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

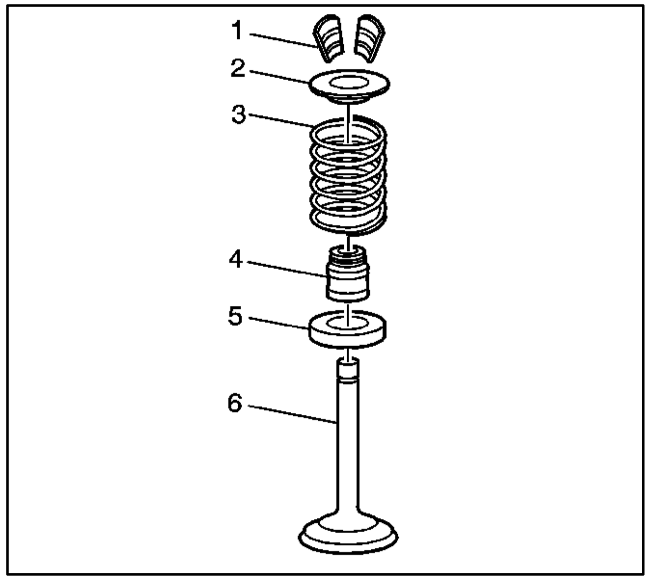
Important: Mark, sort, or organize components for return to their original locations.

1. Use *J 8062* in order to compress the valve springs.

2. Remove the valve stem keys (1).
3. Release and remove *J 8062*.
4. Remove the cap (2).
5. Remove the valve spring (3).
6. Remove the positive valve stem seal (4) from the valve guide.
7. Remove the valve rotator (5).

Important: In order to prevent damage to the valve guide, small burrs on the valve tip and at the stem key groove that interfere with the valve removal can be lightly filed with a fine file or stone to facilitate valve removal.

8. Remove the valve (6).



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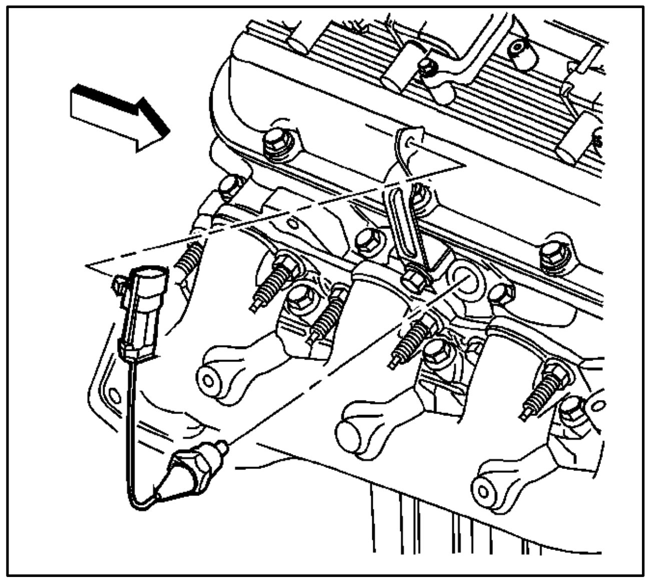
9. Disconnect the engine coolant temperature (ECT) sensor from the bracket.
10. Remove the ECT sensor from the right cylinder head.
11. Remove the ECT sensor bracket and bolt.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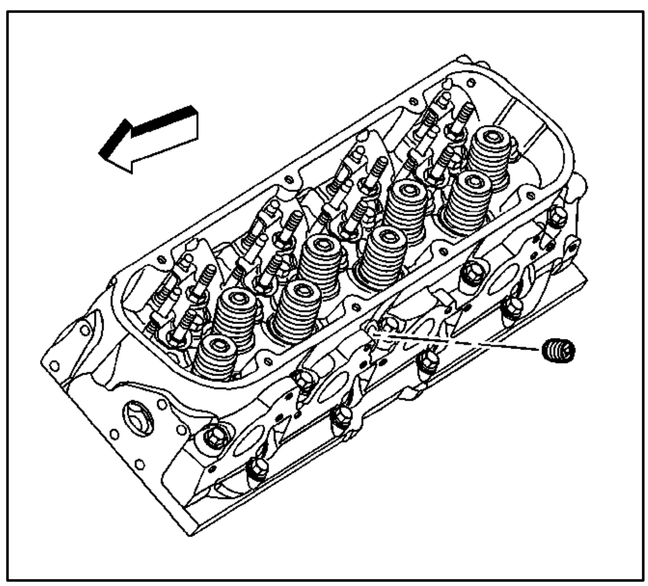
12. Remove the cylinder head coolant hole plug from the left cylinder head.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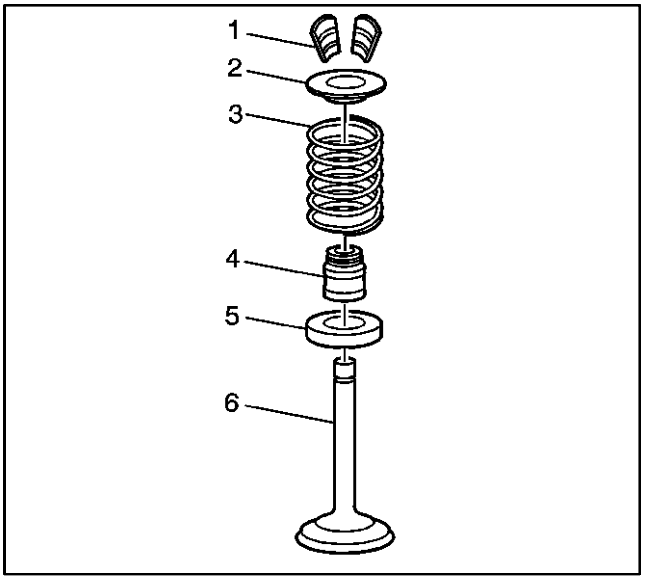


677748

Cylinder Head Cleaning and Inspection

Tools Required

- *J 8089* Carbon Removing Brush
- *J 9666* Valve Spring Tester
- *J 8001* Dial Indicator Set

Cleaning Procedure

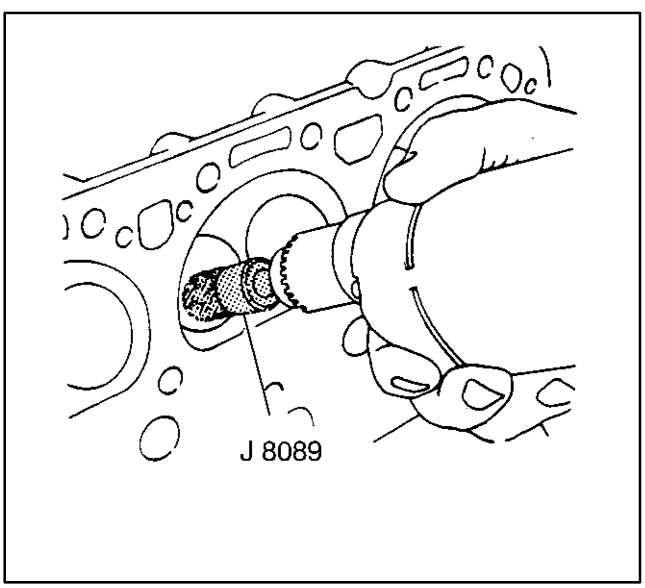
Caution: Wear safety glasses in order to avoid eye damage.

Important: Mark, sort, or organize components for return to their original locations.

1. Clean the valve stems and heads on a buffing wheel.
2. Clean the following components in solvent:
   - Valve stem keys (1)
   - Valve spring cap (2)
   - Valve spring (3)
   - Valve rotators (5)
   - Valve (6)
   - Cylinder head

Caution: Wear safety glasses in order to avoid eye damage

3. Dry the components with compressed air.



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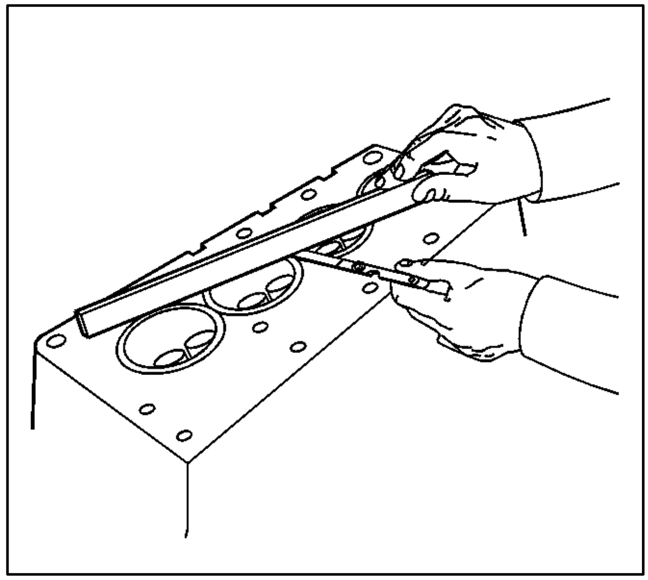
Important: Be careful not to damage the chamber or the valve seat.

4. Use the *J 8089* in order to clean the carbon from the combustion chambers.

Visual Inspection Procedure

Inspect the cylinder head for the following conditions:

- Damaged gasket surfaces.
- Damage to threaded bolt holes.
- Burnt or eroded areas in the combustion chambers.
- Cracks in the exhaust ports and combustion chambers.
- External cracks in the water chamber.
- Restrictions in the intake or exhaust passages.
- Restrictions in the cooling system passages.



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Flatness Measurement Procedure

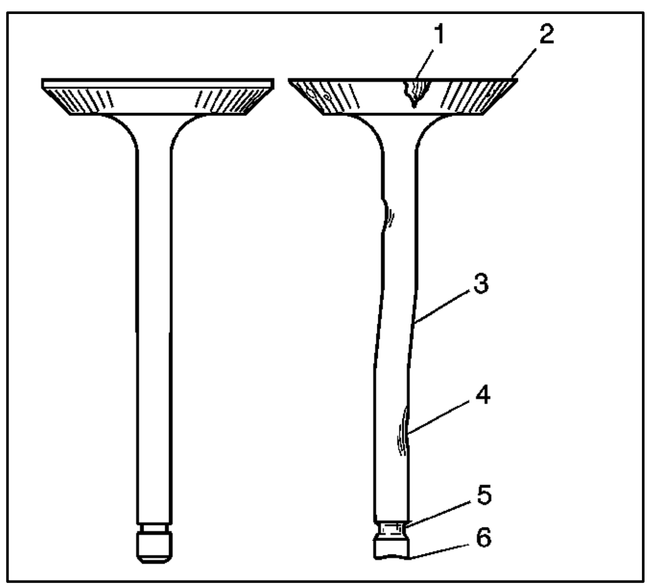
1. Measure the cylinder head for warpage with a straight edge and feeler gauge.
   - A cylinder head block deck with warpage in excess of 0.050 mm (0.002 in) within a 150.0 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head exhaust manifold deck with an overall warpage in excess of 0.102 mm (0.004 in) must be repaired or replaced.
   - A cylinder head intake manifold deck with warpage in excess of 0.080 mm (0.003 in) must be repaired or replaced.
2. A cylinder head block deck can be resurfaced up to 0.305 mm (0.012 in) maximum removal.

Important: Excessive cylinder head resurfacing will affect compression ratio and emission control.

3. A cylinder head that requires excessive resurfacing must be replaced.

Valve Inspection Procedure

1. Inspect the valves for the following conditions:
   - Burnt or damaged areas (1).
   - Undersized valve margin (2).
   - Bent stem (3).
   - Scoring or other damage to the stem (4).
   - Worn key groove (5).
   - Worn stem tip (6).



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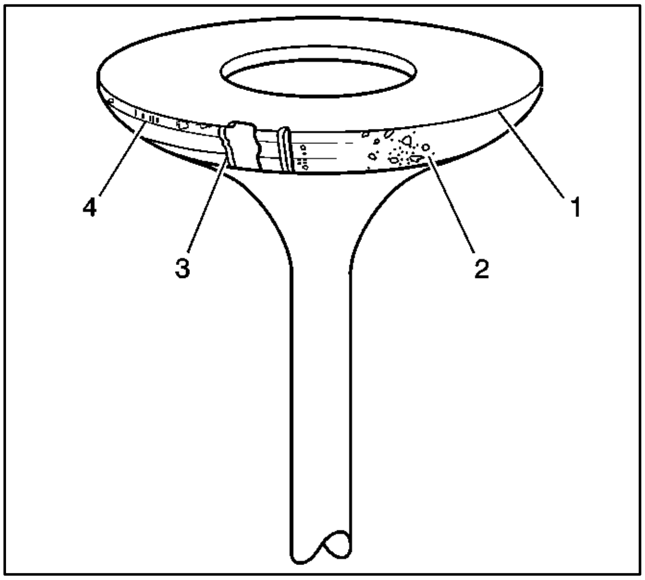

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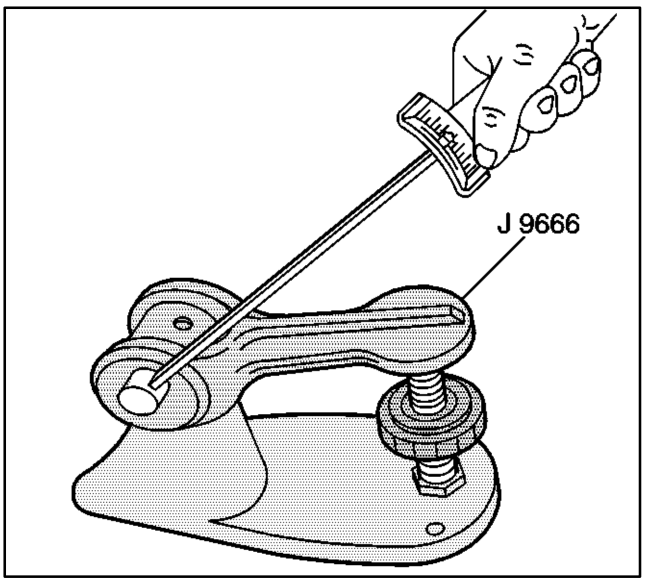
2. Inspect the valve contact surface for the following conditions:
   - Undersized margin (1).
   - Pitted surface (2).
   - Burnt or eroded areas (3).
   - Acceptable edge (margin) (4).

Important: Minor imperfections of the valve may be corrected during reconditioning.

3. Valves with excessive damage must be replaced.



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Valve Spring Inspection and Measurement

Tools Required

J 9666 Valve Spring Tester

1. Inspect the valve springs for broken coils or coil ends.
2. Use the *J 9666* in order to measure the valve spring force. Refer to *Engine Mechanical Specifications* in this supplement.

Important: Add a maximum of one shim up to 0.726 mm (0.030 in) thick to increase tension.

3. If the valve spring tension is low, use a shim to increase tension.
4. Recheck the valve spring tension. A valve spring that does not meet specification must be replaced.

Valve Guide Measurement Procedure

Tools Required

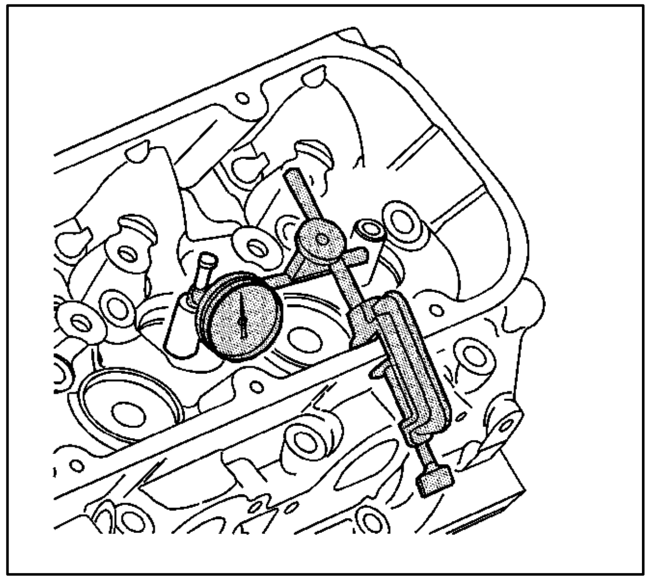
J 8001 Dial Indicator Set

Important: Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky function of the valve and will disturb the engine assembly smoothness.

1. Measure the valve stem-to-guide clearance.
   1.1. Clamp the *J 8001* on the exhaust port side of the cylinder head.

Important: The indicator stem must contact the the side of the valve stem just above the valve guide.

   1.2. Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.
   1.3. Drop the valve head about 1.6 mm (0.062 in) off the valve seat.
   1.4. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to *Engine Mechanical Specifications* in this supplement.



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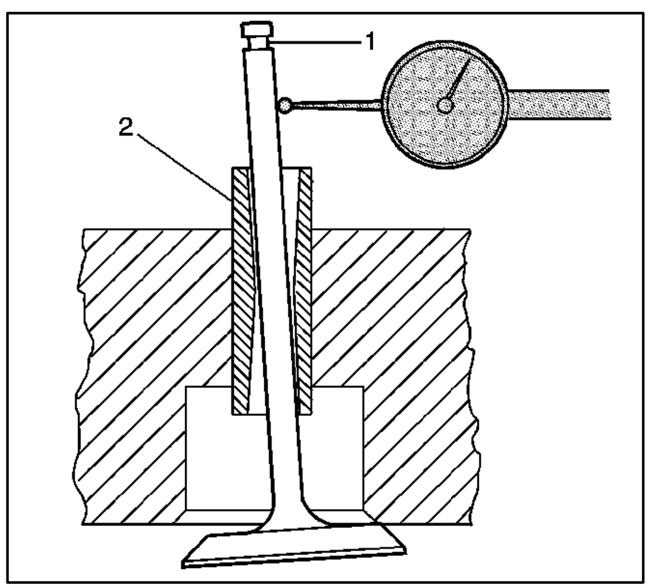
2. Valve guide (2) with excessive clearance must be repaired. Refer to *Valve Guide Reaming/Valve and Seat Grinding* in this supplement.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.



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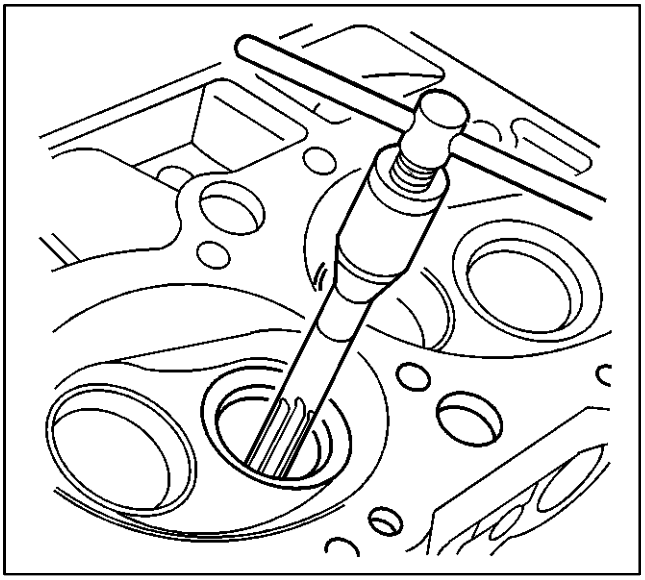

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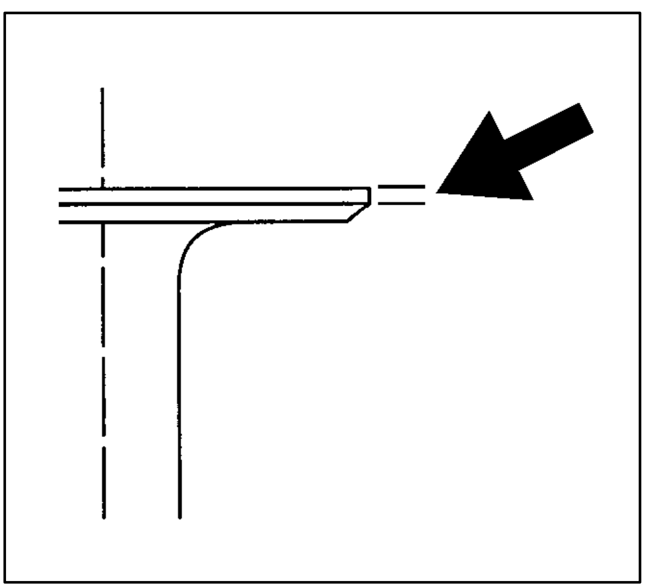
Valve Guide Reaming/Valve and Seat Grinding

Valve Guide Reaming Procedure for Oversized Valve Stems

Notice: The exhaust valve guides are replaceable components and must be serviced properly. The exhaust valve guide must be pressed out and into the cylinder head in the proper directions. The old exhaust valve guide must be removed by pressing out towards the combustion chamber side of the cylinder head. The new exhaust valve guide must be installed by pressing from the combustion chamber side of the cylinder head. Failure to press the exhaust valve guide out and into the cylinder head in the proper directions will damage the cylinder head.

1. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance with the new, oversized valve stems.
2. Always recondition the valve seat after reaming the valve guide bores or installing new valves.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.



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Valve Reconditioning Procedure

1. Replace the valve if the valve stem shows excessive wear or is warped.

Important: Several different types of equipment are available for reconditioning valves. Use the manufacturer's recommendations for their equipment to attain the proper results.

2. Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem.
3. Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.

Valve Seat Reconditioning Procedure

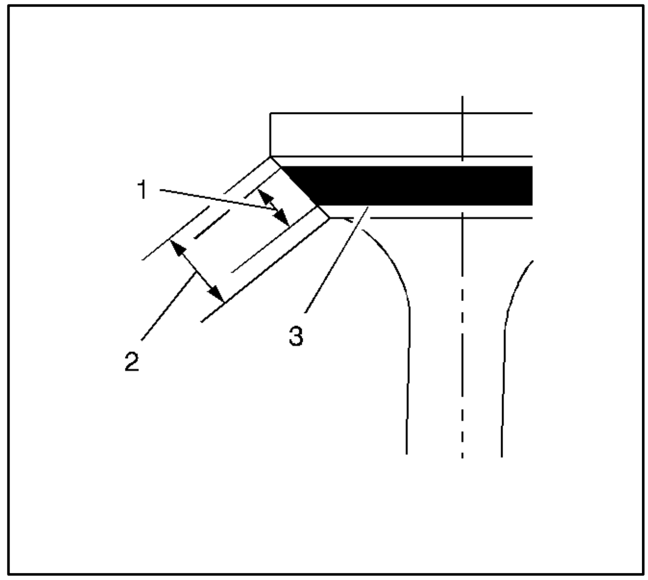
Important: Several different types of equipment are available for reconditioning valve seats. Use the manufacturer's recommendations for their equipment to attain the proper results.

Important: Always recondition the valve seat after reaming the valve guide bores or installing new valves.

1. Recondition the valve seats.
2. The valves must seat perfectly for the engine to deliver optimum power and performance.
3. Ensure that the valve seat and valve are not shrouded after valve seat reconditioning. Adequate flow past the valve seat and valve is essential for cooling the valve head and valve seat area.
4. Correct contact (1) between each valve and its seat in the cylinder head is also essential to ensure the the heat in the valve head is properly carried away.

Important: Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.

5. The valve seats should be concentric to within 0.050 mm (0.002 in) total indicator runout.



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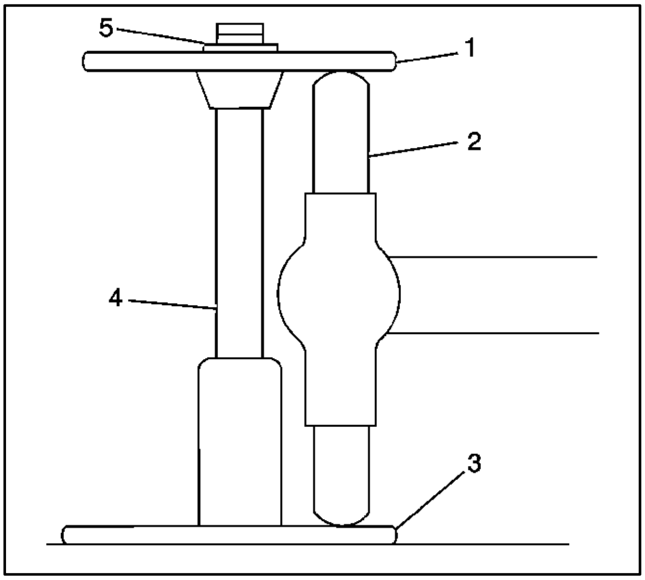

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Cylinder Head Assemble

Tools Required

- *J 8062* Valve Spring Compressor
- *J 43105* Valve Stem Seal Installer

Checking Valve Spring Installed Height

1. Install the valve rotator (3), the valve (4), the valve spring cap (1) and the valve stem keys (5) into the cylinder head.
2. Using a snap gage or inside micrometer, measure the distance from the top of the valve rotator to the bottom of the valve spring cap. Refer to *Engine Mechanical Specifications* in this supplement for proper valve spring installed height specifications.

Important:

- Never shim the spring to obtain an installed height under the specified amount.
- Install the valve spring seat shims under the rotator (between the rotator and the cylinder head spring seat).
- Add a maximum of one valve spring seat shim, up to 0.726 mm (0.030 in) thick to achieve the valve spring installed height specification.
- The combination of valve spring seat shims to correct valve spring installed height and valve spring tension should not exceed 1.524 mm (0.060 in) thick.

3. Install a valve spring seat shim if the valve spring installed height measurement is above the specification.
4. Recheck the valve spring installed height. Replace the cylinder head if the valve spring installed height cannot be obtained.

Valve Installation

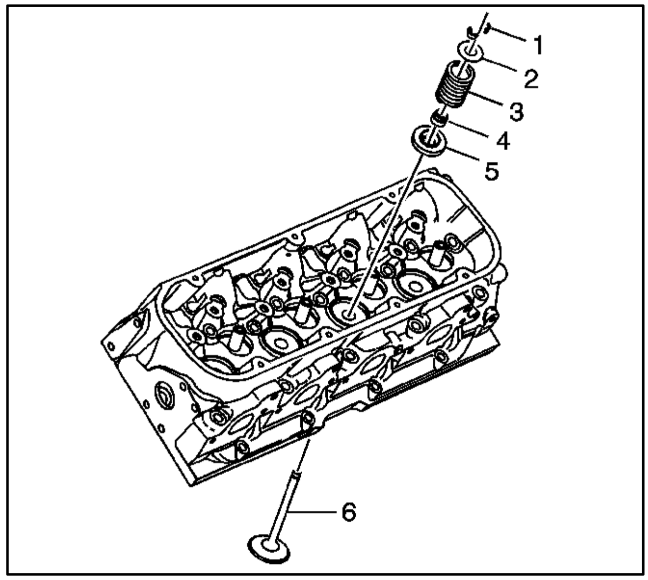
Tools Required

- *J 8062* Valve Spring Compressor
- *J 43105* Valve Stem Seal Installer

Caution: Wear safety glasses in order to avoid eye damage.

Caution: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

1. Lubricate the valve stems (6) with clean engine oil.
2. Insert the valves into the proper locations.
3. Install the necessary valve spring shims onto the cylinder head, if applicable.
4. Lubricate the rotators (5) with clean engine oil.
5. Install the rotators over the guide and on top of the cylinder head or valve spring shims, if applicable.



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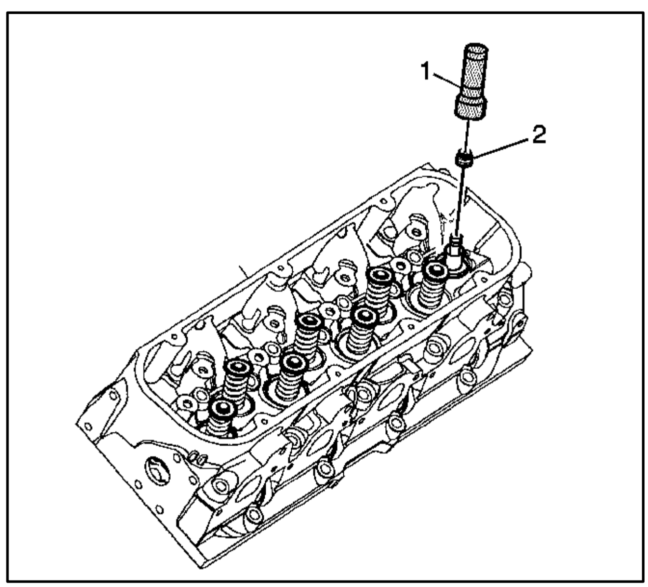
Important: When installing valve stem oil seals onto the valve guides, be careful not to tear the seal lip.

Important: When installing valve seals, *J 43105* must be used to achieve correct installation. Failure to use *J 43105* may cause excessive oil consumption.

6. Lubricate the valve stem seal and the outside diameter of the valve guide with clean engine oil.
7. Install the valve stem oil seals (2) over the valve tip and onto the valve guides using *J 43105*. Tap the valve stem seal onto the valve guide until the *J 43105* fully seats the seal.



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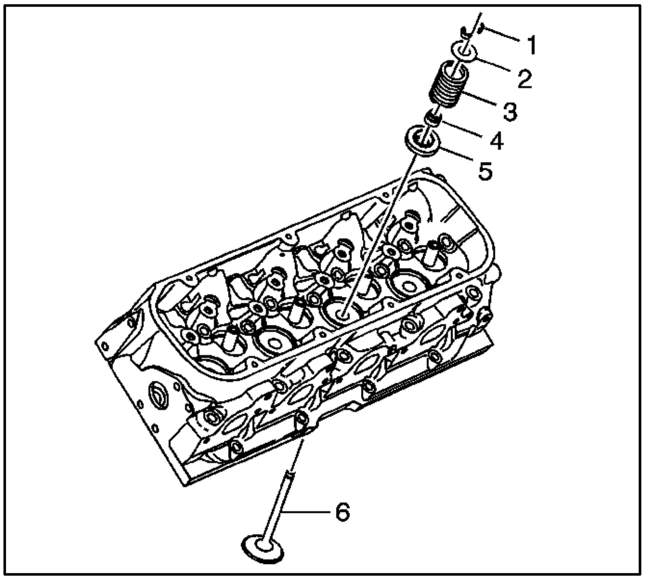

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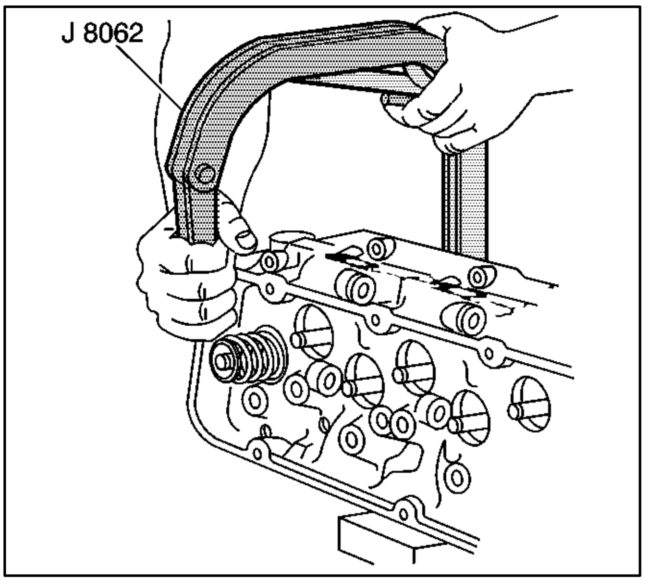
Important: When installing valve springs, the small end of the valve spring must be installed up.

8. Install the valve springs (3).
9. Install the valve spring caps (2).



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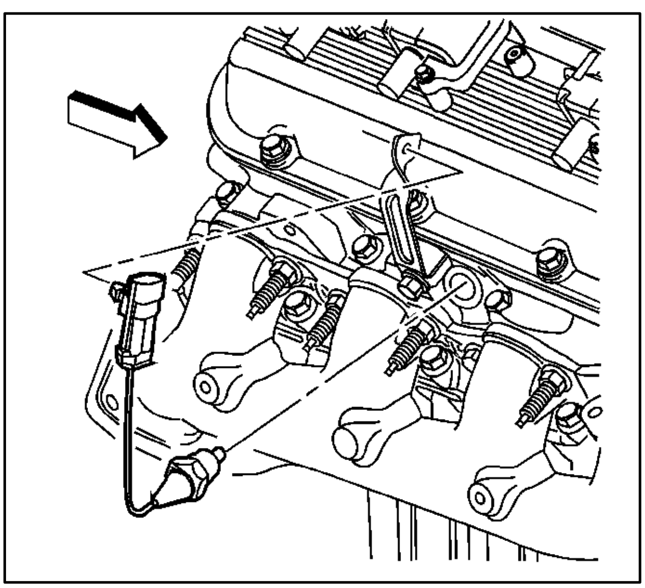
10. Use the *J 8062* in order to compress the valve spring. Compress the spring enough to clearly see the valve stem key grooves of the valve.
11. Install the valve stem keys (1).
    - Use grease to hold the keys in place.
    - Ensure that the keys seat properly in the upper groove of the valve stem.
12. Release and remove the *J 8062*.
13. Lightly tap the end of the valve stem with a plastic-faced hammer to seat the keys.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Notice: Refer to *Fastener Notice* in Cautions and Notices.

14. Install the engine coolant temperature (ECT) sensor into the right cylinder head.

    Tighten

    Tighten the ECT sensor to 20 N·m (15 lb ft).
15. Install the ECT sensor bracket and bolt.

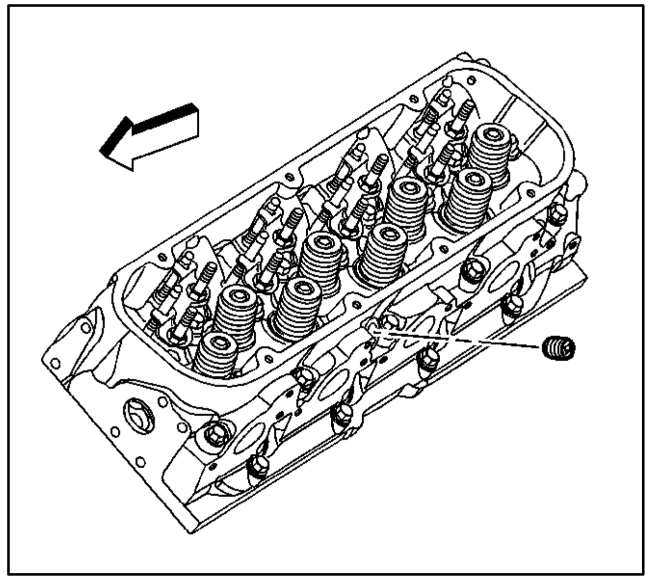
    Tighten

    Tighten the ECT sensor bracket bolt to 50 N·m (37 lb ft).

16. Install the cylinder head coolant hole plug into the left cylinder head.

    Tighten

    Tighten the cylinder head coolant hole plug to 23 N·m (17 lb ft).

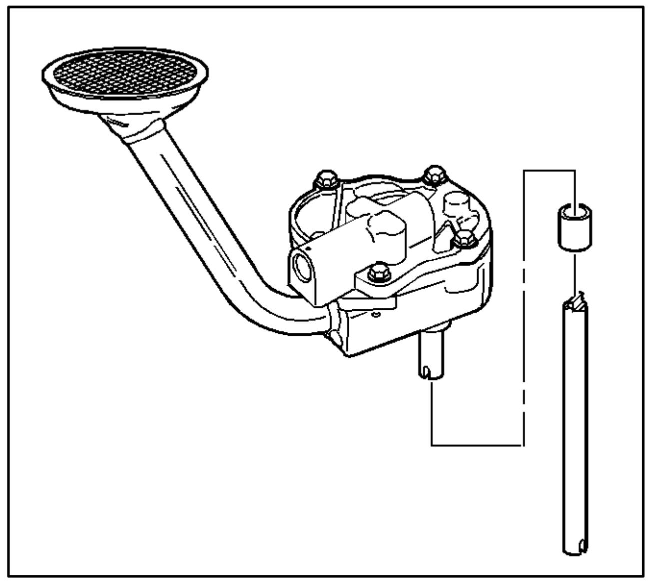


635678

Oil Pump Disassemble

Important: The oil pump pipe has a press fit into the oil pump. DO NOT remove the pipe from the oil pump. The pipe and oil pump are serviced as a complete assembly.

1. Remove the oil pump driveshaft and retainer.



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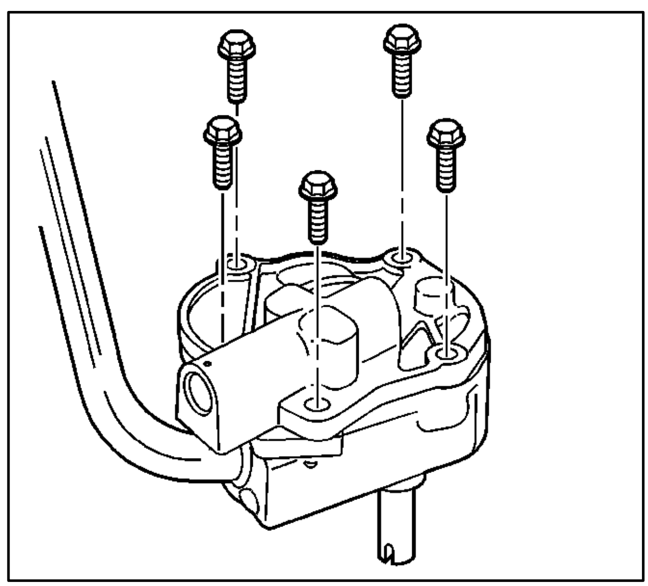
2. Remove the oil pump cover bolts.



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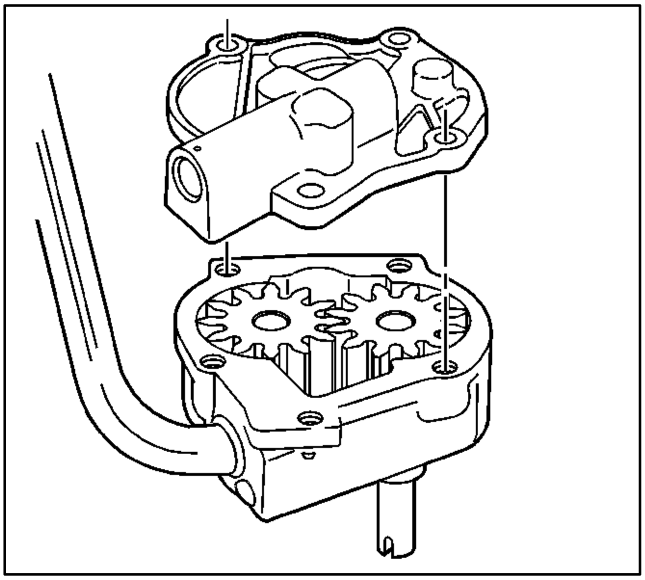

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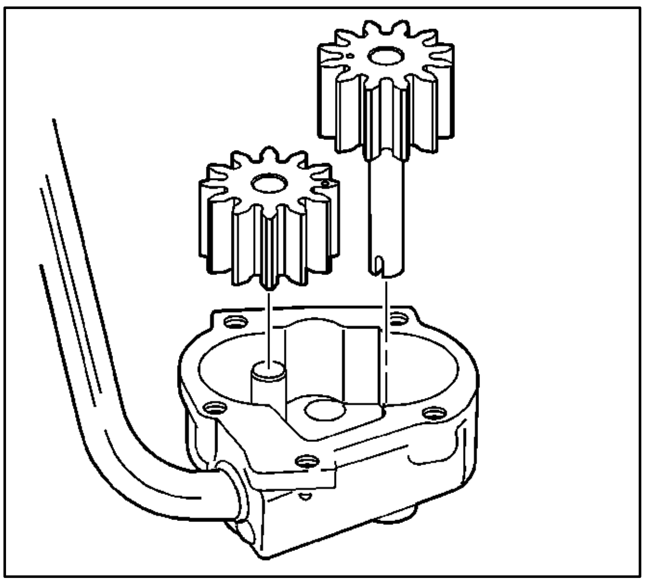
3. Remove the pump cover.



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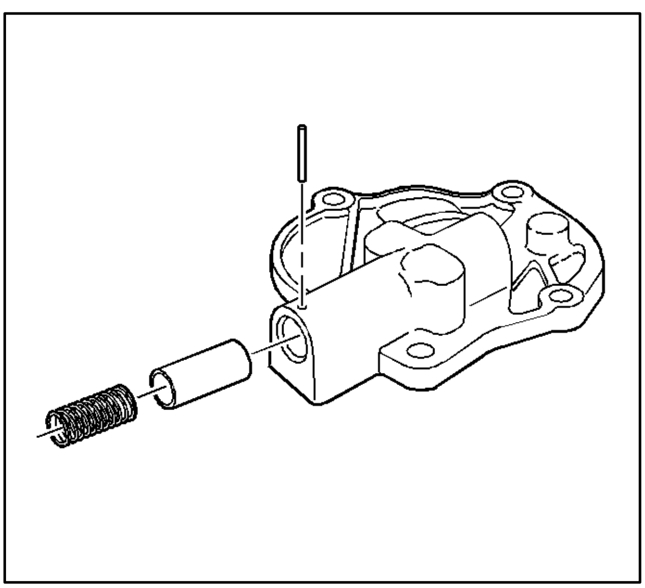
4. Remove the drive gear and the driven gear. Matchmark the gear teeth for assembly.



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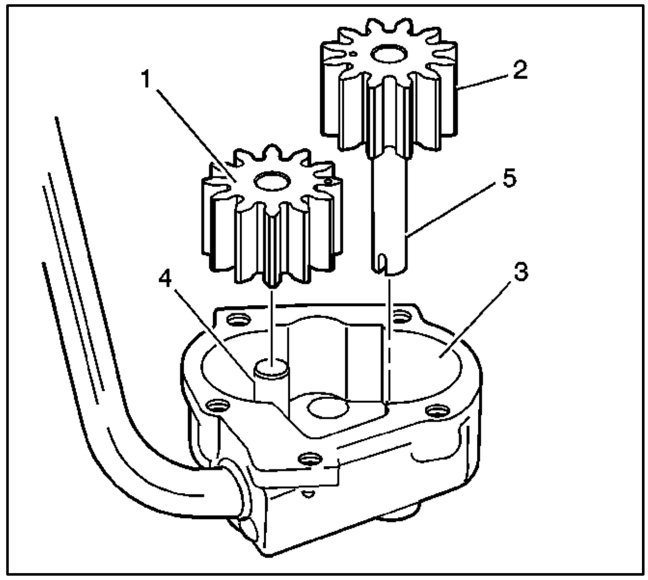
5. Remove the following items:
   5.1. The retaining pin.
   5.2. The pressure relief spring.
   5.3. The pressure relief valve.

Oil Pump Cleaning and Inspection

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
   - Scoring on the top of the gears (1).
   - Damaged gears (2) for the following:
     – Chipping
     – Galling
     – Wear
   - Scoring, damage or casting imperfections to the body (3).
   - Damaged or scored gear shaft (4).
   - Damaged or scored gear shaft (5).
   - Damaged bolt hole threads.
   - Worn oil pump driveshaft bore.
   - Damaged or sticking oil pump pressure relief valve. (Minor imperfections may be removed with a fine oil stone.)
   - Collapsed or broken oil pump pressure relief valve spring.
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
5. During oil pump installation, install a NEW oil pump driveshaft retainer.



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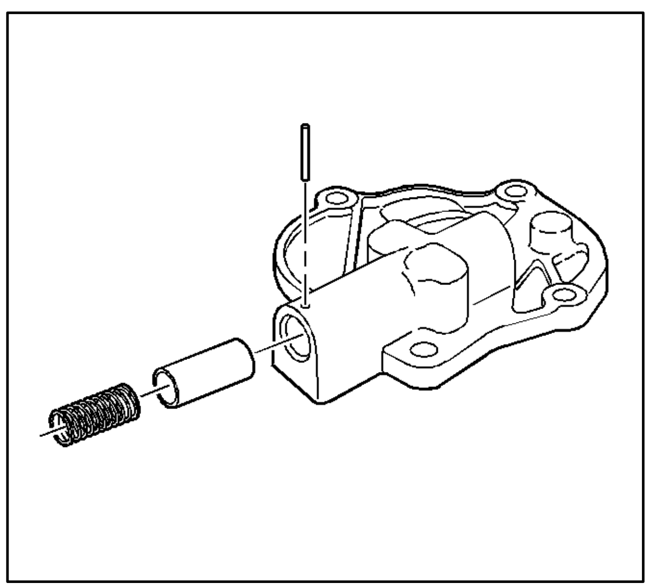
Oil Pump Assemble

Important: Replace the pressure relief valve spring when reusing the oil pump.

1. Install the following items:
   1.1 The pressure relief valve.
   1.2. The pressure relief spring.
   1.3. The retaining pin.



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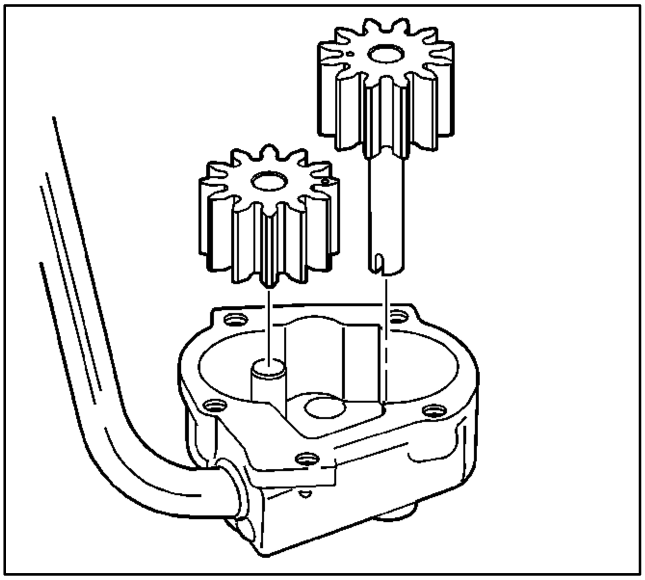

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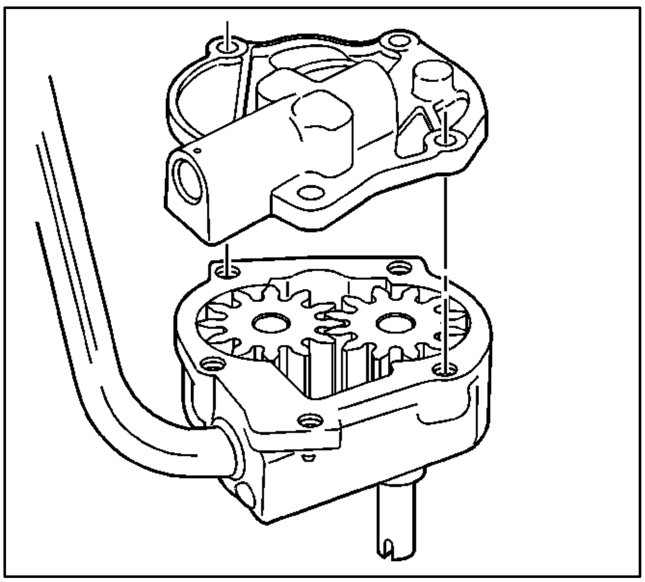
2. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
3. Install the drive gear and the driven gear into the pump body. Align the matching marks on the gears. Install the smooth side of the gear toward the pump cover.



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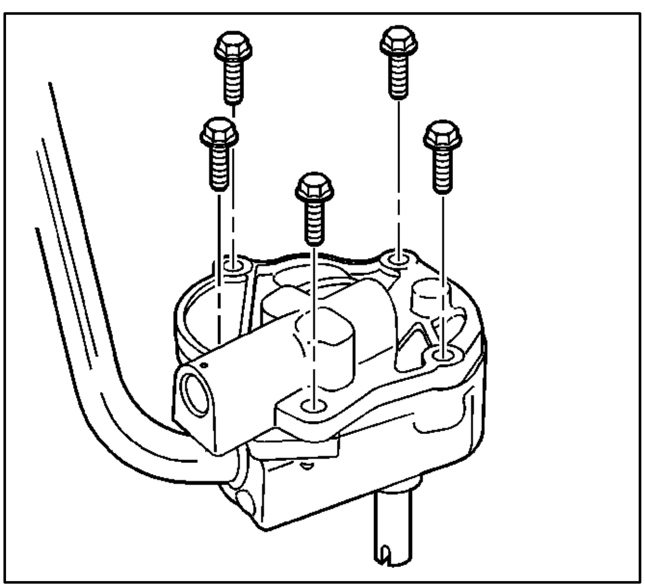
4. Install the oil pump cover.



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Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

5. Install the oil pump cover bolts.

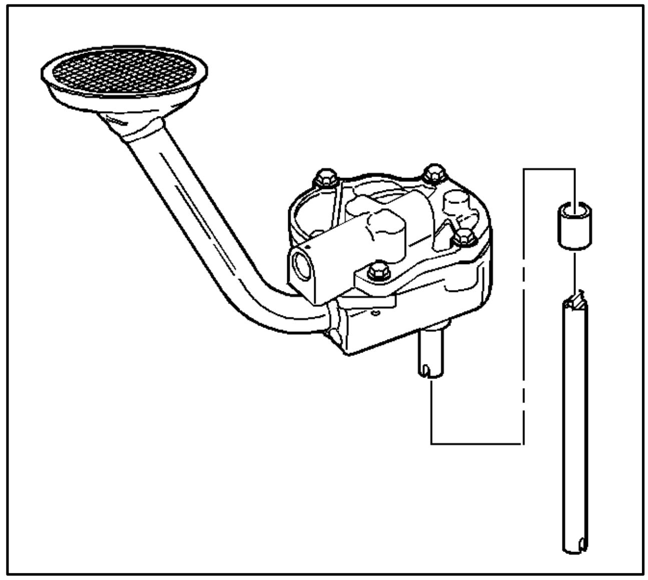
   Tighten

   Tighten the oil pump cover bolts to 12 N·m (106 lb in).

6. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.

Notice: Ensure the oil pump driveshaft is inspected for wear and/or damage, and replaced if necessary. An excessively worn or damaged oil pump driveshaft may fail causing severe engine damage.

7. Install the oil pump driveshaft and the new retainer.



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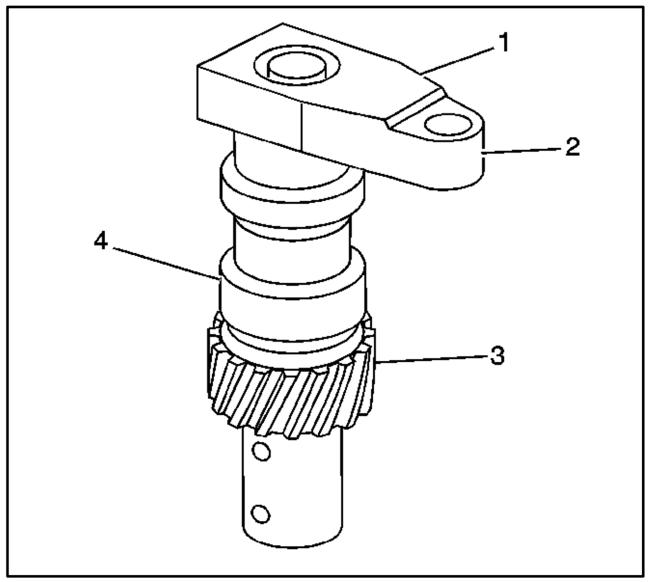
Oil Pump Drive Cleaning and Inspection

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

1. Clean the oil pump drive in cleaning solvent.
2. Dry the oil pump drive with compressed air.
3. Inspect the oil pump drive for the following conditions:
   - Excessive play in the oil pump drive bearing (1).
   - Damage to the oil pump drive clamp bolt hole (2).
   - Damaged gear (3) for the following:
     – Chipping.
     – Galling.
     – Wear.
     – Damage to the oil pump drive shaft tang.
   - Damage to the oil pump drive body (4).
4. If the oil pump drive is to be reused, lubricate the bearing (1) with clean engine oil, and apply grease to the gear (3).



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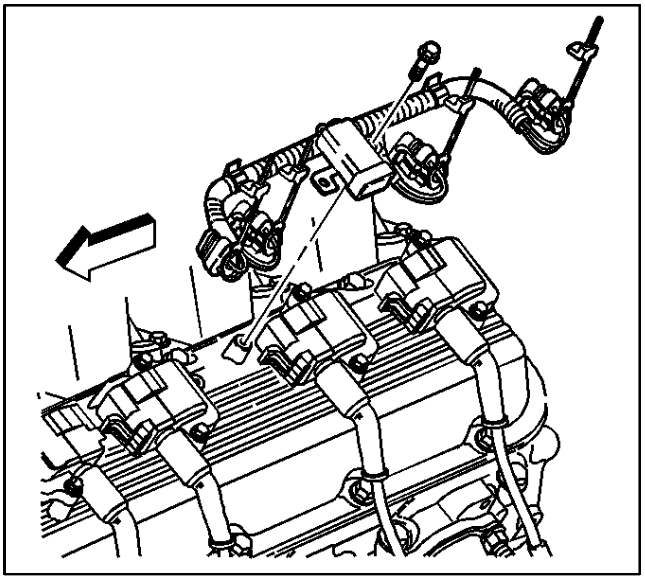

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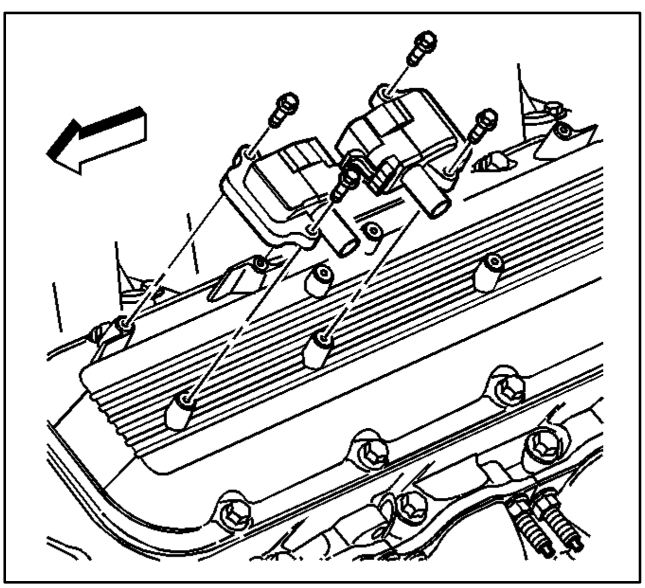
Valve Rocker Arm Cover Cleaning and Inspection

Notice: In order to ensure correct reinstallation, mark the ignition wiring harness connectors for cylinders one and three, and cylinders six and eight prior to disconnection. Failure to reconnect the ignition wiring harness connectors to the proper ignition coils may be result in serious engine damage.

Notice: This component is initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing the self-tapping bolt(s) can lead to damage and unnecessary replacement of the self-tapping bolt(s) and/or the component the self-tapping bolt(s) is threaded into.

1. Remove the white wiring harness clip locks.
2. Disconnect the ignition coil wiring harness from the ignition coils.
3. Remove the ignition coil wiring harness retainer bolts.
4. Open the 2 wiring harness retainers and remove the ignition coil wiring harness.



470887

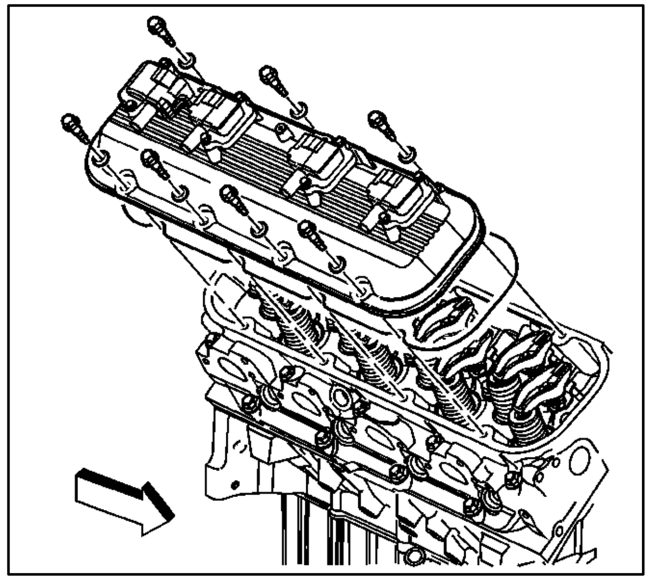
5. Remove the ignition coil bolts.
6. Remove the ignition coils.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

Important: Do not clean or submerge the ignition coils in solvent.

Remove the ignition coils before cleaning the cover in solvent. To prevent damage to the gasket, minimize solvent contact with the gasket.

7. Clean the valve rocker arm cover in solvent.
8. Dry the covers with compressed air.
9. Inspect the covers for the following:
   - Gouges or damage to the sealing surfaces.
   - Cracking or damage to the valve cover gasket.
   - Debris or damage to the bolt hole threads.



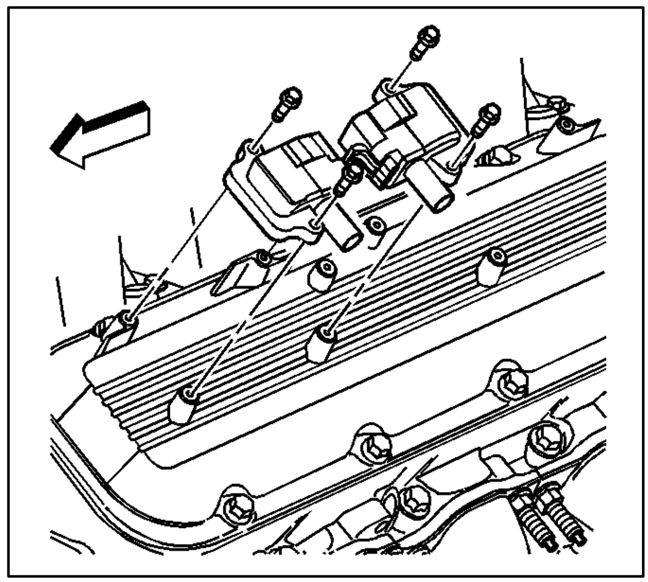
470897

Notice: This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

10. Install the ignition coils.
11. Install the ignition coil bolts.

    Tighten

    Tighten the ignition coil bolts to 12 N·m (106 lb in).

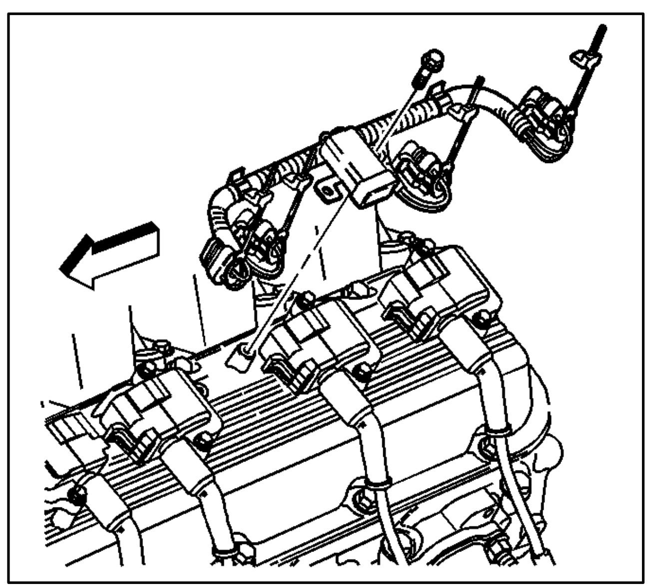


470887

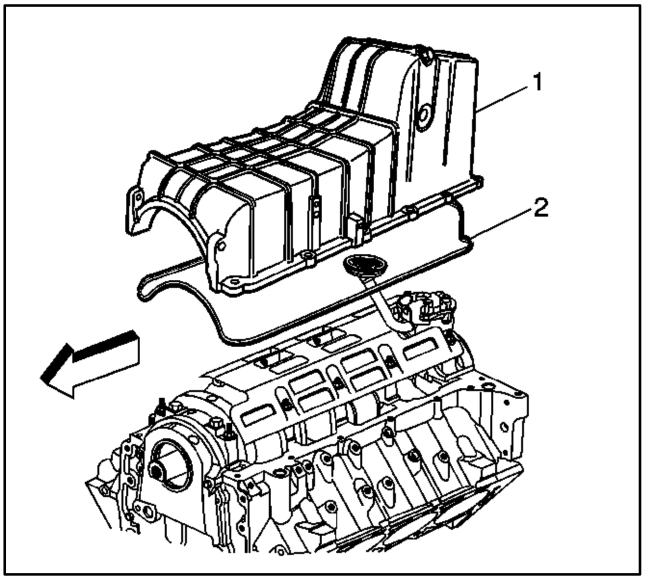
12. Install and secure the ignition coil wiring harness into the 2 wiring harness retainers.
13. Install the ignition coil wiring harness retainer bolts.

    Tighten

    Tighten the ignition coil wiring harness retainer bolts to 12 N·m (106 lb in).
14. Connect the ignition coil wiring harness to the ignition coils, making sure the connectors for cylinders one and three, and cylinders six and eight are connected to the corresponding ignition coils.
15. Install the white wiring harness clip locks.



470659



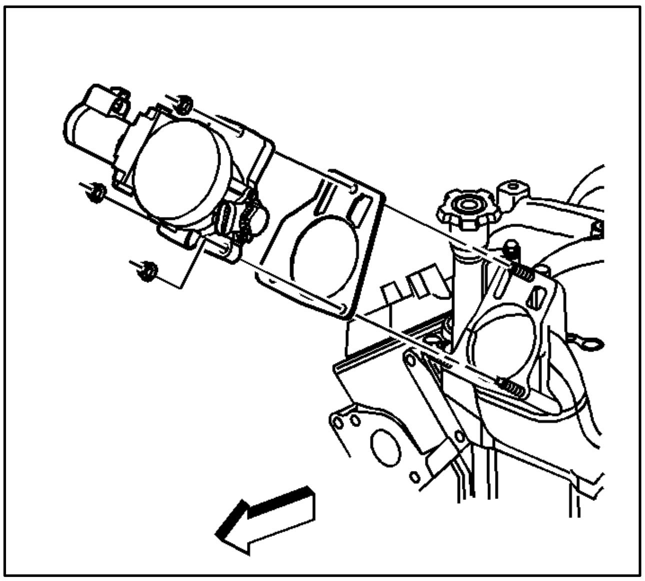
635649

Oil Pan Cleaning and Inspection

1. Remove the oil pan gasket from the groove in the oil pan.
2. Clean the oil pan in solvent.

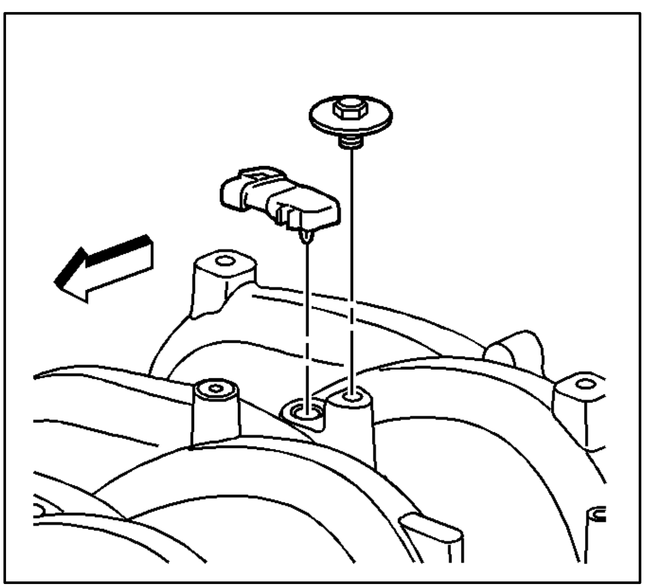
Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

3. Dry the oil pan with compressed air.
4. Inspect the oil pan for the following conditions:
   - The drain plug hole for damaged threads.
   - Gouges or damage to the oil pan sealing surfaces.
   - Cracks or damage to the exterior of the oil pan.
   - Damage to the oil level indicator tube area.
   - Damage to the oil pan gasket.


470760

Intake Manifold Disassemble

1. Remove the throttle body nuts and throttle body.
2. Remove and discard the throttle body gasket.


471023

3. Remove the MAP sensor bolt and MAP sensor.
4. Inspect the MAP sensor seal for damage.

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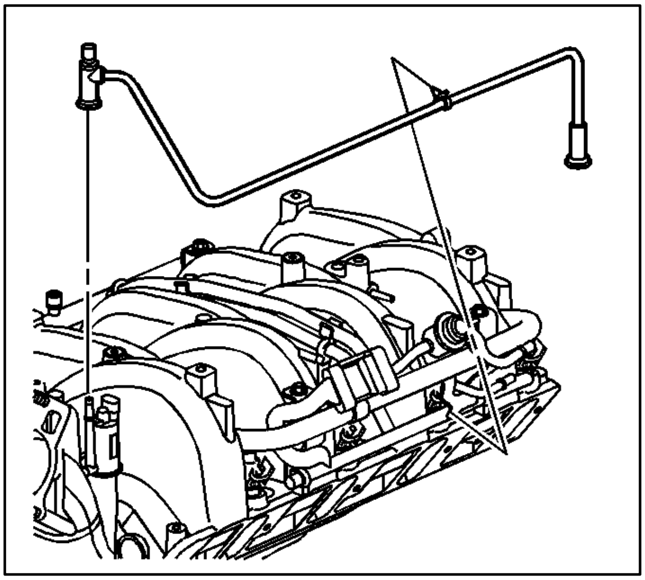
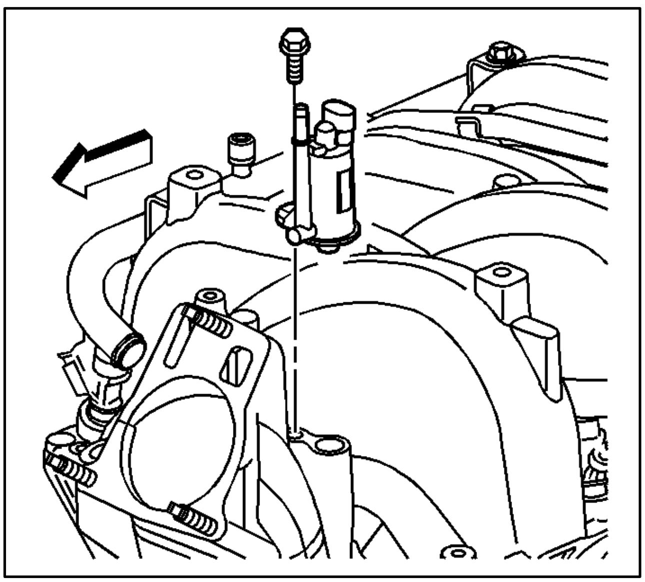


471013

9. Remove the purge solenoid vacuum hose.
10. Remove the purge solenoid bolt and the purge solenoid.
11. Inspect the purge solenoid seal for damage. Replace the seal as needed.



471015

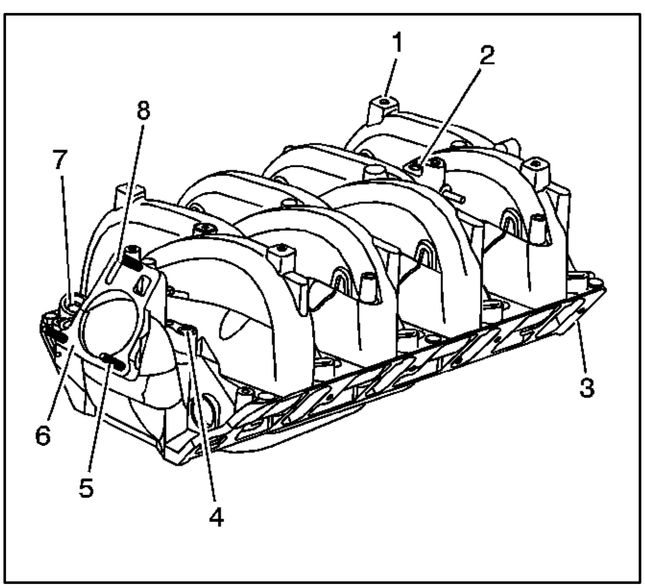
Intake Manifold Cleaning and Inspection

Important: Do not reuse the lower intake manifold gaskets or end seals.

1. Clean the intake manifold in an approved solvent.
   Clean debris out of all bolt holes. Clean the intake manifold gasket sealing surfaces.
   Clean all intake manifold ports.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the intake manifold with compressed air.
3. Inspect the following:
   The intake manifold bolt holes (1) for cracks and/or damage.
   The MAP sensor sealing surface (2) for damage.
   The purge solenoid sealing surface (4) for damage. The purge solenoid bolt has a sealer that may come off during removal of the bolt. Ensure all sealant is removed from the bolt hole.
   The intake manifold-to-cylinder head sealing surfaces (3) for damage.
   The throttle body studs (5) for damage. Replace as necessary.
   The throttle body mounting surface (6) for damage.
   The oil fill tube hole (7) for signs of leakage. Reseal as necessary.
   The PCV port (8) for debris or varnish buildup.



635688

Intake Manifold Assemble

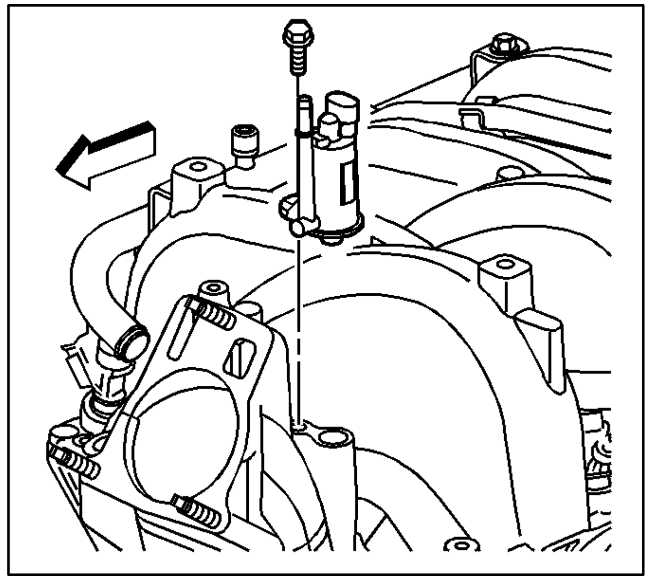
1. Apply a very light film of clean engine oil to the purge solenoid seal.
2. Install the purge solenoid.
3. Apply thread sealer GM P/N 12345493 or equivalent to the threads of the purge solenoid bolt.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the purge solenoid bolt.

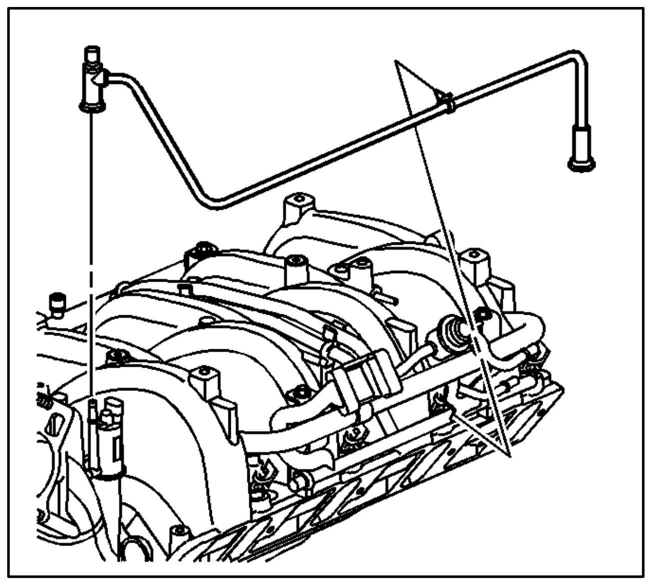
   Tighten

   Tighten the purge solenoid bolt to 10 N m (88 lb in).



471015

5. Install the purge solenoid vacuum hose.



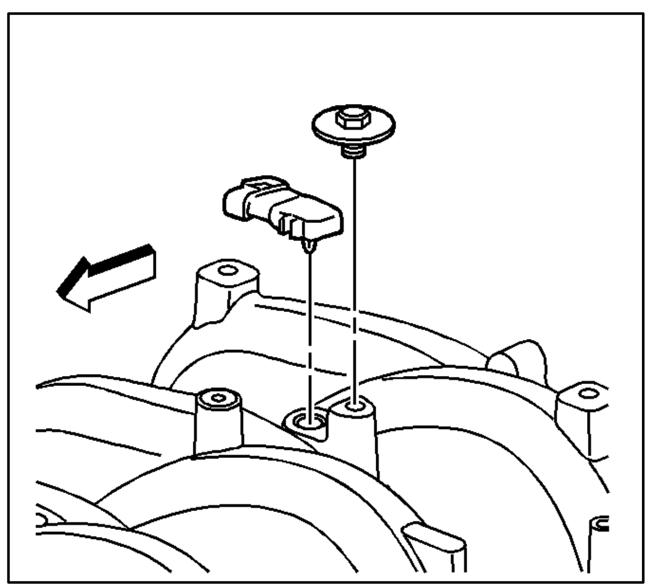
471013

Important: Lubricate the port of the MAP sensor with clean engine oil. Avoid dipping the sensor port directly into the lubricant or using a solid type of lubricant, as they man block the vacuum port signal.

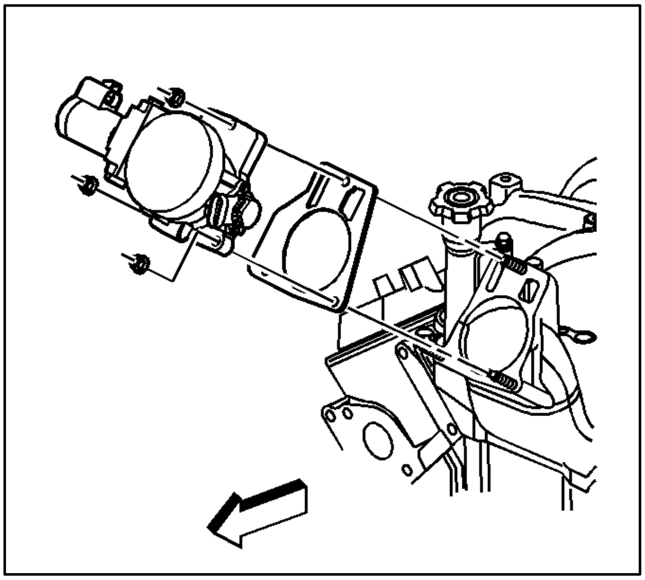
6. Install the MAP sensor.
7. Install the MAP sensor bolt.

   Tighten

   Tighten the MAP sensor bolt to 12 N m (106 lb in).



471023

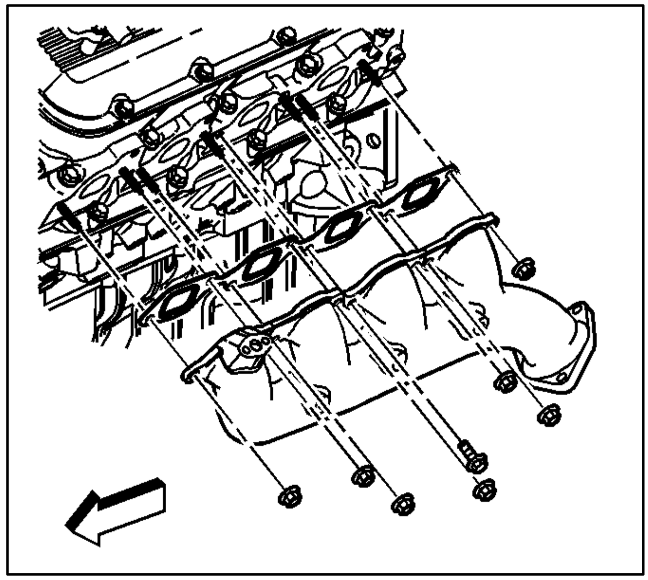


470760

8. Install the throttle body gasket.
9. Install the throttle body.
10. Install the throttle body nuts.

Tighten
Tighten the throttle body nuts to 10 N m (88 lb in).

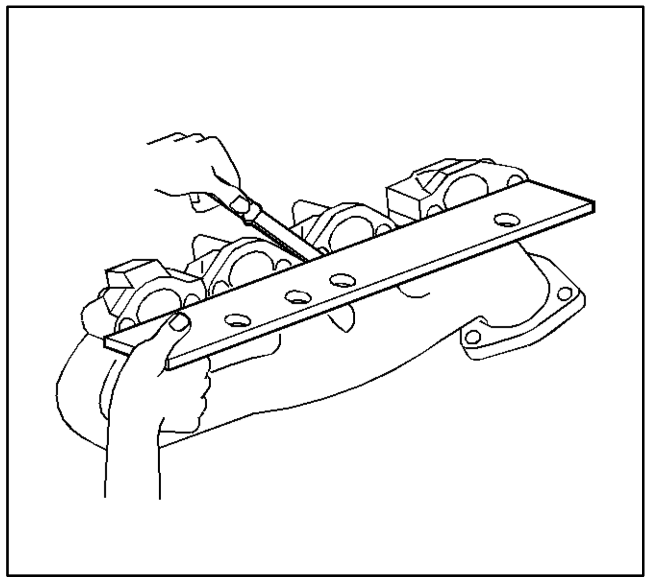
Exhaust Manifold Cleaning and Inspection


470679

1. Clean the exhaust manifolds in solvent.

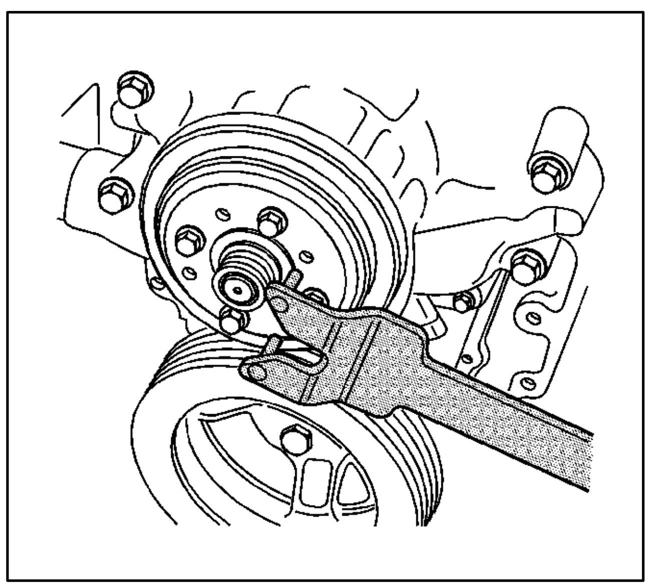
Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
   - Damage to the gasket sealing surfaces.
   - Damage to the exhaust manifold studs.
   - Broken or damaged heat shields.
   - Cracks in the exhaust manifold.
   - Restrictions within the exhaust passages.


66607

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gauge. Exhaust manifold surface flatness variation must not exceed 0.254 mm (0.01 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

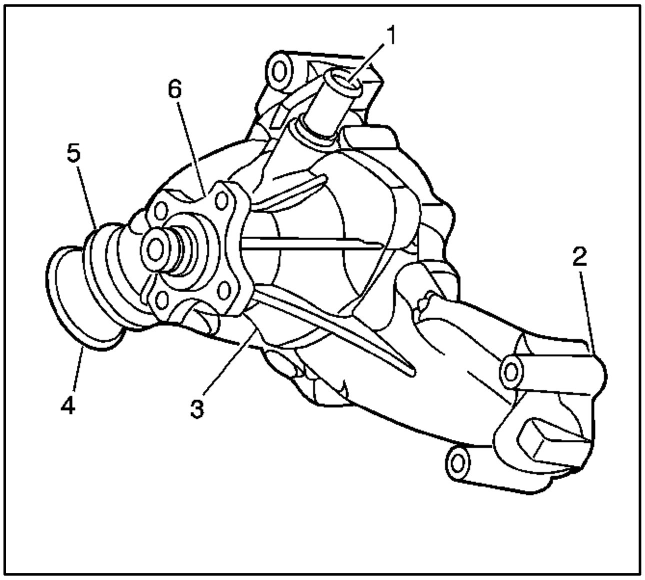
Water Pump Cleaning and Inspection


635640

Tools Required

J 41240 Fan Clutch Wrench

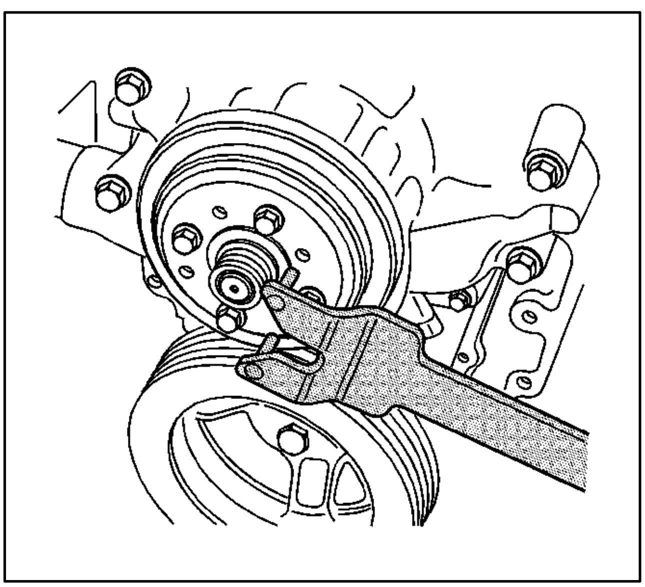
1. Remove the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.
2. Remove the water pump pulley.
3. Inspect the water pump pulley for damage at the belt contact area and the pulley-to-water pump mounting surface.



635719

Important: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

4. Clean all excess dirt and debris from the water pump housing.
5. Inspect the water pump for the following:
   - Leakage at the hose fitting (1).
   - Leakage at the water pump weep hole (3).
   - A stain around the weep hole is acceptable. If leakage occurs (dripping) with the engine running and the cooling system pressurized, replace the water pump.
   - Gasket sealing surfaces (2) for excessive scratches or gouging.
   - Restrictions within the internal coolant passages (4).
   - Excessive side-to-side play in the pulley shaft (5).
     – If the shaft end play exceeds 0.381 mm (0.015 in), replace the water pump.
   - Rotate the pump shaft by hand and inspect for roughness of operation.
     – If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
     – The shaft and fan hub must turn straight and smoothly.
   - Damage to threaded bolt holes (6).
   - Damage to the fan clutch mounting threads (5).


635640

6. Install the water pump pulley.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

7. Install the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.

   Tighten

   Tighten the water pump pulley bolts to 25 N·m (19 lb ft).

Thread Repair

Tools Required

J 29234 Thread Repair Kit

The following procedure is used to accomplish proper and durable thread repairs in the cylinder head and the cylinder block.

Important: Take appropriate precautions to assure that machining chips will not remain inside the engine. For example, block all intake passages, oil drainback holes and exhaust passages with a towel or tape before performing thread repairs.

1. Select the proper size drill as indicated in the schematic charts found in Thread Repair Specifications for the hole being repaired.
2. Drill out the damaged threads to the original depth or completely through for through holes.

Caution: Refer to Safety Glasses Caution in Cautions and Notices in the WCC Service Manual.

3. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
4. Select the correct size tap, using the appropriate chart for the hole being repaired.
5. Coat the tap and the hole with spray machining oil.
6. Tap the hole to the original depth. In order to clean the threads, reverse the rotation of the tap periodically.
7. Use solvent to clean out all of the chips.
8. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
9. Tap the hole again to clean the threads. The tap should thread in with little resistance.

Important: Make sure all of the chips are cleared from the hole.

10. Use solvent to clean out all of the chips.
11. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
12. Use a flashlight to confirm that all of the chips are removed from the hole.
13. Continue to clean the hole until all of the chips are cleared.
14. Install the heli-coil insert as follows:
    - 14.1. In order to determine the correct size installation tool and length insert, refer to the appropriate picture and chart.
    - 14.2. Screw the insert on the mandrel of the installation tool until the driving tang is fully engaged in the driving contour.
    - 14.3. Coat the insert with spray machining oil.

14.4. Install the insert as follows:
   14.4.1. Slide the prewinder over the mandrel and insert.
   14.4.2. Rotate the mandrel clockwise until 1 or 2 threads of the insert are threaded into the prewinder.
   14.4.3. Place the insert in position on the threaded hole being repaired.
   14.4.4. Rotate the mandrel clockwise until the insert is flush with the top surface of the threaded hole.
   14.4.5. Remove the prewinder except when repairing cylinder head bolts.
   14.4.6. Continue to install the insert until reaching the original thread depth.
   14.4.7. Remove the mandrel.

14.5. Remove the driving tang from the thread insert as follows. The tang must be removed in order to allow passage of the fastener through the insert.
   14.5.1. Place the square end of the punch, no chamfer, on the tang after installation.
   14.5.2. Strike the punch sharply with the hammer. The tang will break off at the notch.

15. Clean the hole using compressed air. Take appropriate steps to ensure that chips are not blown into the engine.

Service Prior to Assembly

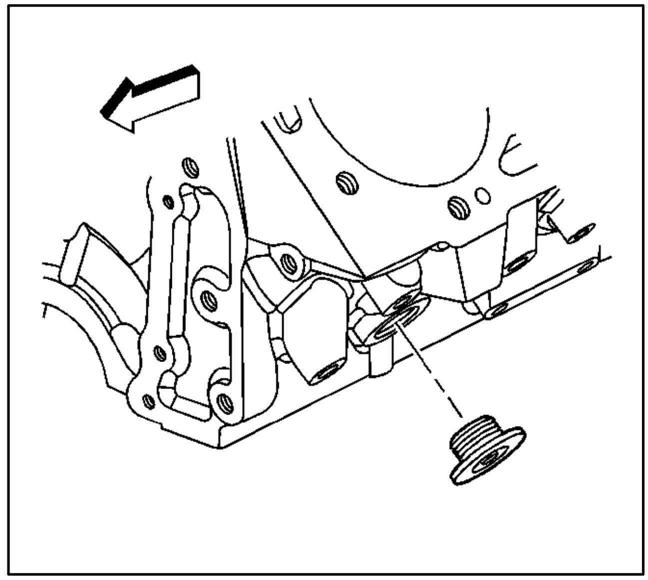
- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer’s specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

Engine Block Plug Installation

Tools Required

J 41712 Oil Pressure Sending Unit Socket

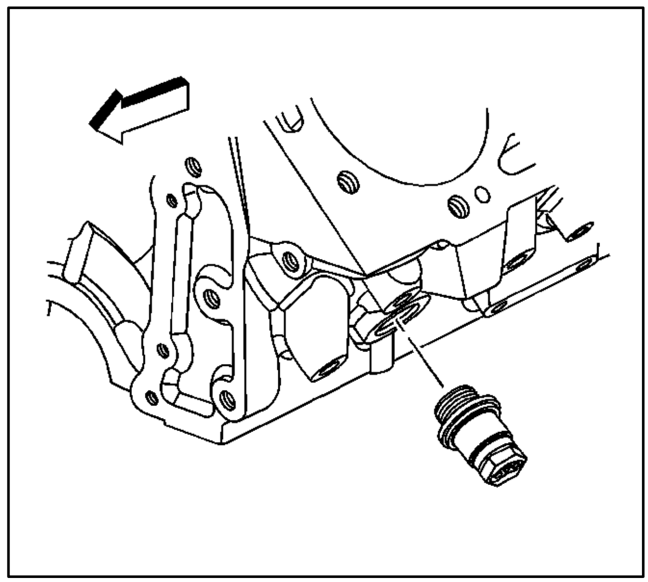
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.


635657

1. Apply sealant GM P/N 12346004 or equivalent to the threads of the coolant hole plug.
2. Install the engine coolant hole plug into the block.

   Tighten

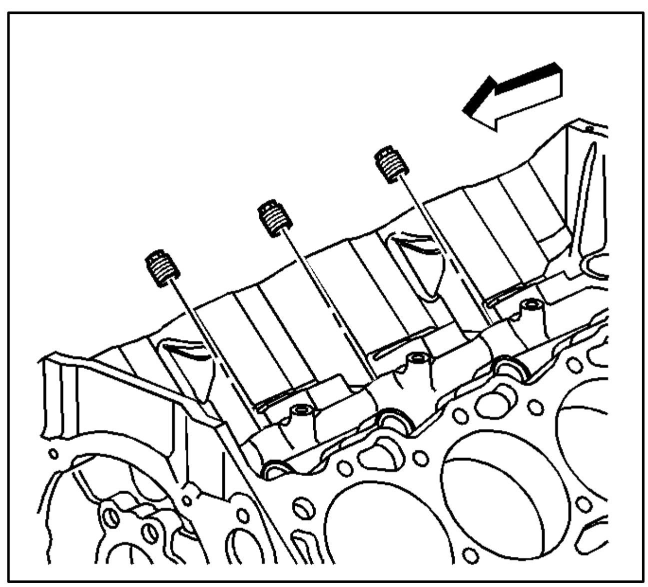
   Tighten the engine coolant hole plug to 60 N·m (40 lb ft).


635660

3. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block heater (if applicable).
4. Install the engine block heater into the block.

   Tighten

   Tighten the engine block heater to 60 N·m (40 lb ft).

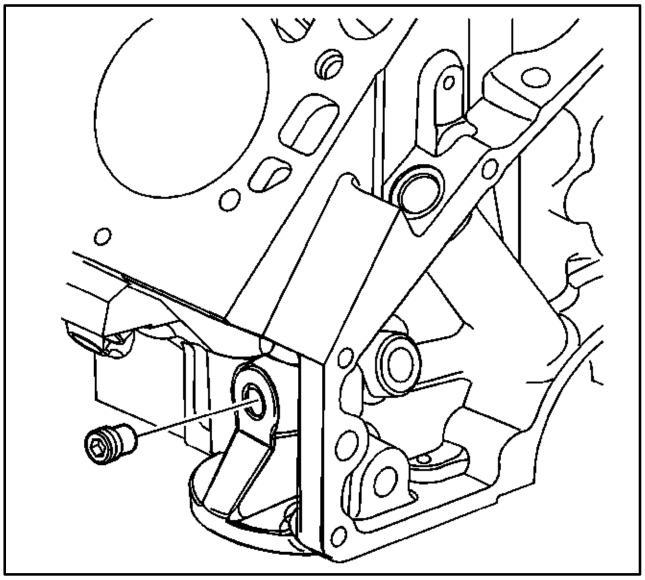

471137

Important: Cylinder block oil gallery plugs with a square drive are English taper threads. Plugs with a hex drive are Metric straight threads. Ensure the correct plugs are used during reassembly.

5. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.
6. Install the engine block top oil gallery plugs.

   Tighten

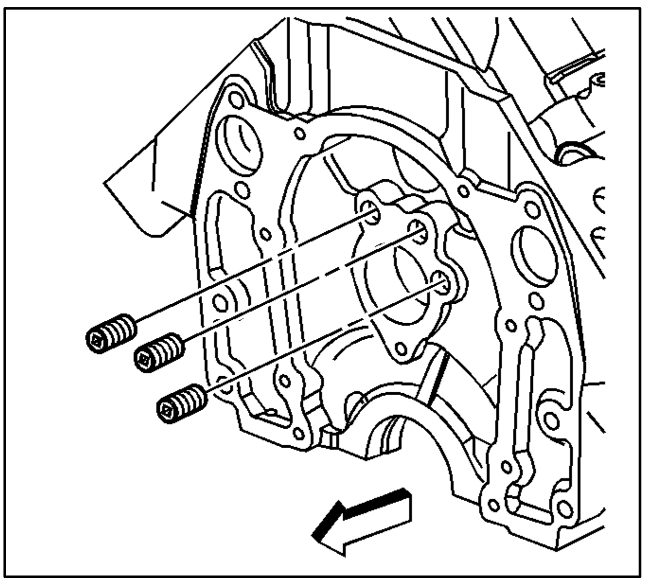
   Tighten the top oil gallery plugs to 20 N·m (15 lb ft).


471138

7. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plug.
8. Install the engine block left side oil gallery plug.

Tighten

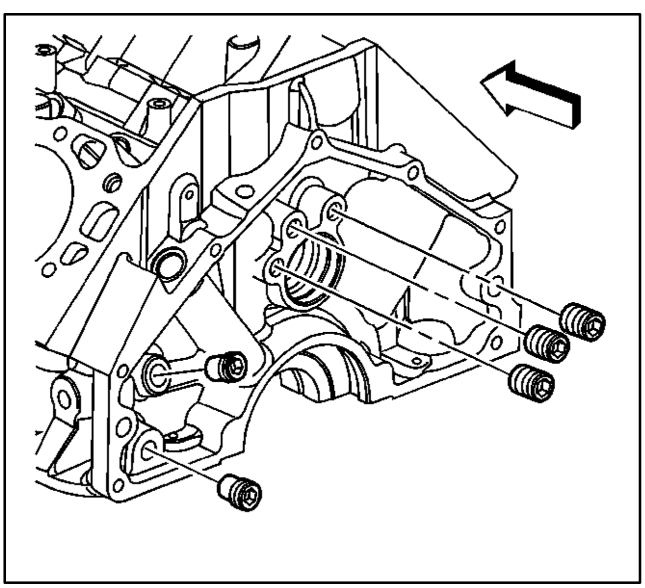
Tighten the left oil gallery plug to 30 N·m (22 lb ft).


471133

9. Apply sealant GM P/M 12346004 or equivalent to the threads of the oil gallery plugs.
10. Install the front oil gallery plugs.

Tighten

Tighten the front oil gallery plugs to 30 N·m (22 lb ft).


471134

11 Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.
12. Install the rear oil gallery plugs.

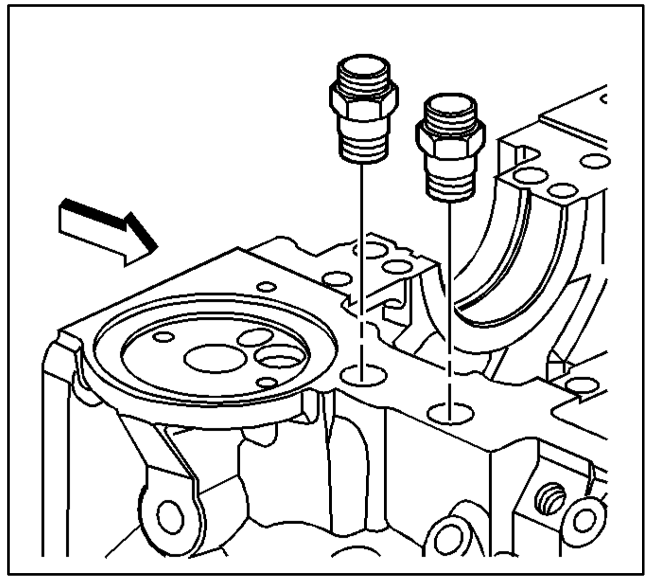
Tighten

Tighten the rear oil gallery plugs to 30 N·m (22 lb ft).

13. Apply sealant GM P/N 12345493 or equivalent to the threads of the engine block oil cooler hose fittings.
14. Install the engine block oil cooler hose fittings.

    Tighten

    Tighten the engine block oil cooler hose fittings to 23 N·m (17 lb ft).



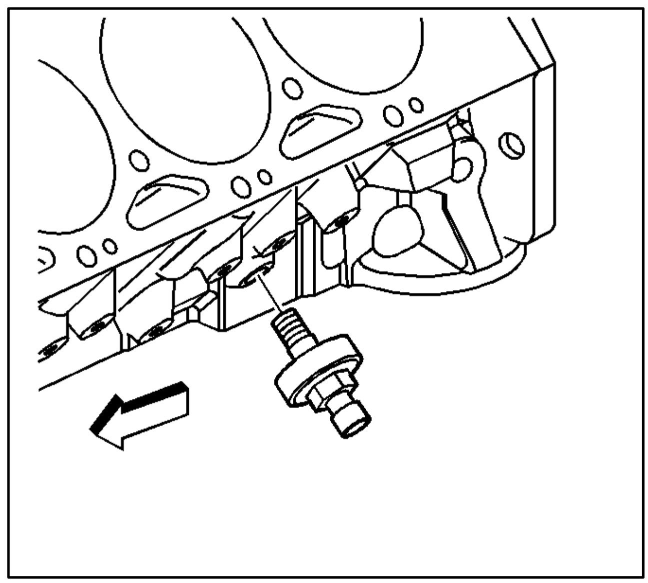
471126

Important: Do not overtighten the knock sensor or engine damage may occur.

15. Install the left knock sensor to the engine block.

    Tighten

    Tighten the left knock sensor to 20 N·m (15 lb ft).

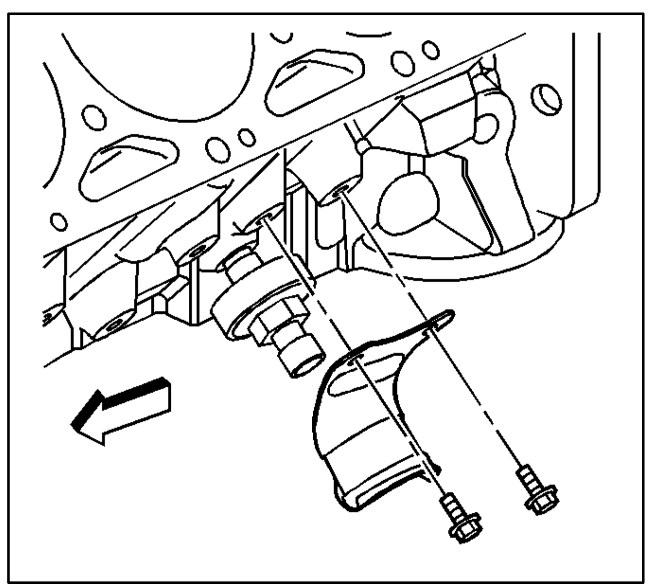


471081

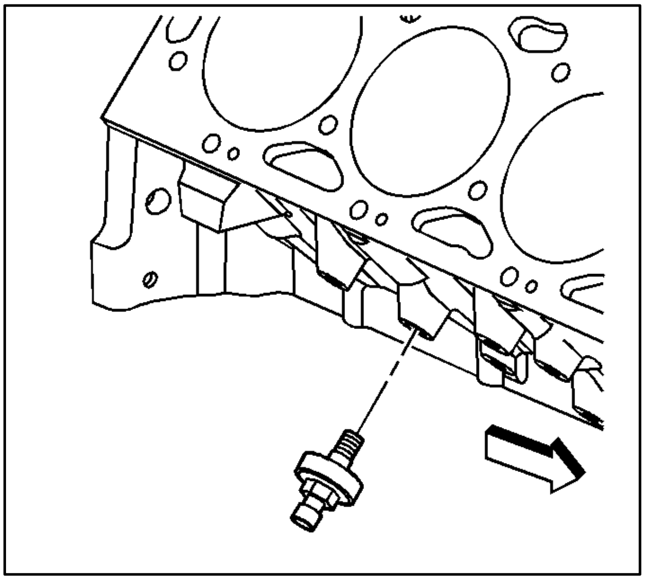
16. Install the left side knock sensor shield.
17. Install the left side knock sensor shield bolts.

    Tighten

    Tighten the left side knock sensor shield bolts to 12 N·m (106 lb in).



471100



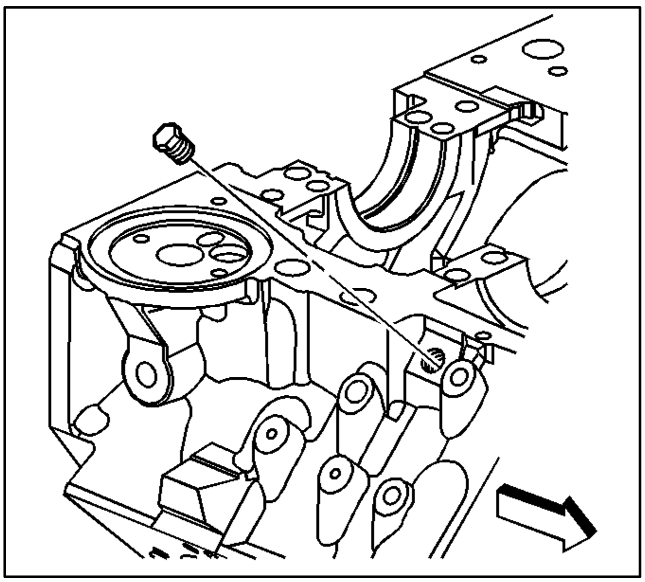
471076

Important: Do not overtighten the knock sensor or engine damage may occur.

18. Install the right knock sensor to the engine block.

    Tighten

    Tighten the right side knock sensor to 20 N·m (15 lb ft).

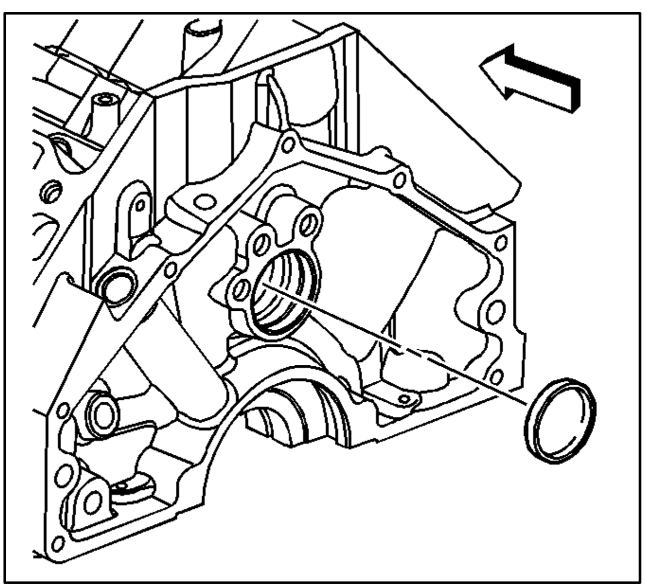


470568

19. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block coolant drain hole plugs.
20. Install the engine block coolant drain hole plugs.

    Tighten

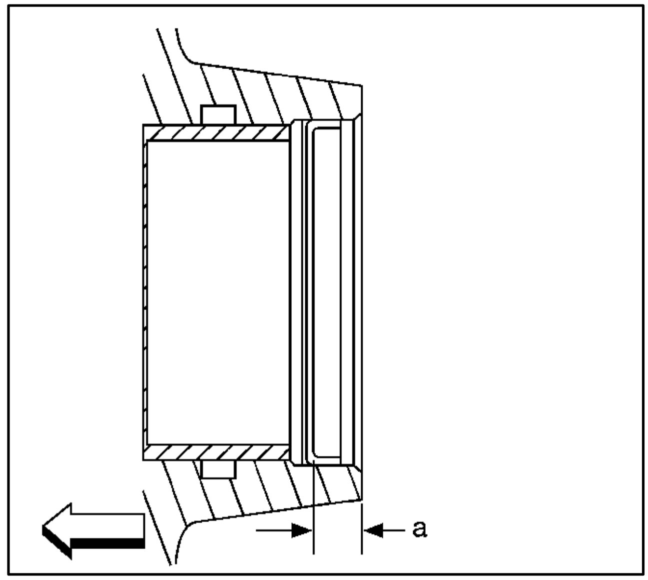
    Tighten the coolant drain hole plugs to 20 N·m (15 lb ft).



471118

21. Apply sealer GM P/N 12377901 to the outside diameter of the new camshaft rear bearing hole plug.

22. Install the NEW camshaft rear bearing hole plug to the proper depth (a) of 7.600 – 6.200 mm (0.299 – 0.244 in).

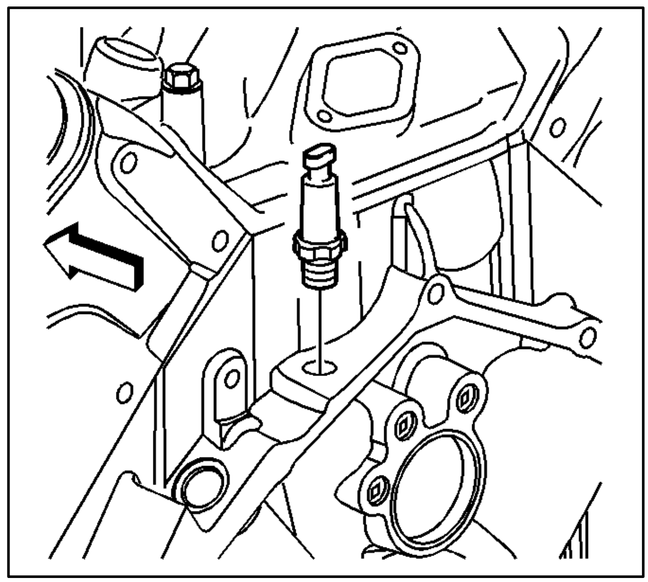


471122

23. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil pressure sensor.
24. Install the oil pressure sensor.

    Tighten

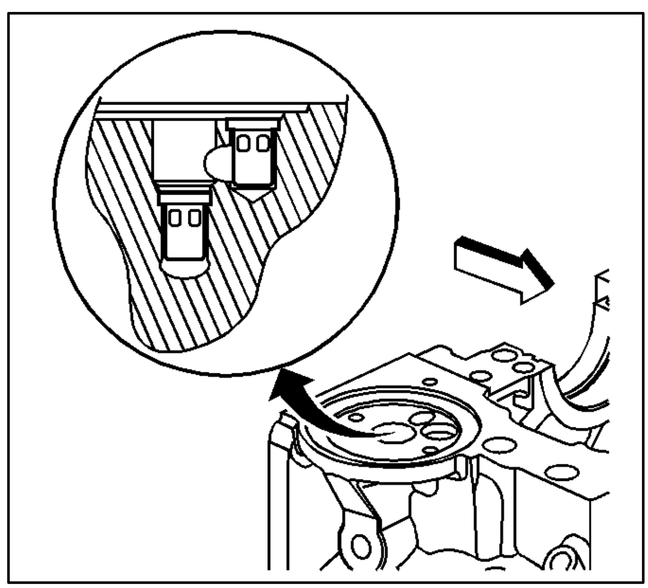
    Using the *J 41712*, tighten the oil pressure sensor to 30 N·m (22 lb ft).



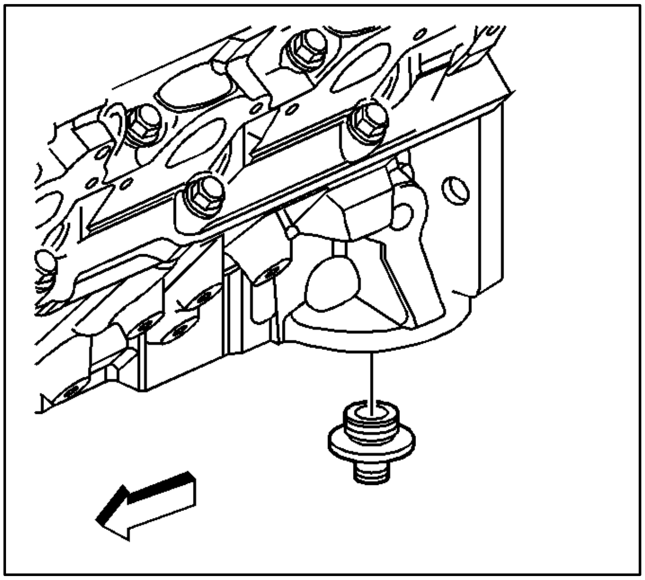
471089

Oil Filter Adapter Installation

1. If removed, install the new oil bypass valves. Stake the tangs on the oil bypass valves.



471143



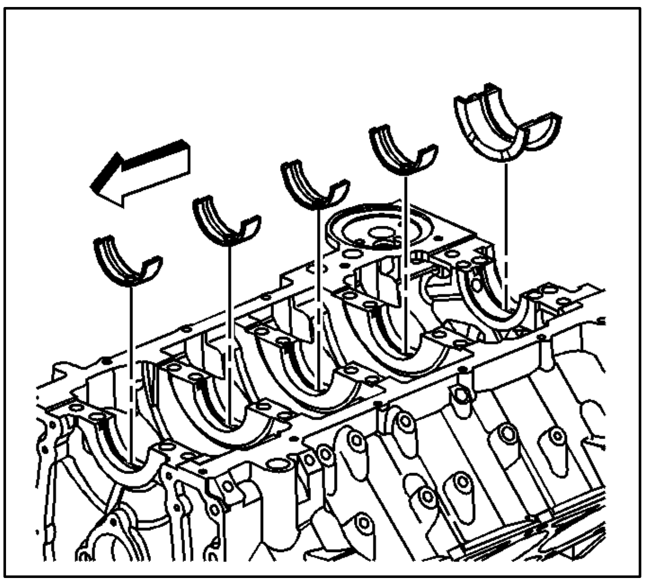
471026

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the oil filter fitting.

   Tighten

   Tighten the oil filter fitting to 66 N·m (49 lb ft).



471041

Crankshaft and Bearings Installation

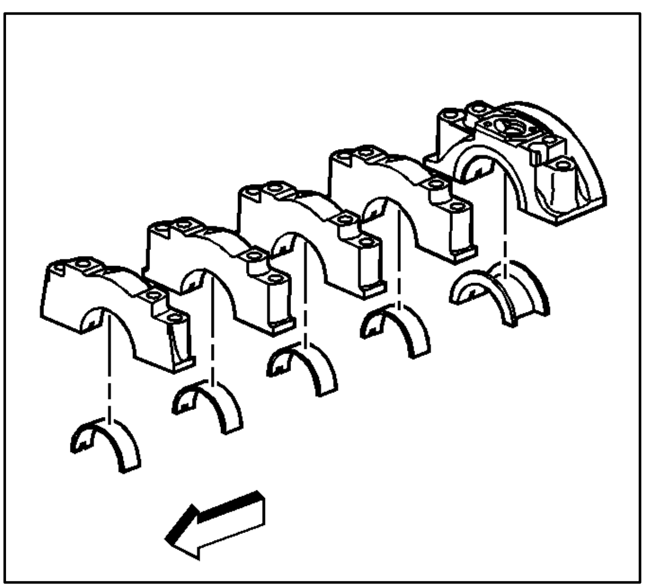
Tools Required

- *J 8001* Dial Indicator Set
- *J 36660-A* Torque Angle Meter

Important:

- Lubricate the crankshaft bearings and crankshaft with clean engine oil.
- If undersized bearings are used, ensure that the bearings are fitted to the proper journals.

1. Install the crankshaft upper bearings into the block. Apply clean engine oil to the bearing surfaces.

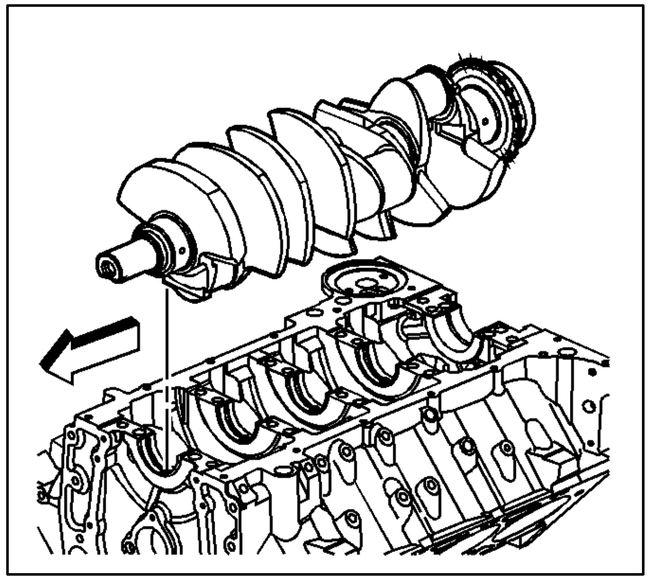


471044

2. Install the crankshaft lower bearings into the crankshaft bearing caps. Apply clean engine oil to the bearing surfaces.

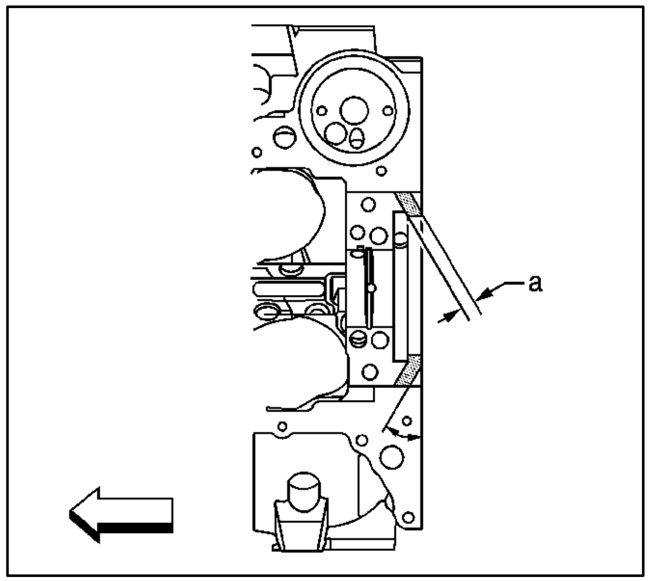
Important: Care should be taken when installing the crankshaft so the crankshaft position sensor reluctor ring is not damaged. If the reluctor ring becomes damaged, the crankshaft must be replaced.

3. Install the crankshaft.



471047

4. Apply a 13 mm (0.500 in) light film (a) of GM P/N 1052942 or equivalent to the rear bearing cap sealing face or to the rear bearing cap channel of the engine block. Apply the sealant from the corner of the rear thrust bearing pocket to the edge of the channel.



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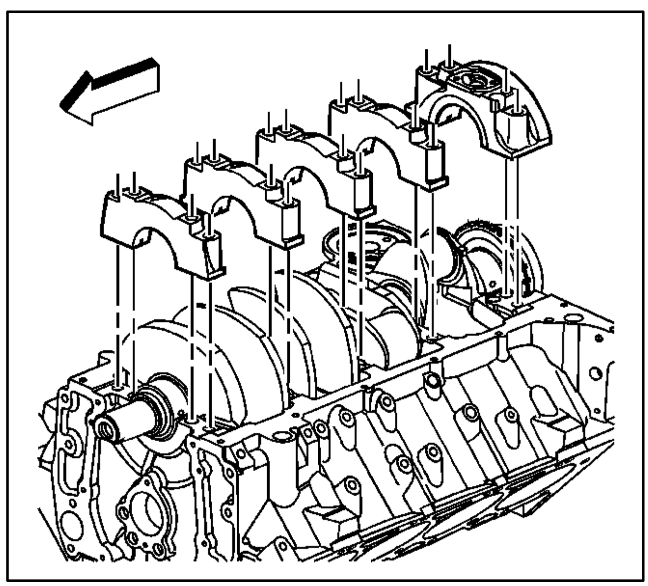
Notice: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

Important: Care should be taken when installing the rear bearing cap to prevent damage to the crankshaft position sensor reluctor wheel. If the reluctor wheel is damaged, the crankshaft must be replaced.

Important: Ensure that the triangle symbols on the crankshaft bearing caps are facing the front of the engine.

5. Install the crankshaft bearing caps.



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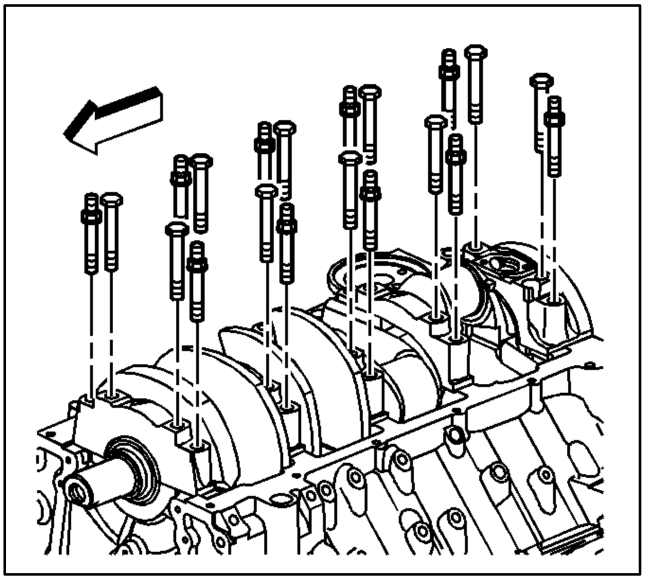


Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

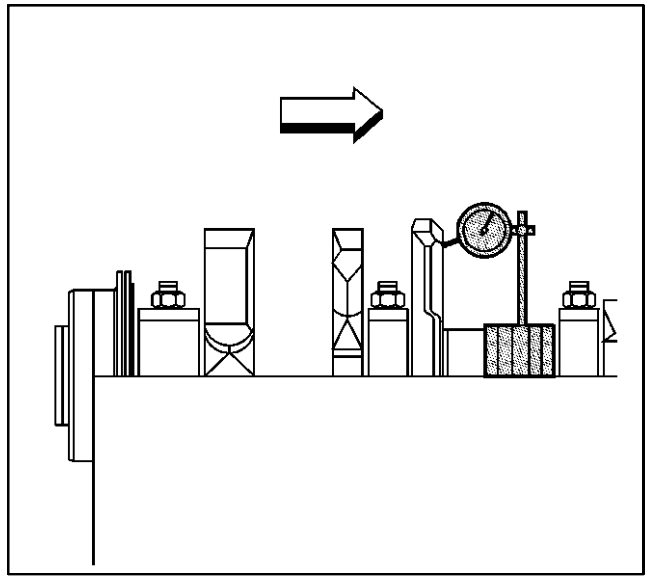
Important: Tighten the crankshaft bearing cap inner bolts before tightening the crankshaft bearing cap outer studs.

6. Install the crankshaft bearing cap bolts and studs.

   Tighten

   - Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).
   - Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).
   - Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.
   - Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.

7. Measure the crankshaft end play as follows:
    7.1. Install the *J 8001* or equivalent to the cylinder block, with the dial indicator plunger against one of the counterweights of the crankshaft.
    7.2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
    7.3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward, and read the end play measurement on the dial indicator. An optional method is to insert a feeler gauge between the crankshaft and the bearing surface and measure the clearance. Refer to *Engine Mechanical Specifications* in this supplement.
    7.4. If the correct end play cannot be obtained, inspect for the following conditions:
        - Verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications* in this supplement.
        - Inspect the crankshaft thrust wall surface for wear and/or excessive runout. Refer to *Engine Mechanical Specifications* in this supplement.
    7.5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition(s) could cause a lack of clearance at the bearing:
        - Burrs on the crankshaft bearing cap.
        - Foreign material between the bearing and the block.
        - Foreign material between the bearing and the bearing cap.
        - A faulty crankshaft bearing.
        - Improper size bearing.



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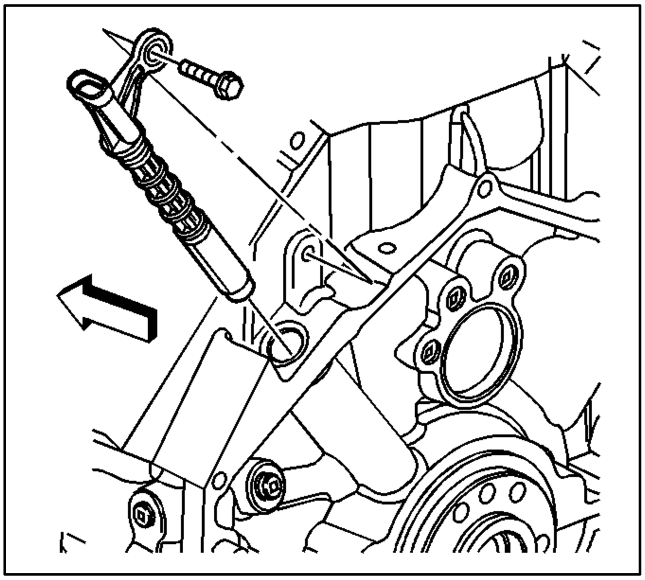

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Important: Ensure that the crankshaft position sensor is fully seated against the crankshaft reluctor ring. The upper flange on the sensor MAY NOT seat against the engine block.

Important: The crankshaft position sensor bolt has a thread sealant applied to the threads. The thread sealant may have come off during the removal of the bolt. Ensure that the bolt hole is clean of any debris before installing the crankshaft sensor bolt.

8. Inspect both crankshaft position sensor O-rings for cuts, cracks, tears or damage. Replace the O-rings as needed. Lubricate the crankshaft position sensor O-rings with clean engine oil.
9. Install the crankshaft position sensor into the block

   There may be a slight resistance as the O-rings seat into the engine block.
10. Apply thread sealer GM P/N 12345493 or equivalent to the crankshaft position sensor bolt.
11. Install the crankshaft position sensor bolt.

    Tighten

    Tighten the crankshaft position sensor bolt to 12 N·m (106 lb in).

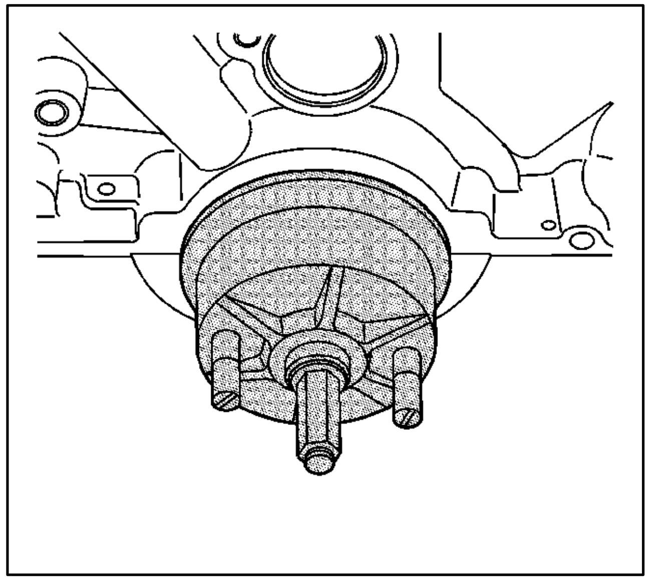
Crankshaft Rear Oil Seal Installation

Tools Required

J 42849 Crankshaft Rear Seal Installer

Important: Crankshaft rear oil seal and engine flywheel installation requires adequate space for installation. If the engine stand does not allow suitable space to use the *J 42849*, install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor.

1. Make sure the crankshaft rear chamfer is free of grit, loose rust, and burrs. Correct as needed.
2. Apply a very light film of oil onto the crankshaft sealing surface.
   DO NOT apply oil to the sealing surface of the engine block.
3. Install the seal on the *J 42849*.
4. position *J 42849* against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Rotate the center nut until the *J 42849* bottoms.
7. Remove the *J 42849*.



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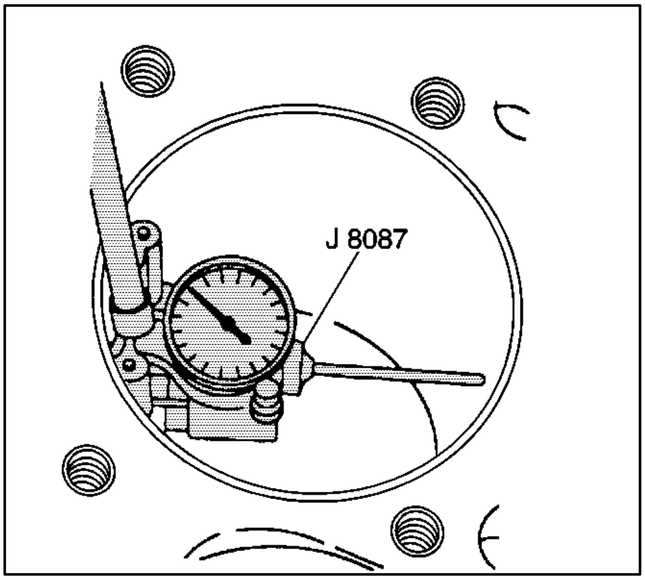

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Piston, Connecting Rod, and Bearing Installation

Tools Required

- *J 8037* Piston Ring Compressor
- *J 8087* Cylinder Bore Gauge

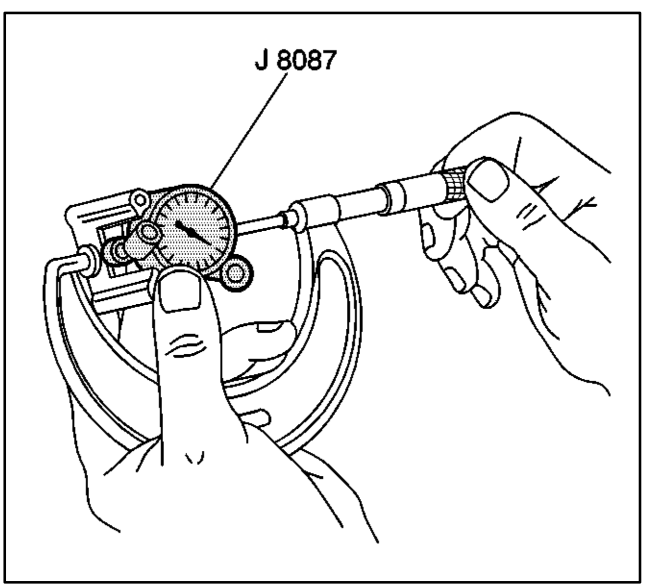
Piston Selection

Important: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.

To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications the cylinder must be resized to accept a new, oversized piston.

For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

1. Inspect the engine block cylinder bore. Refer to *Engine Block Cleaning and Inspection* in this supplement.
2. Inspect the piston/connecting rod assembly for damage. Refer to *Piston and Connecting Rod Assemble* in this supplement.
3. Use the *J 8087* and measure the cylinder bore diameter. Refer to *Engine Block Cleaning and Inspection* in this supplement.



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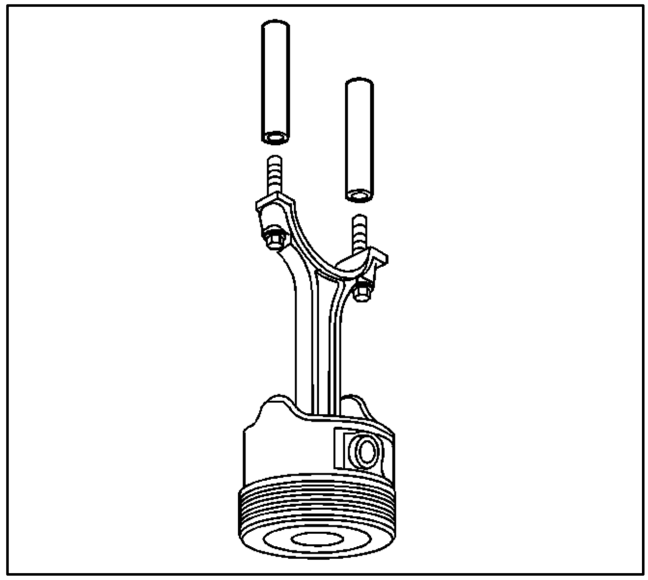
4. Measure the *J 8087* with a micrometer and record the reading.
5. Compare the cylinder bore measurement to the specifications. Refer to *Engine Mechanical Specifications* in this supplement.
   - 5.1. If the cylinder bore is within specifications, select the original piston or a new, original size piston.
   - 5.2. If the cylinder bore is not within specifications, select the next oversized piston/connecting rod assembly, then bore and hone the cylinder bore to fit the oversize piston.

Piston Installation

1. Coat the following components with clean engine oil:
   - The piston
   - The piston rings
   - The cylinder bore
   - The bearing surfaces
2. Install rubber fuel line onto the connecting rod bolts.



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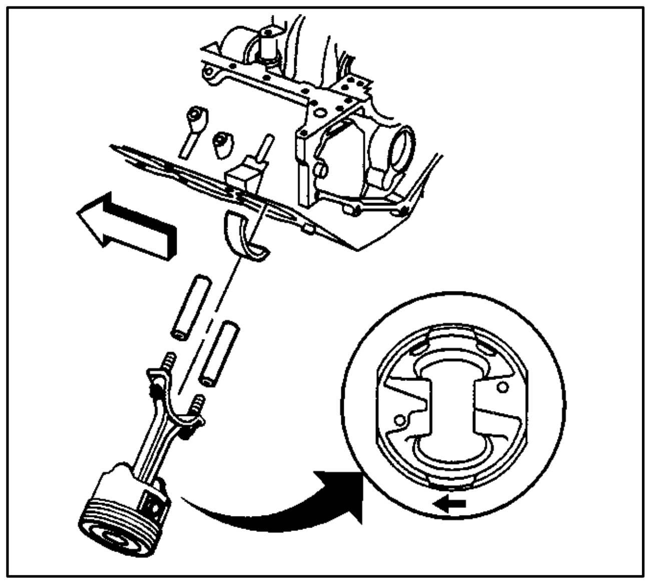
Important: The mark on the top of the piston must face the front of the engine block. When assembled, the flanges on the connecting rod and cap should face to the front of block on the left bank and to the rear of block on the right bank.

3. Install the piston, connecting rod and upper connecting rod bearing through the top of the engine block.



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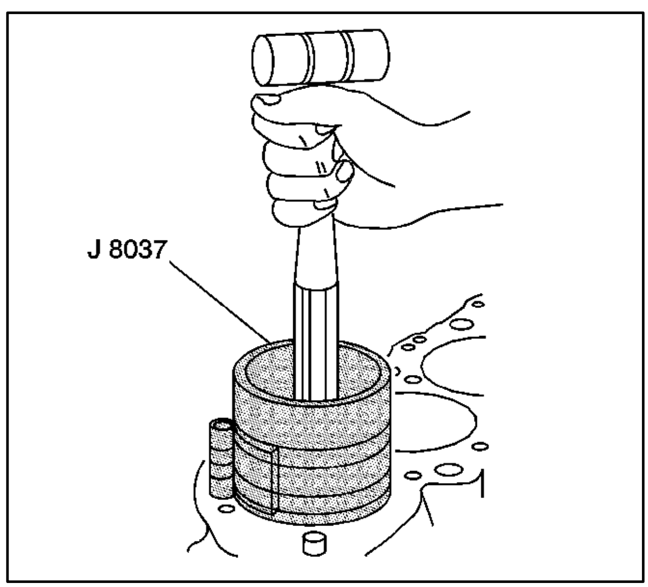
4. Install the *J 8037* onto the piston and compress the piston rings.
5. Use the *J 8037* and lightly tap the top of the piston with a wooden hammer handle.
6. Hold the *J 8037* firmly against the engine block until all of the piston rings have entered the cylinder bore.



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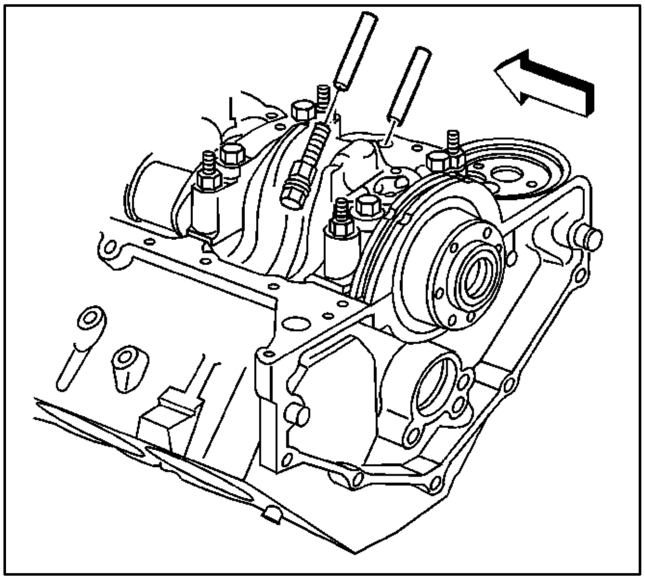

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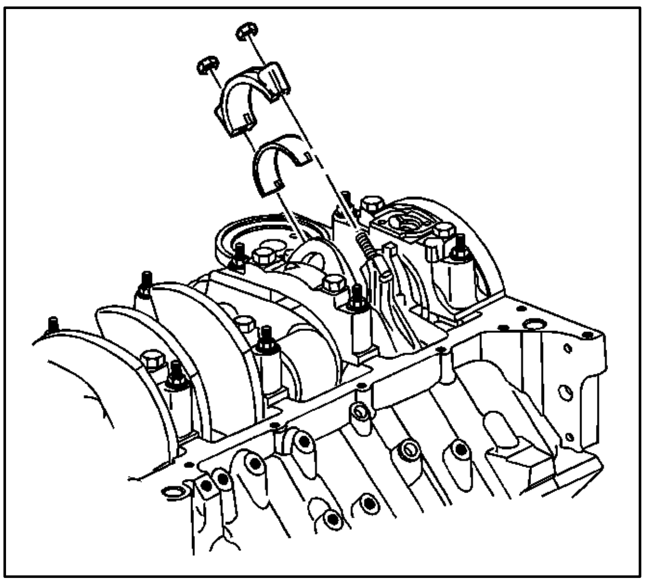
7. Use the rubber fuel line in order to guide the connecting rod onto the crankshaft journal.
8. Remove the rubber fuel line.



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9. Install the connecting rod cap and lower connecting rod bearing.

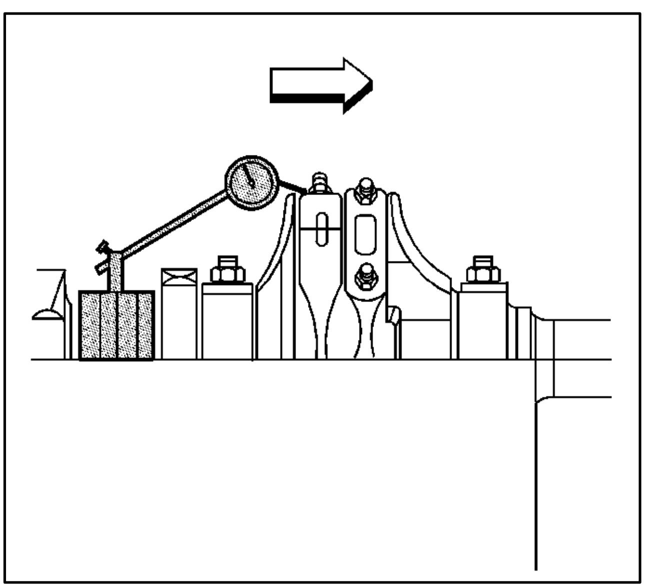
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: When installing the piston/connecting rod assembly, NEW connecting rod nuts must be installed.

10. Install the new connecting rod nuts.

    Tighten

    Tighten the connecting rod nuts to 30 N·m (22 lb ft) plus an additional 90 degrees.



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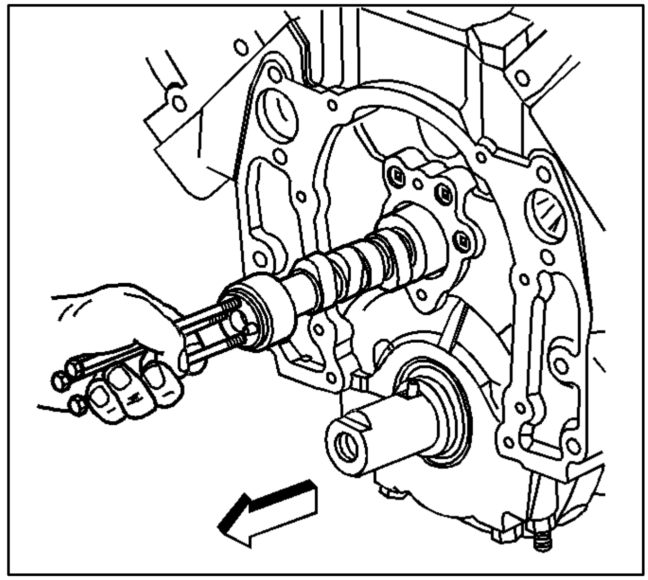
11. Once the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly (parallel to the crankpin) in order to make sure that they have side clearance.
12. Use a feeler gauge or a dial indicator to measure the side clearance between the connecting rod caps. The rod side clearance should be 0.384 – 0.686 mm (0.0151 – 0.0270 in).

Camshaft Installation



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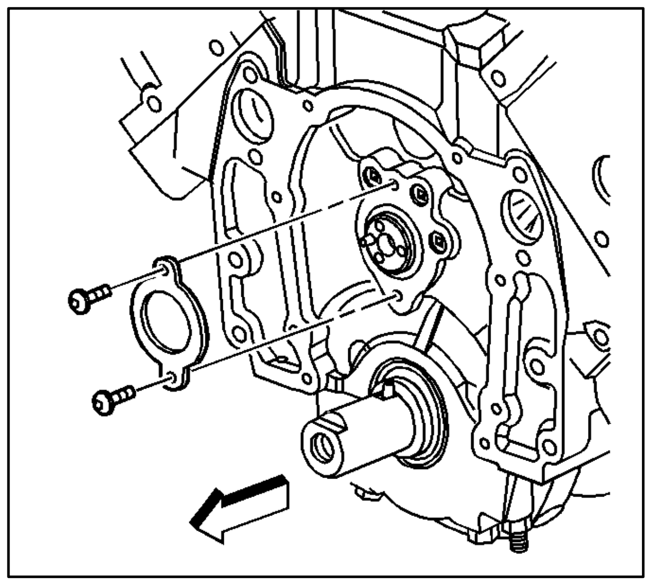
1. Lubricate the following components with clean engine oil, engine oil supplement GM P/N 1052367, or equivalent:
   - The camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

2. Install the three 8 – 1.25 x 100 mm bolts in the camshaft front bolt holes.
3. Using the bolts as a handle, install the camshaft.
4. Remove the three bolts from the front of the camshaft.



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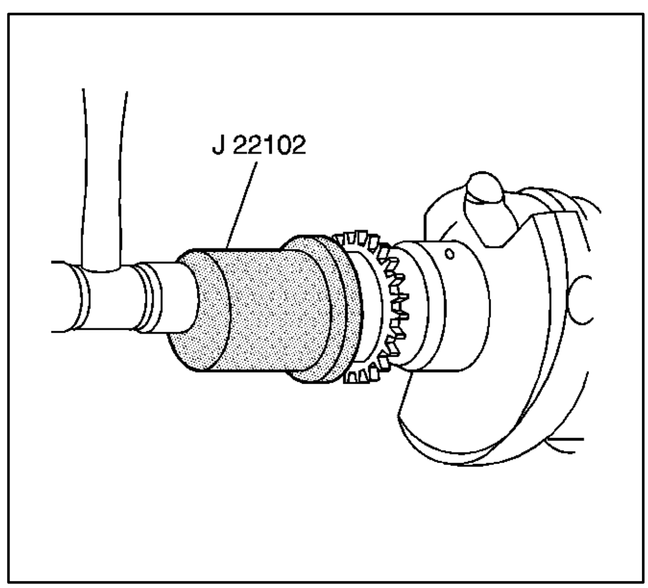
5. Install the camshaft retainer.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

6. Install the camshaft retainer bolts.

   Tighten
   Tighten the camshaft retainer bolts to 12 N·m (106 lb in).

Timing Chain and Sprockets Installation



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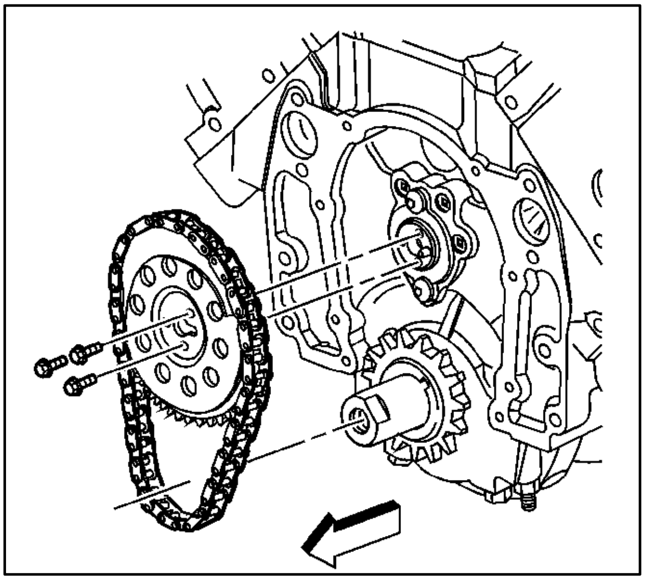
Tools Required

J 22102 Crankshaft Sprocket Installer

1. Use the *J 22102* in order to install the crankshaft sprocket.
   Align the keyway of the crankshaft sprocket with the crankshaft pin.
2. Rotate the crankshaft until the crankshaft sprocket alignment mark is in the 12 o'clock position.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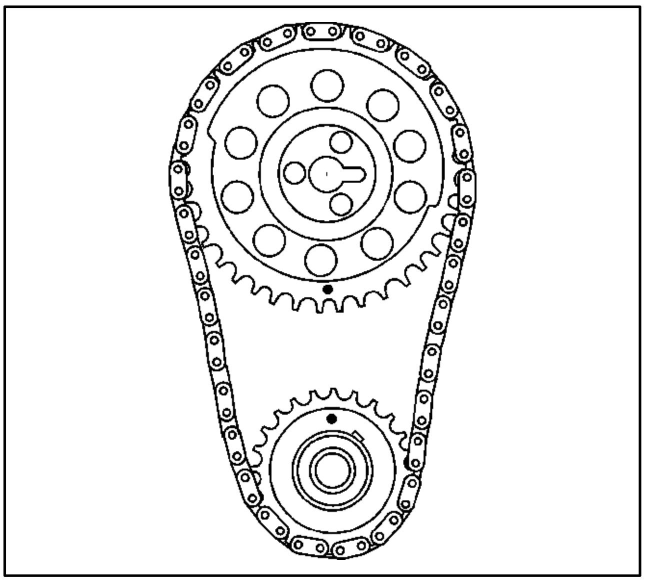
Important: Install the camshaft sprocket with the alignment mark in the 6 o'clock position.

Important: The sprocket teeth must mesh with the timing chain in order to prevent damage to the camshaft retainer.

Important: Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may dislodge the rear camshaft plug and/or damage the camshaft.

3. Install the camshaft sprocket and timing chain.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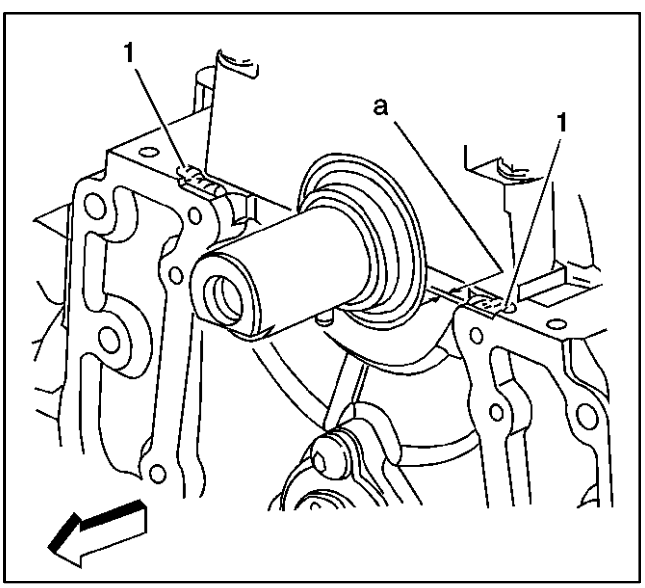
4. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

5. Install the camshaft sprocket bolts.

   Tighten

   - Tighten the three camshaft sprocket bolts to 30 N·m (22 lb ft).
   - Tighten the camshaft sprocket bolts in a second pass to 30 N·m (22 lb ft).



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Engine Front Cover Installation

Tools Required

J 42851 Front Cover Oil Seal Installer

1. Install the NEW crankshaft front oil seal using the *J 42851*.
2. Lubricate the sealing surface of the crankshaft front oil seal with clean engine oil.

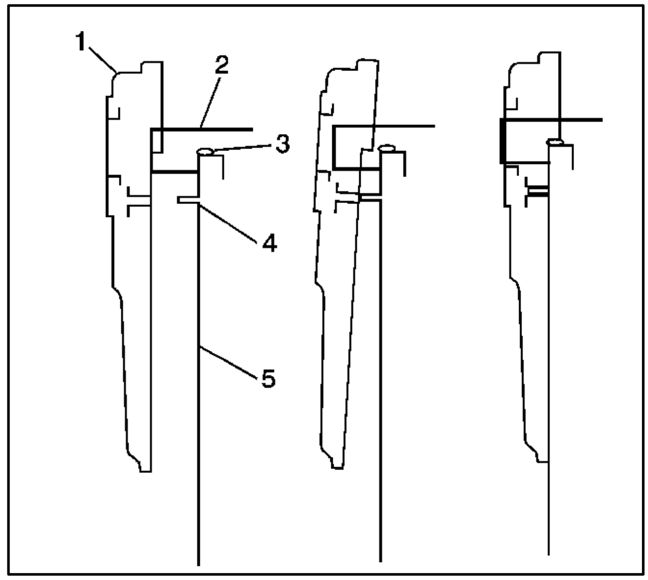
Important: The engine front cover must be installed and the fasteners tightened while the sealant is still wet to the touch.

3. Apply the sealant GM P/N 12346286 or equivalent in two sealant points (1) on the engine block where the front cover meets the oil pan.

4. Install the engine front cover gasket into the front cover.

Important: The following method must be used when installing the engine front cover. Failure to follow the instructions will push the sealant out, which may cause an oil leak.

5. Install the engine front cover.
   5.1. Hold the front cover (1) up to the crankshaft (2).
   5.2. Lift the front cover (1) while sliding the cover over the crankshaft (2).
   5.3. Slide the front cover towards the engine block (5) while keeping the cover raised.
   5.4. Lower the cover down over the dowel pin (4), allowing the front cover to rest on the sealant (3).



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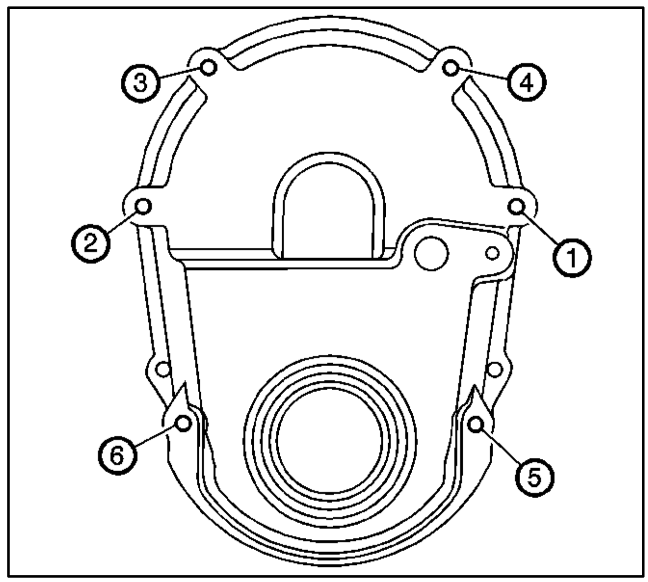
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

6. Install the engine front cover bolts.

   Tighten

   - Tighten the engine front cover bolts in sequence to 6 N·m (54 lb in) in the first pass.
   - Tighten the engine front cover bolts in sequence to 12 N·m (106 lb in) in the second pass.



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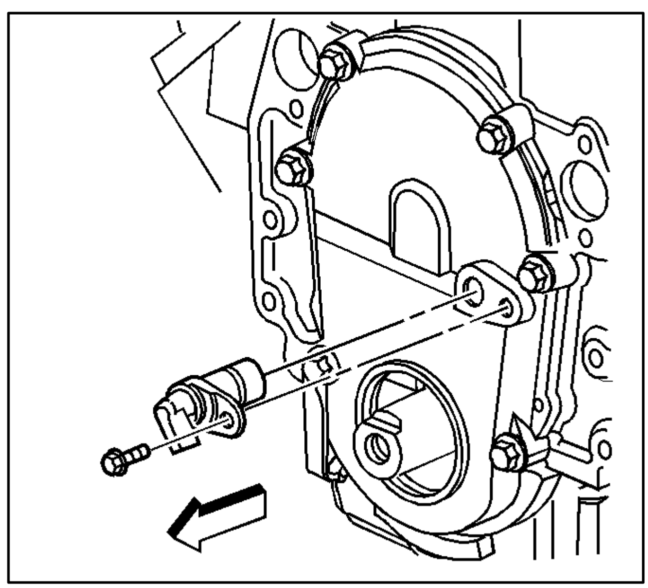
7. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.
8. Apply a light film of clean engine oil to the camshaft position sensor O-ring
9. Install the camshaft position sensor.

Notice: This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

10. Install the camshaft position sensor bolt.

    Tighten

    Tighten the camshaft position sensor bolt to 12 N·m (106 lb in).



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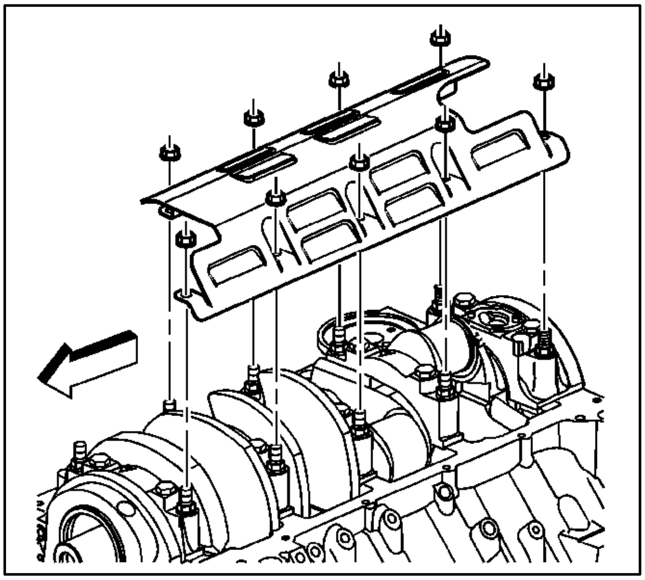

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Oil Pump, Pump Screen and Deflector Installation

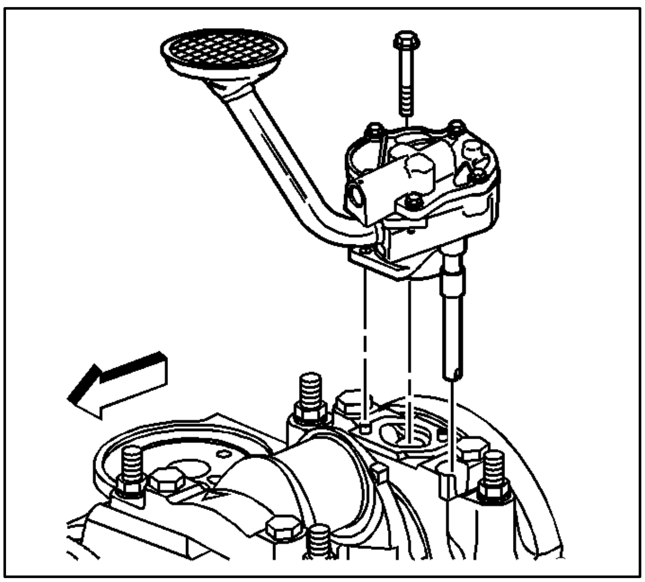
1. Install the crankshaft oil deflector.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the crankshaft oil deflector nuts.

   Tighten

   Tighten the crankshaft oil deflector nuts to 50 N·m (37 lb ft).



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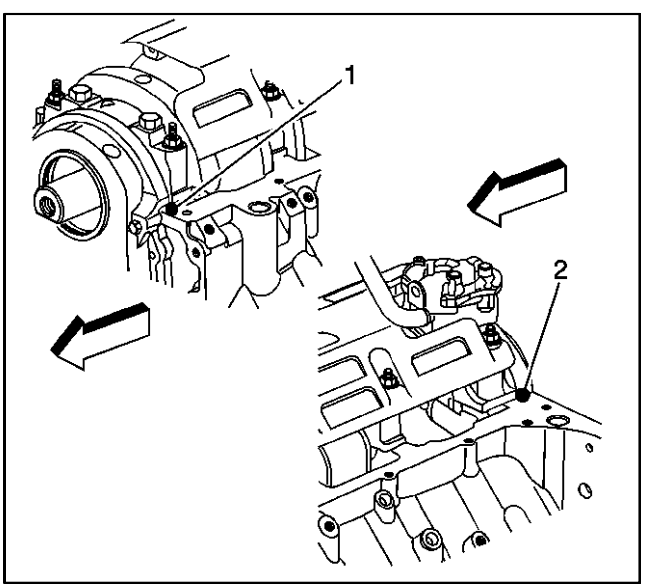
Important: During assembly, install a NEW oil pump driveshaft retainer. Slightly heat retainer above room temperature for ease of installation onto the oil pump driveshaft.

3. Assemble the oil pump, driveshaft, and a NEW retainer.
4. Install the oil pump assembly. Position the oil pump onto the locating pins.
5. Install the bolt attaching the oil pump to the rear crankshaft bearing cap.

   Tighten

   Tighten the oil pump bolt to 75 N·m (55 lb ft).
6. Pour clean engine oil into the oil pump pickup screen.
7. Rotate crankshaft in direction of engine rotation in order to prime the oil pump.



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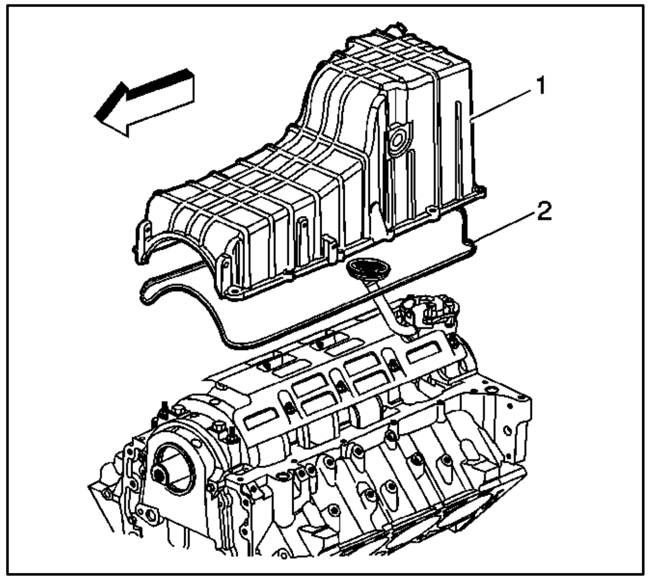
Oil Pan Installation

Important: The oil pan must be installed within five minutes of the sealer being applied or the sealer will begin to cure, causing an inadequate seal.

1. Apply sealant GM P/N 12346286 to the side of the front cover (1) and rear (2) crankshaft bearing cap, on both the left and right sides (four locations total).

2. Install the new oil pan gasket (2) into the oil pan groove.
3. Install the oil pan (1).



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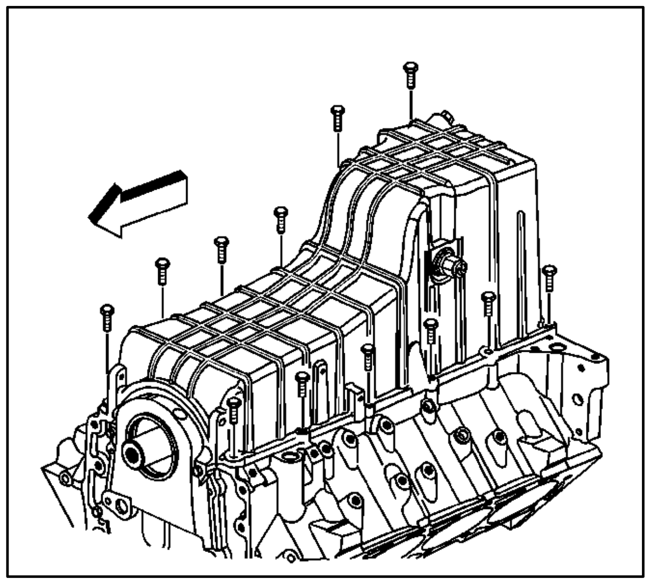
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the oil pan bolts.



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5. Tighten the oil pan bolts in sequence.

   Tighten

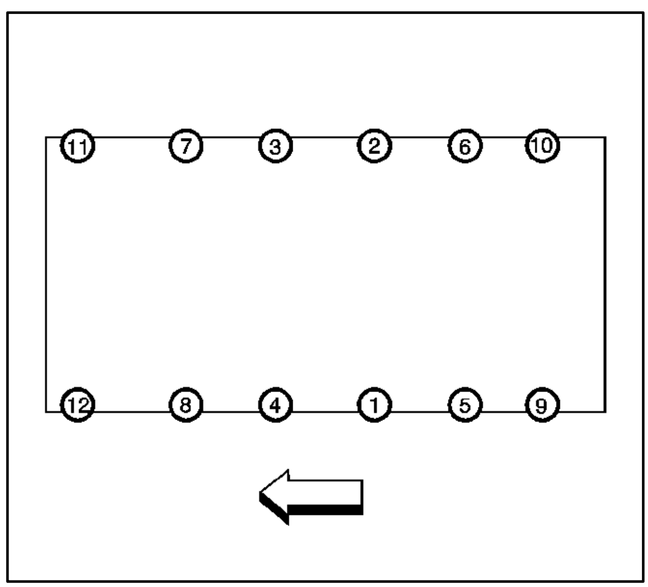
   - Tighten the oil pan bolts in sequence to 10 N·m (88 lb in) in a first pass.
   - Tighten the oil pan bolts in sequence to 25 N·m (18 lb ft) in a second pass.
6. Install the oil pan drain plug.

   Tighten

   Tighten the oil pan drain plug to 28 N·m (21 lb ft).
7. Install the oil level switch, if applicable.

   Tighten

   Tighten the oil level switch to 14 N·m (10 lb ft).



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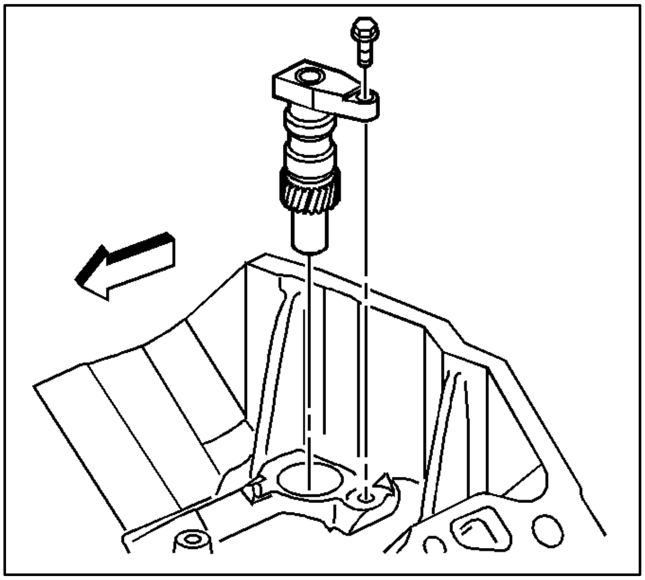

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Oil Pump Drive Installation

1. Apply grease to the oil pump drive gear for ease of assembly.

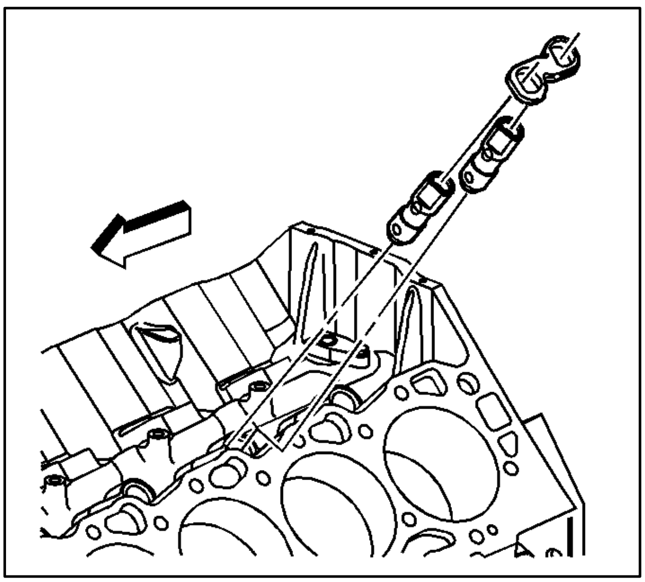
Notice: Ensure both components are aligned correctly or serious engine damage will occur.

2. Line up the oil pump drive gear with the oil pump drive shaft.
3. Install the oil pump drive, making sure that the oil pump drive is fully seated in the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the oil pump drive bolt.

   Tighten
   Tighten the oil pump drive bolt to 25 N·m (18 lb ft).



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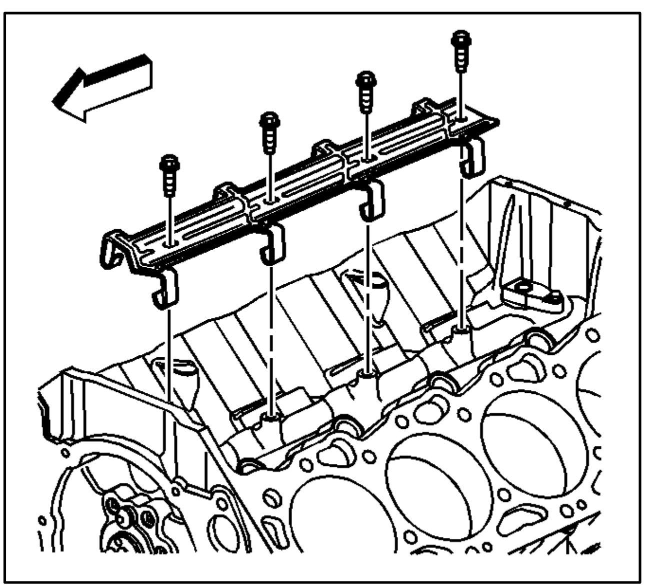
Valve Lifter Installation

Important: If a new camshaft is installed, replace all the valve lifters.

1. Coat the valve lifter rollers with prelube, GM P/N 1052367 or equivalent.

Important: If reusing the valve lifters, install in their original location. The valve lifter guide retainer must contact all of the valve lifter guides. If the valve lifter guide retainer is bent, the valve lifter guide retainer must be replaced.

2. Install the valve lifters.
3. Install the valve lifter guides over the flats on the valve lifters, making sure the rollers of the valve lifters are properly aligned with the camshaft lobes.



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4. Install the valve lifter guide retainer.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

5. Install the valve lifter guide retainer bolts.

   Tighten
   Tighten the valve lifter guide retainer bolts to 25 N·m (18 lb ft).

Cylinder Head Installation – Left

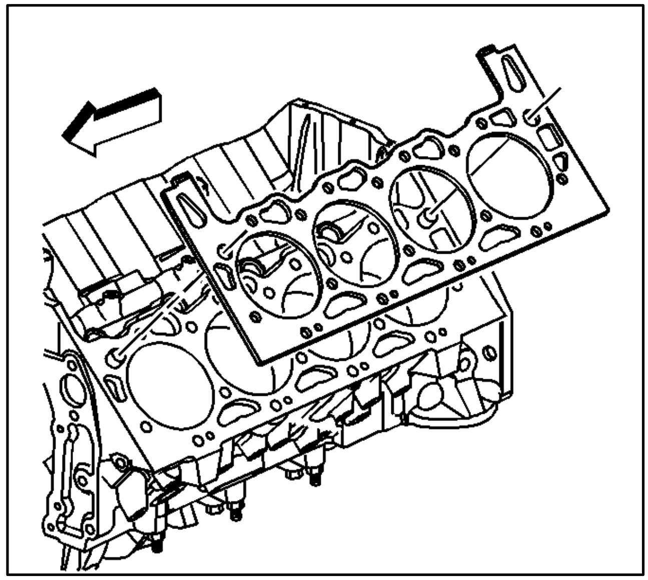
Tools Required

J 36660-A Torque Angle Meter

Important: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket.

Align the cylinder head gasket locating mark to face up. The tabs on the bottom of the head gasket should be positioned at the front cylinder location when properly installed.

1. Place the cylinder head gasket in position over the cylinder head locating pins.



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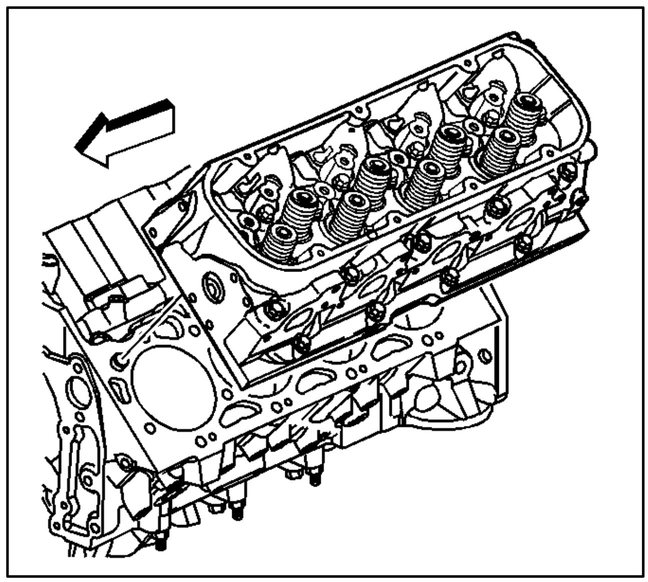
Important: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

2. Install the cylinder head to the block.



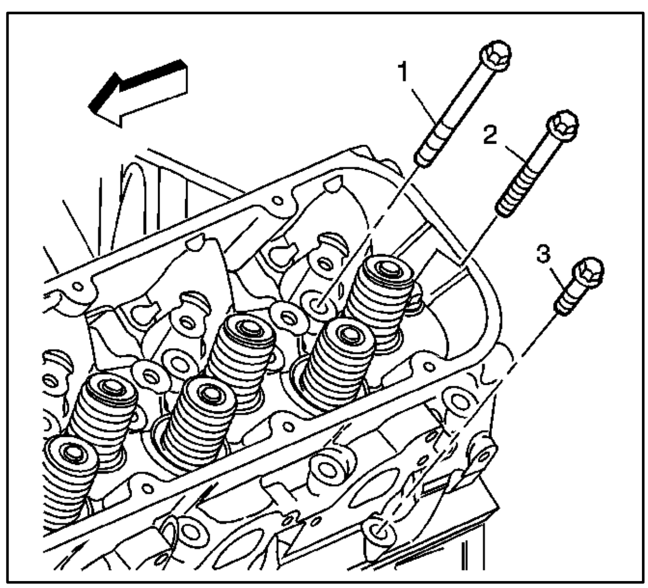
470916

Notice: Always use NEW cylinder head bolts when servicing the cylinder head.

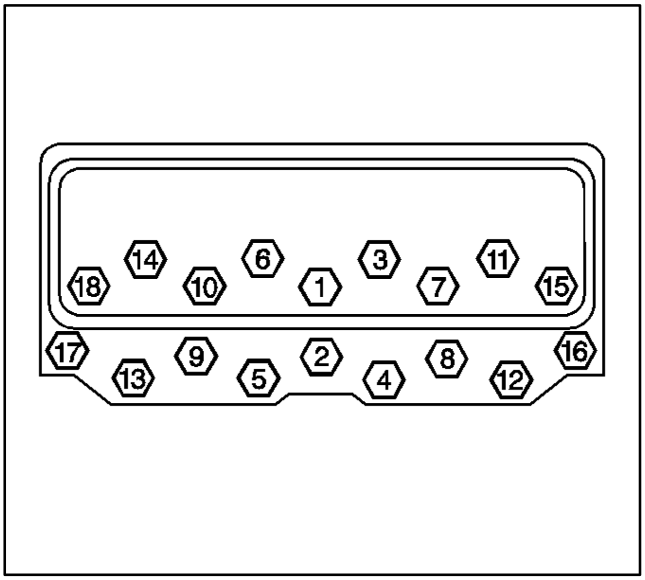
Do not reuse the cylinder head bolts, because the bolts may stretch or break causing engine damage.

Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the cylinder head bolts. Refer to *Use of RTV and Anaerobic Sealer* in this supplement.



470914



470987

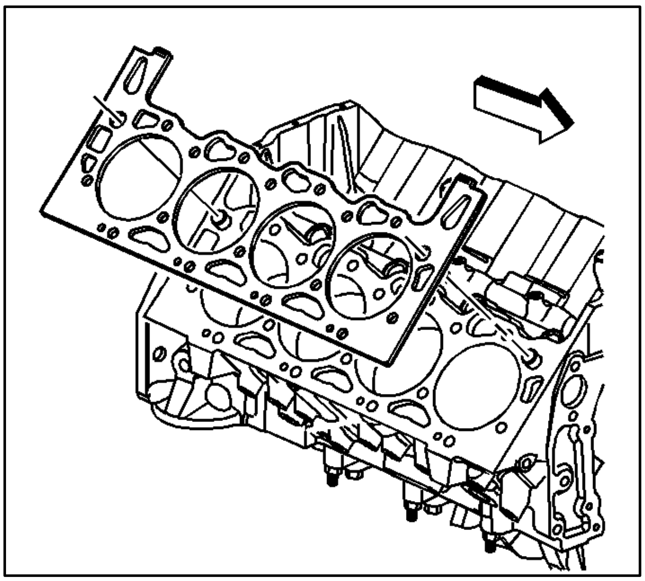
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

   Tighten

   - Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).
   - Retighten the bolts in a second pass in sequence 30 N·m (22 lb ft), then an additional 120 degrees using the *J 36660-A*.
   - Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17) an additional 60 degrees, bolts (15 and 18) an additional 45 degrees, and bolts (4, 5, 12, 13) an additional 30 degrees a final pass in sequence using the *J 36660-A*.


470992

Cylinder Head Installation – Right

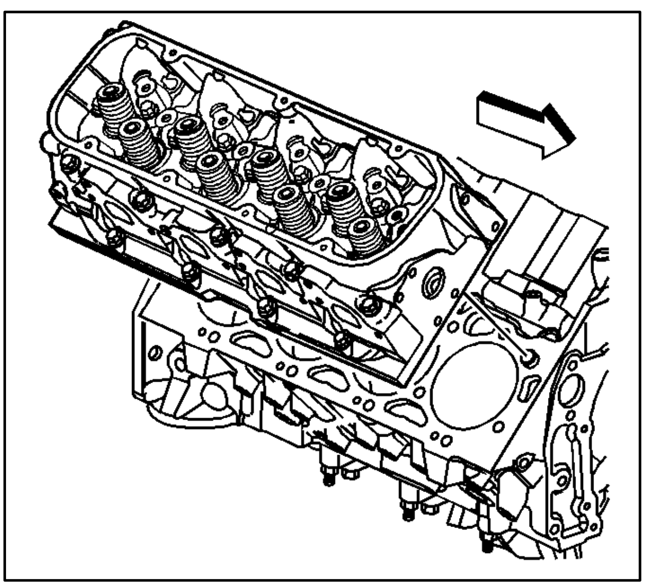
Tools Required

J 36660-A Torque Angle Meter

Important: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket.

Align the cylinder head gasket locating mark to face up. The tabs on the bottom of the head gasket should be positioned at the front cylinder location when properly installed.

1. Place the cylinder head gasket in position over the cylinder head locating pins.


470991

Important: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

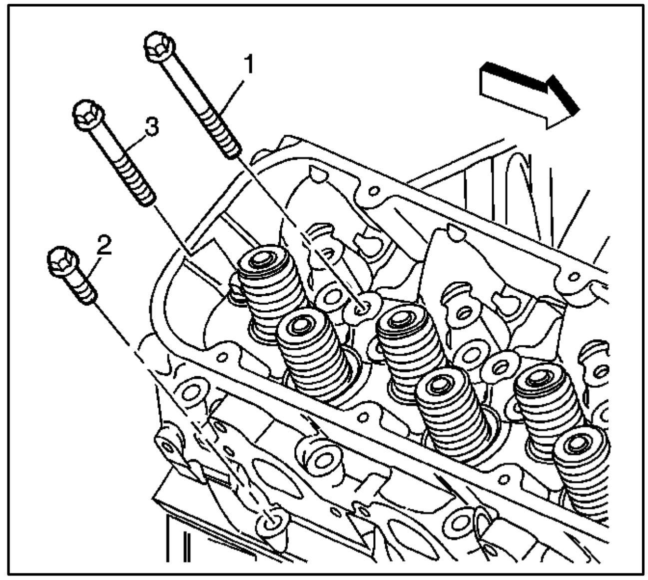
2. Install the cylinder head to the block.

Notice: Always use NEW cylinder head bolts when servicing the cylinder head.

Do not reuse the cylinder head bolts because the bolts may stretch or break causing engine damage.

Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the cylinder head bolts. Refer to *Use of RTV and Anaerobic Sealer* in this supplement.



470989

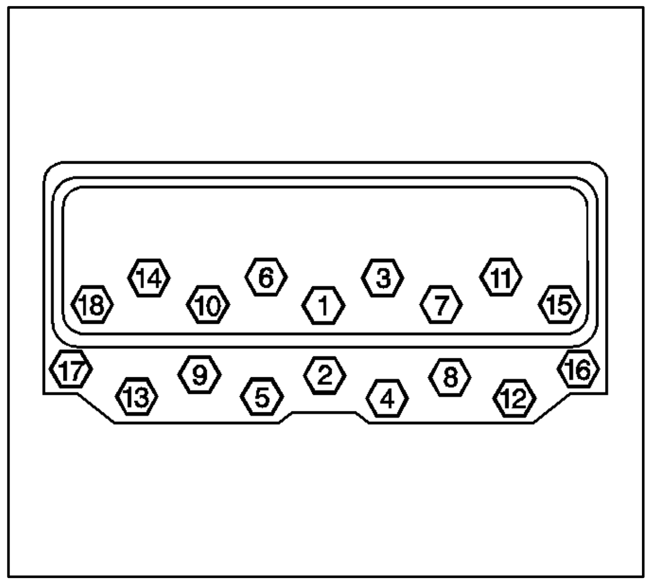
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

   Tighten

   - Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).
   - Retighten the bolts a second pass in sequence to 30 N·m (22 lb ft), then an additional 120 degrees using the *J 36660-A*.
   - Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17) an additional 60 degrees, bolts (15 and 18) an additional 45 degrees, and bolts (4, 5, 12, 13) an additional 30 degrees a final pass in sequence using the *J 36660-A*.



470987

Valve Rocker Arm and Push Rod

Important: Be sure to keep parts in order. Parts must be put back from where they were removed.

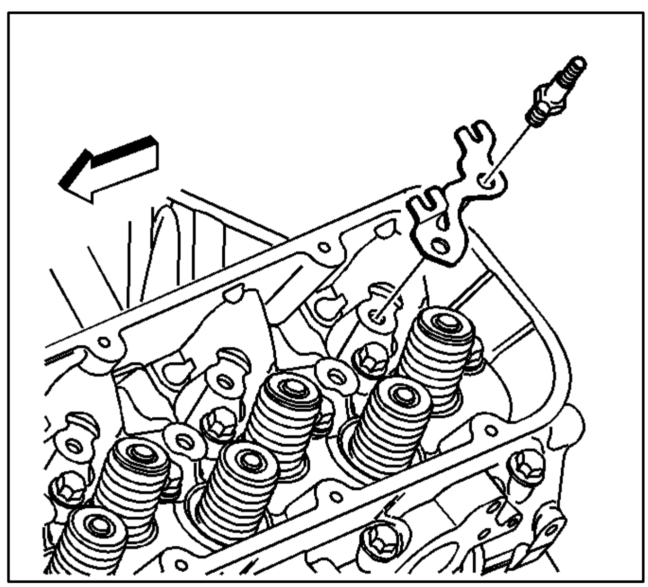
1. Apply sealer GM P/N 12346004 or equivalent to the valve rocker arm stud-to-cylinder head threads.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

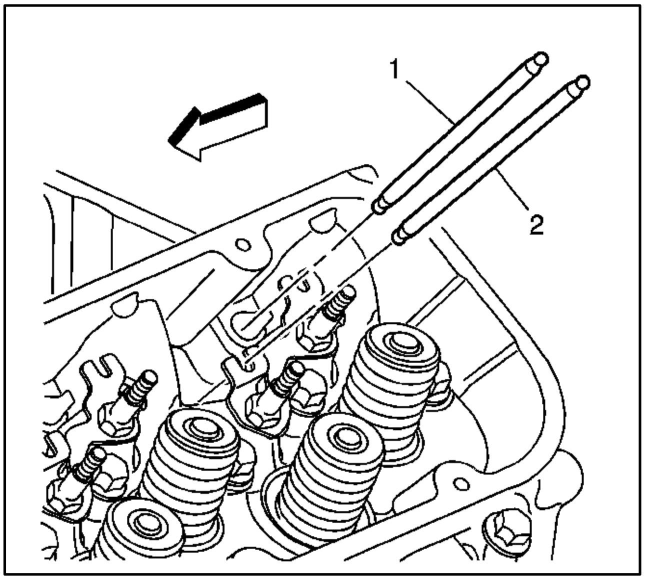
2. Install the push rod guides and valve rocker arm studs onto the cylinder head.

   Tighten

   Tighten the valve rocker arm studs to 50 N·m (37 lb ft).



470906

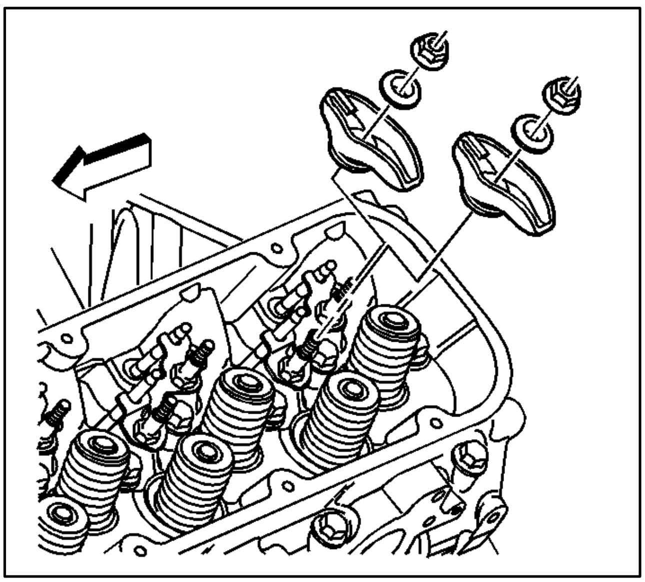


470903

Important: The 8.1 L engine uses different length intake and exhaust valve push rods.

The exhaust valve push rods (2) are longer than the intake valve push rods (1).

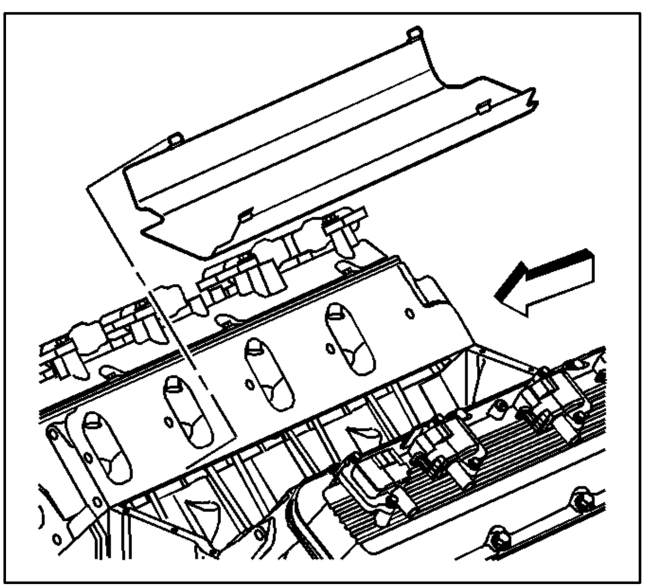
3. Install the valve push rods.


470899

4. Coat the valve rocker arm and valve rocker arm ball bearing surfaces with prelube GM P/N 1052367 or equivalent.
5. Install the valve rocker arms, the valve rocker arm balls and the valve rocker arm nuts.

   Tighten

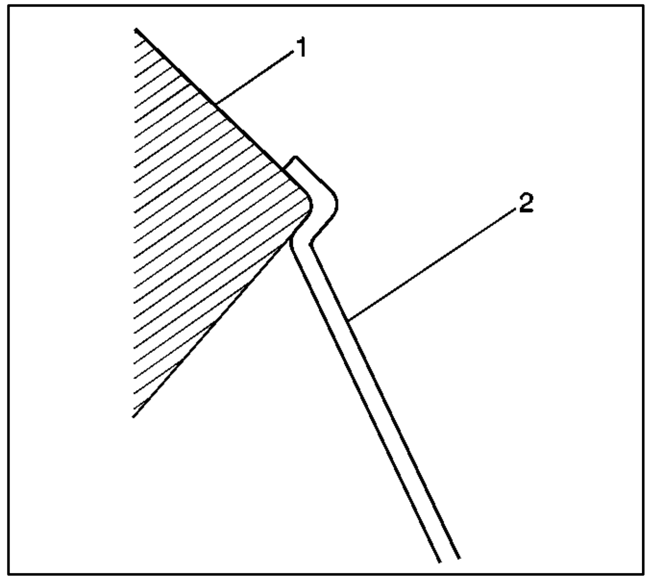
   Tighten the valve rocker arm nuts slowly, to 25 N·m (18 lb ft), while guiding the tips of the rocker arms over the tips of the valves.


470786

Intake Manifold Installation

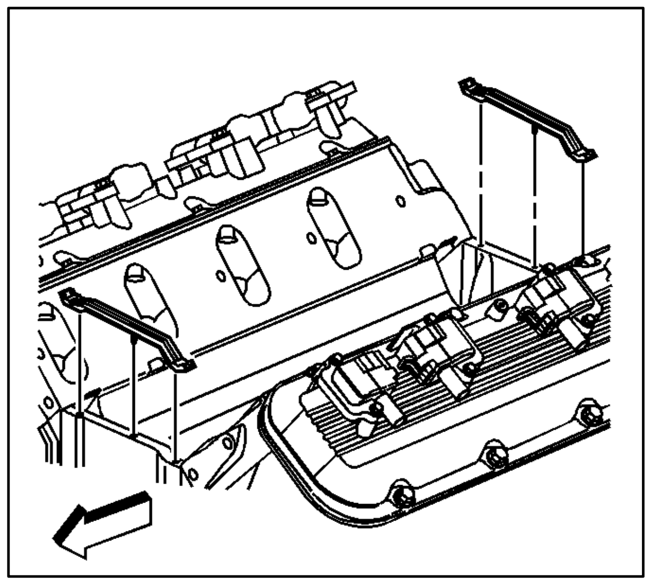
1. Install the splash shield.

2. Ensure the splash shield (2) snap fits between the cylinder heads (1).



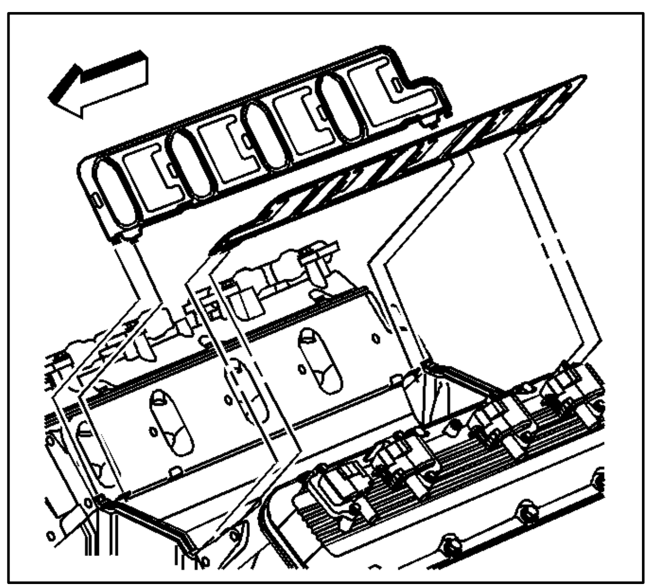
413867

3. Install the new intake manifold end seals.

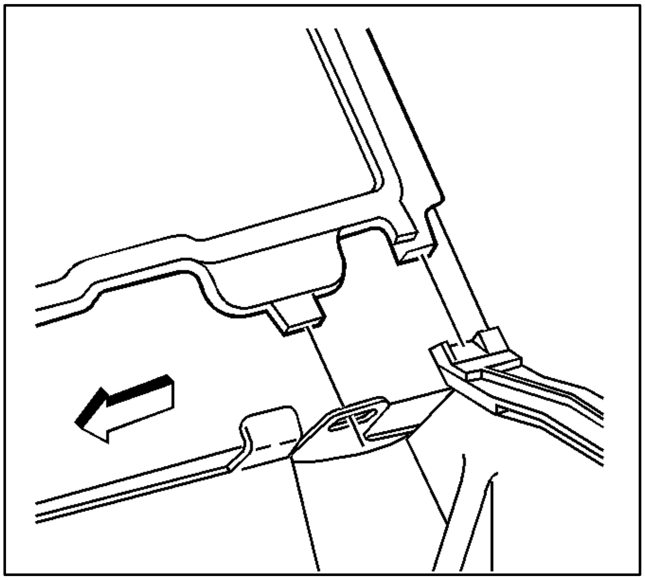


470783

4. Install the new intake manifold side gaskets onto the cylinder heads.

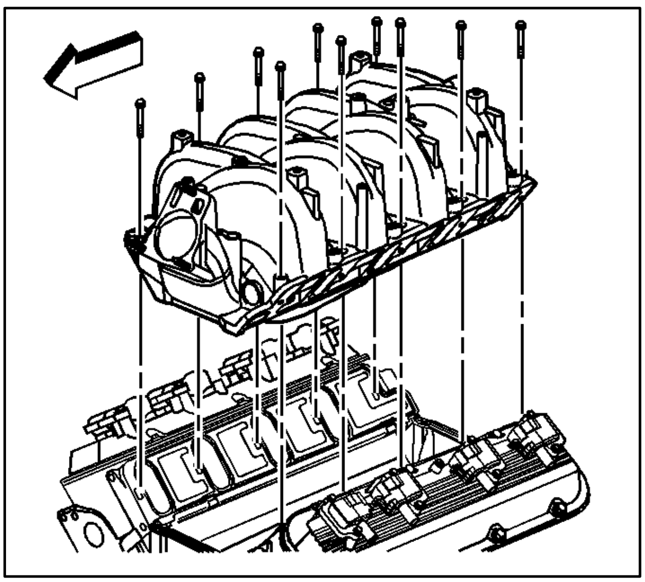


470779



470778

5. Ensure the intake manifold gasket tabs align with the holes in the head gaskets.
6. Ensure the intake manifold gasket tabs align with the slots in the intake manifold end seals.



470775

7. Install the intake manifold onto the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

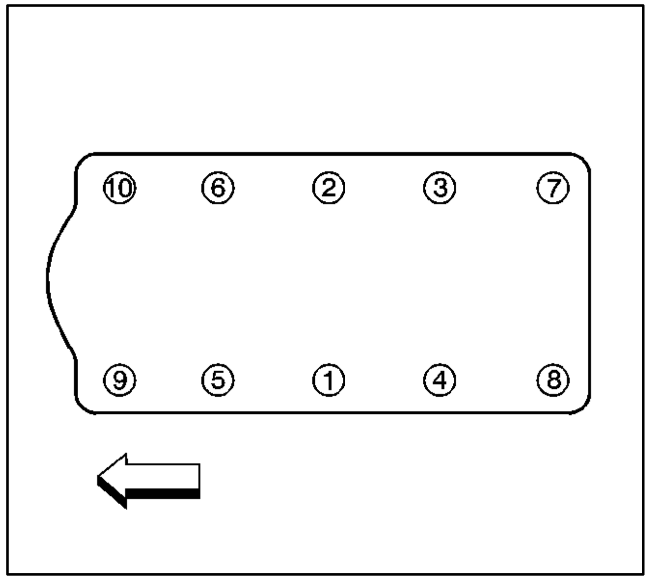
Notice: Ensure the intake manifold does not shift as the intake manifold bolts are tightened in the proper sequence. Failure to follow the entire intake manifold bolt tightening sequence exactly, may result in an oil leak and serious engine damage.

Important: The entire intake manifold tightening sequence must be promptly completed due to the anaerobic thread adhesive. The final pass of the tightening sequence must be completed before the adhesive starts to cure, or false torque readings and ineffective thread locking may result.

8. Apply thread adhesive GM P/N 12345382 or equivalent to a minimum of eight threads of the intake manifold bolts.
9. Install the intake manifold bolts.
10. Tighten the intake manifold bolts in sequence, using four passes.

Tighten

- Tighten the intake manifold bolts in sequence to 5 N·m (44 lb in) on the first pass.
- Tighten the intake manifold bolts in sequence to 5 N·m (44 lb in) on the second pass.
- Inspect the intake manifold joints for signs of intake manifold shifting. Correct as required.
- Tighten the intake manifold bolts in sequence to 10 N·m (88 lb in) on the third pass.
- Tighten the intake manifold bolts in sequence to 12 N·m (106 lb in) on the final pass.



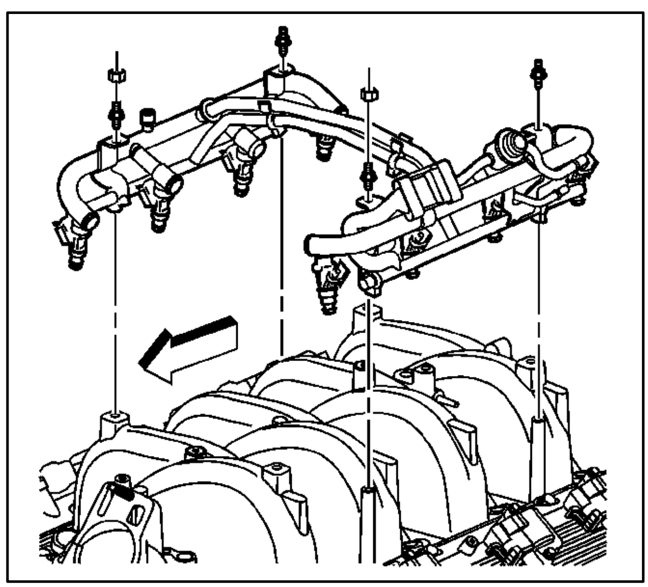
640010

Important: Lubricate the injector O-ring seals with clean engine oil and install onto the spray tip end of each injector.

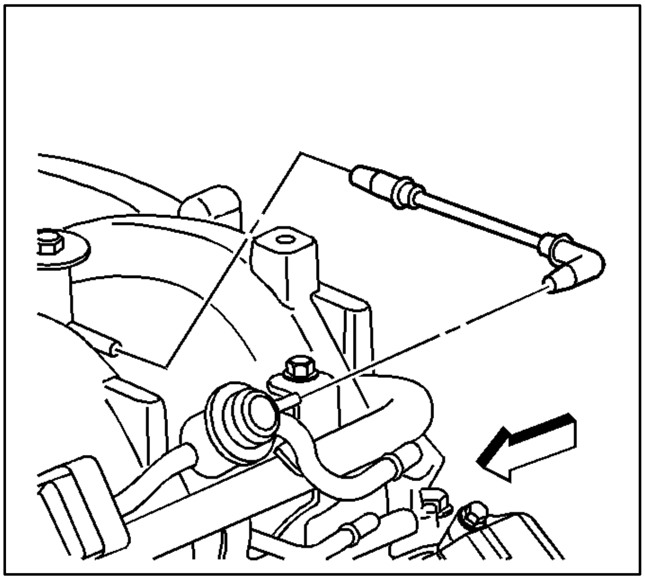
11. Install the fuel injection fuel rail.
12. Install the fuel injection fuel rail studs and/or bolts.

Tighten

Tighten the fuel injection fuel rail studs and/or bolts to 12 N·m (106 lb in).

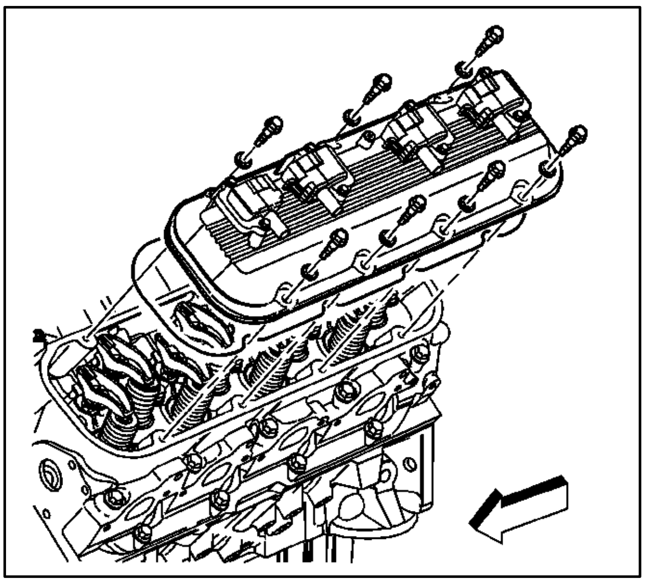


470774



470770

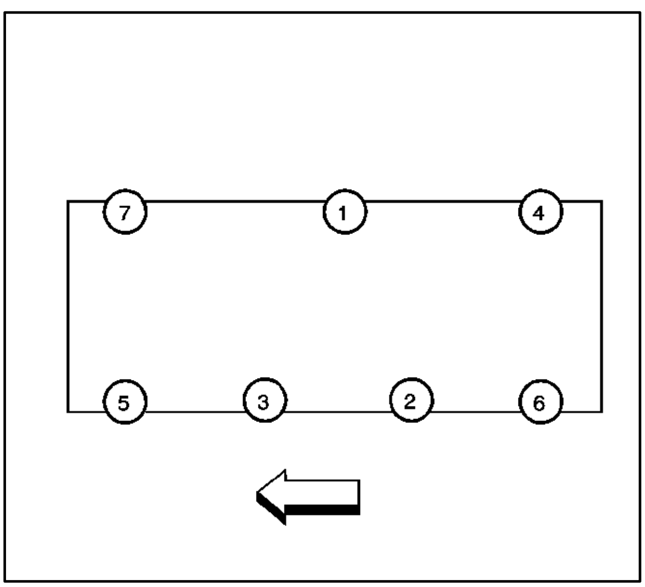
13. Install the fuel pressure regulator vacuum hose.



470890

Valve Rocker Arm Cover Installation – Left

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.



677858

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

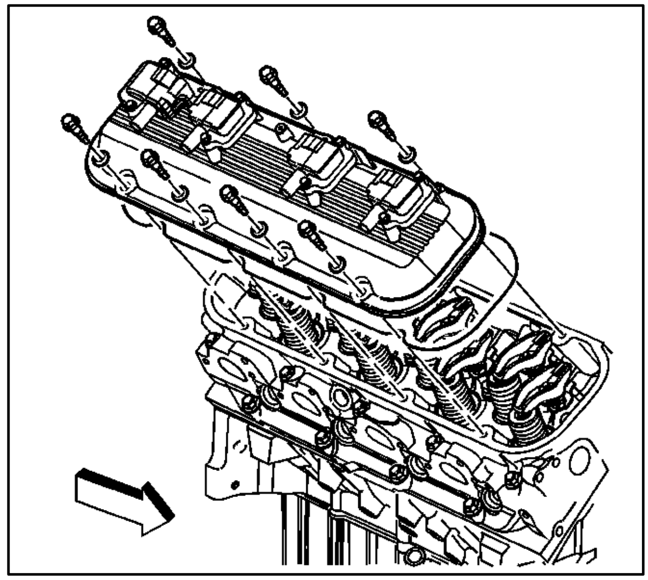
4. Tighten the valve rocker arm cover bolts in sequence using two passes.

   Tighten

   - Tighten the valve rocker arm cover bolts to 6 N·m (54 lb in) for the first pass.
   - Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in) for the second pass.

Valve Rocker Arm Cover Installation – Right

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.



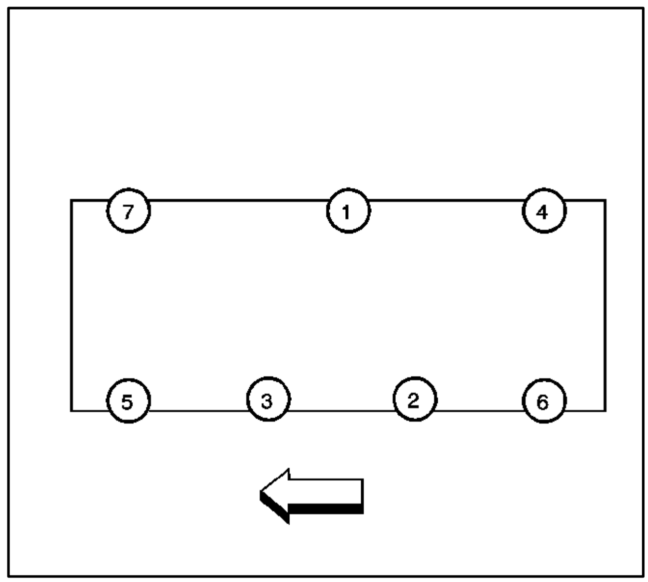
470897

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Tighten the valve rocker arm cover bolts in sequence using two passes.

   Tighten

   - Tighten the valve rocker arm cover bolts to 6 N·m (54 lb in) for the first pass.
   - Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in) for the second pass.



677858

Water Pump Installation

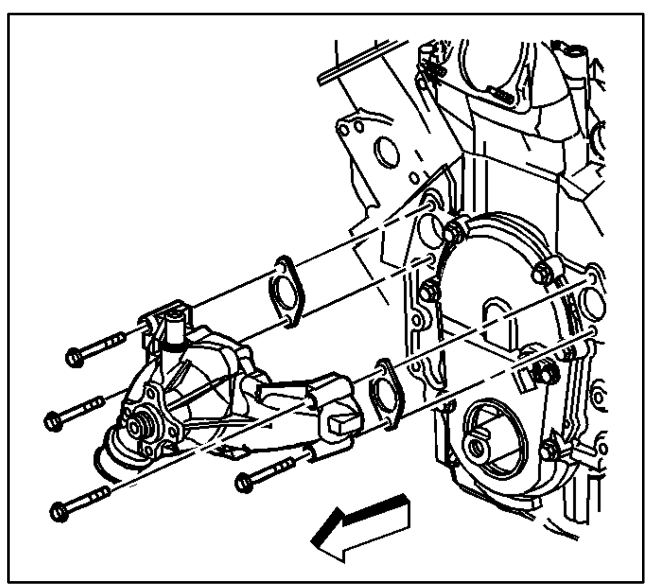
1. Place the water pump gaskets and the water pump into position.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

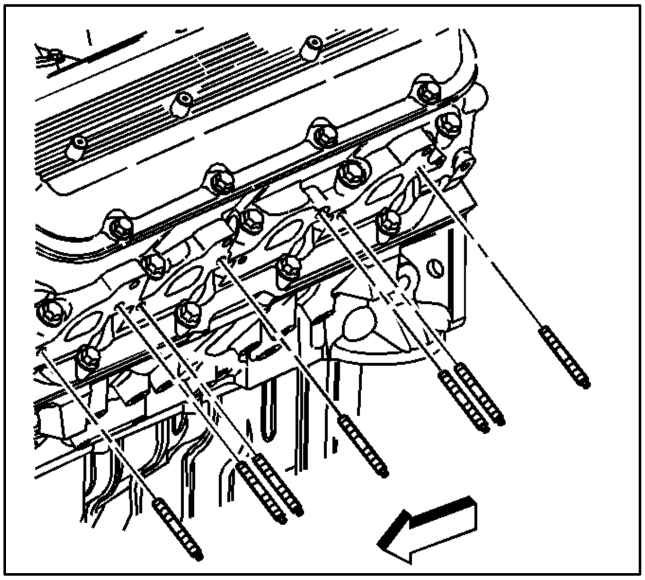
2. Install the water pump bolts.

   Tighten

   - Tighten the water pump bolts to 25 N·m (18 lb ft) for the first pass.
   - Tighten the water pump bolts to 50 N·m (37 lb ft) for the final pass.



470792



470683

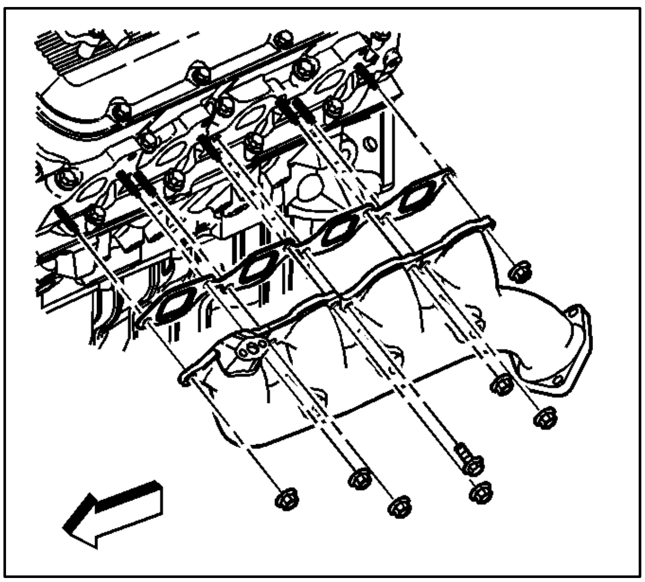
Exhaust Manifold Installation – Left

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the exhaust manifold studs into the cylinder head (if necessary).

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

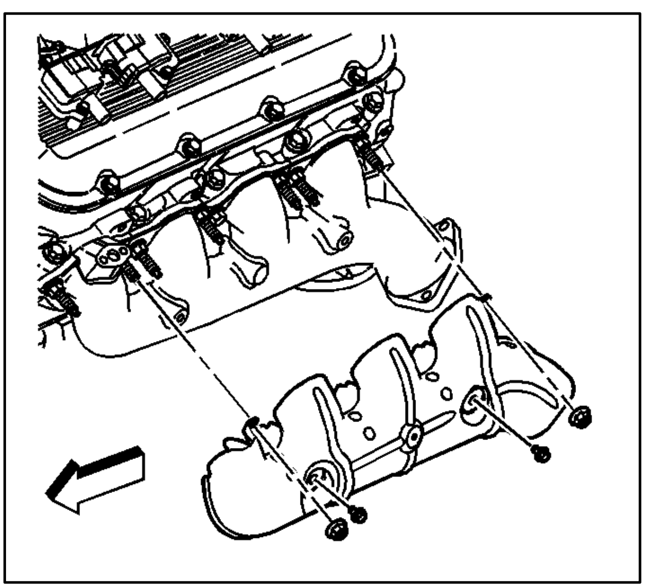


470679

2. Install the NEW left exhaust manifold gasket.
3. Install the left exhaust manifold.
4. Install the left exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the left exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the left exhaust manifold nuts to 16 N·m (12 lb ft).



470676

5. Install the left exhaust manifold heat shield.
6. Install the left exhaust manifold heat shield bolts and nuts.

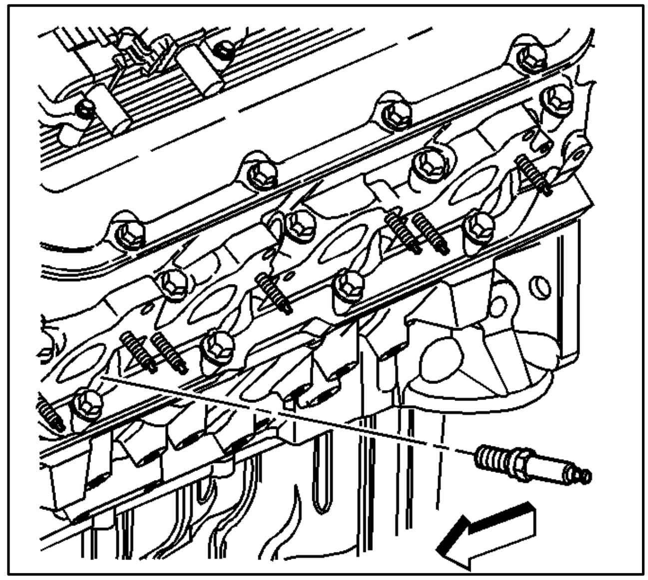
   Tighten

   Tighten the left exhaust manifold heat shield bolts and nuts to 25 N·m (18 lb ft).

7. Install the left spark plugs.

   Tighten

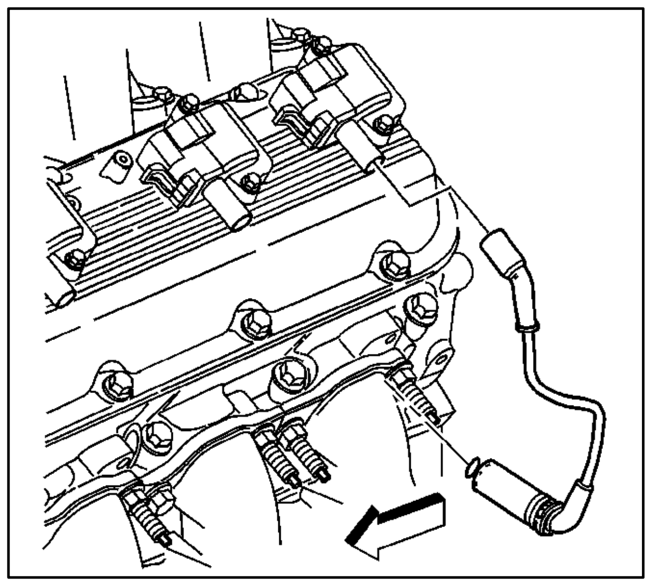
   Tighten the left spark plugs to 20 N·m (15 lb ft).



470690

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire onto the spark plug by using the metal heat shield.

8. Install the left spark plug wires to the spark plugs and ignition coils.



470666

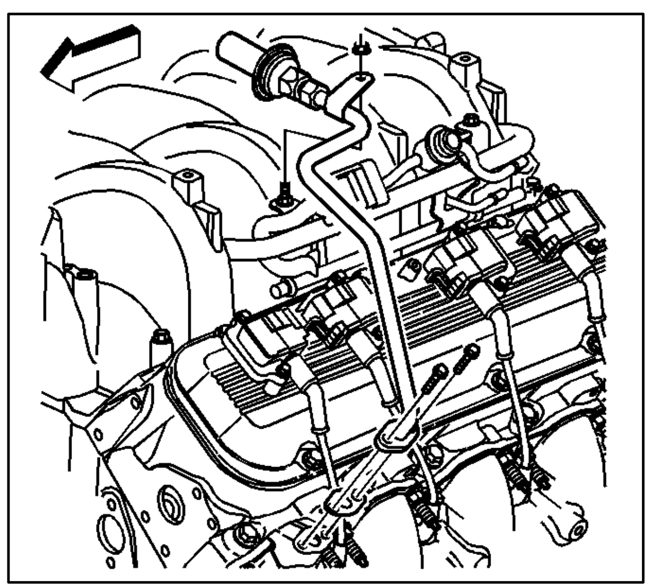
9. Install the secondary air injection pipe and NEW secondary air injection pipe gaskets.
10. Connect the secondary air injection pipe to the secondary air injection pump pipe.
11. Install the secondary air injection pipe bolts to the left exhaust manifold.

    Tighten

    Tighten the secondary air injection pipe bolts to 25 N·m (18 lb ft).
12. Install the secondary air injection pipe nut to the fuel injection fuel rail stud.

    Tighten

    Tighten the secondary air injection pipe nut to 12 N·m (106 lb in).



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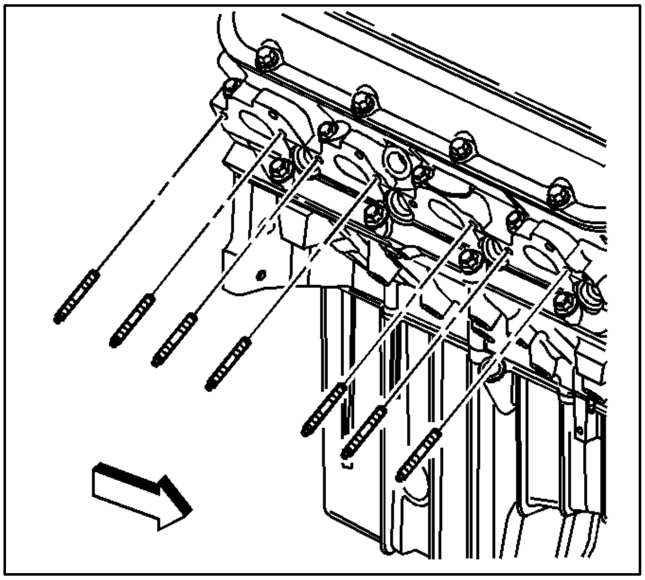


470723

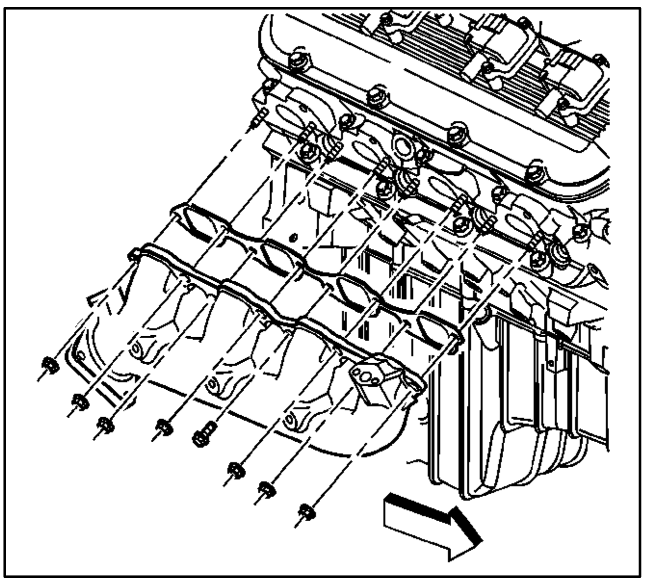
Exhaust Manifold Installation – Right

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the exhaust manifold studs into the cylinder head (if necessary).

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

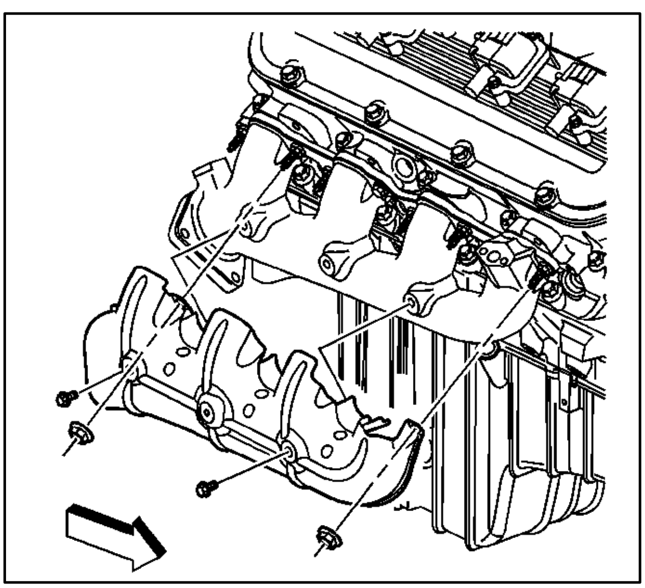


470719

2. Install the NEW right exhaust manifold gasket.
3. Install the right exhaust manifold.
4. Install the right exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the right exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the right exhaust manifold nuts to 16 N·m (12 lb ft).



470706

5. Install the right exhaust manifold heat shield.
6. Install the right exhaust manifold heat shield bolts and nuts.

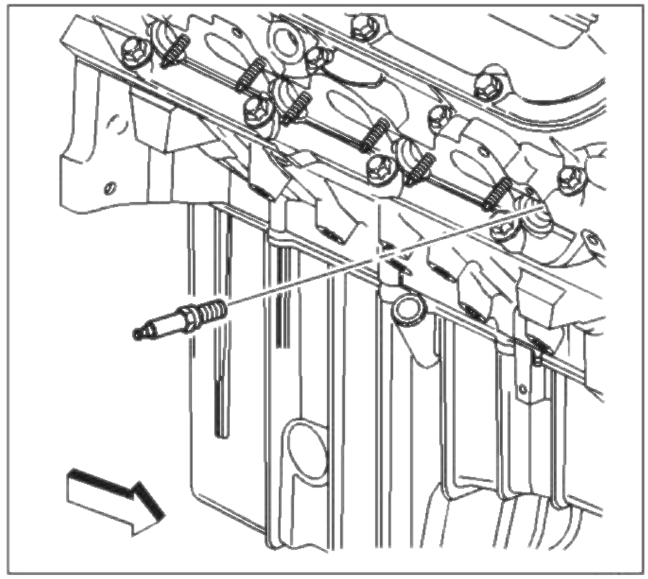
   Tighten

   Tighten the right exhaust manifold heat shield bolts and nuts to 25 N·m (18 lb ft).

7. Install the right spark plugs.

   Tighten

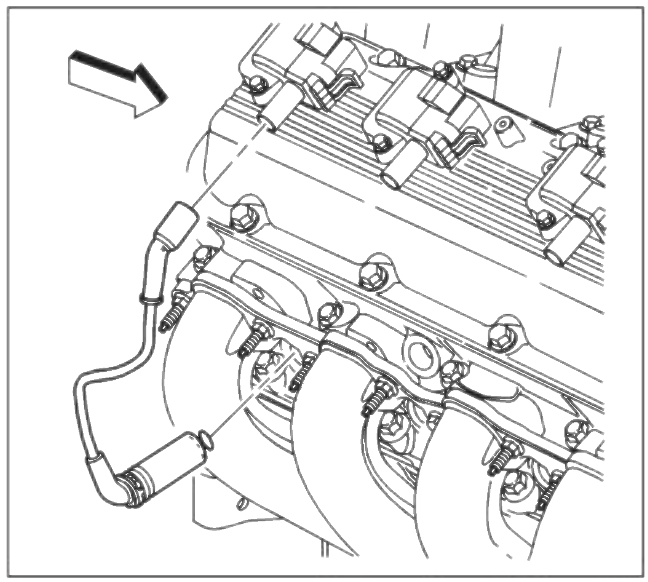
   Tighten the right spark plugs to 20 N·m (15 lb ft).



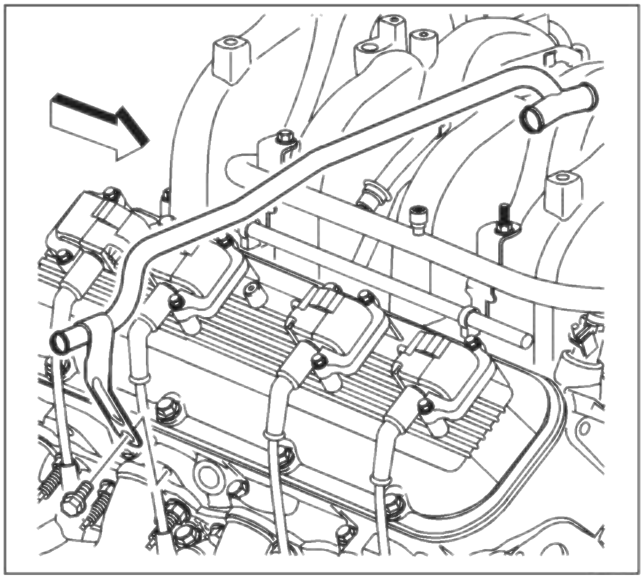
470727

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire onto the spark plug by using the metal heat shield.

8. Install the right spark plug wires to the spark plugs and ignition coils.



470704

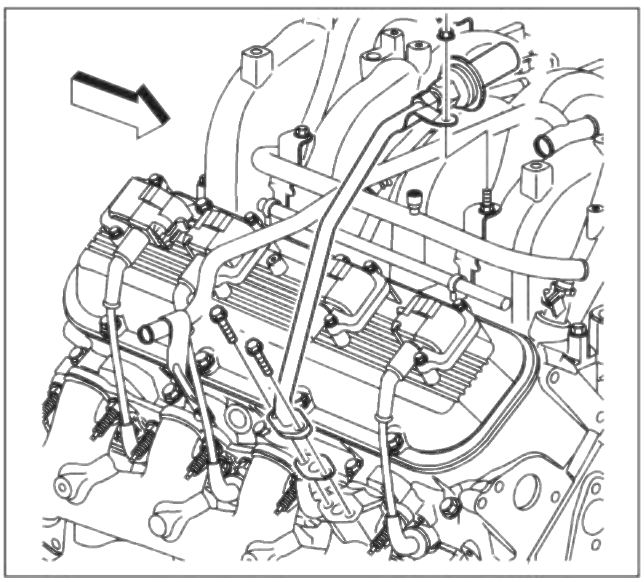


470646

9. Install the secondary air injection pump pipe.
10. Install the secondary air injection pump pipe bolt to the right cylinder head.

    Tighten

    Tighten the secondary air injection pump pipe bolt to 50 N·m (37 lb ft).



470644

11. Install the secondary air injection pipe and NEW secondary air injection pipe gasket.
12. Connect the secondary air injection pipe to the secondary air injection pump pipe.
13. Install the secondary air injection pipe bolts to the right exhaust manifold.

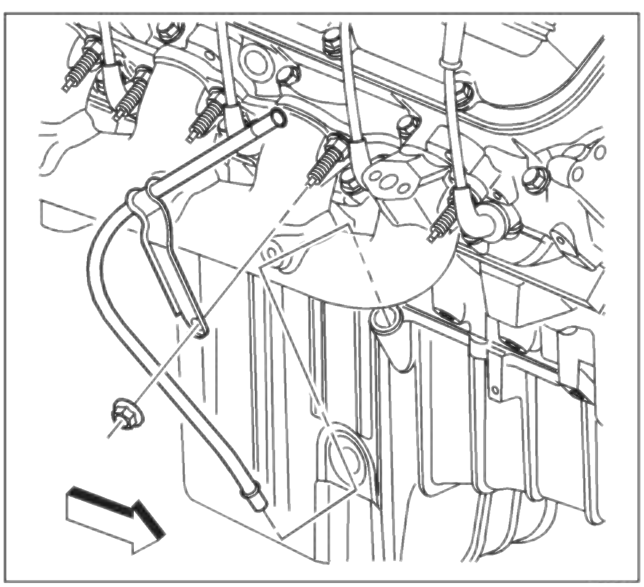
    Tighten

    Tighten the secondary air injection pipe bolts to 25 N·m (18 lb ft).

14. Install the secondary air injection pipe nut to the fuel injection fuel rail stud.

    Tighten

    Tighten the secondary air injection pipe nut to 12 N·m (106 lb in).



470630

Oil Level Indicator and Tube Installation

Important: Make sure the oil level indicator tube does not come in contact with the spark plug wires. Route the spark plug wires around the oil level indicator tube.

1. Install a NEW O-ring seal onto the oil level indicator tube.
2. Install the oil level indicator tube into the oil pan.
3. Install the oil level indicator tube bracket to the exhaust manifold stud.

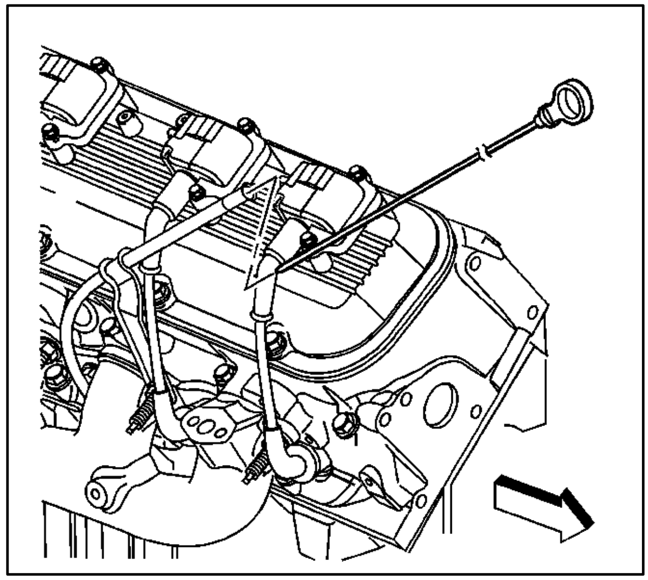
Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the oil level indicator tube bracket nut to the exhaust manifold stud.

   Tighten

   Tighten the oil level indicator tube bracket nut to 18 N·m (13 lb ft).

5. Install the oil level indicator into the oil level indicator tube.



470627

Engine Flywheel Housing Installation

1. Install the transmission converter covers.
2. Install the transmission converter cover bolts.

   Tighten

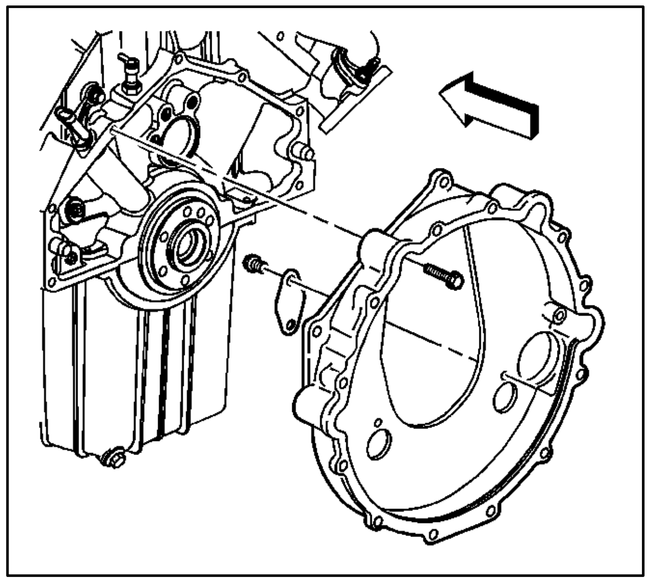
   Tighten the transmission converter cover bolts to 12 N·m (106 lb in).
3. Install the engine flywheel housing

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

4. Install the engine flywheel housing bolts.

   Tighten

   Tighten the flywheel housing bolts to 67 N·m (49 lb ft).



470599

Engine Flywheel Installation

Important: Make sure the flywheel is installed correctly. Engine Side is stamped on the flywheel to assist with installation.

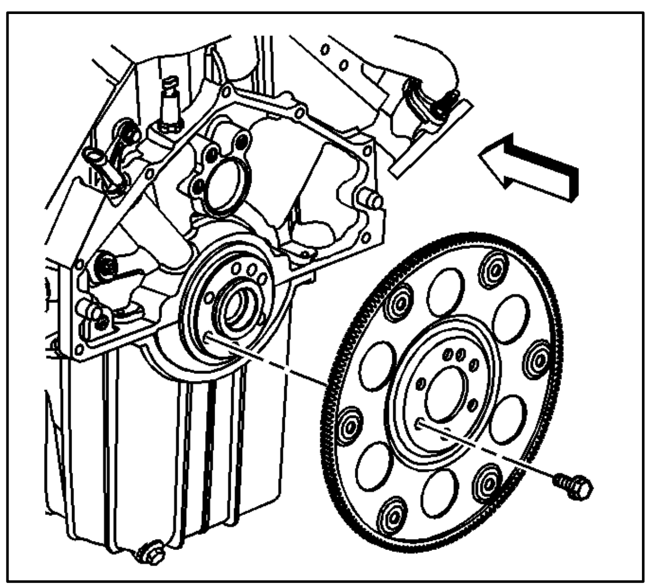
1. Install the engine flywheel.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

2. Install the engine flywheel bolts.

   Tighten

   - Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the first pass.
   - Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for the final pass.



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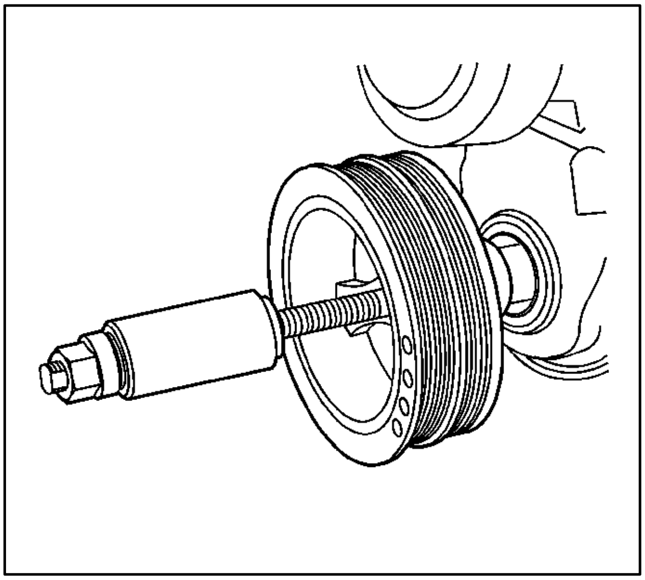


639537

Crankshaft Balancer Installation

Tools Required

- *J 42845* Crankshaft Balancer Installer
- *J 42847* Flywheel Holding Tool

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

Important: Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.

Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

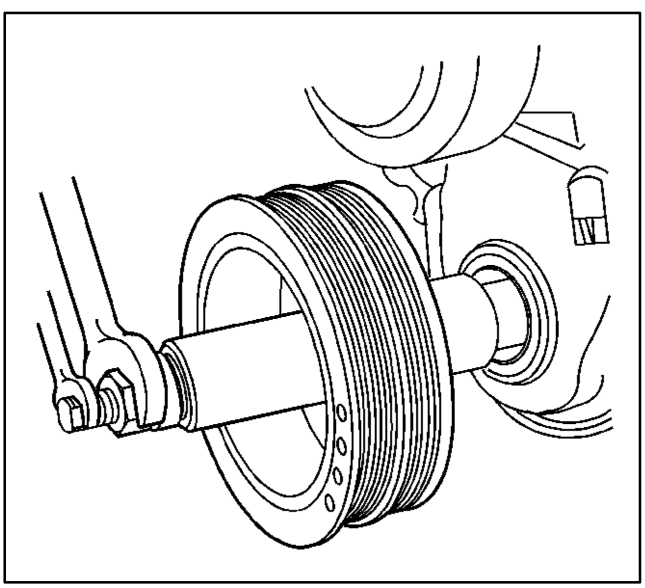
1. Install the *J 42847* to the starter bolt holes.

   Tighten

   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).

Important: Apply grease or clean engine oil to the inside of the crankshaft balancer or the end of the crankshaft, to prevent galling during assembly.

2. Install the balancer onto the end of the crankshaft.



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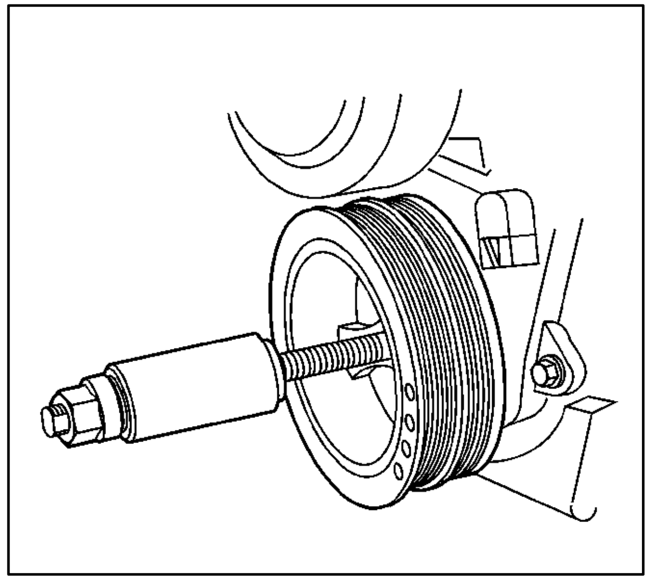
Important: Apply the lubricant that comes with *J 42845* each time the tool is used. Failure to lubricate *J 42845* may prevent the balancer from installing completely.

3. Use the *J 42845* in order to install the balancer.

Notice: Ensure the crankshaft balancer is installed to the proper depth. The crankshaft balancer nose must be seated against the crankshaft sprocket. Failure to install the crankshaft balancer properly may result in improper torque to the crankshaft balancer bolt. An improperly torqued crankshaft balancer bolt may loosen causing serious engine damage.

4. Tighten the *J 42845* until the crankshaft balancer is completely seated against the crankshaft sprocket.

5. Remove the *J 42845* from the crankshaft.



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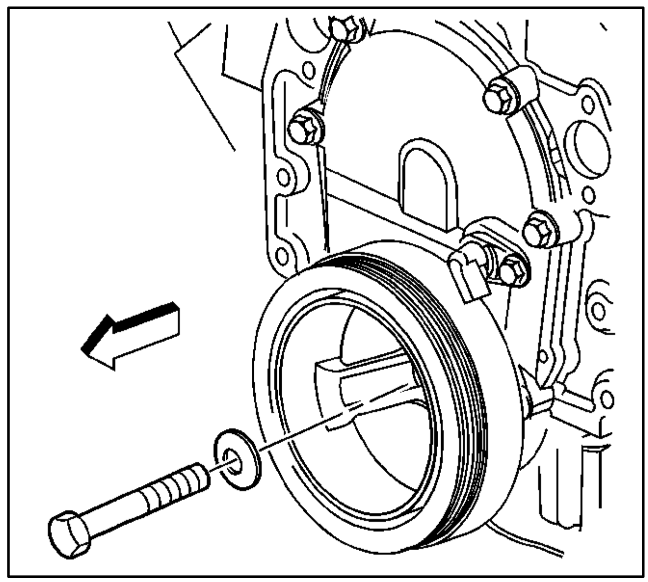
6. Install the crankshaft balancer washer and bolt.

   Tighten

   Tighten the crankshaft balancer bolt to 255 N·m (189 lb ft).
7. Remove the *J 42847*.



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ENGINE ELECTRICAL

8.1L

Engine Electrical – 8.1L

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Auxiliary Battery Relay Bolt	3.4 N·m	30 lb in
Auxiliary Battery Relay Nut	7.5 N·m	66 lb in
Auxiliary Battery Tray Bolt/Nut	25 N·m	18 lb ft
Auxiliary Battery Tray Reinforcement Bolt	25 N·m	18 lb ft
Battery Hold-Down Retainer Bolt	23 N·m	17 lb ft
Battery Tray Bolt/Nut	25 N·m	18 lb ft
Engine Harness Ground Nut	9 N·m	80 lb in
Engine Harness Nut	2 N·m	18 lb in
Engine Oil Level Tube Bracket Bolt	12 N·m	106 lb in
Forward Lamp Wiring Harness Ground Bolt	6 N·m	53 lb in
Fuse Holder Screw	2 N·m	18 lb in
Fuse/Relay Center Nut	9 N·m	80 lb in
Generator Bolt	50 N·m	37 lb ft
Generator Bracket Bolt	50 N·m	37 lb ft
Generator Bracket Nut	41 N·m	30 lb ft
Generator Nut	8 N·m	71 lb in
Generator Shaft Nut	75 N·m	55 lb ft
Ground Strap Bolt	16 N·m	12 lb ft
Ground Strap Nut	9 N·m	80 lb in
Ground Wire Bolt	27 N·m	20 lb ft
Junction Block Nut	4 N·m	35 lb in
Negative Battery Cable	17 N·m	13 lb ft
Positive Battery Cable	17 N·m	13 lb ft
Positive Battery Cable Clip Bolt	8 N·m	71 lb in
Positive Cable Nut to Starter	10 N·m	89 lb in
Secondary Ground Bolt	4.5 N·m	40 lb in
Starter Motor Bolt	50 N·m	37 lb ft
Starter Motor Heat Shield Bolt	3 N·m	35 lb in
Starter Motor Heat Shield Nut	5 N·m	44 lb in
Transmission Dipstick and Fill Tube Bracket Bolt	12 N·m	106 lb in
Transmission Oil Fill Tube Nut	25 N·m	18 lb ft

Battery Usage

Standard Option	
Service Part Number	19001810
Cold Cranking Amperage (CCA)	600 A
Reserve Capacity Rating	115 Minutes
Replacement Battery Number	78-6YR

Starter Motor Usage

Applications	Starter Type
8.1L (L18)	PG-260M

Generator Usage

K68 Single	
Generator Model	AD230
Rated Output	105 A
Load Test Output	73 A
KG8 Single	
Generator Model	AD244
Rated Output	130 A
Load Test Output	91 A

Schematic and Routing Diagrams

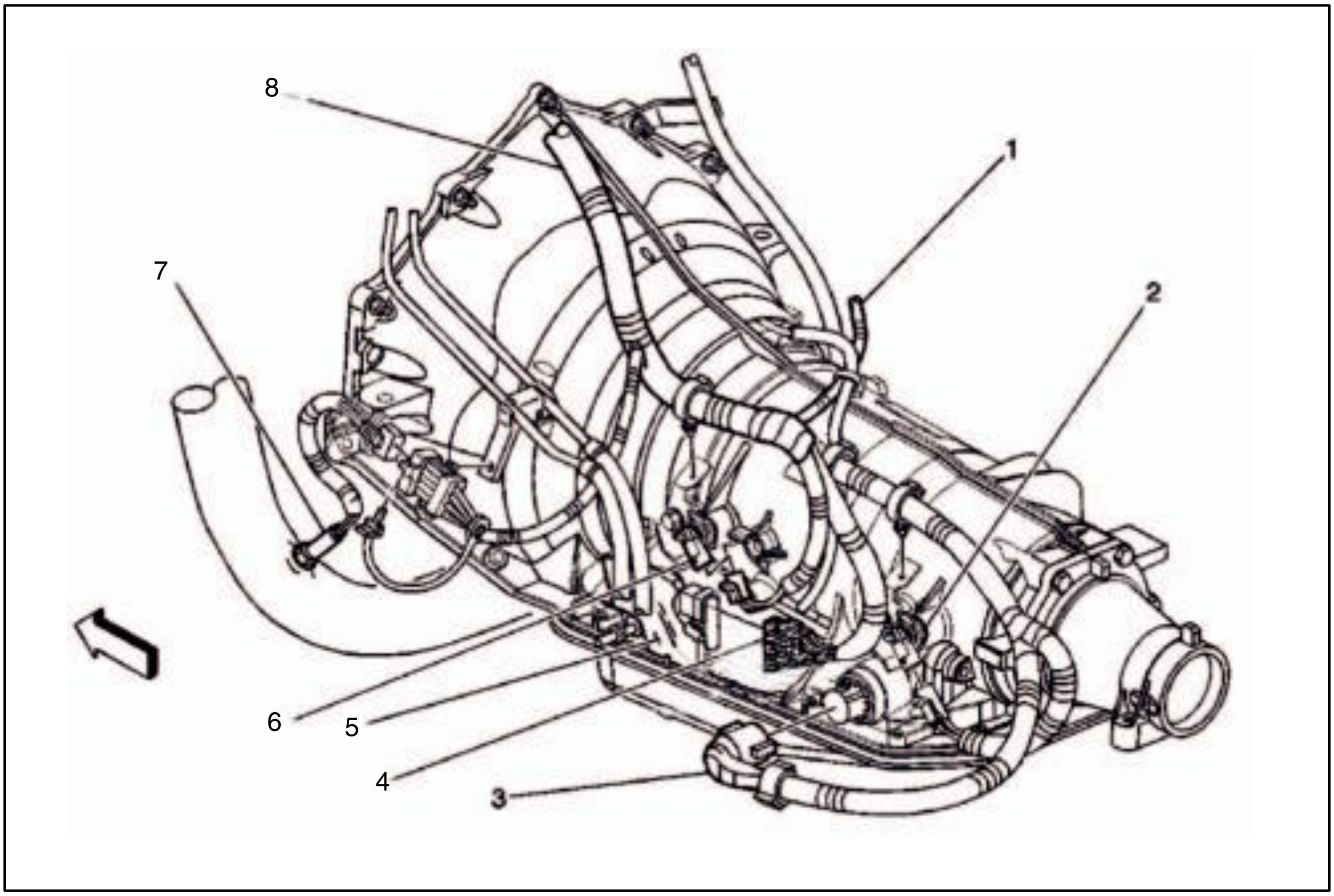
Engine Electrical Schematic Icons

Icon	Icon Definition
	Refer to *ESD Notice* in Cautions and Notices in the WCC Service Manual.

Component Locator

Engine Electrical Component Views

C122, PNP Switch, VSS and TISS Sensors – Automatic Transmission



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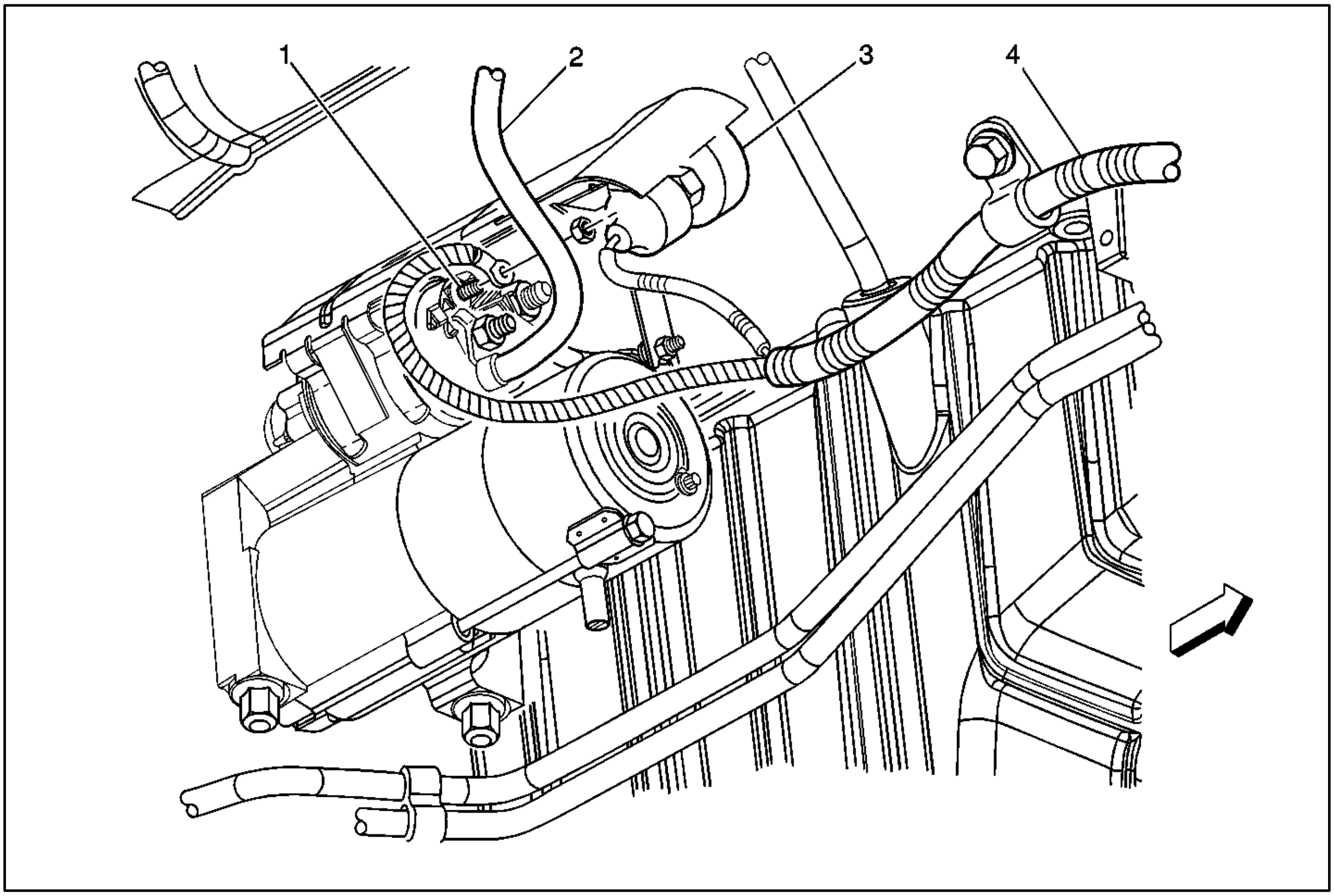
Legend

(1) Breakout to Heated Oxygen Sensor – Bank 2 (L18)
(2) Vehicle Speed Sensor (VSS)
(3) Connector C122
(4) Park/Neutral Position Switch (PNP) C1
(5) Park/Neutral Position Switch (PNP)
(6) Automatic Transmission Input Shaft Speed (ISS) Sensor
(7) Heated Oxygen Sensor – Bank 1 (L18)
(8) Engine Wiring Harness

Starter and Knock Sensor – Bank 2



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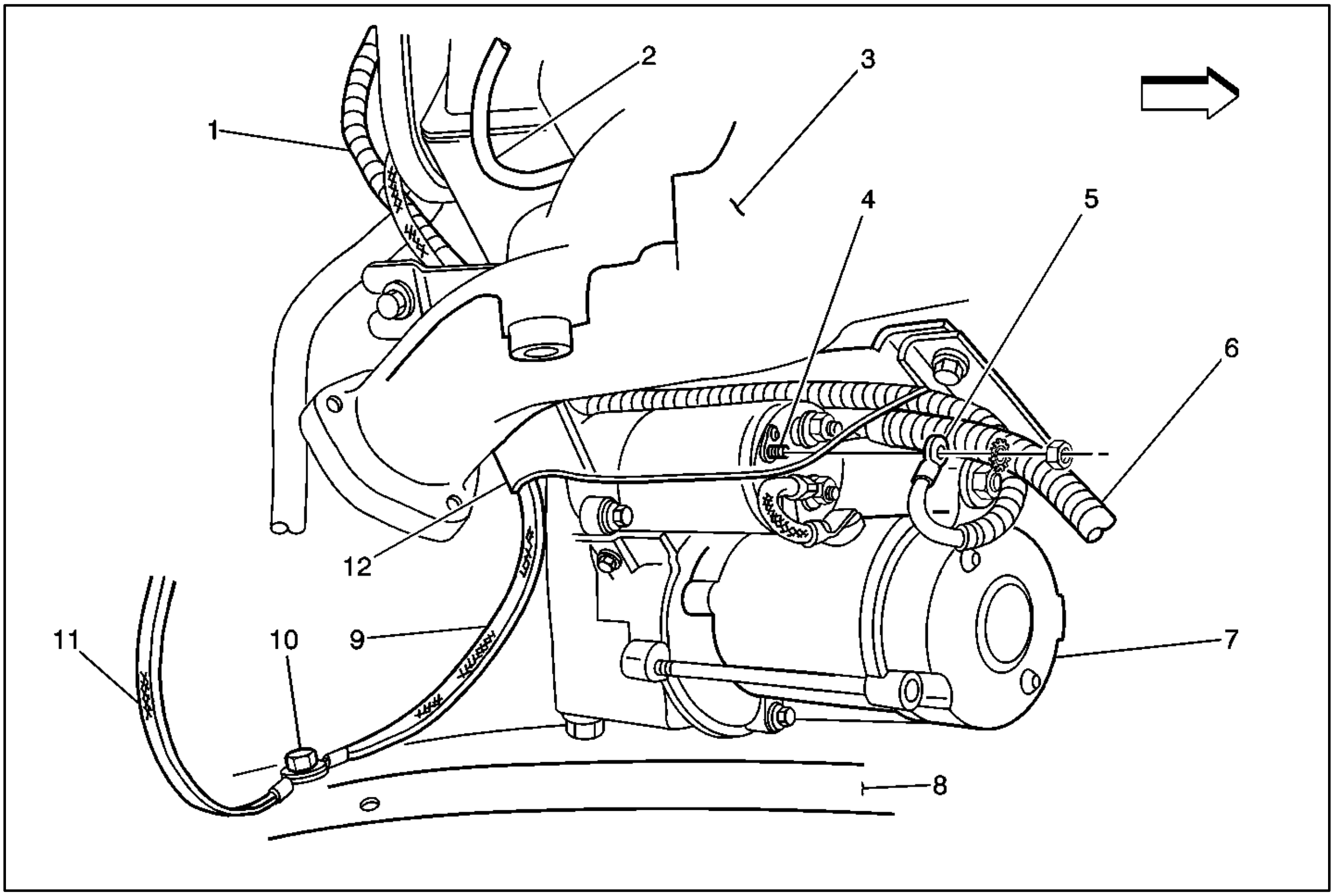
Legend

(1) Starter Solenoid Terminal
(2) Battery Positive Wire for Starter
(3) Knock Sensor – Bank 2
(7) Engine Harness

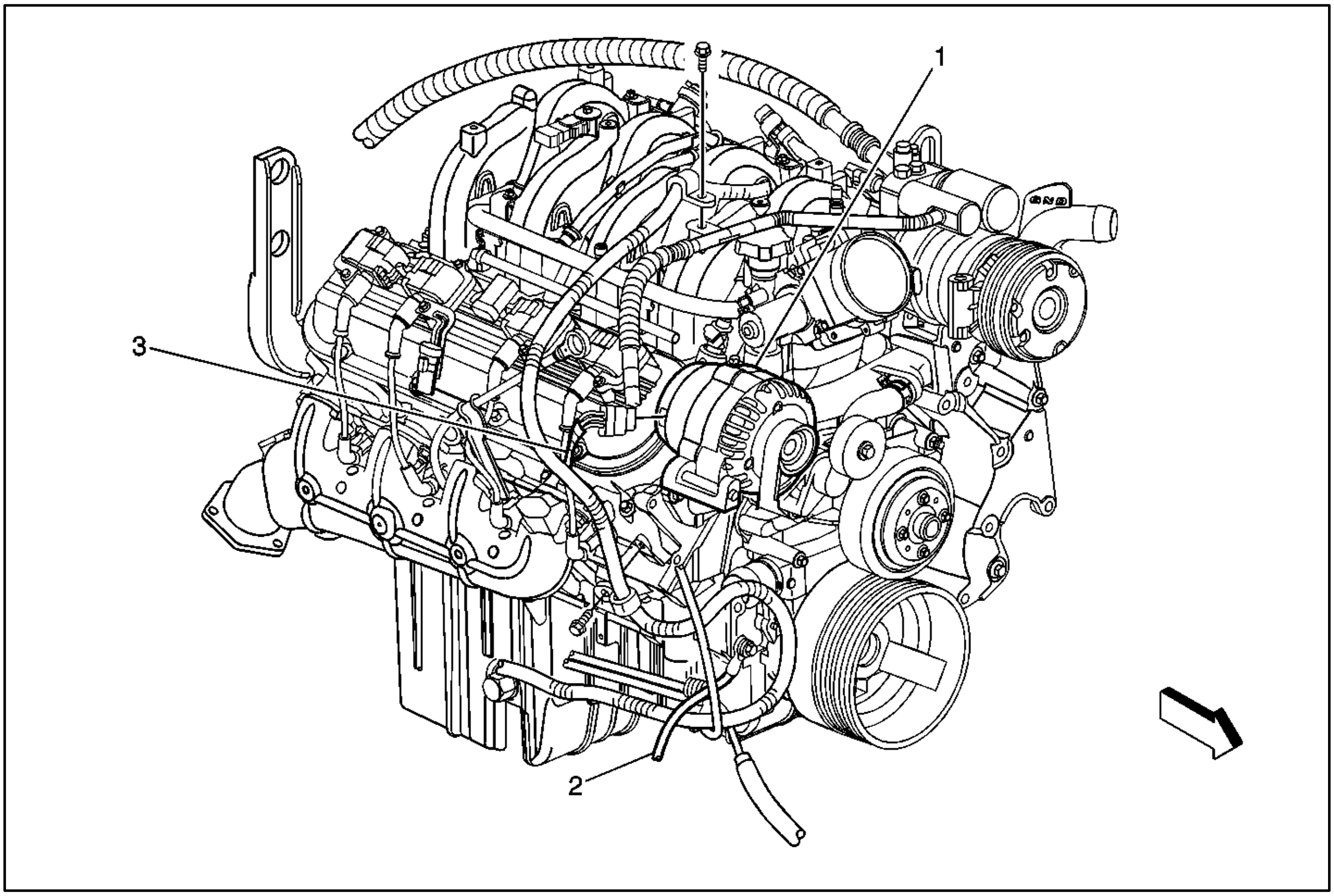
G110 and Starter



Legend

(1) Engine Harness
(2) Glow Plug Wiring
(3) Exhaust Manifold
(4) Starter Solenoid Stud
(5) Starter Wire
(6) Battery Positive Cable
(7) Starter
(8) Frame
(9) Ground Strap from Engine
(10) G110
(11) Ground from Body
(12) Heat Shield

G102 and Generator Wiring



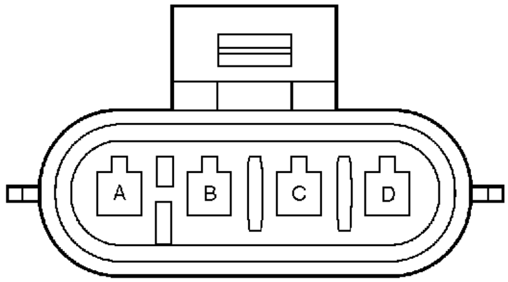
712947

Legend

(1) Generator
(2) Battery Negative Cable to Ground G102
(3) Generator Connector

Engine Electrical Connector End Views

Generator



Connector Part Information		• Similar to 12186565 (Cavity A Blocked) • 4 Way F Metri-Pack 150 Series	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	—	—	—
B	RED	225	Generator Turn On Signal
C	GRY	23	Generator Field Duty Cycle
D	PNK	739	Generator Switched Ignition Feed

Diagnostic Information and Procedures

Diagnostic Starting Point – Engine Electrical

Begin the system diagnosis with the following *Diagnostic System Check – Engine Electrical*. The Diagnostic System Check will provide the following information:

- The identification of the control module(s) which command the system.
- The ability of the control module(s) to communicate through the serial data circuit.
- The identification of any stored diagnostic trouble codes (DTCs) and their status.

The use of the Diagnostic System Check will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check – Engine Electrical

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. Lack of communication may be due to a partial malfunction of the class 2 serial data circuit or due to a total malfunction of the class 2 serial data circuit. The specified procedure will determine the particular condition.
4. The symptom list in Symptoms will determine the correct diagnostic procedure to use.
5. The presence of DTCs which begin with U indicate some other module is not communicating. The specified procedure will compile all the available information before tests are performed.

Diagnostic System Check – Engine Electrical

Step	Action	Yes	No
1	Perform the Battery Inspection/Test. Refer to *Battery Inspection/Test* in this supplement. Does the battery pass the test?	Go to *Step 2*	Go to *Battery Inspection/Test* in this supplement
2	Install a scan tool. Does the scan tool power up?	Go to *Step 3*	Go to *Scan Tool Does Not Power Up* in this supplement
3	1. Turn ON the ignition, with the engine OFF. 2. Attempt to communicate with each module on the class 2 serial data circuit. (If using a Tech 2, obtain this information using the Class 2 Message Monitor feature.) Does the scan tool communicate with any module on the class 2 serial data circuit?	Go to *Step 4*	Go to *Scan Tool Does Not Communicate with Class 2 Device* in this supplement
4	1. Select the Display DTCs function for each module. (If using a Tech 2, use the Class 2 DTC Check feature in order to determine which modules have DTCs set.) 2. Record all of the displayed DTCs, the DTC status, and the module which set the DTC. Does the scan tool display any DTCs?	Go to *Step 5*	Go to *Symptoms – Engine Electrical* in this supplement
5	Does the scan tool display any DTC beginning with U?	Go to *Diagnostic Trouble Code (DTC) List* in this supplement	Go to *Diagnostic Trouble Code (DTC) List* in this supplement

Scan Tool Data List

Powertrain Control Module (PCM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Engine OFF **(8.1L L18)**			
Ignition 1 Signal	Engine 1, 2 Data	Volts	9 – 14V
GEN L – Terminal Signal Command	Engine 2 Data	OK/No Output	OK
GEN F – Terminal Signal	Engine 2 Data	%	10 – 90%

Scan Tool Data Definitions

Ignition 1 Signal: The scan tool displays the current voltage at the battery.

GEN L – Terminal Signal Command: The scan tool displays OK/No Output. The scan tool displays OK until malfunction is detected on the generator L terminal circuit, then it reads No Output.

GEN F – Terminal Signal: The scan tool displays 0% – 100%. The scan tool displays 0% – 5% until the engine is running, then the percentage value varies depending on electrical loads.

Diagnostic Trouble Code (DTC) List

DTC	Diagnostic Procedure	Module(s)
P0562	DTC P0562	PCM
P0563	DTC P0563	PCM
P1637	DTC P1637	PCM
P1638	DTC P1638	PCM
U1300	DTC U1300	TCSCM, PCM, EBCM
U1301	DTC U1301	TCSCM, PCM, EBCM

DTC P0562

Circuit Description

The PCM monitors the system voltage to make sure that the voltage stays within the proper range. If the PCM detects an excessively low system voltage, DTC P0562 will set.

When the charging system detects a fault, the instrument panel cluster (IPC) displays a message or the charge indicator will light.

Conditions for Running the DTC

- Engine run time more than 20 seconds and above 1200 RPM.
- Vehicle speed above 8 km/h (5 mph).

Conditions for Setting the DTC

- The PCM detects an improper voltage below 11 volts for 5 seconds.

Action Taken When the DTC Sets

- The PCM stores the DTC information into memory when the diagnostic runs and fails.
- The PCM will store conditions which were present when the DTC set as Failure Records data only.
- The PCM disables most outputs.
- The transmission defaults to a predetermined gear.
- The torque converter clutch (TCC) operation is inhibited.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The powertrain control module (PCM) receives the clear code command from the scan tool.

DTC P0562

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	With the scan tool monitor the Ignition 1 signal voltage in the PCM data list. Does the scan tool display Ignition 1 voltage greater than the specified value?	11 V	Go to *Step 4*	Go to *Step 3*
3	Test the ignition feed circuit to the PCM for high resistance or open. Did you find and correct the condition?	—	Go to *Step* 7	Go to *Step 5*
4	1. Inspect for poor connections at the PCM. 2. If you find a poor connection, repair the condition as necessary. Did you find and correct the condition?	—	Go to *Step* 7	Go to *Step 6*
5	Repair the ignition feed circuit to the PCM for an open or a short to ground. Is the action complete?	—	Go to *Step* 7	—
6	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step* 7	—
7	1. Select the Diagnostic Trouble Code (DTC) option and the Clear DTC Information option using the scan tool. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text, if applicable. Does the DTC reset?	—	Go to *Step 2*	System OK

DTC P0563

Circuit Description

The powertrain control module (PCM) continuously monitors that the system voltage stays within the proper range. If the PCM detects an excessively high system voltage, DTC P0563 will set. A high voltage condition may cause a stalling condition or other driveability concerns.

Conditions for Running the DTC

- The engine run time is more than 20 seconds.
- Engine running above 1200 RPM.
- Vehicle speed above 8 km/h (5 mph).

Conditions for Setting the DTC

- The PCM senses the system voltage is above 19 volts.
- All of the conditions are present for 5 seconds.

Action Taken When the DTC Sets

- The PCM stores DTC P0563 in the PCM memory when the diagnostic runs and fails.
- The PCM will record the operating conditions at the time the diagnostic fails. The PCM stores this information in Failure Records.
- The PCM disables most outputs.
- The transmission defaults to a predetermined gear.
- The torque converter clutch (TCC) operation is inhibited.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P0563

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Turn OFF all the accessories. 2. Measure the battery voltage at the battery using the DMM. 3. Operate the engine speed above 2000 RPM. Is the battery voltage less than the specified value?	19 V	Go to *Step 4*	Go to *Step 3*
3	Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Is the action complete?	—	Go to *Step 5*	—
4	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 5*	—
5	1. Select the Diagnostic Trouble Code (DTC) option and the Clear DTC Information option using the scan tool. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text, if applicable. Does the DTC reset?	—	Go to *Step 2*	System OK

DTC P1637

Circuit Description

The PCM uses the generator turn on signal circuit to control the load of the generator on the engine. A high side driver in the PCM applies a voltage to the voltage regulator. This signals the voltage regulator to turn the field circuit ON and OFF. When the PCM turns ON the high side driver, the voltage regulator turns ON the field circuit. When the PCM turns OFF the high side driver, the voltage regulator turns OFF the field circuit.

The PCM monitors the state of the generator turn on signal circuit. The PCM should detect a low generator turn on signal circuit voltage when the key is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the PCM should detect a high generator turn on signal circuit. The PCM performs key ON and RUN tests to determine the status of the generator turn on signal circuit. During the key ON test, if the PCM detects a high generator turn on signal circuit voltage, DTC P01637 will set. DTC P1637 will also set if, during the RUN test, the PCM detects a low generator turn on signal circuit. When the DTC sets, the PCM will turn on the charge indicator in the IPC.

Conditions for Running the DTC

- The ignition is ON.
- The engine speed is more than 1000 RPM.

Conditions for Setting the DTC

- The PCM detects the GEN L–Terminal active with the ignition ON.
- The PCM detects the GEN L–Terminal inactive with the engine operating.
- The above conditions are present for 6 seconds.

Action Taken When the DTC Sets

- The PCM will record the operating conditions present when the DTC set as Failure Records data only.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P1637

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, monitor the DTC information for DTC P1637 in Engine Controls. Does the scan tool indicate that DTC P1637 has passed?	—	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Test the generator turn on signal circuit for a short or open. Did you find and correct the condition?	—	Go to *Step 6*	Go to *Step 4*
4	Inspect for poor connections at the harness connector of the PCM. Did you find and correct the condition?	—	Go to *Step 6*	Go to *Step 5*
5	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 6*	—
6	1. Review and record the scan tool Fail Records data. 2. Clear any DTCs. 3. Operate the vehicle within the Fail Records conditions as noted. 4. Using a scan tool, monitor the specific DTC info for this DTC. Does the scan tool indicate that this DTC failed this ignition?	—	Go to *Step 2*	System OK

DTC P1638

Circuit Description

The PCM uses the generator field duty cycle signal circuit to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to the high side of the field winding in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field winding ON and OFF. The PCM uses the PWM signal input to determine the generator load on the engine. This allows the PCM to adjust the idle speed to compensate for high electrical loads.

The PCM monitors the state of the generator field duty cycle signal circuit. When the key is in the RUN position and the engine is OFF, the PCM should detect a duty cycle near 0 percent. However, when the engine is running, the duty cycle should be between 5 percent and 100 percent. The PCM monitors the PWM signal using a key ON test and a RUN test. During the tests, if the PCM detects an out of range PWM signal, DTC P1638 will set. When the DTC sets, the PCM will turn on the charge indicator in the IPC.

Conditions for Running the DTC

Key ON Test

- No generator, CKP sensors, or CMP sensor DTCs are set.
- The key is in the RUN position.
- The engine is not running.

Run Test

- No generator, CKP sensors, or CMP sensor DTCs are set.
- The engine is less than 3000 RPM.

Conditions for Setting the DTC

- During the ignition ON test, the PCM detects a PWM signal is between10 – 40 percent for more than 6 seconds.
- During the RUN test, the PCM detects a PWM signal less then 5 percent for more than 6 seconds.

Action Taken When the DTC Sets

- The PCM will store the conditions present when the DTC sets as Fail Records data only.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P1638

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, observe the GEN – F Terminal parameter in the PCM data list. Does the scan tool indicate that the GEN – F Terminal parameter is within the specified range?	10 – 95%	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Connect test lamp to battery positive voltage. 4. Turn ON the ignition, with the engine OFF. 5. Probe the F Terminal in the generator connector with the test lamp. 6. Observe the GEN – F Terminal Signal parameter in the PCM data list. Is the GEN – F Terminal Signal parameter near the specified value?	100%	Go to *Charging System Test* in this supplement	Go to *Step 4*
4	Test the generator field duty cycle signal circuit for a short or open. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 5*

DTC P1638 (cont'd)

Step	Action	Value(s)	Yes	No
5	Inspect for poor connections at the harness connector of the PCM. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 6*
6	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 7*	—
7	1. Review and record the scan tool Fail Records data. 2. Clear any DTCs. 3. Operate the vehicle within the Fail Records conditions as noted. 4. Using a scan tool, monitor the Specific DTC info for this DTC. Does the scan tool indicate that this DTC failed this ignition?	—	Go to *Step 2*	System OK

Symptoms – Engine Electrical

Important: The following steps must be completed before using the symptom tables.

1. Perform *Diagnostic System Check – Engine Electrical* before using the Symptom Tables in order to verify that all of the following are true:
   - There are no DTCs set.
   - The control module(s) can communicate via the serial data link.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to one of the following system operations in this supplement:
   - *Battery Description and Operation*
   - *Starting System Description and Operation*
   - *Charging System Description and Operation*

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Starting and Charging Systems. Refer to *Checking Aftermarket Accessories* in the WCC Service Manual.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- *Starter Solenoid Does Not Click*
- *Starter Solenoid Clicks, Engine Does Not Crank*
- *Engine Cranks Slowly*
- *Battery Inspection/Test*
- *Charge Indicator Always On (8.1L)*
- *Charge Indicator Inoperative (8.1L)*
- *Charging System Test*
- *Generator Noise Diagnosis*

Starter Solenoid Does Not Click

Step	Action	Yes	No
Schematic Reference: *Starting and Charging Schematics*			
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn the ignition switch to the START position. Does the engine crank?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Turn the ignition switch to the START position. Does the starter motor relay click?	Go to *Step 7*	Go to *Step 4*
4	1. Remove the starter motor relay. 2. Connect a test light from the supply voltage circuit of the starter motor relay coil circuit to ground. 3. With the transmission in park, turn the ignition switch to the START position. Does the test light illuminate?	Go to *Step 5*	Go to *Step 6*
5	1. Connect a test light from the supply voltage circuit of the starter motor relay coil circuit to the control circuit of the starter motor relay coil circuit. 2. With the transmission in park, turn the ignition switch to the START position. Does the test light illuminate?	Go to *Step 13*	Go to *Step 10*
6	1. Turn OFF the ignition. 2. Disconnect the Park Neutral Position (PNP) switch. Refer to *Park/Neutral Position Switch Replacement* in this supplement. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 10 amp fused jumper between the starter motor relay coil control circuits of the PNP switch. 5. With the transmission in park, turn the ignition switch to the START position. Does the scan tool display any DTCs?	Go to *Step 14*	Go to *Step 11*
7	1. Turn OFF the ignition. 2. Remove the starter motor relay. 3. Connect a test lamp between the battery positive voltage circuit of the starter motor relay switch circuit and a good ground. Does the test lamp illuminate?	Go to *Step 8*	Go to *Step 17*
8	Connect a 30 amp fused jumper between the battery positive voltage circuit of the starter motor relay switch circuit and the supply voltage circuit of the starter solenoid. Does the engine crank?	Go to *Step 13*	Go to *Step 9*
9	Does the fuse in the jumper open?	Go to *Step 18*	Go to *Step 12*
10	Test the control circuit of the starter motor relay for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 19*
11	Test the supply voltage circuit of the starter motor relay coil circuit for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 15*
12	Test the supply voltage circuit of the starter solenoid for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 16*

Starter Solenoid Does Not Click (cont'd)

Step	Action	Yes	No
13	Inspect for poor connections at the starter motor relay. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 19*
14	Inspect for poor connection at the PNP switch harness connector. If OK, perform the *Park/Neutral Position Switch Adjustment* in this supplement. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 20*
15	Inspect for poor connections at the ignition switch harness connector. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 21*
16	Inspect for poor connections at the starter solenoid. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 22*
17	Repair the open or high resistance in the battery positive voltage circuit of the starter motor relay switch circuit. Did you complete the repair?	Go to *Step 23*	—
18	Repair the short to ground in the supply voltage circuit of the starter solenoid. Did you complete the repair?	Go to *Step 23*	—
19	Replace the starter motor relay. Did you complete the replacement?	Go to *Step 23*	—
20	Replace the PNP switch. Refer to *Park/Neutral Position Switch Replacement* in this supplement. Did you complete the replacement?	Go to *Step 23*	—
21	Replace the Ignition Switch. Refer to *Ignition Switch Replacement – On Vehicle* (Tilt Column) in this supplement. Did you complete the replacement?	Go to *Step 23*	—
22	Replace the starter. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 23*	—
23	Operate the system for which the symptom occurred. Did you correct the condition?	System OK	Go to *Step 2*

Starter Solenoid Clicks, Engine Does Not Crank

Step	Action	Yes	No
Schematic Reference: *Starting and Charging Schematics*			
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn the ignition switch to the START position. Does the starter solenoid click?	Go to *Step 3*	Go to *Starter Solenoid Does Not Click* in this supplement
3	Inspect the engine and belt drive system for mechanical binding (seized engine, seized generator). Does the engine move freely?	Go to *Step 4*	Go to *Engine Will Not Crank – Crankshaft Will Not Rotate* in this supplement
4	Test the battery positive cable between the battery and the starter solenoid for high resistance. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 5*
5	Test the ground circuit between the battery and the starter motor for a high resistance. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 6*
6	Inspect for poor connections at the starter. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 7*
7	Replace the starter. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 8*	—
8	Operate the system for which the symptom occurred. Did you correct the condition?	System OK	Go to *Step 2*

Engine Cranks Slowly

Perform the following checks:

- Battery – Battery Inspection/Test. Refer to *Battery Inspection/Test* in this supplement.
- Wiring – Inspect the wiring for damage. Inspect all connections to the starter motor, solenoid, battery, and all ground connections. Refer to *Intermittents and Poor Connections* Diagnosis in the WCC Service Manual.
- Engine – Make sure the engine is not seized. Refer to *Symptoms – Engine Mechanical* in this supplement.

If the battery, the wiring and the engine are functioning properly and the engine continues to crank slowly, replace the starter motor. Refer to *Starter Motor Replacement* in this supplement.

Charge Indicator Always On (8.1L)

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Start the engine. Does the charge indicator remain illuminated?	Go to *Step 3*	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Turn ON the ignition, with the engine OFF. Does the charge indicator remain illuminated?	Go to *Step 4*	Go to *Charging System Test* in this supplement

Charge Indicator Always On (8.1L) (cont'd)

Step	Action	Yes	No
4	Test the charge indicator control circuit for a short to ground. Did you find and correct the condition?	Go to *Step 6*	Go to *Step 5*
5	**Important:** The replacement PCM must be programed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Did you complete the replacement?	Go to *Step 6*	—
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Charge Indicator Inoperative (8.1L)

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn ON the ignition, with the engine OFF. Observe the charge indicator on the instrument panel cluster (IPC). Is the charge indicator illuminated?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Connect a 3 amp fused jumper wire between the charge indicator control circuit and a good ground. 4. Turn ON the ignition, with the engine OFF. Does the charge indicator remain OFF?	Go to *Step 4*	Go to *Charging System Test* in this supplement
4	Test the charge indicator control circuit for an open or high resistance. Did you find and correct the condition?	Go to *Step 7*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Inspect the charge indiactor lamp for an open and replace if necessary. Did you find and correct the condition?	Go to *Step 7*	Go to *Step 6*
6	**Important:** The replacement PCM must be programed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Did you complete the replacement?	Go to *Step 7*	—
7	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Battery Inspection/Test

Tools Required

J 42000 Digital Battery Tester

Diagnostic Aids

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

Important: The battery test using the *J 42000* requires correct connections to the battery terminals. A failure to obtain the correct connections during the test may result in a failed test on a good battery.

Follow these instructions in order to avoid an incorrect diagnosis because of connections:

- If testing the vehicle with the battery cables still connected, wiggle the *J 42000* clips on the terminal bolt. This may cut through any coating or through any oxidation that may be present on the bolt.
  Even new bolts contain a protective coating that may insulate or cause a resistance in the test circuit.
- If correct connections to the battery terminal bolts in the vehicle are in doubt, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the test adapters on the terminals.
  4. Follow the instructions for testing a removed battery.
- If the tester displays a REPLACE BATTERY result for a battery tested in the vehicle with the battery cables connected, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the tester adapters.
  4. Follow the instructions for testing a removed battery.
  5. Replace the battery only if the second test shows a REPLACE BATTERY result.
     Use the test code from the second test for any warranty purposes.
- Use the correct terminal adapters.
  Do not use any common bolts or a combination of bolts, of nuts, and of washers as adapters when testing the battery.
- Use the test adapters that are provided with the *J 42000* or P/N 12303040 terminal adapters. If the adapters that are provided with the *J 42000* require replacement, use P/N 12303040. Any other adapter may not contact the correct areas of the battery terminal, causing a resistance that may result in an invalid battery test result.

Important: Always write the test code displayed by the tester on the repair order for any warranty purposes. The number is a unique code that describes the test data for a particular battery at a particular time. The test code may occasionally repeat when you retest the same battery. More often, each test will result in a different code. Use the test code from the second, or out of vehicle, test.

Battery Inspection/Test

Step	Action	Value(s)	Yes	No
Caution: Refer to Battery Disconnect Caution in Cautions and Notices.				
1	Inspect the battery for a cracked, broken, or damaged case, which may be indicated by battery acid leakage. Is the battery OK?	—	Go to *Step 2*	Go to *Step 19*
2	Compare the cold cranking amperage (CCA) and reserve capacity (RC) of the battery to the original battery or original equipment (OE) specification. Refer to *Battery Usage* in this supplement. Does the battery meet or exceed the specifications?	—	Go to *Step 3*	Go to *Step 19*
3	Does the hydrometer display a yellow dot?	—	Go to *Step* 4	Go to *Step 5*
4	Tap the hydrometer lightly on top with the handle of a small screwdriver in order to dislodge any air bubbles inside the battery. Does the hydrometer still display a yellow dot?	—	Go to *Step 19*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Attempt to rotate the negative battery cable connector clockwise with light finger pressure. Does the negative connector rotate?	—	Go to *Step 6*	Go to *Step 7*
6	Use a torque wrench in order to verify the torque to loosen the negative battery terminal bolt. Is the torque above the specified value?	10 N·m (88 lb in)	Go to *Step 8*	Go to *Step 7*

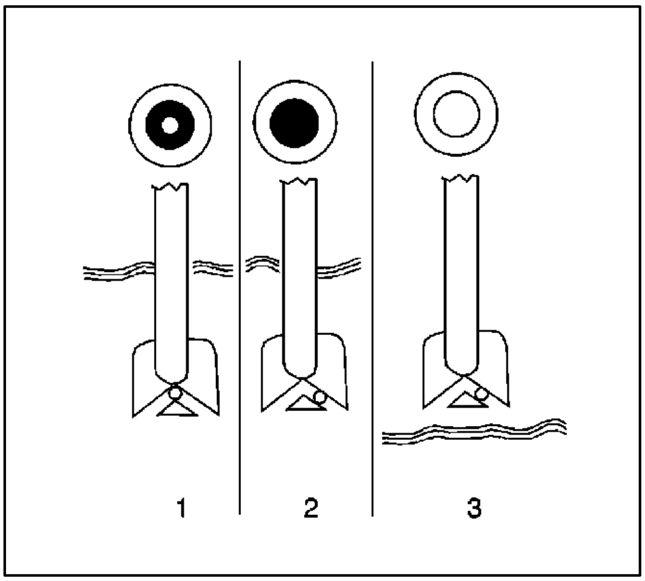
Battery Inspection/Test (cont'd)

Step	Action	Value(s)	Yes	No
7	Disconnect the negative battery cable. Is the cable disconnected?	—	Go to *Step 9*	—
8	1. Disconnect the negative battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end. • There is foreign material present inside the nut in the battery terminal. • Damage to the battery terminal face or cable connector ring. Is the repair complete?	—	Go to *Step 9*	—
9	Rotate the positive battery cable connector clockwise with light finger pressure. Does the positive connector rotate?	—	Go to *Step 10*	Go to *Step 11*
10	Use a torque wrench in order to verify the torque to loosen the positive battery terminal bolt. Is the torque above the specified value?	10 N·m (88 lb in)	Go to *Step 12*	Go to *Step 11*
11	Disconnect the positive battery cable. Is the cable disconnected?	—	Go to *Step 13*	—
12	1. Disconnect the positive battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end. • There is foreign material present inside the nut in the battery terminal. • Damage to the battery terminal face or cable connector ring. Is the repair complete?	—	Go to *Step 13*	—
13	1. Clean and wire brush the lead face of both battery terminals and the metal contact rings in both cable connectors. 2. Remove the bolts from the cable connectors in order to provide access to the connector rings as needed. 3. If either of the battery terminals or the cable rings are excessively damaged or corroded, replace as needed. Are the metal connecting parts clean and in good condition?	—	Go to *Step 14*	—
14	1. Connect the positive battery cable to the battery positive terminal. 2. Tighten the cable bolt to the specified value. Is the cable bolt properly tightened?	15 N·m (11 lb ft)	Go to *Step 15*	—
15	1. Connect the negative battery cable to the battery negative terminal. 2. Tighten the cable bolt to the specified value. Is the cable bolt properly tightened?	15 N·m (11 lb ft)	Go to *Step 16*	—
16	**Important:** Ensure that all of the electrical loads are turned OFF. 1. Install the *J 42000*. 2. Follow the directions supplied with the tester. 3. Follow any direction displayed on the tester. Did the tester pass the battery?	—	Go to *Step 17*	Go to *Step 18*

Battery Inspection/Test (cont'd)

Step	Action	Value(s)	Yes	No
17	1. Press the CODE button on the *J 42000*. 2. For warranty purposes, write the displayed code on the repair order. Did you complete this action?	—	Battery OK	—
18	1. Press the CODE button on the *J 42000*. 2. For warranty purposes, write the displayed code on the repair order. 3. Replace the battery. Refer to *Battery Replacement* in the WCC Service Manual. Did you complete the replacement?	—	Battery OK	—
19	Replace the battery. Refer to *Battery Replacement* in the WCC Service Manual. Did you complete the replacement?	—	Battery OK	—

Battery Charging



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- For best results, use an automatic taper-rate battery charger with a voltage capability of 16 volts.
- A battery showing a green dot in the hydrometer (1) does not need to be charged unless the *J 42000* has shown that the battery needs to be charged.
- A battery showing a dark dot in the hydrometer (2) should be charged unless the *J 42000* has indicated no charge is needed.
- Do not charge a battery when the built in hydrometer is clear or yellow in the center (3). Tap the hydrometer lightly in order to dislodge any air bubbles. The bubbles may cause a false indication. If the hydrometer is still clear or yellow, replace the battery.
- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen; allow the battery to warm to room temperature and test it before charging.

Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

1. The battery charger capacity. The higher the charger's amperage, the less time it will take to charge the battery.
2. The state-of-charge of the battery. A completely discharged battery requires more than twice as much charging time as a half charged battery. In a discharged battery with a voltage below 11 volts, the battery has a very high internal resistance and may only accept a very low current at first. Later, as the charging current causes the acid content to increase in the electrolyte, the charging current will increase. Extremely discharged batteries may not activate the reversed voltage protection in some chargers. Refer to the manufacturers instructions for operating this circuitry.
3. The temperature of the battery. The colder the battery is, the more time it takes to recharge the battery. The charging current accepted by a cold battery is very low at first; then, as the battery warms, the charging current will increase.

Charging Procedure

Notice: Turn OFF the ignition when connecting or disconnecting the battery cables, the battery charger or the jumper cables. Failure to do so may damage the PCM or other electronic components.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

When charging side-terminal batteries with the battery cables connected, connect the charger to the positive cable bolt and to a ground located away from the battery. When charging side-terminal batteries with the battery cables disconnected, install the battery side terminal adapters and connect the charger to the adapters.

Tighten

Tighten the battery side terminal adapters to 15 N·m (11 lb ft).

Use the following procedure to charge the battery:

1. Turn OFF the charger.
2. Ensure that all of the battery terminal connections are clean and tight.
3. Connect the charger positive lead to the battery positive terminal.

Notice: Do not connect the negative charger lead to the housings of other vehicle electrical accessories or equipment. The action of the battery charger may damage such equipment.

4. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.
5. Turn ON the charger and set to the highest setting for normal charging.
6. Inspect the battery every half hour after starting the battery charger.
   - Charge the battery until the hydrometer has a green dot or until the taper-rate charger indicates that the battery is fully charged, whichever occurs first.
   - Tap the hydrometer lightly in order to dislodge any air bubbles. The bubbles may cause a false indication.
   - Estimate the battery temperature by feeling the side of the battery. If it feels hot to the touch or its temperature is over 45°C (125°F), discontinue charging and allow the battery to cool before resuming charging.
7. After charging, test the battery. Refer to *Battery Inspection/Test* in this supplement.

Battery Electrical Drain/Parasitic Load Test

Battery Electrical Drain

If the vehicle exhibits a low or dead battery after an overnight period, or discharges over a period of 2 or 3 days, the electrical system should be checked for an excessive electrical drain. This is referred to as parasitic current drain.

If a battery needs recharging and no cause is evident, check the vehicle for excessive parasitic current drain.

One or more on-board solid state control modules, such as the PCM, may at some time exhibit a failure mode that causes a high parasitic drain on the vehicle's battery. When the battery is disconnected to install an ammeter, etc., the excessive current drain may not occur once the circuit continuity is restored. Even though cycling the ignition key to the RUN and then to the OFF position may cause such a drain to recur, there may be drains that will not recur unless the vehicle systems are reactivated in a road test. Since the ignition switch must not be rotated to the ACCESSORY, RUN or START position with an ammeter installed between the battery terminal and the battery cable, a current drain test tool must be used as described in the following procedures.

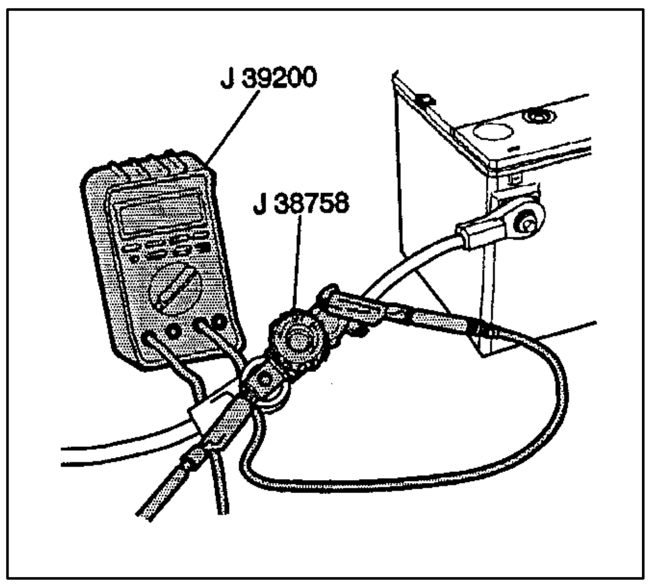
Before starting this procedure, ensure that the ignition switch is in the LOCK position, all electrical accessories are turned OFF, the door glass is open and the doors are closed.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

Notice: Do not turn the parasitic draw test switch to the OFF position with the engine running. Damage will occur to the vehicle's electrical system.

Notice: The test switch must be in the ON position when removing the fuses in order to maintain continuity in the electrical system. This avoids damaging the digital multimeter due to accidental overloading, such as a door being opened to change a fuse.

1. Disconnect the battery negative cable.



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2. Install the male end of the *J 38758* to the battery negative terminal.
3. Turn OFF the test switch.
4. Install the battery negative cable to the female end of the test switch.
5. Turn ON the test switch.
6. Road test the vehicle while activating all accessories, including the radio and the air conditioning.

7. Turn OFF the ignition switch. Remove the key.

Important: From this point on, electrical continuity must be maintained in the ground circuit of the battery through the *J 38758* in the ON position or through the *J 39200*.

8. Components such as PCM have timers that draw several amps of current while they cycle down. This can give a false parasitic drain reading. Wait 15 minutes for these components to power down before continuing this test.
9. Set the *J 39200* to the 10 A scale.

Important: If an ammeter other than the *J 39200* is used, ensure that the vehicle does not have a high current drain that would damage the ammeter when connected to the circuit. This can be done using the following procedure:

- 9.1. Connect a jumper wire with an in-line 10 A fuse *J 36169-A* to the terminals of the test switch.
- 9.2. Turn the test switch to the OFF position.
- 9.3. Wait ten seconds.
- 9.4. If the fuse does not blow, the current is less than 10 A and the ammeter can be used safely.
- 9.5. Turn the test switch to the ON position before the fused jumper wire is removed and the multimeter is installed.

10. Connect the ammeter to the test switch terminals.
11. Turn OFF the test switch. This allows the current to flow through the ammeter.
12. Wait at least 60 seconds, then check the current reading.
    - When there is a current reading of 2 A or less, turn ON the test switch, this maintains continuity in the electrical system.
    - Then, switch the meter down to the 2 A scale, for a more accurate reading, when the test switch is reopened.
13. Take the reading in milli-amps.
14. Note the battery reserve capacity. Refer to *Battery Usage* in this supplement.
    - Divide this number by 4.
    - Compare this to the multimeter reading.
    - The current drain should not exceed this number.
    - Example: If a battery has a reserve capacity of 100 minutes, the current drain should not exceed 25 milli-amps. If the vehicle has a diesel engine with 2 batteries, add the reserve capacities together and divide this total by four.

Notice: Always turn the test switch knob to the ON position before removing each fuse to maintain continuity in the electrical system and to avoid damaging the meter due to accidental overloading, such as opening a door to change a fuse.

15. When the current draw is too high, remove the electrical system fuses one at a time until the draw returns to a value less than or equal to specifications.
16. Repeat the parasitic current drain test procedure after any repair has been completed.
17. When the cause of the excessive current draw has been located and repaired, remove the meter and the parasitic draw test switch and terminal adapters.
18. Connect the negative cable to the battery negative terminal.

Battery Common Causes of Failure

A battery is not designed to last forever. With proper care, however, the battery will provide years of good service. If the battery tests good but still fails to perform well, the following are some of the more common causes:

1. A vehicle accessory was left on overnight.
2. The driving speeds have been slow with frequent stops (stop-and-go driving) with many electrical accessories in use, particularly air conditioning, headlights, wipers, heated rear window, cellular telephone, etc.
3. The electrical load has exceeded the generator output (particularly with the addition of aftermarket equipment).
4. Existing conditions in the charging system, including the following possibilities:
    - A slipping belt
    - A bad generator
5. The battery has not been properly maintained, including a loose battery hold down or missing battery insulator if used.
6. There are mechanical conditions in the electrical system, such as a short or a pinched wire, attributing to power failure. Refer to *General Electrical Diagnosis Procedures* in the WCC Service Manual.

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. A fully charged battery will not freeze until the ambient temperature gets below −54°C (−65°F). However, a battery with a low state of charge may freeze at temperatures as high as −7°C (20°F). Since freezing may ruin a battery, the battery should be protected against freezing by keeping it properly charged. As long as the green eye is visible in the hydrometer, the freezing point of the battery will be somewhere below −32°C (−25°F).

Battery Protection During Vehicle Storage

Certain devices on the vehicle maintain a small continuous current drain (parasitic load) on the battery. A battery that is not used for an extended period of time will discharge. Eventually permanent damage will result. Discharged batteries will also freeze in cold weather. Refer to *Battery Inspection/Test* in this supplement.

In order to maintain a battery state of charge while storing the vehicle for more than 30 days:

Important: If a green dot is not visible in the hydrometer, charge the battery. Refer to Battery Charging.

1. Make sure the that the green dot is visible in the built-in hydrometer.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

2. Disconnect the battery (negative) ground to protect the battery from discharge by parasitic current drains.

When the battery cannot be disconnected:

1. Maintain a high state of charge.
2. Establish a regular schedule for recharging the battery every 20-45 days.

A battery that has remained in a discharged state for a long period of time is difficult to recharge or may be permanently damaged.

Jump Starting in Case of Emergency

Caution: Batteries produce explosive gases. Batteries contain corrosive acid. Batteries supply levels of electrical current high enough to cause burns. Therefore, in order to reduce the risk of personal injury while working near a battery, observe the following guidelines:

- ***Always shield your eyes.***
- ***Avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow battery acid to contact the eyes or the skin.***
  - ***Flush any contacted areas with water immediately and thoroughly.***
  - ***Get medical help.***

Notice: This vehicle has a 12 volt, negative ground electrical system. Make sure the vehicle or equipment being used to jump start the engine is also 12 volt, negative ground. Use of any other type of system will damage the vehicle's electrical components.

This vehicle has a 12 volt positive, negative ground electrical system. Do not try to jump start a vehicle if you are unsure of the other vehicle's positive voltage or ground position. The booster (charged) battery and the discharged battery should be treated carefully when using jumper cables.

1. Position the vehicle with the booster (charged) battery so that the jumper cables will comfortably reach the battery of the other vehicle.
   - Do not let the 2 vehicles touch.
   - Make sure that the jumper cables do not have loose clamps or missing insulation.
2. Perform the following steps on both vehicles:
   - 2.1. Place the automatic transmission in PARK.
   - 2.2. Block the wheels.
   - 2.3. Set the parking brake.
   - 2.4. Turn off all electrical loads that are not needed (leave the hazard flashers ON).
   - 2.5. Turn OFF the ignition switch.

Important: Some vehicles have a battery remote positive stud. ALWAYS use the battery remote positive stud in order to give or to receive a jump start.

3. Attach the end of one jumper cable to the positive terminal of the discharged battery.
4. Attach the other end of the first cable to the positive terminal of the booster battery.
5. Attach one end of the remaining jumper cable to the negative terminal of the booster battery.
6. Make the final connection of the negative jumper cable to the block or suitable bracket connected directly to the block, away from the battery.
7. Start the engine of the vehicle that is providing the jump start and turn off all electrical accessories. Raise the engine RPM to approximately 1500 RPM.
8. Crank the engine of the vehicle with the weak battery.

   If the engine does not crank or cranks too slowly, perform the following steps:
   - 8.1. Turn the ignition OFF.
   - 8.2. Allow the booster vehicle engine to run at approximately 1500 RPM for 5 minutes.
   - 8.3. Attempt to start the engine of the vehicle with the discharged battery.
9. Reverse the steps exactly when removing the jumper cables. The negative battery cable must first be disconnected from the engine that was jump started.

Starter Motor Noise Diagnosis

Diagnostic Aids

- Inspect the flywheel ring gear for damage or unusual wear.
- Shim the starter if applicable.
- In order to add pinion to ring gear clearance a full size shim must be used. Do not shim only 1 starter mounting bolt. There are 3 shims available in different shapes (for clearance). All are 1 mm (0.039 in) thick.

Starter Motor Noise Diagnosis

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Start the engine. Does the starter operate normally?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Start the engine while listening to the starter motor turn. Is there a loud "whoop" (it may sound like a siren if the engine is revved while the starter is engaged) after the engine starts, but while the starter is still held in the engaged position?	Go to *Step 6*	Go to *Step 4*
4	Do you hear a "rumble", a "growl", or, in some cases, a "knock" as the starter is coasting down to a stop after starting the engine?	Go to *Step 7*	Go to *Step 5*
5	When the engine is cranked, do you hear a high-pitched whine after the engine cranks and starts normally? (This is often diagnosed as a starter drive gear hang-in or a weak solenoid.)	Go to *Step 8*	Go to *Step 7*
6	Inspect the flywheel ring gear for the following: • Chipped gear teeth • Missing gear teeth • Milled teeth Is the flywheel bent, or does it have damaged teeth?	Go to *Step 9*	Go to *Step 10*
7	1. Remove the starter motor. Refer to *Starter Motor Replacement* in this supplement. 2. Inspect the starter motor bushings and clutch gear. Does the clutch gear have chipped or milled teeth or worn bushings?	Go to *Step 10*	Go to *Step 9*
8	Shim the starter motor away from the flywheel by adding shims between the starter motor and the engine block one at a time. Flywheel runout may make this noise appear to be intermittent. Did you complete the repair?	Go to *Step 11*	—
9	Replace the flywheel. Refer to *Engine Flywheel Replacement* in this supplement. Did you complete the replacement?	Go to *Step 11*	—
10	Replace the starter motor. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 11*	—
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Charging System Test

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Battery Inspection/Test?	—	Go to *Step 2*	Go to *Battery Inspection/Test* in this supplement
2	1. Turn OFF all electrical loads. 2. Start the engine. 3. With a DMM measure the voltage at the battery. Does the DMM indicate the voltage is within the specified value?	11.0 – 15.5 Volts	Go to *Step 3*	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual

Charging System Test (cont'd)

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Connect a charging system tester to the battery (follow the manufacturer instructions). 3. Operate the engine at 2500 RPM. 4. Adjust the carbon pile as necessary in order to obtain the maximum current output. Is the generator output within 10 A of the specified value?	Go to *Generator Usage* in this supplement	Go to *Step 9*	Go to *Step 4*
4	1. Maintain the engine speed at 2500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop between the generator output terminal and the battery positive terminal. Is the voltage above the specified value?	0.5 V	Go to *Step 6*	Go to *Step 5*
5	1. Maintain the engine speed at 2500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop between the battery negative terminal and the generator metal housing. Is the voltage above the specified value?	0.5 V	Go to *Step 7*	Go to *Step 8*
6	Test the battery positive circuit between the generator output terminal and the battery positive terminal for a high resistance. Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 7*
7	Repair the high resistance in the ground circuit between the generator housing and the battery negative terminal. Did you complete the repair?	—	Go to *Step 9*	—
8	Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Did you complete the repair?	—	Go to *Step 9*	—
9	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to *Step 3*

Generator Noise Diagnosis

Diagnostic Aids

Noise from a generator may be due to electrical or mechanical noise. Electrical noise (magnetic whine) usually varies with the electrical load placed on the generator and is a normal operating characteristic of all generators. When diagnosing a noisy generator, it is important to remember that loose or misaligned components around the generator may transmit the noise into the passenger compartment and that replacing the generator may not solve the problem.

Generator Noise Diagnosis

Step	Action	Yes	No
1	Test the generator for proper operation using the Generator Tester. Refer to *Charging System Test* in this supplement. Is the generator operating properly?	Go to *Step 2*	Go to *Step 11*
2	1. Start the engine. Verify that the noise can be heard. 2. Turn OFF the engine. 3. Disconnect the 4-way connector from the generator. 4. Start the engine. 5. Listen for the noise. Has the noise stopped?	Go to *Step 11*	Go to *Step 3*

Generator Noise Diagnosis (cont'd)

Step	Action	Yes	No
3	1. Turn OFF the engine. 2. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement. 3. Spin the generator pulley by hand. Does the generator shaft spin smoothly and without any roughness or grinding noise?	Go to *Step 4*	Go to *Step 12*
4	Inspect the generator for a loose pulley and/or pulley nut. Is the generator pulley or pulley nut loose?	Go to *Step 11*	Go to *Step 5*
5	1. Loosen all of the generator mounting bolts. 2. Tighten the generator mounting bolts to specifications and in the proper sequence (if necessary). Refer to *Generator Replacement (8.1L)* in this supplement. 3. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement. 4. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 6*
6	Inspect the generator for the following conditions: • Strained or stretched electrical connections • Hoses or other vehicle equipment resting on the generator (which may cause the noise to be transmitted into the passenger compartment) Are any electrical connections pulling on the generator or are any hoses, etc. resting on the generator?	Go to *Step 7*	Go to *Step 8*
7	1. Reroute the electrical connections to relieve the tension. 2. Reroute the hoses, etc. away from the generator. 3. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 8*
8	Inspect the drive belt for proper tension. Refer to *Drive Belt Vibration Diagnosis* in this supplement. Is the drive belt loose?	Go to *Step 9*	Go to *Step 10*
9	1. Replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement. 2. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 12*
10	Compare the vehicle with a known good vehicle. Do both vehicles make the same noise?	System OK	Go to *Step 12*
11	Tighten or replace the generator pulley and pulley nut as necessary. Refer to *Generator Pulley Replacement* in this supplement. Is the repair complete?	Go to *Step 13*	—
12	**Important:** If no definite generator problems were found, be sure that all other possible sources of objectionable noise are eliminated before replacing the generator. Replacing the generator may not change the noise level if the noise is a normal characteristic of the generator or the generator mounting. Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Has the noise decreased or stopped?	Go to *Step 13*	—
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 2*

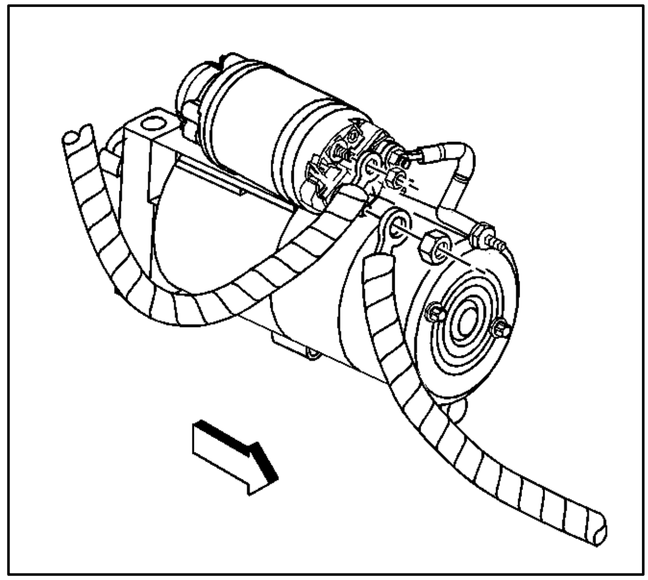
Repair Instructions

Starter Motor Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

1. Disconnect the negative battery cable.
2. Raise and suitably support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
3. Remove the positive cable nut.
4. Remove the positive cable from the starter.
5. Remove the engine harness nut.
6. Remove the engine harness from the starter.



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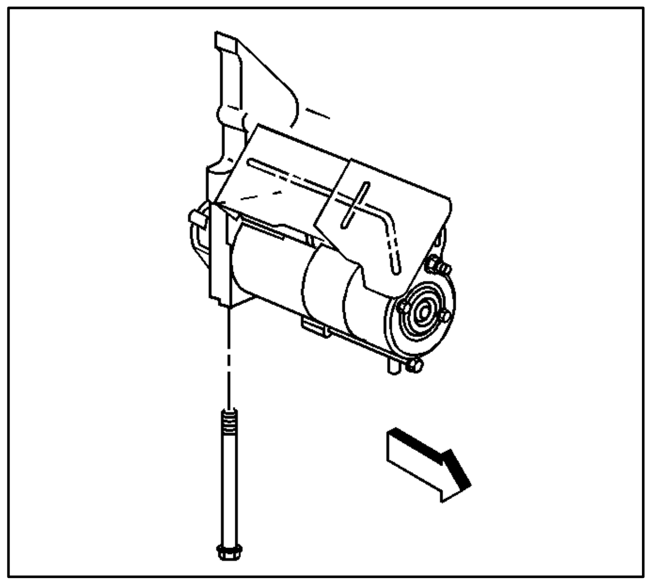
7. Remove the starter motor bolts.
8. Remove the starter.



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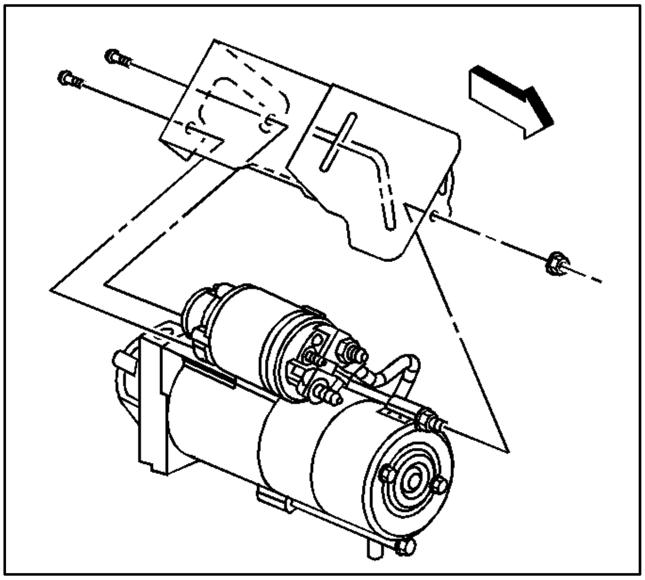

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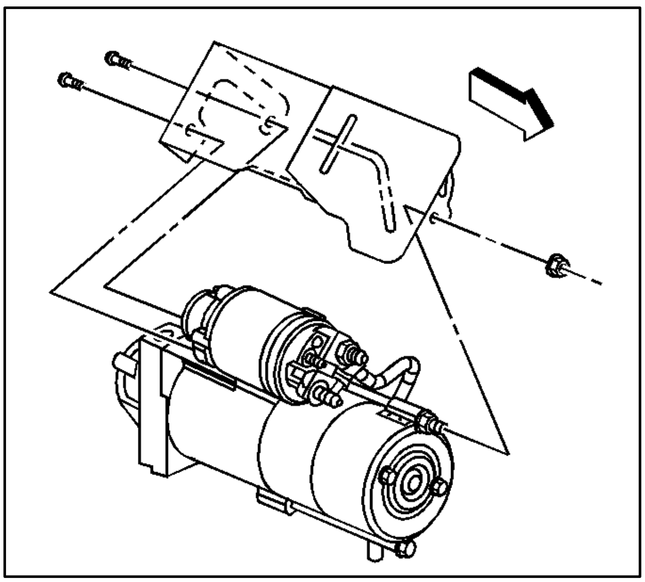
9. Remove the starter heat shield bolts, nut and shield, if necessary.



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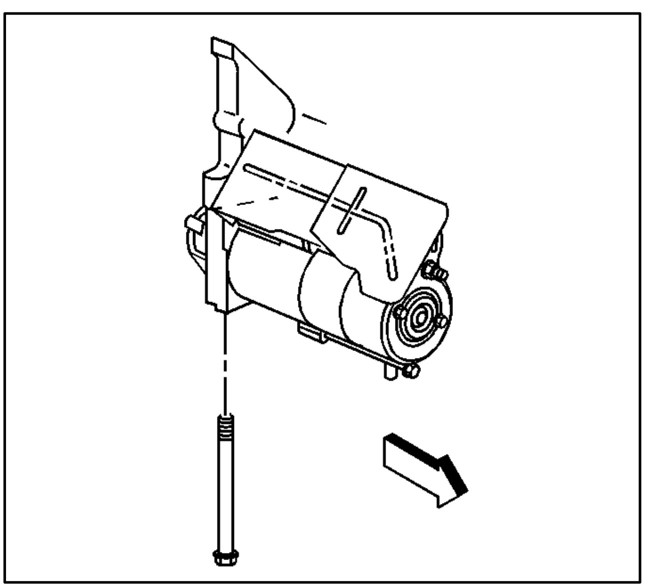
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the starter heat shield, nut and bolts if necessary.

   Tighten

   - Tighten the starter heat shield bolts to 3 N·m (35 lb in).
   - Tighten the starter heat shield nut to 5 N·m (44 lb in).



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2. Install the starter motor bolts.

   Tighten

   Tighten the starter motor bolts to 50 N·m (37 lb ft).

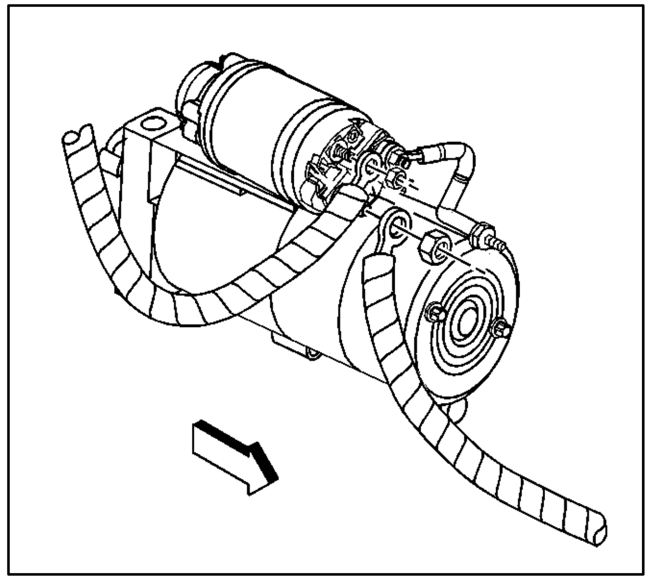
3. Install the engine harness to the starter.
4. Install the engine harness nut.

   Tighten

   Tighten the engine harness nut to 2 N·m (18 lb in).
5. Install the positive cable to the starter.
6. Install the positive cable nut.

   Tighten

   Tighten the positive cable nut to 10 N·m (89 lb in).
7. Lower the vehicle.
8. Connect the negative battery cable.



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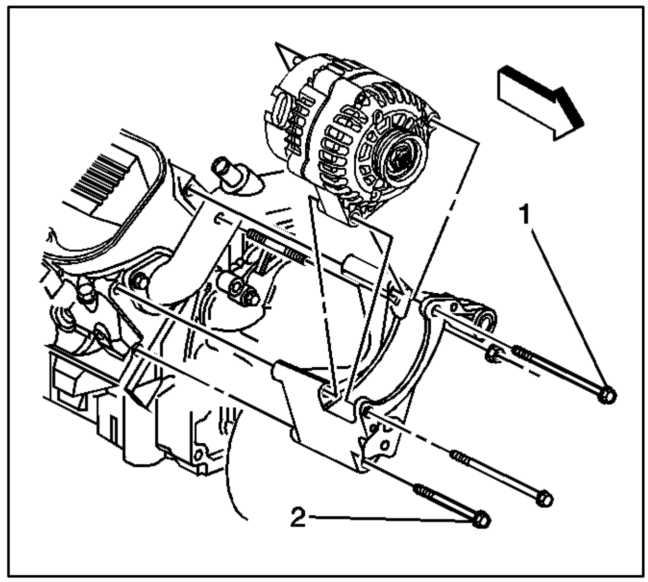
Generator Bracket Replacement

Removal Procedure

1. Remove the generator. Refer to *Generator Replacement (8.1L)* in this supplement.
2. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement.
3. Remove the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement* in this supplement.
4. Remove the generator bracket bolt (2) and nut.



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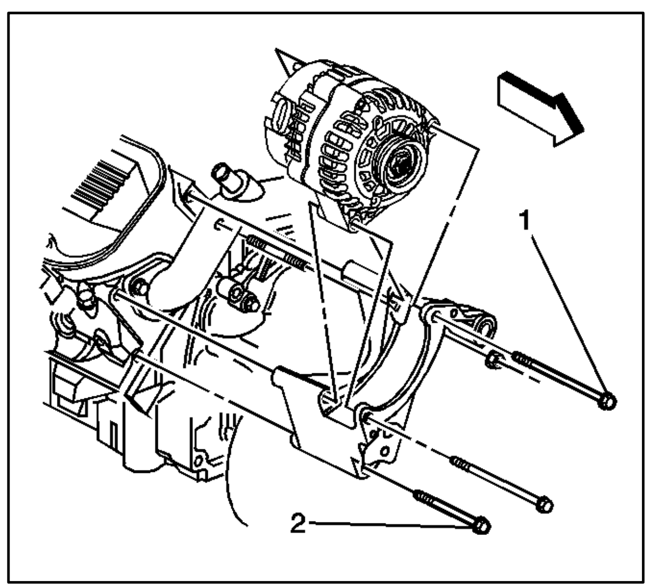
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator bracket bolt (2) and nut.

   Tighten

   - Tighten the generator bracket bolt to 50 N·m (37 lb ft).
   - Tighten the generator bracket nut to 41 N·m (30 lb ft).
2. Install the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement* in this supplement.
3. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement.
4. Install the generator. Refer to *Generator Replacement (8.1L)* in this supplement.



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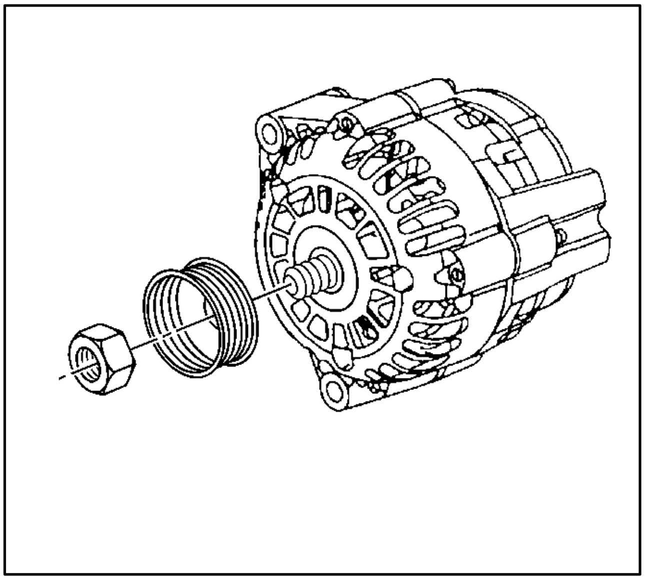

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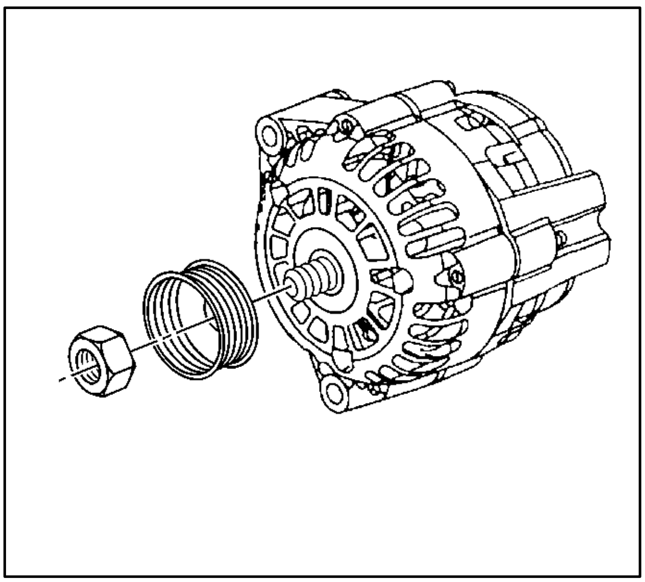
Generator Pulley Replacement

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
2. Install a T-50 TORX® bit into the generator shaft.
3. Remove the generator shaft nut and washer.
4. Remove the generator pulley.



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Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator pulley, washer and shaft nut.

   Tighten

   Tighten the generator shaft nut to 75 N·m (55 lb ft).
2. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.

Generator Replacement (8.1L)

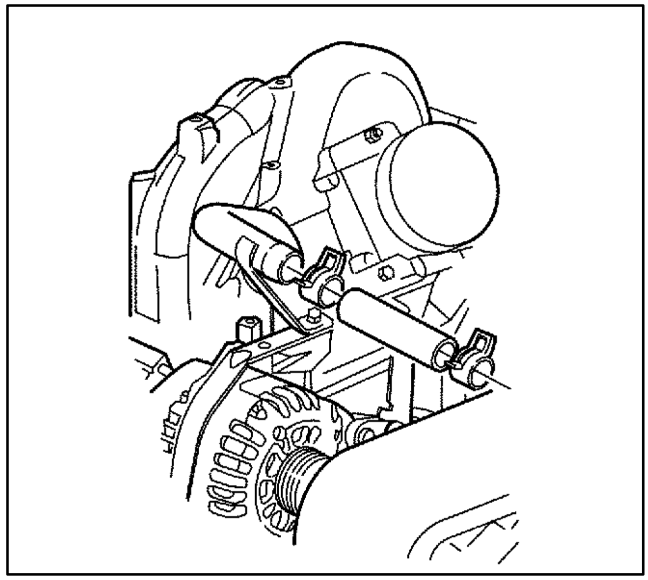
Removal Procedure

The removal and installation serve only as a guide. Additional operations may be required on some vehicles to remove other equipment in order to gain access to the generator, the drive belt, and the brackets.

Caution: Failure to observe Step 1 in this procedure may result in an injury to the live battery lead at the generator.

Caution: Refer to battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

1. Disconnect the negative battery cable.
2. Remove the air intake duct from the throttle body and MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Remove the MAF/IAT sensor. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.
4. Remove the engine oil fill tube from the oil pipe.
5. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
6. Remove the transmission dipstick and fill tube bracket retaining bolt from the oil level indicator tube bracket.
7. Remove the transmission dipstick and fill tube bracket from the oil level indicator tube bracket.



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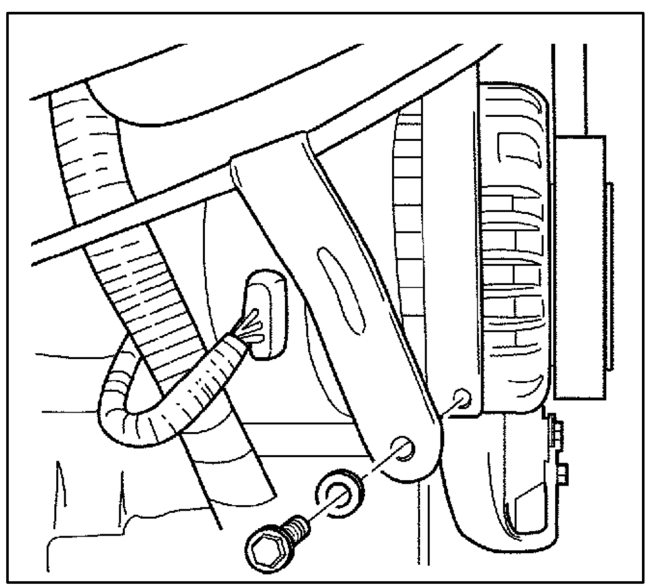
8. Remove the oil level indicator tube retaining bolt and washer from the oil level indicator tube bracket.
9. Remove the oil level indicator tube bracket from the generator mounting bracket.



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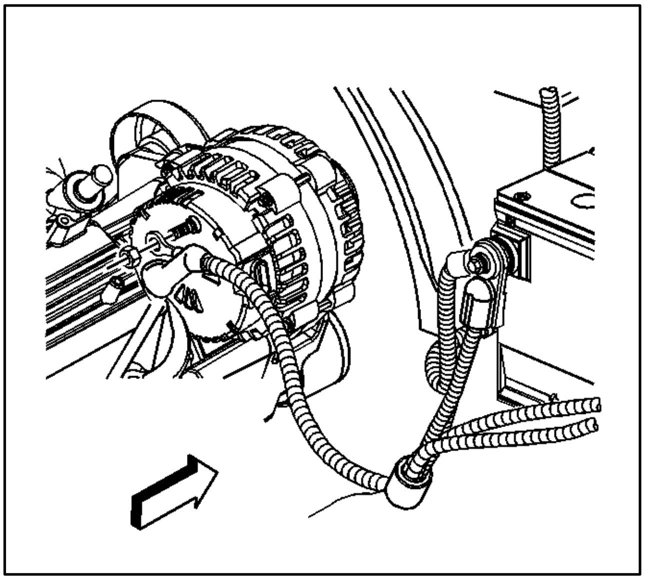
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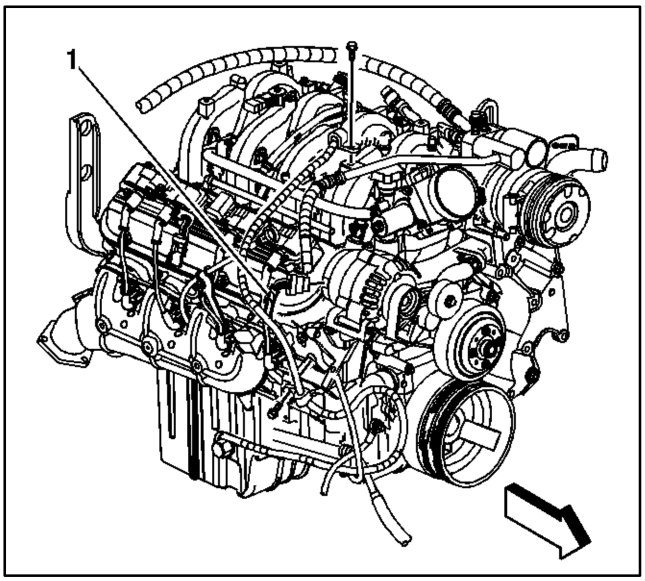
10. Remove the terminal nut and positive power cable from the rear of the generator.



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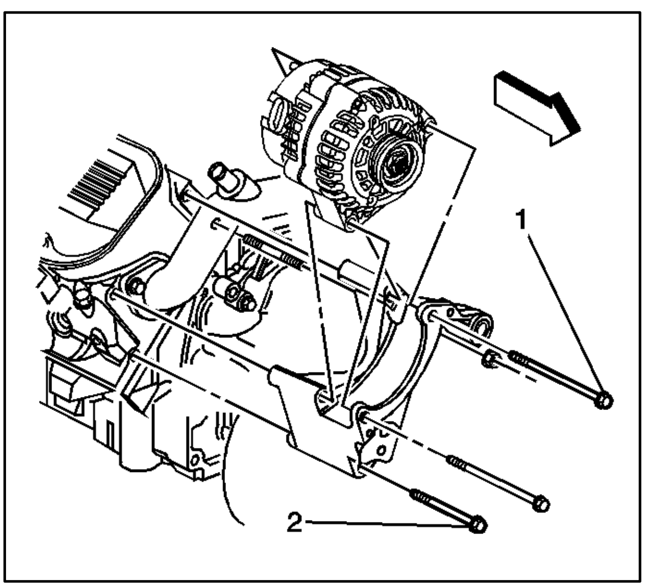
11. Disconnect the electrical connector from the side of the generator.



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12. Remove the generator mounting bolts and the generator from the mounting bracket.

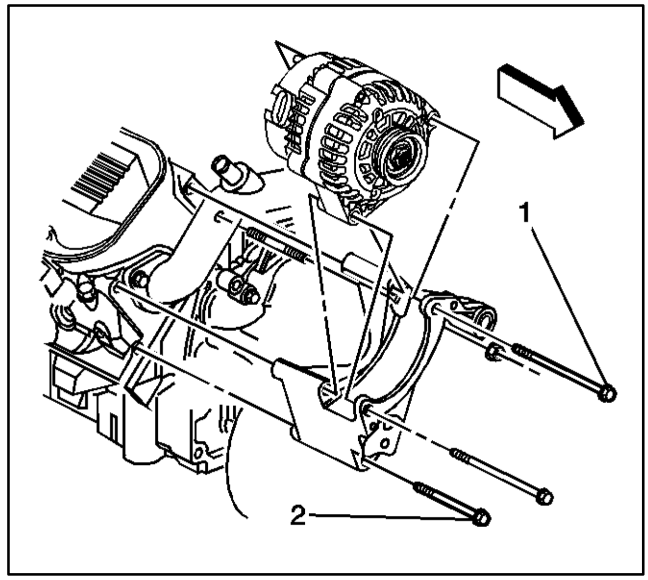
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator and mounting bolts to the mounting bracket.

   Tighten

   Tighten the generator mounting bolts to 50 N·m (37 lb ft).



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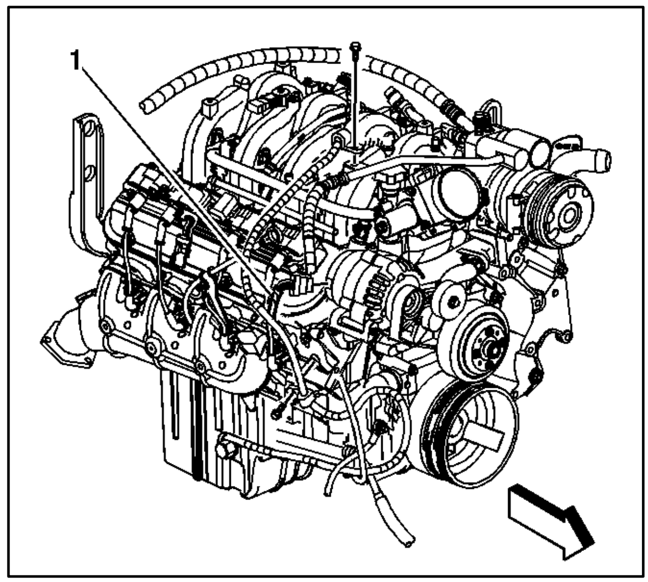
2. Connect the electrical connector to the side of the generator.



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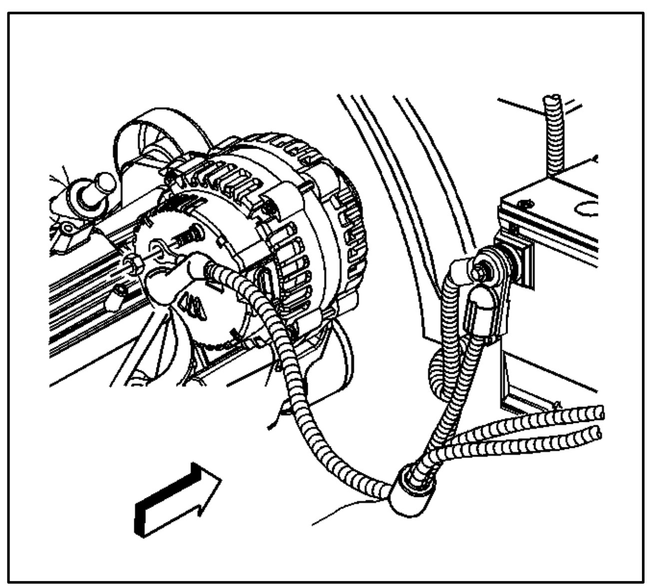
3. Install the positive power cable and terminal inlet to the rear of the generator.

   Tighten

   Tighten the battery terminal nut to 12 N·m (106 lb in).



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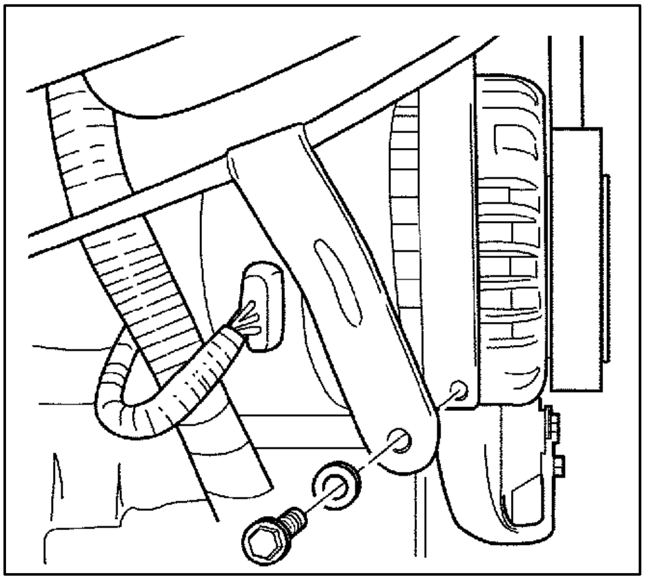
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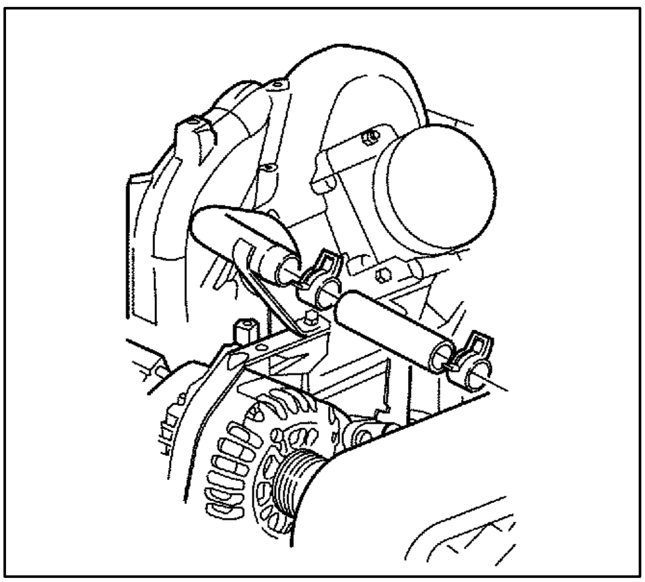
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4. Install the oil level tube indicator bracket to the generator mounting bracket.
5. Install the oil level tube retaining washer and bolt to the oil level indicator tube bracket and the generator bracket.

   Tighten

   Tighten the tube bracket to generator bracket bolt to 12 N·m (106 lb in).
6. Install the transmission dipstick and fill tube bracket to the oil level indicator tube bracket.
7. Install the transmission dipstick and fill tube bracket retaining bolt to the oil level indicator tube bracket.

   Tighten

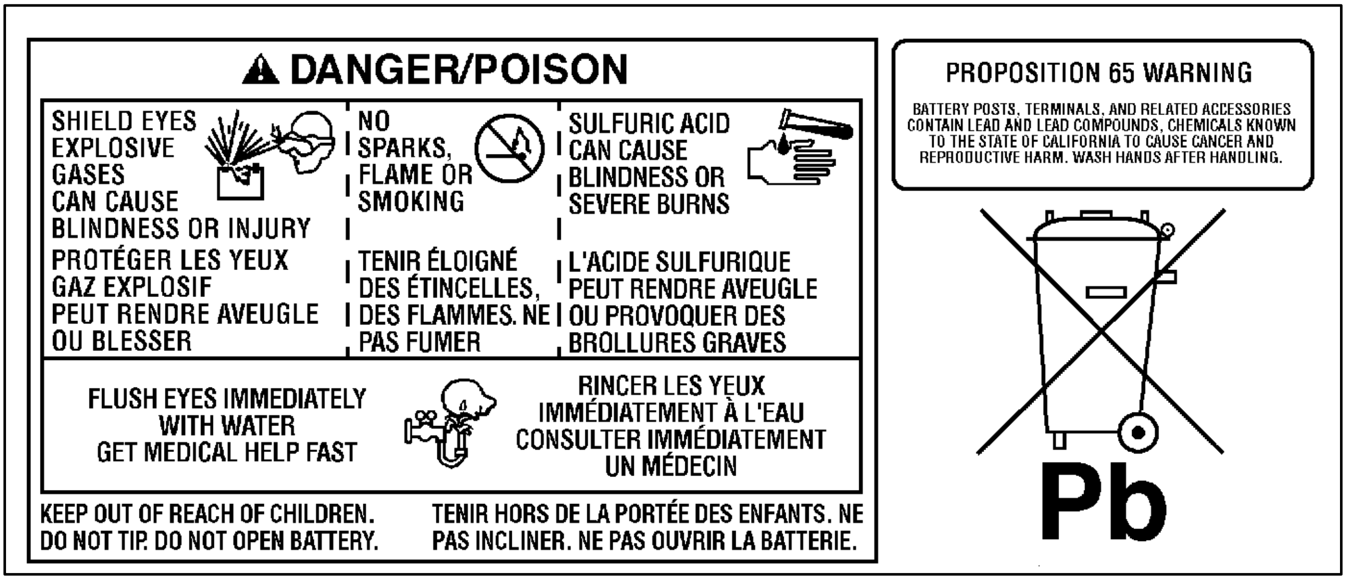
   Tighten the transmission dipstick and fill tube bracket retaining bolt to 12 N·m (106 lb in).
8. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.
9. Install the engine oil fill tube to the oil pipe.
10. Install the MAF/IAT sensor. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.
11. Install the air intake duct to the throttle body and MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
12. Connect the negative battery cable.

Description and Operation

Battery Description and Operation

Caution: Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- ***Always shield your eyes and avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow the battery electrolyte to contact the eyes or the skin. Flush immediately and thoroughly any contacted areas with water and get medical help.***
- ***Follow each step of the jump starting procedure in order.***
- ***Treat both the booster and the discharged batteries carefully when using the jumper cables.***



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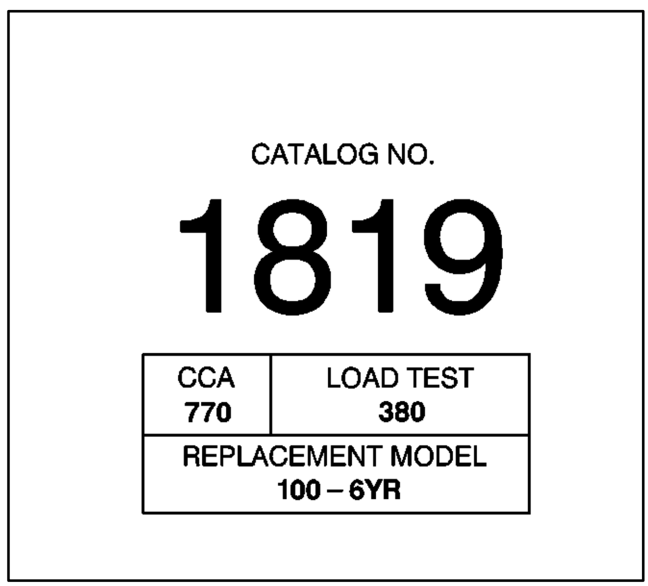
The maintenance free battery is standard. There are no vent plugs in the cover. The battery is completely sealed except for two small vent holes in the side. These vent holes allow the small amount of gas that is produced in the battery to escape.

The battery has three functions as a major source of energy:

- Engine cranking
- Voltage stabilizer
- Alternate source of energy with generator overload.

The battery specification label contains information about the following:

- The test ratings
- The original equipment catalog number
- The recommended replacement model number



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Battery Ratings

A battery has 2 ratings:

- Reserve capacity
- Cold cranking amperage

When a battery is replaced use a battery with similar ratings. Refer to the battery specification label on the original battery or refer to *Battery Usage* in this supplement.

Reserve Capacity

Reserve capacity is the amount of time in minutes it takes a fully charged battery, being discharged at a constant rate of 25 amperes and a constant temperature of 27°C (80°F) to reach a terminal voltage of 10.5 volts. Refer to *Battery Usage* in this supplement for the reserve capacity rating of the original equipment battery.

Cold Cranking Amperage

The cold cranking amperage is an indication of the ability of the battery to crank the engine at cold temperatures. The cold cranking amperage rating is the minimum amperage the battery must maintain for 30 seconds at −18°C (0°F) while maintaining at least 7.2 volts. Refer to *Battery Usage* in this supplement for the cold cranking amperage rating for this vehicle.

Starting System Description and Operation

The PG-260M is a non-repairable starter motor. It has pole pieces that are arranged around the armature within the starter housing. When the solenoid windings are energized, the pull-in winding circuit is completed to ground through the starter motor. The hold-in winding circuit is completed to ground through the solenoid. The windings work together magnetically to pull in and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. At the same time, the plunger closes the solenoid switch contacts in the starter solenoid. Full battery voltage is then applied directly to the starter motor and it cranks the engine.

As soon as the solenoid switch contacts close, current stops flowing thorough the pull-in winding as battery voltage is now applied to both ends of the windings. The hold-in winding remains energized; its magnetic field is strong enough to hold the plunger, shift lever, starter drive assembly, and solenoid switch contacts in place to continue cranking the engine. When the engine starts, the pinion gear overrun sprag protects the armature from excessive speed until the switch is opened.

When the ignition switch is released from the CRANK position, voltage is removed from the starter solenoid S terminal. Current flows from the motor contacts through both windings to ground at the end of the hold-in winding. However, the direction of the current flow through the pull-in winding is now in the opposite direction of the current flow when the winding was first energized.

The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter motor is turned off.

Charging System Description and Operation

Generator

The AD-230 and AD-244 generators are non-repairable. They are electrically similar to earlier models. The generators feature the following major components:

- The delta stator
- The rectifier bridge
- The rotor with slip rings and brushes
- A conventional pulley
- Dual internal fans
- A voltage regulator

The pulley and the fan cool the slip ring and the frame.

The AD stands for Air-cooled Dual internal fan; the 2 is an electrical design designator; the 30/44 denotes the outside diameter of the stator laminations in millimeters, over 100 millimeters. The generators is rated at 105 and 130 amperes respectively.

The generator features permanently lubricated bearings. Service should only include the tightening of mounting components. Otherwise, the generator is replaced as a complete unit.

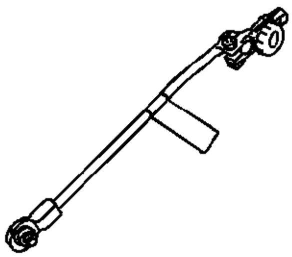
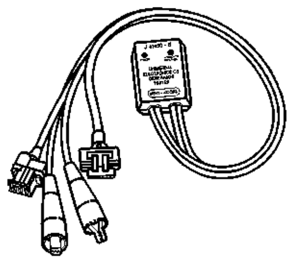
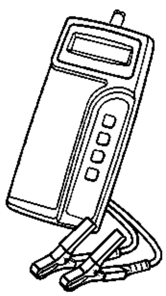
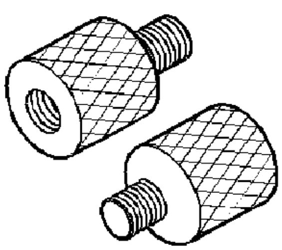
Regulator

The voltage regulator controls the field current of the rotor in order to limit system voltage. The regulator switches the current on and off at a rate of 400 cycles per second in order to perform the following functions:

- Radio noise control
- Obtain the correct average current needed for proper system voltage control

At high speeds, the on-time may be 10 percent with the off-time at 90 percent. At low speeds, the on-time may be 90 percent and the off-time 10 percent.

Special Tools and Equipment

Illustration	Tool Number/ Description
 3432	Parasitic Draw Test Switch Tool
 317080	CS Generator Electronic Tester
 404758	Digital Battery Tester
 3431	Battery Side Terminal Adapters

ENGINE CONTROLS

8.1L

Diagnostic Information and Procedures

Diagnostic Starting Point – Engine Electrical

Begin the system diagnosis with the following *Diagnostic System Check – Engine Electrical*. The Diagnostic System Check will provide the following information:

- The identification of the control module(s) which command the system.
- The ability of the control module(s) to communicate through the serial data circuit.
- The identification of any stored diagnostic trouble codes (DTCs) and their status.

The use of the Diagnostic System Check will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check – Engine Electrical

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. Lack of communication may be due to a partial malfunction of the class 2 serial data circuit or due to a total malfunction of the class 2 serial data circuit. The specified procedure will determine the particular condition.
4. The symptom list in Symptoms will determine the correct diagnostic procedure to use.
5. The presence of DTCs which begin with U indicate some other module is not communicating. The specified procedure will compile all the available information before tests are performed.

Diagnostic System Check – Engine Electrical

Step	Action	Yes	No
1	Perform the Battery Inspection/Test. Refer to *Battery Inspection/ Test* in this supplement. Does the battery pass the test?	Go to *Step 2*	Go to *Battery Inspection/Test* in this supplement
2	Install a scan tool. Does the scan tool power up?	Go to *Step 3*	Go to *Scan Tool Does Not Power Up* in this supplement
3	1. Turn ON the ignition, with the engine OFF. 2. Attempt to communicate with each module on the class 2 serial data circuit. (If using a Tech 2, obtain this information using the Class 2 Message Monitor feature.) Does the scan tool communicate with any module on the class 2 serial data circuit?	Go to *Step 4*	Go to *Scan Tool Does Not Communicate with Class 2 Device* in this supplement
4	1. Select the Display DTCs function for each module. (If using a Tech 2, use the Class 2 DTC Check feature in order to determine which modules have DTCs set.) 2. Record all of the displayed DTCs, the DTC status, and the module which set the DTC. Does the scan tool display any DTCs?	Go to *Step 5*	Go to *Symptoms – Engine Electrical* in this supplement
5	Does the scan tool display any DTC beginning with U?	Go to *Diagnostic Trouble Code (DTC) List* in this supplement	Go to *Diagnostic Trouble Code (DTC) List* in this supplement

Scan Tool Data List

Powertrain Control Module (PCM)

Scan Tool Parameter	Data List	Units Displayed	Typical Data Value
Ignition ON/Engine OFF **(8.1L L18)**			
Ignition 1 Signal	Engine 1, 2 Data	Volts	9 – 14V
GEN L – Terminal Signal Command	Engine 2 Data	OK/No Output	OK
GEN F – Terminal Signal	Engine 2 Data	%	10 – 90%

Scan Tool Data Definitions

Ignition 1 Signal: The scan tool displays the current voltage at the battery.

GEN L – Terminal Signal Command: The scan tool displays OK/No Output. The scan tool displays OK until malfunction is detected on the generator L terminal circuit, then it reads No Output.

GEN F – Terminal Signal: The scan tool displays 0% – 100%. The scan tool displays 0% – 5% until the engine is running, then the percentage value varies depending on electrical loads.

Diagnostic Trouble Code (DTC) List

DTC	Diagnostic Procedure	Module(s)
P0562	DTC P0562	PCM
P0563	DTC P0563	PCM
P1637	DTC P1637	PCM
P1638	DTC P1638	PCM
U1300	DTC U1300	TCSCM, PCM, EBCM
U1301	DTC U1301	TCSCM, PCM, EBCM

DTC P0562

Circuit Description

The PCM monitors the system voltage to make sure that the voltage stays within the proper range. If the PCM detects an excessively low system voltage, DTC P0562 will set.

When the charging system detects a fault, the instrument panel cluster (IPC) displays a message or the charge indicator will light.

Conditions for Running the DTC

- Engine run time more than 20 seconds and above 1200 RPM.
- Vehicle speed above 8 km/h (5 mph).

Conditions for Setting the DTC

- The PCM detects an improper voltage below 11 volts for 5 seconds.

Action Taken When the DTC Sets

- The PCM stores the DTC information into memory when the diagnostic runs and fails.
- The PCM will store conditions which were present when the DTC set as Failure Records data only.
- The PCM disables most outputs.
- The transmission defaults to a predetermined gear.
- The torque converter clutch (TCC) operation is inhibited.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The powertrain control module (PCM) receives the clear code command from the scan tool.

DTC P0562

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	With the scan tool monitor the Ignition 1 signal voltage in the PCM data list. Does the scan tool display Ignition 1 voltage greater than the specified value?	11 V	Go to *Step 4*	Go to *Step 3*
3	Test the ignition feed circuit to the PCM for high resistance or open. Did you find and correct the condition?	—	Go to *Step* 7	Go to *Step 5*
4	1. Inspect for poor connections at the PCM. 2. If you find a poor connection, repair the condition as necessary. Did you find and correct the condition?	—	Go to *Step* 7	Go to *Step 6*
5	Repair the ignition feed circuit to the PCM for an open or a short to ground. Is the action complete?	—	Go to *Step* 7	—
6	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step* 7	—
7	1. Select the Diagnostic Trouble Code (DTC) option and the Clear DTC Information option using the scan tool. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text, if applicable. Does the DTC reset?	—	Go to *Step 2*	System OK

DTC P0563

Circuit Description

The powertrain control module (PCM) continuously monitors that the system voltage stays within the proper range. If the PCM detects an excessively high system voltage, DTC P0563 will set. A high voltage condition may cause a stalling condition or other driveability concerns.

Conditions for Running the DTC

- The engine run time is more than 20 seconds.
- Engine running above 1200 RPM.
- Vehicle speed above 8 km/h (5 mph).

Conditions for Setting the DTC

- The PCM senses the system voltage is above 19 volts.
- All of the conditions are present for 5 seconds.

Action Taken When the DTC Sets

- The PCM stores DTC P0563 in the PCM memory when the diagnostic runs and fails.
- The PCM will record the operating conditions at the time the diagnostic fails. The PCM stores this information in Failure Records.
- The PCM disables most outputs.
- The transmission defaults to a predetermined gear.
- The torque converter clutch (TCC) operation is inhibited.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P0563

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Turn OFF all the accessories. 2. Measure the battery voltage at the battery using the DMM. 3. Operate the engine speed above 2000 RPM. Is the battery voltage less than the specified value?	19 V	Go to *Step 4*	Go to *Step 3*
3	Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Is the action complete?	—	Go to *Step 5*	—
4	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 5*	—
5	1. Select the Diagnostic Trouble Code (DTC) option and the Clear DTC Information option using the scan tool. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text, if applicable. Does the DTC reset?	—	Go to *Step 2*	System OK

DTC P1637

Circuit Description

The PCM uses the generator turn on signal circuit to control the load of the generator on the engine. A high side driver in the PCM applies a voltage to the voltage regulator. This signals the voltage regulator to turn the field circuit ON and OFF. When the PCM turns ON the high side driver, the voltage regulator turns ON the field circuit. When the PCM turns OFF the high side driver, the voltage regulator turns OFF the field circuit.

The PCM monitors the state of the generator turn on signal circuit. The PCM should detect a low generator turn on signal circuit voltage when the key is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the PCM should detect a high generator turn on signal circuit. The PCM performs key ON and RUN tests to determine the status of the generator turn on signal circuit. During the key ON test, if the PCM detects a high generator turn on signal circuit voltage, DTC P01637 will set. DTC P1637 will also set if, during the RUN test, the PCM detects a low generator turn on signal circuit. When the DTC sets, the PCM will turn on the charge indicator in the IPC.

Conditions for Running the DTC

- The ignition is ON.
- The engine speed is more than 1000 RPM.

Conditions for Setting the DTC

- The PCM detects the GEN L–Terminal active with the ignition ON.
- The PCM detects the GEN L–Terminal inactive with the engine operating.
- The above conditions are present for 6 seconds.

Action Taken When the DTC Sets

- The PCM will record the operating conditions present when the DTC set as Failure Records data only.
- The instrument panel cluster (IPC) displays a message.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P1637

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, monitor the DTC information for DTC P1637 in Engine Controls. Does the scan tool indicate that DTC P1637 has passed?	—	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Test the generator turn on signal circuit for a short or open. Did you find and correct the condition?	—	Go to *Step 6*	Go to *Step 4*
4	Inspect for poor connections at the harness connector of the PCM. Did you find and correct the condition?	—	Go to *Step 6*	Go to *Step 5*
5	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 6*	—
6	1. Review and record the scan tool Fail Records data. 2. Clear any DTCs. 3. Operate the vehicle within the Fail Records conditions as noted. 4. Using a scan tool, monitor the specific DTC info for this DTC. Does the scan tool indicate that this DTC failed this ignition?	—	Go to *Step 2*	System OK

DTC P1638

Circuit Description

The PCM uses the generator field duty cycle signal circuit to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to the high side of the field winding in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field winding ON and OFF. The PCM uses the PWM signal input to determine the generator load on the engine. This allows the PCM to adjust the idle speed to compensate for high electrical loads.

The PCM monitors the state of the generator field duty cycle signal circuit. When the key is in the RUN position and the engine is OFF, the PCM should detect a duty cycle near 0 percent. However, when the engine is running, the duty cycle should be between 5 percent and 100 percent. The PCM monitors the PWM signal using a key ON test and a RUN test. During the tests, if the PCM detects an out of range PWM signal, DTC P1638 will set. When the DTC sets, the PCM will turn on the charge indicator in the IPC.

Conditions for Running the DTC

Key ON Test

- No generator, CKP sensors, or CMP sensor DTCs are set.
- The key is in the RUN position.
- The engine is not running.

Run Test

- No generator, CKP sensors, or CMP sensor DTCs are set.
- The engine is less than 3000 RPM.

Conditions for Setting the DTC

- During the ignition ON test, the PCM detects a PWM signal is between10 – 40 percent for more than 6 seconds.
- During the RUN test, the PCM detects a PWM signal less then 5 percent for more than 6 seconds.

Action Taken When the DTC Sets

- The PCM will store the conditions present when the DTC sets as Fail Records data only.
- The malfunction indicator lamp (MIL) will not illuminate.

Conditions for Clearing the DTC

- The Conditions for Setting the DTC are no longer present.
- A history DTC will clear after 40 malfunction free ignition cycles.
- The Powertrain Control Module (PCM) receives the clear code command from the scan tool.

DTC P1638

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Engine Electrical Diagnostic System Check?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool, observe the GEN – F Terminal parameter in the PCM data list. Does the scan tool indicate that the GEN – F Terminal parameter is within the specified range?	10 – 95%	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Connect test lamp to battery positive voltage. 4. Turn ON the ignition, with the engine OFF. 5. Probe the F Terminal in the generator connector with the test lamp. 6. Observe the GEN – F Terminal Signal parameter in the PCM data list. Is the GEN – F Terminal Signal parameter near the specified value?	100%	Go to *Charging System Test* in this supplement	Go to *Step 4*
4	Test the generator field duty cycle signal circuit for a short or open. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 5*

DTC P1638 (cont'd)

Step	Action	Value(s)	Yes	No
5	Inspect for poor connections at the harness connector of the PCM. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 6*
6	**Important:** The replacement PCM must be programmed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Is the action complete?	—	Go to *Step 7*	—
7	1. Review and record the scan tool Fail Records data. 2. Clear any DTCs. 3. Operate the vehicle within the Fail Records conditions as noted. 4. Using a scan tool, monitor the Specific DTC info for this DTC. Does the scan tool indicate that this DTC failed this ignition?	—	Go to *Step 2*	System OK

Symptoms – Engine Electrical

Important: The following steps must be completed before using the symptom tables.

1. Perform *Diagnostic System Check – Engine Electrical* before using the Symptom Tables in order to verify that all of the following are true:
   - There are no DTCs set.
   - The control module(s) can communicate via the serial data link.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to one of the following system operations in this supplement:
   - *Battery Description and Operation*
   - *Starting System Description and Operation*
   - *Charging System Description and Operation*

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Starting and Charging Systems. Refer to *Checking Aftermarket Accessories* in the WCC Service Manual.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- *Starter Solenoid Does Not Click*
- *Starter Solenoid Clicks, Engine Does Not Crank*
- *Engine Cranks Slowly*
- *Battery Inspection/Test*
- *Charge Indicator Always On (8.1L)*
- *Charge Indicator Inoperative (8.1L)*
- *Charging System Test*
- *Generator Noise Diagnosis*

Starter Solenoid Does Not Click

Step	Action	Yes	No
Schematic Reference: *Starting and Charging Schematics*			
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn the ignition switch to the START position. Does the engine crank?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Turn the ignition switch to the START position. Does the starter motor relay click?	Go to *Step 7*	Go to *Step 4*
4	1. Remove the starter motor relay. 2. Connect a test light from the supply voltage circuit of the starter motor relay coil circuit to ground. 3. With the transmission in park, turn the ignition switch to the START position. Does the test light illuminate?	Go to *Step 5*	Go to *Step 6*
5	1. Connect a test light from the supply voltage circuit of the starter motor relay coil circuit to the control circuit of the starter motor relay coil circuit. 2. With the transmission in park, turn the ignition switch to the START position. Does the test light illuminate?	Go to *Step 13*	Go to *Step 10*
6	1. Turn OFF the ignition. 2. Disconnect the Park Neutral Position (PNP) switch. Refer to *Park/Neutral Position Switch Replacement* in this supplement. 3. Turn ON the ignition, with the engine OFF. 4. Connect a 10 amp fused jumper between the starter motor relay coil control circuits of the PNP switch. 5. With the transmission in park, turn the ignition switch to the START position. Does the scan tool display any DTCs?	Go to *Step 14*	Go to *Step 11*
7	1. Turn OFF the ignition. 2. Remove the starter motor relay. 3. Connect a test lamp between the battery positive voltage circuit of the starter motor relay switch circuit and a good ground. Does the test lamp illuminate?	Go to *Step 8*	Go to *Step 17*
8	Connect a 30 amp fused jumper between the battery positive voltage circuit of the starter motor relay switch circuit and the supply voltage circuit of the starter solenoid. Does the engine crank?	Go to *Step 13*	Go to *Step 9*
9	Does the fuse in the jumper open?	Go to *Step 18*	Go to *Step 12*
10	Test the control circuit of the starter motor relay for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 19*
11	Test the supply voltage circuit of the starter motor relay coil circuit for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 15*
12	Test the supply voltage circuit of the starter solenoid for an open or high resistance. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 16*

Starter Solenoid Does Not Click (cont'd)

Step	Action	Yes	No
13	Inspect for poor connections at the starter motor relay. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 19*
14	Inspect for poor connection at the PNP switch harness connector. If OK, perform the *Park/Neutral Position Switch Adjustment* in this supplement. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 20*
15	Inspect for poor connections at the ignition switch harness connector. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 21*
16	Inspect for poor connections at the starter solenoid. Did you find and correct the condition?	Go to *Step 23*	Go to *Step 22*
17	Repair the open or high resistance in the battery positive voltage circuit of the starter motor relay switch circuit. Did you complete the repair?	Go to *Step 23*	—
18	Repair the short to ground in the supply voltage circuit of the starter solenoid. Did you complete the repair?	Go to *Step 23*	—
19	Replace the starter motor relay. Did you complete the replacement?	Go to *Step 23*	—
20	Replace the PNP switch. Refer to *Park/Neutral Position Switch Replacement* in this supplement. Did you complete the replacement?	Go to *Step 23*	—
21	Replace the Ignition Switch. Refer to *Ignition Switch Replacement – On Vehicle* (Tilt Column) in this supplement. Did you complete the replacement?	Go to *Step 23*	—
22	Replace the starter. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 23*	—
23	Operate the system for which the symptom occurred. Did you correct the condition?	System OK	Go to *Step 2*

Starter Solenoid Clicks, Engine Does Not Crank

Step	Action	Yes	No
Schematic Reference: *Starting and Charging Schematics*			
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn the ignition switch to the START position. Does the starter solenoid click?	Go to *Step 3*	Go to *Starter Solenoid Does Not Click* in this supplement
3	Inspect the engine and belt drive system for mechanical binding (seized engine, seized generator). Does the engine move freely?	Go to *Step 4*	Go to *Engine Will Not Crank – Crankshaft Will Not Rotate* in this supplement
4	Test the battery positive cable between the battery and the starter solenoid for high resistance. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 5*
5	Test the ground circuit between the battery and the starter motor for a high resistance. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 6*
6	Inspect for poor connections at the starter. Did you find and correct the condition?	Go to *Step 8*	Go to *Step 7*
7	Replace the starter. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 8*	—
8	Operate the system for which the symptom occurred. Did you correct the condition?	System OK	Go to *Step 2*

Engine Cranks Slowly

Perform the following checks:

- Battery – Battery Inspection/Test. Refer to *Battery Inspection/Test* in this supplement.
- Wiring – Inspect the wiring for damage. Inspect all connections to the starter motor, solenoid, battery, and all ground connections. Refer to *Intermittents and Poor Connections* Diagnosis in the WCC Service Manual.
- Engine – Make sure the engine is not seized. Refer to *Symptoms – Engine Mechanical* in this supplement.

If the battery, the wiring and the engine are functioning properly and the engine continues to crank slowly, replace the starter motor. Refer to *Starter Motor Replacement* in this supplement.

Charge Indicator Always On (8.1L)

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Start the engine. Does the charge indicator remain illuminated?	Go to *Step 3*	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Turn ON the ignition, with the engine OFF. Does the charge indicator remain illuminated?	Go to *Step 4*	Go to *Charging System Test* in this supplement

Charge Indicator Always On (8.1L) (cont'd)

Step	Action	Yes	No
4	Test the charge indicator control circuit for a short to ground. Did you find and correct the condition?	Go to *Step 6*	Go to *Step 5*
5	**Important:** The replacement PCM must be programed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Did you complete the replacement?	Go to *Step 6*	—
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Charge Indicator Inoperative (8.1L)

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Turn ON the ignition, with the engine OFF. Observe the charge indicator on the instrument panel cluster (IPC). Is the charge indicator illuminated?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Disconnect the generator connector. 3. Connect a 3 amp fused jumper wire between the charge indicator control circuit and a good ground. 4. Turn ON the ignition, with the engine OFF. Does the charge indicator remain OFF?	Go to *Step 4*	Go to *Charging System Test* in this supplement
4	Test the charge indicator control circuit for an open or high resistance. Did you find and correct the condition?	Go to *Step 7*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Inspect the charge indiactor lamp for an open and replace if necessary. Did you find and correct the condition?	Go to *Step 7*	Go to *Step 6*
6	**Important:** The replacement PCM must be programed. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board)* in this supplement. Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement* in this supplement. Did you complete the replacement?	Go to *Step 7*	—
7	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Battery Inspection/Test

Tools Required

J 42000 Digital Battery Tester

Diagnostic Aids

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

Important: The battery test using the *J 42000* requires correct connections to the battery terminals. A failure to obtain the correct connections during the test may result in a failed test on a good battery.

Follow these instructions in order to avoid an incorrect diagnosis because of connections:

- If testing the vehicle with the battery cables still connected, wiggle the *J 42000* clips on the terminal bolt. This may cut through any coating or through any oxidation that may be present on the bolt.
  Even new bolts contain a protective coating that may insulate or cause a resistance in the test circuit.
- If correct connections to the battery terminal bolts in the vehicle are in doubt, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the test adapters on the terminals.
  4. Follow the instructions for testing a removed battery.
- If the tester displays a REPLACE BATTERY result for a battery tested in the vehicle with the battery cables connected, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Install the tester adapters.
  4. Follow the instructions for testing a removed battery.
  5. Replace the battery only if the second test shows a REPLACE BATTERY result.
     Use the test code from the second test for any warranty purposes.
- Use the correct terminal adapters.
  Do not use any common bolts or a combination of bolts, of nuts, and of washers as adapters when testing the battery.
- Use the test adapters that are provided with the *J 42000* or P/N 12303040 terminal adapters. If the adapters that are provided with the *J 42000* require replacement, use P/N 12303040. Any other adapter may not contact the correct areas of the battery terminal, causing a resistance that may result in an invalid battery test result.

Important: Always write the test code displayed by the tester on the repair order for any warranty purposes. The number is a unique code that describes the test data for a particular battery at a particular time. The test code may occasionally repeat when you retest the same battery. More often, each test will result in a different code. Use the test code from the second, or out of vehicle, test.

Battery Inspection/Test

Step	Action	Value(s)	Yes	No
Caution: Refer to Battery Disconnect Caution in Cautions and Notices.				
1	Inspect the battery for a cracked, broken, or damaged case, which may be indicated by battery acid leakage. Is the battery OK?	—	Go to *Step 2*	Go to *Step 19*
2	Compare the cold cranking amperage (CCA) and reserve capacity (RC) of the battery to the original battery or original equipment (OE) specification. Refer to *Battery Usage* in this supplement. Does the battery meet or exceed the specifications?	—	Go to *Step 3*	Go to *Step 19*
3	Does the hydrometer display a yellow dot?	—	Go to *Step* 4	Go to *Step 5*
4	Tap the hydrometer lightly on top with the handle of a small screwdriver in order to dislodge any air bubbles inside the battery. Does the hydrometer still display a yellow dot?	—	Go to *Step 19*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Attempt to rotate the negative battery cable connector clockwise with light finger pressure. Does the negative connector rotate?	—	Go to *Step 6*	Go to *Step 7*
6	Use a torque wrench in order to verify the torque to loosen the negative battery terminal bolt. Is the torque above the specified value?	10 N·m (88 lb in)	Go to *Step 8*	Go to *Step 7*

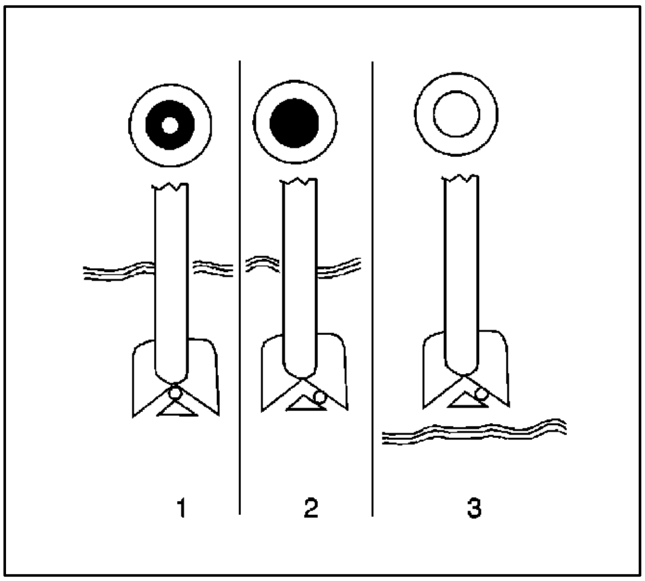
Battery Inspection/Test (cont'd)

Step	Action	Value(s)	Yes	No
7	Disconnect the negative battery cable. Is the cable disconnected?	—	Go to *Step 9*	—
8	1. Disconnect the negative battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end. • There is foreign material present inside the nut in the battery terminal. • Damage to the battery terminal face or cable connector ring. Is the repair complete?	—	Go to *Step 9*	—
9	Rotate the positive battery cable connector clockwise with light finger pressure. Does the positive connector rotate?	—	Go to *Step 10*	Go to *Step 11*
10	Use a torque wrench in order to verify the torque to loosen the positive battery terminal bolt. Is the torque above the specified value?	10 N·m (88 lb in)	Go to *Step 12*	Go to *Step 11*
11	Disconnect the positive battery cable. Is the cable disconnected?	—	Go to *Step 13*	—
12	1. Disconnect the positive battery cable. 2. Inspect for the following conditions and repair as needed: • The cable bolt is too long or deformed at the end. • There is foreign material present inside the nut in the battery terminal. • Damage to the battery terminal face or cable connector ring. Is the repair complete?	—	Go to *Step 13*	—
13	1. Clean and wire brush the lead face of both battery terminals and the metal contact rings in both cable connectors. 2. Remove the bolts from the cable connectors in order to provide access to the connector rings as needed. 3. If either of the battery terminals or the cable rings are excessively damaged or corroded, replace as needed. Are the metal connecting parts clean and in good condition?	—	Go to *Step 14*	—
14	1. Connect the positive battery cable to the battery positive terminal. 2. Tighten the cable bolt to the specified value. Is the cable bolt properly tightened?	15 N·m (11 lb ft)	Go to *Step 15*	—
15	1. Connect the negative battery cable to the battery negative terminal. 2. Tighten the cable bolt to the specified value. Is the cable bolt properly tightened?	15 N·m (11 lb ft)	Go to *Step 16*	—
16	**Important:** Ensure that all of the electrical loads are turned OFF. 1. Install the *J 42000*. 2. Follow the directions supplied with the tester. 3. Follow any direction displayed on the tester. Did the tester pass the battery?	—	Go to *Step 17*	Go to *Step 18*

Battery Inspection/Test (cont'd)

Step	Action	Value(s)	Yes	No
17	1. Press the CODE button on the *J 42000*. 2. For warranty purposes, write the displayed code on the repair order. Did you complete this action?	—	Battery OK	—
18	1. Press the CODE button on the *J 42000*. 2. For warranty purposes, write the displayed code on the repair order. 3. Replace the battery. Refer to *Battery Replacement* in the WCC Service Manual. Did you complete the replacement?	—	Battery OK	—
19	Replace the battery. Refer to *Battery Replacement* in the WCC Service Manual. Did you complete the replacement?	—	Battery OK	—

Battery Charging



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- For best results, use an automatic taper-rate battery charger with a voltage capability of 16 volts.
- A battery showing a green dot in the hydrometer (1) does not need to be charged unless the *J 42000* has shown that the battery needs to be charged.
- A battery showing a dark dot in the hydrometer (2) should be charged unless the *J 42000* has indicated no charge is needed.
- Do not charge a battery when the built in hydrometer is clear or yellow in the center (3). Tap the hydrometer lightly in order to dislodge any air bubbles. The bubbles may cause a false indication. If the hydrometer is still clear or yellow, replace the battery.
- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen; allow the battery to warm to room temperature and test it before charging.

Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

1. The battery charger capacity. The higher the charger's amperage, the less time it will take to charge the battery.
2. The state-of-charge of the battery. A completely discharged battery requires more than twice as much charging time as a half charged battery. In a discharged battery with a voltage below 11 volts, the battery has a very high internal resistance and may only accept a very low current at first. Later, as the charging current causes the acid content to increase in the electrolyte, the charging current will increase. Extremely discharged batteries may not activate the reversed voltage protection in some chargers. Refer to the manufacturers instructions for operating this circuitry.
3. The temperature of the battery. The colder the battery is, the more time it takes to recharge the battery. The charging current accepted by a cold battery is very low at first; then, as the battery warms, the charging current will increase.

Charging Procedure

Notice: Turn OFF the ignition when connecting or disconnecting the battery cables, the battery charger or the jumper cables. Failure to do so may damage the PCM or other electronic components.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

When charging side-terminal batteries with the battery cables connected, connect the charger to the positive cable bolt and to a ground located away from the battery. When charging side-terminal batteries with the battery cables disconnected, install the battery side terminal adapters and connect the charger to the adapters.

Tighten

Tighten the battery side terminal adapters to 15 N·m (11 lb ft).

Use the following procedure to charge the battery:

1. Turn OFF the charger.
2. Ensure that all of the battery terminal connections are clean and tight.
3. Connect the charger positive lead to the battery positive terminal.

Notice: Do not connect the negative charger lead to the housings of other vehicle electrical accessories or equipment. The action of the battery charger may damage such equipment.

4. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.
5. Turn ON the charger and set to the highest setting for normal charging.
6. Inspect the battery every half hour after starting the battery charger.
   - Charge the battery until the hydrometer has a green dot or until the taper-rate charger indicates that the battery is fully charged, whichever occurs first.
   - Tap the hydrometer lightly in order to dislodge any air bubbles. The bubbles may cause a false indication.
   - Estimate the battery temperature by feeling the side of the battery. If it feels hot to the touch or its temperature is over 45°C (125°F), discontinue charging and allow the battery to cool before resuming charging.
7. After charging, test the battery. Refer to *Battery Inspection/Test* in this supplement.

Battery Electrical Drain/Parasitic Load Test

Battery Electrical Drain

If the vehicle exhibits a low or dead battery after an overnight period, or discharges over a period of 2 or 3 days, the electrical system should be checked for an excessive electrical drain. This is referred to as parasitic current drain.

If a battery needs recharging and no cause is evident, check the vehicle for excessive parasitic current drain.

One or more on-board solid state control modules, such as the PCM, may at some time exhibit a failure mode that causes a high parasitic drain on the vehicle's battery. When the battery is disconnected to install an ammeter, etc., the excessive current drain may not occur once the circuit continuity is restored. Even though cycling the ignition key to the RUN and then to the OFF position may cause such a drain to recur, there may be drains that will not recur unless the vehicle systems are reactivated in a road test. Since the ignition switch must not be rotated to the ACCESSORY, RUN or START position with an ammeter installed between the battery terminal and the battery cable, a current drain test tool must be used as described in the following procedures.

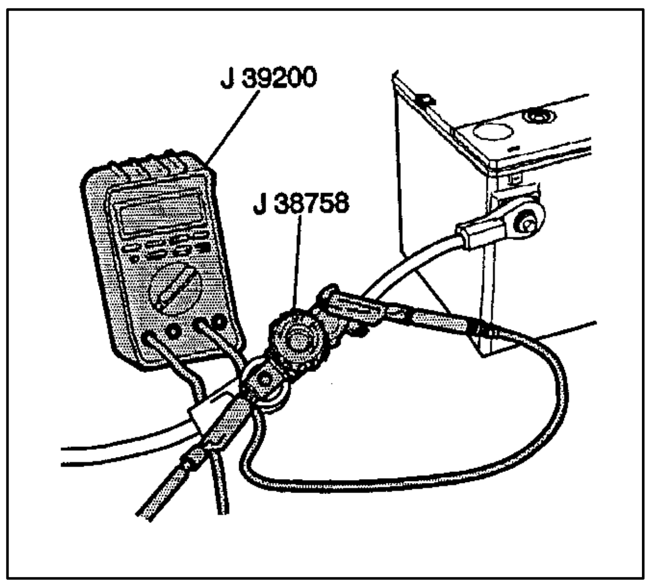
Before starting this procedure, ensure that the ignition switch is in the LOCK position, all electrical accessories are turned OFF, the door glass is open and the doors are closed.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

Notice: Do not turn the parasitic draw test switch to the OFF position with the engine running. Damage will occur to the vehicle's electrical system.

Notice: The test switch must be in the ON position when removing the fuses in order to maintain continuity in the electrical system. This avoids damaging the digital multimeter due to accidental overloading, such as a door being opened to change a fuse.

1. Disconnect the battery negative cable.



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2. Install the male end of the *J 38758* to the battery negative terminal.
3. Turn OFF the test switch.
4. Install the battery negative cable to the female end of the test switch.
5. Turn ON the test switch.
6. Road test the vehicle while activating all accessories, including the radio and the air conditioning.

7. Turn OFF the ignition switch. Remove the key.

Important: From this point on, electrical continuity must be maintained in the ground circuit of the battery through the *J 38758* in the ON position or through the *J 39200*.

8. Components such as PCM have timers that draw several amps of current while they cycle down. This can give a false parasitic drain reading. Wait 15 minutes for these components to power down before continuing this test.
9. Set the *J 39200* to the 10 A scale.

Important: If an ammeter other than the *J 39200* is used, ensure that the vehicle does not have a high current drain that would damage the ammeter when connected to the circuit. This can be done using the following procedure:

   9.1. Connect a jumper wire with an in-line 10 A fuse *J 36169-A* to the terminals of the test switch.
   9.2. Turn the test switch to the OFF position.
   9.3. Wait ten seconds.
   9.4. If the fuse does not blow, the current is less than 10 A and the ammeter can be used safely.
   9.5. Turn the test switch to the ON position before the fused jumper wire is removed and the multimeter is installed.

10. Connect the ammeter to the test switch terminals.
11. Turn OFF the test switch. This allows the current to flow through the ammeter.
12. Wait at least 60 seconds, then check the current reading.
    - When there is a current reading of 2 A or less, turn ON the test switch, this maintains continuity in the electrical system.
    - Then, switch the meter down to the 2 A scale, for a more accurate reading, when the test switch is reopened.
13. Take the reading in milli-amps.
14. Note the battery reserve capacity. Refer to *Battery Usage* in this supplement.
    - Divide this number by 4.
    - Compare this to the multimeter reading.
    - The current drain should not exceed this number.
    - Example: If a battery has a reserve capacity of 100 minutes, the current drain should not exceed 25 milli-amps. If the vehicle has a diesel engine with 2 batteries, add the reserve capacities together and divide this total by four.

Notice: Always turn the test switch knob to the ON position before removing each fuse to maintain continuity in the electrical system and to avoid damaging the meter due to accidental overloading, such as opening a door to change a fuse.

15. When the current draw is too high, remove the electrical system fuses one at a time until the draw returns to a value less than or equal to specifications.
16. Repeat the parasitic current drain test procedure after any repair has been completed.
17. When the cause of the excessive current draw has been located and repaired, remove the meter and the parasitic draw test switch and terminal adapters.
18. Connect the negative cable to the battery negative terminal.

Battery Common Causes of Failure

A battery is not designed to last forever. With proper care, however, the battery will provide years of good service. If the battery tests good but still fails to perform well, the following are some of the more common causes:

1. A vehicle accessory was left on overnight.
2. The driving speeds have been slow with frequent stops (stop-and-go driving) with many electrical accessories in use, particularly air conditioning, headlights, wipers, heated rear window, cellular telephone, etc.
3. The electrical load has exceeded the generator output (particularly with the addition of aftermarket equipment).
4. Existing conditions in the charging system, including the following possibilities:
   - A slipping belt
   - A bad generator
5. The battery has not been properly maintained, including a loose battery hold down or missing battery insulator if used.
6. There are mechanical conditions in the electrical system, such as a short or a pinched wire, attributing to power failure. Refer to *General Electrical Diagnosis Procedures* in the WCC Service Manual.

Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. A fully charged battery will not freeze until the ambient temperature gets below −54°C (−65°F). However, a battery with a low state of charge may freeze at temperatures as high as −7°C (20°F). Since freezing may ruin a battery, the battery should be protected against freezing by keeping it properly charged. As long as the green eye is visible in the hydrometer, the freezing point of the battery will be somewhere below −32°C (−25°F).

Battery Protection During Vehicle Storage

Certain devices on the vehicle maintain a small continuous current drain (parasitic load) on the battery. A battery that is not used for an extended period of time will discharge. Eventually permanent damage will result. Discharged batteries will also freeze in cold weather. Refer to *Battery Inspection/Test* in this supplement.

In order to maintain a battery state of charge while storing the vehicle for more than 30 days:

Important: If a green dot is not visible in the hydrometer, charge the battery. Refer to Battery Charging.

1. Make sure the that the green dot is visible in the built-in hydrometer.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

2. Disconnect the battery (negative) ground to protect the battery from discharge by parasitic current drains.

When the battery cannot be disconnected:

1. Maintain a high state of charge.
2. Establish a regular schedule for recharging the battery every 20-45 days.

A battery that has remained in a discharged state for a long period of time is difficult to recharge or may be permanently damaged.

Jump Starting in Case of Emergency

Caution: Batteries produce explosive gases. Batteries contain corrosive acid. Batteries supply levels of electrical current high enough to cause burns. Therefore, in order to reduce the risk of personal injury while working near a battery, observe the following guidelines:

- ***Always shield your eyes.***
- ***Avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow battery acid to contact the eyes or the skin.***
  - ***Flush any contacted areas with water immediately and thoroughly.***
  - ***Get medical help.***

Notice: This vehicle has a 12 volt, negative ground electrical system. Make sure the vehicle or equipment being used to jump start the engine is also 12 volt, negative ground. Use of any other type of system will damage the vehicle's electrical components.

This vehicle has a 12 volt positive, negative ground electrical system. Do not try to jump start a vehicle if you are unsure of the other vehicle's positive voltage or ground position. The booster (charged) battery and the discharged battery should be treated carefully when using jumper cables.

1. Position the vehicle with the booster (charged) battery so that the jumper cables will comfortably reach the battery of the other vehicle.
   - Do not let the 2 vehicles touch.
   - Make sure that the jumper cables do not have loose clamps or missing insulation.
2. Perform the following steps on both vehicles:
   2.1. Place the automatic transmission in PARK.
   2.2. Block the wheels.
   2.3. Set the parking brake.
   2.4. Turn off all electrical loads that are not needed (leave the hazard flashers ON).
   2.5. Turn OFF the ignition switch.

Important: Some vehicles have a battery remote positive stud. ALWAYS use the battery remote positive stud in order to give or to receive a jump start.

3. Attach the end of one jumper cable to the positive terminal of the discharged battery.
4. Attach the other end of the first cable to the positive terminal of the booster battery.
5. Attach one end of the remaining jumper cable to the negative terminal of the booster battery.
6. Make the final connection of the negative jumper cable to the block or suitable bracket connected directly to the block, away from the battery.
7. Start the engine of the vehicle that is providing the jump start and turn off all electrical accessories. Raise the engine RPM to approximately 1500 RPM.
8. Crank the engine of the vehicle with the weak battery.

   If the engine does not crank or cranks too slowly, perform the following steps:
   8.1. Turn the ignition OFF.
   8.2. Allow the booster vehicle engine to run at approximately 1500 RPM for 5 minutes.
   8.3. Attempt to start the engine of the vehicle with the discharged battery.
9. Reverse the steps exactly when removing the jumper cables. The negative battery cable must first be disconnected from the engine that was jump started.

Starter Motor Noise Diagnosis

Diagnostic Aids

- Inspect the flywheel ring gear for damage or unusual wear.
- Shim the starter if applicable.
- In order to add pinion to ring gear clearance a full size shim must be used. Do not shim only 1 starter mounting bolt. There are 3 shims available in different shapes (for clearance). All are 1 mm (0.039 in) thick.

Starter Motor Noise Diagnosis

Step	Action	Yes	No
1	Did you perform the Engine Electrical Diagnostic System Check?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Electrical* in this supplement
2	Start the engine. Does the starter operate normally?	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual	Go to *Step 3*
3	Start the engine while listening to the starter motor turn. Is there a loud “whoop” (it may sound like a siren if the engine is revved while the starter is engaged) after the engine starts, but while the starter is still held in the engaged position?	Go to *Step 6*	Go to *Step 4*
4	Do you hear a “rumble”, a “growl”, or, in some cases, a “knock” as the starter is coasting down to a stop after starting the engine?	Go to *Step 7*	Go to *Step 5*
5	When the engine is cranked, do you hear a high-pitched whine after the engine cranks and starts normally? (This is often diagnosed as a starter drive gear hang-in or a weak solenoid.)	Go to *Step 8*	Go to *Step 7*
6	Inspect the flywheel ring gear for the following: • Chipped gear teeth • Missing gear teeth • Milled teeth Is the flywheel bent, or does it have damaged teeth?	Go to *Step 9*	Go to *Step 10*
7	1. Remove the starter motor. Refer to *Starter Motor Replacement* in this supplement. 2. Inspect the starter motor bushings and clutch gear. Does the clutch gear have chipped or milled teeth or worn bushings?	Go to *Step 10*	Go to *Step 9*
8	Shim the starter motor away from the flywheel by adding shims between the starter motor and the engine block one at a time. Flywheel runout may make this noise appear to be intermittent. Did you complete the repair?	Go to *Step 11*	—
9	Replace the flywheel. Refer to *Engine Flywheel Replacement* in this supplement. Did you complete the replacement?	Go to *Step 11*	—
10	Replace the starter motor. Refer to *Starter Motor Replacement* in this supplement. Did you complete the replacement?	Go to *Step 11*	—
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Charging System Test

Step	Action	Value(s)	Yes	No
Schematic Reference: *Starting and Charging Schematics*				
1	Did you perform the Battery Inspection/Test?	—	Go to *Step 2*	Go to *Battery Inspection/Test* in this supplement
2	1. Turn OFF all electrical loads. 2. Start the engine. 3. With a DMM measure the voltage at the battery. Does the DMM indicate the voltage is within the specified value?	11.0 – 15.5 Volts	Go to *Step 3*	Go to *Intermittents and Poor Connections Diagnosis* in the WCC Service Manual

Charging System Test (cont'd)

Step	Action	Value(s)	Yes	No
3	1. Turn OFF the ignition. 2. Connect a charging system tester to the battery (follow the manufacturer instructions). 3. Operate the engine at 2500 RPM. 4. Adjust the carbon pile as necessary in order to obtain the maximum current output. Is the generator output within 10 A of the specified value?	Go to *Generator Usage* in this supplement	Go to *Step 9*	Go to *Step 4*
4	1. Maintain the engine speed at 2500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop between the generator output terminal and the battery positive terminal. Is the voltage above the specified value?	0.5 V	Go to *Step 6*	Go to *Step 5*
5	1. Maintain the engine speed at 2500 RPM and continue to operate the generator at the load test value. 2. Measure the voltage drop between the battery negative terminal and the generator metal housing. Is the voltage above the specified value?	0.5 V	Go to *Step 7*	Go to *Step 8*
6	Test the battery positive circuit between the generator output terminal and the battery positive terminal for a high resistance. Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 7*
7	Repair the high resistance in the ground circuit between the generator housing and the battery negative terminal. Did you complete the repair?	—	Go to *Step 9*	—
8	Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Did you complete the repair?	—	Go to *Step 9*	—
9	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to *Step 3*

Generator Noise Diagnosis

Diagnostic Aids

Noise from a generator may be due to electrical or mechanical noise. Electrical noise (magnetic whine) usually varies with the electrical load placed on the generator and is a normal operating characteristic of all generators. When diagnosing a noisy generator, it is important to remember that loose or misaligned components around the generator may transmit the noise into the passenger compartment and that replacing the generator may not solve the problem.

Generator Noise Diagnosis

Step	Action	Yes	No
1	Test the generator for proper operation using the Generator Tester. Refer to *Charging System Test* in this supplement. Is the generator operating properly?	Go to *Step 2*	Go to *Step 11*
2	1. Start the engine. Verify that the noise can be heard. 2. Turn OFF the engine. 3. Disconnect the 4-way connector from the generator. 4. Start the engine. 5. Listen for the noise. Has the noise stopped?	Go to *Step 11*	Go to *Step 3*

Generator Noise Diagnosis (cont'd)

Step	Action	Yes	No
3	1. Turn OFF the engine. 2. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement. 3. Spin the generator pulley by hand. Does the generator shaft spin smoothly and without any roughness or grinding noise?	Go to *Step 4*	Go to *Step 12*
4	Inspect the generator for a loose pulley and/or pulley nut. Is the generator pulley or pulley nut loose?	Go to *Step 11*	Go to *Step 5*
5	1. Loosen all of the generator mounting bolts. 2. Tighten the generator mounting bolts to specifications and in the proper sequence (if necessary). Refer to *Generator Replacement (8.1L)* in this supplement. 3. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement. 4. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 6*
6	Inspect the generator for the following conditions: • Strained or stretched electrical connections • Hoses or other vehicle equipment resting on the generator (which may cause the noise to be transmitted into the passenger compartment) Are any electrical connections pulling on the generator or are any hoses, etc. resting on the generator?	Go to *Step 7*	Go to *Step 8*
7	1. Reroute the electrical connections to relieve the tension. 2. Reroute the hoses, etc. away from the generator. 3. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 8*
8	Inspect the drive belt for proper tension. Refer to *Drive Belt Vibration Diagnosis* in this supplement. Is the drive belt loose?	Go to *Step 9*	Go to *Step 10*
9	1. Replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement. 2. Start the engine. Has the noise decreased or stopped?	System OK	Go to *Step 12*
10	Compare the vehicle with a known good vehicle. Do both vehicles make the same noise?	System OK	Go to *Step 12*
11	Tighten or replace the generator pulley and pulley nut as necessary. Refer to *Generator Pulley Replacement* in this supplement. Is the repair complete?	Go to *Step 13*	—
12	**Important:** If no definite generator problems were found, be sure that all other possible sources of objectionable noise are eliminated before replacing the generator. Replacing the generator may not change the noise level if the noise is a normal characteristic of the generator or the generator mounting. Replace the generator. Refer to *Generator Replacement (8.1L)* in this supplement. Has the noise decreased or stopped?	Go to *Step 13*	—
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 2*

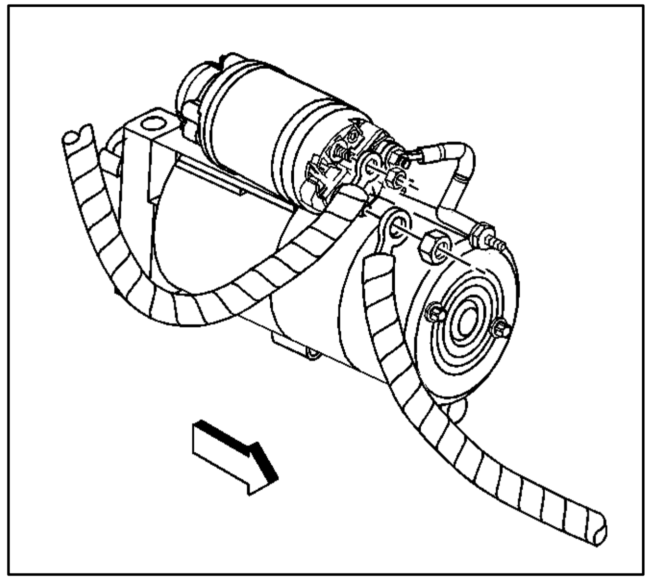
Repair Instructions

Starter Motor Replacement

Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

1. Disconnect the negative battery cable.
2. Raise and suitably support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in the WCC Service Manual.
3. Remove the positive cable nut.
4. Remove the positive cable from the starter.
5. Remove the engine harness nut.
6. Remove the engine harness from the starter.



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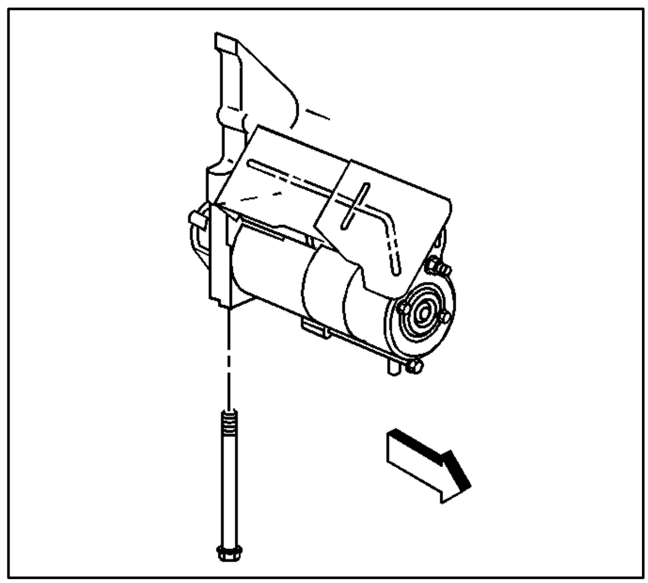
7. Remove the starter motor bolts.
8. Remove the starter.



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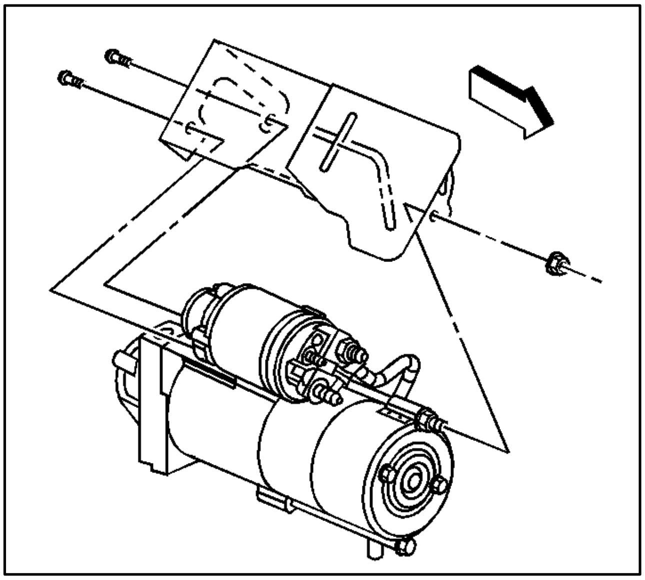

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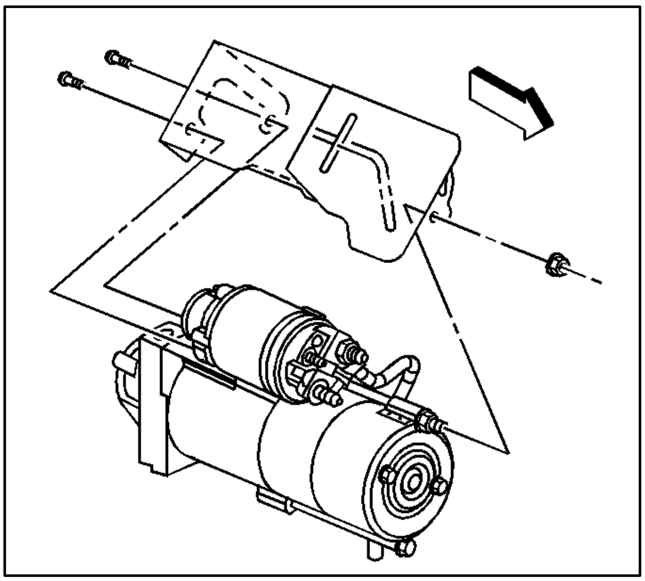
9. Remove the starter heat shield bolts, nut and shield, if necessary.



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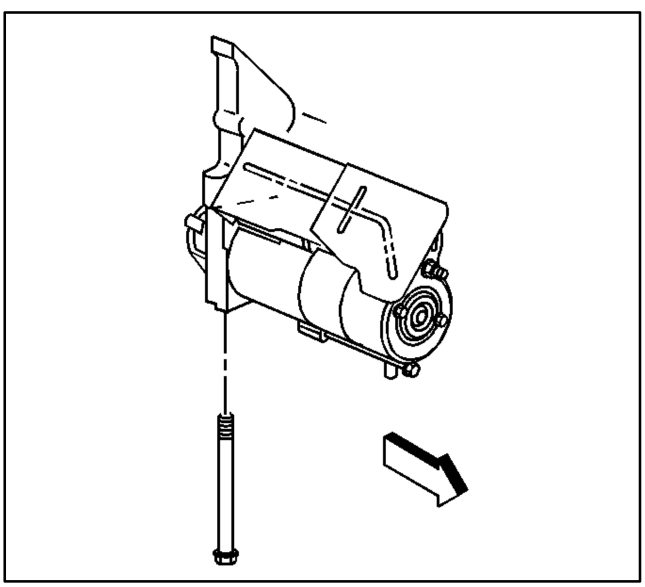
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the starter heat shield, nut and bolts if necessary.

   Tighten

   - Tighten the starter heat shield bolts to 3 N·m (35 lb in).
   - Tighten the starter heat shield nut to 5 N·m (44 lb in).



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2. Install the starter motor bolts.

   Tighten

   Tighten the starter motor bolts to 50 N·m (37 lb ft).

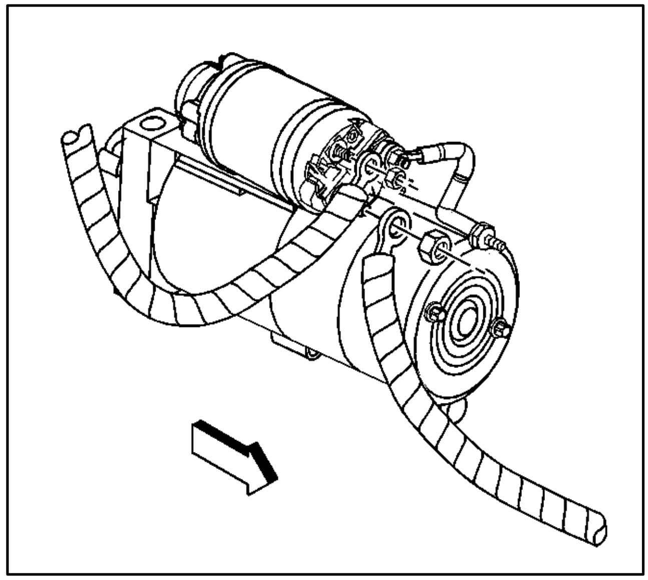
3. Install the engine harness to the starter.
4. Install the engine harness nut.

   Tighten

   Tighten the engine harness nut to 2 N·m (18 lb in).
5. Install the positive cable to the starter.
6. Install the positive cable nut.

   Tighten

   Tighten the positive cable nut to 10 N·m (89 lb in).
7. Lower the vehicle.
8. Connect the negative battery cable.



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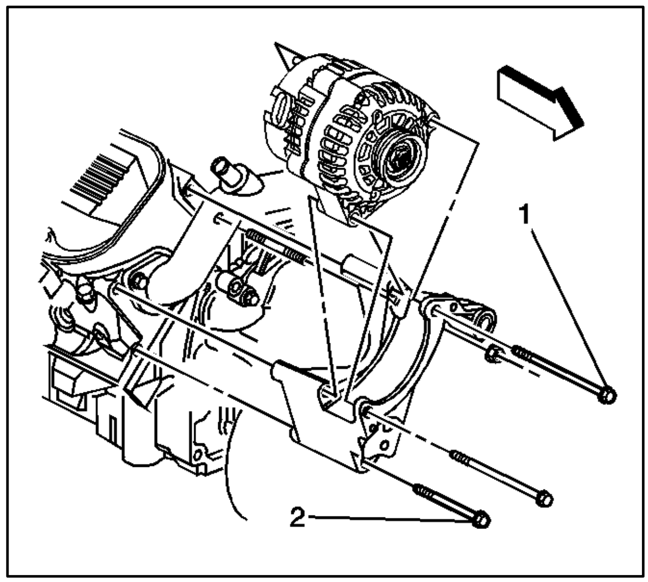
Generator Bracket Replacement

Removal Procedure

1. Remove the generator. Refer to *Generator Replacement (8.1L)* in this supplement.
2. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement.
3. Remove the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement* in this supplement.
4. Remove the generator bracket bolt (2) and nut.



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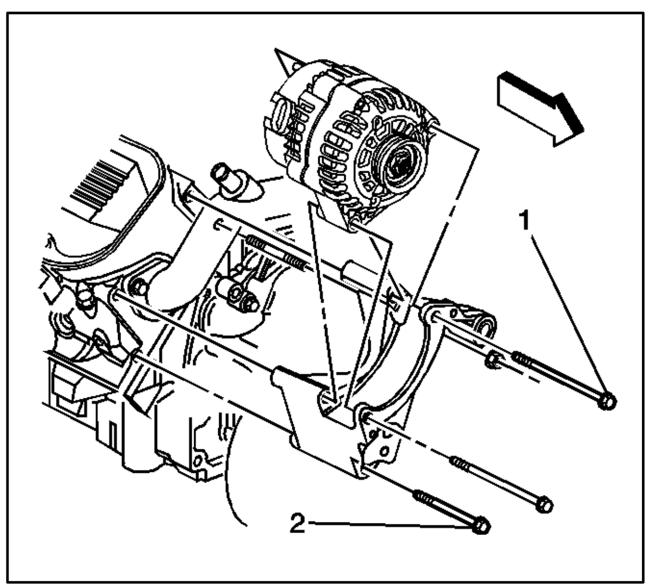
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator bracket bolt (2) and nut.

   Tighten

   - Tighten the generator bracket bolt to 50 N·m (37 lb ft).
   - Tighten the generator bracket nut to 41 N·m (30 lb ft).
2. Install the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement* in this supplement.
3. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* in this supplement.
4. Install the generator. Refer to *Generator Replacement (8.1L)* in this supplement.



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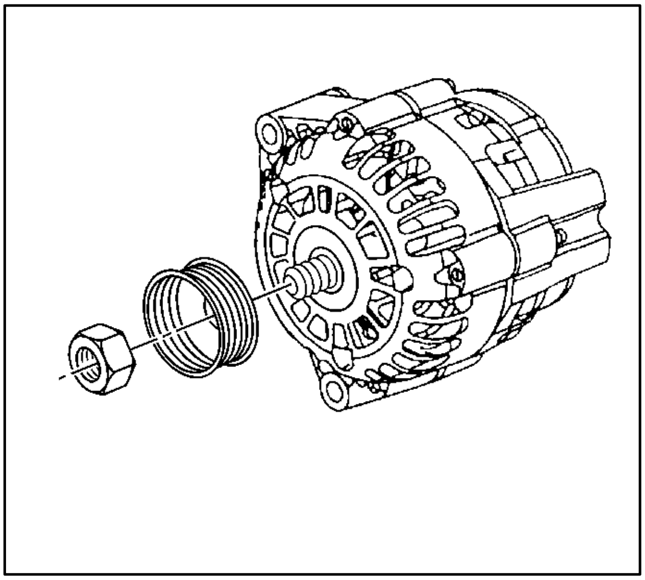

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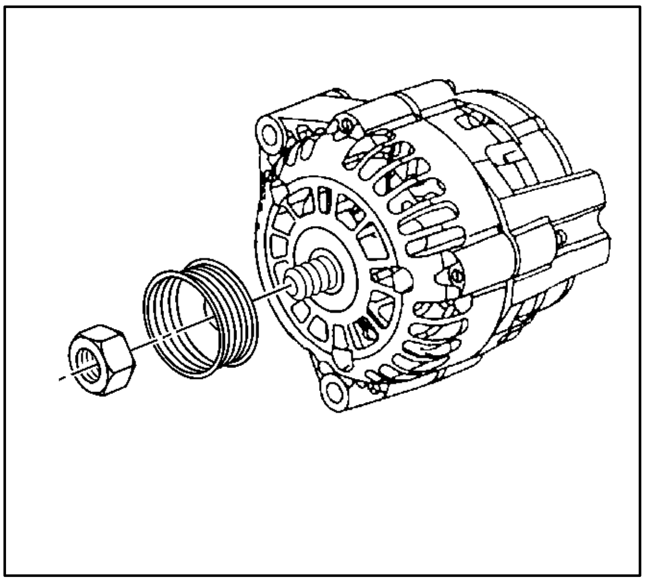
Generator Pulley Replacement

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
2. Install a T-50 TORX® bit into the generator shaft.
3. Remove the generator shaft nut and washer.
4. Remove the generator pulley.



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Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator pulley, washer and shaft nut.

   Tighten

   Tighten the generator shaft nut to 75 N·m (55 lb ft).
2. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.

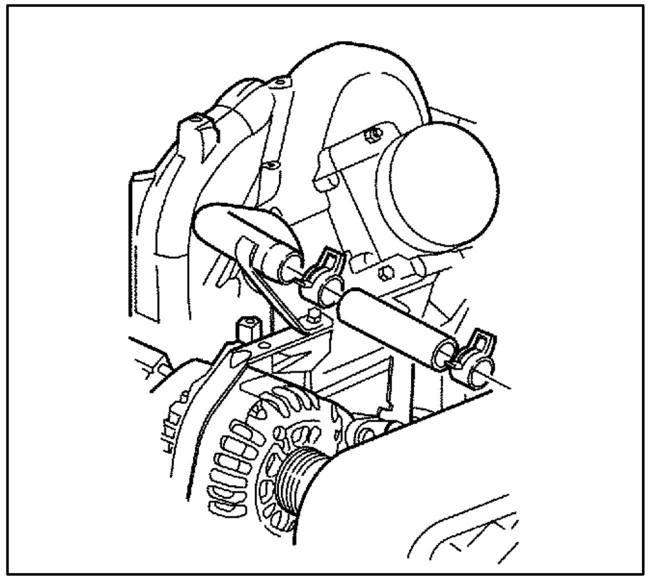
Generator Replacement (8.1L)

Removal Procedure

The removal and installation serve only as a guide. Additional operations may be required on some vehicles to remove other equipment in order to gain access to the generator, the drive belt, and the brackets.

Caution: Failure to observe Step 1 in this procedure may result in an injury to the live battery lead at the generator.

Caution: Refer to battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.



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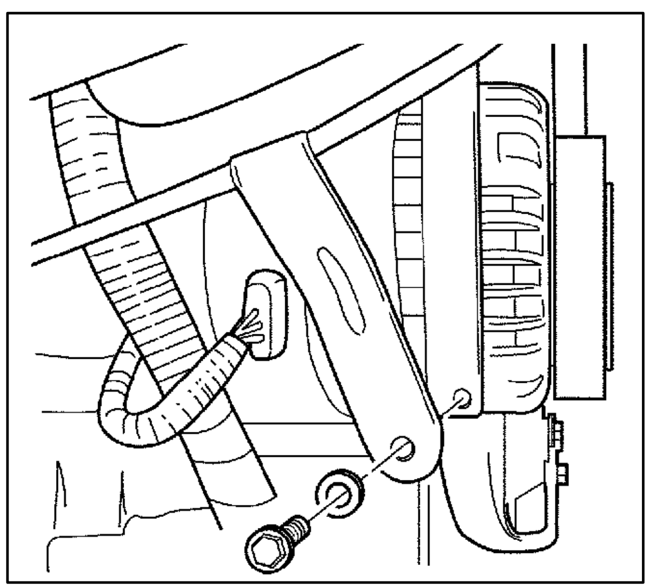
1. Disconnect the negative battery cable.
2. Remove the air intake duct from the throttle body and MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
3. Remove the MAF/IAT sensor. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.
4. Remove the engine oil fill tube from the oil pipe.
5. Remove the drive belt. Refer to *Drive Belt Replacement* in this supplement.
6. Remove the transmission dipstick and fill tube bracket retaining bolt from the oil level indicator tube bracket.
7. Remove the transmission dipstick and fill tube bracket from the oil level indicator tube bracket.



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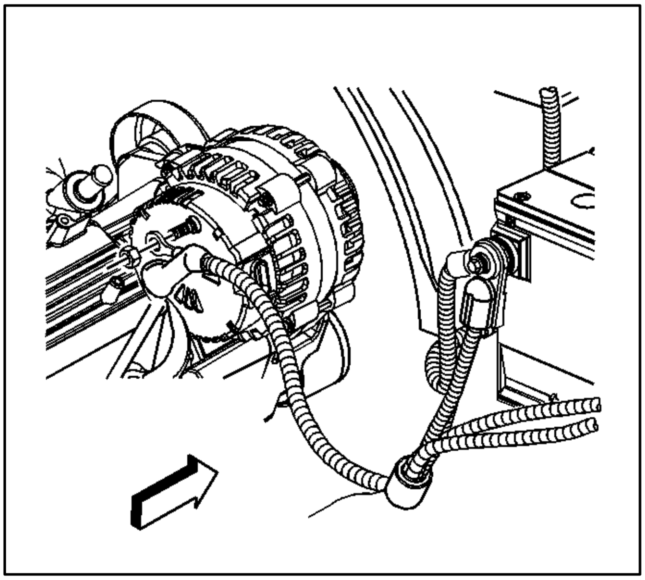
8. Remove the oil level indicator tube retaining bolt and washer from the oil level indicator tube bracket.
9. Remove the oil level indicator tube bracket from the generator mounting bracket.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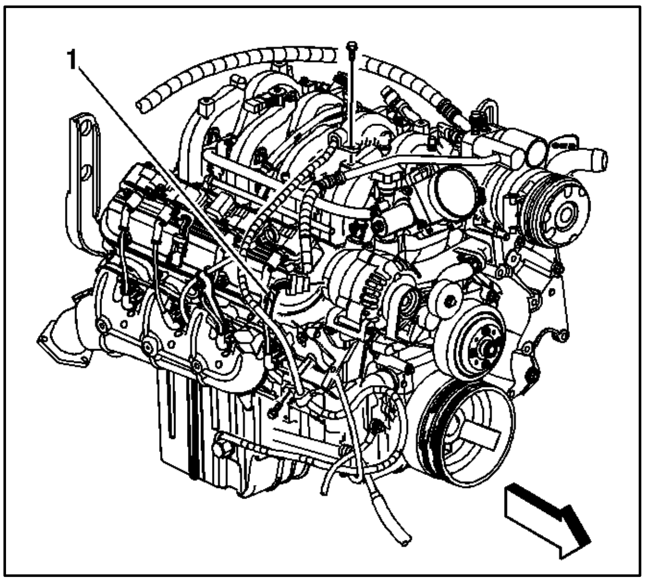
10. Remove the terminal nut and positive power cable from the rear of the generator.



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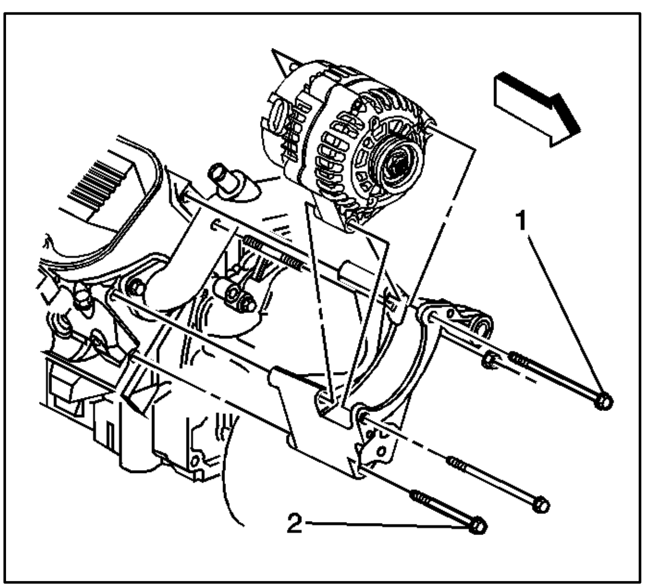
11. Disconnect the electrical connector from the side of the generator.



747120

12. Remove the generator mounting bolts and the generator from the mounting bracket.

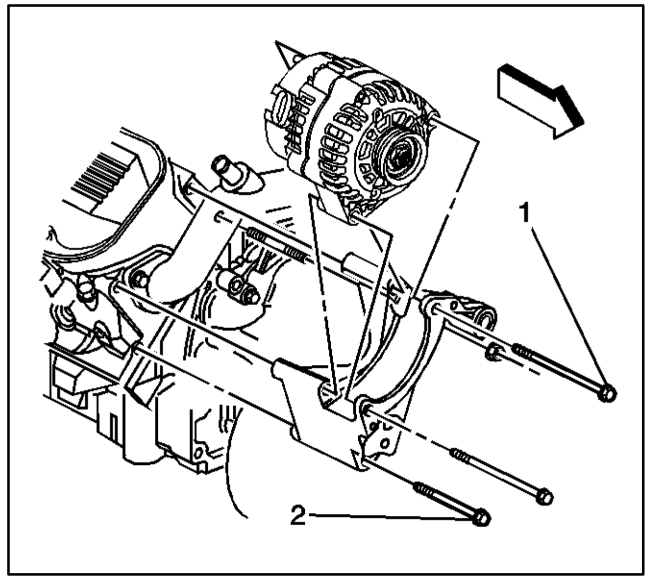
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

1. Install the generator and mounting bolts to the mounting bracket.

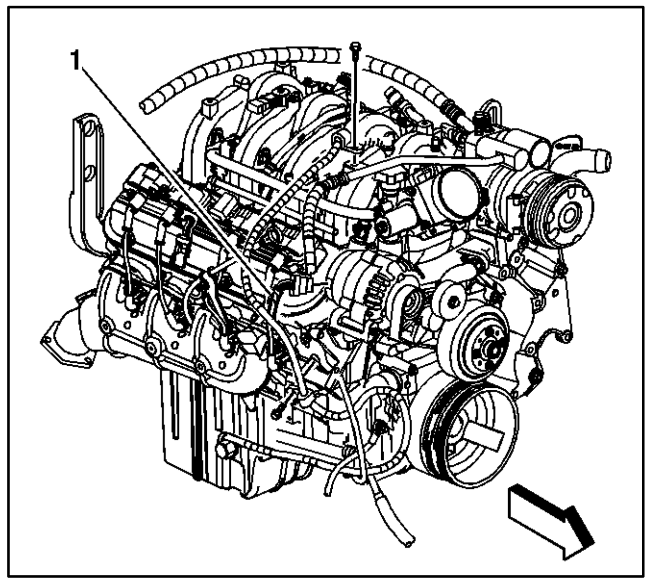
   Tighten

   Tighten the generator mounting bolts to 50 N·m (37 lb ft).



747120

2. Connect the electrical connector to the side of the generator.

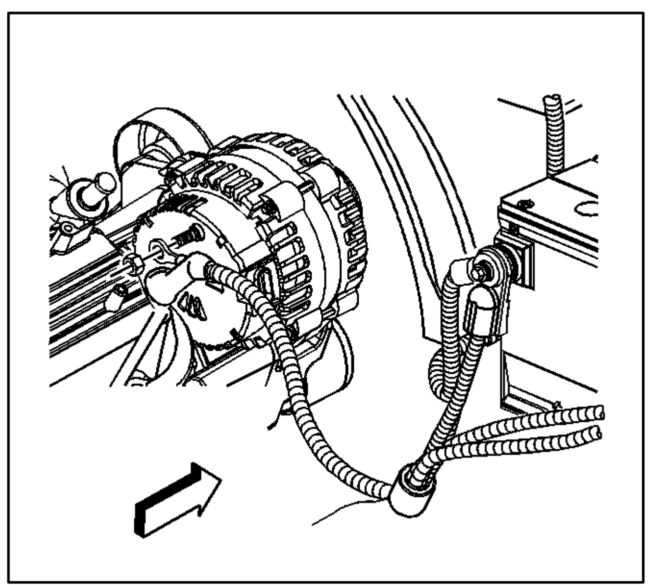


747122

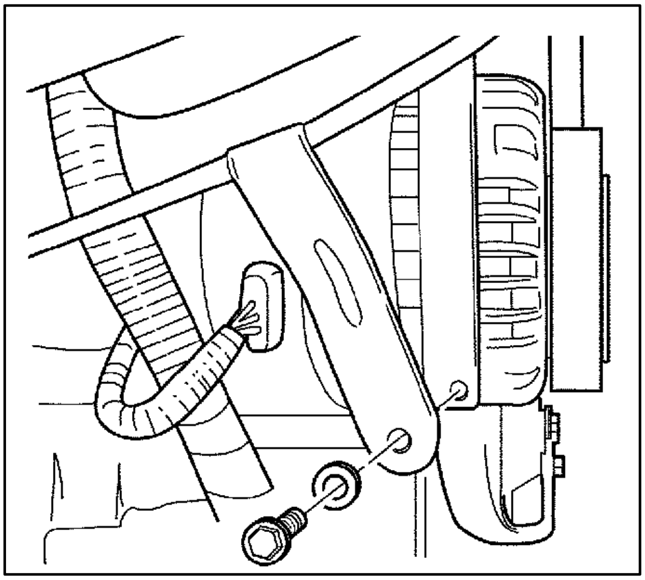
3. Install the positive power cable and terminal inlet to the rear of the generator.

   Tighten

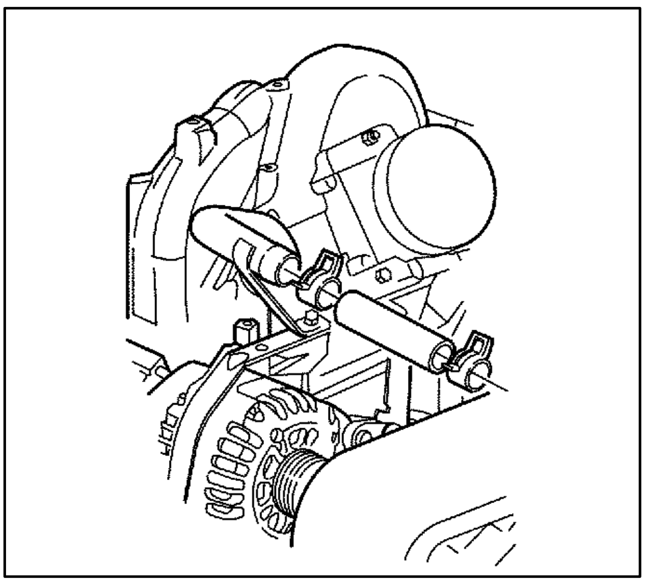
   Tighten the battery terminal nut to 12 N·m (106 lb in).



747121



WRK61022



WRK62002

4. Install the oil level tube indicator bracket to the generator mounting bracket.
5. Install the oil level tube retaining washer and bolt to the oil level indicator tube bracket and the generator bracket.

   Tighten

   Tighten the tube bracket to generator bracket bolt to 12 N·m (106 lb in).
6. Install the transmission dipstick and fill tube bracket to the oil level indicator tube bracket.
7. Install the transmission dipstick and fill tube bracket retaining bolt to the oil level indicator tube bracket.

   Tighten

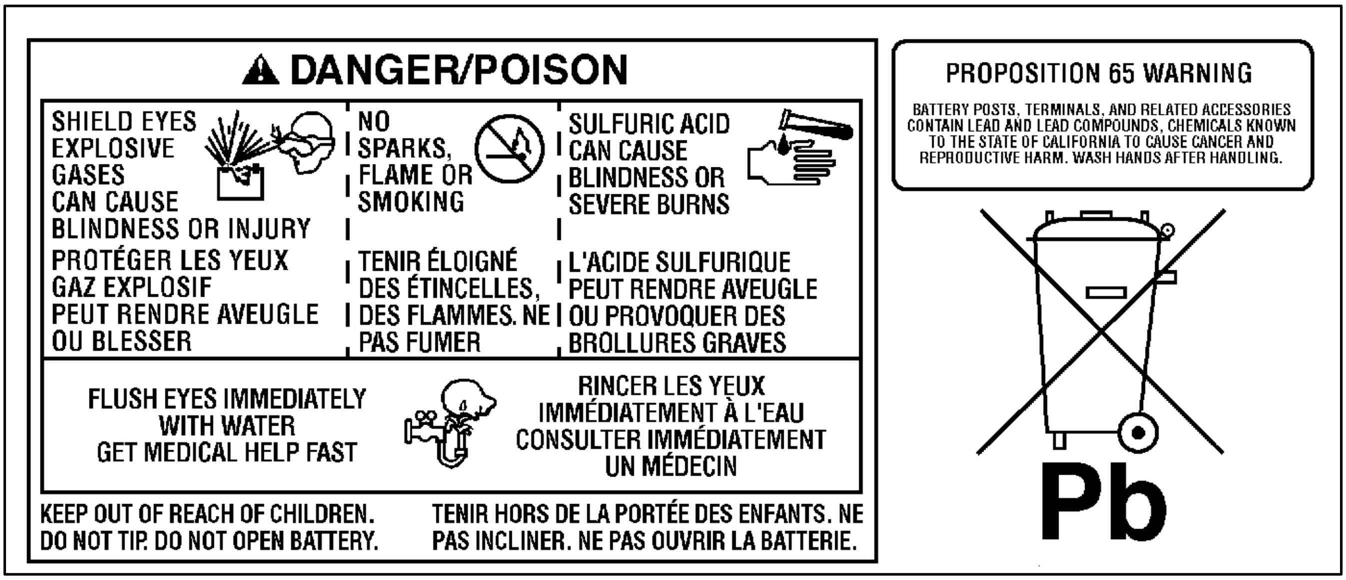
   Tighten the transmission dipstick and fill tube bracket retaining bolt to 12 N·m (106 lb in).
8. Install the drive belt. Refer to *Drive Belt Replacement* in this supplement.
9. Install the engine oil fill tube to the oil pipe.
10. Install the MAF/IAT sensor. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.
11. Install the air intake duct to the throttle body and MAF/IAT sensor. Refer to *Air Intake Duct Replacement (8.1L)* in this supplement.
12. Connect the negative battery cable.

Description and Operation

Battery Description and Operation

Caution: Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- ***Always shield your eyes and avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow the battery electrolyte to contact the eyes or the skin. Flush immediately and thoroughly any contacted areas with water and get medical help.***
- ***Follow each step of the jump starting procedure in order.***
- ***Treat both the booster and the discharged batteries carefully when using the jumper cables.***



754326

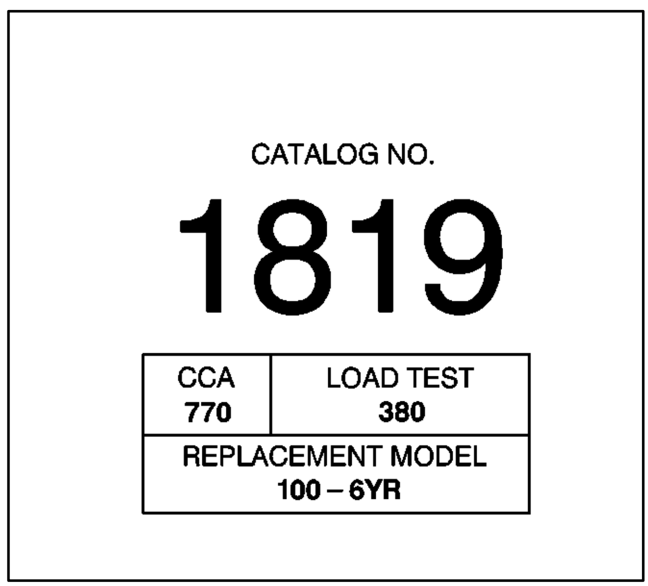
The maintenance free battery is standard. There are no vent plugs in the cover. The battery is completely sealed except for two small vent holes in the side. These vent holes allow the small amount of gas that is produced in the battery to escape.

The battery has three functions as a major source of energy:

- Engine cranking
- Voltage stabilizer
- Alternate source of energy with generator overload.

The battery specification label contains information about the following:

- The test ratings
- The original equipment catalog number
- The recommended replacement model number



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Battery Ratings

A battery has 2 ratings:

- Reserve capacity
- Cold cranking amperage

When a battery is replaced use a battery with similar ratings. Refer to the battery specification label on the original battery or refer to *Battery Usage* in this supplement.

Reserve Capacity

Reserve capacity is the amount of time in minutes it takes a fully charged battery, being discharged at a constant rate of 25 amperes and a constant temperature of 27°C (80°F) to reach a terminal voltage of 10.5 volts. Refer to *Battery Usage* in this supplement for the reserve capacity rating of the original equipment battery.

Cold Cranking Amperage

The cold cranking amperage is an indication of the ability of the battery to crank the engine at cold temperatures. The cold cranking amperage rating is the minimum amperage the battery must maintain for 30 seconds at −18°C (0°F) while maintaining at least 7.2 volts. Refer to *Battery Usage* in this supplement for the cold cranking amperage rating for this vehicle.

Starting System Description and Operation

The PG-260M is a non-repairable starter motor. It has pole pieces that are arranged around the armature within the starter housing. When the solenoid windings are energized, the pull-in winding circuit is completed to ground through the starter motor. The hold-in winding circuit is completed to ground through the solenoid. The windings work together magnetically to pull in and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. At the same time, the plunger closes the solenoid switch contacts in the starter solenoid. Full battery voltage is then applied directly to the starter motor and it cranks the engine.

As soon as the solenoid switch contacts close, current stops flowing thorough the pull-in winding as battery voltage is now applied to both ends of the windings. The hold-in winding remains energized; its magnetic field is strong enough to hold the plunger, shift lever, starter drive assembly, and solenoid switch contacts in place to continue cranking the engine. When the engine starts, the pinion gear overrun sprag protects the armature from excessive speed until the switch is opened.

When the ignition switch is released from the CRANK position, voltage is removed from the starter solenoid S terminal. Current flows from the motor contacts through both windings to ground at the end of the hold-in winding. However, the direction of the current flow through the pull-in winding is now in the opposite direction of the current flow when the winding was first energized.

The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter motor is turned off.

Charging System Description and Operation

Generator

The AD-230 and AD-244 generators are non-repairable. They are electrically similar to earlier models. The generators feature the following major components:

- The delta stator
- The rectifier bridge
- The rotor with slip rings and brushes
- A conventional pulley
- Dual internal fans
- A voltage regulator

The pulley and the fan cool the slip ring and the frame.

The AD stands for Air-cooled Dual internal fan; the 2 is an electrical design designator; the 30/44 denotes the outside diameter of the stator laminations in millimeters, over 100 millimeters. The generators is rated at 105 and 130 amperes respectively.

The generator features permanently lubricated bearings. Service should only include the tightening of mounting components. Otherwise, the generator is replaced as a complete unit.

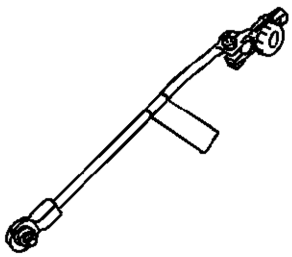
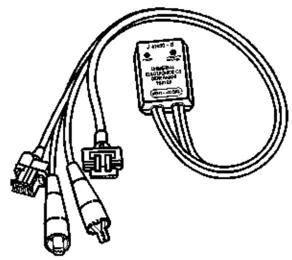
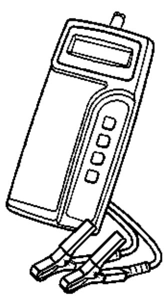
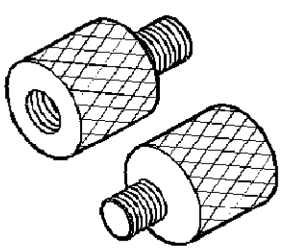
Regulator

The voltage regulator controls the field current of the rotor in order to limit system voltage. The regulator switches the current on and off at a rate of 400 cycles per second in order to perform the following functions:

- Radio noise control
- Obtain the correct average current needed for proper system voltage control

At high speeds, the on-time may be 10 percent with the off-time at 90 percent. At low speeds, the on-time may be 90 percent and the off-time 10 percent.

Special Tools and Equipment

Illustration	Tool Number/ Description
 3432	J 38758 Parasitic Draw Test Switch Tool
 317080	J 41450-B CS Generator Electronic Tester
 404758	J 42000 Digital Battery Tester
 3431	GM P/N 12303040 Battery Side Terminal Adapters

BLANK

Engine Controls – 8.1L

Specifications

Temperature vs Resistance

°C	°F	OHMS
Temperature vs Resistance Values (Approximate)		
150	302	47
140	284	60
130	266	77
120	248	100
110	230	132
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459

Temperature vs Resistance (cont'd)

°C	°F	OHMS
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
*5	23	12300
*10	14	16180
*15	5	21450
*20	*4	28680
*30	*22	52700
*40	*40	100700

Ignition System Specifications

Application	Specification	
	Metric	English
Firing Order	1–8–7–2–6–5–4–3	
Spark Plug Wire Resistance	10,000 ohms per ft	
Spark Plug Torque	15 N·m	11 lb ft
Spark Plug Gap	1.52 mm	0.060 in
Spark Plug Type	TJ14R-P15 [Denso plug type]	

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Assembly to Floor Fasteners	20 N·m	15 lb ft
Air Cleaner Assembly Mounting Bolt	9 N·m	80 lb in
Air Intake Duct Clamps	4 N·m	35 lb in
Camshaft Position (CMP) Sensor Bolt	12 N·m	106 lb in
Crankshaft Position (CKP) Sensor Bolt	12 N·m	106 lb in
Engine Coolant Temperature (ECT) Sensor	17 N·m	13 lb ft
Engine Sight Shield Bolts	10 N·m	89 lb in
Engine Sight Shield Bracket Bolts	10 N·m	89 lb in
Evaporative Emission (EVAP) Purge Solenoid Shoulder Bolt	10 N·m	89 lb in
Fuel Balance Pump Fittings	30 N·m	22 lb ft

Fuel Fill Hose Clamp	2.5 N·m	22 lb in
Fuel Fill Pipe Ground Strap Screw	9 N·m	80 lb in
Fuel Fill Pipe Housing to Fill Pipe Bolts	2.3 N·m	20 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Fuel Fill Vent Hose Clamp	2.5 N·m	22 lb in
Fuel Filter Fitting	27 N·m	20 lb ft
Fuel Rail Attaching Bolts	12 N·m	106 lb in
Fuel Tank Shield Bolts-Rear	75 N·m	55 lb ft
Fuel Tank Strap Bolts-Front or Rear	35 N·m	26 lb ft
Heated Oxygen Sensor (HO2S)	41 N·m	30 lb ft
Ignition Coil Attaching Bolts	12 N·m	106 lb in
Knock Sensor (KS)	20 N·m	15 lb ft
Powertrain Control Module (PCM) Connector End Bolts	8 N·m	70 lb in
Throttle Body Attaching Bolts	10 N·m +/– 2.0 N·m	88.5 lb in

Fuel System Specifications

Use regular unleaded gasoline rated at 87 octane or higher. It is recommended that the gasoline meet specifications which were developed by the American Automobile Manufacturers Association (AAMA) and endorsed by the Canadian Motor Vehicle Manufacturers Association for better vehicle performance and engine protection. Gasoline meeting the AAMA specification could provide improved driveability and emission control system performance compared to other gasolines. For more information, write to: American Automobile Manufacturers Association, 7430 Second Ave., Suite 300, Detroit, MI, 48202.

Be sure the posted octane is at least 87. If the octane is less than 87, you may get a heavy knocking noise when you drive. If it is bad enough, it can damage your engine.

If you are using fuel rated at 87 octane or higher and you hear heavy knocking, your engine needs service. But do not worry if you hear a little pinging noise when you are accelerating or driving up a hill. That's normal, and you do not have to buy a higher octane fuel to get rid of pinging. It is the heavy, constant knock that means you have a problem.

Notice: Your vehicle was not designed for fuel that contains methanol. Do not use methanol fuel which can corrode metal parts in your fuel system and also damage plastic and rubber parts. This kind of damage would not be covered under your warranty.

If your vehicle is certified to meet California Emission Standards (indicated on the underhood emission control label), it is designed to operate on fuels that meet California specifications. If such fuels are not available in states adopting California emissions standards, your vehicle will operate satisfactorily on fuels meeting federal specifications, but emissions control system performance may be affected. The malfunction indicator lamp on your instrument panel may turn on and/or your vehicle may fail a smog test. See "Malfunction Indicator Lamp" in the Index. If this occurs, return to your authorized GM dealer for diagnosis to determine the cause of the failure. In the event it is determined that the cause of the condition is the type of fuels used, repairs may not be covered by your warranty.

Some gasolines that are not reformulated for low emissions may contain an octane-enhancing additive called methylcyclopentadienyl manganese tricarbonyl (MMT). Ask your service station operator whether or not the fuel contains MMT. General Motors does not recommend the use of such gasolines. If fuels containing MMT are used, spark plug life may be reduced and your emission control system performance may be affected. The malfunction indicator lamp (MIL) on your instrument panel may turn ON. If this occurs, return to your authorized GM dealer for service.

To provide cleaner air, all gasolines in the United States are now required to contain additives that will help prevent deposits from forming in your engine and fuel system, allowing your emission control system to function properly. Therefore, you should not have to add anything to the fuel. In addition, gasolines containing oxygenates, such as ethers and ethanol, and reformulated gasolines may be available in your area to contribute to clean air. General Motors recommends that you use these gasolines, particularly if they comply with the specification described earlier.

Fuels in Foreign Countries (Gasoline Engines)

If you plan on driving in another country outside the United States or Canada, the proper fuel may be hard to find. Never use leaded gasoline or any other fuel not recommended in the previous text on fuel. Costly repairs caused by use of improper fuel would not be covered by your warranty.

To check on fuel availability, ask an auto club or contact a major oil company that does business in the country where you will be driving.

Service Parts Group Numbers

Application	Service Parts Group Number
Accelerator Pedal	3.451
Air Cleaner Assembly	3.402
Air Filter	3.410
Camshaft Position (CMP) Sensor	2.383
Crankshaft Position (CKP) Sensor	2.383
Engine Coolant Level Switch	1.203
Engine Coolant Temperature (ECT) Sensor	3.682
Engine Oil Level Sensor	1.516
Engine Oil Pressure Sensor	1.800
EVAP Canister	3.130
EVAP Fuel Tank Pressure Sensor	3.140
EVAP Hoses and Pipes	3.145
EVAP Purge Solenoid	3.140
EVAP Vent Valve	3.140
Fuel Hoses and Pipes	3.163
Fuel Injectors	3.300
Fuel Pump	3.900
Fuel Pump Relay	3.900
Fuel Rail Assembly	3.330
Fuel Sender	3.107
Fuel Tank	3.001
Fuel Tank Straps	3.022
Heated Oxygen Sensor	3.682
Ignition Coil	2.170
Inline Fuel Filter	3.890
Intake Air Duct	3.417
Intake Air Temperature (IAT) Sensor	3.682
Knock Sensors	2.383
Manifold Absolute Pressure (MAP) Sensor	3.682
Mass Air Flow (MAF) Sensor	3.682
Positive Crankcase Vent Valve	1.745
Powertrain Control Module (PCM)	3.670
Throttle Body Assembly	3.335
Throttle Position (TP) Sensor	3.339

Diagnostic Trouble Code (DTC) Type Definitions

Emissions Related DTCs

Action Taken When the DTC Sets – Type A

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame/Failure Records.

Action Taken When the DTC Sets – Type B

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC – Type A or Type B

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Non-Emissions Related DTCs

Action Taken When the DTC Sets – Type C

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC – Type C

- A last test failed, or current DTC, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.
- Specifications

Diagnostic Trouble Code (DTC) Type(s)

Diagnostic Trouble Code (DTC)	Domestic	Unleaded Export
P0102	B	B
P0103	B	B
P0107	B	B
P0108	B	B
P0112	B	B
P0113	B	B
P0117	B	B
P0118	B	B
P0131	B	B
P0132	B	B
P0134	B	B
P0151	B	B
P0154	B	B
P0200	B	B
P0230	B	B
P0325	B	B
P0327	B	B
P0332	B	B
P0335	B	B
P0336	B	B
P0341	B	B
P0342	B	B
P0343	B	B
P0351–P0358	B	B
P0404	B	B

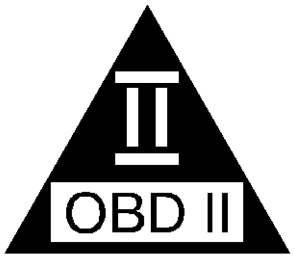
P0405	B	B
P0443	B	B
P0506	B	B
P0507	B	B
P0562	C	C
P0563	C	C

Diagnostic Trouble Code (DTC) Type(s) (cont'd)

Diagnostic Trouble Code (DTC)	Domestic	Unleaded Export
P0601	A	A
P0602	A	A
P0604	A	A
P0606	A	A
P0650	B	B
P1111	C	C
P1112	C	C
P1114	C	C
P1115	C	C
P1120	A	A
P1125	A	A
P1220	A	A
P1221	A	A
P1275	C	C
P1276	C	C
P1280	C	C
P1281	C	C
P1285	C	C
P1286	C	C
P1336	A	A
P1404	B	B
P1504	C	C
P1514	A	A
P1515	A	A
P1516	A	A
P1517	A	A
P1518	A	A
P1574	C	C
P1635	B	B
P1637	C	C
P1638	C	C
P1639	B	B
P1654	C	C
P1665	C	C
P1683	B	B
U1300	C	C
U1301	C	C

Schematic and Routing Diagrams

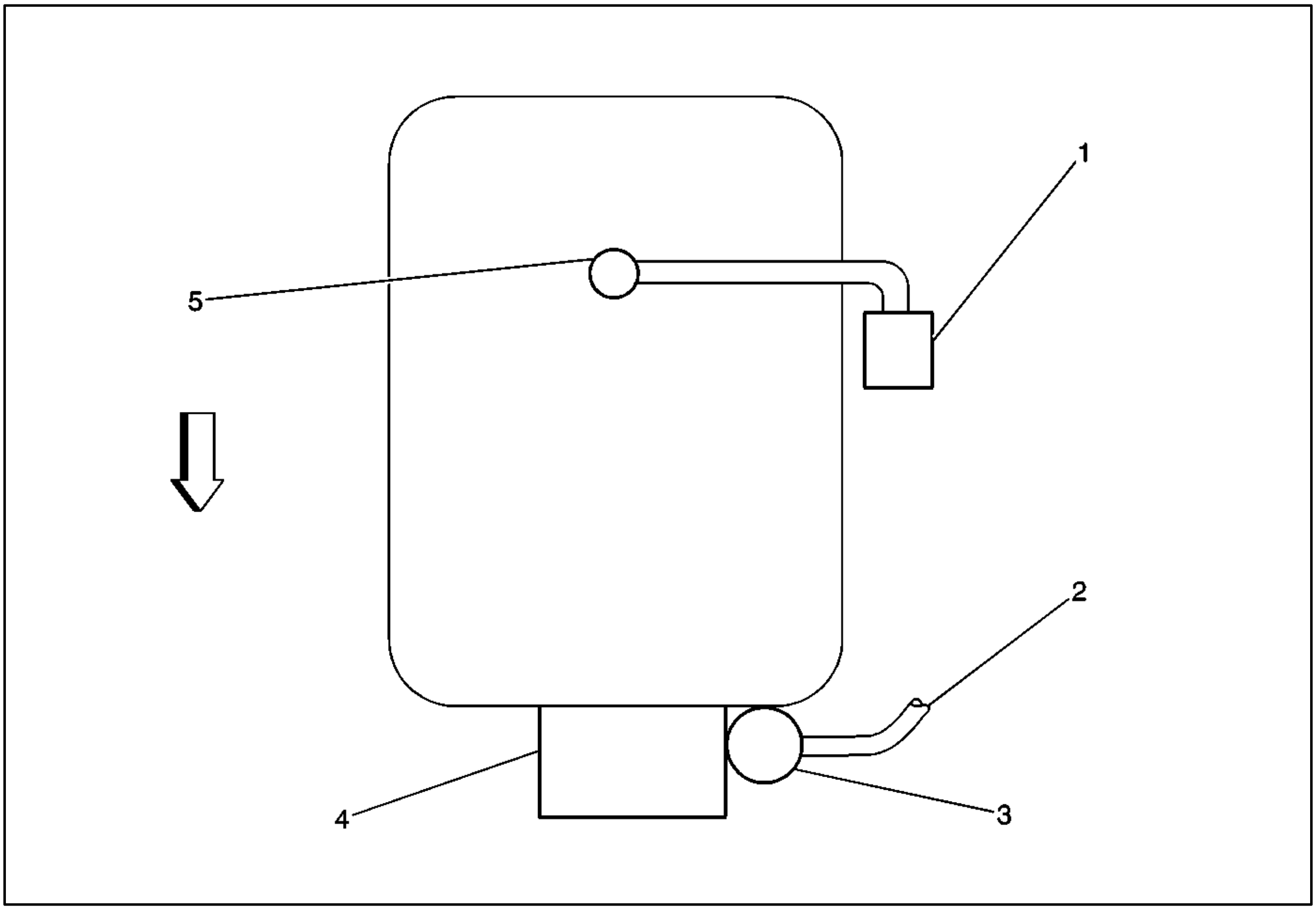
Cooling System Schematic Icons

Icon	Icon Definition
 19385	Refer to *OBD II Symbol Description Notice* in Cautions and Notices in the WCC Service Manual.
 19384	Refer to *ESD Notice* in Cautions and Notices in the WCC Service Manual.

Component Locator

Engine Controls Component Views

Emission Hose Routing Diagram (Vacuum Hose Routing)



688663

Legend

(1) DELETED

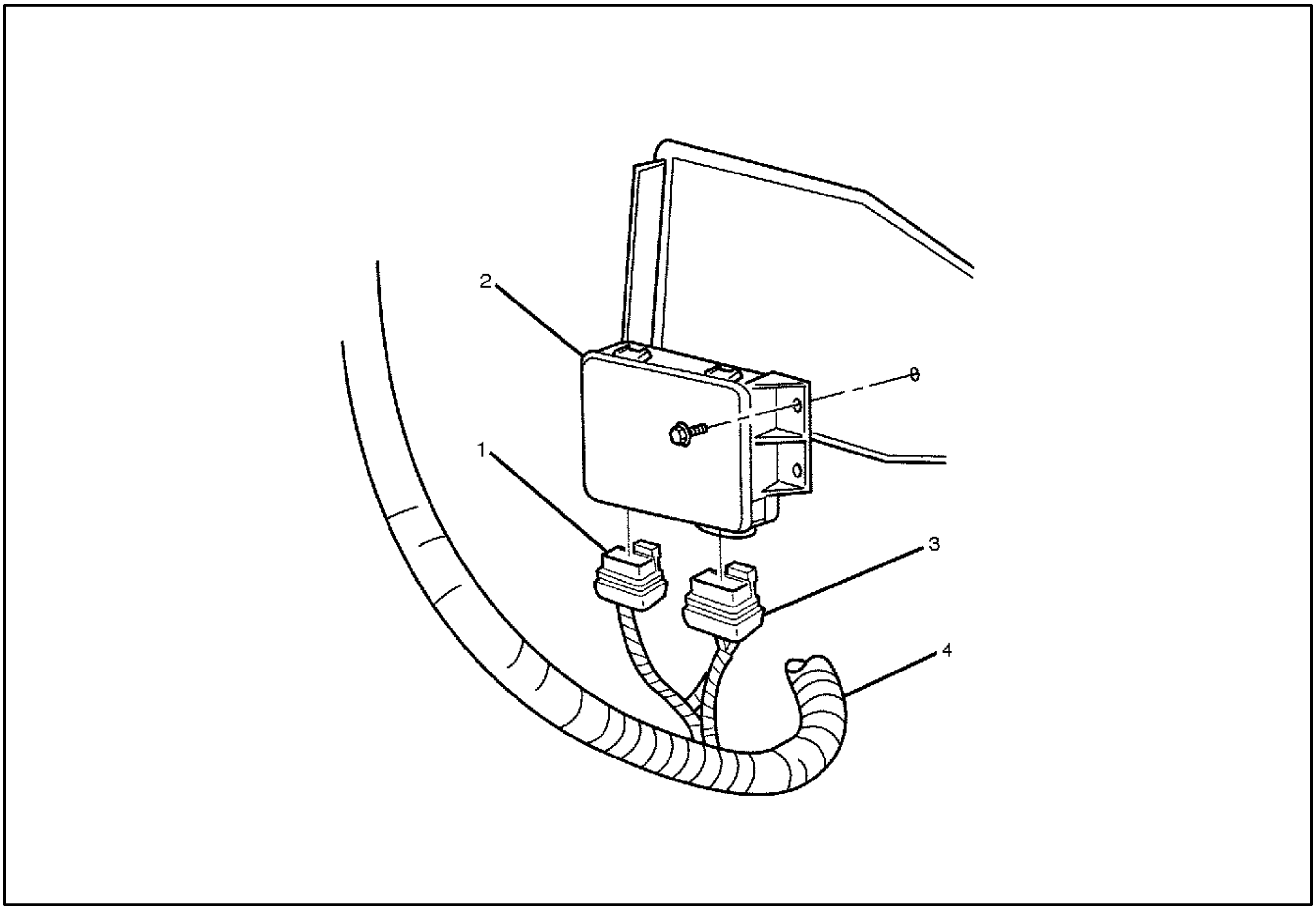
(2) EVAP Purge Pipe

(3) EVAP Purge Solenoid Valve

(4) Throttle Body

(5) Intake Manifold Vacuum Source

Throttle Actuator Control (TAC) Module



WRK64052

Legend

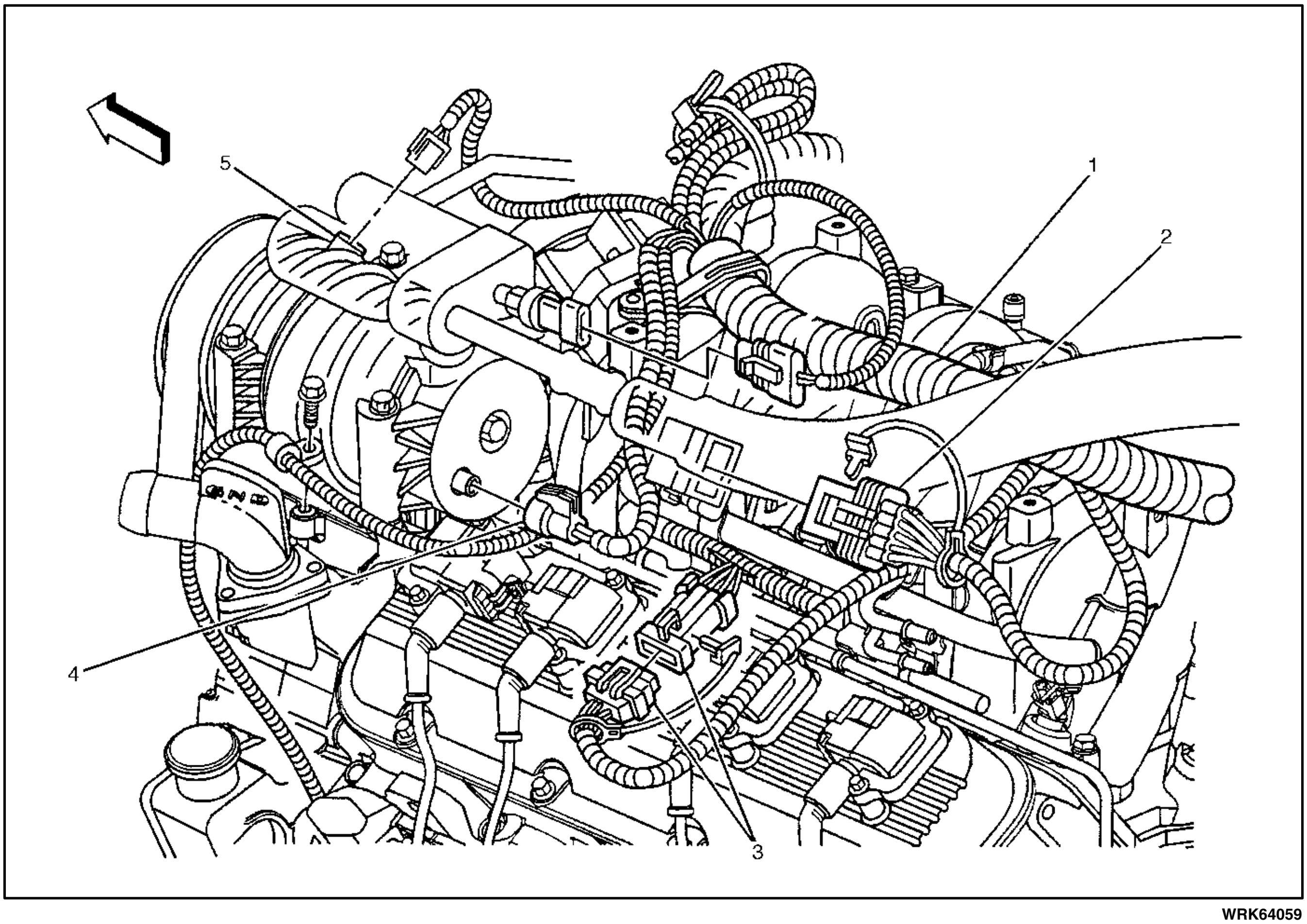
(1) TAC Module Connector C2

(2) Throttle Actuator Control (TAC) Module

(3) TAC Connector C1

(4) IP Harness

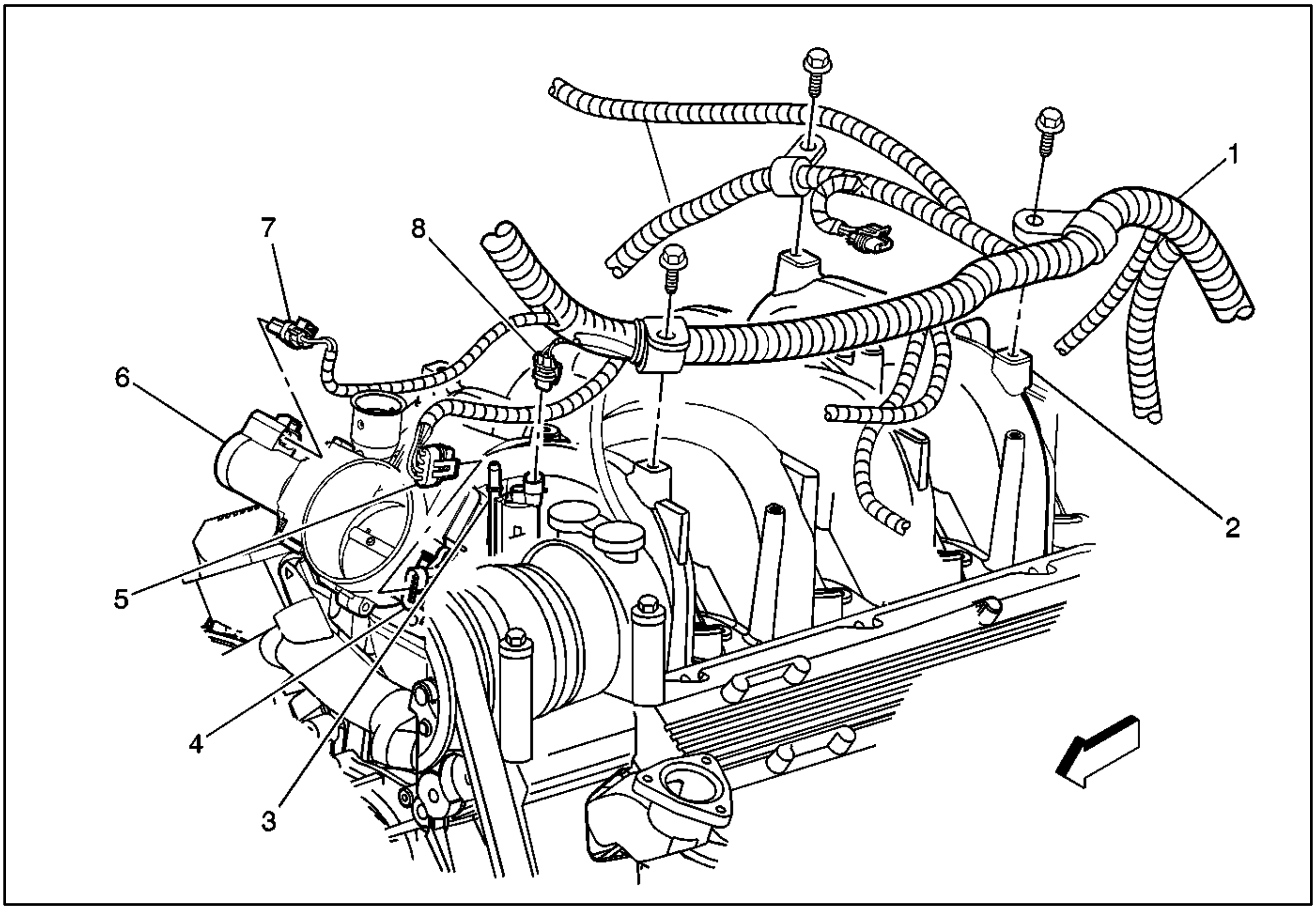
A/C Compressor Connectors, C105, and C148



Legend

(1) Engine Harness
(2) Connector C105 to Fuel Injector Harness
(3) Connector C148 to Ignition Coil Harness – Left Side
(4) A/C High Pressure Cut-Out Switch
(5) A/C Compressor Clutch Connector

Throttle Body and EVAP Control

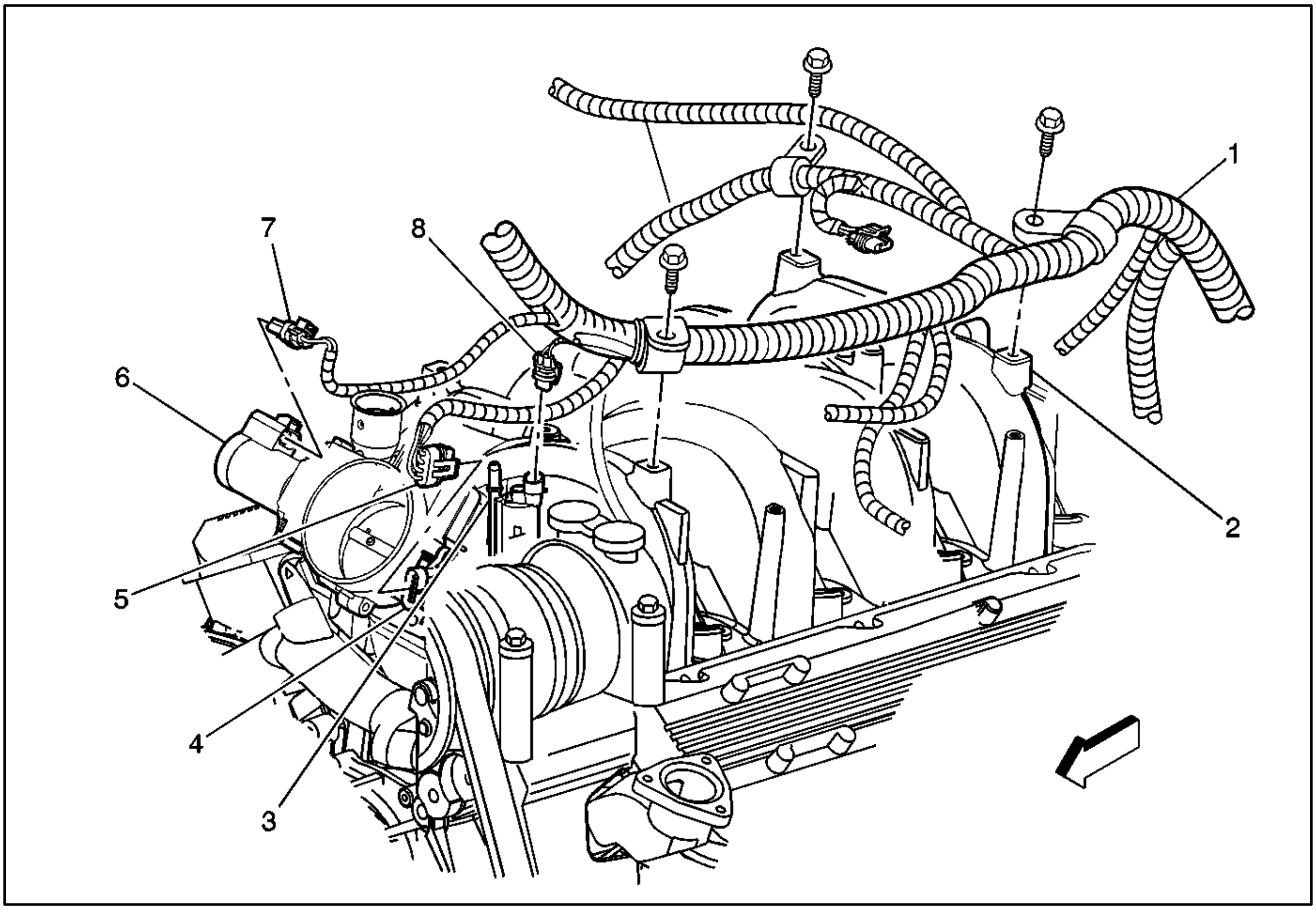


696068

Legend

(1) Engine Harness
(2) Intake Manifold
(3) Evaporative Emission (EVAP) Canister Purge Solenoid
(4) Throttle Position Sensor (TPS)
(5) Throttle Position Sensor (TPS) Connector
(6) Throttle Actuator Control Motor
(7) Throttle Actuator Control Motor Connector
(8) Evaporative Emission (EVAP) Canister Purge Solenoid Connector

Camshaft Position (CMP) Sensor and Knock Sensor (KS) – Left Side

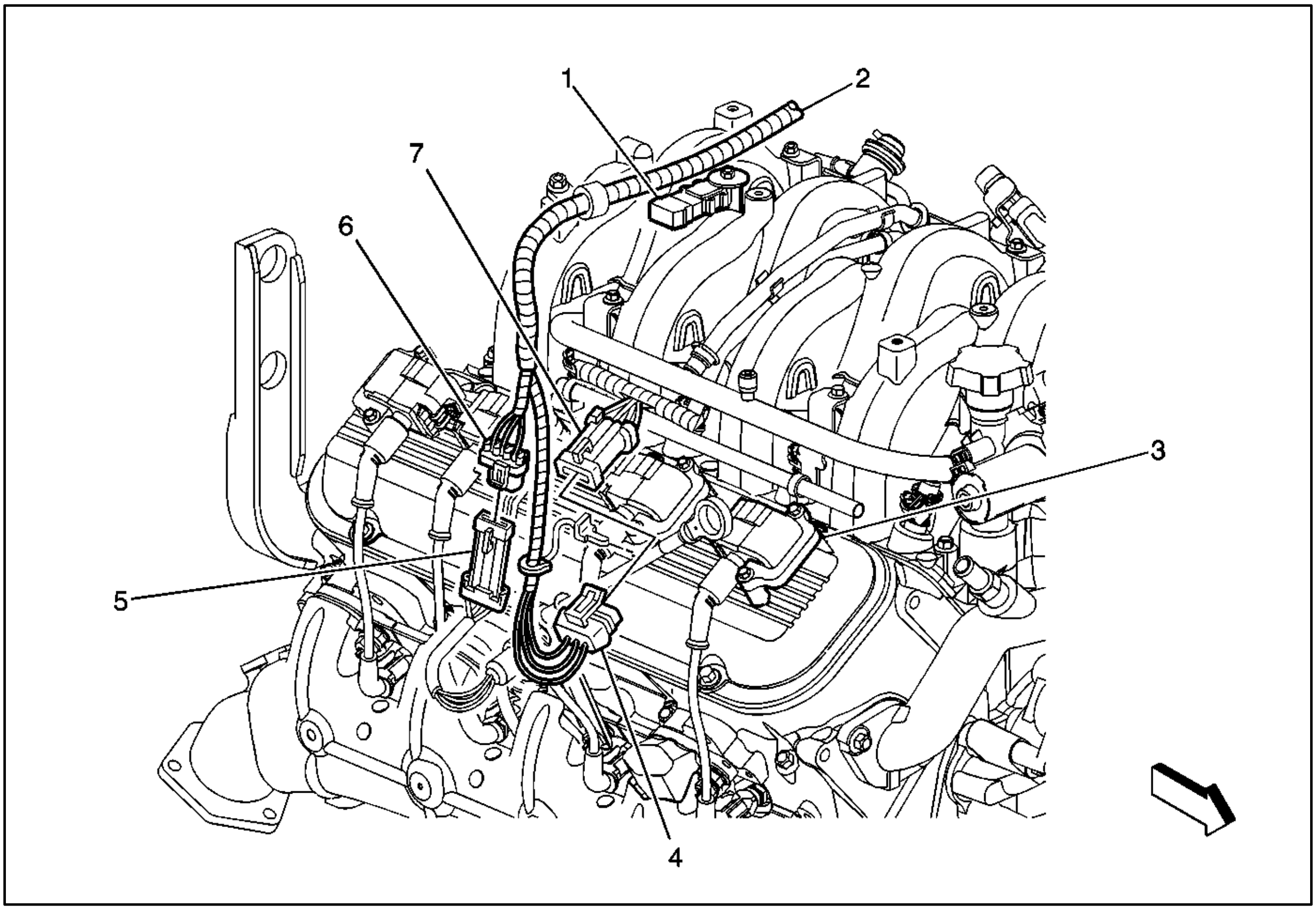


Legend

(1) Camshaft Position (CMP) Sensor

(2) Knock Sensor (KS) – Left Side

MAP Sensor, ECT Sensor, and Ignition Coils – Right Side

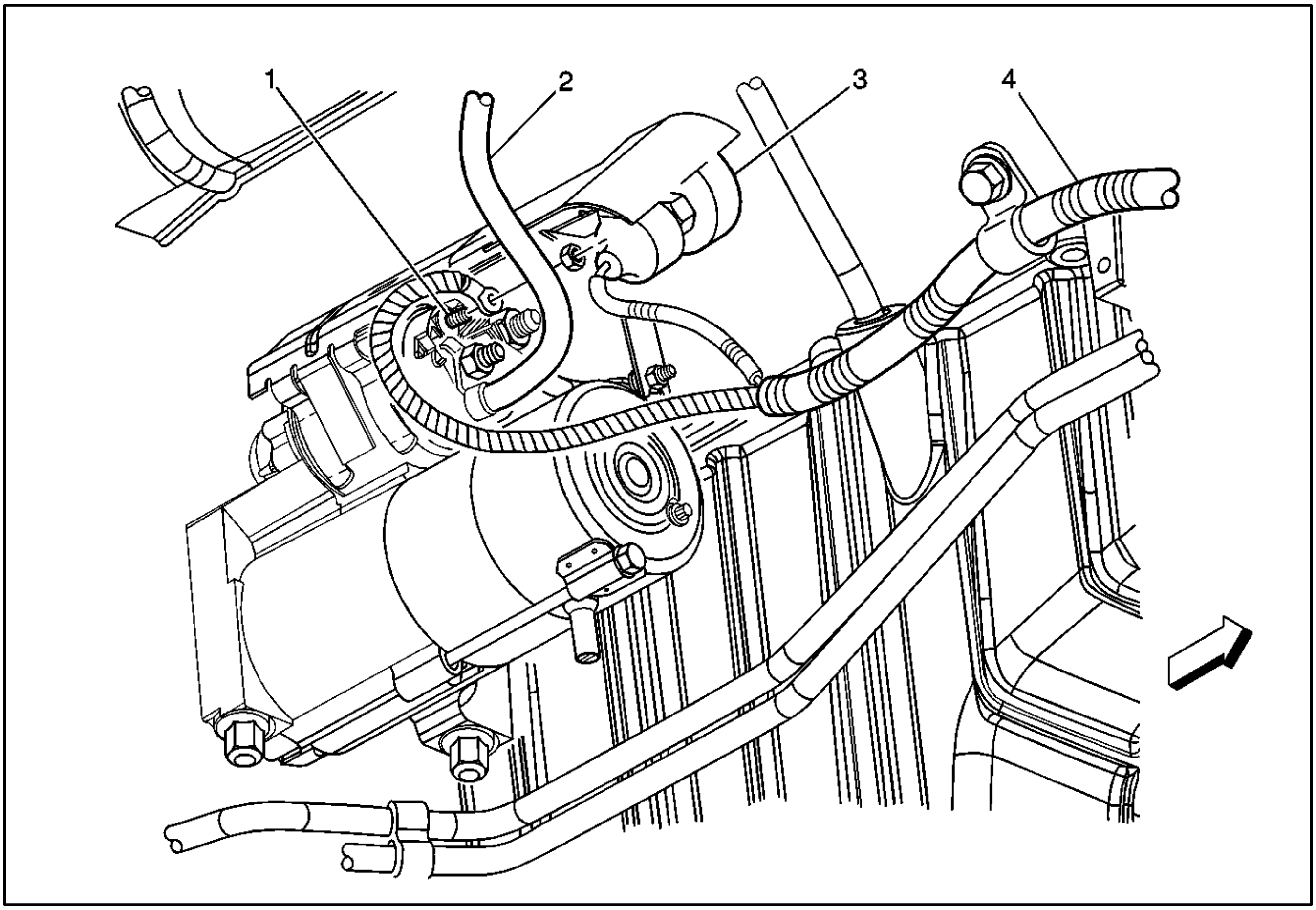


696072

Legend

(1) Manifold Absolute Pressure (MAP) Sensor
(2) Engine Harness
(3) Ignition Coil (IC) – Right Side (Typical)
(4) Connector C190 – Engine Harness
(5) Engine Coolant Temperature (ECT) Sensor Connector
(6) ECT Sensor – Engine Harness
(7) C190 Right Side Ignition Coil Harness

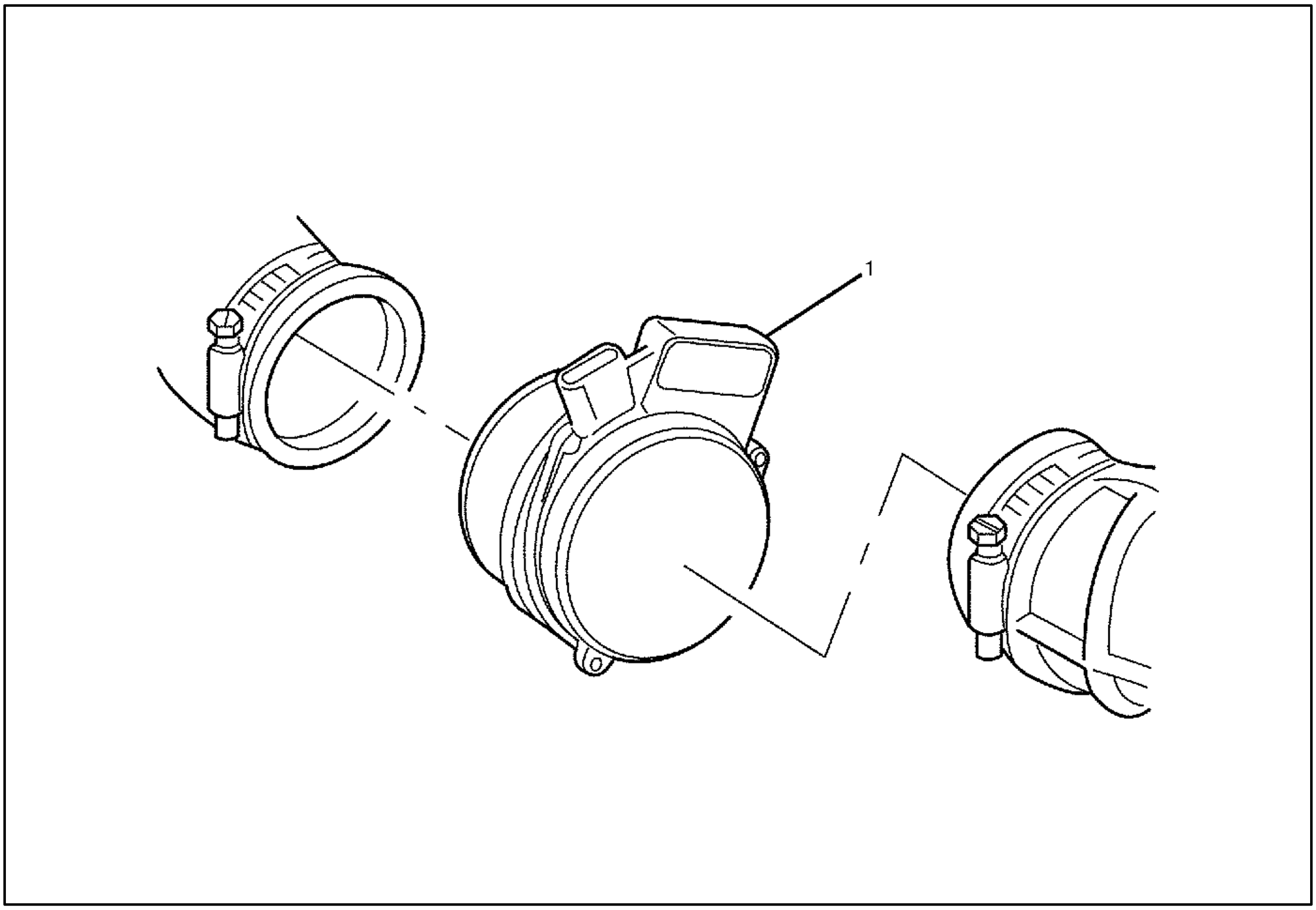
Starter and Knock Sensor – Bank 2



Legend

(1) Starter Solenoid Terminal
(2) Battery Positive Wire for Starter
(3) Knock Sensor – Bank 2
(4) Engine Harness

MAF and IAT Sensor

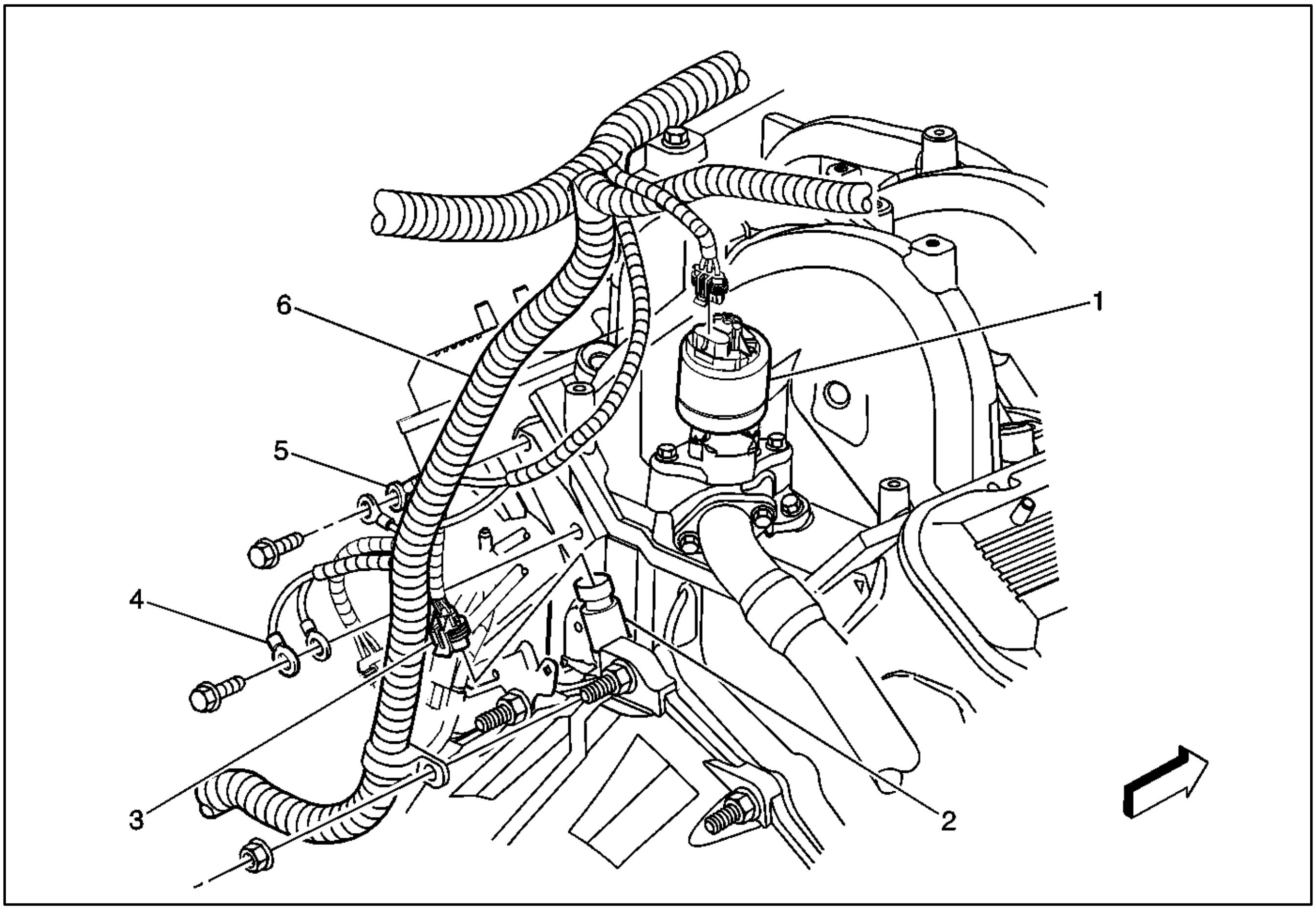


WRK64046

Legend

(1) MAF and IAT Sensor

Engine Oil Pressure (EOP) Sensor G100, G101, G110, and G111

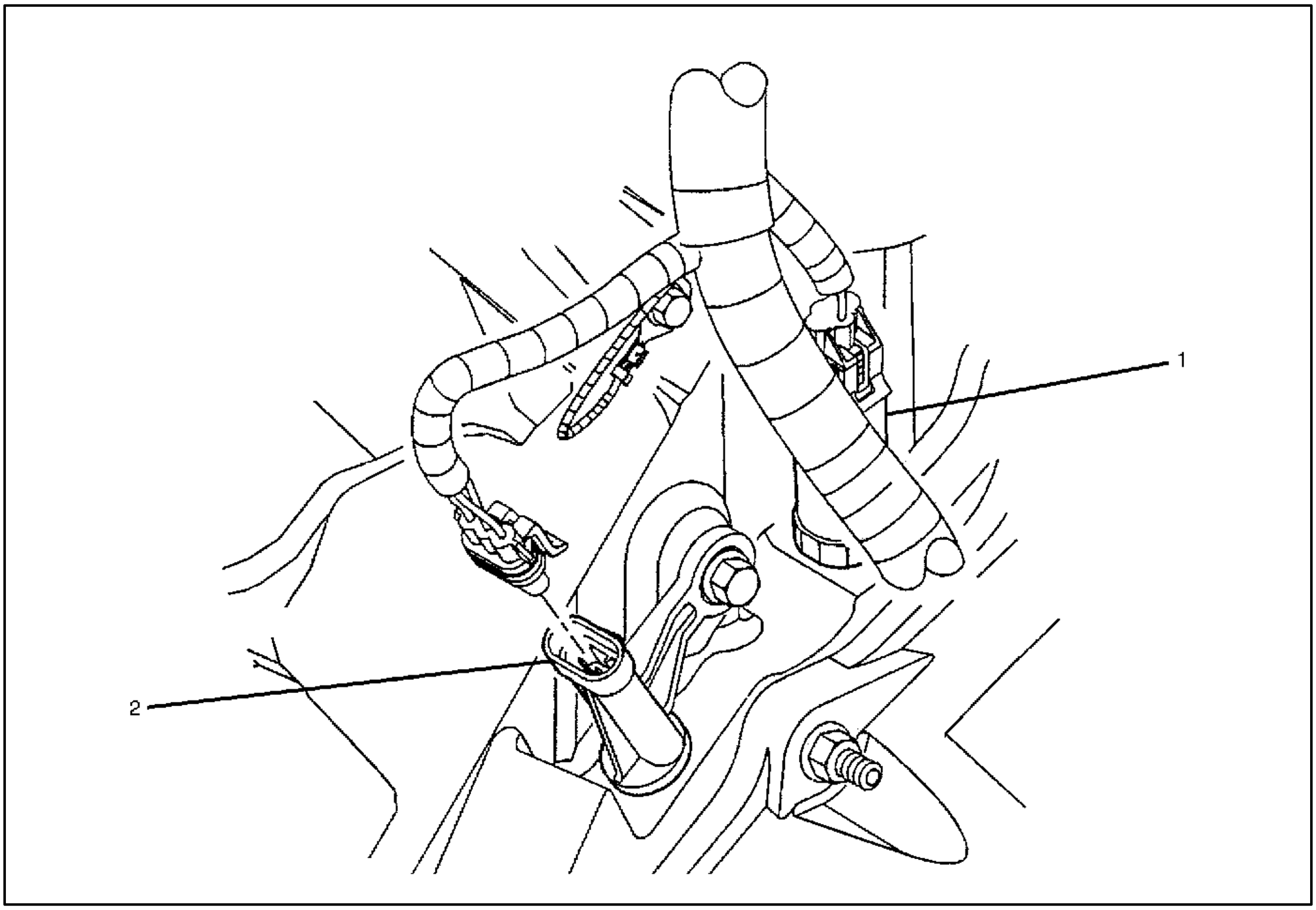


696079

Legend

(1) EGR Valve - **DELETED 2004 MY**
(2) Engine Oil Pressure (EOP) Sensor
(3) Engine Oil Pressure (EOP) Sensor Connector
(4) Ground G110, G111
(5) Ground G100, G101
(6) Engine Harness

Crankshaft Position (CKP) Sensor and Engine Oil Pressure (EOP) Sensor



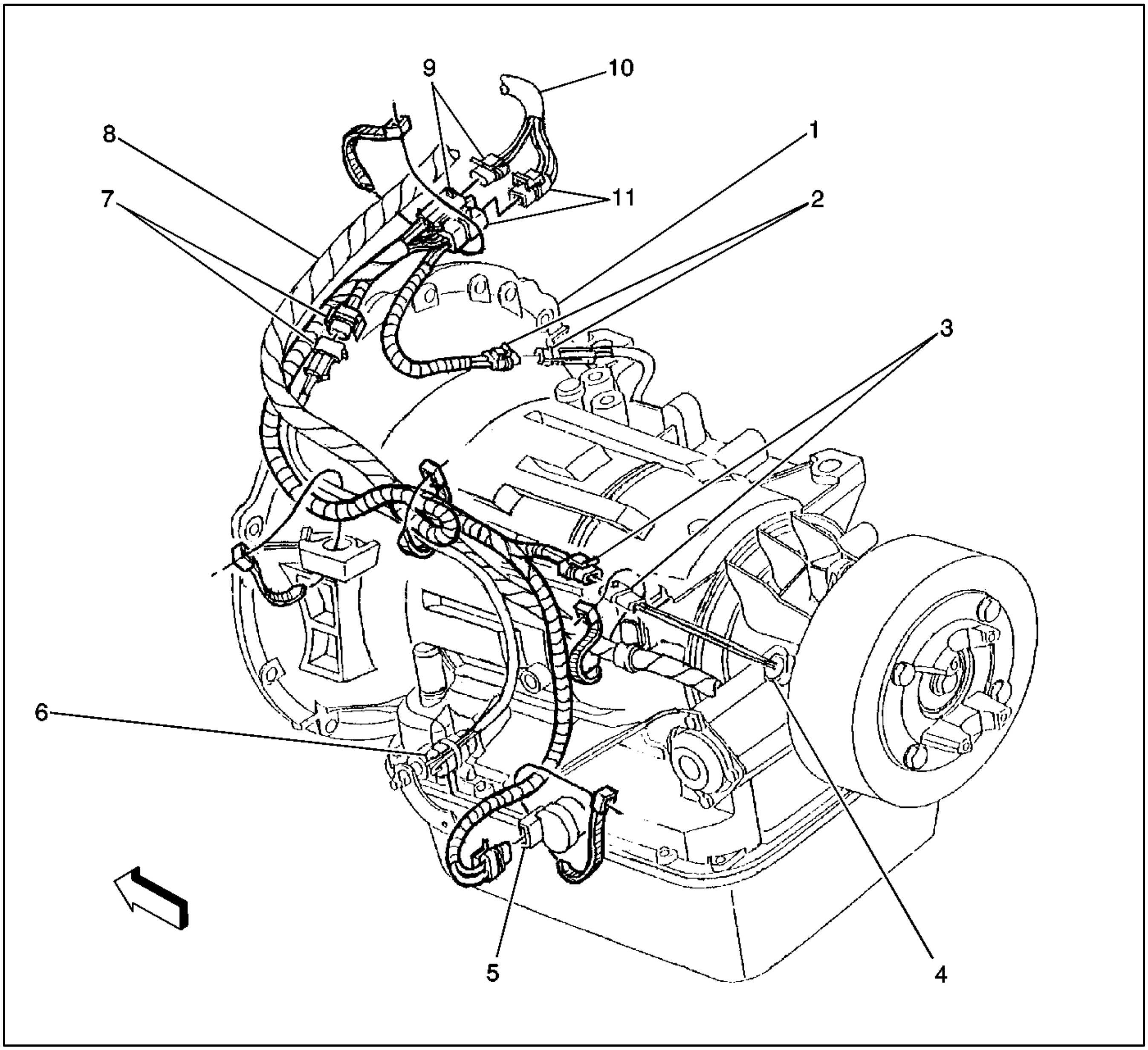
WRK64055

Legend

(1) Engine Oil Pressure (EOP) Sensor

(2) Crankshaft Position (CKP) Sensor

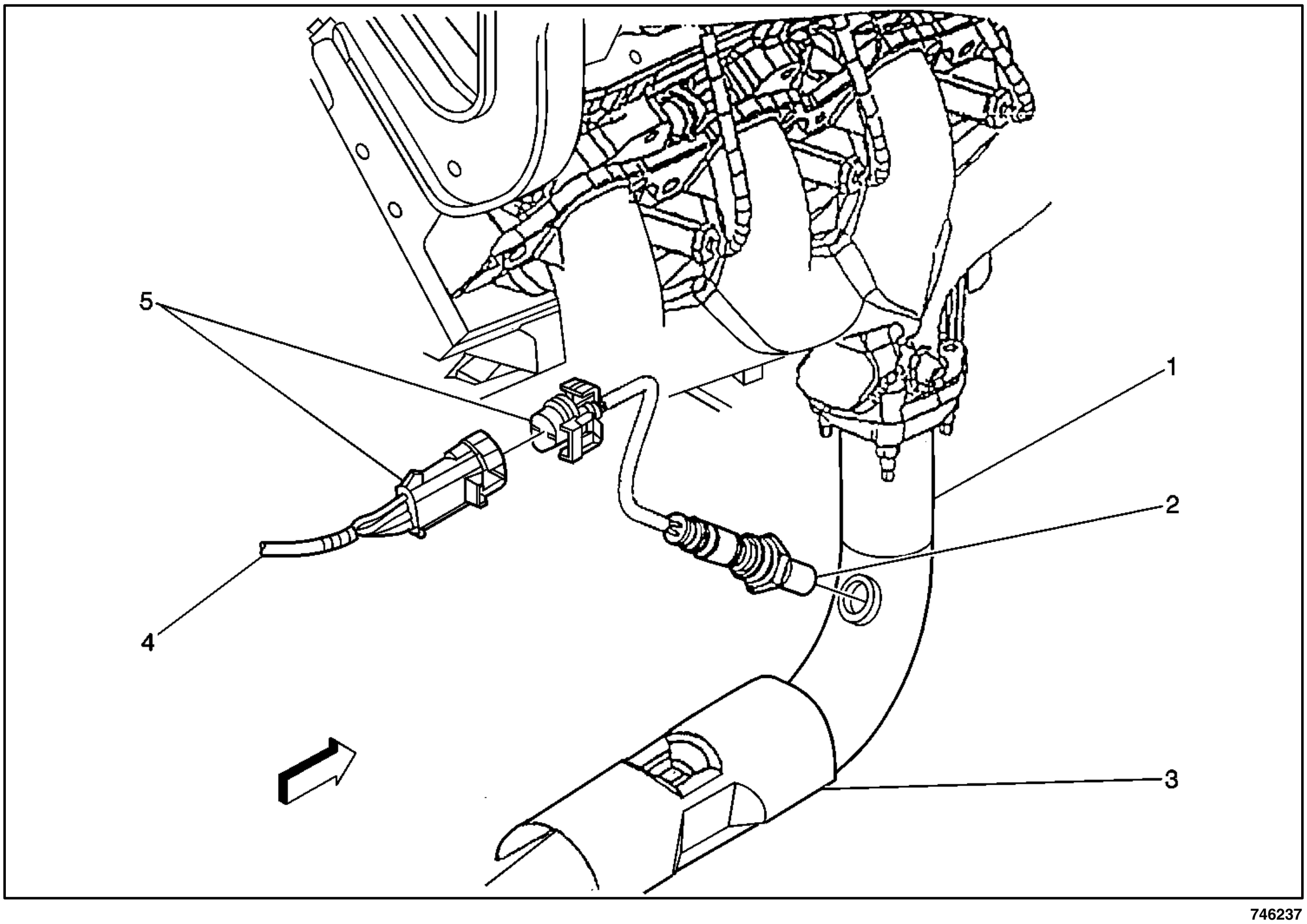
Automatic Transmission



Legend

(1) Automatic Transmission
(2) Backup Lamp Switch Connector (2 cavities)
(3) Vehicle Speed Sensor Connector (2 cavities)
(4) Vehicle Speed Sensor
(5) Automatic Transmission Modulator
(6) Neutral Safety Switch
(7) Neutral Safety Switch Connector (2 cavities)
(8) Battery Cable
(9) Connector C408 (2 cavities)
(10) Engine Harness
(11) Connector C409 (8 cavities)

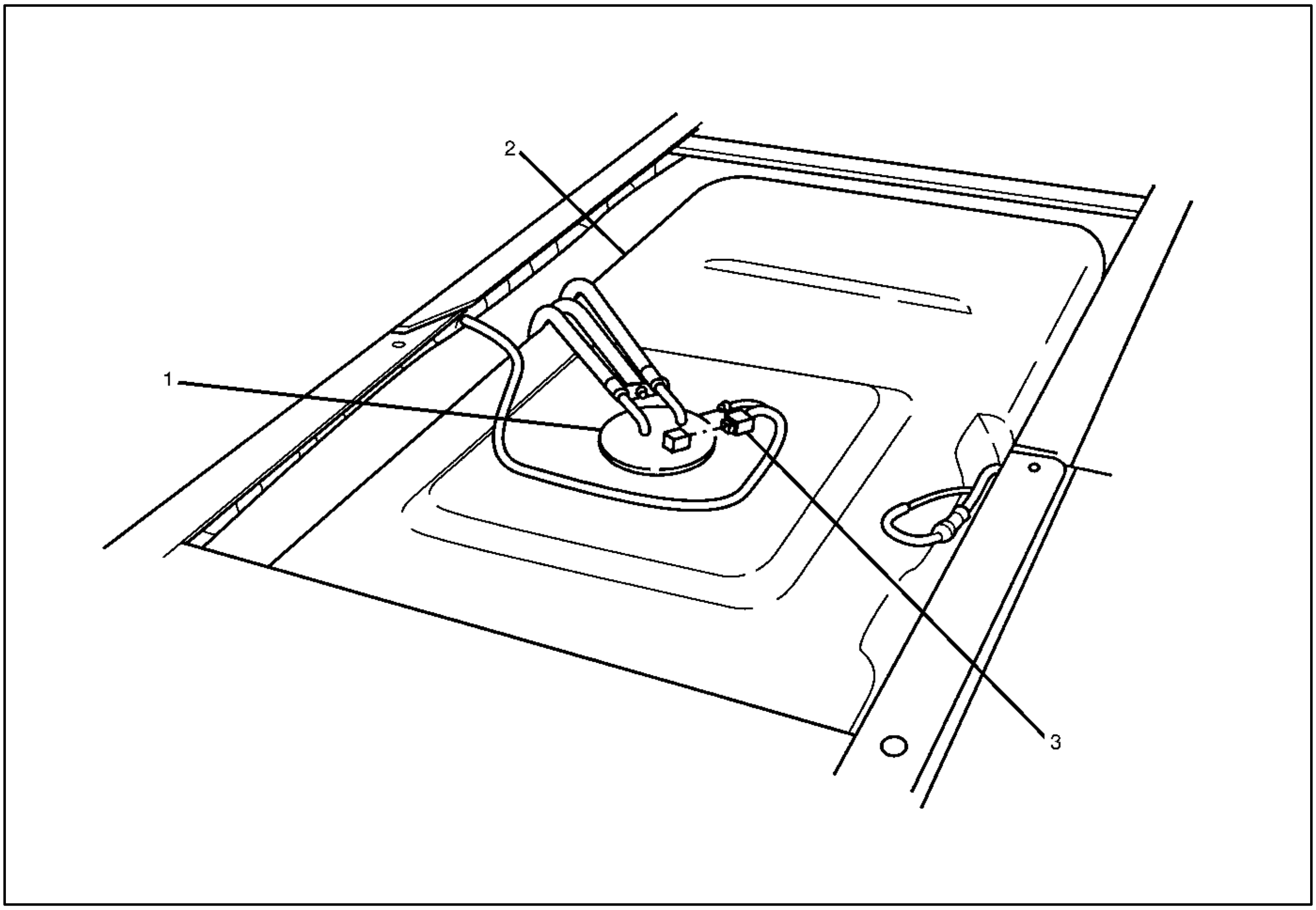
Heated Oxygen Sensor (H02S) – Bank 2



Legend

(1) Exhaust Pipe
(2) Heated Oxygen Sensor (hO2S) Bank 2 Sensor 1
(3) Catalytic Converter
(4) Engine Harness
(5) HO2S Connector

Fuel Tank and G404

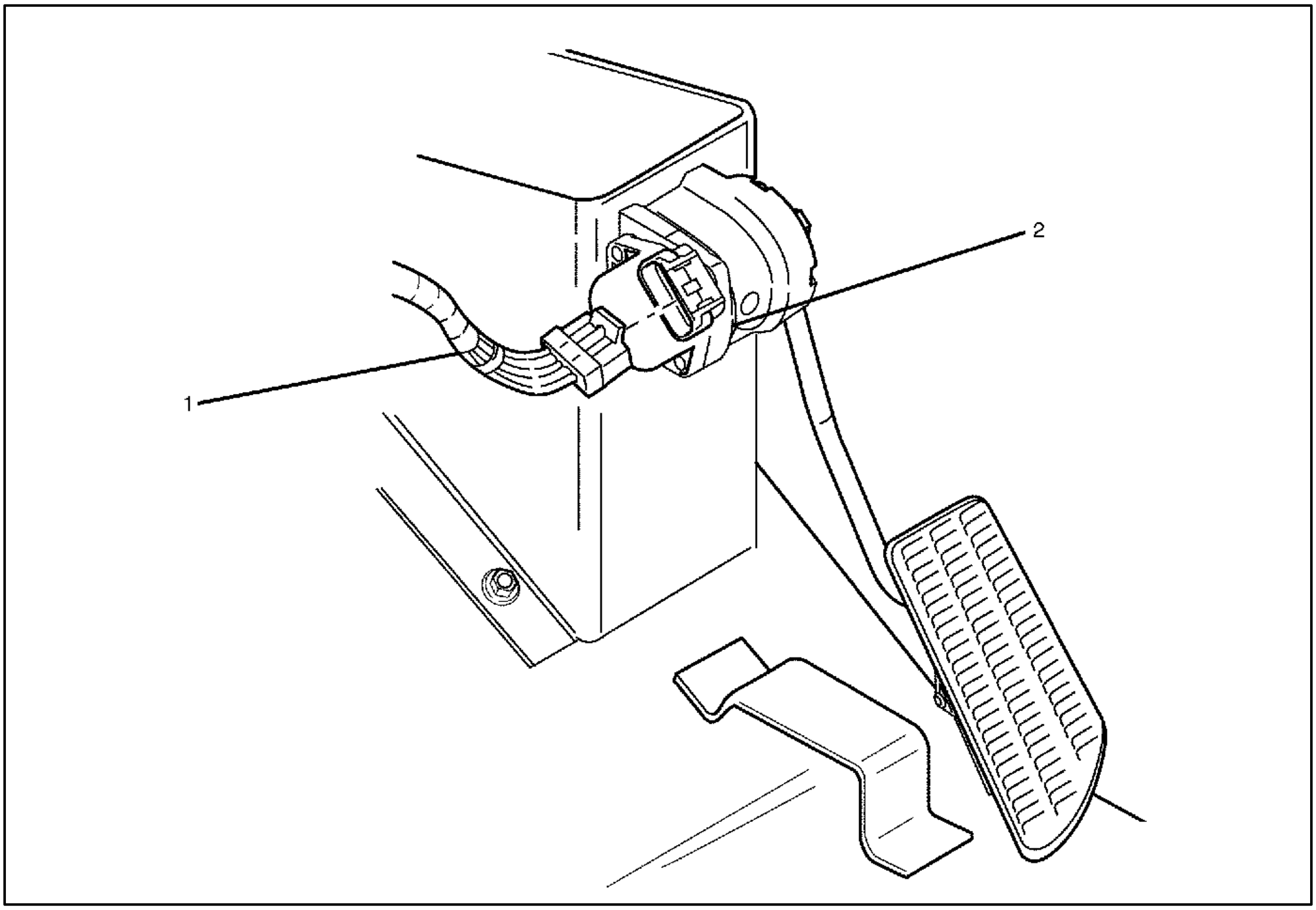


WRK64051

Legend

(1) Fuel Pump and Sender Assembly
(2) Fuel Tank
(3) Fuel Pump and Sender Assembly Connector

Accelerator Pedal Position (APP) Sensor



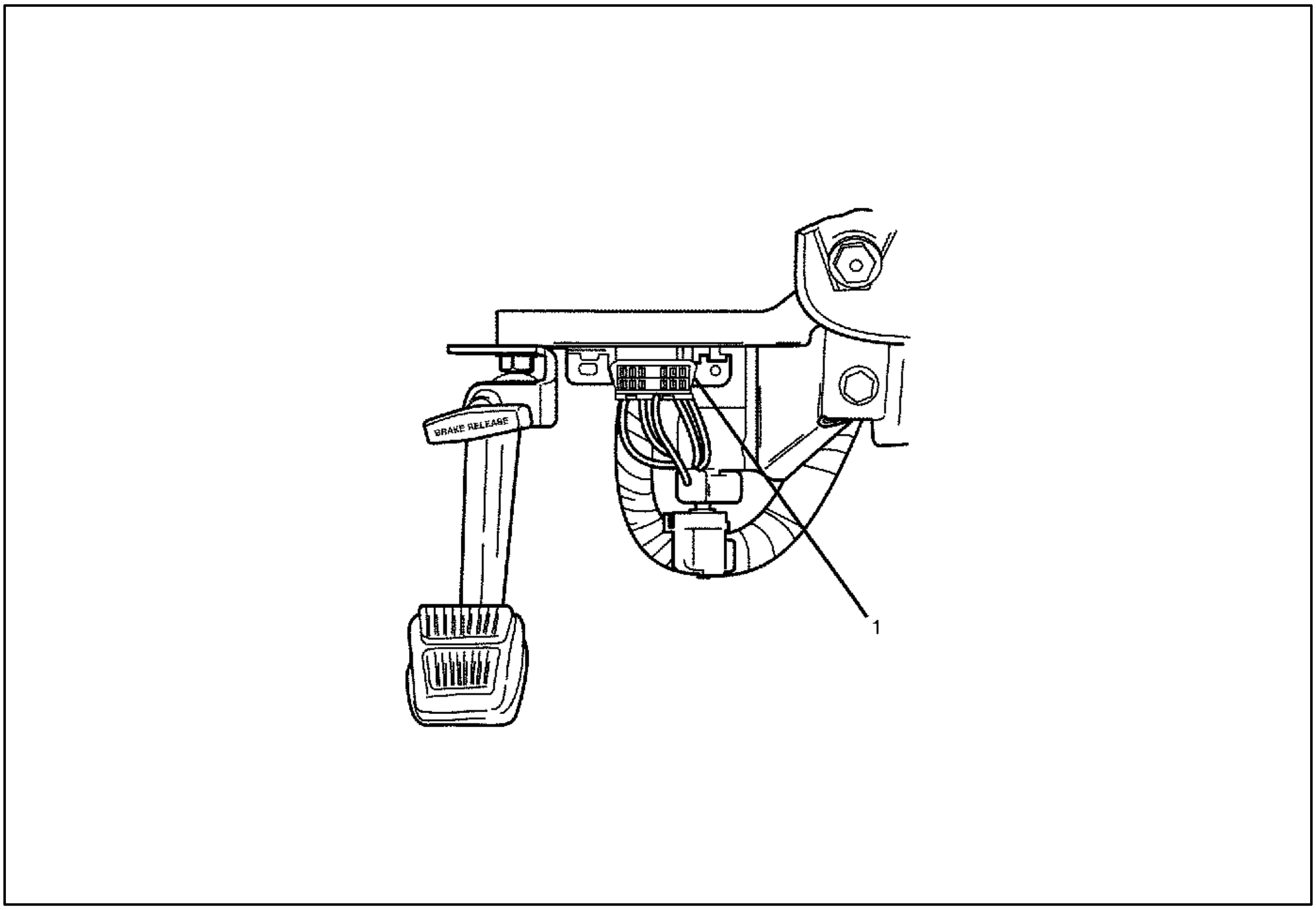
WRK64024

Legend

(1) IP Harness

(2) Accelerator Pedal Position (APP) Sensor

Data Link Connector (DLC)



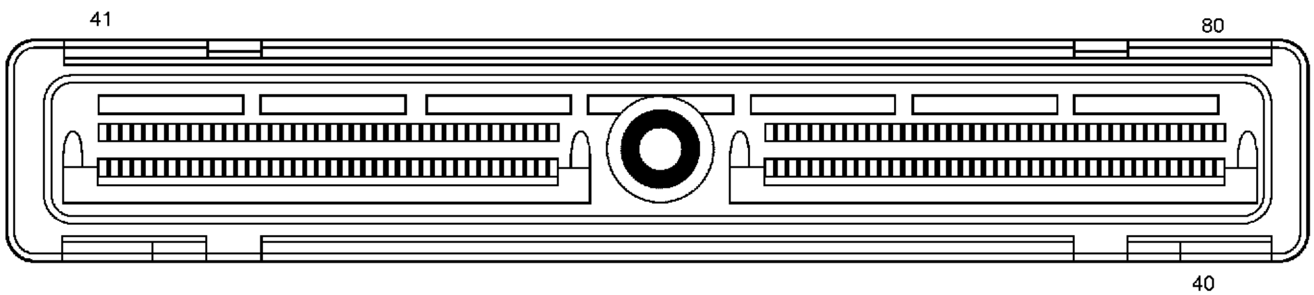
WRK64050

Legend

(1) Data Link Connector (DLC)

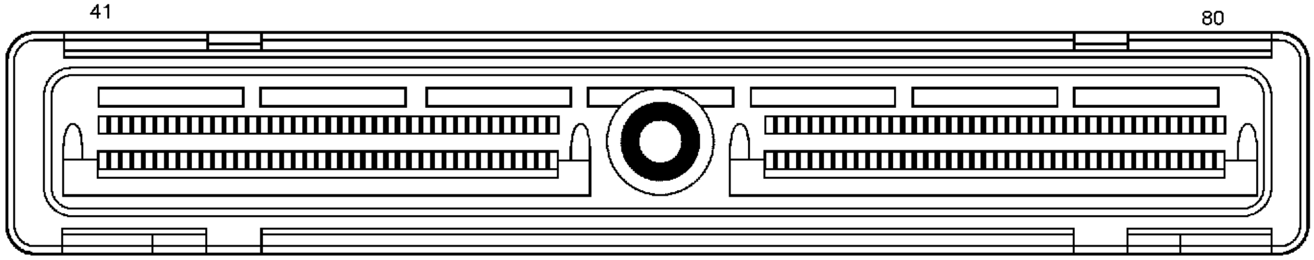
Powertrain Control Module (PCM) Connector End Views

C1 Powertrain Control Module (PCM)



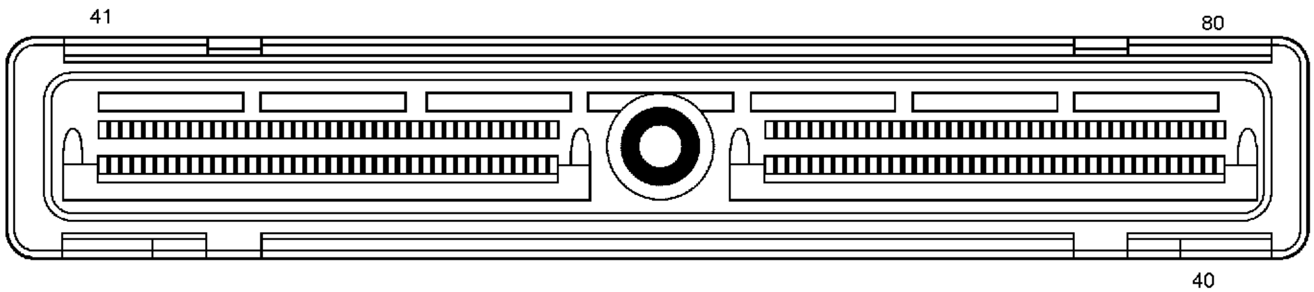
Connector Part Information			• 12191489 • 80-Way F Micro-Pack (BLUE)
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BLK/WHT	451	Ground to G108
2	LT GRN	1867	CKP 12V Reference
3	PNK/BLK	1746	Fuel Injector 3 Control
4	LT GRN/BLK	1745	Fuel Injector 2 Control
5–10	—	—	Not Used
11	LT BLU	1876	Knock Sensor 2 Signal
12	DK BLU/WHT	1869	CKP Sensor Signal
13	—	—	Not Used
14	ORN/BLK	1061	TAC UART Data
15	DK BLU/WHT	774	TAC UART Data
16–18	—	—	Not Used
19	PNK	439	Ignition 1 Voltage
20	ORN	440	B+ Voltage
21	YEL/BLK	1868	CKP Low Reference
22	—	—	Not Used
23	BLK	470	Fuel Sender Return
24–25	—	—	Not Used
26	BLK/WHT	451	HO2S LO Bank 2 Sensor 1
27–28	—	—	Not Used
29	BLK/WHT	451	HO2S LO Bank 1 Sensor 1
30–31	—	—	Not Used
32	BLK/WHT	771	PRNDL A Input
33	PPL	420	TCC Brake Switch Signal
34	WHT	776	Trans Range Switch Signal P

C1 Powertrain Control Module (PCM) (cont'd)



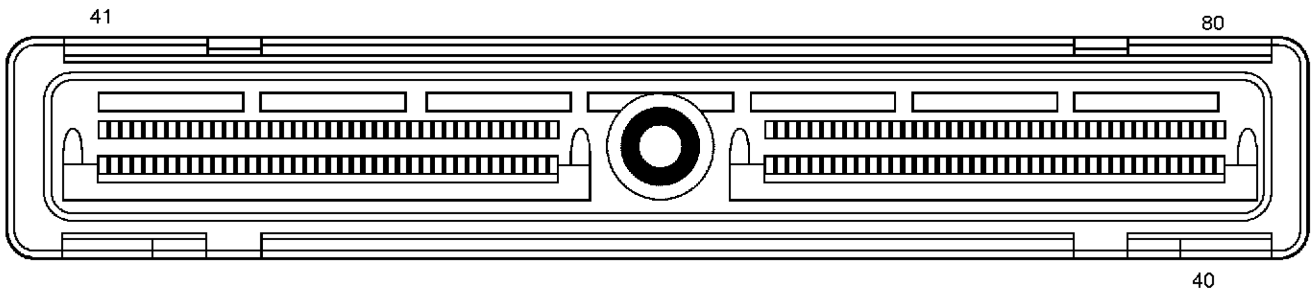
Connector Part Information			• 12191489 • 80-Way F Micro-Pack (BLUE)
Pin	Wire Color	Circuit No.	Function
35	—	—	Not Used
36	BLK	1744	Fuel Injector 1 Control
37	YEL/BLK	846	Fuel Injector 6 Control
38–39	—	—	Not Used
40	BLK/WHT	551	Ground to G108
41	—	—	Not Used
42	DK BLU	473	Auxiliary Fan Relay
43	RED/BLK	877	Fuel Injector 7 Control
44	LT BLU/BLK	844	Fuel Injector 4 Control
45–46	—	—	Not Used
47	—	—	Not Used
48	GRY	597	MAP 5 Volt Reference
49–50	—	—	Not Used
51	DK BLU	496	Knock Sensor 1 Signal
52–53	—	—	Not Used
54	ORN/BLK	469	MAP Low Reference
55	—	—	Not Used
56	—	—	Not Used
57	ORN	440	Battery Positive Voltage
58	PPL	1807	Class 2 Serial Data
59	DK GRN	1049	Class 2 Serial Data
60	—	—	Not Used
61	PNK/BLK	632	CMP Low Reference/Return
62–65	—	—	Not Used
66	PPL	1666	HO2S High Bank2 Sensor 1
67–68	—	—	Not Used
69	PPL/WHT	1665	HO2S High Bank 1 Sensor 1
70–71	—	—	Not Used

C1 Powertrain Control Module (PCM) (cont'd)



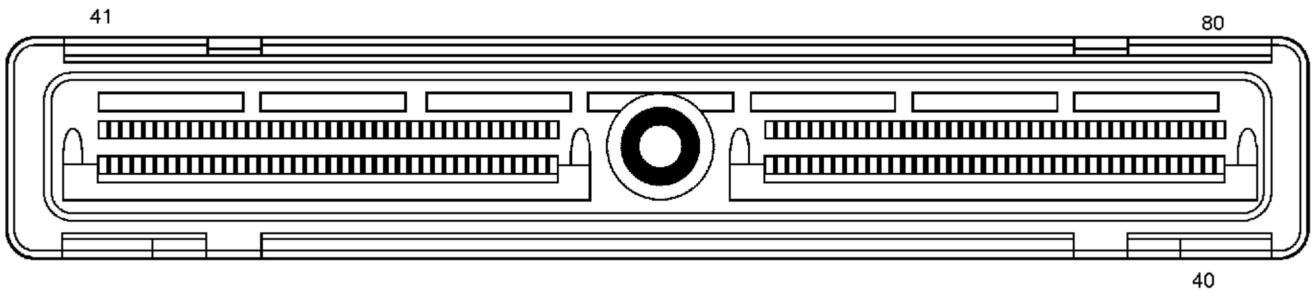
Connector Part Information			• 12191489 • 80-Way F Micro-Pack (BLUE)
Pin	**Wire Color**	**Circuit No.**	**Function**
72	YEL	772	PRNDL B Input
73	BRN/WHT	633	CMP Signal
74	YEL	410	ECT Sensor Signal
75	—	—	Not Used
76	BLK/WHT	845	Fuel Injector 5 Control
77	DK BLU/WHT	878	Fuel Injector 8 Control
78–79	—	—	Not Used
80	GRY	720	ECT Low Reference Return

C2 Powertrain Control Module (PCM)



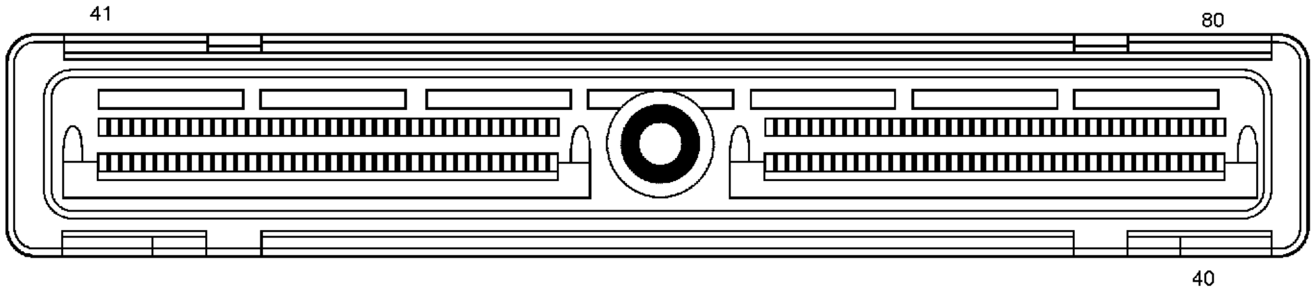
Connector Part Information			• 12191488 • 80 Way F Micro-Pack (RED)
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BLK/WHT	551	Ground to G108
2	PPL	999	UN·managed Torque Signal
3–4	—	—	Not Used
5	TAN/BLK	464	Delivered Torque Signal
6	—	—	Not Used
7	—	—	Not Used
8	—	—	Not Used
9	DK GRN/WHT	465	Fuel Pump Relay Control
10	WHT	121	Engine Speed Signal (Tach Signal)
11	DK BLU	604	A/C High Pressure Switch Signal
12–14	—	—	Not Used
15	RED	225	Generator Turn On Signal
16	—	—	Not Used
17	DK GRN/WHT	762	A/C Request Signal
18–20	—	—	Not Used
21	YEL	400	TOSS High (Replicated)
22–24	—	—	Not Used
25	TAN	472	IAT Sensor Signal
26	PPL	2121	Ignition Coil 1 Control
27	RED	2127	Ignition Coil 7 Control
28	LT BLU/WHT	2126	Ignition Coil 6 Control
29	DK GRN/WHT	2124	Ignition Coil 4 Control
30	—	—	Not Used
31	YEL	492	MAF Sensor Signal
32	LT GRN	432	MAP Sensor Signal
33	—	—	Not Used
34	DK GRN/WHT	428	EVAP Purge Control
35	BRN	25	BAT Indicator Control
36	—	—	Not Used

C2 Powertrain Control Module (PCM) (cont'd)



Connector Part Information			• 12191488 • 80 Way F Micro-Pack (RED)
Pin	**Wire Color**	**Circuit No.**	**Function**
37	WHT/BLK	499	Reduced Power Lamp Control
38	PPL	30	Fuel Gauge Signal
39	RED	631	CMP Sensor 12 Volt Reference
40	BLK/WHT	451	Ground to G108
41	—	—	Not Used
42	—	—	Not Used
43	DK GRN/WHT	459	A/C Clutch Relay Control
44–45	—	—	Not Used
46	BRN/WHT	419	MIL Control
47–49	—	—	Not Used
50	DK GRN/WHT	817	Vehicle Speed Sensor Output
51	—	—	Not Used
52	GRY	23	Generator Field Duty Cycle
53	—	—	Not Used
54	PPL	1589	Fuel Level Sensor Signal
55	DK GRN	603	A/C Low Pressure Switch Signal
56	—	—	Not Used
57	BLK	552	IAT Low Reference
58	—	—	Not Used
59	PPL	806	Crank Request Signal
60	BRN	2129	Ignition Coil Reference Low LH
61	BRN/WHT	2130	Ignition Coil Reference Low RH
62	GRY	773	PRNDL C Input
63–65	—	—	Not Used
66	PPL/WHT	2128	Ignition Coil 8 Control
67	RED/WHT	2122	Ignition Coil 2 Control
68	DK GRN	2125	Ignition Coil 5 Control
69	LT BLU	2123	Ignition Coil 3 Control

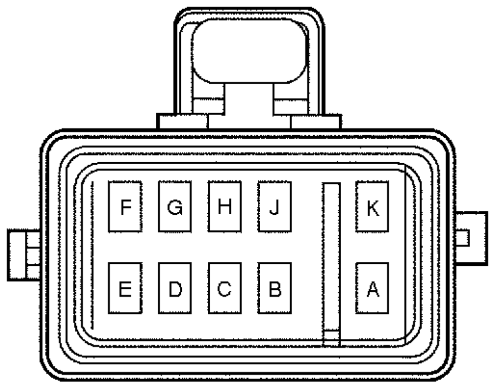
C2 Powertrain Control Module (PCM) (cont'd)



WRK64028

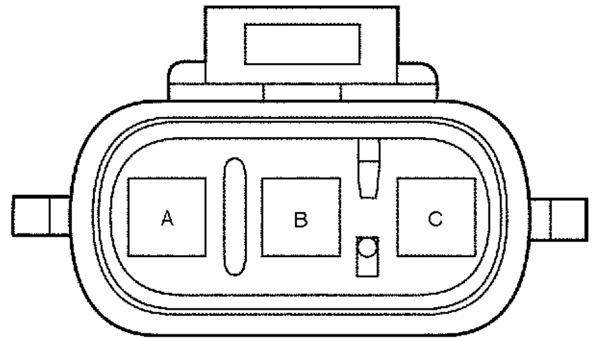
Connector Part Information			• 12191488 • 80 Way F Micro-Pack (RED)
Pin	Wire Color	Circuit No.	Function
70–73	—	—	Not Used
74	PNK	414	HO2S Heater Feed
75–79	—	—	Not Used
80	DK GRN	676	HO2S Low Reference

Accelerator Pedal Position (APP) Sensor



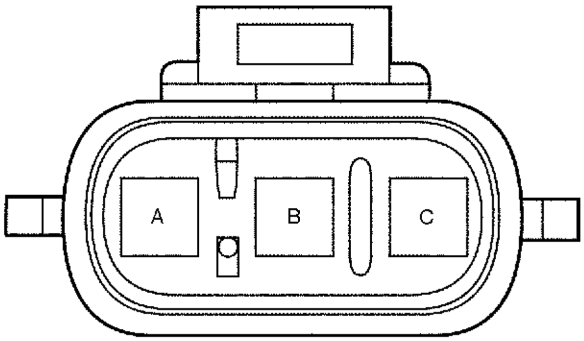
Connector Part Information	• 15318071 • 10 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRY	1273	Low Reference
B	PPL	1272	Low Reference
C	LT BLU	1162	APP Sensor 2 Signal
D	TAN	1274	5 Volt Reference
E	YEL/BLK	1275	Low Reference
F	DK BLU	1161	APP Sensor 1 Signal
G	WHT/BLK	1164	5 Volt Reference
H	—	—	Not Used
J	BRN	1271	5 Volt reference
K	DK GRN	1163	APP Sensor 3 Signal

Camshaft Position (CMP) Sensor



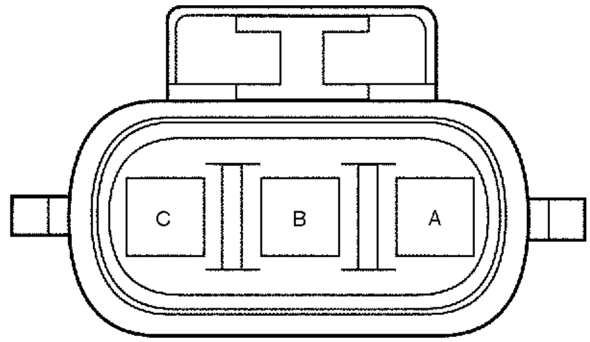
Connector Part Information	• 12129946 • 3 Way F Metri-Pack 150 Series (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK/BLK	631	12 Volt Reference
B	BRN/WHT	632	Low Reference
C	PNK	633	CMP Signal

Crankshaft Position (CKP) Sensor



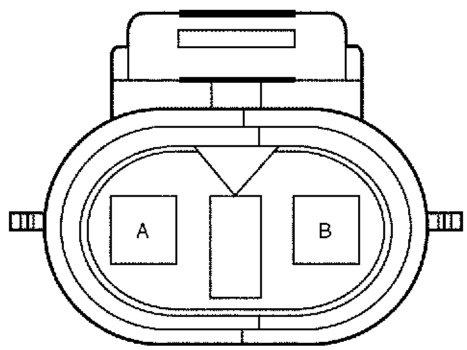
Connector Part Information	• 15324165 • 3 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	LT GRN	1867	12 Volt Reference
B	YEL/BLK	1868	Low Reference
C	DK BLU/ WHT	1869	CKP Sensor Signal

Engine Coolant Temperature (ECT) Sensor



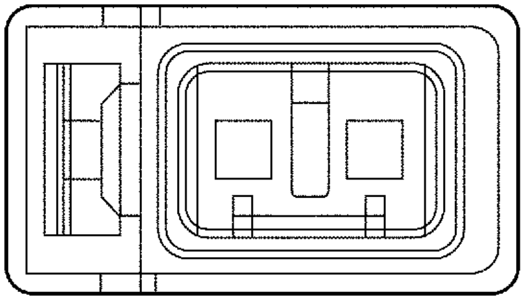
Connector Part Information	• 12110293 • 3 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	452	Coolant Temperature Sensor Return
B	YEL	410	PCM Coolant Temperature Signal
C	DK GRN	35	Temperature Gauge Signal

Evaporative Emission (EVAP) Canister Purge Valve



Connector Part Information	• 12124037 • 5 Way F Metri-Pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	539	Fused Ignition Positive Voltage
B	DK GRN/WHT	428	Canister Purge Solenoid Output

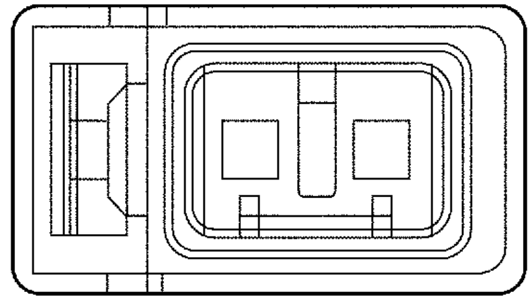
Fuel Injector 1



WRK64035

Pin	Wire Color	Circuit No.	Function
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
A	PNK	339	Fused Ignition Positive Voltage
B	BLK	1744	Fuel Injector 1 Output

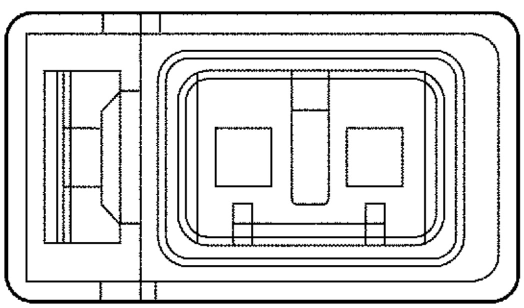
Fuel Injector 3



WRK64035

Pin	Wire Color	Circuit No.	Function
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
A	PNK	339	Fused Ignition Positive Voltage
B	PNK/BLK	1746	Fuel Injector 3 Output

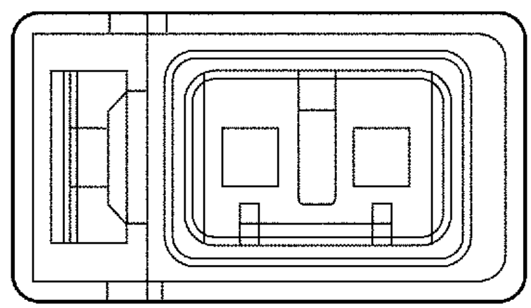
Fuel Injector 2



WRK64035

Pin	Wire Color	Circuit No.	Function
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
A	PNK	239	Fused Ignition Positive Voltage
B	LT GRN/BLK	1745	Fuel Injector 2 Output

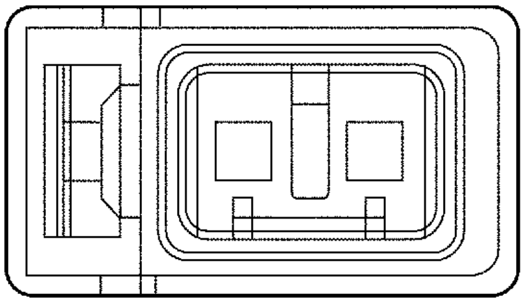
Fuel Injector 4



WRK64035

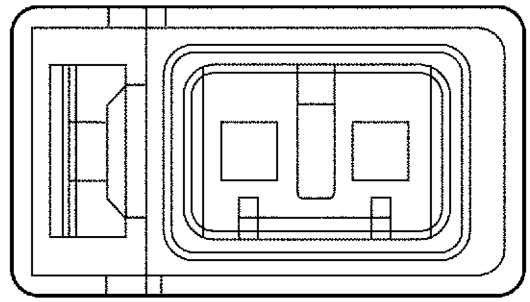
Pin	Wire Color	Circuit No.	Function
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
A	PNK	239	Fused Ignition Positive Voltage
B	LT BLU/BLK	844	Fuel Injector 4 Output

Fuel Injector 5



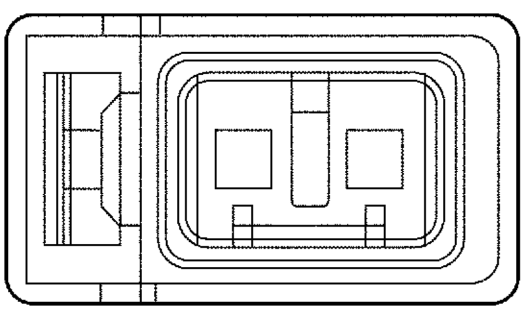
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	339	Fused Ignition Positive Voltage
B	BLK/WHT	845	Fuel Injector 5 Output

Fuel Injector 7



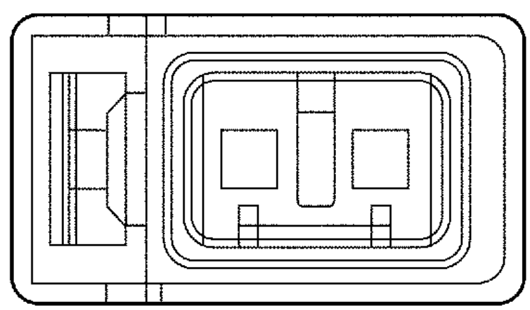
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	339	Fused Ignition Positive Voltage
B	RED/BLK	877	Fuel Injector 7 Output

Fuel Injector 6



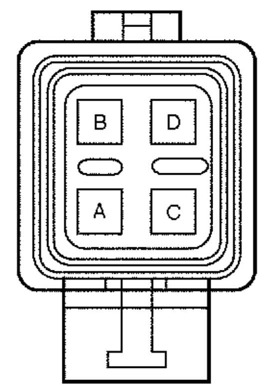
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	239	Fused Ignition Positive Voltage
B	YEL/BLK	846	Fuel Injector 6 Output

Fuel Injector 8



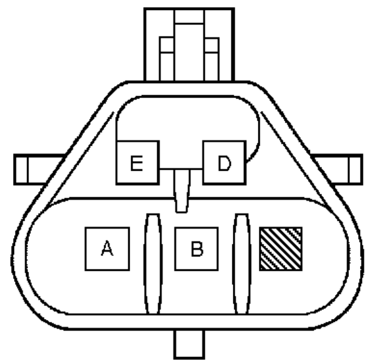
Connector Part Information		• Similar to 15326181 • 2 Way F Lock Tab Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PNK	239	Fused Ignition Positive Voltage
B	DK BLU/WHT	878	Fuel Injector 8 Control

Fuel Tank Meter Connector



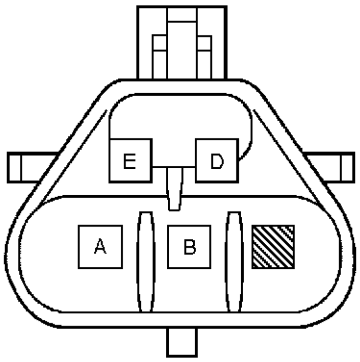
Connector Part Information	• 12160563 • 4 Way F Metri-pack (NAT)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL	1589	Sending Unit Level Signal
B	GRY	120	Fuel Pump Power Feed
C	BLK	150	Ground
D	BLK	470	Sending Unit Level Low Reference to PCM

Heated Oxygen Sensor (HO2S), Bank 1, Sensor 1 (LF)



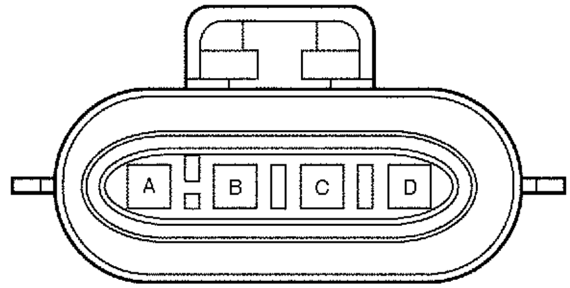
Connector Part Information	• 12092840 • 5M M/P 150 (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK/WHT	451	HO2S Bank 1 Sensor 1 Low
B	PPL/WHT	1665	HO2S Bank 1 Sensor 1 High
C	–	–	Not Used
D	PNK	414	Ignition 1 Voltage
E	DK GRN	676	Ground

Heated Oxygen Sensor (HO2S), Bank 2, Sensor 1 (RF)



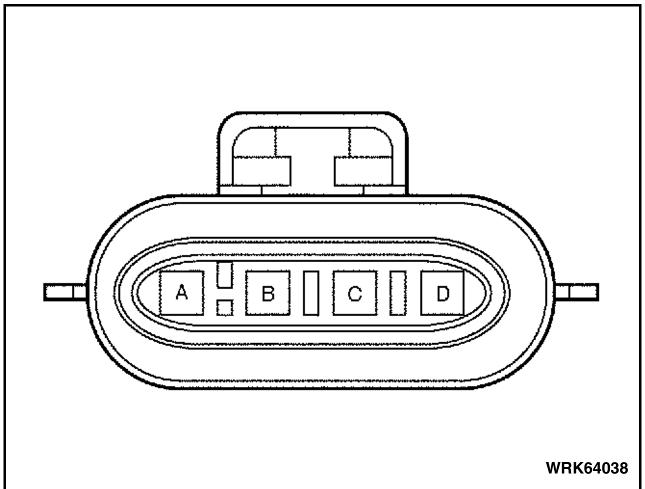
Connector Part Information	• 12092840 • 5M M/P 150 (NAT)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK/WHT	451	HO2S Bank 1 Sensor 1 Low
B	PPL	1666	HO2S Bank 1 Sensor 1 High
C	—	—	Not Used
D	PNK	414	Ignition 1 Voltage
E	DK GRN	676	Ground

Ignition Coil Connector Cylinder 1



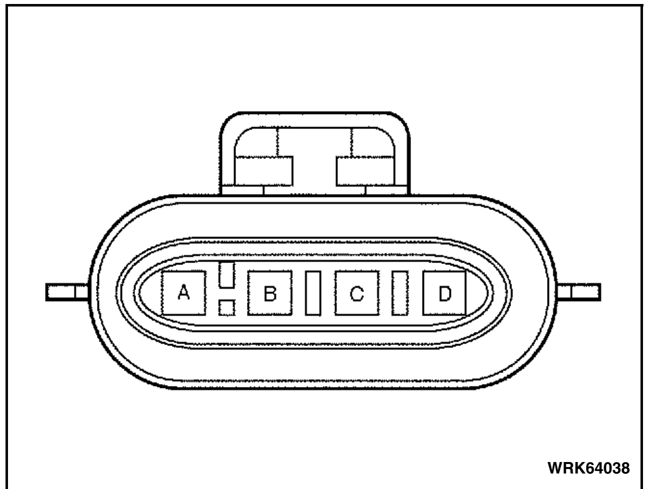
Connector Part Information	• 12186694 • 4 Way F Metri-pack (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2129	Reference Low
C	PPL	2121	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 2



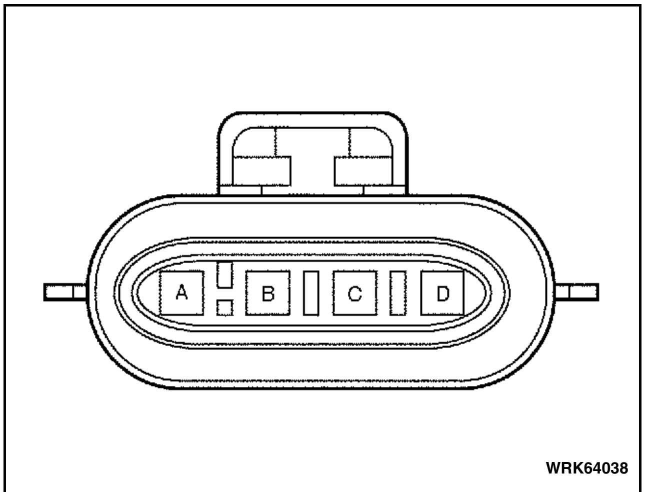
Connector Part Information	• 12186694 • 4 Way F Metri-pack (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2130	Reference Low
C	RED	2122	Ignition Control Signal
D	PNK	239	Ignition Positive Voltage

Ignition Coil Connector Cylinder 3



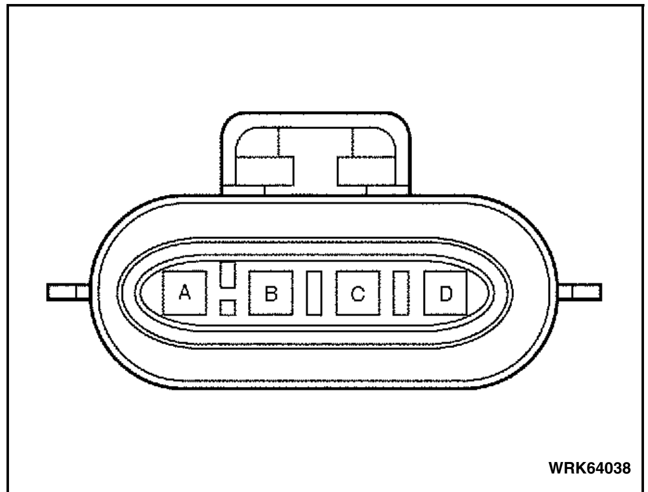
Connector Part Information	• 12186694 • 4 Way F Metri-pack (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2129	Reference Low
C	LT BLU	2123	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 4



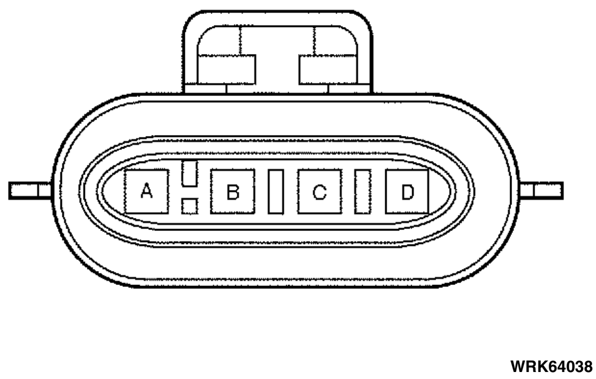
Connector Part Information		• 12186694 • 4 Way F Metri-pack (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2130	Reference Low
C	DK GRN	2124	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 5



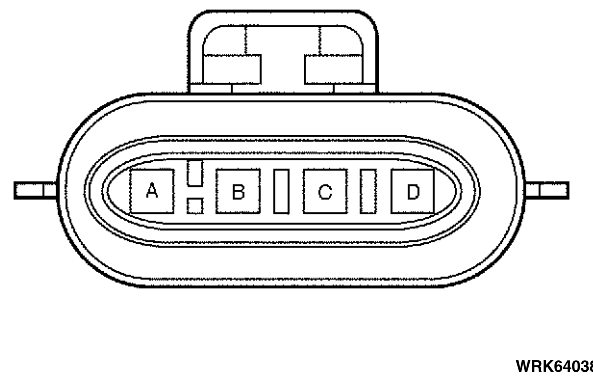
Connector Part Information		• 12186694 • 4 Way F Metri-pack (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2129	Reference Low
C	DK GRN	2125	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 6



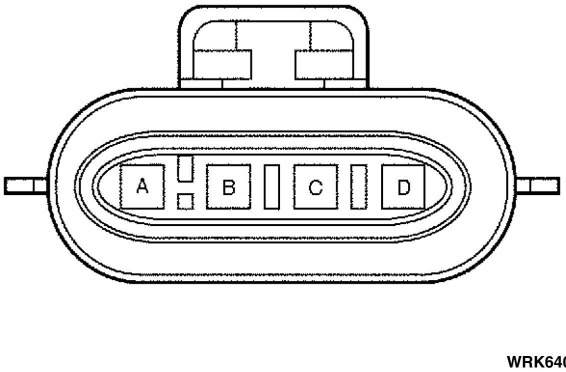
Connector Part Information	• 12186694 • 4 Way F Metri-pack (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2130	Reference Low
C	LT BLU	2126	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 7



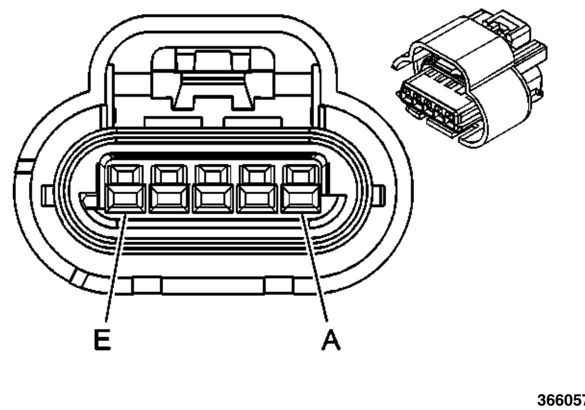
Connector Part Information	• 12186694 • 4 Way F Metri-pack (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2129	Reference Low
C	RED	2127	Ignition Control Signal
D	PNK	339	Ignition Positive Voltage

Ignition Coil Connector Cylinder 8



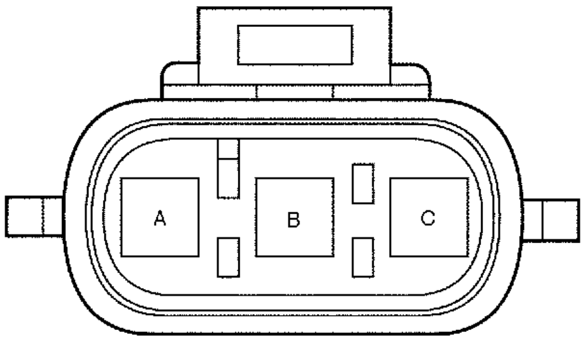
Connector Part Information		• 12186694 • 4 Way F Metri-pack (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	450	Ground to G111
B	BRN	2130	Reference Low
C	PPL	2128	Ignition Control Signal
D	PNK	239	Ignition Positive Voltage

Mass Air Flow (MAF) and Intake Air Temperature (IAT) Sensor



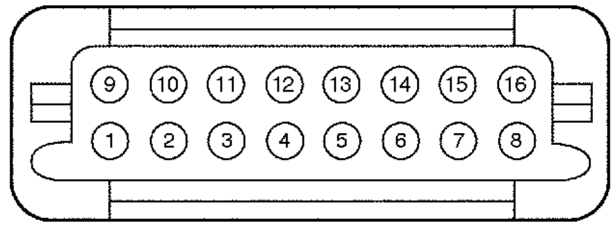
Connector Part Information		• 15305555 • 5 Way F GT 150 Series (BLK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BLK	552	Low Reference
B	TAN	472	IAT Sensor Signal
C	BLK/WHT	451	Ground
D	PNK	539	Ignition 1 Voltage
E	YEL	492	MAF Sensor Signal

Manifold Absolute Pressure (MAP) Sensor



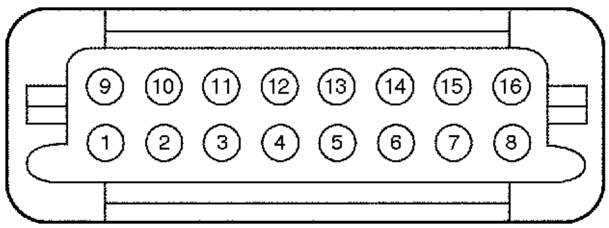
Connector Part Information	• 12129946 • 3 Way F Metri-pack 150 Series (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	ORN/BLK	469	Manifold Absolute Pressure (MAP) Sensor Return
B	LT GRN	432	Manifold Absolute Pressure (MAP) Sensor Signal
C	GRY	597	Reference Voltage Feed (5 Volt)

Throttle Actuator Control (TAC) Module – C1



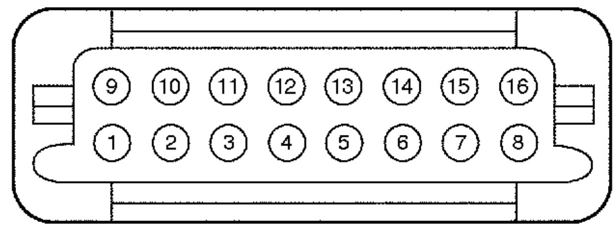
Connector Part Information	• 121910651 • 6 Way F Micro-pack 100 Series (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	DK GRN	485	TP Sensor 1 Signal
2	GRY	416	5 Volt Reference
3	BLK	452	Low Reference
4	DK BLU	84	Cruise Control Set/Coast Switch Signal
5	GRY/BLK	87	Cruise Control Resume/Accel Switch Signal
6	WHT	17	CHMSL Supply Voltage
7	PNK	639	Ignition 1 Voltage
8	BRN	582	Throttle Actuator Control (TAC) Motor Control – 2
9	LT BLU/BLK	1688	5 Volt Reference
10	BLK/WHT	1704	Low Reference
11	PPL	486	TP Sensor 2 Signal
12	ORN/BLK	1061	UART Serial Data (Secondary)
13	DK BLU/WHT	774	UART Serial Data (Tertiary)
14	GRY	397	Cruise Control On Switch Signal

Throttle Actuator Control (TAC) Module – C1



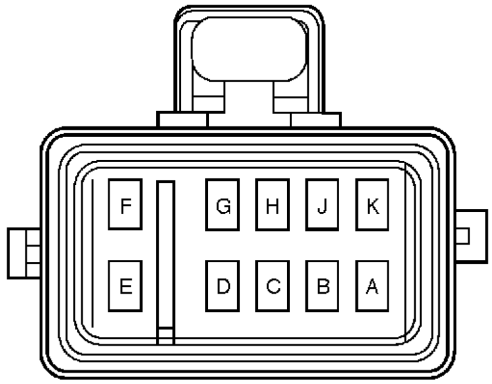
Connector Part Information	• 121910651 • 6 Way F Micro-pack 100 Series (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
15	BLK/WHT	451	Ground
16	YEL	581	Throttle Actuator Control (TAC) Motor Control – 1

Throttle Actuator Control (TAC) Module – C2



Connector Part Information	• 12177081 • 10 Way F Metri-pack 150 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRY	1273	Low Reference
B	PPL	1272	Low Reference
C	LT BLU	1162	Accelerator Pedal Position Sensor 2 Signal
D	TAN	1274	5 Volt Reference
E	YEL/BLK	1275	5 Volt Reference
F	DK BLU	1161	Electronic Throttle Position – Signal 1
G	WHT/BLK	1164	5 Volt Reference
H	—	—	Not Used
J	BRN	1271	Low Reference
K	DK GRN	1163	Accelerator Pedal Position Sensor 3 Signal

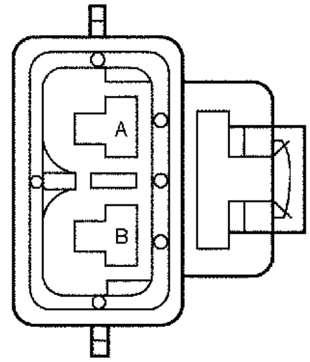
Throttle Actuator Control (TAC) Motor



WRK64042

Connector Part Information	• 12077900 • 2 Way F Metri-pack 280 Series (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	BRN	582	Throttle Motor Control – 2
B	YEL	581	Throttle Motor Control – 1

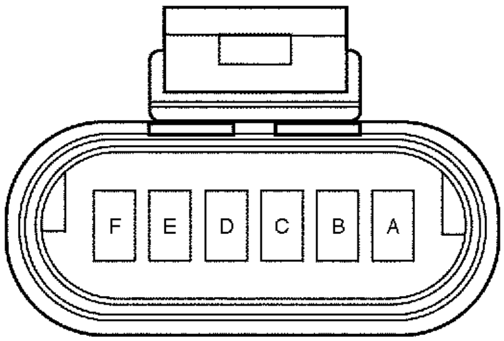
Throttle Position (TP) Sensor (Dual Track)



WRK64043

Connector Part Information	• 12162261 • 6 Way F Metri-pack 150.2 Series P2S (BLK)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	GRY	416	5 Volt Reference
B	BLK	452	Low Reference
C	DK GRN	485	Throttle Position (TP) Sensor 1 Signal
D	LT BLU/BLK	1688	5 Volt Reference
E	BLK/WHT	1704	Low Reference
F	PPL	486	Throttle Position (TP) Sensor 2 Signal

Vehicle Speed Sensor (VSS)



Connector Part Information	• 12191065 • 16 Way F Micro-pack 100 Series (GRY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PPL/WHT	821	VSS High to Trans Control Module
B	LT GRN/BLK	822	VSS Low to Trans Control Module

Diagnostic Information and Procedures

Diagnostic Starting Point – Engine Controls

Begin the system diagnosis with *Diagnostic System Check – Engine Controls*. The Diagnostic System Check – Engine Controls will provide the following information:

- The identification of the control modules which command the system
- The ability of the control modules to communicate through the serial data circuit
- The identification of any stored diagnostic trouble codes (DTCs) and their status

The use of the Diagnostic System Check – Engine Controls will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check – Engine Controls

Description

The Diagnostic System Check is an organized approach to identifying a condition that is created by a malfunction in the powertrain control system. The Diagnostic System Check must be the starting point for any driveability concern. The Diagnostic System Check directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time, and prevents the replacement of good parts.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Lack of communication may be because of a partial or a total malfunction of the class 2 serial data circuit. The specified procedure determines the particular condition.
5. This step stores the powertrain control module (PCM) diagnostic trouble code (DTC) information into the scan tools memory. After you complete the diagnostic procedure, review the captured information in order to catch the next DTC if the control module stores multiple DTCs. Review the Freeze Frame/Failure Records data. Use this information in order to determine how frequently and how recently the DTC set. This information may help diagnose an intermittent condition. Information about the operating conditions at the time that the DTC set may also help diagnose an intermittent condition. Capturing the stored information saves the data that the PCM loses during the following conditions:
   - When a diagnostic procedures instructs you to clear the DTCs.
   - When a diagnostic procedure instructs you to disconnect the PCM connectors.
   - When a diagnostic procedure instructs you to replace the PCM.
6. The presence of DTCs which begin with ”U”, indicate that some other module is not communicating. Following the specified procedure will gather all the available information before you perform the tests.
8. If there are other modules with DTCs set, refer to the DTC list. The DTC list directs you to the appropriate diagnostic procedure. If the control module stores multiple powertrain DTCs, diagnose the DTCs in the following order:
   - Component level DTCs, such as sensor DTCs, solenoid DTCs, and relay DTCs—Diagnose the multiple DTCs within this category in numerical order. Begin with the lowest numbered DTC, unless the diagnostic table directs you otherwise.
   - System level DTCs, for example, misfire DTCs, fuel trim DTCs, and catalyst DTCs.

Diagnostic System Check for Engine Controls

<table>
<tr><th>Step</th><th>Action</th><th>Yes</th><th>No</th></tr>
<tr><td>1</td><td>Important:
DO NOT perform this diagnostic if there is not a driveability concern, unless another procedure directs you to this diagnostic.
Before you proceed with diagnosis, search for applicable service bulletins.
Unless a diagnostic procedure instructs you, DO NOT clear the DTCs.
If there is a condition with the starting system, refer to Diagnostic System Check – Engine Electrical in Engine Electrical.
Ensure the battery has a full charge.
Ensure the battery cables are clean and tight.
Ensure the PCM grounds are clean, tight, and in the correct location.
Install a scan tool.
Does the scan tool turn ON?</td><td>Go to Step 2</td><td>Go to Scan Tool Does Not Power Up in Data Link Communications</td></tr>
<tr><td>2</td><td>Turn ON the ignition, with the engine OFF.
Attempt to establish communication with the listed control modules. If you are using a Tech 2, obtain the information using the Class 2 Message Monitor feature.
PCM
EBCM
Does the scan tool communicate with all the listed control modules?</td><td>Go to Step 3</td><td>Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications</td></tr>
<tr><td>3</td><td>Attempt to start the engine. Does the engine start and idle?</td><td>Go to Step 4</td><td>Go to Engine Cranks but Does Not Run</td></tr>
<tr><td>4</td><td>Select the DTC display function for the following control modules:
PCM/TCM
EBCM
Does the scan tool display any DTCs?</td><td>Go to Step 5</td><td>Go to Step 9</td></tr>
<tr><td>5</td><td>With a scan tool, select Captured Info in order to store the powertrain DTC information.
Is the action complete?</td><td>Go to Step 6</td><td>—</td></tr>
<tr><td>6</td><td>Does the scan tool display DTCs which begin with a ”U”?</td><td>Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications</td><td>Go to Step 7</td></tr>
<tr><td>7</td><td>Does the scan tool display DTCs P0601, P0602, P0604, P0606, or P1683?</td><td>Go to DTC P0601–P0607, P1600, P1621, P1627, or P1683</td><td>Go to Step 8</td></tr>
<tr><td>8</td><td>Does the scan tool display DTCs P0562, P0563, P1637, or P1638?</td><td>Go to Diagnostic Trouble Code (DTC) List in Engine Electrical</td><td>Go to Diagnostic Trouble Code (DTC) List</td></tr>
<tr><td>9</td><td>Is the customer’s concern with the automatic transmission?</td><td>Go to Automatic Transmission – 5 Speed Alison</td><td>Go to Step 10</td></tr>
</table>

Diagnostic System Check for Engine Controls (cont'd)

Step	Action	Yes	No
10	1. Review the following symptoms. 2. Refer to the applicable symptom diagnostic table. • *Hard Start* • *Surges/Chuggles* • *Lack of Power, Sluggishness, or Sponginess Detonation/Spark Knock* • *Hesitation, Sag, Stumble* • *Cuts Out, Misses Poor Fuel Economy* • *Poor Fuel Fill Quality* • *Rough, Unstable, or Incorrect Idle and Stalling* • *Dieseling, Run-On* • *Backfire* Did you find and correct the condition?	System OK	Go to *Intermittent Conditions*

Scan Tool Data List

The Engine Scan Tool Data List contains all engine related parameters that are available on the scan tool. The list is arranged in alphabetical order. A given parameter may appear in any one of the data lists, and in some cases may appear more than once, or in more than one data list in order to group certain related parameters together.

Use the Engine Scan Tool Data List only after the following is determined: The Engine Controls Diagnostic Check is completed.

No diagnostic trouble codes (DTCs).

On-board diagnostics are functioning properly.

Scan tool values from a properly running engine may be used for comparison with the engine you are diagnosing. The Engine Scan Tool Data List represents values that would be seen on a normal running engine.

Important: A scan tool that displays faulty data should not be used. The scan tool problem should be reported to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

Only the parameters listed below are referenced in this service manual for use in diagnosis. If all values are within the typical range described below, refer to *Symptoms – Engine Controls* for diagnosis.

The column labeled Data List indicates where a parameter can be located on the scan tool. Refer to the scan tool operating manual for the exact locations of the data lists. The following is a description of each term listed:

All: The Parameter is in all of the data lists indicated below.

Eng 1: Engine Data 1 List

Eng 2: Engine Data 2 List

FF/FR: Freeze Frame/Failure Records

FT: Fuel Trim Data List

MF: Misfire Data List

TAC: Throttle Actuator Control (TAC) Data

Scan Tool Data List

Engine Idling/Radiator Hose Hot/Closed Throttle/Park or Neutral/Closed Loop/Accessories Off			
Scan Tool Parameter	**Data List**	**Parameter Range/Units**	**Typical Data Values**
A/C Clutch Feedback Signal	Eng 2	Yes/No	No
A/C Compressor Cycling Switch	Eng 2	Open/Closed	Closed
A/C Relay Command	Eng 1, 2, MF	On/Off	Off
A/C Request Signal	Eng 2	Yes/No	No
A/C Sec. High Pressure Switch	Eng 2	Open/Closed	Open
Air Fuel Ratio	FF, FR	Ratio	14.7:1
APP Average	TAC	0–100%	0%
APP Indicated Angle	Eng 1, Eng 2, FT, TAC	0–100%	0%
APP Sensor 1	TAC	0–5.0 volts	0.4–0.9 volts
APP Sensor 2	TAC	5.0–0 volts	4.5–4.1 volts
APP Sensor 3	TAC	5.0–0 volts	4.2–3.7 volts
APP Sensor 1 Angle	TAC	0–100%	0%
APP Sensor 2 Angle	TAC	0–100%	0%
APP Sensor 3 Angle	TAC	0–100%	0%
APP Sensor 1 and 2 Disagree	TAC	Yes/No	No
APP Sensor 1 and 3 Disagree	TAC	Yes/No	No
APP Sensor 2 and 3 Disagree	TAC	Yes/No	No
APP Sensor 1 Out of Range	TAC	Yes/No	No
APP Sensor 2 Out of Range	TAC	Yes/No	No
APP Sensor 3 Out of Range	TAC	Yes/No	No
BARO	Eng 1, FT, FF/FR	kPa/volts	85–104 kPa/3.5–4.9 Volts Varies w/Altitude
CMP Sensor–High to Low	Eng 2	Counts	Varies
CMP Sensor–Low to High	Eng	2	Counts Varies
Cold Startup	Eng 2, EE	Yes/No	Varies
Cruise Control Active	Eng 1, TAC	Yes/No	No
Cruise On/Off Switch	TAC	On/Off	Off
Cruise Resume/Accel Switch	TAC	Resume/Accel	Resume
Cruise Set/Coast Switch	TAC	Set/Coast	Coast
Cycles of Misfire Data	MF	0–100 Counts	Varies
Desired Idle Speed	Eng 1, Eng 2, TAC, FF/FR	RPM	PCM Controlled
DTC Set This Ignition	Eng 1, 2, FT	Yes/No	No
ECT Sensor	Eng 1, Eng 2, FT, MF, FF/FR	−39° to +140°C (−38° to +284°F)	88–105°C (190–221°F)
Engine Load	All	0–100%	1–4% @ Idle 7–9 % @ 2500 RPM
Engine Run Time	All	Hrs, Min, Sec	Varies
Engine Speed	All	0–10,000 RPM	500–700 RPM
EVAP Purge Solenoid Command	Eng 1, FT	0–100%	10–25%
Fail Counter	FF, FR	Counts	Varies
Fuel Trim Cell	Eng 1, FT	0–23	16, 17
Fuel Trim Learn	Eng 1, FT	Enabled/Disabled	Enabled (may Toggle)

Scan Tool Data List (cont'd)

Engine Idling/Radiator Hose Hot/Closed Throttle/Park or Neutral/Closed Loop/Accessories Off			
Scan Tool Parameter	**Data List**	**Parameter Range/Units**	**Typical Data Values**
Generator F Terminal Signal	Eng 2	Percent	Varies
Generator L Terminal Signal Command	Eng 2	Active/Inactive	Active
HO2S Bank 1 Sensor 1	Eng 1, FT	Millivolts	10–1,000 mV and Varying
HO2S Bank 2 Sensor 1	Eng 1, FT	Millivolts	10–1,000 mV and Varying
IAT Sensor	Eng 1, Eng 2, FT	−39° to +140°C (−38° to +284°F) 35°C (91°F)	Depends on ambient temperature
IC Circuit Cylinder 1–8	MF	OK/Fault	OK
Ignition 1 Signal	Eng 1, Eng 2, FT, TAC	0–25 volts	11.5–14.5 Volts
Inj. PWM Average Bank 1	Eng 2, FT, FF/FR, MF	Milliseconds	2–6
Inj. PWM Average Bank 2	Eng 2, FT, FF/FR, MF	Milliseconds	2–6
Knock Retard	Eng 1	0.0°–16°	0°
Long Term FT Avg. Bn1	FT	Percentage	Near 0%
Long Term FT Avg. Bn2	FT	Percentage	Near 0%
Long Term FT Bank 1	Eng 1, Eng 2, FT, FF/FR	Percentage	Near 0%
Long Term FT Bank 2	Eng 1, Eng 2, FT, FF/FR	Percentage	Near 0%
Loop Status	Eng 1, 2, FT, FF/FR	Open/Closed	Closed
MAF Frequency	Eng 2	0–31,999 Hz	2,000–3,000 Hz
MAF Sensor	All	Grams Per Second (g/s)	1–9 g/s @ Idle (depends on altitude) 15–26 g/s @ 2,500 RPM (depends on altitude)
MAP Sensor	All	kPa	20–48 kPa
MAP Sensor	Eng 1, Eng 2	Volts	1.0–2.0 volts Varies with altitude
MIL Command	Eng 2	Off/On	Off
Misfire Current Cyl. 1–8	MF	0–200 Counts	0
Misfire History Cyl. 1–8	MF	0–65,535 Counts	0
Not Run Counter	FF, FR	Counts	Varies
Pass Counter	FF, FR	Counts	Varies
PCM Reset	Eng 1, Eng 2, EVAP, FT	Yes/No	No
Reduced Engine Power	Eng 1, TAC	Yes/No	No
Short Term FT Avg. Bn1	FT	Percentage	Near 0%
Short Term FT Avg. Bn2	FT	Percentage	Near 0%
Short Term FT Bank 1	Eng 1, Eng 2, FT, FF/FR	Percentage	Near 0%
Short Term FT Bank 2	Eng 1, Eng 2, FT, FF/FR	Percentage	Near 0%
Spark	Eng 1, Eng 2, FT, MF	Degrees	15–20°
Start Up ECT	Eng 2, FT, FF/FR	C°/F°	Varies
Stoplamp Pedal Switch	Eng 2, TAC, FF/FR	Applied/Released	Released
TAC/PCM Comm Signal	Eng 1, TAC	Yes/No	Yes
TCC Brake Pedal Switch	Eng 1, Eng 2	On/Off	Off
TP Desired Angle	Eng 1, Eng 2,TAC	0–100%	0%
TP Indicated Angle	All	0–100%	0%
TP Sensor 1	TAC	0–5.0 volts	0.4–0.9 volts
TP Sensor 2	TAC	5.0–0 volts	4.8–4.3 volts
TP Sensor 2 Out of Range	TAC	Yes/No	No

Scan Tool Data List (cont'd)

Engine Idling/Radiator Hose Hot/Closed Throttle/Park or Neutral/Closed Loop/Accessories Off			
Scan Tool Parameter	**Data List**	**Parameter Range/Units**	**Typical Data Values**
TP Sensor 1 Angle	TAC	0–100%	0%
TP Sensor 2 Angle	TAC	100–0%	100%
TP Sensors Disagree	TAC	Yes/No	No
TP Sensor 1 Out of Range	TAC	Yes/No	No
Vehicle Speed Sensor	All	km/h mph	0
Warm-Ups w/o Emission Faults	Eng 2	0–255 Counts	Varies
Warm-Ups w/o Non-Emission Faults	Eng 2	0–255 Counts	Varies

Scan Tool Data Definitions

The Engine Scan Tool Data Definitions contains a brief description of all engine related parameters available on the scan tool. The list is in alphabetical order. A given parameter may appear in any one of the data lists. In some cases, the parameter may appear more than once or in more than one data list in order to group certain related parameters together.

A/C Compressor Cycling Switch: The scan tool displays Open or Closed. This parameter displays the state of the A/C compressor cycling switch. The A/C compressor cycling switch is a normally closed switch.

A/C Relay Command: The scan tool displays ON or OFF. This parameter displays the powertrain control module (PCM) commanded state of the A/C clutch control relay. When the scan tool displays ON, the A/C clutch should be engaged.

A/C Request: The scan tool displays Yes or No. The A/C Request displays the state of the A/C request input circuit from the heating, ventilation, and air conditioning (HVAC) controls. The powertrain control module (PCM) uses the A/C request signal in order to determine whether the A/C compressor operation is being requested.

A/C Sec. High Press. Switch: The scan tool displays Open or Closed. This parameter displays the state of the A/C secondary high pressure switch. The A/C secondary high pressure switch is normally open.

Air Fuel Ratio: The scan tool displays the ratio of the air to fuel. A typical ratio is about 14.7:1.

APP Average: The scan tool displays 0–125 counts. The throttle actuator control (TAC) module takes the voltages from the 3 accelerator pedal position (APP) sensors, averages the readings and converts the readings into counts. The scan tool displays the average. The average is different on every vehicle.

APP Indicated Angle: The scan tool displays 0–100 percent. The scan tool displays the APP in percentage. When the APP is at rest, the display shows 0 percent. When the APP is fully depressed, the display shows 100 percent.

APP Sensor 1: The scan tool displays 0–5 volts. When the accelerator pedal is at 0 percent (pedal at rest), the display shows less than 1.1 volt. When the accelerator pedal is at 100 percent (pedal fully depressed), the display shows more than 2.0 volts.

APP Sensor 2: The scan tool displays 5–0 volts. When the accelerator pedal is at 0 percent (pedal at rest), the display shows more than 3.9 volts. When the accelerator pedal is at 100 percent (pedal fully depressed), the display shows less than 3.0 volt.

APP Sensor 3: The scan tool displays 5–0 volts. When the accelerator pedal is at 0 percent (pedal at rest), display shows more than 3.2 volts. When the accelerator pedal is at 100 percent (pedal fully depressed), the display shows less than 3.5 volts.

APP Sensor 1 Angle: The scan tool displays 0–100 percent. When the accelerator pedal is at rest, display shows 0 percent. When the accelerator pedal is fully depressed, the display shows 100 percent. This percentage indicates to the TAC module the actual pedal position.

APP Sensor 2 Angle: The scan tool displays 0–100 percent. When the accelerator pedal is at rest, the display shows 0 percent. When the accelerator pedal is fully depressed, the display shows 100 percent. This percentage indicates to the TAC module the actual pedal position

APP Sensor 3 Angle: The scan tool displays 0–100 percent. When the accelerator pedal is at rest, the display shows 0 percent. When the accelerator pedal is fully depressed, the display shows 100 percent. This percentage indicates to the TAC module the actual pedal position.

APP Sensor 1 Out of Range: The scan tool displays Yes or No. If the APP sensor voltage is not within the specifications, the scan tool displays YES. If the APP sensor voltage is within the specifications, the scan tool displays No.

APP Sensor 2 Out of Range: The scan tool displays Yes or No. If the APP sensor voltage is not within the specifications, the scan tool displays YES. If the APP sensor voltage is within the specifications, the scan tool displays No.

APP Sensor 3 Out of Range: The scan tool displays Yes or No. If the APP sensor voltage is not within the specifications, the scan tool displays YES. If the APP sensor voltage is within the specifications, the scan tool displays No.

APP Sen. 1 and APP Sen. 2 Disagree: The scan tool displays Yes or No. When the TAC module receives a signal voltage from APP sensor 1 not in proper relationship to APP sensor 2, the scan tool displays YES. The scan tool displays NO under the normal operating conditions.

APP Sen. 1 and APP Sen. 3 Disagree: The scan tool displays Yes or No. When the TAC module receives a signal voltage from APP sensor 1 not in proper relationship to APP sensor 3, the scan tool displays YES. The scan tool displays NO under the normal operating conditions.

APP Sen. 2 and APP Sen. 3 Disagree: The scan tool displays Yes or No. When the TAC module receives a signal voltage from APP Sensor 2 not in proper relationship to APP sensor 3, the scan tool displays YES. The scan tool displays NO under the normal operating conditions.

BARO: The scan tool displays a range of 10–105 kPa and 0.00–5.00 volts. The barometric pressure reading is determined from the manifold absolute pressure (MAP) sensor signal. The PCM monitors the MAP signal during key up or wide-open throttle (WOT) conditions. The barometric pressure compensates for altitude differences.

CMP Sensor–High to Low: The scan tool displays 0–65,535 counts. The counts increment as the PCM detects the camshaft position (CMP) sensor signal voltage going from high to low.

CMP Sensor–Low to High: The scan tool displays 0–65,535 counts. The counts increment as the PCM detects the CMP signal voltage going from low to high.

Cold Start Up: The scan tool displays Yes or No. A cold start-up is when the engine coolant temperature (ECT) rises above a predetermined temperature during an ignition cycle. The next ignition cycle the ECT should be below a predetermined temperature. Also the ECT and the intake air temperature (IAT) are less than 50° C (122° F) and are within 3° C (5° F) of each other at start-up. When the above is true, the scan tool displays Yes.

Cruise On/Off Switch: The scan tool displays On or Off. When you activate the cruise control switch, the scan tool displays ON. The switch, when in the ON position, sends a signal voltage to the throttle actuator control (TAC) module. This allows all other functions of the Cruise Control. When you turn OFF the cruise control switch, the scan tool displays Off.

Cruise Resume/Accel: The scan tool displays On or Off. When the cruise control switch is in the ON position and the Resume/Accel switch is activated, the scan tool displays ON. When the Resume/Accel switch is released, the scan tool displays Off.

Cruise Set/Coast: The scan tool displays On or Off. When the cruise control switch is in the ON position and the Set/Coast switch is activated, the scan tool displays ON. When the Set/Coast switch is released, the scan tool displays OFF.

Cycles of Misfire Data: The scan tool displays a range of 0–100. The PCM counts the number of misfire tests during 200 engine revolutions.

Desired Idle Speed: The scan tool displays a range of 0–3,187 RPM. The PCM commands the desired idle speed. The PCM compensates for various engine loads based on ECT in order to keep the engine at the desired speed.

DTC Set This Ignition: The scan tool displays Yes or No. This parameter indicates if a diagnostic trouble code (DTC) set during the current ignition cycle.

ECT Sensor: The scan tool displays a range of −39°C to +140°C (−38°F to +284°F). The PCM applies 5 volts to the ECT sensor circuit. The sensor is a thermistor which changes internal resistance as the engine temperature changes. When the sensor is cold, internal resistance high, the PCM senses a high signal voltage and interprets the voltage as a cold engine. As the sensor warms, internal resistance decreases, the voltage signal decreases and the PCM interprets the lower voltage as a warm engine.

Engine Load: The scan tool displays a range of 0–100 percent. The PCM calculates the engine load from engine speed and mass air flow (MAF) sensor readings. The engine load increases with an increase in RPM or airflow.

Engine Run Time: The scan tool displays Hours, Minutes, Seconds. This displays the amount of engine run time for the current ignition cycle. When you cycle the ignition OFF, the timer resets to zero.

Engine Speed: The scan tool displays a range of 0–10,000 RPM. The PCM computes engine speed from the ignition reference pulses. The engine speed should remain close to desired idle under various engine loads with the engine idling.

EVAP Canister Purge Solenoid Command: The scan tool displays a range of 0–100 percent. The PCM supplies a pulse width modulated (PWM) duty cycle to control the EVAP purge solenoid valve. 0 percent indicates no purge. 100 percent indicates full purge.

Fail Counter: The scan tool displays the number of times that a diagnostic has failed.

Fuel Trim Cell: The scan tool displays a range of 0–23. The PCM determines from the manifold absolute pressure (MAP) and RPM inputs which fuel trim cell to operate the engine in. The fuel trim cell displayed on the scan tool is the cell that the engine is operating under.

Fuel Trim Learn: The scan tool displays Enabled or Disabled. When conditions are appropriate for enabling long term fuel trim corrections, the scan tool displays Enabled. This indicates that the long term fuel trim is responding to the short term fuel trim. If the scan tool displays Disabled, then long term fuel trim will not respond to changes in short term fuel trim.

Generator F Terminal Signal Command: The scan tool displays Active or Inactive. The scan tool displays inactive if the PCM does not detect a correct voltage on the F-terminal circuit. The scan tool displays active under normal operating conditions.

Generator L Terminal Signal Command: The scan tool displays Active or Inactive. The scan tool displays inactive if the PCM does not detect a correct voltage on the L-terminal circuit. The scan tool displays active under normal operating conditions.

HO2S Bank 1 and Bank 2 Sensor 1: The scan tool displays a range of 0–1,106 mV. The heated oxygen sensor (HO2S) bank 1 and bank 2 sensor 1 parameter represents the fuel control exhaust oxygen sensor output voltage. The voltage fluctuates constantly within a range between 10–1,000 mV, while operating in Closed Loop.

IAT Sensor: The scan tool displays a range of −39°C to +140°C (−38°F to +284°F). The PCM converts the resistance of the intake air temperature sensor to degrees. The PCM uses the IAT in order to adjust fuel delivery and spark timing according to incoming air density.

IC Circuit Cylinder 1–8: The scan tool displays OK or Fault. If there is a problem with an ignition control circuit, the scan tool displays Fault. The scan tool displays OK under the normal operating conditions.

Ignition 1 Signal: The scan tool displays 0–25.5 volts. The ignition 1 represents the system voltage measured by the PCM at the ignition feed circuit.

Inj. PWM Average Bank 1 and Bank 2: The scan tool displays a range of 0–1,000 milliseconds. The injector average indicates the amount of time the PCM commands each injector ON during each engine cycle. A longer injector pulse width causes more fuel to be delivered. The injector pulse width increases with an increased engine load.

Knock Retard: The scan tool displays a range of 0.0–16 degrees. Knock retard indicates the amount of spark the PCM removes from the ignition control (IC) spark advance in response to the signal from the knock sensors (KS).

Long Term FT Ave Bn1 and Bn2: The scan tool displays percentage. This parameter indicates the average of all long term fuel trim cells. The short term fuel trim cells are rated, for the amount of which they are used. For example, an idle cell is rated higher than a wide open cell. If a fueling malfunction occurs in the idle cell and the wide open cell, the average would be more affected by the idle cell than the wide open cell. A negative value significantly below 0 percent indicates that the fuel system is rich and fuel delivery is being reduced. A positive value significantly more than 0 percent indicates that a lean condition exists and the PCM compensates by adding fuel. When the average of the cells reach a predetermined high or low, a fuel trim DTC sets.

Long Term FT Bank 1 and Bank 2: The scan tool displays percentage. The PCM derives the long term fuel trim from the short term fuel trim value. The long term fuel trim represents a long term correction of fuel delivery. A value of 0 percent indicates that fuel delivery requires no compensation in order to maintain the PCM commanded air/fuel ratio. A negative value significantly below 0 percent indicates that the fuel system is rich and the PCM is reducing the fuel delivery. A positive value significantly more than 0 percent indicates that a lean condition exists and the PCM compensates by adding fuel. Fuel trim values at maximum authority indicates an excessively rich or lean system.

Loop Status: The scan tool displays Open or Closed. Closed Loop indicates that the PCM is controlling fuel delivery according to oxygen sensor voltage. In Open Loop, the PCM ignores the oxygen sensor voltage and bases the amount of fuel to be delivered on throttle position (TP) sensor, engine coolant, and MAF sensor inputs only.

MAF Frequency: The scan tool displays a range of 0–31,999 Hz. The MAF sensor is a hot wire type air flow sensor. The PCM converts current draw needed by the MAF to keep the hot wires at a constant into a frequency signal. The scan tool displays this frequency in a hertz signal.

MAF Sensor: The scan tool displays a range of 0.0–655 g/s. The mass air flow (MAF) is the MAF input frequency converted to grams of air per second. This indicates the amount of air entering the engine.

MAP Sensor: Scan Tool Range 10–105 kPa/0.0–5 volts. The manifold absolute pressure (MAP) sensor measures the change in the intake manifold pressure from engine load, and speed changes. As intake manifold pressure increases, the intake vacuum decreases resulting in a higher MAP sensor voltage and kPa reading. The PCM uses the MAP sensor signal for the following: (1) Updating the BARO reading; (2) Enabling factor for several of the diagnostics.

MIL Command: The scan tool displays On or Off. The scan tool indicates if the PCM has commanded the malfunction indicator lamp (MIL) ON.

Mileage Since DTC Cleared: The scan tool displays the mileage record since the DTC was cleared.

Misfire Current Cyl. #1 – #8: The scan tool displays a range of 0–255 counts. The misfire current counters increment at a rate according to the number of possible misfires the PCM detects on each cylinder during the last 200 cylinder firing events. The counters may normally display some activity, but the activity should be nearly equal for all the cylinders.

Misfire History Cyl. #1 – #8: The scan tool displays a range of 0–65,535 counts. The misfire history counters display the total level of misfire that has been detected on each cylinder. The misfire history counters will not update or show any activity until a misfire DTC P0300 has become active. The misfire history counters will update every 200 cylinder firing events.

Not Run Counter: The scan tool displays counts from 0–65,535. The scan tool displays the number of times a DTC diagnostic has not reached its predetermined criteria in order to run since its first failure.

Pass Counter: The scan tool displays counts from 0–65,535. The scan tool displays the number of times a DTC has passed.

PCM Reset: The scan tool displays Yes or No. This parameter indicates when the internal PCM resets. The scan tool displays YES when an internal PCM reset occurred. The scan tool displays NO under the normal operating conditions.

Reduced Engine Power: The scan tool displays Active or Inactive. The scan tool displays Active when the PCM receives a signal from the TAC module that a throttle actuator control system fault is occurring. The PCM limits the engine power.

Short Term FT Ave Bn1 and Bn2: The scan tool displays percentage. This parameter indicates the average of the short term fuel trim cells. The short term fuel trim cells are rated for the amount of which they are used. For example, the PCM rates an idle cell higher than a wide open cell. If a fueling malfunction occurs in the idle cell and the wide open cell, the idle cell would affect more than then the wide open cell. A negative value significantly below 0 percent indicates that the fuel system is rich and the PCM is reducing the fuel delivery. A positive value significantly more than 0 percent indicates that a lean condition exists and the PCM is compensating by adding fuel. When the average of the cells reach a predetermined high or low, a fuel trim DTC sets.

Short Term FT Bank 1 and Bank 2: The scan tool displays percentage. The short term fuel trim represents a short term correction to fuel delivery by the PCM in response to the amount of time the fuel control oxygen sensor voltage spends above or below the 450 mV threshold. If the oxygen sensor voltage mainly remains less than 450 mV, indicating a lean air/fuel mixture, short term fuel trim increases into the positive range above 0 percent. The PCM adds fuel. If the oxygen sensor voltage stays mainly above the threshold, the short term fuel trim decreases below 0 percent into the negative range. The PCM reduces the fuel delivery in order to compensate for the indicated rich condition. Under certain conditions such as an extended idle and a high ambient temperature, the canister purge may cause the short term fuel trim to read in the negative range during normal operation. The fuel trim values at maximum authority may indicate an excessively rich or lean system.

Spark: The scan tool displays a range of −64 to +64 degrees. The scan tool displays the amount of degrees the PCM commands the spark advance on the IC circuit. The PCM computes the desired spark advance using the following: (1) engine coolant temperature (ECT), (2) engine speed (RPM), (3) load, (4) vehicle speed. The PCM adjusts the timing.

Start Up ECT: The scan tool displays a range of −39°C to +140°C (−38°F to +284°F). The scan tool displays the engine ECT at the time the engine was started. The PCM uses start-up ECT for certain DTCs.

Stoplamp Pedal Switch: The scan tool displays Applied or Released. This parameter indicates the state of the brake switch circuit input. The scan tool displays Applied when you apply the vehicle brakes. The scan tool displays Released when you release the vehicle brakes.

TAC/PCM Communication: The scan tool displays OK or Fault. If the communication between the TAC module and the PCM is interrupted the scan tool displays Fault. The scan tool displays OK under the normal operating conditions.

TCC Brake Pedal Switch: The scan tool displays Applied or Released. This parameter indicates the state of the TCC/CC brake switch circuit input. Open indicates 0 voltage input (brake switch open, brake pedal applied). Closed indicates a B+ voltage input (brake switch closed, brake pedal released). When you apply the vehicle brakes, the scan tool displays Applied. The torque converter clutch and cruise control disengages. When you release the vehicle brakes, the scan tool displays Released. This allows the cruise control to be resumed and the torque converter clutch to engage.

TP Desired Angle: The scan tool displays 0–100 percent. The PCM indicates the desired throttle angle commanded by the vehicle operator.

TP Indicated Angle: The scan tool displays 0–100 percent. The throttle position (TP) indicated angle displays in percentage the amount of throttle opening.

TP Sensor 1 Angle: The scan tool displays 0–100 percent. The scan tool displays the amount of throttle opening in percentage. Closed throttle displays 0 percent and wide open throttle displays near 100 percent.

TP Sensor 2 Angle: The scan tool displays 0–100 percent. The scan tool displays the amount of throttle opening in percentage. Closed throttle displays 0 percent and wide open throttle displays near 100 percent.

TP Sensor 1: The scan tool displays 0–5 volts. The scan tool displays the amount of throttle opening in volts. Closed throttle displays about 1 volt and wide open throttle displays above 3.5 volts.

TP Sensor 2: The scan tool displays 5–0 volts. The scan tool displays the amount of throttle opening in volts. Closed throttle displays about 4 volts and wide open throttle displays below 1.5 volts.

TP Sensors Disagree: The scan tool displays Yes or No. When the throttle actuator control (TAC) module receives a signal voltage from one of the TP sensors not in proper relationship to the other, the scan tool displays YES. The scan tool displays NO under normal operating conditions.

TP Sensor 1 Out of Range: The scan tool displays Yes or No. If the PCM detects that the voltage is below 1 volt at closed throttle or above 3.5 volts at wide open throttle, the scan tool displays YES. If the voltages are within specifications, the scan tool displays NO.

TP Sensor 2 Out of Range: The scan tool displays Yes or No. If the PCM detects that the voltage is above 4 volts at closed throttle or below 1.5 volts at wide open throttle, the scan tool displays YES. If the voltages are within specifications, the scan tool displays NO.

Vehicle Speed Sensor: The scan tool displays km/h and mph. The vehicle speed sensor signal is converted into km/h and mph for display on the scan tool.

Warm Ups w/o Emission Faults: The scan tool displays a range of 0–255. This parameter counts the number of warm up cycles without an emission fault present. The counter increments to 255 and rolls back to 0 unless a fault occurs. If a fault occurs, the counter reverts back to 0 until the fault is corrected. Clearing the information with a scan tool or a loss of power to the PCM also resets the counter to 0.

Warm Ups w/o Non-Emission Faults: The scan tool displays a range of 0–255. This parameter counts the number of warm up cycles without a non-emission fault present. The counter increments to 255 and rolls back to 0 unless a fault occurs. If a fault occurs, the counter reverts back to 0 until the fault is corrected. Clearing information with a scan tool or a loss of power to the PCM also resets the counter to 0.

Diagnostic Trouble Code (DTC) List

DTC	Diagnostic Procedure	Modules
P0102	*DTC P0102*	PCM
P0103	*DTC P0103*	PCM
P0107	*DTC P0107*	PCM
P0108	*DTC P0108*	PCM
P0112	*DTC P0112*	PCM
P0113	*DTC P0113*	PCM
P0117	*DTC P0117*	PCM
P0118	*DTC P0118*	PCM
P0131	*DTC P0131 or P0151*	PCM
P0132	*DTC P0132 or P0152*	PCM
P0134	*DTC P0134 or P0154*	PCM
P0151	*DTC P0131 or P0151*	PCM
P0152	*DTC P0132 or P0152*	PCM
P0154	*DTC P0134 or P0154*	PCM
P0200	*DTC P0200*	PCM
P0230	*DTC P0230*	PCM
P0325	*DTC P0325*	PCM
P0327	*DTC P0327 or P0332*	PCM
P0332	*DTC P0327 or P0332*	PCM
P0335	*DTC P0335*	PCM
P0336	*DTC P0336*	PCM
P0341	*DTC P0341*	PCM
P0342	*DTC P0342*	PCM
P0343	*DTC P0343*	PCM
P0351–P0358	*DTC P0351–P0358*	PCM
P0404	*DTC P0404*	PCM
P0405	*DTC P0405*	PCM
P0443	*DTC P0443*	PCM
P0506	*DTC P0506*	PCM
P0507	*DTC P0507*	PCM
P0562	*DTC P0562 in Engine Electrical*	PCM
P0563	*DTC P0563 in Engine Electrical*	PCM
P0601	*DTC P0601–P0607, P1600, P1621, P1627, or P1683*	PCM
P0602	*DTC P0601–P0607, P1600, P1621, P1627, or P1683*	PCM
P0604	*DTC P0601–P0607, P1600, P1621, P1627, or P1683*	PCM
P0606	*DTC P0601–P0607, P1600, P1621, P1627, or P1683*	PCM
P0650	*DTC P0650*	PCM
P1111	*DTC P1111*	PCM
P1112	*DTC P1112*	PCM
P1114	*DTC P1114*	PCM
P1115	*DTC P1115*	PCM
P1120	*DTC P1120*	PCM
P1125	*DTC P1125*	PCM
P1220	*DTC P1220*	PCM
P1221	*DTC P1221*	PCM
P1258	*DTC P1258 in Engine Cooling*	PCM
P1275	*DTC P1275*	PCM
P1276	*DTC P1276*	PCM
P1280	*DTC P1280*	PCM

Diagnostic Trouble Code (DTC) List (cont'd)

DTC	Diagnostic Procedure	Modules
P1281	*DTC P1281*	PCM
P1285	*DTC P1285*	PCM
P1286	*DTC P1286*	PCM
P1336	*DTC P1336*	PCM
P1404	*DTC P1404*	PCM
P1514	*DTC P1514*	PCM
P1515	*DTC P1515*	PCM
P1516	*DTC P1516*	PCM
P1517	*DTC P1517*	PCM
P1518	*DTC P1518*	PCM
P1635	*DTC P1635*	PCM
P1637	*DTC P1637 in Engine Electrical*	PCM
P1638	*DTC P1638 in Engine Electrical*	PCM
P1639	*DTC P1639*	PCM
P1683	*DTC P0601–P0607, P1600, P1621, P1627, or P1683*	PCM
—	*Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications*	PCM, SDM, IPC, BCM, EBCM, HVAC

DTC P0102

Circuit Description

The mass air flow (MAF) sensor is an air flow meter that measures the amount of air entering the engine. The powertrain control module (PCM) uses the MAF sensor frequency signal in order to provide the correct fuel delivery for a wide range of engine speeds and loads. A small quantity of air entering the engine indicates deceleration or idle. A large quantity of air entering the engine indicates an acceleration or high load situation. The MAF sensor has an ignition 1 voltage circuit, a ground circuit and a signal circuit. The PCM applies a voltage to the sensor on the signal circuit. The sensor uses the voltage in order to produce a frequency based on inlet air flow through the sensor bore. DTC P0102 will set If the PCM detects a frequency signal lower than the possible range of a normally operating MAF sensor.

Conditions for Running the DTC

- The engine is running.
- The engine speed is greater than 300 RPM.
- The ignition 1 signal is greater than 8 volts.

Conditions for Setting the DTC

The MAF sensor frequency signal is less than 10 Hz.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

Inspect for the following conditions:

- A misrouted harness—Inspect the MAF sensor harness in order to ensure that it is not routed too close to the following:
  - Secondary ignition wires or coils
  - Solenoids
  - Relays
  - Motors
- A low minimum air rate may cause this DTC to set during deceleration. Inspect for the following conditions:
  - A plugged intake air duct or dirty air filter element
  - Objects blocking the MAF sensor air inlet screen
  - Throttle bore and throttle plate coking
- A wide open throttle (WOT) acceleration from a stop should cause the mass air flow display on a scan tool to increase from about 6–12 gm/s at idle to about 230 gm/s or more at the time of the 1–2 shift. If not, inspect for a restriction.
- Any uN·metered air entering the engine may cause this DTC to set. Inspect for vacuum leaks in the following components:
  - The intake manifold
  - The throttle body
  - The mass air flow (MAF) sensor seal
  - The manifold absolute pressure (MAP) sensor seal
  - The EVAP canister purge valve seal
  - The fuel meter body seal
  - The brake booster system
  - The air induction system
  - The crankcase ventilation system, refer to *Crankcase Ventilation System Inspection/Description* in Engine Mechanical 8.1L.
- If the problem is intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. This step verifies the signal circuit from the MAF sensor electrical connector to the PCM. A voltage reading of less than 4 volts, or more than 6 volts indicates a malfunction in the wiring or a poor connection.
6. This step tests the signal circuit of the MAF sensor for a short to another 5-olt reference circuit.

DTC P0102

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics – 8.1L*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. With a scan tool observe the MAF sensor frequency parameter. Does the scan tool indicate that the MAF sensor frequency is less than the specified value?	10 Hz	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	Inspect the fuse that supplies the ignition 1 voltage circuit of the MAF sensor. Is the fuse open?	—	Go to *Step 14*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Disconnect the MAF sensor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Measure the voltage from the signal circuit of the MAF sensor to a good ground. Refer to *Measuring Voltage* in Wiring Systems. Does the voltage measure near the specified value?	5 V	Go to *Step 6*	Go to *Step 8*
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the MAF sensor and a good ground. Refer to *Using Fused Jumper Wires* in Wiring Systems. 3. Start the engine. Do any additional DTCs set?	—	Go to *Step 16*	Go to *Step 7*
7	1. Turn OFF the ignition. 2. Connect a test lamp between the ignition 1 voltage circuit of the MAF sensor and the ground circuit of the MAF sensor. Refer to *Troubleshooting with a Test Lamp* in Wiring Systems. 3. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to *Step 18*	Go to *Step 11*
8	Does the voltage measure less than the specified value?	4.5 V	Go to *Step 10*	Go to *Step 9*
9	**Important:** Disconnecting the PCM connectors may eliminate the short to voltage if the signal circuit is shorted to another PCM circuit. 1. Turn OFF the ignition. 2. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Turn ON the ignition, with the engine OFF. 4. Measure the voltage from the signal circuit of the MAF sensor to a good ground. Does the voltage measure near the specified value?	0.0 V	Go to *Step 12*	Go to *Step 15*

DTC P0102 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the signal circuit between the PCM and the MAF sensor for the following conditions: • A high resistance or an open • A short to ground • A short to the ground circuit of the MAF sensor Did you find and correct the condition?	—	Go to *Step 22*	Go to *Step 12*
11	Connect a test lamp between the ignition 1 voltage circuit of the MAF sensor and a good ground. Refer to *Troubleshooting with a Test Lamp* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 13*	Go to *Step 14*
12	Test for continuity at the harness connector of the PCM from the signal circuit of the MAF sensor to all other circuits at both PCM connectors. Refer to *Testing for Continuity* in Wiring Systems. Does the DMM indicate continuity between any other circuit?	—	Go to *Step 17*	Go to *Step 19*
13	Repair the high resistance or an open in the ground circuit of the MAF sensor. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	—
14	1. Repair the short to ground or an open in the ignition 1 voltage circuit of the MAF sensor. Refer to *Wiring Repairs* in Wiring Systems. 2. Replace the fuse if necessary. Did you complete the repair?	—	Go to *Step 22*	Go to *Step 20*
15	Repair the short to voltage in the signal circuit of the MAF sensor. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	
16	Repair the short between the signal circuit of the MAF sensor and the circuit for which the DTC set. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	
17	Repair the circuits that are shorted together. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	
18	Inspect for poor connections at the harness connector of the MAF sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 22*	Go to *Step 20*
19	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 22*	Go to *Step 21*
20	Replace the MAF sensor. Did you complete the replacement?	—	Go to *Step 22*	
21	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 22*	

DTC P0102 (cont'd)

Step	Action	Value(s)	Yes	No
22	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 23*	Go to *Step 2*
23	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0103

Circuit Description

The mass air flow (MAF) sensor is an air flow meter that measures the amount of air entering the engine. The powertrain control module (PCM) uses the MAF sensor frequency signal in order to provide the correct fuel delivery for a wide range of engine speeds and loads. A small quantity of air entering the engine indicates deceleration or idle. A large quantity of air entering the engine indicates an acceleration or high load situation. The MAF sensor has an ignition 1 voltage circuit, a ground circuit and a signal circuit. The PCM applies a voltage to the sensor on the signal circuit. The sensor uses the voltage in order to produce a frequency based on inlet air flow through the sensor bore. DTC P0103 will set if the PCM detects a frequency signal higher than the possible range of a normally operating sensor.

Conditions for Running the DTC

- The engine is running.
- The engine run time is greater than 0.5 seconds.
- The engine speed is at least 300 RPM.
- The ignition 1 signal is greater than 8 volts.

Conditions for Setting the DTC

The MAF sensor frequency signal is equal to or more than 13,000 Hertz.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Water entering the air intake system that reaches the MAF sensor could cause this DTC to set. The water rapidly cools the hot sensing elements in the sensor causing a false indication of excessive air flow. Inspect the following areas for evidence of water intrusion:
  - The air induction system
- If the problem is intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. This step tests for electromagnetic interference (EMI) on the signal circuit of the MAF sensor. A frequency reading with the MAF sensor disconnected indicates an EMI related fault or a poor connection. Disconnecting the MAF sensor may set additional related DTCs.
4. This step eliminates any conditions which can cause a DTC to set with a normally operating MAF sensor.

DTC P0103

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
3	1. Turn OFF the ignition. 2. Disconnect the MAF sensor harness connector. 3. Start the engine. 4. With a scan tool observe the MAF sensor frequency parameter. Does the scan tool display the specified value? 0 Hz	—	Go to *Step 5*	Go to *Step 4*
4	Inspect the MAF sensor harness for incorrect routing at the following locations: Secondary ignition wires or coils • Solenoids • Relays • Motors Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 6*
2	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 3*	Go to *Diagnostic Aids*
5	Inspect for poor connections at the harness connector of the MAF sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 7*
6	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 8*
7	Replace the MAF sensor. Refer to 64829. Did you complete the replacement?	—	Go to *Step 9*	—
8	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 9*	—
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0107

Circuit Description

The manifold absolute pressure (MAP) sensor responds to pressure changes in the intake manifold. The pressure changes occur based on the engine load. The MAP sensor has the following:

- A 5-volt reference circuit
- A low reference circuit
- A signal circuit

The powertrain control module (PCM) supplies 5 volts to the MAP sensor on the 5-volt reference circuit. The PCM, also, provides a ground on the low reference circuit. The MAP sensor provides a signal to the PCM on the signal circuit which is relative to the pressure changes in the manifold. The PCM should detect a low signal voltage at a low MAP, such as during an idle or a deceleration. The PCM should detect a high signal voltage at a high MAP, such as the ignition is ON, with the engine OFF, or at a wide open throttle (WOT). Certain vehicle models will also use the MAP sensor in order to determine the barometric pressure (BARO). This occurs when the ignition switch is turned ON, with the engine OFF. The BARO reading may also be updated whenever the engine is operated at WOT. The PCM monitors the MAP sensor signal for voltage outside of the normal range.

If the PCM detects a MAP sensor signal voltage that is excessively low, DTC P0107 will set.

Conditions for Running the DTC

- DTCs P1120, P1125, P1220, P1221, P1275, P1276, P1280, P1281, P1285, P1286, P1514, P1515, P1516, 1517, or DTC P1518 are not set.
- The engine is running.
- The throttle angle is more than 0 percent when engine speed is less than 800 RPM.
- The throttle angle is more than 12.5 percent when engine speed is more than 800 RPM.

Conditions for Setting the DTC

The MAP sensor voltage is less than 0.10 volts for more than 2 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the MAP sensor vacuum source for leaks, restrictions or poor connections.
- Inspect any circuitry that is suspected of causing an intermittent. Refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The MAP sensor 5-volt reference circuit is shared with other sensors. If DTC P1635 is set, this indicates that the 5-volt reference circuit is either shorted to ground or shorted to voltage and should be diagnosed first. The short may be on another sensor 5-volt reference circuit.
4. Operate the vehicle within the same conditions as when the DTC failed. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in locating an intermittent condition.

DTC P0107

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information using the scan tool. Does the scan tool indicate that DTC P1635 is current?	—	Go to *DTC P1635*	Go to *Step 3*
3	With a scan tool observe the MAP sensor voltage. Does the voltage measure less than the specified value?	0.10 V	Go to *Step 5*	Go to *Step 4*
4	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 5*	Go to *Diagnostic Aids*
5	1. Turn OFF the ignition. 2. Disconnect the MAP sensor harness connector. 3. Connect a DMM between the 5-volt reference circuit of the MAP sensor and a good ground. 4. Turn ON the ignition, with engine OFF. Does the voltage measure near the specified value?	5.0 V	Go to *Step 6*	Go to *Step 7*
6	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the 5-volt reference circuit of the MAP sensor and the signal circuit of the MAP sensor. 3. Turn ON the ignition, with engine OFF. Does the scan tool indicate that the voltage is near the specified value?	5.0 V	Go to *Step 9*	Go to *Step 8*
7	1. Turn OFF the ignition. 2. Test the 5-volt reference circuit of the MAP sensor for a short to ground or an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 13*	Go to *Step 10*
8	1. Turn OFF the ignition. 2. Test the signal circuit of the MAP sensor for a short to ground or an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 13*	Go to *Step 10*
9	Inspect for poor connections at the harness connector of the MAP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 13*	Go to *Step 11*
10	Inspect for poor connections at the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 13*	Go to *Step 12*

DTC P0107 (cont'd)

Step	Action	Value(s)	Yes	No
11	Replace the MAP sensor. Refer to Manifold Absolute Pressure (MAP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 13*	—
12	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 13*	—
13	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 14*	Go to *Step 2*
14	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0108

Circuit Description

The manifold absolute pressure (MAP) sensor responds to pressure changes in the intake manifold. The pressure changes occur based on the engine load. The MAP sensor has the following:

- A 5-volt reference circuit
- A low reference circuit
- A signal circuit

The powertrain control module (PCM) supplies 5 volts to the MAP sensor on the 5-volt reference circuit. The PCM, also, provides a ground on the low reference circuit. The MAP sensor provides a signal to the PCM on the signal circuit which is relative to the pressure changes in the manifold. The PCM should detect a low signal voltage at a low MAP, such as during an idle or a deceleration. The PCM should detect a high signal voltage at a high MAP, such as the ignition is ON, with the engine OFF, or at a wide open throttle (WOT). Certain vehicle models will also use the MAP sensor in order to determine the barometric pressure (BARO). This occurs when the ignition switch is turned ON, with the engine OFF. The BARO reading may also be updated whenever the engine is operated at WOT. The PCM monitors the MAP sensor signal for voltage outside of the normal range. If the PCM detects a MAP sensor signal voltage that is excessively high, DTC P0108 will set.

Conditions for Running the DTC

- DTCs P1120, P1125, P1220, P1221, P1275, P1276, P1280, P1281, P1285, P1286, P1514, P1515, P1516, 1517, or P1518 are not set.
- The engine is running.
- The throttle angle is 0 percent when engine speed is less than 1200 RPM.
- The throttle angle is less than 20 percent when engine speed is more than 1200 RPM.

Conditions for Setting the DTC

The MAP sensor voltage is more than 4.9 volts for more than 2 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the MAP sensor vacuum source for leaks, for restrictions, or for poor connections.
- Inspect any circuitry that is suspected of causing an intermittent. Refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The MAP sensor 5-volt reference circuit is shared with other sensors. If DTC P1635 is set, this indicates that the 5-volt reference circuit is either shorted to ground or shorted to voltage and should be diagnosed first. The short may be on another sensor 5-volt reference circuit.
4. Operate the vehicle within the same conditions as when the DTC failed. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in locating an intermittent condition.

DTC P0108

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the Diagnostic Trouble Code (DTC) Information using the scan tool. Does the scan tool indicate that DTC P1635 is current?	—	Go to *DTC P1635*	Go to *Step 3*
3	**Important:** If the engine idle is rough, unstable or incorrect, repair the idle condition before using this table. Refer to Rough, Unstable, or Incorrect Idle and Stalling. Let the engine idle. Does the scan tool indicate that the MAP sensor voltage is more than the specified value?	4.9 V	Go to *Step 5*	Go to *Step 4*
4	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 5*	Go to *Diagnostic Aids*
5	1. Turn OFF the ignition. 2. Disconnect the MAP sensor electrical connector. 3. Turn ON the ignition, with engine OFF. Does the scan tool indicate that the MAP sensor voltage is less than the specified value?	0.10 V	Go to *Step 6*	Go to *Step 8*
6	1. Turn OFF the ignition. 2. Connect a DMM between the 5-volt reference circuit and the low reference circuit of the MAP sensor. 3. Turn ON the ignition, with engine OFF. Does the voltage measure within the specified range?	4.7–5.2 V	Go to *Step 11*	Go to *Step 7*
7	Does the voltage measure more than the specified value?	5.2 V	Go to *Step 10*	Go to *Step 9*
8	Test the signal circuit of the MAP sensor for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 12*
9	Test the reference low circuit of the MAP sensor for an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 12*
10	Test the 5-volt reference circuit of the MAP sensor for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 12*
11	Inspect for poor connections at the MAP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 13*

DTC P0108 (cont'd)

Step	Action	Value(s)	Yes	No
12	Inspect for poor connections at the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 14*
13	Replace the MAP sensor. Refer to Manifold Absolute Pressure (MAP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 15*	—
14	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
15	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 16*	Go to *Step 2*
16	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0112

Circuit Description

The intake air temperature (IAT) sensor contains a semiconductor device which changes the resistance based on the temperature. The IAT sensor is located within the mass air flow (MAF) sensor. The IAT sensor has a signal circuit and a ground circuit. The powertrain control module (PCM) applies 5 volts on the signal circuit to the sensor. The PCM monitors the changes in this voltage caused by changes in the resistance of the sensor in order to determine intake air temperature.

When the intake air is cold, the sensor (thermistor) resistance is high. The PCM signal voltage is only pulled down a small amount through the sensor to a ground, therefore, the PCM senses a high signal voltage. When the intake air is warm, the sensor resistance is low.

The signal voltage is pulled down a greater amount, therefore, the PCM senses a low signal voltage.

When the PCM senses a signal voltage lower than the normal operating range of the sensor, this diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- DTCs P0102, P0103, P0117, P0118, P0500, P0502, or P0503 are not set.
- The engine coolant temperature (ECT) is less than 135°C (275°F)
- The engine run time is more than 30 seconds.
- The vehicle speed is 40 km/h (25 mph) or more.

Conditions for Setting the DTC

The intake air temperature (IAT) is more than 139°C (282°F) for 5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- If the engine has sat overnight, the engine coolant temperature (ECT) and the intake air temperature (IAT) values should display within a few degrees of each other. If the temperatures are not within 3°C (5°F), refer to Temperature vs Resistance.
- If you determine that the DTC occurs intermittently, performing the P1112 diagnostic table may isolate the cause of the fault.

For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step determines if the malfunction is present.
3. Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and the Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions, such as RPM, load, vehicle speed, temperature etc. that you observed. This will isolate when the DTC failed.
4. The IAT sensor is part of the MAF sensor. An intake air temperature below −30°C (−22°F) indicates the PCM and the IAT wiring are OK.
5. Disconnecting the PCM allows using the DMM in order to check continuity of the circuits. This aids in locating an open or a shorted circuit.

DTC P0112

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*

DTC P0112 (cont'd)

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the IAT display on the Engine 1 Data List of the scan tool. Is the IAT above the specified value?	139°C (282°F)	Go to *Step 4*	Go to *Step 3*
3	1. Turn ON the ignition, with the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in Conditions for Running the DTC. 6. Select the Diagnostic Trouble Code (DTC) option, the Specific DTC option, then enter the DTC number using the scan tool. Does the scan tool indicate that this diagnostic failed this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Disconnect the IAT sensor electrical connector. 2. Observe the IAT display on the scan tool. Is the IAT at the specified value?	−39°C (−38°F)	Go to *Step 6*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Disconnect the PCM connector C2 located on the opposite side of the manufacturers logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Check the IAT signal circuit for a short to a ground. Refer to Testing for Short to Ground in Wiring Systems. 4. If you find the IAT sensor signal circuit is grounded, repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Is the IAT signal circuit grounded?	—	Go to *Step 8*	Go to *Step 7*
6	Replace the IAT sensor. Refer to 64829. Is the action complete?	—	Go to *Step 8*	—
7	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Is the action complete?	—	Go to *Step 8*	—
8	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 9*	Go to *Step 2*
9	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0113

Circuit Description

The intake air temperature (IAT) sensor contains a semiconductor device which changes the resistance based on the temperature. The IAT sensor is located within the mass air flow (MAF) sensor. The IAT sensor has a signal circuit and a ground circuit. The powertrain control module (PCM) applies 5 volts on the signal circuit to the sensor. The PCM monitors the changes in this voltage caused by changes in the resistance of the sensor in order to determine intake air temperature.

When the intake air is cold, the sensor resistance is high. The PCM signal voltage is only pulled down a small amount through the sensor to a ground, therefore, the PCM senses a high signal voltage. When the intake air is warm, the sensor resistance is low. The signal voltage is pulled down a greater amount, therefore, the PCM senses a low signal voltage.

When the PCM senses a signal voltage higher than the normal operating range of the sensor, this diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- DTCs P0102, P0103, P0117, P0118, P0500, P0502, or P0503 are not set.
- The engine coolant temperature (ECT) is more than 0°C (32°F).
- The vehicle speed is less than 11 km/h (7 mph).
- The MAF is less than 15 g/s.
- The engine run time is more than 100 seconds.

Conditions for Setting the DTC

The IAT is less than −35°C (−31°F) for more than 5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- If the engine has sat overnight, the ECT and the IAT values should display within a few degrees of each other. If the temperatures are not within 3°C (5°F), refer to Temperature vs Resistance.
- If you determine that the DTC occurs intermittently, performing the P1111 diagnostic table may isolate the cause of the fault.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step determines if the malfunction is present. Using this kit prevents damage to the harness connector terminals.
4. Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and the Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions such as the RPM, load, vehicle speed, temperature, etc. that you observed. This will isolate when the DTC failed.
5. An intake air temperature above 139°C (282°F) indicates the PCM and IAT sensor wiring is OK.
6. An intake air temperature above 139°C (282°F) indicates the PCM and IAT sensor signal circuit is OK.
7. Disconnecting the PCM allows using the DMM in order to test for continuity of the circuits. This aids in locating an open or a shorted circuit.
8. Disconnecting the PCM allows using the DMM in order to test for a short to voltage.
9. Disconnecting the PCM allows using the DMM in order to test for continuity of the circuits. This aids in locating an open or a shorted circuit. Probe one lead to the IAT sensor signal circuit and probe the other lead to each terminal at the PCM harness connectors.
16. Inspect for proper terminal tension and connections at the PCM harness before replacing the PCM.

DTC P0113

Step	Action	Value(s)	Yes	No
Schematic Reference: *MAP, ECT, and Air Meter (IAC and MAF)*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the IAT sensor display on the Engine 1 Data List of the scan tool. Is the IAT sensor at the specified value?	– 39°C (– 38°F)	Go to *Step 3*	Go to *Step 4*
3	Are DTCs P1635 and P1639 also set?	—	Go to *Step 14*	Go to *Step 5*
4	1. Turn ON the ignition, with the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in Conditions for Running the DTC. 6. Select the Diagnostic Trouble Code (DTC) option, the Specific DTC option, then enter the DTC number using the scan tool. Does the scan tool indicate that this diagnostic failed this ignition?	—	Go to *Step 5*	Go to *Diagnostic Aids*
5	1. Disconnect the IAT sensor electrical connector. 2. Jumper the IAT sensor signal circuit and low reference circuit together. 3. Observe the IAT parameter on the scan tool. Is the IAT sensor at the specified value?	140°C (284°F)	Go to *Step 8*	Go to *Step 6*
6	Jumper the IAT sensor signal circuit to a known good ground. Is the IAT sensor at the specified value?	140°C (284°F)	Go to *Step 10*	Go to *Step 7*
7	1. Turn OFF the ignition. 2. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the IAT sensor signal circuit for an open. Refer to *Testing for Continuity* in Wiring Systems. Is the IAT sensor signal circuit open?	—	Go to *Step 11*	Go to *Step 16*
8	1. Turn OFF the ignition. 2. Remove the jumper harness from the IAT sensor harness connector. 3. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. 4. Turn ON the ignition, with the engine OFF. 5. Probe the IAT signal circuit at the PCM harness connector using the DMM connected to ground. Refer to Probing Electrical Connectors in Wiring Systems. Does the DMM display a voltage?	—	Go to *Step 14*	Go to *Step 9*

DTC P0113 (cont'd)

Step	Action	Value(s)	Yes	No
9	Test for continuity from the IAT signal circuit to all other PCM circuits at both the PCM harness connectors using the DMM. Refer to *Testing for Continuity* in Wiring Systems. Does the DMM display continuity within the specified range from the IAT sensor signal circuit to any other PCM circuit?	0–2 ohm	Go to *Step 15*	Go to *Step 12*
10	1. Turn OFF the ignition. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. 2. Inspect the IAT sensor low reference circuit for an open. Refer to *Testing for Continuity* in Wiring Systems. Is the IAT sensor ground circuit open?	—	Go to *Step 13*	Go to *Step 16*
11	Repair the IAT sensor signal circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair ?	—	Go to *Step 18*	—
12	Replace the IAT sensor. Refer to 64829. Did you complete the replacement?	—	Go to *Step 18*	—
13	Repair the IAT sensor low reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair ?	—	Go to *Step 18*	—
14	Repair the IAT sensor signal circuit for a short to voltage. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 18*	—
15	Repair the short between the IAT sensor signal circuit and the PCM circuit that had continuity. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 18*	—
16	1. Inspect the PCM harness connector for poor connections. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the condition as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and repair the condition?	—	Go to *Step 18*	Go to *Step 17*
17	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 18*	—
18	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 19*	Go to *Step 2*
19	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0117

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor, sometimes called a thermistor, that measures the temperature of the engine coolant. The powertrain control module (PCM) supplies 5 volts to the ECT signal circuit. When the ECT is cold, the sensor resistance is high. When the ECT increases, the sensor resistance lowers. With high sensor resistance, the PCM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the PCM detects a lower voltage on the ECT signal circuit. If the PCM detects an excessively low ECT signal voltage, which is a high temperature indication, this diagnostic trouble code (DTC) will set.

Conditions for Running the DTC

- The engine run time is more than 10 seconds.

OR

- The engine run time is less than 10 seconds when the IAT is less than 50°C (122°F).

Conditions for Setting the DTC

The ECT sensor temperature is more than 139°C (282°F) for more than 20 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- An overheating condition may cause this DTC to set.
- After starting the engine, the ECT should rise steadily to about 90°C (194°F), then stabilize when the thermostat opens.
- Use the Temperature vs Resistance Value Table in order to test the ECT sensor at various temperature levels in order to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs Resistance.
- If the malfunction is not present at this time refer to DTC 1114.
- If an intermittent condition is suspected, refer to *Intermittent Conditions*.

DTC P0117

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. Observe the ECT sensor temperature display. Does the scan tool indicate that the ECT sensor temperature is greater than the specified value?	138°C (280°F)	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Disconnect the ECT sensor. Refer to *Engine Coolant Temperature (ECT) Sensor Replacement*. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, observe the ECT sensor temperature. Does the scan tool indicate that the ECT sensor temperature is less than the specified value?	−38°C (−36°F)	Go to *Step 6*	Go to *Step 5*
5	1. Turn OFF the Ignition. 2. Disconnect the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Test the signal circuit of the ECT sensor for a short to ground or a short to any reference low circuit. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 8*	Go to *Step 7*
6	Replace the ECT sensor. Refer to *Engine Coolant Temperature (ECT) Sensor Replacement.* Did you complete the replacement?	—	Go to *Step 8*	
7	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 8*	
8	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 9*	Go to *Step 2*
9	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0118

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor, sometimes called a thermistor, that measures the temperature of the engine coolant. The powertrain control module (PCM) supplies 5 volts to the ECT signal circuit. When the ECT is cold, the sensor resistance is high.

When the ECT increases, the sensor resistance lowers. With high sensor resistance, the PCM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the PCM detects a lower voltage on the ECT signal circuit. If the PCM detects an excessively high ECT signal voltage, which is a low temperature indication, this diagnostic trouble code (DTC) will set.

Conditions for Running the DTC

- The engine has been running for more than 60 seconds.

OR

- The engine run time is less than 60 seconds when the IAT is more than 0°C (32°F).

Conditions for Setting the DTC

The ECT sensor temperature is less than −39°C (−38°F) for 20 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- If a short to a separate 5-volt source occurs this DTC may set. If this condition exists, a continuity test to all other PCM circuits will be necessary in order to diagnose the specific circuit.
- After starting the engine, the ECT should rise steadily to about 90°C (194°F) then stabilize when the thermostat opens.
- Use the Temperature vs Resistance table in order to test the ECT sensor at various temperature levels in order to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to Temperature vs Resistance.
- If a malfunction is not present at this time, refer to DTC 1115.
- If an intermittent condition is suspected, refer to *Intermittent Conditions*.

DTC P0118

Step	Action	Value(s)	Yes	No
Schematic Reference: *MAP, ECT, and Air Meter (IAC and MAF)*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, observe the ECT sensor temperature. Does the scan tool indicate that the ECT sensor temperature is less than the specified value?	−38°C (−36°F)	Go to *Step 4*	Go to *Step 3*

DTC P0118 (cont'd)

Step	Action	Value(s)	Yes	No
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Turn OFF the ignition. 2. Disconnect the ECT sensor harness connector. Refer to *Engine Coolant Temperature (ECT) Sensor Replacement*. 3. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor and the low reference circuit. Refer to Using Fused Jumper Wires. 4. Turn ON the ignition, with the engine OFF. 5. With a scan tool, observe the ECT sensor temperature. Does the scan tool indicate ECT sensor temperature more than the specified value?	138°C (280°F)	Go to *Step 8*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Connect a 3-amp fused jumper wire between the signal circuit of the ECT sensor and a known good ground. Refer to Using Fused Jumper Wires. 3. Turn ON the ignition, with the engine OFF. 4. With a scan tool, observe the ECT sensor temperature. Does the scan tool indicate ECT sensor temperature more than the specified value?	138°C (280°F)	Go to *Step 7*	Go to *Step 6*
6	1. Test the signal circuit of the ECT sensor for the following conditions: • A short to voltage • A high resistance • An open circuit 2. Repair the circuit as necessary. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 7*
7	1. Test the ECT sensor low reference circuit for high resistance or an open. 2. Repair the circuit as necessary. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 9*
8	1. Inspect for poor connections at the harness connector of the ECT sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. Repair the connections as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 10*

DTC P0118 (cont'd)

Step	Action	Value(s)	Yes	No
9	1. Turn OFF the ignition. 2. Disconnect the PCM harness connectors. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 4. Repair the connections as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 11*
10	Replace the ECT sensor. Refer to *Engine Coolant Temperature (ECT) Sensor Replacement*. Did you complete the replacement?	—	Go to *Step 12*	—
11	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 12*	—
12	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 13*	Go to *Step 2*
13	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0131 or P0151

Circuit Description

The heated oxygen sensor (HO2S) is a sensor designed to create a voltage relative to the oxygen content in the engine exhaust stream. The control module supplies the HO2S with signal high and low circuits. Ignition voltage and ground are supplied to the HO2S heater by independent circuits. The oxygen content of the exhaust indicates when the engine is operating lean or rich. When the HO2S detects that the engine is operating rich, the signal voltage is high, and decreases the signal voltage as the engine runs leaner. This oscillation above and below the bias voltage, sometimes referred to as activity or switching, can be monitored with the HO2S signal voltage.

The HO2S contains a heater that is necessary in order to quickly warm the sensor to operating temperature. The heater also maintains the operating temperature during extended idle conditions. The HO2S needs to be at a high temperature in order to produce a voltage. When the HO2S reaches operating temperature, the control module monitors the HO2S bias, or reference, voltage. It also monitors the HO2S signal voltage for Closed Loop fuel control. During normal Closed Loop fuel control operation, the control module will add fuel, or enrich the mixture, when the HO2S detects a lean exhaust content. The control module will subtract fuel, or ”lean out” the mixture, when the HO2S detects a rich exhaust condition. Certain vehicle models utilize an oxygen sensor behind the catalytic converter in order to monitor the catalyst efficiency. This DTC is designed to detect an HO2S voltage that remains at a low voltage for more than a specified number of seconds during the test conditions. This DTC is set during the following conditions:

- There is an HO2S circuit conditions that results in a false lean exhaust condition.
- The HO2S is correctly detecting a lean air/fuel ratio resulting from either a vacuum leak or a fuel control system fault.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0117, P0118, P0125, P0128, P0200, P0300, P0351–P0358, P0401, P0404, P0405, P0410, P0418, P0443, P0446, P0449, P1120, P1220, P1221, P1258, or P1404 are not set.
- The secondary air injection (AIR) diagnostics i not active.
- The ignition voltage is more than 9 volts.
- The fuel system is operating in Closed Loop.
- The fuel trim learn is enabled.
- The throttle position (TP) indicated angle is between 3–70 percent.

Conditions for Setting the DTC

The HO2S signal voltage remains below 87 mV for 33 seconds or more.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The heated oxygen sensor (HO2S) wire—The sensor pigtail may be in contact with the exhaust manifold or the exhaust system.
- An oxygen supply inside the HO2S is necessary for proper operation. The HO2S wires provides the supply of oxygen. Inspect the HO2S wires and connections for breaks or contamination. Refer to *Heated Oxygen Sensor (HO2S) Wiring Repairs* in Wiring Systems.
- Check for intermittent ground in the signal wire between the connector and the sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems.
- Lean injectors—Perform the Injector Balance Test. Refer to Fuel Injector Balance Test with Tech 2.
- Fuel contamination—Water near the in-tank fuel pump inlet can be delivered to the injectors. The water causes a lean exhaust and can set a DTC. Refer to *Alcohol/Contaminants-in Fuel Diagnosis*.
- Fuel pressure—The system will be lean if fuel the pressure is low. Refer to *Fuel System Diagnosis*.

- Exhaust leaks—An exhaust leak near the HO2S can cause a lean condition. Refer to Exhaust Leakage in Engine Exhaust.
- Vacuum or crankcase leaks can cause a lean condition.
- If the above are OK, the HO2S may be at fault.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. In order to determine if the engine is lean during Power Enrichment mode, operate the vehicle under higher throttle/acceleration conditions while monitoring scan tool HO2S voltage and the power enrichment parameter. A lean condition will cause HO2S voltage to be less than 598 mV during power enrichment.
5. Monitor the HO2S voltage of the opposite bank sensor. If the voltage activity of the opposite bank sensor is similar to the voltage activity of the suspect sensor check for lean conditions that would affect both cylinder banks. An opposite bank sensor with normal HO2S voltage activity indicates the suspect HO2S needs replacement or a lean condition exists only on the suspect HO2S cylinder bank.

DTC P0131 or DTC P0151

Step	Action	Value(s)	Yes	No
Schematic Reference: *HO2S Circuit*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Run the engine until the engine reaches a normal operating temperature. 2. Using the scan tool, monitor the HO2S voltage for the sensor that applies to this DTC. Does the HO2S voltage measure less than the specified value?	86 mV	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Turn OFF the ignition. 2. Disconnect the HO2S connector for the sensor that applies to this DTC. 3. Turn ON the ignition, with the engine OFF. 4. Using a DMM, check the voltage of the affected HO2S high signal circuit. Does the HO2S voltage measure within the specified range?	351–551 mV	Go to *Step 5*	Go to *Step 6*

DTC P0131 or DTC P0151 (cont'd)

Step	Action	Value(s)	Yes	No
5	1. The HO2S may be detecting a lean exhaust condition. Check for one of the following conditions: • Any water intrusion into the HO2S connector • An exhaust leak between the HO2S and the engine–Refer to Exhaust Leakage in Engine Exhaust. • Any vacuum leaks • An incorrect fuel pressure • Any lean fuel injectors • An inaccurate mass air flow (MAF) sensor 2. Repair any of the above or similar engine conditions as necessary. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 8*
6	1. Turn OFF the ignition. 2. Disconnect the PCM connector that contains the HO2S high signal circuit. 3. Using a DMM, measure and record the resistance between the HO2S high signal circuit and ground. 4. Measure and record the resistance between the HO2S high signal circuit and the HO2S low reference circuit. Is the resistance infinite on both circuits?	∞	Go to *Step 10*	Go to *Step 7*
7	Repair the short to ground or short to the HO2S low reference circuit in the HO2S high signal circuit. Refer to in Wiring Systems. Did you complete the repair?	—	Go to *Step 12*	—
8	Inspect for poor connections at the harness connector of the affected HO2S. Refer to *Testing for Intermittent and Poor Connections* and Heated Oxygen Sensor (HO2S) *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 9*
9	Replace the HO2S. Refer to *Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1* or *Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1*. Did you complete the replacement?	—	Go to *Step 12*	—
10	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 11*
11	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 12*	
12	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the engine for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC, as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 13*	Go to *Step 2*
13	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0132 or P0152

Circuit Description

The heated oxygen sensor (HO2S) is a sensor designed to create a voltage relative to the oxygen content in the engine exhaust stream. The control module supplies the HO2S with high and low signal circuits. Ignition voltage and ground are supplied to the HO2S heater by independent circuits. The oxygen content of the exhaust indicates when the engine is operating lean or rich. When the HO2S detects that the engine is operating rich, the signal voltage is high, and decreases the signal voltage as the engine runs learner. This oscillation above and below the bias voltage, sometimes referred to as activity or switching, can be monitored with the HO2S signal voltage.

The HO2S contains heater that is necessary in order to quickly warm the sensor to operating temperature. The heater also maintains the operating temperature during extended idle conditions. The HO2S needs to be at a high temperature in order to produce a voltage. When the HO2S reaches operating temperature, the control module monitors the HO2S bias, or reference, voltage. It also monitors the HO2S signal voltage for Closed Loop fuel control. During normal Closed Loop fuel operation, the control module will add fuel, or enrich the mixture, when the HO2S detects a lean exhaust content. The control module will subtract fuel, or ”lean out” the mixture, when the HO2S detects a rich exhaust condition. Certain vehicle models use an oxygen sensor behind the catalytic converter in order to monitor the catalyst efficiency.

This DTC is designed to detect an HO2S voltage that remains at a high voltage for more than a specified number of seconds during the test conditions.

This DTC is set during the following conditions:

- There is an HO2S circuit fault that results in a false rich exhaust condition.
- The HO2S is correctly detecting a rich air/fuel ratio resulting from either a fuel control fault or an emission system fault.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0117, P0118, P0125, P0128, P0200, P0300, P0351–P0358, P0401, P0404, P0405, P0410, P0418, P0443, P0446, P0449, P1120, P1220, P1221, P1258, or P1404 are not set.
- The secondary air injection (AIR) is not active.
- The ignition voltage is more than 9 volts.
- The fuel system is operating in Closed Loop.
- The fuel trim learn is enabled.
- The throttle position (TP) indicated angle is between 3–50 percent.

Conditions for Setting the DTC

The HO2S signal voltage remains above 977 mV for 33 seconds or more.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect for the following components and systems:
  – The HO2S electrical connections—Inspect for evidence of water intrusion. Water present in the connector causes the ignition 1 voltage supply to the heater to bleed over to the signal circuit.
  – A rich injector—Perform the Injector Balance Test. Refer to Fuel Injector Balance Test with Tech 2.
  – A leaking injector– Refer to *Fuel System Diagnosis*.
  – The fuel pressure regulator– Inspect the vacuum line going to the fuel pressure regulator for evidence of fuel. Refer to the Fuel System Diagnosis.
  – Evaporative emissions (EVAP) canister purge—Inspect the canister for fuel saturation. If full of fuel, check the canister

control and hoses. Refer to Evaporative Emission (EVAP) Control System Description.
   - MAF sensor – Disconnect the MAF sensor and see if the rich condition is corrected. If so, check for proper installation. If installed OK, replace the MAF sensor. If the MAF sensor is installed backwards, the system goes rich. The plastic portion of the sensor has arrows cast into it indicating proper air flow direction. The arrows must point towards the engine.
   - HO2S oxygen supply—An oxygen supply inside the HO2S is necessary for proper operation. The HO2S wires provide the supply of oxygen. Inspect the HO2S wires and connections for breaks or contamination. Refer to *Heated Oxygen Sensor (HO2S) Wiring Repairs* in Wiring Systems.
   - TP sensor—An intermittent TP sensor output causes the system to go rich, due to a false indication of the engine accelerating.
- Use the Freeze Frame/Failure Records data in order to locate an intermittent condition in the following ways: If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in determining how many miles since the DTC set.
   - The Fail Counter and Pass Counter can also aid in determining how many ignition cycles the diagnostic reported a pass or a fail.
   - Operate the vehicle within the same Freeze Frame conditions that you observed in order to isolate when the DTC failed. Use the following conditions for your tests:
      - RPM
      - Load
      - Vehicle speed
      - Temperature

For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step numbers on the diagnostic table.

3. In order to determine if the engine is rich during deceleration fuel cut-off (DFCO) mode operation, operate the vehicle up to highway speed conditions and release the accelerator pedal allowing the vehicle to coast in gear. Monitor the scan tool HO2S voltage and the DFCO parameter. A rich condition will cause HO2S voltage to be more than 468 mV during DFCO.
5. Monitor the HO2S voltage of the opposite bank sensor. If the voltage activity of the opposite bank sensor is similar to the voltage activity of the suspect sensor check for rich conditions that would affect both cylinder banks. An opposite bank sensor with normal HO2S voltage activity indicates the suspect HO2S is defective or a rich condition exists only on the suspect HO2S cylinder bank.
8. An HO2S contaminated by silicon will have a white, powdery deposit on the portion of the HO2S that is exposed to the exhaust stream. The usual cause of silica contamination is the use of un-approved silicon RTV engine gasket material or the use of silicon based sprays or fluids within the engine. If the cause of this contamination is not corrected, the replacement HO2S will also be contaminated.

DTC P0132 or P0152

Step	Action	Value(s)	Yes	No
Schematic Reference: *HO2S Circuit*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Run the engine until the engine reaches a normal operating temperature. 2. Using a scan tool, monitor the HO2S voltage for the sensor that applies to this DTC. Is the HO2S voltage fixed at more than the value specified?	976 mV	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*

DTC P0132 or P0152 (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the HO2S connector for the sensor that applies to this DTC. 3. Turn ON the ignition, with the engine OFF. 4. Using a DMM, check the voltage on the HO2S high signal circuit of the affected sensor. Does the HO2S voltage measure within the specified range?	351–551 mV	Go to *Step 5*	Go to *Step 6*
5	1. The HO2S is detecting a rich exhaust condition or may be contaminated. Check for one of the following conditions: • Any water intrusion into the HO2S connector A silicon contaminated HO2S • The engine oil contaminated by fuel • An EVAP canister purge condition An incorrect fuel pressure • A leaking fuel pressure regulator • Any rich fuel injectors • An inaccurate MAF sensor 2. Repair any of the above or similar engine conditions as necessary. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 8*
6	1. Turn OFF the ignition. 2. Disconnect the PCM connector that contains the HO2S high signal circuit. 3. Turn ON the ignition, with the engine OFF. 4. Using a DMM, measure the voltage between the HO2S high signal circuit PCM connector terminal on the harness side and ground. Does the voltage measure more than the specified value?	20 mV	Go to *Step 7*	Go to *Step 10*
7	Repair the short to voltage in the HO2S high signal circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 12*	—
8	Inspect for poor connections at the harness connector of the affected HO2S. Refer to *Testing for Intermittent and Poor Connections* and Heated Oxygen Sensor (HO2S) *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 9*
9	**Important:** Before replacing a contaminated HO2S determine and repair the cause of the contamination. Replace the HO2S. Refer to *Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1* or *Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1.* Did you complete the replacement?	—	Go to *Step 12*	—
10	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 12*	Go to *Step 11*
11	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 12*	—

DTC P0132 or P0152 (cont'd)

Step	Action	Value(s)	Yes	No
12	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC, as specified in the supporting text. Did the DTC run and pass?	—	Go to *Step 13*	Go to *Step 2*
13	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0134 or P0154

Circuit Description

The heated oxygen sensor (HO2S) is a sensor designed to create a voltage relative to the oxygen content in the engine exhaust stream. The control module supplies the HO2S with signal high and low circuits. Ignition voltage and ground are supplied to the HO2S heater by independent circuits. The oxygen content of the exhaust indicates when the engine is operating lean or rich. When the HO2S detects that the engine is operating rich, the signal voltage is high, and decreases the signal voltage as the engine runs leaner. This oscillation above and below the bias voltage, sometimes referred to as activity or switching, can be monitored with the HO2S signal voltage.

The HO2S contains a heater that is necessary in order to quickly warm the sensor to operating temperature. The heater also maintains the operating temperature during extended idle conditions. The HO2S needs to be at a high temperature in order to produce a voltage. When the HO2S reaches operating temperature, the control module monitors the HO2S bias, or reference, voltage. It also monitors the HO2S signal voltage for Closed Loop fuel control During normal Closed Loop fuel control operation, the control module will add fuel, or enrich the mixture, when the HO2S detects a lean exhaust content. The control module will subtract fuel, or ”lean out” the mixture, when the HO2S detects a rich exhaust condition. Certain vehicle models utilize an oxygen sensor behind the catalytic converter in order to monitor the catalyst efficiency.

This diagnostic trouble code (DTC) determines if the HO2S is functioning properly. The DTC checks for an adequate number of HO2S voltage transitions above and below the bias range of 300–600 mV. This DTC sets when the powertrain control module (PCM) fails to detect a minimum number of voltage transitions above and below the bias range during the test period.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0117, P0118, P0125, P0128, P0200, P0300, P0351–P0358, P0401, P0404, P0405, P0410, P0418, P0443, P0446, P0449, P1120, P1220, P1221, P1258, or P1404 are not set.
- The secondary air injection (AIR) is not active.
- The ignition voltage is more than 9 volts.
- The engine run time is more than 409 seconds.

Conditions for Setting the DTC

The HO2S signal voltage is steady between 350–550 mV for 60 seconds or more.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the following components and systems:
  - The exhaust system for leaks upstream of the affected HO2S.
  - An oxygen supply inside the HO2S is necessary for proper operation.
  - The HO2S wires provide the supply of oxygen. Inspect the HO2S wires and connections for breaks or contamination. Refer to *Heated Oxygen Sensor (HO2S) Wiring Repairs* in Wiring Systems.
  - An HO2S that is loose causes this DTC to set.
- Use the Freeze Frame/Failure Records data in order to locate an intermittent condition in the following ways:
  - If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in determining how many miles since the DTC set.
  - The Fail Counter and Pass Counter can also aid in determining how many ignition cycles the diagnostic reported a pass or a fail.
  - Operate the vehicle within the same Freeze Frame conditions that you observed in

order to isolate when the DTC failed. Use the following conditions for your tests:
  - The RPM
  - The load
  - The vehicle speed
- The temperature

For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. If the HO2S voltage is varying outside the specified range, the condition is not present.
4. If the test lamp is illuminated, the HO2S Low reference circuit between C1-60 and S136 is OK.
5. This step checks for proper HO2S heater circuit operation up to the HO2S connector.
6. If the voltage is below the specified value, the high signal circuit is OK.
7. If the voltage is below the specified value, the remainder of the HO2S low reference circuits are OK.

DTC P0134 or P0154

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Start the engine. 2. Allow the engine to reach operating temperature. 3. Raise and hold the engine speed at 1,200 RPM for 2 minutes. 4. Observe the HO2S voltage with a scan tool. Is the HO2S voltage varying outside the specified range?	350–550 mV	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Condition for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Turn OFF the ignition. 2. Disconnect the affected HO2S connector. 3. Connect a test lamp between the affected HO2S Low reference circuit on the PCM harness side and battery voltage. 4. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to *Step 5*	Go to *Step 11*
5	Connect a test lamp between the HO2S heater high control and the heater low control circuit terminals on the engine harness side. Start the engine. Does the test lamp illuminate?	—	Go to *Step 6*	Go to *Step 9*
6	1. Disconnect the HO2S connector that applies to this DTC. 2. Turn ON the ignition, with the engine OFF. 3. Jumper the HO2S high signal circuit to a good ground. 4. Observe the HO2S voltage with a scan tool. Is the voltage below the specified value? 200 mv	—	Go to *Step 7*	Go to *Step 8*

DTC P0134 or P0154 (cont'd)

Step	Action	Value(s)	Yes	No
7	1. Remove the jumper from the previous step. 2. Jumper the HO2S high signal circuit to the low signal circuit. 3. Observe the HO2S voltage with a scan tool. Is the HO2S voltage below the specified value?	200 mv	Go to *Step 13*	Go to *Step 12*
8	Test the HO2S high signal circuit for an open or high resistance. Refer to *Circuit Testing* and Heated Oxygen Sensor (HO2S) *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
9	Test the HO2S heater high control circuit for an open, high resistance, or short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 10*
10	Test the HO2S heater low control circuit for an open, high resistance or short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
11	Test the low reference circuit between S413 and ground for an open or high resistance. Refer to *Circuit Testing* and Heated Oxygen Sensor (HO2S) *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
12	Test the affected HO2S low reference circuit for an open or high resistance. Refer to *Circuit Testing* and Heated Oxygen Sensor (HO2S) *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
13	Inspect for poor connections at the harness connector of the affected HO2S. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 15*
14	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 16*
15	Replace the affected HO2S. Refer to *Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1* and *Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1.* Did you complete the replacement?	—	Go to *Step 17*	—
16	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
17	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC, as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 18*	Go to *Step 2*
18	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0200

Circuit Description

The powertrain control module (PCM) enables the appropriate fuel injector on the intake stroke for each cylinder. An ignition voltage is supplied to the fuel injectors. The PCM controls each fuel injector by grounding the control circuit via a solid state device called a driver. The PCM monitors the status of each driver. If the PCM detects an incorrect voltage for the commanded state of the driver, a fuel injector control diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- The engine speed is more than 400 RPM.
- The ignition voltage is between 6–18 volts.

Conditions for Setting the DTC

The PCM detects an incorrect voltage on a fuel injector control circuit.

The condition exists for 5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Performing the Fuel Injector Coil test may help isolate an intermittent condition. Refer to *Fuel Injector Coil Test*.
- For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

4. This step tests for voltage at the fuel injector harness connector. The INJ fuse supplies power to the coil side of the fuel injector harness connector. If the fuse is open, a short to ground on the fuel injector B+ supply circuit is indicated. The INJ fuse also supplies voltage to the ignition coils. If the fuse is open inspect the circuits to the ignition coils for a short to ground.
5. This step verifies that the PCM is able to control the fuel injector. If the test lamp blinks, then the PCM and wiring are OK.
6. This step tests if a ground is constantly being applied to the fuel injector.

DTC P0200

Step	Action	Value(s)	Yes	No
Schematic Reference: *Fuel Injector Controls*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. With a scan tool clear the DTCs. 2. Idle the engine at the normal operating temperature. 3. With a scan tool, monitor the misfire current counters. Are any of the misfire current counters incrementing?	—	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*

DTC P0200 (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the appropriate harness connector of the fuel injector. 3. Turn ON the ignition, with the engine OFF. 4. Probe the ignition voltage circuit of the fuel injector with a test lamp connected to a good ground. Does the test lamp illuminate?	—	Go to *Step 5*	Go to *Step 11*
5	1. Connect the J 34730–2C fuel injector test lamp between the control circuit and the ignition voltage circuit of the fuel injector harness connector. 2. Start the engine. Does the test lamp blink?	—	Go to *Step 9*	Go to *Step 6*
6	Does the test lamp remain illuminated at all times?	—	Go to *Step 8*	Go to *Step 7*
7	Test the control circuit of the fuel injector for a short to voltage or an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 10*
8	Test the control circuit of the fuel injector for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 13*
9	Inspect for poor connections at the harness connector of the fuel injector. Refer to *Testing for Intermittent and Poor Connections* and Repairing Connector Terminals in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 12*
10	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and Repairing Connector Terminals in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 13*
11	**Important:** The INJ fuse also supplies voltage to the ignition coil modules. If the fuse is open inspect all related circuits for a short to ground. Repair the ignition voltage circuit of the fuel injector for an open or a short to ground. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 14*	—
12	Replace the fuel injector. Refer to Fuel Injector Replacement. Did you complete the replacement?	—	Go to *Step 14*	—
13	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 14*	—
14	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 15*	Go to *Step 2*
15	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0230

Circuit Description

The powertrain control module (PCM) provides ignition positive voltage to the coil side of the fuel pump relay. When the ignition switch is first turned ON, the PCM energizes the fuel pump relay, which applies power to the fuel pump. The PCM enables the fuel pump relay as long as the engine is cranking or running, and crankshaft reference pulses are received. If no crankshaft reference pulses are received, the PCM de-energizes the fuel pump relay after 2 seconds. The PCM monitors the voltage on the fuel pump relay control circuit. If the PCM detects an incorrect voltage on the fuel pump relay control circuit, DTC P0230 sets.

Conditions for Running the DTC

- The engine speed is more than 400 RPM.
- The ignition voltage is between 6–18 volts.

Conditions for Setting the DTC

- The PCM detects that the commanded state of the driver and the actual state of the control circuit do not match.
- All the above conditions are present for a minimum of 2.5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Listen for a click when the fuel pump relay operates. Command both the ON and OFF states. Repeat the commands as necessary.
4. This step verifies that the PCM is providing voltage to the fuel pump relay.
5. This step tests for an open in the ground circuit to the fuel pump relay.
6. This step tests if voltage is constantly being applied to the control circuit of the fuel pump relay.

DTC P0230

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, command the fuel pump ON and OFF. Does the fuel pump relay turn ON and OFF with each command?	—	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Intermittent Conditions*

DTC P0230 (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the fuel pump relay. 3. Turn ON the ignition, with the engine OFF. 4. Probe the control circuit of the fuel pump relay with a test lamp connected to a good ground. 5. With a scan tool, command the fuel pump ON and OFF. Does the test lamp turn ON and OFF with each command?	—	Go to *Step 5*	Go to *Step 6*
5	1. Connect a test lamp between the control circuit of the fuel pump relay and the ground circuit of the relay. 2. With a scan tool, command the fuel pump ON and OFF. Does the test lamp turn ON and OFF with each command?	—	Go to *Step 9*	Go to *Step 11*
6	Does the test lamp remain illuminated with each command?	—	Go to *Step 8*	Go to *Step 7*
7	Test the control circuit of the fuel pump relay for a short to ground or an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 10*
8	Test the control circuit of the fuel pump relay for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 10*
9	Inspect for poor connections at the fuel pump relay. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 12*
10	Inspect for poor connections at the harness connectors of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 14*	Go to *Step 13*
11	Repair the ground circuit of the relay. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 14*	—
12	Replace the fuel pump relay. Did you complete the replacement?	—	Go to *Step 14*	—
13	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 14*	—
14	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC reset?	—	Go to *Step 2*	Go to *Step 15*
15	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0325

Circuit Description

The knock sensors (KS) produce an AC signal when specific frequencies are detected. When the engine operates, the powertrain control module (PCM) learns a minimum and maximum frequency of noise of normal engine operation. The knock sensor KS system monitors both knock sensors in order to determine if knock is present. If the KS system determines that excessive knock is present, the PCM retards the spark timing based on the signals from the KS system. The PCM then retards timing until no knock is present.

Conditions for Running the DTC

- The engine is running.
- The engine run time more than 10 seconds. The ignition 1 signal is more than 10 volts. Conditions for Setting the DTC
- A malfunction with the KS system or circuits within the PCM are faulty for 15 seconds or more.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

DTC P0325

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If you can hear the engine knock, repair the engine mechanical problem before proceeding with this diagnostic. 1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 3*	Go to *Intermittent Conditions*
3	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 4*	—
4	1. Use the scan tool in order to clear the DTCs 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the conditions for Running the DTC as specified in the supporting text. Does the scan tool indicate that this test ran and passed?	—	Go to *Step 5*	Go to *Step 2*
5	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0327 or P0332

Circuit Description

The knock sensors produce an AC signal when specific frequencies are detected. When the engine operates, the powertrain control module (PCM) learns a minimum and maximum frequency of noise of normal engine operation. The knock sensor (KS) system monitors both knock sensors in order to determine if knock is present. If the KS system determines that excessive knock is present the PCM retards the spark timing based on the signals from the KS system. The PCM then retards the timing until no knock is present. When the PCM detects a frequency that is less than or more than a defined range, DTC P0327 will set for a failure in knock sensor (1) which is located on bank 1 on the drivers side of the engine or DTC P0332 will set for a failure in knock sensor (2) which is located on bank 2 on the passenger side of the engine.

Conditions for Running the DTC

DTCs P0117, P0118, P0125, P1114, P1115, P1120, P1220, or P1221 are not set.

The engine speed is between 1,600–3,000 RPM.

The manifold absolute pressure (MAP) is less than 45 kPa.

The engine coolant temperature (ECT) is more than 60°C (140°F). The engine run time is more than 20 seconds.

Ignition is more than 10 volts.

Conditions for Setting the DTC

The PCM determines that this frequency is less than or more than the expected amount for 3 seconds or more.

Action Taken When the DTC Sets

The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.

The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.

A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.

Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

Check the knock sensor for proper installation. A knock sensor that is loose or over torqued may cause either DTC to set.

For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This verifies the malfunction is present.
3. This test will isolate the knock sensor from the rest of the circuit.
4. Tapping on the engine block near the appropriate knock sensor will simulate an engine knock.

DTC P0327 or P0332

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*

DTC P0327 or P0332 (cont'd)

Step	Action	Value(s)	Yes	No
2	**Important:** If an engine knock can be heard, repair the engine mechanical condition before proceeding with this diagnostic. 1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC as close to the Freeze Frame/Failure Records data that you observed. Does the scan tool indicate that this diagnostic failed this ignition?	—	Go to *Step 3*	Go to *Diagnostic Aids*
3	1. Disconnect the knock sensor harness of the appropriate knock sensor. 2. Set the DMM to the 400K ohm scale. 3. Measure the resistance of the appropriate knock sensor using the DMM connected to battery ground. Is the resistance of the knock sensor within the specified range?	93–107 K ohm	Go to *Step 4*	Go to *Step 6*
4	1. With the DMM still connected, set the DMM to the 400 mv AC hertz scale. Refer to M*easuring Frequency* in Wiring Systems. **Important:** Do not tap on plastic engine components. 2. Tap on the engine block near the appropriate knock sensor while observing the signal indicated on the DMM. Is any signal indicated on the DMM while tapping on the engine block near the knock sensor?	—	Go to *Step 5*	Go to *Step 6*
5	1. Disconnect the PCM connector Refer to *Powertrain Control Module (PCM) Replacement*. 2. Refer to *Circuit Testing* in Wiring Systems. Test the KS signal circuit between the PCM and the knock sensor connector for the following: • An open • A short to voltage • A short to ground Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 7*
6	Replace the knock sensor. Refer to Knock Sensor (KS) 1 Replacement or Knock Sensor (KS) 2 Replacement. Did you complete the replacement?	—	Go to *Step 9*	—
7	1. Inspect the KS signal circuit for a poor connection at the PCM or the Knock sensor harness connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 9*	Go to *Step 8*
8	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 9*	—

DTC P0327 or P0332 (cont'd)

Step	Action	Value(s)	Yes	No
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0335

Circuit Description

The crankshaft position (CKP) sensor signal indicates the crankshaft speed and position. The CKP sensor is connected directly to the powertrain control (PCM) module, and consists of the following circuits:

- The 12-volt reference circuit
- The low reference circuit
- The CKP sensor signal circuit

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0341, P0342 , or P0343 are not set.
- The camshaft position (CMP) sensor is transitioning.
- The mass air flow (MAF) is more than 3 g/s in the crank mode.
- The MAF is more than 5 g/s in the running mode.

Conditions for Setting the DTC

The PCM determines no signal from the CKP sensor for more than 3 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The following conditions may cause this DTC to set:
  - Poor connections/terminal tension at the sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems.
  - Crankshaft reluctor wheel damage or improper installation
  - Excessive air gap between the CKP sensor and the reluctor wheel
  - The engine running out of fuel
  - Foreign material passing between the sensor and the reluctor wheel
- Excess crankshaft end play causes the CKP sensor reluctor wheel to move out of aligN·ment with the CKP sensor. This could result in any one of the following conditions:
  - A no start
  - A start and stall
  - Erratic performance
- For an intermittent, refer to *Intermittent Conditions*.
- A faulty CMP sensor can give similar results. Check CMP sensor before CKP/PCM.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. This step determines if the fault is present.
6. This step simulates a CKP sensor signal to the PCM. If the PCM receives the signal, the fuel pump will operate for about two seconds.
11. The CKP system variation learn procedure must be performed anytime the relationship between the CKP sensor and the CKP reluctor wheel is changed.

DTC P0335

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Does the engine start and continue to run?	—	Go to *Step 3*	Go to *Step 4*

DTC P0335 (cont'd)

Step	Action	Value(s)	Yes	No
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the conditions for running the DTC as specified in the supporting text or as close as the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	***Caution: Before proceeding, remove the fuses for the ignition coil and fuel injector feed circuits in order to prevent personal injury from engine rotation, sparks, and excessive engine fueling.*** 1. Turn ON the ignition, with the engine OFF. 2. Disconnect the Crankshaft Position (CKP) sensor harness connector. Refer to *Crankshaft Position (CKP) Sensor Replacement.* 3. Measure the voltage from the CKP sensor 12-volt reference circuit and a good ground using the DMM. Does the DMM display the specified value?	B+	Go to *Step 5*	Go to *Step 7*
5	Measure the voltage between the CKP sensor 12-volt reference circuit and the CKP sensor low reference circuit using the DMM. Does the DMM display the specified value?	B+	Go to *Step 6*	Go to *Step 8*
6	Momentarily connect the test lamp between the CKP sensor signal circuit and the CKP sensor 12-volt reference circuit. Does the fuel pump operate when ignition voltage was applied to the CKP sensor signal circuit?	—	Go to *Step 10*	Go to *Step 9*
7	1. Test for an open in the CKP sensor 12-volt reference circuit. Refer to *Circuit Testing* in Wiring Systems. 2. If you find an open or a short to ground, repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 13*
8	1. Test for an open or a poor connection in the CKP sensor low reference circuit. Refer to *Testing for Continuity* or *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find an open or poor connection, repair the condition as necessary. Refer to *Wiring Repairs* or *Repairing Connector Terminals* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 13*
9	1. Test the CKP sensor signal circuit for the following: • An open • A short to ground • A short to voltage 2. Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 10*

DTC P0335 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Inspect for poor connections at the CKP sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection repair the condition as necessary. Refer to *Repairing Connector Terminals* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 11*
11	**Important:** The CKP system variation learn procedure must be performed anytime the relationship between the CKP sensor and the CKP reluctor wheel is changed. Refer to *CKP System Variation Learn Procedure.* 1. Remove the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement. 2. Visually inspect the CKP sensor for the following conditions: • Physical damage • Loose or improper installation • Wiring routed too closely to secondary ignition components 3. Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 12*
12	1. Replace the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement. 2. Perform the CKP system variation learn procedure. Refer to CKP System Variation Learn Procedure. Did you complete the repair?	—	Go to *Step 15*	—
13	1. Inspect for poor connections at the PCM. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the condition as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 15*	Go to *Step 14*
14	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
15	1. Operate the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 16*	Go to *Step 2*
16	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0336

Circuit Description

The crankshaft position (CKP) sensor signal indicates the crankshaft speed and position. The CKP sensor is connected directly to the powertrain control (PCM) module, and consists of the following circuits:

- The 12-volt reference circuit.
- The low reference circuit.
- The CKP sensor signal circuit.

Conditions for Running the DTC

The engine is cranking or running.

Conditions for Setting the DTC

The PCM determines that the CKP sensor signal is out of range for more than 120 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The following conditions may cause this DTC to set:
  - Poor connections—Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems.
  - Crankshaft reluctor wheel damage or improper installation
  - Excessive air gap between the sensor and the reluctor wheel
  - The engine running out of fuel
  - If the crankshaft rotates backwards, this DTC sets. This condition is only with vehicles equipped with a manual transmission. This condition occurs when a vehicle is on an incline and the clutch is released and an engine stall occurs.
  - Foreign material passing between the sensor and the reluctor wheel
  - A faulty CMP sensor. This should be checked first.
- Excess crankshaft end play will cause the CKP sensor reluctor wheel to move out of aligN·ment with the CKP sensor. This could result in any one of the following:
  - A no start
  - A start and stall
  - Erratic performance
- An improperly installed crankshaft could cause excess crankshaft end play.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step verifies that the malfunction is present.
3. This step tests for electromagnetic interference (EMI) on the CKP sensor circuits.

DTC P0336

Step	Action	Yes	No
Schematic Reference: *CMP, CKP, and KS*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If DTC P0335 is also set, diagnose DTC P0335 before proceeding with this DTC. 1. Install a scan tool. 2. Start the engine and idle for 2 minutes. Does the scan tool indicate that DTC P0336 failed this ignition?	Go to *Step 3*	Go to *Diagnostic Aids*

DTC P0336 (cont'd)

Step	Action	Yes	No
3	1. Visually/Physically inspect all circuits going to the crankshaft position sensor for the following: • Routed too close to secondary ignition wires or components • Routed too close to after-market add on electrical equipment • Routed too close to solenoids, relays, and motors 2. If you find incorrect routing, correct the harness routing. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 4*
4	1. Inspect for poor connections at the CKP sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection repair the terminal as necessary. Refer to Repairing Connector Terminals in Wiring Systems. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 5*
5	Inspect for poor connections at the PCM for the CKP sensor circuits. If you find a poor connection repair the terminal as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 6*
6	1. Remove the CKP sensor. Refer to Crankshaft Position (CKP) Sensor Replacement. 2. Inspect the CKP sensor for signs of damage. 3. If you find the CKP to be damaged, refer to Crankshaft Position (CKP) Sensor Replacement. 4. Perform the CKP system variation learn procedure. Refer to CKP System Variation Learn Procedure. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 7*
7	1. Inspect the CKP reluctor wheel for damage. 2. If you find the CKP reluctor wheel damaged, refer to *Crankshaft and Bearings Installation* in Engine Mechanical 8.1L. 3.. Perform the CKP system variation learn procedure. Refer to CKP System Variation Learn Procedure. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 8*
8	1. Replace the CKP sensor. Refer to *Crankshaft Position (CKP) Sensor Replacement.* 2. Perform the CKP system variation learn procedure. Refer to *CKP System Variation Learn Procedure.* Did you complete the replacement?	Go to *Step 9*	—
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate vehicle within the Conditions for Running this DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0341

Circuit Description

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel on the camshaft. The powertrain control module (PCM) provides a 12-volt reference to the CMP sensor as well as a low reference and a signal circuit.

The CMP sensor determines whether a cylinder is on a firing stroke or on an exhaust stroke. As the camshaft rotates, the reluctor wheel interrupts a magnetic field produced by a magnet within the sensor. The sensors internal circuitry detects this and produces a signal which the PCM reads. The PCM uses this 1X signal in combination with the crankshaft position (CKP) sensor 24X signal in order to determine crankshaft position and stroke. This diagnostic for the CMP sensor checks for a loss of CMP sensor signal.

Observe that as long as the PCM receives the CKP sensor 24X signal, the engine will start. The PCM can determine top dead center for all cylinders by using the CKP sensor 24X signal alone. The CMP sensor 1X signal is used by the PCM to determine if the cylinder at top dead center is on the firing stroke or the exhaust stroke. The system attempts synchronization and looks for an increase in engine speed indicating the engine started. If the PCM does not detect an increase in engine speed, the PCM assumes it incorrectly synchronized to the exhaust stroke and re-syncs to the opposite cam position. A slightly longer cranking time may be a symptom of this condition.

Conditions for Running the DTC

The engine speed is less than 4,000 RPM.

Conditions for Setting the DTC

The PCM detects that a CMP to CKP mis-match has occurred.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The following conditions may cause this DTC to set:
  - Camshaft reluctor wheel damage
  - The sensor coming in contact with the reluctor wheel
  - A cracked or damaged sensor
  - Foreign material passing between the sensor and reluctor wheel
- If you find damage to the reluctor wheel or camshaft, refer to Camshaft Replacement in Engine Mechanical 8.1L.
- If the condition is suspected to be intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step verifies that the malfunction is present. A hard start is observed when a malfunction is present.
3. This step inspects for electromagnetic interference (EMI) on the CMP sensor circuits.
6. Damage to the face of the sensor could indicate foreign material passing between the CMP sensor and the reluctor wheel. This condition would cause this DTC to set. Damage to the reluctor wheel would affect the CMP sensor output.

DTC P0341

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If there are any other CMP sensor DTCs set, diagnose those DTCs first. 1. Install a scan tool. 2. Idle the engine for 2 minutes. Does the scan tool indicate that DTC P0341 failed this ignition?	—	Go to *Step 3*	Go to *Diagnostic Aids*
3	1. Visually and physically inspect all circuits going to the camshaft position sensor for the following: • Routed too close to secondary ignition wires or components • Routed too close to after-market add-on electrical equipment Routed too close to solenoids, relays, and motors 2. If you find incorrect routing, correct the harness routing. Did you find and correct the condition?	—	Go to *Step 8*	Go to *Step 4*
4	1. Inspect for poor connections at the CMP sensor. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the terminal as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 8*	Go to *Step 5*
5	1. Inspect for poor connections at the PCM for the CMP sensor circuits. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the terminal as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 8*	Go to *Step 6*
6	1. Remove the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement. 2. Inspect the CMP sensor for signs of damage. Does the CMP sensor show signs of damage?	—	Go to *Diagnostic Aids*	Go to *Step 7*
7	Replace the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 8*	—
8	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 9*	Go to *Step 2*
9	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0342

Circuit Description

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel on the camshaft. The powertrain control module (PCM) provides a 12-volt reference circuit to the CMP sensor as well as a low reference and a signal circuit.

The CMP sensor determines whether a cylinder is on a firing stroke or on an exhaust stroke. As the camshaft rotates, the reluctor wheel interrupts a magnetic field produced by a magnet within the sensor. The sensors internal circuitry detects this and produces a signal which the PCM reads. The PCM uses this 1X signal in combination with the CKP sensor 24X signal in order to determine crankshaft position and stroke. This diagnostic for the CMP sensor checks for a loss of CMP sensor signal. Observe that as long as the PCM receives the CKP sensor 24X signal, the engine will start. The PCM can determine top dead center for all cylinders by using the CKP sensor 24X signal alone. The CMP sensor 1X signal is used by the PCM to determine if the cylinder at top dead center is on the firing stroke or the exhaust stroke. The system attempts synchronization and looks for an increase in engine speed indicating the engine started. If the PCM does not detect an increase in engine speed, the PCM assumes it incorrectly synchronized to the exhaust stroke and re-syncs to the opposite cam position. A slightly longer cranking time may be a symptom of this condition.

Conditions for Running the DTC

The engine speed is less than 4,000 RPM.

Conditions for Setting the DTC

The PCM detects the cam signal is stuck low when the signal should be high for 1.5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The following conditions may cause this DTC to set:
  - Camshaft reluctor wheel damage
  - The sensor coming in contact with the reluctor wheel
  - Foreign material passing between the sensor and the reluctor wheel
- Using Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in determining how many miles since the DTC set. The Fail Counter and Pass Counter can also aid determining how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions such as RPM, load, vehicle speed, temperature, etc. that you observed. This will isolate when the DTC failed.
- The CMP sensor output can be tested. The sensor must be supplied with a power and a ground. The engine must be cranking to perform this test. You can measure the duty cycle at the signal circuit of the sensor. The duty cycle should be between 45–55 percent for a good sensor.
- If the problem is intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step verifies that the fault is present. A hard start is observed when a malfunction is present.
4. This step tests the CMP sensor 12-volt reference circuit from the PCM to the CMP.
5. This step tests the CMP sensor low reference circuit from the PCM to the CMP.
6. This step tests the CMP sensor signal circuit. Applying a voltage causes the CAM signal input – high to low and low to high parameter to increase if the circuit and the PCM are operating properly.
7. This step tests the resistance of the CMP sensor 12-volt reference circuit from the PCM to the CMP sensor.
9. This step tests the resistance of the CMP sensor low reference circuit from the PCM to the CMP sensor.

DTC P0342

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the CAM signal input high to low and low-to-high transition parameter using the scan tool. Does the scan tool parameter increment?	—	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Turn OFF the ignition. 2. Disconnect the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement. 3. Turn ON the ignition, with the engine OFF. 4. Measure the voltage on the CMP sensor 12-volt reference circuit using the DMM connected to battery ground. Does the voltage measure near the specified value?	B+	Go to *Step 5*	Go to *Step 7*
5	Measure the voltage from the CMP sensor 12-volt reference circuit to the CMP sensor low reference circuit using the DMM. Does the voltage measure near the specified voltage?	B+	Go to *Step 6*	Go to *Step 9*
6	1. Start the engine. 2. Monitor the CAM signal input high-to-low and low-to-high transition using the scan tool. 3. Momentarily and repeatedly probe the signal circuit with the test lamp connected to B+. Does the CAM signal input high to low and low to high transition counters increment when the test lamp contacts the signal circuit?	—	Go to *Step 15*	Go to *Step 10*
7	1. Turn OFF the ignition. 2. Disconnect the PCM connector C2, located on the opposite side of the manufacturers logo. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Test the resistance of the CMP sensor 12-volt reference circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 8*	Go to *Step 12*
8	Inspect the CMP 12-volt reference circuit for the following: • A grounded circuit • A poor connection Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
9	1. Turn OFF the ignition. 2. Disconnect the PCM connector C1 located on the same side as the manufacturers logo. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Test the resistance of the CMP low reference circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 16*	Go to *Step 13*

DTC P0342 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Disconnect the PCM connector C1, located on the same side as the manufactures logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the resistance of the CMP signal circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 11*	Go to *Step 14*
11	1. Turn ON the ignition, with the engine OFF. 2. Test the CMP signal circuit for the following: • A grounded circuit • A circuit shorted to a voltage Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
12	1. Inspect the CMP sensor 12-volt reference circuit for an open. 2. If you find an open circuit, repair the CMP sensor 12-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
13	Repair the CMP low reference circuit for an open. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 19*	—
14	Repair the CMP signal circuit for an open. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 19*	—
15	1. Inspect for poor connections at the CMP harness connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 17*
16	1. Inspect the PCM harness connector for poor connections. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 18*
17	Replace the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 19*	—
18	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 19*	—
19	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 20*	Go to *Step 2*
20	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0343

Circuit Description

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel on the camshaft. The powertrain control module (PCM) provides a 12-volt reference circuit to the CMP sensor as well as a low reference and a signal circuit.

The CMP sensor determines whether a cylinder is on a firing stroke or on an exhaust stroke. As the camshaft rotates, the reluctor wheel interrupts a magnetic field produced by a magnet within the sensor. The sensors internal circuitry detects this and produces a signal which the PCM reads. The PCM uses this 1X signal in combination with the crankshaft position (CKP) sensor 24X signal in order to determine crankshaft position and stroke. This diagnostic for the CMP sensor checks for a loss of CMP sensor signal. Observe that as long as the PCM receives the CKP sensor 24X signal, the engine will start. The PCM can determine top dead center for all cylinders by using the CKP sensor 24X signal alone. The CMP sensor 1X signal is used by the PCM to determine if the cylinder at top dead center is on the firing stroke, or the exhaust stroke. The system attempts synchronization and looks for an increase in engine speed indicating the engine started. If the PCM does not detect an increase in engine speed, the PCM assumes it incorrectly synchronized to the exhaust stroke and re-syncs to the opposite cam position. A slightly longer cranking time may be a symptom of this condition.

Conditions for Running the DTC

The engine speed is less than 4,000 RPM.

Conditions for Setting the DTC

The PCM detects the cam signal is stuck high when the signal should be low for 1.5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- The following conditions may cause this DTC to set:
  - Camshaft reluctor wheel damage
  - The sensor coming in contact with the reluctor wheel
  - Foreign material passing between the sensor and the reluctor wheel
- Using Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can aid in determining how many miles since the DTC set. The Fail Counter and Pass Counter can also aid determining how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions such as RPM, load, vehicle speed, temperature, etc. that you observed. This will isolate when the DTC failed.
- The CMP sensor output can be tested. The sensor must be supplied with a power and a ground. The engine must be cranking to perform this test. You can measure the duty cycle at the signal circuit of the sensor. The duty cycle should be between 45–55 percent for a good sensor.
- If the problem is intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step verifies that the fault is present. A hard start is observed when a malfunction is present.
4. This step tests the CMP sensor 12-volt reference circuit from the PCM to the CMP.
5. This step tests the CMP sensor low reference circuit from the PCM to the CMP.
6. This step tests the CMP sensor signal circuit. Applying a voltage causes the CAM signal input – high to low and low to high parameter to increase if the circuit and the PCM are operating properly.
7. This step tests the resistance of the CMP sensor 12-volt reference circuit from the PCM to the CMP sensor.
9. This step tests the resistance of the CMP sensor low reference circuit from the PCM to the CMP sensor.

DTC P0343

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. Monitor the CAM signal input high to low and low to high transition parameter using the scan tool. Does the scan tool parameter increment?	—	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Turn OFF the ignition. Disconnect the CMP sensor. 2. Turn ON the ignition, with the engine OFF. 3. Measure the voltage from the CMP sensor 12-volt reference circuit using the DMM connected to battery ground. Does the voltage measure near the specified value?	B+	Go to *Step 5*	Go to *Step 7*
5	Measure the voltage from the CMP sensor 12 volt reference circuit to the CMP sensor low reference circuit using the DMM. Does the voltage measure near the specified voltage?	B+	Go to *Step 6*	Go to *Step 9*
6	1. Start the engine. 2. Monitor the CAM signal input high to low and low to high transition using the scan tool. 3. Momentarily and repeatedly probe the signal circuit with the test lamp connected to B+. Does the CAM signal input – high to low and low to high transition counters increment when the test lamp contacts the signal circuit?	—	Go to *Step 15*	Go to *Step 10*
7	1. Turn OFF the ignition. 2. Disconnect the PCM connector C2, located on the opposite side of the manufacturers logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the resistance of the CMP sensor 12-volt reference circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 8*	Go to *Step 12*
8	Inspect the CMP sensor 12-volt reference circuit for the following: • A grounded circuit • A poor connection Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
9	1. Turn OFF the ignition. 2. Disconnect the PCM connector C1, located on the same side as the manufacturers logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the resistance of the CMP low reference circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 16*	Go to *Step 13*

DTC P0343 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. 2. Disconnect the PCM connector C1 located on the same side as the manufactures logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Test the resistance of the CMP signal circuit using the DMM. Does the resistance measure within the specified range?	0–5 ohm	Go to *Step 11*	Go to *Step 14*
11	Turn ON the ignition, with the engine OFF. Test the CMP signal circuit for the following: A grounded circuit A circuit shorted to a voltage Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
12	1. Inspect the CMP sensor 12-volt reference circuit for an open. 2. If you find an open circuit, repair the CMP sensor 12-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 16*
13	Repair the CMP sensor low reference circuit for an open. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 19*	—
14	Repair the CMP signal circuit for an open. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 19*	—
15	1. Inspect for poor connections at the CMP harness connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 17*
16	1. Inspect the PCM harness connector for poor connections. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 19*	Go to *Step 18*
17	Replace the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 19*	
18	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 19*	
19	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 20*	Go to *Step 2*
20	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0351–P0358

Circuit Description

The ignition system on this engine uses an individual ignition coil for each cylinder. The powertrain control module (PCM) controls the ignition system operation. The PCM controls each coil using one of eight ignition control (IC) circuits. The PCM commands the IC circuit low when a spark event is requested. This causes the IC module to energize the ignition coil to create a spark at the spark plug. Each ignition coil has the following circuits:

- An ignition positive voltage circuit
- A ground circuit
- An ignition control (IC) circuit
- A reference low circuit

Sequencing and timing are PCM controlled. This DTC sets when the IC circuit is out of range.

Conditions for Running the DTC

The engine is operating.

Conditions for Setting the DTC

The PCM detects the ignition control circuit is grounded, open, or shorted to voltage for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. This step verifies the integrity of the IC circuit and the PCM output.
4. This step tests for a short to ground on the ignition control circuit.

DTC P0351–P0358

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as closely as possible to the Freeze Frame/Failure Records. Does the DTC fail this ignition?	—	Go to *Step 3*	Go to *Intermittent Conditions*
3	1. Turn OFF the engine. 2. Disconnect the respective ignition coil electrical connector. Start the engine. 3. Measure the frequency at the ignition control signal circuit using the DMM set to DC Hertz. Refer to Measuring Frequency in Wiring Systems. Is the frequency within the specified range?	3–20 Hz	Go to *Step 7*	Go to *Step 4*
4	Measure the voltage at the ignition control signal circuit using the DMM. Is the voltage more than the specified value?	1 V	Go to *Step 13*	Go to *Step 5*

DTC P0351-P0358 (cont'd)

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. Disconnect the PCM connector. 2. Test the continuity from the ignition control circuit at the ignition coil electrical connector to the PCM connector using the DMM. Refer to *Testing for Continuity* in Wiring Systems. Does the DMM indicate continuity?	—	Go to *Step 6*	Go to *Step 14*
6	Test the respective ignition control circuit for a short to ground. Refer to Testing for Short to Ground in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 15*
7	1. Turn ON the ignition, with the engine OFF. 2. Probe the ignition 1 voltage circuit of the ignition coil with a test lamp connected to battery ground. Refer to *Troubleshooting with a Test Lamp* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 8*	Go to *Step 9*
8	Probe the ground circuit of the ignition coil with a test lamp connected to B+. Refer to *Troubleshooting with a Test Lamp* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 11*	Go to *Step 10*
9	Repair the open in the ignition 1 voltage circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 17*	—
10	Repair the open in the ground circuit for the ignition coil. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 17*	—
11	Inspect for poor connections at the harness connector of the ignition coil. Refer to *Testing for Intermittent and Poor Connections* and to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 12*
12	Replace the ignition coil. Refer to *Ignition Coil(s) Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
13	Repair the ignition control circuit for a short to voltage. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 17*	—
14	Repair the ignition control circuit for an open circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 17*	—
15	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 16*
16	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 17*	
17	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 18*	Go to *Step 2*

DTC P0351-P0358 (cont'd)

Step	Action	Value(s)	Yes	No
18	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

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DTC P0443

Circuit Description

An ignition voltage is supplied directly to the evaporative emission (EVAP) purge valve. The EVAP purge valve is pulse width modulated (PWM). The powertrain control module (PCM) controls the EVAP purge valve ON time by grounding the control circuit via an internal switch called a driver.

The scan tool displays the amount of ON time as a percentage. The PCM monitors the status of the driver. If the PCM detects an incorrect voltage for the commanded state of the driver, DTC P0443 sets.

Conditions for Running the DTC

- The engine speed is more than 400 RPM.
- The system voltage is between 6–18 volts.

Conditions for Setting the DTC

- The PCM detects that the commanded state of the driver and the actual state of the control circuit do not match.
- The above conditions are present for a minimum of 5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step tests if the concern is active. The EVAP purge valve is PWM. Clicking should be heard or felt when the purge valve is commanded to 50 percent and should stop when the EVAP purge valve is commanded to 0 percent. The rate at which the valve cycles should increase as the commanded state is increased and decrease as the commanded state is decreased. Repeat the commands as necessary.
5. This step verifies that the PCM is providing ground to the EVAP purge valve.
6. This step tests if a ground is constantly being applied to the EVAP purge valve.

DTC P0443

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, command the EVAP purge valve to 50 percent and then to 0 percent. Do you hear or feel a clicking from the EVAP purge valve when it is commanded to 50 percent?	Go to *Step 3*	Go to *Step 4*

DTC P0443 (cont'd)

Step	Action	Yes	No
3	1. Review the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	Go to *Step 4*	Go to *Intermittent Conditions*
4	1. Turn OFF the ignition. 2. Disconnect the EVAP purge valve harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Probe the ignition voltage circuit at the EVAP purge valve harness connector with a test lamp connected to a good ground. Does the test lamp illuminate?	Go to *Step 5*	Go to *Step 11*
5	1. Connect a test lamp between the control circuit and the ignition voltage circuit of the EVAP purge valve harness connector. 2. With a scan tool, command the EVAP purge valve to 50 percent and then to 0 percent. Does the test lamp illuminate or pulse when the EVAP purge valve is commanded to 50 percent?	Go to *Step 9*	Go to *Step 6*
6	Does the test lamp remain illuminated with each command?	Go to *Step 8*	Go to *Step 7*
7	Test the control circuit of the EVAP purge valve for an open or short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 10*
8	Test the control circuit of the EVAP purge valve for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 13*
9	Inspect for poor connections at the harness connector of the EVAP purge valve. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 12*
10	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 13*
11	Repair the ignition voltage circuit of the EVAP purge valve for an open or short to ground. Replace the fuse if necessary. Refer to *Troubleshooting with a Test Lamp* and *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 14*	—
12	Replace the EVAP purge valve. Refer to Evaporative Emission (EVAP) Canister Purge Valve Replacement. Did you complete the replacement?	Go to *Step 14*	—
13	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 14*	—
14	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 15*	Go to *Step 2*
15	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0506

Circuit Description

The electronic throttle control (ETC) system uses various inputs from the powertrain control module (PCM) to control idle speed through serial data circuits to the throttle actuator control (TAC) module. The DC motor located on the throttle body actuates the throttle plate. In order to decrease idle speed, the TAC module commands the throttle closed reducing air flow into the engine and the idle speed decreases. In order to increase idle speed, the TAC module commands the throttle plate open allowing more air to bypass the throttle plate. If the actual idle RPM does not match the desired idle RPM within a calibrated time, this DTC will set.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0118, P0125, P0171, P0172, P0174, P0175, P0200, P0300, P0440, P0442, P0443, P0500, P0502, P0503, P1120, P1220, P1221, or P1441 are not set.
- The engine is running for greater than 60 seconds.
- The engine coolant temperature (ECT) is greater than 60°C (140°F).
- The intake air temperature (IAT) is greater than −10°C (14°F).
- The BARO is greater than 65 kPa.
- The system voltage is between 9–18 volts.
- The vehicle speed is less than 1.7 km/h (1 mph).
- The APP indicated angle is 0 percent.

Conditions for Setting the DTC

- The actual idle speed is 100 RPM less than the desired idle speed.
- All of the above conditions are present for 5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Test Description

The number below refers to the step number on the diagnostic table.

2. This test determines whether the engine can achieve the commanded RPM. DTC P0506 Idle Control System Low RPM

DTC P0506

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Set the parking brake and block the drive wheels. 2. Start the engine. 3. Turn OFF all of the accessories. 4. Use the scan tool RPM control function in order to command the engine RPM to 1,500 RPM and then to 500 RPM and back to 1,500 RPM. Exit the RPM control function. Did the engine speed stay within 100 RPM of the commanded RPM during the above test?	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	Go to *Step 4*	Go to *Intermittent Conditions*
4	Inspect for the following conditions: • Excessive deposits in the throttle body. • Objects blocking the air intake system. • Parasitic load on the engine (i.e., transmission problems, etc.). Did you complete the repair?	Go to *Step 5*	—
5	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 6*	Go to *Step 2*
6	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0507

Circuit Description

The electronic throttle control (ETC) system uses various inputs from the powertrain control module (PCM) to control idle speed through serial data circuits to the throttle actuator control (TAC) module. The DC motor located on the throttle body actuates the throttle plate. In order to decrease idle speed, the TAC module commands the throttle closed reducing air flow into the engine and the idle speed decreases. In order to increase idle speed, the TAC module commands the throttle plate open allowing more air to bypass the throttle plate. If the actual idle RPM does not match the desired idle RPM within a calibrated time, this diagnostic trouble code (DTC) will set.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0118, P0125, P0171, P0172, P0174, P0175, P0200, P0300, P0440, P0442, P0443, P0500, P0502, P0503, P1120, P1220, P1221, or P1441 are not set.
- The engine is operating for more than 60 seconds.
- The engine coolant temperature (ECT) is greater than 60°C (140°F).
- The intake air temperature (IAT) is greater than −10°C (14°F).
- The BARO is greater than 65 kPa.
- The system voltage is between 9–18 volts.
- The vehicle speed is less than 1.7 km/h (1 mph).
- The APP indicated angle is 0 percent.

Conditions for Setting the DTC

The actual idle speed is 200 RPM greater than the desired idle speed.

All of the above conditions are present for 5 seconds.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC

- A current DTC "Last Test Failed" clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Test Description

The number below refers to the step number on the diagnostic table.

2. This test determines whether the engine can achieve the commanded RPM.

DTC P0507

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Set the parking brake and block the drive wheels. 2. Start the engine. 3. Turn OFF all of the accessories. 4. Use the scan tool RPM control function in order to command the engine RPM to 1,500 RPM and then to 500 RPM and back to 1,500 RPM. 5. Exit the RPM control function. Did the engine speed stay within 200 RPM of the commanded RPM during the above test?	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset?	Go to *Step 4*	Go to *Intermittent Conditions*
4	Inspect for the following conditions: • Excessive deposits in the throttle body. • A faulty PCV valve • Air leak on intake system • Check wiring and connectors at the PCM, TAC, throttle actuator motor, and TPS. Did you complete the repair?	Go to *Step 5*	—
5	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 6*	Go to *Step 2*
6	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0601, P0602, P0604, or P1683

Circuit Description

This diagnostic applies to internal microprocessor integrity conditions within the control module. This diagnostic also addresses if the control module is not programmed. The following diagnostic trouble codes (DTCs) are diagnosed in this DTC table:

- DTC P0601
- DTC P0602
- DTC P0604
- DTC P0606
- DTC P1683

Diagnostic Aids

For complete details on programming the PCM, refer to Powertrain Control Module (PCM) Programming (On-Board) Powertrain Control Module (PCM) Programming (Off-Board).

Test Description

The number below refers to the step number on the diagnostic table.

2. A DTC P0602 indicates the PCM is not programmed.

DTC P0601, P0602, P0604, or P1683

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P0602 set?	Go to *Step 3*	Go to *Step 5*
3	Program the PCM. Refer to Powertrain Control Module (PCM) Programming (On-Board) Powertrain Control Module (PCM) Programming (Off-Board). Does DTC P0602 reset?	Go to *Step 4*	Go to *Step 6*
4	1. Ensure that all tool connections are secure. 2. Ensure the programming equipment is operating correctly. 3. Ensure the correct software/calibration package is used. Attempt to program the PCM. Refer to Powertrain Control Module (PCM) Programming (On-Board) Powertrain Control Module (PCM) Programming (Off-Board). Does DTC P0602 reset?	Go to *Step 5*	Go to *Step 6*
5	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 6*	—
6	1. Use the scan tool in order to clear DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 7*	Go to *Step 2*
7	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0650

Circuit Description

Ignition voltage is supplied directly to the malfunction indicator lamp (MIL). The powertrain control module (PCM) controls the lamp by grounding the control circuit via an internal switch called a driver. The primary function of the driver is to supply the ground for the component being controlled.

Each driver has a fault line which is monitored by the PCM. When the PCM is commanding a component ON, the voltage of the control circuit should be low, near 0 volts. When the PCM is commanding the control circuit to a component OFF, the voltage potential of the circuit should be high, near battery voltage. If the fault detection circuit senses a voltage other than what is expected, the fault line status will change causing the diagnostic trouble code (DTC) to set.

Conditions for Running the DTC

- The engine speed is more than 400 RPM.
- The ignition voltage is between 6–18 volts.

Conditions for Setting the DTC

- The PCM detects that the commanded state of the driver and the actual state of the control circuit do not match for a minimum of 5 seconds. Action Taken When the DTC Sets
- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic. Use a scan tool in order to clear the DTC.

Diagnostic Aids

- If the ignition feed circuit is suspected of being open, inspect for other lamps on that circuit not illuminating. An open fuse causes the entire cluster to be inoperative. Also, if the fuse is open, transmission DTCs set.
- Using Freeze Frame/Failure Records data may aid in locating an intermittent condition. If the DTC cannot be duplicated, the information included in the Freeze Frame/Failure Records data can be useful in determining how many miles since the DTC set. The Fail Counter and Pass Counter can also be used to determine how many ignition cycles the diagnostic reported a pass or a fail. Operate vehicle within the same Freeze Frame conditions, such as RPM, load, vehicle speed, temperature etc., that were noted. This will isolate when the DTC failed. For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Command both the ON and the OFF states. Repeat the commands as necessary.
8. If you do not find trouble in the control circuit or the connection at the PCM, the PCM may be faulty. However, this is an extremely unlikely failure.

DTC P0650

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Verify whether the instrument panel is operational. If the instrument panel (IP) is completely inoperative, refer to *Diagnostic System Check – Instrument Cluster* in Instrument Panel, Gauges and Console. 2. Verify whether the MIL turns ON and OFF when commanded. 3. Turn ON the ignition, with the engine OFF. 4. Command the MIL ON and OFF using the scan tool. Repeat the commands as necessary. Does the MIL turn ON and OFF when commanded?	Go to *Diagnostic Aids*	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Disconnect the PCM connector C2, located on the opposite side of the manufacturer logo. Refer to *Powertrain Control Module (PCM) Replacement*. 3. Turn ON the ignition. Is the lamp OFF?	Go to *Step 4*	Go to *Step 5*
4	Probe the lamp control circuit in the PCM harness connector with a fused jumper wire connected to ground. Refer to Using Fused Jumper Wires in Wiring Systems. Is the lamp ON?	Go to *Step 6*	Go to *Step 7*
5	Repair the short to ground in the MIL control circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
6	1. Inspect for poor connections at the PCM. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If you find a poor connection, repair the terminal as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 8*
7	Test for the following conditions: • Faulty instrument panel cluster (IPC). Refer to *Diagnostic System Check – Instrument Cluster* in Instrument Panel, Gauges and Console. • MIL battery positive voltage circuit open or shorted to ground. Refer to *Wiring Repairs* in Wiring Systems. • Control circuit open or shorted to B+. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
8	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 9*	—
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1111

Circuit Description

The intake air temperature (IAT) sensor contains a semiconductor device, a thermistor, which changes the resistance based on the temperature. The IAT sensor is located within the mass air flow (MAF) sensor. The IAT sensor has a signal circuit and a ground circuit. The powertrain control module (PCM) applies 5 volts on the signal circuit to the sensor. The PCM monitors the changes in this voltage caused by changes in the resistance of the sensor in order to determine IAT.

When the intake air is cold, the sensor or thermistor resistance is high. The PCM signal voltage only pulls down a small amount through the sensor to a ground. Therefore, the PCM senses a high signal voltage or low temperature. When the intake air is warm, the sensor resistance is low. The signal voltage pulls down a large amount. Therefore, the PCM senses a low signal voltage or a high temperature.

When the PCM senses a signal voltage higher than the normal operating range of the sensor, this diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- DTCs P0102, P0103, P0117, P0118, P0500, P0502, or P0503 are not set.
- The engine run time is more than 100 seconds.
- The engine coolant temperature (ECT) is more than 0°C (32°F).
- The vehicle speed is less than 11 km/h (7 mph).
- The MAF is less than 15 g/s.

Conditions for Setting the DTC

- The intake air temperature is less than −35°C (−31°F).
- The intermittent condition exists for a total of 5.5 seconds during a 100-second time period.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC

- A current DTC "Last Test Failed" clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- If the engine has sat overnight, the engine coolant temperature and intake air temperature values should display within a few degrees of each other. If the temperatures are not within 3°C (5°F), refer to Temperature vs Resistance.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. If DTC P0113 failed this ignition, this indicates a hard failure is present. When a hard failure is present, both the hard and intermittent DTCs set.
3. Inspects for proper connections.
4. Inspects the wiring harness.
5. Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions, such as RPM, load, vehicle speed, temperature etc., that you observed. This will isolate when the DTC failed. For any test that requires probing the PCM or component harness connectors, use the connector test adapter kit. Using this kit prevents any damage to the harness connector terminals.

DTC P1111

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Idle the engine. 3. Monitor the DTC Information option using the scan tool. Did DTC P0113 fail this ignition? Go to DTC P0113	Go to *Step 3*	—
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the affected sensor value on a scan tool while moving the related harness connectors at the component and the PCM. Does the sensor value change abruptly while a related connector is being moved?	Go to *Step 6*	Go to *Step 4*
4	Observe the affected sensor value on a scan tool while moving the related wiring harnesses. Does the sensor value change abruptly while moving the related electrical harnesses?	Go to *Step 7*	Go to *Step 5*
5	1. Turn ON the ignition, with the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in the Conditions for Running the DTC. 6. Select the DTC option, the Specific DTC option, then enter the DTC number using the scan tool. Does the scan tool indicate that this diagnostic failed this ignition?	Go to *Step 8*	Go to *Diagnostic Aids*
6	Repair the damaged connectors and terminals. Refer to *Connector Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
7	Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
8	1. Re-inspect all the related circuits and the connectors. 2. Replace the sensor and component if all of the circuits have been tested thoroughly and no faults can be found. Is the action complete?	Go to *Step 9*	—
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1112

Circuit Description

The intake air temperature (IAT) sensor contains a semiconductor device, a thermistor, which changes the resistance based on the temperature.

The IAT sensor is located within the mass air flow (MAF) sensor.

The IAT sensor has a signal circuit and a ground circuit. The powertrain control module (PCM) applies 5 volts on the signal circuit to the sensor. The PCM monitors the changes in this voltage caused by changes in the resistance of the sensor in order to determine intake air temperature.

When the intake air is cold, the sensor or thermistor resistance is high. The PCM signal voltage only pulls down a small amount through the sensor to a ground. Therefore, the PCM senses a high signal voltage or low temperature. When the intake air is warm, the sensor resistance is low. The signal voltage pulls down a large amount. Therefore, the PCM senses a low signal voltage, or a high temperature.

When the PCM senses a signal voltage lower than the normal operating range of the sensor, this DTC sets.

Conditions for Running the DTC

- DTCs P0102, P0103, P0117, P0118, P0500, P0502, or P0503 are not set.
- The engine coolant temperature (ECT) is less than 135°C (275°F). The engine run time is more than 30 seconds.
- The vehicle speed is more than 40 km/h (25 mph).

Conditions for Setting the DTC

- The intake air temperature (IAT) is more than 139°C (282°F).
- The intermittent condition exists for a total of 5.5 seconds during a 100–second time period.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- If the engine sat overnight, the engine coolant temperature and intake air temperature values should display within a few degrees of each other. If the temperatures are not within 3°C (5°F), refer to Temperature vs Resistance.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. If DTC P0112 failed this ignition, this indicates a hard failure is present. When a hard failure is present, both the hard and intermittent DTCs set. For any test that requires probing the PCM or component harness connectors, use the connector test adapter kit. Using this kit prevents any damage to the harness connector terminals.
3. Inspects for proper connections.
4. Inspects the wiring harness.
5. Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass or a fail. Operate the vehicle within the same Freeze Frame conditions, such as RPM, load, vehicle speed, temperature etc., that you observed. This will isolate when the DTC failed.

DTC P1112

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Idle the engine. 3. Monitor the DTC Information option using the scan tool. Is DTC P0112 also set?	Go to *DTC P0112*	Go to *Step 3*
3	1. Turn ON the ignition, with the engine OFF. 2. Observe the affected sensor value on a scan tool while moving related harness connectors at the component and the PCM. Does the sensor value change abruptly while a related connector is being moved?	Go to *Step 6*	Go to *Step 4*
4	Observe the affected sensor value on a scan tool while moving the related wiring harnesses. Does the sensor value change abruptly while moving the related electrical harnesses?	Go to *Step 7*	Go to *Step 5*
5	1. Turn ON the ignition, with the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in Conditions for Running the DTC. 6. Select the Diagnostic Trouble Code (DTC) option, the Specific DTC option, then enter the DTC number using the scan tool. Does the scan tool indicate that this diagnostic failed this ignition?	Go to *Step 8*	Go to *Diagnostic Aids*
6	Repair the damaged connectors and terminals. Refer to *Connector Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
7	Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 9*	—
8	1. Re-inspect all the related circuits and the connectors. 2. Replace the sensor and component if all of the circuits have been tested thoroughly and no faults can be found. Is the action complete?	Go to *Step 9*	—
9	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 10*	Go to *Step 2*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1114

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor, sometimes called a thermistor, that measures the temperature of the engine coolant. The powertrain control module (PCM) supplies 5 volts to the ECT signal circuit. When the ECT is cold, the sensor resistance is high. When the ECT increases, the sensor resistance lowers. With high sensor resistance, the PCM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the PCM detects a lower voltage on the ECT signal circuit. If the PCM detects an excessively low ECT signal voltage, which is a high temperature indication, this diagnostic trouble code (DTC) will set.

Conditions for Running the DTC

Engine run time is more than 10 seconds.

Conditions for Setting the DTC

The PCM detects an ECT sensor temperature more than 139° C (282° F) and the intermittent condition exists for a total of 1 second during a 20-second period.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- An intermittent short to ground in the ECT sensor signal circuit could result in a DTC P1114. If the low ECT voltage (high temperature) reading is present, additional sensor circuit voltage codes could be set. Refer to any non-intermittent DTCs that are set.
- Use the Temperature vs Resistance Value scale in order to test the coolant sensor at various temperature levels in order to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability complaints. Refer to Temperature vs Resistance.
- If an intermittent condition is suspected, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

5. If there is no driveability complaint associated with DTC and if the DTC does not reset, then the system is OK.

DTC P1114

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition. 3. Start the engine. Does the scan tool indicate that DTC P0117 also failed? Go to DTC P0117	Go to *Step 3*	—
3	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the ECT sensor temperature while moving the sensor connector and the PCM connector. Does the scan tool indicate an abrupt change in value?	Go to *Step 6*	Go to *Step 4*
4	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the ECT sensor temperature while moving the wiring harness at the sensor and the PCM. Does the scan tool indicate an abrupt change in value?	Go to *Step 7*	Go to *Step 5*
5	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset ?	Go to *Diagnostic Aids*	System OK
6	Repair the connector/terminal as necessary. Refer to *Circuit Testing* and *Connector Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 8*	—
7	Repair the harness/wiring as necessary. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 8*	—
8	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 9*	Go to *Step 2*
9	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1115

Circuit Description

The engine coolant temperature (ECT) sensor is a variable resistor, sometimes called a thermistor, that measures the temperature of the engine coolant. The powertrain control module (PCM) supplies 5 volts to the ECT signal circuit. When the ECT is cold, the sensor resistance is high. When the ECT increases, the sensor resistance lowers. With high sensor resistance, the PCM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the PCM detects a lower voltage on the ECT signal circuit.

If the PCM detects an excessively high signal voltage, which is a low temperature indication, this diagnostic trouble code (DTC) will set.

Conditions for Running the DTC

The engine run time is more than 60 seconds.

Conditions for Setting the DTC

- The PCM detects an ECT sensor temperature less than −35° C (−31° F).
- The intermittent condition exists for a total of 1 second during a 20-second time period.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- An intermittent open or short to voltage in the ECT sensor signal circuit could result in a DTC P1115. If the high ECT voltage (low temperature) reading is present, additional sensor circuit voltage codes could be set. Refer to any non-intermittent DTCs that are set.
- Use the Temperature vs Resistance Value scale in order to test the coolant sensor at various temperature levels in order to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability complaints. Refer to Temperature vs Resistance.
- If an intermittent condition is suspected, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

5. If there is no driveability complaint associated with DTC and if the DTC does not reset, then the system is OK.

DTC P1115

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition. Start the engine. Does the scan tool indicate that DTC P0118 also failed? Go to DTC P0118	Go to *Step 3*	—
3	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the ECT sensor temperature while moving the sensor connector and the PCM connector. Does the scan tool indicate an abrupt change in value?	Go to *Step 6*	Go to *Step 4*
4	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the ECT sensor temperature while moving the wiring harness at the sensor and the PCM. Does the scan tool indicate an abrupt change in value?	Go to *Step 7*	Go to *Step 5*
5	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC reset ?	Go to *Diagnostic Aids*	System OK
6	Repair the connector/terminal as necessary. Refer to *Circuit Testing* and *Connector Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 8*	—
7	Repair the harness/wiring as necessary. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 8*	—
8	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC reset?	Go to *Step 9*	Go to *Step 2*
9	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1120

Circuit Description

The throttle position (TP) sensor is mounted on the throttle body assembly. The sensor is actually 2 individual TP sensors within one housing.

Two separate signal, low reference and 5-volt reference circuits are used to connect the TP sensor assembly to the throttle actuator control (TAC) module. The 2 sensors have opposite functionality. The TP sensor 1 signal voltage is pulled up to reference voltage as the throttle opens, from below 1 volt at closed throttle to above 3.5 volts at wide open throttle (WOT). The TP sensor 2 signal voltage is pulled down to low reference from around 3.8 volts at closed throttle to below 1 volt at WOT. TP sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module.

If an out of range condition is detected with the TP sensor 1, this diagnostic trouble code (DTC) will set and the Reduced Engine Power message will be displayed.

Conditions for Running the DTC

- DTCs P1517 and P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage greater than 5.23 volts.

Conditions for Setting the DTC

- TP sensor 1 signal voltage is less than 0.13 volts or greater than 4.87 volts.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine
- Power modes:
- The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

OR

- The APP indicated angle is limited to 0 percent.
- The control module only allows the engine to idle.

OR

- Under certain conditions the control module commands the engine OFF.
- The message center displays Reduced Engine Power.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- If this DTC is determined to be intermittent, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

32. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1120

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*

DTC P1120 (cont'd)

Step	Action	Value(s)	Yes	No
2	Is DTC P1515, P1516, or P1518 also set?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Remove the air inlet duct from the throttle body assembly. 3. Disconnect the throttle actuator motor harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Close the throttle blade completely by hand while observing the TP sensor 1 voltage on the scan tool. Does the scan tool indicate TP sensor 1 voltage within the specified values?	0.13–0.67 V	Go to *Step 4*	Go to *Step 8*
4	Open the throttle blade to wide open throttle (WOT) by hand while observing the TP sensor 1 voltage parameter on the scan tool. Does the scan tool indicate TP sensor 1 voltage within the specified values?	4.09–4.87 V	Go to *Step 5*	Go to *Step 8*
5	1. Disconnect the TP sensor harness connector. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Use a DMM in order to test the TP sensor low reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 6*
6	1. Turn OFF the ignition for 15 seconds. Reconnect the TAC module harness connector. 2. Reconnect the throttle actuator motor harness connector. Reinstall the air inlet duct. 3. Turn ON the ignition, with the engine OFF. 4. Select the DTC Info. option on the scan tool. 5. Lightly touch and move the related engine wiring harnesses and connectors for the TP sensor while observing the DTC Info. The DTC will set if an intermittent condition is present. Refer to *Connector Repairs* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 7*
7	1. Continue to observe DTC Info. 2. Slowly depress the accelerator pedal to WOT and then slowly return it to the released position 3 times. Does the scan tool indicate this DTC failed this ignition?	—	Go to *Step 26*	Go to *Diagnostic Aids*
8	1. Disconnect the TP sensor harness connector. 2. Measure voltage at the TP sensor 1 signal circuit with a DMM connected to ground. Does the DMM indicate voltage within the specified values?	3.94–6.06 V	Go to *Step 13*	Go to *Step 9*
9	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the TP sensor 1 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 10*

DTC P1120 (cont'd)

Step	Action	Value(s)	Yes	No
10	Use a DMM in order to test the TP sensor 1 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 11*
11	Use a DMM in order to test the TP sensor 1 signal circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 12*
12	1. Disconnect the other TAC module harness connector. 2. Use a DMM in order to test for a short between the TP sensor 1 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 27*
13	Use a DMM in order to test the TP sensor 1, 5-volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	3.94–6.06 V	Go to *Step 23*	Go to *Step 14*
14	Does the DMM indicate voltage greater than the specified value?	6.06 V	Go to *Step 15*	Go to *Step 17*
15	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the TP sensor 1, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 16*
16	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. Disconnect the other TAC module harness connector. Turn ON the ignition, with the engine OFF. 3. Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 21*
17	Disconnect the APP sensor. Does the DMM indicate voltage less than the specified value?	3.94 V	Go to *Step 18*	Go to *Step 29*
18	1. Disconnect the TAC module harness connector containing the TP sensor circuits. 2. Use a DMM in order to test the TP sensor 1, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 19*
19	Use a DMM in order to test the TP sensor 1, 5-volt reference circuit for a short to ground. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 20*
20	Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 21*

DTC P1120 (cont'd)

Step	Action	Value(s)	Yes	No
21	Use a DMM in order to test for a short between the TP sensor 1, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 22*
22	Use a DMM in order to test for a short between the APP sensor 1, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 27*
23	1. Connect a fused jumper between the TP sensor 1 low reference circuit and the TP sensor 1 signal circuit. 2. Use a scan tool in order to observe the TP sensor 1 voltage parameter. Does the scan tool indicate voltage near the specified value?	0 V	Go to *Step 25*	Go to *Step 24*
24	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Use a DMM in order to test the TP sensor 1 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 27*
25	Inspect for poor connections at the TP sensor harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 28*
26	Inspect for poor connections at the APP module harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 29*
27	Inspect for a poor connection at the TAC module harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 31*	Go to *Step 30*
28	Replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Did you complete the replacement?	—	Go to *Step 31*	—
29	Replace the APP sensor. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 31*	—
30	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 31*	—
31	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 32*	Go to *Step 2*
32	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1125

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually three individual APP sensors within one housing. Three separate signal, low reference, and 5-volt reference circuits are used in order to connect the accelerator pedal sensor assembly and the throttle actuator control (TAC) module. If only one APP sensor DTC is set, the redundant APP systems allow the TAC system to continue operating normally. This DTC sets if the PCM detects a condition with more than one APP sensor. One APP sensor DTC will not cause the Reduced Engine Power message to be displayed. Two APP sensor DTCs for the same sensor also will not cause the Reduced Engine Power message to be displayed. However, if two or more DTCs are set involving more than one APP sensor, this DTC will set and the Reduced Engine Power message is displayed.

Conditions for Running the DTC

- DTCs P1517 and P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- Two or more APP sensors are out of range or all three APP sensors disagree, or one APP sensor is out of range and the other two APP sensors disagree.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- The APP sensor 1 and the TP sensor 1 5-volt reference circuits are internally connected within the TAC module. The APP sensor 2 and the TP sensor 2 5-volt reference circuits are internally connected within the TAC module.
- When the TAC module detects a condition within the TAC system more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC Info.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

2. When the problems are corrected which are causing the APP sensor DTCs to set, the status of this DTC will change to History.

DTC P1125

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	This DTC indicates that two or more APP sensor DTCs are also set. Go to the APP sensor DTCs that are set and perform those diagnostic tests.	Go to *Diagnostic Trouble Code (DTC) List*	—

DTC P1220

Circuit Description

The throttle position (TP) sensor is mounted on the throttle body assembly. The sensor is actually two individual TP sensors within one housing. Two separate signal, low reference and 5-volt reference circuits are used to connect the TP sensor assembly to the throttle actuator control (TAC) module. The 2 sensors have opposite functionality. The TP sensor 1 signal voltage is pulled up to reference voltage as the throttle opens, from below 1.0 volt at closed throttle to above 3.5 volts at wide open throttle (WOT). The TP sensor 2 signal voltage is pulled down to low reference from around 3.8 volts at closed throttle to below 1.0 volt at WOT. TP sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module. If an out of range condition is detected with the TP sensor 2, this diagnostic trouble code (DTC) will set and the Reduced Engine Power message will be displayed.

Conditions for Running the DTC

- DTCs P1517 and P1518 are not set.
- The ignition switch in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- The TP sensor 2 voltage is less than 0.13 volts or greater than 4.87 volts.
- All above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent.
  - The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine
  - OFF.
- The message center displays Reduced Engine Power.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion. When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- If this DTC is determined to be intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

12. Using a test lamp reduces the amount of current fed into the signal circuit. The scan tool should display the maximum value for this parameter (5 volts) even though the actual voltage is higher.
18. The TP 2 sensor and the APP 2 sensor share a common 5 volt reference. The 5-volt reference circuits are connected internally within the TAC module. Disconnecting the TAC module will isolate the 5-volt reference circuits.
19. The TP sensor 2 and the APP sensor 2 share a common 5-volt reference. A short to voltage on the APP sensor 2, 5-volt reference circuit will affect the TP sensor 2, 5-volt reference circuit.
34. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1220

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P1515, P1516, or P1518 also set?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	1. Turn OFF the ignition. 2. Remove the air inlet duct from the throttle body assembly. 3. Disconnect the throttle actuator motor harness connector. 4. Turn ON the ignition, with the engine OFF. 5. Close the throttle blade completely by hand while observing the TP sensor 2 voltage parameter on the scan tool. Does the scan tool indicate TP sensor 2 voltage within the specified values?	4.3-4.8 V	Go to *Step 4*	Go to *Step 7*
4	Open the throttle blade to wide open throttle (WOT) by hand while observing the TP sensor 2 voltage parameter on the scan tool. Does the scan tool indicate TP sensor 2 voltage within the specified values?	0.13-1 V	Go to *Step 5*	Go to *Step 7*
5	1. Turn OFF the ignition for 15 seconds. 2. Reconnect the throttle actuator motor harness connector. Reinstall the air inlet duct. 3. Turn ON the ignition, with the engine OFF. 4. Select the DTC Info. option on the scan tool. 5. Lightly touch and move the related engine wiring harnesses and connectors for the TP sensor while observing the DTC Info. The DTC will set if an intermittent condition is present. Refer to *Testing for Intermittent and Poor Connections* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 6*
6	1. Continue to observe the DTC Info. 2. Slowly depress the accelerator pedal to WOT and then slowly return it to the released position 3 times. Does the scan tool indicate this DTC failed this ignition?	—	Go to *Step 26*	Go to *Diagnostic Aids*
7	Use a scan tool, in order to observe the TP sensor 2 voltage parameter. Does the scan tool indicate TP sensor 2 voltage at the specified value?	5 V	Go to *Step 8*	Go to *Step 12*
8	Disconnect the TP sensor harness connector. Does the scan tool indicate TP sensor 2 voltage at the specified value?	0 V	Go to *Step 9*	Go to *Step 13*
9	1. Disconnect the APP sensor harness connector. 2. Turn ON the ignition, with the engine OFF. 3. Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for voltage. Does the DMM indicate voltage near the specified value?	5 V	Go to *Step 10*	Go to *Step 18*

DTC P1220 (cont'd)

Step	Action	Value(s)	Yes	No
10	With a DMM connected between the TP sensor 1 low reference circuit and the TP sensor 2 low reference circuit at the TP sensor harness connector, test for resistance. Does the DMM indicate resistance within the specified values?	0-5 ohm	Go to *Step 14*	Go to *Step 11*
11	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Use a DMM in order to test the TP sensor 2 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 30*
12	1. Disconnect the TP sensor harness connector. 2. Connect a test lamp between the TP sensor 2 signal circuit and battery positive voltage. Does the scan tool indicate TP sensor 2 voltage near the specified value?	5 V	Go to *Step 20*	Go to *Step 15*
13	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Turn ON the ignition. 4. Use a DMM in order to test the TP sensor 2 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 17*
14	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 2 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 24*
15	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Use a DMM in order to test the TP sensor 2 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 16*
16	Use a DMM in order to test the TP sensor 2 signal circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 17*
17	Use a DMM in order to test for a short between the TP sensor 2 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 30*

DTC P1220 (cont'd)

Step	Action	Value(s)	Yes	No
18	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 19*
19	1. Turn OFF the ignition. 2. Disconnect the other TAC module harness connector. Turn ON the ignition, with the engine OFF. 3. Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 24*
20	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the TP sensor circuits. 3. Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 21*
21	Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 22*
22	1. Disconnect the APP sensor harness connector. Disconnect the other TAC module harness connector. Turn ON the ignition, with the engine OFF. 2. Use a DMM in order to test the APP sensor 2 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 23*
23	Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 24*
24	Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 25*
25	Use a DMM in order to test for a short between the TP sensor 2, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 26*
26	Use a DMM in order to test for a short between the APP sensor 2, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 27*

DTC P1220 (cont'd)

Step	Action	Value(s)	Yes	No
27	Use a DMM in order to test the TP sensor 2 signal circuit for high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 28*
28	Use a DMM in order to test the TP sensor 2 low reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 29*
29	Inspect for poor connections at the TP sensor harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 31*
30	Inspect for poor connections at the TAC module harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 33*	Go to *Step 32*
31	Replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Did you complete the replacement?	—	Go to *Step 33*	—
32	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 33*	—
33	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 33*	Go to *Step 2*
34	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1221

Circuit Description

The throttle position (TP) sensor is mounted on the throttle body assembly. The sensor is actually two individual TP sensors within one housing. Two separate signal, low reference and 5-volt reference circuits are used to connect the TP sensor assembly to the throttle actuator control (TAC) module. The 2 sensors have opposite functionality. The TP sensor 1 signal voltage is pulled up to reference voltage as the throttle opens, from below 1 volt at closed throttle to above 3.5 volts at wide open throttle (WOT). The TP sensor 2 signal voltage is pulled down to low reference from around 3.8 volts at closed throttle to below 1 volt at WOT. TP sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module. If an out of range condition is detected with the TP sensors, this diagnostic trouble code (DTC) will set and the Reduced Engine Power message will be displayed.

Conditions for Running the DTC

- DTCs P1517 and P1518 not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- TP sensor 2 disagrees with TP sensor 1 by more than 7.5 percent.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
- The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

OR

- The APP indicated angle is limited to 0 percent.
- The control module only allows the engine to idle.

OR

- Under certain conditions the control module commands the engine
- OFF.
- The message center displays Reduced Engine Power.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- If this DTC is determined to be intermittent, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

21. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1221

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check – Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P1515, P1516, or P1518 also set? Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*	
3	1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the TP sensor 1 and 2 Agree/Disagree parameter. Does the scan tool TP sensor 1 and 2 Agree/Disagree parameter indicate Disagree?	Go to *Step 5*	Go to *Step 4*
4	1. Remove the air inlet duct from the throttle body. 2. Disconnect the throttle actuator motor harness connector. 3. Slowly open the throttle blade to WOT and back to the closed throttle position several times by hand while observing the scan tool TP sensor Agree/Disagree parameter. Does the TP sensor Agree/Disagree parameter change from Agree to Disagree during the above test?Go to *Step 18*	Go to *Step 5*	
5	1. Disconnect the TP sensor harness connector. 2. Disconnect the TAC module harness connectors 3. Test the TP sensor 1, 5-volt reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 6*
6	Use a DMM in order to test for a short between the TP sensor 1, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 7*
7	Use a DMM in order to test the TP sensor 1 signal circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 8*
8	Use a DMM in order to test for a short between the TP sensor 1 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 9*
9	Use a DMM in order to test the TP sensor 1 low reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 10*
10	Use a DMM in order to test for a short between the TP sensor 1 low reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 11*
11	Use a DMM in order to test the TP sensor 2, 5-volt reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 12*

DTC P1221 (cont'd)

Step	Action	Yes	No
12	Use a DMM in order to test for a short between the TP sensor 2, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 13*
13	Use a DMM in order to test the TP sensor 2 signal circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 14*
14	Use a DMM in order to test for a short between the TP sensor 2 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 15*
15	Use a DMM in order to test the TP sensor 2 low reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 16*
16	Use a DMM in order to test for a short between the TP sensor 2 low reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 17*
17	Inspect for poor connections at the harness connector of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 18*
18	Inspect for poor connections at the harness connector of the TP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 20*	Go to *Step 19*
19	Replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Did you complete the replacement?	Go to *Step 20*	—
20	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 21*	Go to *Step 2*
21	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1275

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within one housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly to the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal is pulled up to reference voltage as the accelerator pedal is depressed, from below 1.0 volt at 0 percent pedal travel (pedal at rest) to above 2.0 volts at 100 percent pedal travel (pedal fully depressed). The APP sensor 2 signal is pulled down to low reference from above 4.0 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal is pulled down to low reference from above 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel. Throttle position (TP) sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module. If only one APP sensor DTC is set, the redundant APP systems allow the TAC system to continue operating normally. One APP sensor DTC will not cause the Reduced Engine Power message to be displayed. Two APP sensor diagnostic trouble codes (DTCs) for the same sensor also will not cause the Reduced Engine Power message to be displayed. If an out of range condition is detected with this APP sensor, this DTC will be set.

Conditions for Running the DTC

- DTCs P0601, P0602, P0606, P1517, and P1518 are not set. The ignition switch is in the crank or run position. The ignition voltage is greater than 5.23 volts. Conditions for Setting the DTC
- The APP sensor 1 voltage ranges between 0.25-4.22 volts.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  - The control module will not command Reduced Engine Power mode. The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  - The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  - The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1275 set, a DTC P1276 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

12. This test isolates whether the short is to another TAC system circuit in the harness or within the TAC module.
26. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many

redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1275

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If DTC P1518 or P1120 is also set, refer to the appropriate DTC for further diagnosis. 1. Turn ON the ignition, with the engine OFF and your foot off the accelerator pedal. 2. Use a scan tool in order to observe the APP sensor 1 voltage. Does the scan tool indicate APP sensor 1 voltage within the specified values?	0.25-2.24 V	Go to *Step 3*	Go to *Step 6*
3	Depress the accelerator pedal to the WOT position. Does the scan tool indicate APP sensor 1 voltage within the specified values?	2.24-4.23 V	Go to *Step 4*	Go to *Step 6*
4	1. Turn OFF the ignition for 30 seconds. 2. Turn ON the ignition, with the engine OFF 3. Select the DTC option using the scan tool. 4. Lightly touch and move the related engine wiring harnesses and connectors while monitoring the DTC Information. Did this DTC fail this ignition, during the above test ?	—	Go to *Step 24*	Go to *Step 5*
5	1. Continue to observe the DTC Information. 2. Depress the accelerator pedal to WOT and then return it to the released position. Did this DTC fail this ignition, during the above test ?	—	Go to *Step 19*	Go to *Diagnostic Aids*
6	Disconnect the APP sensor harness connector. Does the scan tool indicate APP sensor 1 voltage at the specified value?	0 V	Go to *Step 7*	Go to *Step 11*
7	Connect a test lamp between the APP sensor 1 signal circuit and B+. Does the scan tool indicate APP sensor 1 voltage at the specified value?	5 V	Go to *Step 8*	Go to *Step 13*
8	Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	4.6-5.4 V	Go to *Step 10*	Go to *Step 9*
9	1. Turn OFF the ignition. 2. Disconnect the throttle actuator motor harness connector. 3. Remove the air inlet duct from the throttle body assembly. 4. Turn ON the ignition. 5. Rotate the throttle blade by hand to WOT and hold. 6. Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	4.6-5.4 V	Go to *Step 21*	Go to *Step 16*

DTC P1275 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Connect a fused jumper between the APP sensor 1 low reference circuit and the APP sensor 1, 5-volt reference circuit. 2. Use a scan tool in order to observe the TP sensor 1 voltage parameter. Does the scan tool indicate TP sensor 1 voltage at the specified value?	0 V	Go to *Step 19*	Go to *Step 17*
11	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 1 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 12*
12	1. Turn OFF the ignition. 2. Disconnect the other TAC module harness connector. 3. Use a DMM in order to test for a short between the APP sensor 1 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*
13	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 1 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 14*
14	Use a DMM in order to test the APP sensor 1 signal circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 15*
15	1. Turn OFF the ignition. 2. Disconnect the other TAC module harness connector. 3. Use a DMM in order to test for a short between the APP sensor 1 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*
16	1. Turn OFF the ignition. 2. Disconnect the TAC module connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*

DTC P1275 (cont'd)

Step	Action	Value(s)	Yes	No
17	1. Disconnect the TAC module connector containing the APP sensor circuits. 2. Use a DMM in order to test the APP sensor 1 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 18*
18	Use a DMM in order to test the TAC module ground circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*
19	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 20*
20	Replace the APP sensor assembly. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the repair?	—	Go to *Step 25*	—
21	Did DTC P1120 set while performing *step 9*?	—	Go to *DTC P1120*	Go to *Step 22*
22	Inspect for poor connections at the harness connector of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
23	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 25*	—
24	Repair the intermittent condition as necessary. Refer to *Connector Repairs* and *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 25*	—
25	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 26*	Go to *Step 2*
26	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1276

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within one housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly to the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal is pulled up to reference voltage as the accelerator pedal is depressed, from below 1 volt at 0 percent pedal travel, with the pedal at rest, to above 2 volts at 100 percent pedal travel, with the pedal fully depressed. The APP sensor 2 signal is pulled down to low reference from above 4 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal is pulled down to low reference from above 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel. throttle position (TP) sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module. If only one APP sensor diagnostic trouble code (DTC) is set, the redundant APP systems allow the TAC system to continue operating normally. One APP sensor DTC will not cause the Reduced Engine Power message to be displayed. Two APP sensor DTCs for the same sensor also will not cause the Reduced Engine Power message to be displayed. If an out of range condition is detected with the APP sensors, this DTC will be set.

Conditions for Running the DTC

- DTCs P0606, P1517, or P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- APP sensor 1 disagrees with APP sensor 2 by more than 10.5 percent and APP sensor 1 disagrees with APP sensor 3 by more than 13.0 percent.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  – The control module will not command Reduced Engine Power mode.
  – The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  – The control module commands Reduced Engine Power mode.
  – The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  – The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  – The control module commands Reduced Engine Power mode.
  – The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  – The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1275 set, a DTC P1276 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step determines if a communication condition exists.
5. This step isolates an internal APP sensor failure. The condition may only occur at a certain accelerator pedal position. Monitoring the APP angles for sensor 2 and sensor 3 is an accurate way of verifying the actual position of the pedal. The APP angles for all 3 sensors should be within a few percent of each other. When the pedal is at rest the APP angle for all 3 sensors should be 0 percent, when the pedal is fully depressed all APP angles should be 100 percent.
6. The APP sensor 1 shares a common 5 volt reference circuit with the TP sensor 1. Monitoring the TP sensor 1 voltage aids in diagnosing the APP sensor 5-volt reference and low reference circuits. If the scan tool displays near 0 volts, the circuits are OK.
9. With the TAC module still connected, this test will help determine a short to the signal circuit either within the TAC module or wiring.
10. This step determines whether the TAC module or a shorted circuit is causing the condition.
19. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1276

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P1518 also set?	—	Go to *DTC P1518*	Go to *Step 3*
3	**Important:** Do not depress the accelerator pedal. 1. Start the engine. 2. Use a scan tool in order to observe the DTC Information. Did any other TAC module or APP sensor DTC set except P1125?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 4*
4	Use a scan tool in order to observe the APP sensor Agree/Disagree parameters. Does the scan tool indicate Disagree for any of the APP Agree/Disagree parameters?	—	Go to *Step 6*	Go to *Step 5*
5	1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the APP sensor angles for all 3 APP sensors. 3. Slowly depress the accelerator pedal, stopping at 25, 50, 75, and 100 percent. 4. Slowly release the accelerator pedal, stopping at 75, 50, 25, and 0 percent. Does the scan tool indicate APP sensor 1 angle within 10.5 percent of the APP sensor 2 angle and APP sensor 1 angle within 13 percent of the APP sensor 3 angle during the above test?	—	Go to *Diagnostic Aids*	Go to *Step 6*
6	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Connect a fused jumper between the APP sensor 1, 5-volt reference circuit and ground. 4. Turn ON the ignition, with the engine OFF. 5. Use a scan tool in order to observe the TP sensor 1 voltage parameter. Does the scan tool indicate TP sensor 1 voltage at the specified value?	0.0 V	Go to *Step 7*	Go to *Step 11*

DTC P1276 (cont'd)

Step	Action	Value(s)	Yes	No
7	Connect a fused jumper between the APP sensor 1, 5 volt reference circuit and the APP sensor 1 low reference circuit. Use a scan tool in order to observe the TP sensor 1 voltage parameter. Does the scan tool indicate TP sensor 1 voltage at specified value?	0.0 V	Go to *Step 8*	Go to *Step 12*
8	1. Connect a fused jumper between the APP sensor 1 signal circuit and the APP sensor 1, 5 volt reference circuit. 2. Use a scan tool in order to observe the APP sensor 1 voltage parameter. Does the scan tool indicate APP sensor 1 voltage near the specified value?	5.0 V	Go to *Step 14*	Go to *Step 9*
9	Use a DMM in order to test for a short between the APP sensor 1 signal circuit and all other APP circuits at the APP sensor harness connector. Does the DMM indicate a short to another circuit?	—	Go to *Step 10*	Go to *Step 13*
10	1. Turn OFF the ignition. 2. Disconnect both of the TAC module harness connectors. 3. Use a DMM in order to test for a short between the APP sensor 1 signal circuit and all other APP circuits at the APP sensor harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 18*	Go to *Step 15*
11	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP circuits. 3. Use a DMM in order to test the APP sensor 1, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 18*	Go to *Step 15*
12	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP circuits. 3. Use a DMM in order to test the APP sensor 1 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 18*	Go to *Step 15*
13	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP circuits. 3. Use a DMM in order to test the APP sensor 1 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find an open or high resistance?	—	Go to *Step 18*	Go to *Step 15*
14	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 18*	Go to *Step 16*

DTC P1276 (cont'd)

Step	Action	Value(s)	Yes	No
15	Inspect for poor connections at the harness connectors of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 18*	Go to *Step 17*
16	Replace the APP sensor assembly. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 18*	—
17	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 18*	—
18	1. Use the scan tool in order to clear the DTCs. Turn OFF the ignition for 30 seconds. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 19*	Go to *Step 2*
19	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1280

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within 1 housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly to the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal is pulled up to reference voltage as the accelerator pedal is depressed, from below 1 volt at 0 percent pedal travel, with the pedal at rest, to above 2 volts at 100 percent pedal travel, with the pedal fully depressed. The APP sensor 2 signal is pulled down to low reference from above 4 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal is pulled down to low reference from above 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel. Throttle position (TP) sensor 1 and APP sensor 1 share a 5-volt reference circuit that are connected within the TAC module.

TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that are connected within the TAC module. If only one APP sensor diagnostic trouble code (DTC) is set, the redundant APP systems allow the TAC system to continue operating normally. One APP sensor DTC will not cause the Reduced Engine Power message to be displayed. Two APP sensor DTCs for the same sensor also will not cause the Reduced Engine Power message to be displayed. If an out of range condition is detected with this APP sensor, this DTC will be set.

Conditions for Running the DTC

- DTCs P0601, P0602, P0606, P1517, or P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- The APP sensor 2 voltage is less than 0.83 volts or greater than 4.81 volts.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  - The control module will not command Reduced Engine Power mode.
  - The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  - The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  - The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1280 set, a DTC P1281 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. TP sensor 2 and the APP sensor 2 share a common 5-volt reference source. Diagnose DTC P1220 first if it is also set.
18. This test determines whether or not the TAC module can recognize a change in signal voltage.
19. There are 3 separate 5-volt reference sources within the TAC module. TP sensor 1 and APP sensor 1 share one 5-volt reference source, TP sensor 2 and APP sensor 2 share another common 5-volt reference source. APP sensor 3 uses the third reference source by itself. This test determines whether the signal circuit is shorted to any one of the 5-volt reference circuits. If a short exists, the corresponding sensor voltage will be pulled low.
20. The previous step found the signal circuit and a 5-volt reference circuit shorted together. This test isolates whether the short is in the harness or within the TAC module.
26. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1280

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If DTC P1518 or P1220 is also set, refer to Diagnostic Trouble Code (DTC) List and diagnose the applicable DTC first. 1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the APP sensor 2 voltage parameter. Does the scan tool indicate APP sensor 2 voltage within the specified values	3.90-4.81 V	Go to *Step 3*	Go to *Step 6*
3	Fully depress the accelerator pedal to the wide open throttle (WOT) position. Does the scan tool indicate APP sensor 2 voltage within the specified values?	0.83-2.9 V	Go to *Step 4*	Go to *Step 6*
4	1. Turn OFF the ignition for 15 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Use a scan tool in order to observe DTC info. 4. Lightly touch and move the related engine wiring harnesses and connectors for the APP sensor while observing the DTC status. 5. If the scan tool indicates this DTC failed this ignition during the above test, repair the intermittent condition as necessary. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 5*
5	Slowly depress the accelerator pedal to wide open throttle (WOT) and then slowly return it to closed throttle while observing the DTC status. Did the scan tool indicator this DTC failed this ignition during the above test?	—	Go to *Step 21*	Go to *Diagnostic Aids*
6	1. Disconnect the APP Sensor harness connector. 2. Use a DMM in order to test the APP sensor 2 signal circuit for voltage. Does the DMM indicate APP sensor 2 signal voltage within the specified values?	3.94-6.06 V	Go to *Step 11*	Go to *Step 7*

DTC P1280 (cont'd)

Step	Action	Value(s)	Yes	No
7	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 2 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 8*
8	Use a DMM in order to test the APP sensor 2 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 9*
9	Use a DMM in order to test the APP sensor 2 signal circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 10*
10	Use a DMM in order to test for a short between the APP sensor 2 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
11	Use a DMM in order to test the APP sensor 2, 5 volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	3.94-6.06 V	Go to *Step 16*	Go to *Step 12*
12	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 13*
13	Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 14*
14	Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 15*
15	Use a DMM in order to test for a short between the APP sensor 2, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
16	With a DMM connected between the APP sensor 2 low reference circuit and the APP sensor 1 low reference circuit, measure the resistance. Does the DMM indicate resistance within the specified value?	0-5ohm	Go to *Step 18*	Go to *Step 17*

DTC P1280 (cont'd)

Step	Action	Value(s)	Yes	No
17	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 2 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
18	Connect a fused jumper between the APP sensor 2 signal circuit and the APP sensor 2 low reference circuit at the APP sensor harness connector. Use a scan tool in order to observe the APP sensor 2 voltage parameter Does the scan tool indicate APP sensor 2 voltage at the specified value?	0 V	Go to *Step 19*	Go to *Step 23*
19	1. Use a scan tool in order to observe the APP sensor 1, APP sensor 3and TP sensor 2 voltage parameters. 2. Connect a fused jumper between the APP sensor 2 signal circuit and the APP sensor 2 low reference circuit at the APP sensor harness connector. Did the scan tool indicate a change in voltage in any of the parameters observed during the above test?	—	Go to *Step 20*	Go to *Step 21*
20	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connectors. 3. Use a DMM in order to test for a short between the APP sensor 2 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
21	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*
22	Replace the APP sensor assembly. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 25*	—
23	Inspect for poor connections at the harness connector of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 24*
24	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement.* Did you complete the replacement?	—	Go to *Step 25*	—
25	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 26*	Go to *Step 2*
26	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1281

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within one housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly to the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal is pulled up to reference voltage as the accelerator pedal is depressed, from below 1.0 volt at 0 percent pedal travel, with the pedal at rest to above 2 volts at 100 percent pedal travel, with the pedal fully depressed). The APP sensor 2 signal is pulled down to low reference from above 4 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal is pulled down to low reference from above 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel. Throttle position (TP) sensor 1 and APP sensor 1 share a 5-volt reference circuit that is connected within the TAC module. TP sensor 2 and APP sensor 2 share a 5-volt reference circuit that is connected within the TAC module. If only 1 APP sensor DTC is set, the redundant APP systems allow the TAC system to continue operating normally. One APP sensor diagnostic trouble code (DTC) will not cause the Reduced Engine Power message to be displayed. Two APP sensor DTCs for the same sensor also will not cause the Reduced Engine Power message to be displayed. If an out of range condition is detected with this APP sensor, this DTC will be set.

Conditions for Running the DTC

- DTCs P0606, P1517, or P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- APP sensor 2 disagrees with APP sensor 1 by more than 10.5 percent and APP sensor 2 disagrees with APP sensor 3 by more than 13.0 percent.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  – The control module will not command Reduced Engine Power mode.
  – The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  – The control module commands Reduced Engine Power mode.
  – The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  – The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  – The control module commands Reduced Engine Power mode.
  – The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  – The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1280 set, a DTC P1281 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the steps numbers on the diagnostic table.

2. This step determines if a communication condition exists.
5. This step isolates an internal APP sensor failure. The condition may only occur at a certain accelerator pedal position. Monitoring the APP angles for sensor 1 and sensor 3 is an accurate way of verifying the actual position of the pedal.
6. The APP sensor 2 shares a common 5-volt reference circuit with the TP sensor 2. Monitoring the TP sensor 2 voltage aids in diagnosing the APP sensor 5-volt reference and low reference circuits. If the scan tool displays near 0 volts, the circuits are OK.
18. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1281

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P1518 also set?	—	Go to *DTC P1518*	Go to *Step 3*
3	**Important:** Do not depress the accelerator pedal. 1. Start the engine. 2. Use a scan tool in order to observe DTC info. Did any other TAC module or APP sensor DTCs set except P1125?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 4*
4	Use a scan tool in order to observe the APP sensor Agree/Disagree parameters. Does the scan tool indicate Disagree for any of the APP sensors Agree/Disagree parameters?	—	Go to *Step 6*	Go to *Step 5*
5	1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the APP sensor angles for all 3 APP sensors. 3. Slowly depress the accelerator pedal, stopping at 25, 50, 75, and 100 percent. 4. Slowly release the accelerator pedal, stopping at 75, 50, 25, and 0 percent. Does the scan tool indicate APP sensor 2 angle within 10.5 percent of the APP sensor 1 angle and APP sensor 2 angle within 13 percent of the APP sensor 3 angle during the above test?	—	Go to *Diagnostic Aids*	Go to *Step 6*
6	1. Turn OFF the ignition. 2. Disconnect the APP sensor harness connector. 3. Connect a fused jumper between the APP sensor 2, 5-volt reference circuit and ground. 4. Turn ON the ignition, with the engine OFF. 5. Use a scan tool in order to observe the TP sensor 2 voltage parameter. Does the scan tool indicate TP sensor 2 voltage at the specified value?	0 V	Go to *Step 7*	Go to *Step 12*
7	Connect a fused jumper between the APP sensor 2, 5-volt reference circuit and the APP sensor 2 low reference circuit. Use a scan tool in order to observe the TP sensor 2 voltage parameter. Does the scan tool indicate TP sensor 2 voltage at specified value?	0 V	Go to *Step 8*	Go to *Step 11*

DTC P1281 (cont'd)

Step	Action	Value(s)	Yes	No
8	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP circuits. 3. Use a DMM in order to test the APP sensor 2 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 9*
9	1. Turn OFF the ignition. 2. Use a DMM in order to test for a short between the APP sensor 2 signal circuit and all other APP circuits at the APP sensor harness connector. Does the DMM indicate a short to another circuit?	—	Go to *Step 10*	Go to *Step 13*
10	1. Disconnect the TAC module harness connector containing the APP sensor circuits. 2. Use a DMM in order to test for a short between the APP sensor 2 signal circuit and all other APP circuits at the APP sensor harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 13*
11	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP circuits. 3. Use a DMM in order to test the APP sensor 2, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 12*
12	Use a DMM in order to test the APP sensor 2 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
13	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 15*
14	Inspect for poor connections at the harness connectors of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 16*
15	Replace the accelerator pedal assembly. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 17*	—
16	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
17	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 18*	Go to *Step 2*
18	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1285

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within one housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly and the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal increases as the accelerator pedal is depressed, from below 1 volt at 0 percent pedal travel, with the pedal at rest, to above 2 volts at 100 percent pedal travel, with the pedal fully depressed. The APP sensor 2 signal decreases from above 4 volts at 0 percent pedal travel, to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal decreases from around 3.8 volts at 0 percent pedal travel, to below 3.1 volts at 100 percent pedal travel. Notice that the signal circuits for APP sensor 2 and APP sensor 3 pull up to 5 volts and the APP sensor 1 signal circuit is referenced to low reference within the TAC module.

Conditions for Running the DTC

DTCs P0606, P1517, and P1518 are not set.

The ignition switch is in the crank or run position.

The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

The APP sensor 3 voltage is less than 01.63 volts, or greater than 4.28 volts.

All above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  - The control module will not command Reduced Engine Power mode.
  - The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  - The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  - The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1285 set, a DTC P1286 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions.*

Test Description

The number below refers to the step number on the diagnostic table.

26. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1285

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If DTC P1518 or P1220 is also set, refer to Diagnostic Trouble Code (DTC) List for further diagnosis. 1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the APP sensor 3 voltage parameter. Does the scan tool indicate APP sensor 3 voltage within the specified values?	3.29-4.28 V	Go to *Step 3*	Go to *Step 6*
3	Fully depress the accelerator pedal to the wide open throttle (WOT) position. Does the scan tool indicate APP sensor 3 voltage within the specified values?	1.63-3.1 V	Go to *Step 4*	Go to *Step 6*
4	1. Turn OFF the ignition for 15 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Use a scan tool in order to observe the DTC option. 4. Lightly touch and move the related engine wiring harnesses and connectors for the APP sensor while monitoring the DTC info status. Did this DTC fail this ignition during the above test?	—	Go to *Step 20*	Go to *Step 5*
5	Slowly depress the accelerator pedal to WOT and then slowly return it to the released position. Did this DTC fail this ignition during the above test?	—	Go to *Step 21*	Go to *Diagnostic Aids*
6	1. Disconnect the APP sensor harness connector. 2. Use a DMM in order to test the APP sensor 3 signal circuit for voltage. Does the DMM indicate APP sensor 3 signal voltage within the specified values?	3.94-6.06 V	Go to *Step 11*	Go to *Step 7*
7	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 3 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 8*
8	Use a DMM in order to test the APP sensor 3 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 9*
9	Use a DMM in order to test the APP sensor 3 signal circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 10*
10	1. Disconnect the other TAC module harness connector. 2. Use a DMM in order to test for a short between the APP sensor 3 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*

DTC P1285 (cont'd)

Step	Action	Value(s)	Yes	No
11	Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	3.94-6.06 V	Go to *Step 16*	Go to *Step 12*
12	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 13*
13	Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 14*
14	Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 15*
15	Use a DMM in order to test for a short between the APP sensor 3, 5-volt reference circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
16	With a DMM connected between the APP sensor 3 low reference circuit and the APP sensor 1 low reference circuit, measure the resistance. Does the DMM indicate resistance within the specified values?	0-5 ohm	Go to *Step 18*	Go to *Step 17*
17	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 3 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
18	1. Use a scan tool in order to observe the APP sensor 3 voltage parameter. 2. Connect a fused jumper between the APP sensor 3 signal circuit and the APP sensor 3 low reference circuit at the APP sensor harness connector. Does the scan tool indicate APP sensor 3 voltage at the specified value?	0 V	Go to *Step 19*	Go to *Step 24*
19	1. Turn OFF the ignition. Disconnect the TAC module. 2. Use a DMM in order to test for a short between the APP sensor 3 signal circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 21*
20	Repair the intermittent connection as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 25*	—

DTC P1285 (cont'd)

Step	Action	Value(s)	Yes	No
21	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 22*
22	Replace the APP sensor assembly. Refer to *Accelerator Pedal Position (APP) Sensor Replacement.* Did you complete the replacement?	—	Go to *Step 25*	—
23	Inspect for poor connections at the harness connector of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 24*
24	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 25*	—
25	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 26*	Go to *Step 2*
26	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1286

Circuit Description

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually 3 individual APP sensors within one housing. Three separate signal, low reference and 5-volt reference circuits connect the APP sensor assembly and the throttle actuator control (TAC) module. Each sensor has a unique functionality. The APP sensor 1 signal increases as the accelerator pedal is depressed, from below 1.0 volt at 0 percent pedal travel, with the pedal at rest, to above 2 volts at 100 percent pedal travel, with the pedal fully depressed. The APP sensor 2 signal decreases from above 4 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. The APP sensor 3 signal decreases from around 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel. Notice that the signal circuits for APP sensor 2 and APP sensor 3 pull up to 5 volts and the APP sensor 1 signal circuit is referenced to low reference within the TAC module.

Conditions for Running the DTC

- DTCs P0606, P1517, or P1518 are not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- APP sensor 3 disagrees with APP sensor 1 by more than 13 percent and APP sensor 3 disagrees with APP sensor 2 by more than 13 percent.
- All of the above conditions are present for less than 1 second.

Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- If one or more APP sensor DTCs are set for a single APP sensor, the following occurs:
  - The control module will not command Reduced Engine Power mode.
  - The control module will use the remaining two APP sensors to calculate throttle response.
- If certain multiple APP sensor DTCs are set for more than one APP sensor, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.
  - The message center displays Reduced Engine Power.
- If all three APP sensors are out of range, the following occurs:
  - The control module commands Reduced Engine Power mode.
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.
  - The message center displays Reduced Engine Power.

Conditions for Clearing the DTC

- A current DTC ”Last Test Failed” clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects throttle movement with a DTC P1285 set, a DTC P1286 also sets.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the steps numbers in the diagnostic table.

2. This step determines if a communication condition exists.
5. This step isolates an internal APP sensor failure. The condition may only occur at a certain accelerator pedal position. Monitoring the APP angles for sensor 1 and sensor 2 is an accurate way of verifying the actual position of the pedal. The APP angles for all 3 sensors should be within a few percent of each other. When the pedal is at rest the APP angle for all 3 sensors should be 0 percent, when the pedal is fully

depressed all APP angles should be 100 percent.

6. The APP sensor 3 has a dedicated 5-volt reference circuit. Monitoring the APP sensor 1 voltage aids in diagnosing the APP sensor 3 5-volt reference circuit. If the scan tool displays 5 volts, the circuits are OK.

25. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1286

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P1518 also set?	—	Go to *DTC P1518*	Go to *Step 3*
3	**Important:** Do not depress the accelerator pedal. 1. Start the engine. 2. Use a scan tool in order to observe the DTC info. Did any other TAC module or APP sensor DTCs set except P1125?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 4*
4	Use a scan tool in order to observe the APP sensor Agree/Disagree parameters. Does the scan tool indicate Disagree for any of the APP sensor Agree/Disagree parameters?	—	Go to *Step 6*	Go to *Step 5*
5	1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to observe the APP sensor angles for all 3 APP sensors. 3. Slowly depress the accelerator pedal, stopping at 25, 50, 75, and 99 percent. 4. Slowly release the accelerator pedal, stopping at 75, 50, 25, and 0 percent. Does the scan tool indicate APP sensor 3 angle within 13 percent of the APP sensor 1 angle and APP sensor 3 angle within 13 percent of the APP sensor 2 angle during the above test?	—	Go to *Diagnostic Aids*	Go to *Step 6*
6	1. Disconnect the APP sensor harness connector. 2. Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for voltage. Does the DMM indicate voltage within the specified values?	3.94-6.06 V	Go to *Step 7*	Go to *Step 14*
7	Use a DMM in order to test the APP sensor 3 signal circuit for voltage. Does the DMM indicate voltage within the specified values?	3.94-6.06 V	Go to *Step 8*	Go to *Step 16*
8	With a DMM connected between the APP sensor 3 low reference circuit and the APP sensor 1 low reference circuit, measure the resistance. Does the DMM indicate resistance within the specified values?	0-5 ohm	Go to *Step 9*	Go to *Step 19*
9	1. Disconnect the TAC module harness connector containing the APP sensor circuits. 2. Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 10*

DTC P1286 (cont'd)

Step	Action	Value(s)	Yes	No
10	Use a DMM in order to test for a short between the APP sensor 3, 5-volt reference circuit and all other APP circuits at the APP sensor harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 11*
11	Use a DMM in order to test the APP sensor 3 signal circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 12*
12	Use a DMM in order to test for a short between the APP sensor 3 signal circuit and all other APP circuits at the APP sensor harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 13*
13	Use a DMM in order to test the APP sensor 3 low reference circuit for resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 20*
14	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 15*
15	Use a DMM in order to test the APP sensor 3, 5-volt reference circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 21*
16	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 3 signal circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 17*
17	Use a DMM in order to test the APP sensor 3 signal circuit for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 18*
18	Use a DMM in order to test for a short between the APP sensor 3 signal circuit and all other APP circuits at the APP sensor harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 19*
19	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the APP sensor circuits. 3. Use a DMM in order to test the APP sensor 3 low reference circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 21*

DTC P1286 (cont'd)

Step	Action	Value(s)	Yes	No
20	Inspect for poor connections at the harness connector of the APP sensor. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 22*
21	Inspect for poor connections at the harness connectors of the TAC module. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 24*	Go to *Step 23*
22	Replace the APP sensor assembly. Refer to Accelerator Pedal Position (APP) Sensor Replacement. Did you complete the replacement?	—	Go to *Step 24*	—
23	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 24*	—
24	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 25*	Go to *Step 2*
25	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1336

Circuit Description

The crankshaft position (CKP) sensor sends pulses to the powertrain control module (PCM) as the reluctor wheel teeth rotate past the CKP sensor. The PCM uses the CKP pulses to synchronize the ignition and fuel injector operation, and to time the interval between each CKP pulse. The PCM determines when an excessive change in crankshaft speed occurs by comparing each new time interval with the previous interval. A misfire causes an unexpected change in the crankshaft speed. A certain amount of acceleration or deceleration is expected between each firing stroke, but if the crankshaft speed changes more than an expected amount, the PCM interprets this as a misfire. The interval between CKP sensor pulses is extremely small. At high engine speeds, slight variations in the following components make misfire detection difficult:

- Crankshaft
- Reluctor wheel
- CKP sensor

The PCM learns variations during the crankshaft position system variation learning procedure. The PCM compensates for these variations when performing misfire calculations. Only a scan tool can command the PCM to perform the crankshaft position system variation learn procedure again.

Perform the learning procedure after the following actions:

- A PCM replacement
- Any operation or repair involving the crankshaft, the CKP sensor, or the CKP sensor to reluctor wheel gap relationship
- An engine replacement
- The ignition switch is in the ON position until the battery is drained

Important: A PCM power disconnect with the ignition ON may erase the stored pulse value and set the DTC P1336.

Disconnecting the PCM will not erase the learned crankshaft position system variation as long as the ignition switch is in the OFF position.

Important: Reprogramming the PCM does not require running the crankshaft position system variation learn procedure unless the PCM is new.

DTC P1336 sets if the crankshaft position system variation is not within an acceptable range, or can not be learned.

Conditions for Running the DTC

DTCs P0335, P0336, P0341, P0342, and P0343 are not set.

Conditions for Setting the DTC

The PCM has not learned the crankshaft position system variation.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame/Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic. Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- If the crankshaft position system variation learn procedure cannot be learned, check for the following conditions:
  - A chipped or damaged reluctor wheel
  - Incorrect aligN·ment of the CKP sensor to the reluctor wheel
  - Excessive crankshaft run-out
  - Interference in the signal circuit to the CKP sensor

Important: If the PCM receives an incorrect crankshaft to camshaft pulse ratio, the PCM will not allow the scan tool to enable the learn procedure.

- Incorrect ratio of crankshaft to camshaft pulses
- The misfire diagnostic is not operable when the engine speed is above 1,000 RPM and DTC P1336 is set.
- When the learn procedure is in progress and the engine speed is at 4,000 RPM, a decrease in engine speed will occur. During the engine coast down, the PCM monitors the CKP sensor signal and stores the pattern.
- This pattern is used to determine if the crankshaft speed variations are due to misfire.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The PCM enables the learn process after the engine coolant temperature of 65°C (150°F) is reached. Engine deceleration occurs when the learn procedure is in progress. The PCM

monitors and records the CKP sensor signal during engine coast-down conditions.

3. Test in Progress on the scan tool indicates the PCM is performing the learn procedure.
4. If a repair is necessary due to a condition which prevented the learn procedure from enabling, the crankshaft position system variation learn procedure must be performed.
5. The ignition must be in the OFF position for at least 10 seconds after the learn procedure is complete and the engine RPM has returned to idle. The PCM saves the signal data after these conditions are met.

DTC P1336

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** If there are any other DTCs set, diagnose before proceeding with this table. Perform the crankshaft position system variation learn procedure as follows. 1. Install the scan tool. 2. Apply the parking brake. 3. Block the drive wheels. 4. Close the hood. 5. Place the transmission in Park (AT) or Neutral (MT). 6. Idle the engine until the specified engine coolant temperature value is reached. 7. Turn OFF all of the accessories. 8. Follow the instructions on the Tech 2 for application of the brakes. **Important:** While the learn procedure is in progress, release the throttle immediately when the engine starts to decelerate. The engine control is returned to the operator and the engine will respond to throttle position after the learn procedure is complete. 9. Enable the Crankshaft Position System Variation Learning Procedure with the scan tool. 10. Slowly raise the engine RPM to the specified value. 11. Immediately release the throttle when the engine speed decreases. Does the scan tool indicate Learn Status as Learned This Ignition?	65°C (150°F) 4,000 RPM	Go to *Step 5*	Go to *Step 3*
3	Attempt the crankshaft position system variation learn procedure as many times as the specified value. Does the scan tool indicate Learn Status as Learned This Ignition? 3	—	Go to *Step 5*	Go to *Step 4*
4	Inspect the crankshaft position (CKP) sensor and the crankshaft reluctor wheel for damage. Refer to Diagnostic Aids. Did you find the condition?	—	Go to *Step 6*	Go to *Diagnostic Aids*
5	Turn OFF the ignition for 15 seconds. Is the action complete?	—	Go to *Step 7*	—
6	Replace the CKP sensor or the reluctor wheel. Refer to Engine Replacement in Engine Mechanical 8.1L. Is the action complete?	—	Go to *Step 7*	—
7	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 8*	Go to *Step 2*
8	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

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DTC P1514

Circuit Description

The PCM uses the throttle position (TP) , BARO, intake air temperature (IAT), and engine RPM in order to calculate an expected mass air flow (MAF) rate. The PCM compares this value to the MAF value and the speed density calculation in order to verify the proper throttle operation.

Conditions for Running the DTC

- DTCs P0601, P0602, P0604, P0606, P1515, P1516, P1517, or P1518 are not set.
- DTCs P1120, P1220, and P1221 are not set at the same time, or P1120 and P1220 are not set at the same time.
- The engine operates longer than 1 second. The engine speed is greater than 500 RPM.

Conditions for Setting the DTC

- The PCM detects that the difference between the actual airflow and the Speed Density calculated airflow is greater than expected.
- All of the above conditions are met for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the throttle blade for being broken, bent, or missing.
- Inspect the TP sensor for proper installation. A sensor that is misaligned could set this DTC.
- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- Physically/visually inspect the throttle body assembly and correct any problems that you observe. Manually move the throttle blade from closed to wide open throttle (WOT). You should not need to use excessive force. The throttle blade should move smoothly through the full range and should return to a slightly open position on its own.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an Intermittent condition, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

5. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1514

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Is DTC P0101, P0102, P0103, P0107, P0108, P0112, P0113, P1111, or P1112 set?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	**Important:** If any of the conditions listed below exist, replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Inspect the throttle body for the following: • TP sensor loose or damaged • Loose or damaged throttle blade • Cracked or bent throttle shaft • Drive mechanism damage Did you find and correct the condition?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 5*	Go to *Step 2*
5	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1515

Circuit Description

The commanded throttle position (TP) , based on accelerator pedal position (APP) and possibly other limiting factors, is compared to the actual throttle position. The two values should be within a calibrated range of each other. Both the powertrain control module (PCM) and the throttle actuator control (TAC) module redundantly monitor the commanded and actual throttle position. This diagnostic trouble code (DTC) sets if the PCM detects an out-of-range condition between commanded and actual pedal position.

Conditions for Running the DTC

- DTCs P0601, P0602, P0604, P0606, P1516, P1517, or P1518 are not set.
- DTCs P1120, P1220 and P1221 are not set at the same time or P1120 and P1220 are not set at the same time.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 8.5 volts.
- The TAC system is not in the battery saver mode.

Conditions for Setting the DTC

- The PCM detects that the commanded and actual throttle positions are not within a calibrated range of each other.
- All above conditions are met for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- If you do not find any trouble, inspect for mechanical problems or binding that may be temperature related. Components may not move freely in extreme heat or cold due to the presence of contaminants or ice formation.
- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. If the TP Indicated Angle does not follow the movement of the throttle blade, and no TP Sensor DTCs are set, there is a mechanical condition with the throttle shaft or the TP Sensor.
16. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1515

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Are DTCs P1518 and P1221 both set also? Go to DTC P1518	—	Go to *Step 3*	—
3	Is DTC P1221 set? Go to DTC P1221	—	Go to *Step 4*	—
4	**Important:** The next test must be started within 15 seconds after the ignition is turned ON. 1. Turn OFF the ignition for 15 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Use a scan tool in order to observe the TP sensor 1 and TP sensor 2 angle parameters. 4. Slowly depress the accelerator pedal to wide open throttle (WOT) and slowly return it to the released position. Does the scan tool indicate both angle parameters increasing as the pedal is depressed to WOT and decreasing as the pedal is moved to the released position?	—	Go to *Diagnostic Aids*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Remove the air duct from the throttle body assembly. 3. Disconnect the Throttle actuator control motor harness connector. Turn ON the ignition, with the engine OFF. 4. With your hand, slowly open the throttle blade to WOT and then to the closed throttle position while observing the TP sensor 1 and TP sensor 2 angle parameters on the scan tool. Does the scan tool indicate both angle parameters increasing as the throttle plate is moved to WOT and decreasing as the pedal is moved to the closed position?	—	Go to *Step 6*	Go to *Step 13*
6	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the throttle actuator control motor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the throttle actuator control motor circuits for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 7*
7	Use a DMM in order to test each throttle actuator control motor circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 8*
8	Use a DMM in order to test each throttle actuator control motor circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 9*
9	1. Disconnect the other TAC module harness connector. 2. Use a DMM in order to test for a short between each throttle actuator control motor circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 10*

DTC P1515 (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Turn OFF the ignition. Reconnect the TAC module. 2. Connect a test lamp between the two throttle actuator control motor circuits at the throttle actuator control motor harness connector. Turn ON the ignition, with the engine OFF and observe the test lamp. Did the test lamp illuminate briefly when the ignition was turned ON?	—	Go to *Step 11*	Go to *Step 13*
11	Inspect for poor connections at the throttle actuator control motor harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 12*
12	Replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
13	Inspect for poor connections at the TAC module harness connectors. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 14*
14	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
15	1. Use a scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 16*	Go to *Step 2*
16	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1516

Circuit Description

The predicted throttle position (TP), based on accelerator pedal position and possibly other limiting factors, is compared to the actual throttle position. The two values should be within a calibrated range of each other. Both the powertrain control module (PCM) and the throttle actuator control (TAC) module redundantly monitor the predicted and actual throttle position. This diagnostic trouble code (DTC) sets if the PCM detects an out of range condition between the predicted and actual throttle position.

Conditions for Running the DTC

- DTC P1518 is not set.
- The ignition switch is in the crank or run position. The ignition voltage is greater than 5.23 volts.
- The TAC system is not in the battery saver mode.

Conditions for Setting the DTC

- The TAC module detects that the predicted and actual throttle positions are not within a calibrated range of each other or the PCM and the TAC cannot determine throttle position or both TP sensors are invalid.
- All of the above conditions are met for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- Ensure that the starting and charging systems are operating properly.
- Low system voltage can cause this DTC to set.
- When the TAC module detects a condition within the TAC system, more than one TAC system-related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.
- For an intermittent, refer to *Intermittent Conditions.*

Test Description

The numbers below refer to the step numbers on the diagnostic table.

7. If the TP Indicated Angle does not follow the movement of the throttle blade, and no TP sensor DTCs are set, there is a mechanical condition with the throttle shaft or the TP sensor.
18. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1516

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Are DTCs P1518 and P1221 both set also?	—	Go to *DTC P1518*	Go to *Step 3*
3	Is DTC P1221 set? Go to DTC P1221	—	Go to *Step 4*	
4	1. Turn OFF the ignition for 15 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Use a scan tool in order to observe the TP sensor 1 and TP sensor 2 angle parameters. 4. Slowly depress the accelerator pedal to wide open throttle (WOT) and slowly return it to the released position. Does the scan tool indicate both angle parameters increasing as the pedal is depressed to WOT and decreasing as the pedal is released?	—	Go to *Diagnostic Aids*	Go to *Step 5*
5	1. Turn OFF the ignition. 2. Disconnect the throttle actuator motor harness connector. Remove the air inlet duct from the throttle body. 3. Inspect the throttle body and throttle plate for debris, damage, and tampering that could cause the throttle plate to bind. If debris is found, clean the throttle body and repair the source of contamination. If the throttle body and/or throttle plate is damaged, replace the throttle body. Refer to *Throttle Body Assembly Replacement*. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 6*
6	Using your hand, slowly open the throttle plate to WOT and back to the closed position several times. Does the throttle plate move smoothly without binding in both directions?	—	Go to *Step 7*	Go to *Step 14*
7	1. Turn ON the ignition, with the engine OFF. 2. Using your hand, slowly open the throttle blade to WOT and then to the closed throttle position while observing the TP sensor 1 and TP sensor 2 angle parameters on the scan tool. Does the scan tool indicate both angle parameters increasing as the throttle blade is moved to WOT and decreasing as it is moved to the closed position?	—	Go to *Step 8*	Go to *Step 15*
8	1. Turn OFF the ignition. 2. Disconnect the TAC module harness connector containing the throttle actuator control motor circuits. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test the throttle actuator control motor circuits for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 9*
9	Use a DMM in order to test each throttle actuator control motor circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 10*

DTC P1516 (cont'd)

Step	Action	Value(s)	Yes	No
10	Use a DMM in order to test each throttle actuator control motor circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 11*
11	1. Disconnect the other TAC module harness connector. 2. Use a DMM in order to test for a short between each throttle actuator control motor circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 12*
12	1. Turn OFF the ignition. Reconnect the TAC module. 2. Connect a test lamp between the two throttle actuator control motor terminals at the throttle actuator control motor harness connector. Turn ON the ignition, with the engine OFF and observe the test lamp. Did the test lamp illuminate briefly when the ignition was turned ON?	—	Go to *Step 13*	Go to *Step 15*
13	Inspect for poor connections at the throttle actuator control motor harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 14*
14	Replace the throttle body assembly. Refer to *Throttle Body Assembly Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
15	Inspect for poor connections at the TAC module harness connectors. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 16*
16	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
17	1. Use a scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 18*	Go to *Step 2*
18	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1517

Circuit Description

The throttle actuator control (TAC) module contains data which is essential for proper TAC system operation. The TAC module continuously tests the integrity of this data. When the TAC module is unable to write or read data to and from RAM or the TAC module is unable to correctly read data from the flash memory or an internal TAC module processor fault is detected, this diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- DTC P1518 is not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 6 volts.

Conditions for Setting the DTC

- The TAC module determines that an internal data test did not pass.
- All of the above conditions are met for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Ensure the starting and charging systems are operating properly.
- Low system voltage can cause this DTC to set.
- Inspect the TAC module connectors for signs of water intrusion.
- When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

Test Description

The number below refers to the step number on the diagnostic table.

4. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1517

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 3*	—
3	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 4*	Go to *Step 2*
4	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1518

Circuit Description

The throttle actuator control (TAC) module and the powertrain control module (PCM) communicate via a dedicated serial data circuit. This serial data circuit is separate from any other serial data circuit on the vehicle. Accurate transmitting and receiving of serial data requires not only good circuit integrity but also adequate system voltage. This diagnostic monitors the accuracy of the serial data transmitted between the TAC Module and the PCM. If the PCM detects a loss of data or invalid data, this diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- DTC P1517 is not set.
- The ignition switch is in the crank or run position.
- The ignition voltage is greater than 5.23 volts.

Conditions for Setting the DTC

- Invalid or missing serial data messages are detected for a predetermined amount of time.
- All of the above conditions met for less than 1 second.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame and/or the Failure Records.
- The control module commands one of the following Reduced Engine Power modes:
  - The APP indicated angle is limited to a predetermined value to limit the amount of throttle control.

  OR
  - The APP indicated angle is limited to 0 percent. The control module only allows the engine to idle.

  OR
  - Under certain conditions the control module commands the engine OFF.
- The Reduced Engine Power lamp will be illuminated.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- DTC P1518 sets if the battery voltage is low. If the customer's concern is slow cranking or no crank because battery voltage is low, ignore DTC P1518. Clear any DTCs from memory that may have set from the low battery voltage condition.
- DTC P1518 sets when there is a short to B+ on the TAC module ground circuit. Inspect the fuses for the circuits that are in the TAC module harness (i.e., cruise, brake). An inspection of the fuses may lead you to the circuit that is shorted to the TAC module ground circuit.
- DTC P1518 sets if the TAC module ignition feed circuit is shorted to a B+ supply circuit. The TAC module stays powered-up when the ignition switch is turned OFF. When the ignition switch is turned ON, the TAC module is powered-up before the PCM. DTC P1518 sets because no communication is detected by the TAC module from the PCM. Inspect related circuits for being shorted to a B+ supply circuit.
- Inspect the TAC module power and ground circuits and the TAC module/PCM serial data circuits for intermittent connections.
- Inspect the TAC module connectors for signs of water intrusion. When this occurs, multiple DTCs could be set with no circuit or component conditions found during diagnostic testing.
- When the TAC module detects a problem within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual problem may correct more than one DTC. Keep this in mind when reviewing captured DTC Info.
- For an intermittent condition, refer to *Intermittent Conditions.*
- DTC P1518 is also set when the PCM is re-programmed through the vehicle class 2 data communications bus.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. Increasing the engine speed to 3000 RPM aids in locating a shorted throttle actuator motor control circuit. Depending on the polarity of the throttle actuator motor transistors, this DTC may not set with a fault in the control circuits. The throttle actuator motor is a bi-directional DC motor. Raising the engine speed changes the polarity of the transistors in the throttle actuator motor. This occurs because one set of the transistors are low (0 volts) and the other set are high (B+).

Therefore, if one set of transistors are at a low voltage and the corresponding circuit is shorted low, DTC P1518 will not set. When the polarity of the transistors change this DTC sets. If this DTC does not Fail This Ignition, continue to monitor this DTC status while moving related harnesses and connectors.

29. When the TAC module detects a condition within the TAC system, more than one TAC system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Disconnecting components during testing may set additional DTCs. Keep this in mind when reviewing the stored information, Capture Info.

DTC P1518

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. Remove the cover from the underhood electrical center. 3. With a test lamp connected to ground, test both sides of the IGN E fuse. Does the test lamp illuminate on at least one side of the fuse?	—	Go to *Step 3*	Go to *Step 24*
3	1. Turn OFF the ignition 2. With a test lamp connected to ground, test for voltage at the IGN E fuse. Does the test lamp illuminate?	—	Go to *Step 22*	Go to *Step 4*
4	Install a scan tool. Is DTC P0606 also set?	—	Go to *DTC P0601-P0607, P1600, P1621, P1627,* or *P1683*	Go to *Step 5*
5	**Important:** If the Driver Information Center is displaying Reduced Engine Power, go to S*tep 6*. 1. Start the engine. 2. Increase the engine speed to 3,000 RPM, if possible. 3. Monitor the diagnostic trouble code (DTC) Info option using the scan tool. Does the scan tool indicate this DTC failed this ignition?	—	Go to *Step 6*	Go to *Diagnostic Aids*
6	1. Turn OFF the ignition. 2. Disconnect the throttle actuator motor harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Use a DMM in order to test for voltage at both throttle actuator motor control circuits. Does the DMM indicate voltage on both circuits above the specified value?	8 V	Go to *Step 12*	Go to *Step 7*
7	1. Turn OFF the ignition. 2. Use a DMM in order to test both throttle actuator motor control circuits for continuity to ground. Does the DMM indicate continuity to ground?	—	Go to *Step 10*	Go to *Step 8*
8	1. Turn OFF the ignition. Remove the IGN E fuse. 2. Use a DMM in order to test the TAC side of the fuse terminal for continuity to ground. Does the DMM indicate continuity to ground?	—	Go to *Step 9*	Go to *Step 11*

DTC P1518 (cont'd)

Step	Action	Value(s)	Yes	No
9	1. Disconnect the TAC module 16-way harness connector. 2. Use a DMM in order to test the TAC side of the fuse terminal for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 25*
10	1. Disconnect the TAC module 16-way harness connector. 2. Use a DMM in order to test the throttle actuator motor control circuits for a short to ground at the TAC module 16-way harness connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 25*
11	1. Turn OFF the ignition. 2. Disconnect the TAC module 16-way harness connector. 3. Use a DMM in order to test the TAC module ignition feed circuit for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 25*
12	1. Turn OFF the ignition. 2. Disconnect the TAC module 16-way connector. Turn ON the ignition, with the engine OFF 3. Use a DMM in order to test for a short to voltage at both throttle actuator motor control circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 13*
13	1. Turn OFF the ignition 2. Disconnect the TAC module 10-way harness connector. 3. Use a DMM in order to test for a short between each throttle actuator motor control circuit and all other TAC module circuits. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 14*
14	Use a DMM in order to test for an open or high resistance in the TAC module ground circuit. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 15*
15	Use a DMM in order to test for voltage on the serial data circuits at the TAC module 16-way harness connector. Does the DMM indicate voltage within the specified values for both circuits?	0-4.5 V	Go to *Step 16*	Go to *Step 18*
16	1. Turn OFF the ignition. 2. Use a DMM in order to test both serial data circuits at the TAC module 16-way harness connector for continuity to ground. Does the DMM indicate OL for both circuits?	—	Go to *Step 20*	Go to *Step 17*

DTC P1518 (cont'd)

Step	Action	Value(s)	Yes	No
17	1. Disconnect the PCM connector containing the TAC module serial data circuits. 2. Use a DMM in order to test both serial data circuits at the TAC module 16-way connector for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 18*
18	Use a DMM in order to test for a short between both serial data circuits and all other circuits at the PCM and TAC module harness connectors. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 19*
19	Use a DMM in order to test for a short to voltage on both serial data circuits at the TAC module 16-way connector. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 26*
20	1. Disconnect the PCM connector that contains the TAC module serial data circuits. 2. Use a DMM in order to test each serial data circuit between the TAC module 16-way harness connector and the PCM harness connector for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 21*
21	1. Reconnect the PCM. Turn ON the ignition. 2. Use a DMM in order to test for voltage on the serial data circuit at the TAC module 16-way harness connector. Does the DMM indicate voltage at the specified value?	0 V	Go to *Step 26*	Go to *Step 25*
22	1. Turn OFF the ignition 2. Disconnect the 16 way TAC module harness connector. 3. Test the TAC module ignition positive voltage circuit for a short to battery voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 23*
23	1. Turn On the ignition. 2. Test both TAC motor circuits for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 25*
24	Test for an open between the IGN E fuse and the Ignition Switch. Refer to *Circuit Testing* , *Wiring Repairs*, and *IGN A Fuse and Ignition Switch* in Wiring Systems. Did you complete the repair?	—	Go to *Step 29*	—
25	Test for poor connections at the TAC module harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 27*
26	Test for poor connections at the PCM harness connector. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 29*	Go to *Step 28*

DTC P1518 (cont'd)

Step	Action	Value(s)	Yes	No
27	Replace the TAC module. Refer to *Throttle Actuator Control (TAC) Module Replacement*. Did you complete the replacement?	—	Go to *Step 29*	—
28	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 29*	—
29	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 30*	Go to *Step 2*
30	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1635

Circuit Description

The powertrain control module (PCM) uses a common 5-volt reference 1 circuit as a sensor feed. This circuit supplies 5 volts to the following sensors:

- The manifold absolute pressure (MAP) sensor
- The PCM monitors the voltage on the 5-volt reference 1 circuit. This DTC sets if the voltage is out of range.

This diagnostic trouble code (DTC) sets if the 5-volt reference circuit is shorted to ground. When the 5-volt reference circuit or signal circuits are shorted to a voltage both DTCs P1635 and P1639 set. The following components or circuits need to be inspected:

- The MAP sensor
- The throttle position (TP) sensor The fuel level sensor
- The fuel tank pressure (FTP) sensor

Conditions for Running the DTC

The engine is running.

Conditions for Setting the DTC

The 5-volt reference circuit is out of range for more than 2 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass and a fail. Operate the vehicle within the same Freeze Frame conditions such as RPM, load, vehicle speed, temperature etc. that you observed. This will isolate when the DTC failed.
- For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The 5-volt reference circuits for the sensors are connected together inside the PCM. Both DTCs P1635 and P1639 set at the same time indicates a 5-volt reference circuit is shorted to a voltage.
3. The 5-volt reference circuits for the sensors are connected together inside the PCM. When only P1635 is set, this indicates a short to ground on one of the 5-volt reference circuits.
5. This step isolates the 5-volt reference circuit from the sensor signal circuit.
6. This step determines if the 5-volt reference circuits or the fuel level sensor signal circuit are only shorted when the fuel pump is enabled. You may have to enable the fuel pump a couple of times to see if the voltages increase. Inspect the fuel pump harness thoroughly for being shorted to the fuel tank pressure sensor or the fuel level sensor.
8. The 5-volt reference circuits may be shorted to another PCM circuit. The shorted circuit may not be apparent when the PCM harness connector is disconnected. Testing continuity from each 5-volt reference circuit isolates the shorted circuit.

DTC P1635

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*

DTC P1635 (cont'd)

Step	Action	Value(s)	Yes	No
2	1. Install a scan tool. 2. Start the engine. 3. Idle the engine for 2 minutes. 4. Monitor the DTCs using a scan tool. Did both DTCs P1635 and P1639 fail this ignition?	—	Go to *Step 5*	Go to *Step 3*
3	Did DTC P1635 fail this ignition?	—	Go to *Step 8*	Go to *Step 4*
4	**Important:** If DTCs P1635 and P1639 set refer to step 5. If only DTC P1635 sets, refer to step 9. 1. Turn ON the ignition, with the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in Conditions for Running the DTC. 6. Select the diagnostic trouble code (DTC) option, the Specific DTC option, then enter the DTC number using the scan tool. You will have to select P1635 and P1639 to determine if both DTCs set at the same time. Does the scan tool indicate that DTC P1635 or P1639 set this ignition?	—	Go to *Step 5*	Go to *Diagnostic Aids*
5	While idling the engine, monitor the voltages for the following sensors: • The fuel level sensor • The MAP sensor Does the scan tool display any of the voltages at or above the specified value?	5 V	Go to *Step 15*	Go to *Step 6*
6	1. Turn OFF the engine, with the ignition ON. 2. Monitor the following voltages using a scan tool: • MAP sensor • Fuel level sensor 3. Enable the fuel pump using the scan tool. Does any of the voltages increase when the fuel pump was turned ON?	—	Go to *Step 10*	Go to *Step 7*
7	1. Turn OFF the ignition. 2. Disconnect the PCM harness connector C1. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Turn ON the ignition, leaving the engine OFF. 4. Connect the DMM to ground. 5. Probe the other lead of the DMM to each 5-volt reference circuit at the PCM harness connector for the following components: • The MAP sensor Do any of the circuits measure more than the specified value?	5.1 V	Go to *Step 11*	Go to *Step 9*

DTC P1635 (cont'd)

Step	Action	Value(s)	Yes	No
8	**Important:** For detailed circuit information, refer to *Engine Controls Schematics.* 1. Turn OFF the ignition. 2. Disconnect the PCM connector C1. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Connect the test lamp to B+. 4. Probe the test lamp to the PCM connector 5-volt reference circuits for the following component • The MAP sensor Does the test lamp illuminate for any of the circuits?	—	Go to *Step 13*	Go to *Step 9*
9	**Important:** • For detailed circuit information, refer to *Engine Controls Schematics.* • Before proceeding, turn off the ignition and remove the following fuses: – IGN A (fuse #49) located in the underhood electrical center – PCM/TCM - BAT (fuse #27) located in the underhood electrical center 1. Disconnect the following components: • The MAP sensor • The fuel level sensor 2. Test continuity from each 5-volt reference circuit to all other PCM circuits at the PCM harness connector using the DMM. Example: probe one lead to the MAP sensor 5-volt reference at the PCM harness connector circuit and probe the other lead to each terminal at the PCM harness connector. This must be performed for each 5-volt reference circuit. Refer to *Testing for Continuity* in Wiring Systems. Do any of the circuits indicate a resistance within the specified range?	0-2 ohm	Go to *Step 12*	Go to *Step 14*
10	Repair the short between the fuel pump circuit and the appropriate 5-volt reference circuit or signal circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 16*	—
11	Repair the short to voltage on the appropriate 5-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 16*	—
12	Repair the short between the appropriate 5-volt reference circuit and the PCM circuit that had continuity. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 17*	—
13	Repair the short to ground on the appropriate 5-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 16*	—
14	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement.* Did you complete the replacement?	—	Go to *Step 16*	—

DTC P1635 (cont'd)

Step	Action	Value(s)	Yes	No
15	Repair the short to voltage on the appropriate signal circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 16*	—
16	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 17*	Go to *Step 2*
17	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P1639

Circuit Description

The powertrain control module (PCM) uses a common 5-volt reference circuit as a sensor feed to the fuel tank pressure (FTP) sensor and the throttle position (TP) sensor.

The PCM monitors the voltage on the 5-volt reference circuit. This diagnostic trouble code (DTC) sets if the voltage is out of range.

Conditions for Running the DTC

- The engine is running. Conditions for Setting the DTC
- The 5-volt reference circuit is out of range for more than 2 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Diagnostic Aids

- Using the Freeze Frame/Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame/Failure Records data can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can also help determine how many ignition cycles the diagnostic reported a pass and a fail. Operate the vehicle within the same Freeze Frame conditions such as RPM, load, vehicle speed, temperature etc. that you observed. This will isolate when the DTC failed.
- For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The 5-volt reference circuits for the sensors are connected together inside the PCM. Both DTCs P1635 and P1639 set at the same time, indicates a 5-volt reference circuit is shorted to a voltage.
3. The 5-volt reference circuits for the sensors are connected together inside the PCM. When only P1639 is set, this indicates a short to ground on one of the 5-volt reference circuits.
5. This step determines if a 5-volt reference circuit is shorted to ground.
6. The 5-volt reference circuits may be shorted to another PCM circuit. The shorted circuit may not be apparent when the PCM harness connector is disconnected. Testing continuity from each 5-volt reference circuit isolates the shorted circuit.

DTC P1639

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Start the engine. 3. Idle the engine for 2 minutes. 4. Monitor the DTCs using a scan tool. Did both DTCs P1635 and P1639 fail this ignition?	—	Go to *DTC P1635*	Go to *Step 3*
3	Did DTC P1639 fail this ignition?	—	Go to *Step 5*	Go to *Step 4*

DTC P1639 (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Turn ON the ignition, leaving the engine OFF. 2. Review the Freeze Frame/Failure Records data for this DTC and observe the parameters. 3. Turn OFF the ignition for 15 seconds. 4. Start the engine. 5. Operate the vehicle within the conditions required for this diagnostic to run, and as close to the conditions recorded in the Freeze Frame/Failure Records as possible. Special operating conditions that you need to meet before the PCM will run this diagnostic, where applicable, are listed in Conditions for Running the DTC. 6. Select the diagnostic trouble code (DTC) option, the Specific DTC option, then enter the DTC number using the scan tool Does the scan tool indicate that DTC set this ignition?	—	Go to *Step 5*	Go to *Diagnostic Aids*
5	1. Turn OFF the ignition. 2. Disconnect the PCM harness connector C1. Refer to *Powertrain Control Module (PCM) Replacement.* 3. Connect the test lamp to B+. 4. Probe the PCM connector 5-volt reference circuits for the MAP sensor. Does the test lamp illuminate for any of the circuits?	—	Go to *Step7*	Go to *Step 6*
6	**Important:** • For detailed circuit information, refer to *Engine Controls Schematics.* • Before proceeding, turn off the ignition and remove the following fuses: – IGN A (fuse #49) located in the underhood electrical center – PCM/TCM - BAT (fuse #27) located in the underhood electrical center 1. Disconnect the following components: • The MAP sensor • The fuel level sensor 2. Test continuity from each 5-volt reference circuit to all other PCM circuits at the PCM harness connector using the DMM. Example: probe one lead to the MAP sensor 5-volt reference at the PCM harness connector circuit and probe the other lead to each terminal at the PCM harness connector. This must be performed for each 5-volt reference circuit. Refer to *Testing for Continuity* in Wiring Systems. Do any of the circuits indicate a resistance within the specified range?	0-2 ohm	Go to *Step 8*	Go to *Step 9*
7	Repair the short to voltage on the appropriate 5-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 10*	—
8	Repair the short between the appropriate 5-volt reference circuit and the PCM circuit that had continuity. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 10*	—

DTC P1639 (cont'd)

Step	Action	Value(s)	Yes	No
9	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 10*	—
10	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 11*	Go to *Step 2*
11	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

Symptoms – Engine Controls

Important Preliminary Checks Before Starting

Perform the Engine Controls Diagnostic Check before using the symptom tables. Refer to *Diagnostic System Check – Engine Controls*. Verify all of the following are true:

- The powertrain control module (PCM) and malfunction indicator lamp (MIL) Service Engine Soon are operating correctly.
- There are no diagnostic trouble codes (DTCs) stored.
- The scan tool data is within the normal operating range, refer to Scan Tool Data List.
- Verify the customer concern and locate the correct symptom in the table of contents. Check the items indicated under that symptom.

Visual/Physical Check

Several of the symptom procedures ask for a careful visual and physical check. This step is extremely important. It can lead to correcting a problem without further checks and can save valuable time.

This check includes:

- The PCM grounds for being clean, tight, and in the proper location
- Vacuum hoses for splits, kinks, and proper connections, as shown on the Vehicle Emission Control Information label—Check thoroughly for any type of leak or restriction.
- The mass air flow (MAF) sensor installation—The arrows on the plastic portion of the sensor must point toward the engine.
- The air intake ducts for being collapsed or for having damaged areas
- Air leaks at throttle body mounting area, MAF sensor, and the intake manifold sealing surfaces
- The ignition wires for cracking, hardness, and carbon tracking The engine harness wiring and terminals for proper connections, pinches, or cuts

Intermittent

Important: Check for improper installation of electrical components if an intermittent condition exists. Inspect for aftermarket theft deterrent devices, lights, and cellular phones. Ensure that no aftermarket equipment is connected to the class 2 circuit. If you can not locate an intermittent condition, a cellular phone signal communication may cause the condition.

Important: The problem may or may not turn ON the malfunction indicator lamp (MIL) or store a DTC. DO NOT use the diagnostic trouble code (DTC) tables for intermittent problems. The fault must be present in order to locate the problem.

Faulty electrical connections or wiring cause most intermittent problems. Perform a careful visual and physical check for the following conditions:

- Poor mating of the connector halves or a terminal not fully seated in the connector body backed out
- An improperly formed or damaged terminal
- Reform or replace connector terminals in the problem circuit in order to insure proper contact tension. Refer to *Connector Repairs* in Wiring Systems.
- Remove the terminal from the connector body in order to check for poor terminal to wire connection. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems.

Road test the vehicle with the DMM connected to the suspected circuit. An abnormal voltage when the malfunction occurs is a good indication that there is a malfunction in the circuit being monitored.

Use a scan tool in order to help detect intermittent conditions. The GM Techline equipment scan tool has several features that you can use to locate an intermittent condition. Use the following features to find intermittent faults:

- You can trigger the Snapshot feature in order to capture and store engine parameters within the scan tool when the malfunction occurs. You can then review this stored information in order to see what caused the malfunction.
- Using a scan tool Freeze Frame/Failure Records can also aid in locating an intermittent condition. Review and capture the information in the Freeze Frame/Failure Record associated with the intermittent DTC being diagnosed. Drive the vehicle in the conditions that were present when the DTC originally set.
- You can use the Plot Function on the scan tool in order to plot selected data parameters. You can then review this stored information. This may aid in locating an intermittent problem. Refer to the scan tool Users Guide for more information.

Important: If the intermittent condition exists as a start and then stall, check for DTCs relating to the vehicle theft deterrent system. Check for improper installation of electrical options such as lights, cellular phones etc.

Any of the following may cause an intermittent malfunction indicator lamp (MIL) with no stored DTC:

- The ignition coils shorted to a ground, arcing at the ignition wires or the spark plugs
- The PCM grounds—Refer to *Engine Controls Schematics*.
- The ignition control (IC) wires for being routed to close to the secondary ignition wires, coils, or the generator—Ensure that all of the circuits

from the PCM to the ignition coils have good connections.
- An open diode across the A/C compressor clutch and other open diodes

Use the following tables when diagnosing a symptom complaint:
- *Hard Start*
- *Surges/Chuggles*
- *Lack of Power, Sluggishness, or Sponginess*
- *Detonation/Spark Knock*
- *Hesitation, Sag, Stumble*
- *Cuts Out, Misses Poor Fuel Economy*
- *Rough, Unstable, or Incorrect Idle and Stalling*
- *Dieseling, Run-On*
- *Backfire*

Intermittent Conditions

A problem may or may not turn ON the malfunction indicator lamp (MIL) or store a DTC. DO NOT use the diagnostic trouble code (DTC) charts for intermittent problems. The fault must be present to locate the problem.

Most intermittent problems are caused by faulty electrical connections or wiring. Inspect for the following conditions:
- Poor mating of the connector halves
- A backed out terminal that is not fully seated in the connector
- Improperly formed or damaged terminal
- Poor terminal to wire connection—This requires removing the terminal from the connector body to check.

All connector terminals in the problem circuit should be carefully checked for proper contact tension.

Road test the vehicle with a DMM connected to a suspected circuit. An abnormal voltage when a malfunction occurs is a good indication that there is a fault in the circuit being monitored.

Use a scan tool in order to help detect intermittent conditions. The scan tool has several features that can be used in order to locate an intermittent condition. Use the following features to find intermittent faults:
- The snapshot feature can be triggered to capture and store engine parameters within the scan tool when the malfunction occurs. This stored information then can be reviewed by the service technician to see what caused the malfunction.

Use the Freeze Frame/Failure Records data from the scan tool in order to locate an intermittent condition. Review and record the information in the Freeze Frame/Failure Record associated with the intermittent DTC being diagnosed. The vehicle may be driven within the conditions that were present when the DTC originally set.

To test the loss of diagnostic code memory, disconnect the manifold absolute pressure (MAP) sensor and idle engine until the Service Engine Soon MIL comes ON. DTC P0107 should be stored and kept in memory when ignition is turned OFF. If not, the powertrain control module (PCM) is faulty. When this test is completed, ensure that you clear the DTC P0107 from memory.

An intermittent Service Engine Soon MIL with no stored DTC, may be caused by the following conditions:
- The ignition coil shorted to ground and arcing at ignition wires or plugs
- The Service Engine Soon MIL wire to PCM shorted to ground
- Poor PCM grounds—Refer to *Engine Controls Schematics*.

Check for improper installation of electrical options such as lights, cellular phones etc. Route ignition control (IC) module wiring away from secondary ignition wires and ignition coils. Check all wires from the PCM to the ignition control module for poor connections.

Check for an open diode across the AC compressor clutch and check for other open diodes.

Hard Start

Problem	Action
DEFINITION: Engine cranks OK, but does not start for a long time. Does eventually run, or may start but immediately dies.	
Preliminary	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Search for bulletins.
Sensor/System	• Check the engine coolant temperature (ECT) sensor for being shifted in value. Connect a scan tool. Compare the engine coolant temperature against the intake air temperature (IAT) on a cold engine. The ECT and IAT sensor values should be within ±3°C (5°F) of each other. If the ECT sensor is out of range with the IAT sensor, check the resistance of the ECT sensor. Refer to Temperature vs Resistance for resistance specifications. Replace the ECT sensor if the resistance is not within the specification. If the sensor is within the specification, repair the ECT signal circuit for high resistance. **Important:** The embossed arrows on the MAF sensor indicate the direction of the intake air flow. The arrows must point toward the engine. • Check the mass air flow (MAF) sensor installation. A MAF sensor that is incorrectly installed may cause a hard start. Install the MAF in the proper direction. Refer to *Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor Replacement*. • Check the camshaft position (CMP) sensor for proper mounting and/or a bad connection. A long crank time occurs if the PCM does not receive a CMP signal.
Fuel System	• Check the fuel pump relay operation. The fuel pump should turn ON for 2 seconds when you turn ON the ignition. Refer to Fuel Pump Electrical Circuit Diagnosis. • A faulty in-tank fuel pump check valve allows the fuel in the lines to drain back to the tank after the engine stops. Refer to *Fuel System Diagnosis*. • Check both injector fuses for being open. An open injector fuse causes four injectors and four ignition coils not to operate. Replace the fuse. Inspect the injector circuits and the ignition coil circuits for an intermittent short to ground. • Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in Fuel Diagnosis*.
Ignition System	• Check both injector fuses for being open. An open injector fuse causes four ignition coils and four injectors not to operate. Replace the fuse. Inspect the ignition coil circuits and the injector circuits for an intermittent short to ground. • Check for proper ignition voltage output with *J 26792* spark tester. Refer to *Electronic Ignition (EI) System Diagnosis*. • Remove the spark plugs and check for the following: – Correct heat range – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Check for bare or shorted ignition wires. Refer to *Spark Plug Wire Inspection*. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.

Hard Start (cont'd)

Problem	Action
Engine Mechanical	• Excessive oil in combustion chamber—Leaking valve seals. Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. • Low cylinder compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Combustion chambers for excessive carbon buildup—Clean the chambers using top engine cleaner. Follow the instructions on the can. • Inspect the following components for incorrect basic engine parts: – Cylinder heads – Camshaft – Pistons, etc. Refer to the appropriate procedures in Engine Mechanical.

Surges/Chuggles

Problem	Action
DEFINITION: Engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.	
Preliminary	• Refer to *Important Preliminary Checks Before Starting* in Symptoms – Engine Controls. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Be sure the driver understands the operation of the transmission torque converter clutch (TCC) and A/C compressor operation as explained in the owners manual. Inform the customer how the TCC and the A/C clutch operates.
Ignition System	• Wet down the secondary ignition system with water from a spray bottle. Wetting down the secondary ignition system may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply the water. • Check for proper ignition voltage output with *J 26792* Spark Tester. Refer to *Electronic Ignition (EI) System Diagnosis*. • Remove the spark plugs and check for the following: – Correct heat range – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. • Gap the spark plugs using a wire gauge gap tool. Refer to Spark Plug Replacement. • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Monitor the Misfire Current Counters while driving the vehicle in the conditions that the misfire occurred. If a cylinder can be located with a misfire, use the DTC P0300 table for diagnosis. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.

Surges/Chuggles (cont'd)

Problem	Action
Sensor/System	• Check the heated oxygen sensors (HO2S). The HO2S should respond quickly to different throttle positions. If they do not, check the HO2S for silicon or other contaminates from fuel or the use of improper RTV sealant. The sensors may have a white , powdery coating and result in a high but false signal voltage rich exhaust indication. The PCM will then reduce the amount of fuel delivered to the engine causing a severe driveability problem. For more information, refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. • Check the mass air flow (MAF) sensor connections. Repair or replace terminals. Refer to *Connector Repairs* in Wiring Systems.
Fuel System	• Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in Fuel Diagnosis*. • Check that each injector harness is connected to the correct injector or cylinder according to the firing order firing order: 1-8-7-2-6-5-4-3. Relocate injector harnesses as necessary. • Check the items that cause an engine to run rich long term fuel trim near –13 percent. For a rich condition, refer to DTC P0132 or P0152. • Check the items that can cause an engine to run lean long term fuel trim near 24 percent. For a lean condition, refer to DTC P0131 or P0151.
Engine Mechanical	• Check engine mechanical for the following: • Check compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Sticking or leaking valves Worn camshaft lobes • Valve timing Bent push rods Worn rocker arms • Broken valve springs • Excessive oil in combustion chamber—Leaking valve seals. • Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L.
Additional Checks	Visually (physically) check vacuum hoses for splits, kinks, and proper connections and routing as shown on Vehicle Emission Control Information label. Diagnostic Information and Procedures

Lack of Power, Sluggishness, or Sponginess

Problem	Action
DEFINITION: Engine delivers less than expected power. Little or no increase in speed when the accelerator pedal is pushed down part way.	
Preliminary Checks	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Remove the air filter element and check for dirt or for being restricted. Refer to Air Cleaner Element Replacement and replace as necessary.
Fuel System	• Check both injector fuses for being open. An open injector fuse causes four ignition coils and four injectors not to operate. Replace the fuse. Inspect the ignition coil circuits and the injector circuits for an intermittent short to ground. Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check the fuel injectors. Refer to *Fuel Injector Coil Test*. • Check the items that cause an engine to run rich long term fuel trim near –13 percent. For a rich condition, refer to DTC P0132 or P0152. • Check the items that can cause an engine to run lean long term fuel trim near 24 percent For a lean condition, refer to DTC P0131 or P0151.

Lack of Power, Sluggishness, or Sponginess (cont'd)

Problem	Action
Sensor/System	• Use a scan tool in order to monitor the knock sensor (KS) system for excessive spark retard activity. Refer to *Knock Sensor (KS) System Description*. • Ignition System • Check both injector fuses for being open. An open injector fuse causes four ignition coils and four injectors not to operate. Replace the fuse. Inspect the ignition coil circuit and the injector circuits for an intermittent short to ground. • Wet down the secondary ignition system with water from a spray bottle. Wetting the secondary ignition system may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as water is applied. • Check for proper ignition voltage output with *J 26792* Spark Tester. • Remove the spark plugs and check for the following: • Correct heat range • Wet plugs • Cracks • Wear • Improper gap • Burned electrodes • Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. • Gap the spark plugs using a wire gauge gap tool. Refer to Spark Plug Replacement. • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Monitor the Misfire Current Counters while driving the vehicle in the conditions that the misfire occurred. If a cylinder can be located with a misfire, use the DTC P0300 table for diagnosis. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.
Engine Mechanical	• Excessive oil in combustion chamber—Leaking valve seals. • Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. • Low cylinder compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Inspect the following components for incorrect basic engine parts: • Camshaft • Cylinder heads • Pistons, etc. • Refer to the appropriate procedures in Engine Mechanical 8.1L.
Additional Checks	• Inspect the following components of the exhaust system for possible restrictions: • The exhaust system for damaged or collapsed pipes • The exhaust manifold for a collapsed inner wall • The mufflers for heat distress or possible internal failure • The three-way catalytic converters for possible plugged conditions—Compare the exhaust system back pressure on each side of engine. Refer to *Restricted Exhaust* in Engine Exhaust.

Detonation/Spark Knock

Problem	Action
DEFINITION: A mild to severe ping, usually worse under acceleration. The engine makes sharp metallic knocks that change with throttle opening.	
Preliminary Checks	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • If the scan tool readings are normal refer to supporting text of the Engine Controls Diagnostic Check and there are no engine mechanical faults, fill the fuel tank with a known high quality fuel that meets the vehicles minimum octane requirements. Refer to Fuel System Specifications. Road test the vehicle and re-evaluate the vehicles performance.
Fuel System	• Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check the items that can cause an engine to run lean long term fuel trim near 24 percent. For a lean condition, refer to DTC P0131 or P0151
Ignition System	Check the spark plugs for being the proper heat range. Refer to *Spark Plug Inspection*.
Engine Cooling System	• Check for obvious overheating problems: • Low engine coolant—Refer to Loss of Coolant in Engine Cooling for the type and amount of engine coolant to be used. • Restricted air flow to the radiator or restricted coolant flow through the radiator. • Inoperative cooling fan—Refer to Fan Clutch Diagnosis in Engine Cooling.
Engine Mechanical	• Check for the following engine mechanical problems: Excessive oil in combustion chamber—Leaking valve seals. Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. • Low cylinder compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Combustion chambers for excessive carbon buildup—Clean the combustion chamber by using top engine cleaner. Follow the instructions on the can. • Inspect the following components for incorrect basic engine parts: – Camshaft – Cylinder heads – Pistons, etc. • Refer to the appropriate procedures in Engine Mechanical 8.1L.
Additional Checks	Check the park/neutral position (PNP) switch operation.

Hesitation, Sag, Stumble

Problem	Action
DEFINITION: Momentary lack of response as the accelerator is pushed down. Can occur at any vehicle speed. Usually more pronounced when first trying to make the vehicle move, as from a stop. May cause the engine to stall if severe enough.	
Preliminary	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*.
Sensor/System	Check the manifold absolute pressure (MAP) sensor operation.

Hesitation, Sag, Stumble (cont'd)

Problem	Action
Fuel System	• Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check both injector fuses for being open. An open injector fuse causes four ignition coils and four injectors not to operate. Replace the fuse. Inspect the ignition coil circuits and the injector circuits for an intermittent short to ground. • Check the fuel injectors. Refer to *Fuel Injector Coil Test*. • Check the items that cause an engine to run rich long term fuel trim near −13 percent. For a rich condition, refer to DTC P0132 or P0152. • Check the items that can cause an engine to run lean long term fuel trim near 24 percent. For a lean condition, refer to DTC P0131 or P0151.
Ignition System	• Wet down the secondary ignition system with water from a spray bottle. Wetting down the secondary ignition system may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply water. Check for proper ignition voltage output with *J 26792* Spark Tester. Refer to *Electronic Ignition (EI) System Diagnosis* for the procedure. • Remove the spark plugs and check for the following: – Correct heat range – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. • Gap the spark plugs using a wire gauge gap tool. Refer to *Spark Plug Replacement.* • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Monitor the Misfire Current Counters while driving the vehicle in the conditions that the misfire occurred. If a cylinder can be located with a misfire, use the DTC P0300 table for diagnosis. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.
Engine Cooling System	Check the engine thermostat for proper operation and for proper heat range. Refer to Thermostat Diagnosis in Engine Cooling.
Additional Checks	Check the generator output voltage. Refer to Diagnostic System Check – Engine Electrical in Engine Electrical for the procedure. Repair the charging system if the generator output voltage is less than 9 volts or more than 16 volts.

Cuts Out, Misses

Problem	Action
DEFINITION: Steady pulsation or jerking that follows engine speed, usually more pronounced as engine load increases. This condition is not normally felt above 1,500 RPM or 48 km/h (30 mph). The exhaust has a steady spitting sound at idle or low speed.	
Preliminary	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Remove the air filter element and check for dirt or for being restricted. Refer to Air Cleaner Element Replacement. Replace as necessary.

Cuts Out, Misses (cont'd)

<table>
<tr><th>Problem</th><th>Action</th></tr>
<tr><td>Fuel System</td><td>Check the fuel injectors. Refer to Fuel Injector Coil Test. Check for incorrect fuel pressure. Refer to Fuel System Diagnosis. Check for a restricted fuel filter. Refer to Fuel System Diagnosis. Check for a contaminated fuel condition. Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
Check items that cause an engine to run rich long term fuel trim near −13 percent. For a rich condition, refer to DTC P0132 or P0152.
Check items that can cause an engine to run lean long term fuel trim near 24 percent. For a lean condition, refer to DTC P0131 or P0151.</td></tr>
<tr><td>Sensor/System</td><td>Use a scan tool in order to monitor the knock sensor (KS) system for excessive spark retard activity.</td></tr>
<tr><td>Ignition System</td><td>Wet down the secondary ignition system with water from a spray bottle. Wetting down the secondary ignition system may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply water.
Check for proper ignition voltage output with J 26792 Spark Tester.
Remove the spark plugs and check for the following:
– Correct heat range
– Wet plugs Cracks
– Wear
– Improper gap
– Burned electrodes
– Heavy deposits
Refer to Spark Plug Inspection.
An improper spark plug gap will cause a driveability problem.
Gap the spark plugs using a wire gauge gap tool. Refer to Spark Plug Replacement.
Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to Spark Plug Inspection for diagnosis of fouled spark plugs.
Monitor the Misfire Current Counters while driving the vehicle in the conditions that the misfire occurred.
Check for loose ignition coil grounds. Refer to Electronic Ignition (EI) System Diagnosis.
Visually and physically inspect the secondary ignition for the following:
– Ignition wires arcing to ground
– Ignition wires for proper engagement to spark plug
– Ignition coils for cracks or carbon tracking</td></tr>
<tr><td>Engine Mechanical</td><td>Check engine mechanical for the following:
– Check compression—Refer to Engine Compression Test in Engine Mechanical 8.1L.
– Sticking or leaking valves Worn camshaft lobes
– Valve timing Bent push rods Worn rocker arms
– Broken valve springs
Excessive oil in combustion chamber—Leaking valve seals.
Refer to Oil Consumption Diagnosis in Engine Mechanical 8.1L.
Inspect the following components for incorrect basic engine parts:
– Camshaft
– Cylinder heads
– Pistons, etc.
Refer to the appropriate procedures in Engine Mechanical 8.1L for diagnosis procedures.</td></tr>
</table>

Cuts Out, Misses (cont'd)

Problem	Action
Additional Checks	• Inspect the following components of the exhaust system for possible restrictions: – The exhaust system for damaged or collapsed pipes – The exhaust manifold for a collapsed inner wall – The mufflers for heat distress or possible internal failure – The three-way catalytic converters for possible plugged conditions—Compare the exhaust system back pressure on each side of engine. Refer to *Restricted Exhaust* in Engine Exhaust. • Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A sudden increase in indicated RPM with little change in actual engine RPM change indicates EMI is present. Check for high voltage components near ignition control circuits if a problem exists. • Check the intake manifold and the exhaust manifold passages for casting flash.

Poor Fuel Economy

Problem	Action
DEFINITION: Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.	
Preliminary	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Check the owners driving habits. – Is the A/C ON or the Defroster mode ON full time? – Are the tires at the correct pressure? – Is there excessively heavy loads being carried? – Is the acceleration rate too much, too often? – Remove the air filter element and check for dirt or for being restricted. Refer to Air Cleaner Element Replacement. Replace as necessary.
Fuel System	• Check the type, quality, and alcohol content of the fuel. Oxygenated fuels have lower energy and may deliver reduced fuel economy. Refer to Fuel System Specifications and Alcohol/Contaminants-in-Fuel Diagnosis. • Check the fuel injectors. Refer to *Fuel Injector Coil Test*. • Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check that each injector harness is connected to the correct injector and cylinder according to the firing order: 1-8-7-2-6-5-4-3. Relocate the injector harnesses as necessary. Check for foreign material accumulation in the throttle bore, coking on the throttle valve, or on the throttle shaft. • Check items that cause an engine to run rich long term fuel trim near −13 percent. For a rich condition, refer to DTC P0132 or P0152.
Sensor/System	• Check the air intake system and crankcase for air leaks. • Check the crankcase ventilation valve for proper operation. Place a finger over the inlet hole in the valve end several times. The valve should snap back. If not, replace the valve. • Check for proper calibration of the speedometer. Connect *J 33431-B* Signal Generator to the vehicle speed sensor (VSS) electrical connector. Turn ON the ignition with the tester ON and monitor the speedometer. The speedometer should indicate 86 km/h (54 mph). • Use a scan tool in order to monitor the knock sensor (KS) system for excessive spark retard activity. Refer to *Knock Sensor (KS) System Description*.

Poor Fuel Economy (cont'd)

Problem	Action
Ignition System	• Check for proper ignition voltage output with *J 26792* Spark Tester. • Remove the spark plugs and check for the following: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. • Gap the spark plugs using a wire gauge gap tool. Refer to *Spark Plug Replacement.* • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Visually and physically inspect the secondary ignition for the following: – Ignition wires arcing to ground – Ignition wires for proper routing • Wetting down the secondary ignition system with water from a spray bottle may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply water. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.
Engine Cooling System	• Check the engine coolant level for being low. Refer to Loss of Coolant in Engine Cooling. • Check the engine thermostat for proper operation and for the correct heat range. Refer to Thermostat Diagnosis in Engine Cooling.
Engine Mechanical	• Check engine mechanical for the following: – Sticking or leaking valves – Worn camshaft lobes Valve timing – Bent push rods Worn rocker arms – Broken valve springs – Excessive oil in combustion chamber—Leaking valve seals. – Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. – Low cylinder compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Inspect the following components for incorrect basic engine parts: – Camshaft – Cylinder heads – Pistons, etc. • Refer to the appropriate procedures in Engine Mechanical 8.1L for diagnosis procedures.

Poor Fuel Economy (cont'd)

Problem	Action
Additional Checks	• Visually and physically check the vacuum hoses for splits, kinks, and proper connections and routing as shown on Vehicle Emission Control Information label. • Inspect the following components of the exhaust system for possible restrictions: – The exhaust system for damaged or collapsed pipes – The exhaust manifold for a collapsed inner wall – The mufflers for heat distress or possible internal failure – The three-way catalytic converters for possible plugged conditions—Compare the exhaust system back pressure on each side of engine. Refer to *Restricted Exhaust* in Engine Exhaust. • Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A scan tool can usually detect EMI by monitoring the engine RPM. A sudden increase in RPM with little change in actual engine RPM change indicates EMI is present. Check for high voltage components, near ignition control circuits, if a problem exists. • Check the park neutral position (PNP) switch circuit. • Check the intake and the exhaust manifold passages for casting flash. • Check the brake system for dragging or improper operation. Refer to Brake Caliper Inspection in Brakes. Ensure that the vehicle operator does not drive with a foot on the brake pedal.

Poor Fuel Fill Quality

Problem	Action
Difficult to fill	• Check valve stuck closed • Fill limiter vent valve stuck closed • Evaporative emission (EVAP) canister restricted • EVAP vent valve stuck closed • Restricted vapor lines • High reid vapor pressure or high fuel temperature • Fuel filler hose is pinched or kinked • Ignition ON
Over fill	• Pressure relief valve in fill limiter vent valve stuck open • Pressure relief valve in fill limiter vent valve is leaking • Fill limiter vent valve stuck open • Fill limiter vent valve is leaking
Premature shut-off of the fuel dispensing nozzle	• Fill limiter vent valve stuck closed EVAP canister restricted • EVAP vent valve stuck closed • Restricted vapor lines • High reid vapor pressure or high fuel temperature • Ignition switch ON
Fuel Spitback	• Check valve stuck open • Check valve stuck closed • Check valve leaking • High reid vapor pressure or high fuel temperature
Liquid to EVAP canister	• Fill limiter vent valve stuck open • Fill limiter vent valve leaking
Liquid leak to ground	• Pressure relief valve in fill limiter vent valve stuck open, or leaking • Fuel filler hose loose or torn • Fill limiter vent valve stuck open
Fuel Odor	• Pressure relief in fuel limiter vent valve stuck open, or leaking • Saturated EVAP canister

Rough, Unstable, or Incorrect Idle and Stalling

Problem	Action
DEFINITION: Engine runs unevenly at idle. If severe, the engine or vehicle may shake. Engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Checks	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*. • Remove and check the air filter element for dirt or for being restricted. Refer to Air Cleaner Element Replacement. Replace as necessary.
Fuel System	• Check the fuel injectors. Refer to *Fuel Injector Coil Test*. • Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check that each injector harness is connected to the correct injector/cylinder according to the firing order: 1-8-7-2-6-5-4-3. Relocate injector harnesses as necessary. • Check items that cause an engine to run rich long term fuel trim near −13 percent. For a rich condition, refer to DTC P0132 or P0152. • Check items that can cause an engine to run lean long term fuel trim near 24 percent. For a lean condition, refer to DTC P0131 or P0151.
Sensor/System	• Check the crankcase ventilation valve for proper operation. Place a finger over the inlet hole of the valve end several times. The valve should snap back. If not, replace the valve. • Use a scan tool in order to monitor the knock sensor (KS) system for excessive spark retard activity.
Ignition System	• Check for proper ignition voltage output with *J 26792* Spark Tester. Refer to *Electronic Ignition (EI) System Diagnosis* for procedure. • Remove spark plugs and check for the following: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. • Gap the spark plugs using a wire gauge gap tool. Refer to Spark Plug Replacement. • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Visually and physically inspect the secondary ignition for the following: – Ignition wires arcing to ground – Ignition wires for proper routing • Wetting down the secondary ignition system with water from a spray bottle may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply water. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.

Rough, Unstable, or Incorrect Idle and Stalling (cont'd)

Problem	Action
Engine Mechanical	• Check engine mechanical for the following: – Check compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. – Sticking or leaking valves Worn camshaft lobes – Valve timing Bent push rods Worn rocker arms – Broken valve springs – Excessive oil in combustion chamber—Leaking valve seals. – Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. – Low cylinder compression. Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Inspect the following components for incorrect basic engine parts: – Camshaft – Cylinder heads – Pistons, etc. • Refer to the appropriate procedures in Engine Mechanical 8.1L for diagnosis procedures.
Additional Checks	• Inspect the following components of the exhaust system for possible restrictions: – The exhaust system for damaged or collapsed pipes – The exhaust manifold for a collapsed inner wall – The mufflers for heat distress or possible internal failure – The three-way catalytic converters for possible plugged conditions—Compare the exhaust system back pressure on each side of engine. Refer to *Restricted Exhaust* in Engine Exhaust. • Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A scan tool can usually detect EMI by monitoring the engine RPM. A sudden increase in RPM with little change in actual engine RPM change indicates that EMI is present. If a problem exists, check routing of secondary ignition wires or high voltage components near the ignition control circuits. • Check the park neutral position (PNP) switch circuit. • Check for faulty motor mounts. Refer to Engine Mount Inspection in Engine Mechanical 8.1L. • Check the intake manifold and the exhaust manifold passages for casting flash.

Dieseling, Run-On

Problem	Action
DEFINITION: Engine continues to run after key is turned OFF, but runs very rough. If the engine runs smooth, check the ignition switch and the ignition switch adjustment.	
Preliminary Checks	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*.
Fuel System	• Inspect the injectors for a leaking condition. Refer to *Fuel System Diagnosis* for the proper procedure. • Diagnostic Information and Procedures

Backfire

Problem	Action
DEFINITION: Fuel ignites in the intake manifold or in the exhaust system, making a loud popping noise.	
Preliminary Checks	• Refer to *Important Preliminary Checks Before Starting in Symptoms – Engine Controls*. • Search for bulletins. • Check the powertrain control module (PCM) grounds for being clean, tight, and in the proper locations. Refer to *Engine Controls Schematics*.
Fuel System	• Check for incorrect fuel pressure. Refer to *Fuel System Diagnosis*. • Check for a restricted fuel filter. Refer to *Fuel System Diagnosis*. • Check for a contaminated fuel condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis*. • Check the fuel injectors. Refer to *Fuel Injector Coil Test*. • Check that each injector harness is connected to the correct injector or cylinder according to the firing order: 1-8-7-2-6-5-4-3. Relocate injector harnesses as necessary.
Sensor/System	• Check the air intake system and crankcase for air leaks. • Check the crankcase ventilation valve for proper operation. Place a finger over the inlet hole in the valve end several times. The valve should snap back. If not, replace the valve. • Check for proper calibration of speedometer. Connect *J 33431-B* • Signal Generator to the vehicle speed sensor (VSS) electrical connector. Ignition ON, tester ON and monitor the speedometer. The speedometer should indicate 86 km/h (54 mph). • Use a scan tool in order to monitor the knock sensor (KS) system for excessive spark retard activity. Refer to *Knock Sensor (KS) System Description*.
Ignition System	• Check for proper ignition voltage output with *J 26792* Spark Tester. • Check for an intermittent ignition system malfunction in the following circuits: – Intermittent ignition control circuit – Use the scan tool's Snapshot feature in order to help locate an intermittent ignition failure. • Remove spark plugs and check for the following: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Refer to *Spark Plug Inspection*. • An improper spark plug gap will cause a driveability problem. Gap the spark plugs using a wire gauge gap tool. Refer to *Spark Plug Replacement.* • Determine the cause of the fouling before replacing the spark plugs if the spark plugs are gas, coolant, or oil fouled. Refer to *Spark Plug Inspection* for diagnosis of fouled spark plugs. • Visually and physically inspect the secondary ignition for the following: – Ignition wires arcing to ground – Ignition wires for proper routing • Wetting down the secondary ignition system with water from a spray bottle may help locate damaged or deteriorated components. Look and listen for arcing or misfiring as you apply water. • Check for loose ignition coil grounds. Refer to *Electronic Ignition (EI) System Diagnosis*.

Backfire (cont'd)

Problem	Action
Engine Cooling System	• Check the engine coolant level for being low. Refer to Loss of Coolant in Engine Cooling. • Check the engine thermostat for proper operation and for the correct heat range. Refer to Thermostat Diagnosis in Engine Cooling.
Engine Mechanical	• Check engine mechanical for the following: – Sticking or leaking valves – Worn camshaft lobes Valve timing – Bent push rods Worn rocker arms – Broken valve springs – Excessive oil in combustion chamber—Leaking valve seals. • Refer to *Oil Consumption Diagnosis* in Engine Mechanical 8.1L. • Low cylinder compression—Refer to *Engine Compression Test* in Engine Mechanical 8.1L. • Inspect the following components for incorrect basic engine parts: – Camshaft – Cylinder heads – Pistons, etc. • Refer to the appropriate procedures in Engine Mechanical 8.1L for diagnosis procedures.
Additional Checks	• Visually and physically check the vacuum hoses for splits, kinks, and proper connections and routing as shown on the Vehicle Emission Control Information label. • Check the intake manifold and the exhaust manifold passages for casting flash. • Inspect the following components of the exhaust system for possible restrictions: – The exhaust system for damaged or collapsed pipes – The exhaust manifold for a collapsed inner wall – The mufflers for heat distress or possible internal failure – The three-way catalytic converters for possible plugged conditions—Compare the exhaust system back pressure on each side of engine. Refer to *Restricted Exhaust* in Engine Exhaust. – Electromagnetic interference (EMI) on the reference circuit can cause an engine miss condition. A scan tool can usually detect EMI by monitoring the engine RPM. A sudden increase in RPM with little change in actual engine RPM change may indicate that EMI is present. If a problem exists, check for high voltage components near the ignition control circuits. Check the park/neutral position (PNP) switch operation. • Check for faulty motor mounts. Refer to Engine Mount Inspection in Engine Mechanical 8.1L. • Check the intake manifold and the exhaust manifold passages for casting flash

Engine Cranks but Does Not Run

Description

The Engine Cranks but Does Not Run diagnostic table is an organized approach to identifying a condition that causes an engine not to start. The Engine Cranks but Does Not Run diagnostic table directs the service technician to the appropriate system diagnosis. The Engine Cranks but Does Not Run diagnostic table assumes the following:

- The battery is completely charged. Refer to Battery Inspection/Test in Engine Electrical.
- The cranking speed is within specifications. Refer to Engine Cranks Slowly in Engine Electrical.
- There is adequate fuel in the fuel tank.

Diagnostic Aids

Inspect for the following conditions:

- Mass air flow (MAF) is compared to a calculated mass air flow based upon the manifold absolute pressure (MAP), throttle position (TP), and engine RPM readings. A skewed or unresponsive MAP sensor at KEY ON will cause the predicted air flow value to be inaccurate. Compare MAP and TP sensor values to that of a known good vehicle.
- Faulty engine coolant temperature (ECT) sensor—Using a scan tool, compare engine coolant temperature with intake air temperature (IAT) on a completely cool engine. Engine coolant temperature should be within 3° C (5° F) of the intake air temperature. If not, replace the ECT sensor. Refer to *Engine Coolant Temperature (ECT) Sensor Replacement*.
- For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The number below refers to the step number on the diagnostic table.

3. This step determines if the fuel pump is operating electrically.

Engine Cranks But Does Not Run

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the DTC information. Does the scan tool display DTCs P0230, P0335, P0336, P0601, P0602, _P0604, P0606, P1626, or P1631?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	With a scan tool, command the fuel pump ON. Does the fuel pump turn ON?	—	Go to *Step 4*	Go to *Fuel Pump Electrical Circuit Diagnosis*
4	1. Turn OFF the ignition. 2. Install the J 34730-1A Fuel Pressure Gauge. Refer to Fuel Pressure Gage Installation and Removal. 3. Turn ON the ignition, with the engine OFF. 4. With a scan tool, command the fuel pump ON. Is the fuel pressure within the specified range while the fuel pump is operating?	384-425 kPa (55-62 psi)	Go to *Step 5*	Go to *Fuel System Diagnosis*
5	1. Turn OFF the ignition. 2. Disconnect an injector connector. 3. Install the *J 34730-405* Injector Test Lamp to the injector connector. 4. Attempt to start the engine. Does the test lamp blink while the engine is cranking?	—	Go to *Step 6*	Go to *DTC P0200*
6	1. Turn OFF the ignition. Disconnect a spark plug wire. 2. Install the *J 26792* Spark Tester to the spark plug wire. 3. Attempt to start the engine. Does the spark tester spark?	—	Go to *Step 7*	Go to *Electronic Ignition (EI) System Diagnosis*
7	Inspect for the following conditions: • Collapsed air intake duct • Restricted air filter element—Refer to Air Cleaner Element Replacement. • Spark plugs for being gas or coolant fouled—Refer to *Spark Plug Inspection*. If the spark plugs are fouled, determine what caused the condition. • Engine mechanical condition (worn timing chain and gears, low compression, etc.)–Refer to Symptoms – Engine Mechanical in Engine Mechanical 8.1L. • Restricted exhaust system—Refer to *Restricted Exhaust* in Engine Exhaust. • The engine coolant temperature (ECT) sensor is NOT close to the actual engine temperature. Refer to DTC P0117 or DTC P0118. • Compare MAP/BARO parameters to another vehicle. The parameters should be close in value. Refer to DTC P0102 or DTC P0103. • TP sensor for being stuck in range Did you find and correct the condition?	—	Go to *Step 8*	Go to *Diagnostic Aids*
8	1. With a scan tool, clear the DTCs. 2. Attempt to start the engine. Does the engine start and continue to operate?	—	Go to *Step 9*	Go to *Step 2*

Engine Cranks But Does Not Run (cont'd)

Step	Action	Value(s)	Yes	No
9	1. Idle the engine. 2. Allow the engine to reach operating temperature. 3. With a scan tool, observe the DTC Information. Are any DTCs displayed?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 10*
10	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

Fuel Pump Electrical Circuit Diagnosis

Circuit Description

When the ignition is turned ON, the powertrain control module (PCM) will turn ON the in-tank fuel pump. The in-tank fuel pump will remain ON as long as the engine is cranking or running and the PCM is receiving reference pulses. If there are no reference pulses, the PCM will turn the in-tank fuel pump OFF 2 seconds after the ignition is turned ON or 2 seconds after the engine stops running.

Diagnostic Aids

A fuel pump prime terminal is available at the underhood bussed electrical center (UBEC). Refer to the UBEC cover for terminal location.

The following conditions may have caused the fuel pump fuse to open:

- The fuse is faulty.
- There is an intermittent short in the fuel pump power feed circuit.
- The fuel pump has an intermittent internal problem.

For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Command both the ON and OFF states. Repeat the commands as necessary.
3. This step determines if the condition is located on the coil side or the switch side of the circuit.
4. This step verifies that the PCM is providing voltage to the fuel pump relay.
5. This step tests for an open in the ground circuit to the fuel pump relay.
6. This step determines if a voltage is constantly being applied to the fuel pump relay.
12. To gain access to the fuel pump connector, the fuel tank may need to be removed.
13. This step determines if the condition with the circuit is intermittent. If the fuse does not open, inspect the supply voltage circuit between the fuse and the fuel pump for an intermittent condition.
15. Use the same amperage fuse in the jumper as is used to protect the fuel pump circuit.
16. To gain access to the fuel pump connector, the fuel tank may need to be removed.
17. Inspect the ground connection for the fuel pump. Be certain all ground connections are clean and tight.

Fuel Pump Electrical Diagnosis

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics-8.1L*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With a scan tool, command the fuel pump relay ON and OFF. Does the fuel pump turn ON and OFF?	—	Go to *Diagnostic Aids*	Go to *Step 3*
3	With a scan tool, command the fuel pump relay ON and OFF. Do you hear a click when you command the fuel pump relay ON and OFF?	—	Go to *Step 9*	Go to *Step 4*

Fuel Pump Electrical Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the fuel pump relay. 3. Turn ON the ignition, with the engine OFF. 4. Probe the control circuit of the fuel pump relay with a test lamp that is connected to a good ground. 5. With a scan tool, command the fuel pump relay ON and OFF. Does the test lamp turn ON and OFF?	—	Go to *Step 5*	Go to *Step 6*
5	1. Connect a test lamp between the control circuit of the fuel pump relay and the ground circuit of the fuel pump relay. 2. With a scan tool, command the fuel pump relay ON and OFF. Does the test lamp turn ON and OFF?	—	Go to *Step 19*	Go to *Step 22*
6	Does the test lamp remain illuminated with each command?	—	Go to *Step 7*	Go to *Step 8*
7	Test the control circuit of the fuel pump relay for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 26*
8	Test the control circuit of the fuel pump relay for a short to ground or an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 20*
9	Turn ON the ignition, with the engine OFF. Does the fuel pump operate continuously?	—	Go to *Step 10*	Go to *Step 11*
10	1. Turn OFF the ignition. Disconnect the fuel pump relay. 2. Turn ON the ignition, with the engine OFF. Does the fuel pump operate continuously?	—	Go to *Step 21*	Go to *Step 25*
11	Is the fuel pump fuse open?	—	Go to *Step 12*	Go to *Step 14*
12	1. Test the supply voltage circuit of the fuel pump for a grounded circuit between the fuel pump fuse and the fuel pump. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. 2. Replace the fuel pump fuse if necessary. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 13*
13	1. Install all disconnected electrical components. Install a new fuel pump fuse. 2. With a scan tool, turn ON the fuel pump. Is the fuel pump fuse open?	—	Go to *Step 24*	Go to *Intermittent Conditions*
14	1. Turn OFF the ignition. Disconnect the fuel pump relay. 2. Turn ON the ignition, with the engine OFF. 3. Probe the battery voltage circuit of the fuel pump relay switch with a test lamp that is connected to a good ground. Does the test lamp illuminate?	—	Go to *Step 15*	Go to *Step 23*
15	Connect a 20-amp fused jumper wire between the battery voltage circuit of the fuel pump relay switch and the supply voltage circuit of the fuel pump. Does the fuel pump operate?	—	Go to *Step 19*	Go to *Step 16*
16	Test the supply voltage circuit of the fuel pump for an open or high resistance between the fuel pump relay and the fuel pump. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 17*

Fuel Pump Electrical Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
17	**Important:** Inspect the ground circuit for being tight, corrosion on terminals, or damage to the wiring harness. Test the ground circuit of the fuel pump for an open or high resistance. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 18*
18	Inspect for poor connections at the fuel pump. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 24*
19	Inspect for poor connections at fuel pump relay. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 25*
20	Inspect for poor connections at the harness connector of the PCM. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 26*
21	Repair the supply voltage circuit of the fuel pump for a short to voltage. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
22	Repair the open fuel pump relay ground circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
23	Repair the battery voltage circuit of the fuel pump relay switch. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
24	**Important:** Inspect for poor connections at the fuel pump, within the fuel tank, before replacing the fuel pump. 1. Replace the fuel pump. Refer to *Fuel Sender Assembly Replacement*. 2. Replace the fuel pump fuse if necessary. Did you complete the replacement?	—	Go to *Step 27*	—
25	Replace the fuel pump relay. Did you complete the replacement?	—	Go to *Step 27*	—
26	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 27*	—
27	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to *Step 2*

Fuel System Diagnosis

System Description

When the ignition is turned ON, the powertrain control module (PCM) will turn ON the in-tank fuel pump. The in-tank fuel pump will remain ON as long as the engine is cranking or running and the PCM is receiving ignition reference pulses. If there are no ignition reference pulses, the PCM will turn the in-tank fuel pump OFF 2 seconds after the ignition is turned ON or 2 seconds after the engine stops running.

The in-tank fuel pump is an electric pump attached to the fuel sender assembly. The fuel pump is designed to provide fuel at a pressure above the pressure needed by the fuel injectors. A fuel pressure regulator, in the fuel tank, keeps the fuel available to the fuel injectors at a regulated pressure.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step verifies that the fuel pump is operating.
4. This step tests for an internal fuel leak. If the fuel pressure drops during this test, then an internal loss of pressure is indicated.

10. This step tests for a loss of fuel pressure between the fuel feed pipe shut-off adapter and the fuel pump.
11. This step tests for a leaking fuel injector, or fuel pressure regulator. If the fuel pressure remains constant during this test, the fuel injectors are not leaking fuel.
16. This step determines if the fuel pressure regulator, or the fuel pump, is the cause of the low fuel pressure. If the pressure rises above the specified value, the fuel pump is OK.
18. This step verifies that a circuit condition is not the cause of a fuel pressure concern. Inspect all fuel pump electrical circuits thoroughly.

Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
Schematic Reference: *Fuel System Diagnosis Figure*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	**Important:** Inspect the fuel system for damage, or external leaks, before proceeding with this diagnostic. 1. Turn ON the ignition, with the engine OFF. 2. Command the fuel pump ON with a scan tool. Does the fuel pump operate?	—	Go to *Step 3*	Go to *Fuel Pump Electrical Circuit Diagnosis*
3	**Important:** Verify there is adequate fuel in the fuel tank before proceeding with this diagnostic. 1. Turn OFF the ignition. 2. Turn OFF all of the accessories. ***Caution: Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete. in Cautions and Notices.*** 3. Install the *J 34730-1A* Fuel Pressure Gauge. 4. Place the bleed hose of the fuel pressure gauge into an approved gasoline container. 5. Turn ON the ignition, with the engine OFF. 6. Command the fuel pump ON with a scan tool. 7. Bleed the air out of the fuel pressure gauge. **Important:** It may be necessary to command the fuel pump ON several times, in order to obtain the highest possible fuel pressure. 8. Do not start the engine. 9. Command the fuel pump ON with a scan tool. 10. Observe the fuel pressure gauge, with the fuel pump commanded ON. Is the fuel pressure within the specified value?	384–425 kPa (55-62 psi)	Go to *Step 4*	Go to *Step 12*
4	**Important:** The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant. Monitor the fuel pressure gauge for 1 minute. Does the fuel pressure drop more than the specified value?	34 kPa (5 psi)	Go to *Step 9*	Go to *Step 5*

Fuel System Diagnosis (cont'd)

Step	Action	Values	Yes	No
5	1. Relieve the fuel pressure to the first specified value. 2. Monitor the fuel pressure gauge for 5 minutes. Does the fuel drop more than the second specified value?	69 kPa (10 psi) 14 kPa (2 psi)	Go to Step 24	Go to Step 6
6	1. Turn OFF the ignition for 15 seconds. 2. Turn ON the ignition, with the engine OFF. 3. Monitor the fuel pressure gauge. 4. Start the engine. Does the fuel pressure drop the specified value when the engine is started?	21-69 kPa (3-10 psi)	Go to Step 7	Go to Step 8
7	1. Operate the vehicle within the conditions of the customers concern. 2. Monitor the fuel related parameters with a scan tool. Do any of the scan tool parameters indicate a lean condition?	—	Go to Step 17	Go to Symptoms - Engine Controls
8	1. Disconnect the vacuum hose from the fuel pressure regulator. 2. Monitor the fuel pressure gauge. 3. Idle the engine. 4. Apply 12-14 inches of vacuum to the fuel pressure regulator with a hand held vacuum pump. Does the fuel pressure drop the specified value when the vacuum is applied?	21-69 kPa (3-10 psi)	Go to Step 21	Go to Step 23
9	1. Turn OFF the ignition. 2. Remove the vacuum hose from the fuel pressure regulator. 3. Turn ON the ignition, with the engine OFF. 4. Command the fuel pump ON with a scan tool. 5. Inspect for a fuel leak from the fuel pressure regulator vacuum port. Is the fuel pressure regulator leaking fuel?	—	Go to Step 23	Go to Step 10
10	1. Turn OFF the ignition. 2. Relieve the fuel pressure. Refer to Fuel Pressure Relief Procedure. 3. Disconnect the fuel feed hose and the fuel return hose from the fuel rail pipes. Refer to Quick Connect Fitting(s) Service (Metal Collar). 4. Install the J 37287 Fuel Pipe Shut-off adapters between the fuel hoses and the fuel rail pipes. 5. Open the valves on the fuel pipe shut-off adapters. 6. Turn ON the ignition, with the engine OFF. 7. Command the fuel pump ON with a scan tool. 8. Bleed the air from the fuel pressure gauge. 9. Command the fuel pump ON and then OFF with a scan tool. 10. Close the fuel feed pipe shut-off valve. 11. Monitor the fuel pressure gauge for 1 minute. Does the fuel pressure remain constant?	—	Go to Step 19	Go to Step 11

Fuel System Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
11	1. Turn OFF the ignition. 2. Open the fuel feed pipe shut-off valve. 3. Turn ON the ignition, with the engine OFF. 4. Command the fuel pump ON and then OFF with a scan tool. 5. Close the fuel return pipe shut-off valve. 6. Monitor the fuel pressure gauge for 1 minute. Does the fuel pressure remain constant?	—	Go to *Step 23*	Go to *Step 20*
12	Is the fuel pressure above the specified value?	427 kPa (62 psi)	Go to *Step 14*	Go to *Step 13*
13	Is the fuel pressure above the specified value?	0 kPa (0 psi)	Go to *Step 16*	Go to *Step 17*
14	1. Turn OFF the ignition. 2. Relieve the fuel pressure. Refer to *Fuel Pressure Relief Procedure*. 3. Disconnect the fuel return hose from the fuel rail return pipe. Refer to Quick Connect Fitting(s) Service (Metal Collar). 4. Attach a length of flexible fuel hose to the fuel rail outlet passage. 5. Place the open end of the flexible fuel hose into an approved gasoline container. 6. Turn ON the ignition, with the engine OFF. 7. Monitor the fuel pressure gauge while the fuel pump is operating. Is the fuel pressure within the specified value?	385-425 kPa (55-62 psi)	Go to *Step 22*	Go to *Step 15*
15	Inspect the fuel rail return pipe and fuel rail outlet passage for a restriction. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 23*
16	1. Turn OFF the ignition. 2. Relieve the fuel pressure. Refer to *Fuel Pressure Relief Procedure*. 3. Disconnect the fuel return hose from the fuel rail return pipe. Refer to Quick Connect Fitting(s) Service (Metal Collar). 4. Install the fuel pipe shut-off adapter between the fuel return pipe and the fuel rail. 5. Open the valve in the fuel pipe shut-off adapter. 6. Turn ON the ignition with the engine OFF. 7. Command the fuel pump ON with a scan tool. 8. Bleed the air from the fuel system. 9. Monitor the fuel pressure gauge. ***Notice:*** Do not allow the fuel pressure to exceed 517 kPa (100 psi). Excessive pressure may damage the fuel system. 10. Slowly close the valve in the fuel return pipe shut-off adapter. 11. Command the fuel pump ON with a scan tool. Does the fuel pressure rise above the specified value?	425 kPa (62 psi)	Go to *Step 23*	Go to *Step 17*
17	Inspect the following for a restriction: • Fuel filter • Fuel feed pipe Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 18*

Fuel System Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
18	Inspect the harness connectors and ground circuits of the fuel pump for poor connections. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 19*
19	1. Remove the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*. 2. Inspect the following items: • The fuel pump flex hose for damage • The in-tank fuel pump harness connectors for poor connections • The fuel strainer for a restriction • Contaminates in the fuel tank Did you find and correct the condition?	—	Go to *Step 25*	Go to *Step 24*
20	1. Turn OFF the ignition. 2. Raise the fuel rail, with the fuel lines connected. Refer to *Fuel Rail Assembly Replacement*. 3. Turn ON the ignition, with the engine OFF. 4. Command the fuel pump ON with a scan tool. 5. Locate and replace the leaking fuel injector. Refer to Fuel Injector Replacement. Is the replacement complete?	—	Go to *Step 25*	—
21	Locate and repair the restricted fuel return line. Is the repair complete?	—	Go to *Step 25*	—
22	Replace the fuel pressure regulator. Refer to Fuel Pressure Regulator Replacement. Is the replacement complete?	—	Go to *Step 25*	—
23	Replace the fuel pump. Refer to *Fuel Sender Assembly Replacement*. Is the replacement complete?	—	Go to *Step 25*	—
24	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to *Step 3*

Fuel Injector Coil Test

Circuit Description

The powertrain control module (PCM) enables the appropriate fuel injector on the intake stroke for each cylinder. A voltage is supplied directly to the fuel injectors. The PCM controls each fuel injector by grounding the control circuit via a solid state device called a driver. A fuel injector coil winding resistance that is too high, or low, will affect engine driveability. A fuel injector control circuit DTC may not set, but a misfire may be apparent. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

Diagnostic Aids

- Monitoring the misfire current counters, or misfire graph, may help isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.

- Perform the fuel injector coil test within the conditions of the customers concern. A fuel injector condition may only be apparent at a certain temperature, or under certain conditions.
- If the fuel injector coil test does not isolate the condition perform the fuel injector balance test. Refer to Fuel Injector Balance Test with Special Tool or Fuel Injector Balance Test with Tech 2.

Test Description

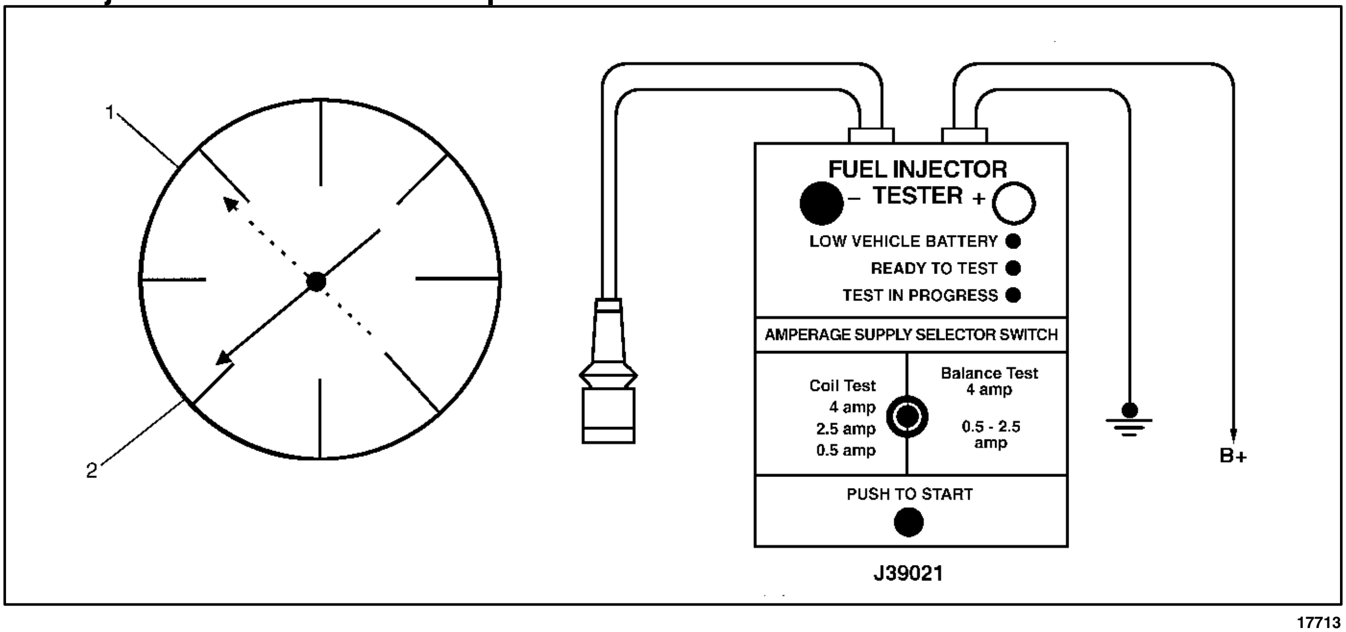
The numbers below refer to the step numbers on the diagnostic table.

3. This step tests each fuel injector resistance within a specific temperature range. If any of the fuel injectors display a resistance outside of the specified value, replace the fuel injector.
4. This step determines if all of the fuel injectors are within 3 ohms of each other. If the highest resistance value is within 3 ohms of the lowest resistance value, then all of the fuel injector coil windings are OK.
5. This step determines which fuel injector is faulty. After subtracting the highest and lowest resistance values from the average value, replace the fuel injector that has the greatest resistance difference from the average.

Fuel Injector Coil Test

Step	Action	Value(s)	Yes	No
Schematic Reference: *Fuel Injector Controls*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Observe the engine coolant temperature (ECT) with a scan tool. Is the ECT value within the specified range?	10-32°C (50-90°F)	Go to *Step 3*	Go to *Step 4*
3	Measure the resistance of each fuel injector with a DMM. Refer to *Testing for Continuity* in Wiring Systems. Do any of the fuel injectors display a resistance outside the specified range?	11-14 ohm	Go to *Step 6*	Go to *Diagnostic Aids*
4	1. Measure the resistance of each fuel injector with a DMM. Refer to *Testing for Continuity* in Wiring Systems. 2. Record each fuel injector value. 3. Subtract the lowest resistance value from the highest resistance value. Is the difference equal to or less than the specified value?	3 ohm	Go to *Diagnostic Aids*	Go to *Step 5*
5	1. Add all of the fuel injector resistance values, to obtain a total resistance value. 2. Divide the total resistance value by the number of fuel injectors, to obtain an average resistance value. 3. Subtract the lowest, and the highest, individual fuel injector resistance values from the average resistance value. 4. Replace the fuel injector that displays the greatest resistance difference, above or below the average. Refer to Fuel Injector Replacement. Did you complete the replacement?	—	Go to *Step 7*	—
6	Replace the fuel injector or fuel injectors that are out of the specified range. Refer to Fuel Injector Replacement. Did you complete the replacement?	11-14 ohm	Go to *Step 7*	—
7	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to *Step 2*

Fuel Injector Balance Test with Special Tool



(1) First Reading
(2) Second Reading

Fuel Injector Balance Test Example (Typical)

Cylinder	1	2	3	4
1st Reading	296 kPa (43 psi)	296 kPa (43 psi)	296 kPa (43 psi)	296 kPa (43 psi)
2nd Reading	131 kPa (19 psi)	117 kPa (17 psi)	124 kPa (18 psi)	145 kPa (21 psi)
Amount of Drop	165 kPa (24 psi)	179 kPa (26 psi)	172 kPa (25 psi)	151 kPa (22 psi)
Average Range:156-176 kPa (22.5-25.5 psi)	Injector OK	Replace fuel injector – too much fuel pressure drop	Injector OK	Replace fuel injector – too little fuel pressure drop

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. The engine coolant temperature (ECT) must be below the operating temperature in order to avoid irregular fuel pressure readings due to hot soak fuel boiling.
6. If the pressure drop value for each fuel injector is within 10 kPa (1.5 psi) of the average pressure drop value, the fuel injectors are flowing properly. Calculate the pressure drop value for each fuel injector by subtracting the second pressure reading from the first pressure reading. Refer to the illustration above.

Fuel Injector Balance Test Procedure

Step	Action	Value(s)	Yes	No
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Did you perform the fuel injector coil test?	—	Go to *Step 3*	Go to *Fuel Injector Coil Test*
3	**Important:** Do not perform this test if the engine coolant temperature is above 94°C (201°F). Observe the ECT parameter with a scan tool. Does the scan tool indicate that the ECT parameter is less than the specified value?	94°C (201°F)	Go to *Step 4*	—
4	**Important:** Verify there is adequate fuel in the fuel tank before proceeding with this diagnostic. 1. Turn OFF the ignition. 2. Install the fuel pressure gage. Refer to Fuel Pressure Gage Installation and Removal. 3. Turn ON the ignition, with the engine OFF. 4. Command the fuel pump ON with a scan tool. **Important:** • It may be necessary to command the fuel pump ON a few times, in order to obtain the highest possible fuel pressure. • Do not start the engine. 5. Observe the fuel pressure gage, with the fuel pump commanded ON. Is the fuel pressure within the specified range?	384-425 kPa (55-62 psi)	Go to *Step 5*	Go to Fuel System Diagnosis
5	**Important:** The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant. Monitor the fuel pressure gage for 1 minute. Does the fuel pressure drop more than the specified value?	34 kPa (5 psi)	Go to *Fuel System Diagnosis*	Go to *Step 6*

Fuel Injector Balance Test Procedure (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Connect the *J 39021* Fuel Injector Tester and the *J 39021-380* Fuel Injector Test Harness to a fuel injector. 2. Set the amperage supply selector switch on the fuel injector tester to the Balance Test 0.5-2.5 amp position. 3. Command the fuel pump ON and then OFF with a scan tool. 4. Record the fuel pressure indicated by the fuel pressure gauge after the fuel pressure stabilizes. This is the first pressure reading. **Important:** Record the fuel pressure value immediately after the fuel injector stops pulsing. The fuel pressure may rise after the fuel injector stops pulsing. Do not record the higher fuel pressure value. 5. Energize the fuel injector by depressing the Push to Start Test button on the fuel injector tester. 6. Record the fuel pressure indicated by the fuel pressure gauge. This is the second fuel pressure reading. 7. Repeat steps 1-6 for each fuel injector. 8. Subtract the second pressure reading from the first pressure reading for one fuel injector. The result is the pressure drop value. 9. Obtain a pressure drop value for each fuel injector. 10. Add all of the individual pressure drop values. This is the total pressure drop. 11. Divide the total pressure drop by the number of fuel injectors. This is the average pressure drop. Does any fuel injector have a pressure drop value that is more than the average pressure drop or less than the average pressure drop by the specified value?	10 kPa (1.5 psi)	Go to *Step 7*	Go to Symptoms – Engine Controls
7	Replace the affected fuel injector. Refer to Fuel Injector Replacement. Did you complete the replacement?	—	Go to *Step 8*	
8	Operate the vehicle in order to verify the repair. Does a driveability condition still exist?	—	Go to *Symptoms – Engine Controls*	System OK

Fuel Injector Balance Test with Tech 2

Circuit Description

The scan tool first energizes the fuel pump and then the injectors for a precise amount of time allowing a measured amount of fuel into the manifold. This causes a drop in system fuel pressure that can be recorded and used to compare each injector.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. The engine coolant temperature (ECT) must be below the operating temperature in order to avoid irregular fuel pressure readings due to hot soak fuel boiling.
4. The fuel pressure should be within the specified range. Refer to *Fuel System Diagnosis* if the fuel pressure is not within the specified range.
5. The fuel pressure should reach a steady value. Refer to *Fuel System Diagnosis* if the fuel pressure does not stabilize.
6. If the pressure drop value for each fuel injector is within 10 kPa (1.5 psi) of the average pressure drop value, the fuel injectors are flowing properly. Calculate the pressure drop value for each fuel injector by subtracting the second pressure reading from the first pressure reading.

Fuel Injector Balance Test with Tech 2

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Did you perform the fuel injector coil test?	—	Go to *Step 3*	Go to *Fuel Injector Coil Test*
3	**Important:** Do not perform this test if the engine coolant temperature is above 94°C (201°F). Observe the ECT parameter with a scan tool. Does the scan tool indicate that the ECT parameter is less than the specified value?	94°C (201°F)	Go to *Step 4*	
4	**Important:** Verify there is adequate fuel in the fuel tank before proceeding with this diagnostic. 1. Turn OFF the ignition. 2. Turn OFF all of the accessories. 3. Install the fuel pressure gage. Refer to Fuel Pressure Gage Installation and Removal. 4. Turn ON the ignition, with the engine OFF. 5. Command the fuel pump ON with a scan tool. **Important:** It may be necessary to command the fuel pump ON a few times in order to obtain the highest possible fuel pressure. 6. Do not start the engine. 7. Observe the fuel pressure gage, with the fuel pump commanded ON. Is the fuel pressure within the specified value?	384-425 kPa (55-62 psi)	Go to *Step 5*	Go to *Fuel System Diagnosis*
5	**Important:** The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant. Monitor the fuel pressure gage for 1 minute. Does the fuel pressure drop more than the specified value?	34 kPa (5 psi)	Go to Fuel System Diagnosis	Go to *Step 6*

Fuel Injector Balance Test with Tech 2 (cont'd)

Step	Action	Value(s)	Yes	No
6	1. With a scan tool, select the Fuel Injector Balance Test function, within the Special Functions menu. 2. Select an injector to be tested. 3. Press Enter. This will prime the fuel system. **Important:** Record the fuel pressure value immediately after the fuel injector stops pulsing. The fuel pressure may rise after the fuel injector stops pulsing. Do not record the higher fuel pressure value. Record the fuel pressure indicated by the fuel pressure gauge after the fuel pressure stabilizes. This is the 1st pressure reading. 4. Energize the fuel injector by depressing the Pulse Injector button on the scan tool. This will energize the injector and decrease the fuel pressure. 5. Record the fuel pressure indicated by the fuel pressure gauge after the fuel injector has stopped pulsing. This is the 2nd pressure reading. 6. Press Enter again to bring you back to the Select Injector screen. 7. Repeat for each fuel injector. 8. Subtract the 2nd pressure reading from the 1st pressure reading for one fuel injector. The result is the pressure drop value. 9. Obtain a pressure drop value for each fuel injector. 10. Add all of the individual pressure drop values. This is the total pressure drop. 11. Divide the total pressure drop by the number of fuel injectors. This is the average pressure drop. Does any fuel injector have a pressure drop value that is either higher than the average pressure drop or lower than the average pressure drop by the specified value?	10 kPa (1.5 psi)	Go to *Step 7*	Go to *Symptoms – Engine Controls*
7	Replace the affected fuel injector. Refer to Fuel Injector Replacement. Did you complete the replacement?	—	Go to *Step 8*	—
8	Operate the vehicle in order to verify the repair. Does a driveability condition still exist?	—	Go to *Symptoms – Engine Controls*	System OK

Fuel Tank Leak Test

The diagnosis of fuel odor may be a condition of leaking fuel tank, filler neck, or filler cap. A defective filler cap, or a plugged or pinched vent pipe can cause a collapsed fuel tank. Loose mounting straps or foreign material in tank may be the cause of a rattle at the fuel tank.

Leak Check Procedure

Caution: Place a dry chemical (Class B) fire extinguisher near the area before performing a Fuel Tank Leak Check. Before removing the fuel tank for a suspected leak, make sure that the fuel pipes or the tubes are not leaking onto the tank. Once removed, make sure that the fuel is not leaking around the fuel sender O-ring. Failure to follow these precautions may result in personal injury.

1. This check requires the fuel sender and O-ring to be installed.

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

2. Disconnect the battery cables.
3. Drain the fuel tank. Refer to Fuel Tank Draining Procedure.
4. Remove the fuel tank. Refer to *Fuel Tank Replacement*
5. Cap the fuel feed tube and the fuel return tube on the fuel sender.
6. Connect a piece of hose to the filler tube nipple and plug the opposite end.
7. Submerge the tank in water or apply a soap solution to the outside of the tank.
8. Apply 35 kPa (5 psi) air pressure to the vent hose of the fuel tank (a leak will show up as bubbles).

Alcohol/Contaminants-in-Fuel Diagnosis

Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start, or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel rail, and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust, or deterioration.

Alcohol concentrations of 10 percent or greater in fuel can be detrimental to fuel system components. Alcohol contamination may cause fuel system corrosion, deterioration of rubber components, and subsequent fuel filter restriction. Fuel contaminated with alcohol may cause driveability conditions such as hesitation, lack of power, stalling, or no start. Some types of alcohol are more detrimental to fuel system components than others.

Alcohol in Fuel Testing Procedure

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear. If alcohol contamination is suspected then use the following procedure to test the fuel quality.

1. Using a 100 ml specified cylinder with 1 ml graduation marks, fill the cylinder with fuel to the 90 ml mark.
2. Add 10 ml of water in order to bring the total fluid volume to 100 ml and install a stopper.
3. Shake the cylinder vigorously for 10-15 seconds.
4. Carefully loosen the stopper in order to release the pressure.
5. Re-install the stopper and shake the cylinder vigorously again for 10-15 seconds.
6. Put the cylinder on a level surface for approximately 5 minutes in order to allow adequate liquid separation.

If alcohol is present in the fuel, the volume of the lower layer (which would now contain both alcohol and water) will be more than 10 ml. For example, if the volume of the lower layer is increased to 15 ml, this indicates at least 5 percent alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.

Particulate Contaminants in Fuel Testing Procedure

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear. If the sample appears cloudy, or contaminated with water (as indicated by a water layer at the bottom of the sample) use the following procedure to diagnose the fuel.

1. Using an approved fuel container, draw approximately 0.5 liter of fuel.
2. Place the cylinder on a level surface for approximately 5 minutes in order to allow settling of the particulate contamination.

Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles. If particles are found clean the entire fuel system thoroughly. Refer to *Fuel System Cleaning.*

Electronic Ignition (EI) System Diagnosis

Circuit Description

The electronic ignition system uses an individual ignition coil for each cylinder. The powertrain control (PCM) module controls the ignition operation through eight individual IC control circuits. Each bank of four ignition coils is connected to the PCM, power, or ground by the following circuits:

- Low reference
- Chassis ground
- Ignition 1 voltage
- The appropriate IC control circuit

The PCM triggers an ignition coil by grounding the appropriate IC control circuit using information from the crankshaft position (CKP) and camshaft position (CMP) sensors.

Diagnostic Aids

Important: A missing camshaft position (CMP) sensor may cause a long crank condition.

The crankshaft position (CKP) signal must be available for the engine to start. The CMP signal is not needed to start and operate the engine. The PCM can determine when a cylinder is on either the firing or exhaust stroke by the 24X signal.

Remove any debris from the PCM connector surfaces before servicing the

PCM. Inspect the PCM connector gaskets when diagnosing or replacing the PCM. Ensure that the gaskets are installed correctly. The gaskets prevent water intrusion into the PCM.

For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. Monitoring the misfire current counters determines if a fault is present.
10. A good indication that the fuse is open is all off the misfire current counters are incrementing on one side of the engine. Inspect the ignition positive voltage circuit for a grounded circuit. If the fuse is open and the ignition coil circuits are OK, inspect the injector circuits for being grounded.

Electronic Ignition (EI) System Diagnosis

Step	Action	Value(s)	Yes	No
Schematic Reference: *Ignition Control, Bank 1 (Left Side)*				
1	Did you perform the Diagnostic System Check – Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check – Engine Controls*
2	Are DTCs P0335, P0336, or P0351-P0358 set?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	**Important:** • This table assumes that there are no injector circuit malfunctions or mechanical malfunctions. • If more than one cylinder is misfiring on one side of the engine, inspect the ignition coil ignition 1 voltage circuit or ground circuit for an open. 1. Install a scan tool. 2. Idle the engine. 3. Using a scan tool, monitor all the Misfire Current counters on the misfire data list. Do any of the Misfire Current counters increment?	—	Go to *Step 4*	Go to *Diagnostic Aids*
4	Do the misfire current counters increment for most cylinders on one bank of the engine?	—	Go to *Step 10*	Go to *Step 5*
5	1. Inspect the spark plug wire for open circuits, cracks, or improper seating of terminals at the spark plug or coil before proceeding with test. Refer to *Spark Plug Wire Inspection*. 2. Check spark at the plug with the *J 26792* Spark Tester or equivalent while cranking. A few sparks then nothing is considered no spark. Is adequate spark present?	—	Go to *Step 26*	Go to *Step 6*
6	Measure the spark plug wire resistance. Refer to *Spark Plug Wire Inspection.* Does the resistance measure near the specified value? 10,000 ohm/ft	—	Go to *Step 7*	Go to *Step 25*
7	1. Turn OFF the ignition. 2. Disconnect the ignition coil electrical harness connector that corresponds to the Misfire Current counter that was incrementing. 3. Turn ON the ignition, with the engine OFF. 4. Probe the ignition 1 voltage circuit at the ignition coil electrical connector using the *J 34142-B* Test Lamp connected to battery ground. Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 8*	Go to *Step 12*
8	Probe the ignition 1 voltage circuit at the ignition coil electrical connector to the ignition coil ground circuit using the *J 34142-B.* Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 9*	Go to *Step 15*
9	Probe the ignition 1 voltage circuit at the ignition coil electrical connector to the ignition coil low reference circuit using the *J 34142-B.* Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 23*	Go to *Step 19*

Electronic Ignition (EI) System Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Inspect for an open ignition coil fuse. 2. Locate and repair the ignition 1 voltage circuit for a grounded circuit if the fuse is open. Refer to *Wiring Repairs* in Wiring Systems. 3. Replace the fuse. Refer to *General Electrical Diagnosis Procedures* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 11*
11	Repair the open in the ignition voltage circuit between the fuse block and the splice. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
12	1. Disconnect the main ignition coil 8-way connector. 2. Probe the ignition 1 voltage circuit at the ignition coil main 8-way connector using the *J 34142-B* connected to battery ground. Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 13*	Go to *Step 14*
13	Repair the open ignition 1 voltage circuit between the splice and the ignition coil connector. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
14	Repair the open ignition 1 voltage circuit between the fuse block fuse and splice. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
15	1. Disconnect the main ignition coil 8-way connector. 2. Probe the coil ignition 1 voltage circuit to the ignition coil ground circuit at the ignition coil main electrical 8-way connector using the *J 34142-B* connected the battery ground. Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 16*	Go to *Step 18*
16	1. Inspect for a poor connection at the main ignition coil 8-way electrical connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. Repair poor connections as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 17*
17	Repair the open ground circuit between the main 8-way connector and the ignition coil connector. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
18	Repair the open ground circuit between the ground and the main 8-way connector. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
19	Disconnect the main ignition coil 8-way connector. Probe the ignition 1 voltage circuit at the ignition coil main electrical 8-way connector to the ignition coil low reference circuit using the *J 34142-B*. Refer to *Probing Electrical Connectors* in Wiring Systems. Does the test lamp illuminate?	—	Go to *Step 20*	Go to *Step 22*

Electronic Ignition (EI) System Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
20	1. Inspect for a poor connection at the main ignition coil electrical 8-way connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. If a poor connection is found, repair as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 21*
21	Repair the open low reference circuit between the main 8-way connector and the ignition coil connector. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
22	Repair the open low reference circuit between the PCM and the splice. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 27*	—
23	1. Inspect for poor connections at the ignition coil harness connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. 2. Repair poor connections as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 27*	Go to *Step 24*
24	Replace the ignition coil. Refer to *Ignition Coil(s) Replacement*. Did you complete the replacement?	—	Go to *Step 27*	—
25	Replace the spark plug wire. Refer to Spark Plug Wire Replacement. Did you complete the replacement?	—	Go to *Step 27*	—
26	Replace the spark plug. Refer to *Spark Plug Replacement*. Did you complete the replacement?	—	Go to *Step 27*	—
27	1. Remove all test equipment. 2. Reconnect any disconnected components, fuses, etc. 3. Turn OFF ignition for 30 seconds. 4. Start engine and operate vehicle. 5. Observe the MIL, vehicle performance, and driveability. Does vehicle operate normally, with no MIL illumination and no stored DTCs?	—	System OK	Go to *Diagnostic Trouble Code (DTC) List*

Repair Instructions

Powertrain Control Module (PCM) Replacement

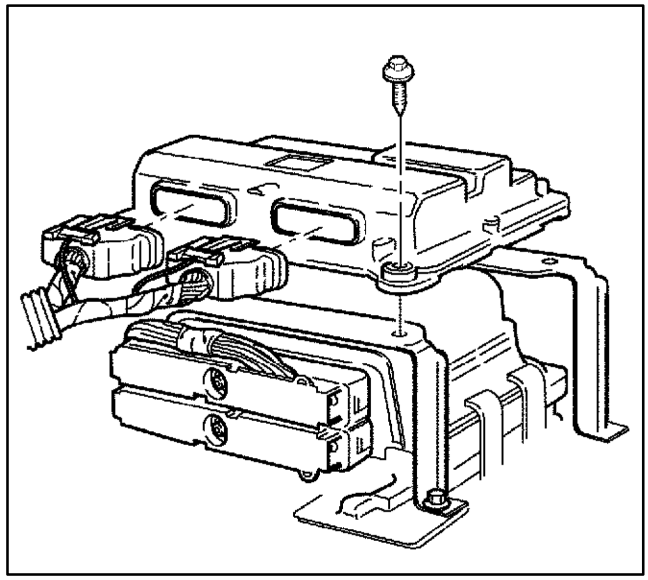
Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices in the WCC Service Manual.

Notice: Refer to PCM and ESD Notice in Cautions and Notices in the WCC Service Manual.

Notice: Refer to Ignition and PCM Notice in Cautions and Notices in the WCC Service Manual.

1. Disconnect the negative battery cable.
2. Remove the transmission control module (TCM). Refer to *Transmission Control Module Replacement* in this supplement.
3. Disconnect the powertrain control module (PCM) connectors.



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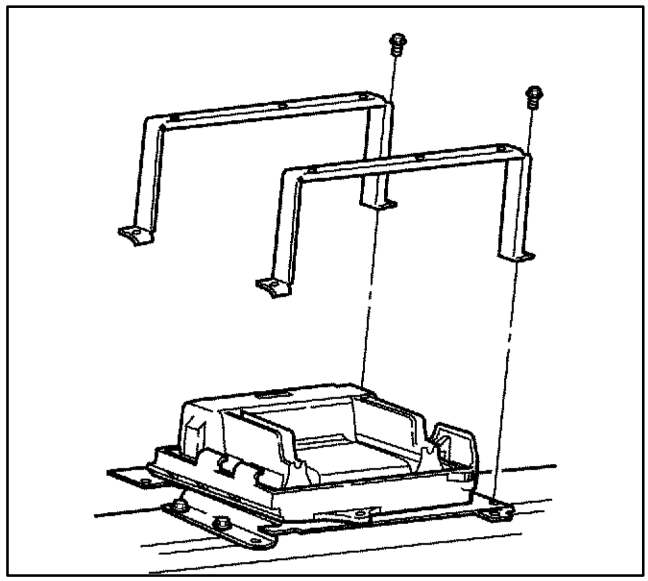
4. Remove the TCM mounting bracket bolts and mounting brackets.



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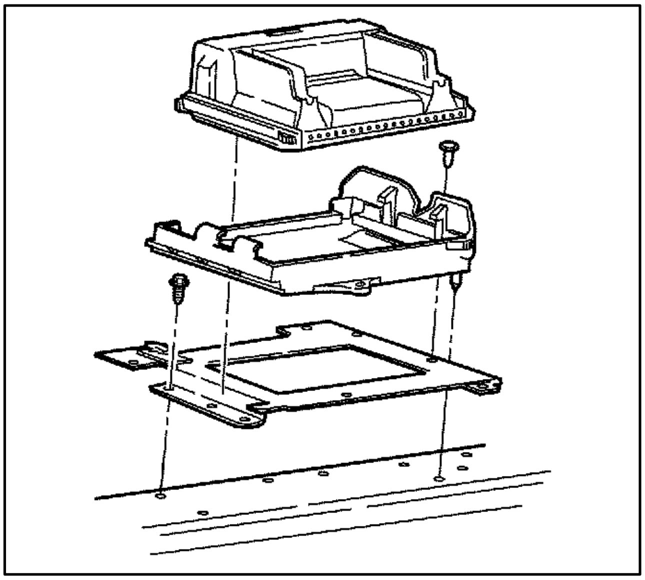

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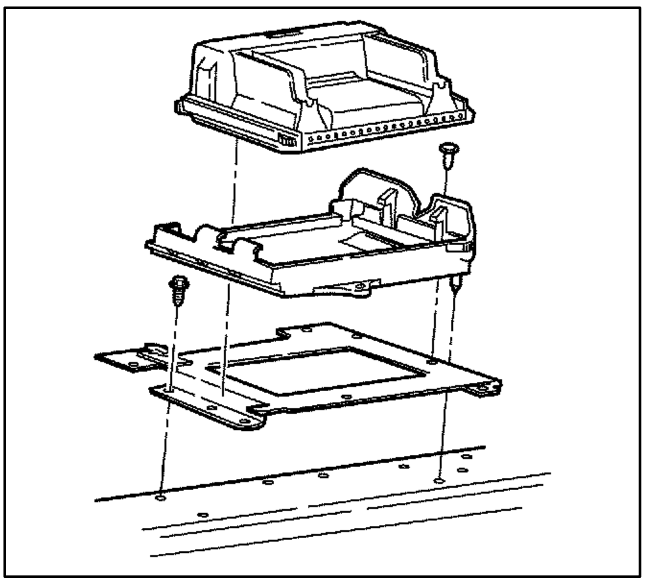
5. Disengage the PCM housing bail retainer from the edge of the PCM.
6. Disengage the PCM housing plastic retainers from the edge of the PCM and lift the PCM out of the PC housing assembly.
7. If necessary, remove the push-in retainers from the PCM housing assembly and the PCM bracket, and remove the housing assembly from the bracket.
8. If necessary, remove the PCM bracket retaining bolts and the bracket.



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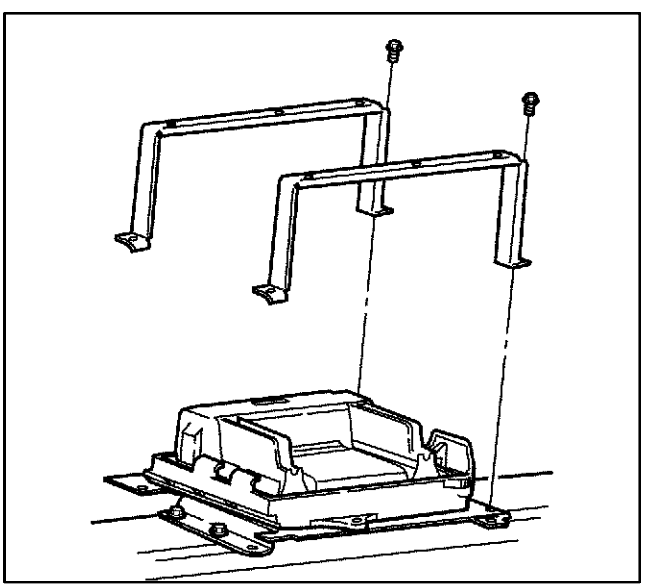
Installation Procedure

Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

1. If removed, install the PCM bracket and retaining bolts

   Tighten

   Tighten the PCM bracket retaining bolts to 17 N·m (13 lb ft).
2. If removed, install PCM housing assembly and push-in retainers to the PCM bracket.
3. Install the PCM into the PCM housing assembly, making sure that the PCM housing plastic retainers snap over the edge of the PCM.
4. Engage the PCM housing bail retainer over the edge of the PCM.



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5. Install the TCM mounting brackets and mounting bracket bolts

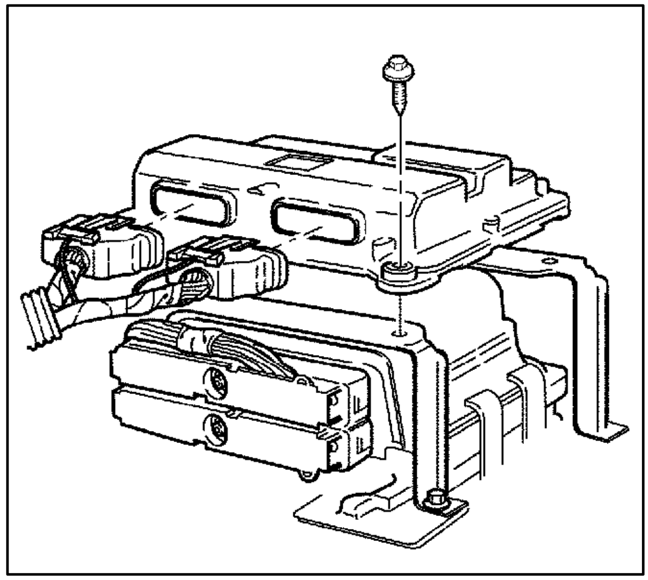
   Tighten

   Tighten the TCM mounting bracket bolts to 6 N·m (53 lb in).

6. Connect the PCM connectors.

   Tighten

   Tighten the PCM connector end bolts to 8 N·m (70 lb in).
7. Install the TCM. Refer to *Transmission Control Module Replacement* in this supplement.
8. Connect the negative battery cable.
9. If a new PCM is being installed, program the PCM. Refer to *Powertrain Control Module (PCM) Programming (On-Board)* or *Powertrain Control Module (PCM) Programming (Off-Board).*



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Throttle Actuator Control (TAC) Module Replacement

Removal Procedure

1. Disconnect the throttle actuator control (TAC) module harness connectors from the TAC module.
2. Remove the TAC module retaining bolts.
3. Remove the TAC module.

Installation Procedure

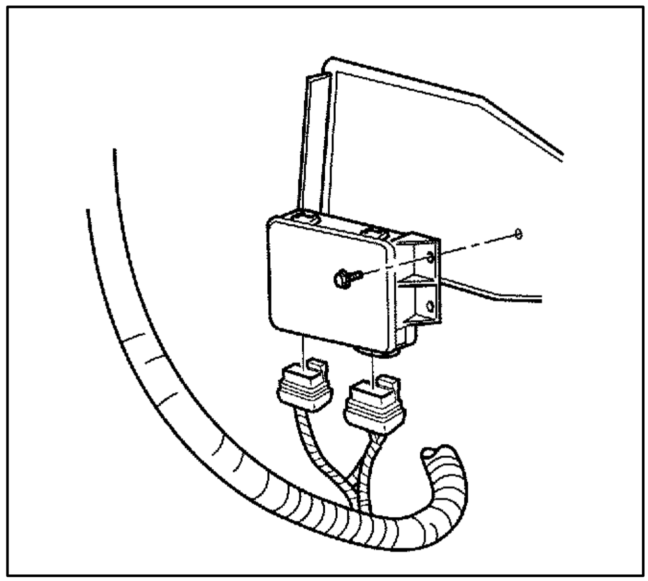
1. Install the TAC Module.

Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

2. Install the TAC retaining bolts.

   Tighten

   Tighten the TAC module retaining bolts to 1.9 N·m (17 lb in).
3. Connect the TAC module harness connectors to the TAC module.



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Powertrain Control Module (PCM) Programming (On-Board)

Before Programming a Control Module

Important: Do NOT program a control module unless you are directed by a service procedure or you are directed by a General Motors Corporation service bulletin. Programming a control module at any other time will not permanently correct a customers concern.

Ensure the following conditions are met before programming a control module:

- Vehicle system voltage
  - There is no charging system concern. All charging system concerns must be repaired before programming a control module.
  - Battery voltage is greater than 12 volts but less than 16 volts. The battery must be charged before programming the control module if the battery voltage is low.
  - A battery charger is NOT connected to the vehicle's battery. Incorrect system voltage or voltage fluctuations from a battery charger, may cause programming failure or control module damage.
  - Turn OFF or disable any system that may put a load on the vehicle's battery.
    - Twilight sentinel
    - Interior lights
    - Daytime running lights (DRL)–Applying the parking brake, on most vehicles, disables the DRL system. Refer to the Owners manual.
    - Heating, ventilation, and air conditioning (HVAC) systems
    - Engine cooling fans etc.
- The ignition switch is in the proper position. The scan tool prompts you to turn ON the ignition, with the engine OFF. Do NOT change the position of the ignition switch during the programming procedure, unless instructed to do so.
- All tool connections are secure.
  - RS-232
  - The connection at the DLC is secure.
  - Voltage supply circuits
- DO NOT disturb the tool harnesses while programming. If an interruption occurs during the programming procedure, programming failure or control module damage may occur.

Remote Programming

1. Turn OFF the ignition.
2. Install the Tech 2 to the data link connector (DLC).
3. Turn ON the ignition, with the engine OFF.
4. Turn OFF all of the vehicle accessories.
5. With the Tech 2, select Service Programming.
6. Identify vehicle information as requested by the Tech 2.
7. Select the type of module you are programming.
8. Select the type of programming to be performed.
9. Verify the displayed VIN with the vehicle VIN. If the displayed VIN does not match the actual VIN, write down the actual VIN and correct the VIN at the Techline terminal.
10. When complete, Exit Service Programming.
11. Turn OFF the Tech 2 and disconnect the Tech 2 from the vehicle.
12. Turn OFF the ignition.
13. Connect the Tech 2 to the Techline terminal.
14. Select Service Programming.
15. Select Tech 2 as the tool you are using.
16. Select the type of programming to be performed.
17. Verify the displayed VIN with the vehicle VIN. Correct the VIN as necessary.
18. Select the type of module you are programming.
19. Identify what type of programming that you are performing.
    - Normal—This type of programming is for updating an existing calibration or programming a new controller.
    - Vehicle Configuration Index (VCI)–This selection is used if the vehicle VIN is unavailable or not recognized by the Techline terminal. Observe, you will need to contact the Techline Customer Support center to use this option.
    - Reconfigure—This is to reconfigure a vehicle, such as tire size and axle ratio changes.
20. Select the appropriate calibration file.
21. Ensure all connections are secure.
22. Select Reprog to initiate the download of the new calibration to the Tech 2.
23. After the download is complete, turn OFF the Tech 2.
24. Disconnect the Tech 2 from the Techline terminal.
25. Install the Tech 2 to the data link connector (DLC).
26. Turn ON the Tech 2.
27. Turn ON the ignition, with the engine OFF.
28. Select Service Programming.

Important: DO NOT turn OFF the ignition if the programming procedure is interrupted or unsuccessful. Ensure that all the PCM and DLC connections are secure and the Techline operating software is up to date. Attempt to reprogram the control module. If the control module cannot be programmed, replace the control module. Refer to *Powertrain Control Module (PCM) Replacement*

29. Select Program.

30. After the download is complete, EXIT Service Programming.
31. Turn OFF the ignition for 30 seconds.
32. Turn OFF the Tech 2.
33. If a control module is replaced the following service procedures must be performed:
    - The Crankshaft Variation Learn Procedure
    - The Idle Learn Procedure

Programming Verification

1. With a scan tool, clear the DTCs.
2. Attempt to start the engine.
3. Repeat the Service Programming procedure if the engine does not start or operates poorly. Perform the following procedures before programming the PCM:
    - Ensure the control module and DLC connections are OK.
    - Ensure the Techline operating software is up to date.
    - Ensure the calibration part number is correct for the vehicle.
4. Attempt to program the control module. If the control module still cannot be programmed properly, replace the control module. Refer to *Powertrain Control Module (PCM) Replacement*. You must program the replacement control module.

Powertrain Control Module (PCM) Programming (Off-Board)

Before Programming a Control Module

Important:

- Do NOT program a control module unless you are directed by a service procedure or you are directed by a General Motors Corporation service bulletin. Programming a control module at any other time will not permanently correct a customer's concern.
- The Off-Board Programming is used in situations where a control module must be programmed without having the vehicle present. The Off-Board Programming Adapter must be used to perform the Off-Board Programming procedure. The adapter allows the control module to power up and allows the Tech 2 to communicate with the control module.
- DO NOT disturb the tool harnesses while programming. If an interruption occurs during the programming procedure, programming failure or control module damage may occur.

Ensure that all connections are secure at the following locations:

- The Off-Board Programming Adapter
- The Tech 2
- The control module
- The Techline terminal

Off-Board Programming

1. Obtain the VIN of the vehicle for which the control module is being programmed.
2. With the Techline terminal, select Service Programming.
3. Select Tech 2, Reprogram ECU, and Off-Board Programming Adapter as the ECU location.
4. Connect the control module, Off-Board Programming Adapter, and the Tech 2 as described on the Techline terminal. Ensure you use the correct harness connector from the Off-Board Programming Adapter kit.
5. With the Tech 2, select Service Programming Request Information function. The Tech 2 communicates with the control module and receives the access code.
6. With the Tech 2, exit the Service Programming Request Information.
7. Disconnect the Tech 2 from the Off-Board Programming Adapter.
8. Connect the Tech 2 to the Techline terminal.
9. Turn ON the Tech 2.
10. With the Techline terminal, enter the VIN of the vehicle that will be receiving the control module.
11. The Techline terminal will display the message, attaching to database.
12. Identify what type of programming that you are performing.
13. Select the appropriate calibration file.
14. Ensure all connections are secure.
15. The Techline terminal displays a summary screen that summarizes your selections. After confirming you choices, the Techline terminal automatically loads the calibration files to the Tech 2.
16. After the download is complete, turn OFF the Tech 2.
17. Disconnect the Tech 2 from the Techline terminal.
18. Connect the Tech 2 to the Off-Board Programming Adapter.
19. With the Tech 2, select Service Programming.

Important: DO NOT turn OFF the Off-Board Programming Adapter if the programming procedure is interrupted or unsuccessful. Ensure the control module and the Off-Board Programming Adapter connections are secure and the Techline operating software is up to date. Attempt to reprogram the control module. If the control module cannot be programmed, replace the control module.

20. With the Tech 2, select Program.
21. After the download is complete, exit Service Programming.
22. Turn OFF the Off-Board Programming Adapter.

CKP System Variation Learn Procedure

Important: For additional diagnostic information, refer to DTC P1336.

1. Install a scan tool.
2. With a scan tool, monitor the powertrain control module (PCM) for diagnostic trouble codes (DTCs). If other DTCs are set, except DTC P1336, refer to Diagnostic Trouble Code (DTC) List for the applicable DTC that set.
3. Close the vehicle's hood.
4. With a scan tool, select the crankshaft position system variation learn procedure.
5. Observe the fuel cutoff for the engine that you are performing the learn procedure on.
6. The scan tool instructs you to perform the following:

- Apply the vehicles parking brake.
- Block the drive wheels.
- Cycle the ignition from OFF to ON.
- Apply and hold the brake pedal. Start and idle the engine.
- Turn OFF the A/C.
- Place the vehicle's transmission in Park (A/T) or Neutral (M/T). The scan tool monitors certain component signals to determine if all the conditions are met to continue with the procedure.
- The scan tool only displays the condition that inhibits the procedure. The scan tool monitors the following components:
  - Crankshaft position (CKP) sensors activity – If there is a CKP sensor condition, refer to DTC P0335 or DTC P0336.
  - Camshaft position (CMP) sensor activity—If there is a CMP sensor condition, refer to DTC P0341, DTC P0342 , or DTC P0343.
  - Engine coolant temperature—If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

7. With the scan tool, enable the crankshaft position system variation learn procedure.

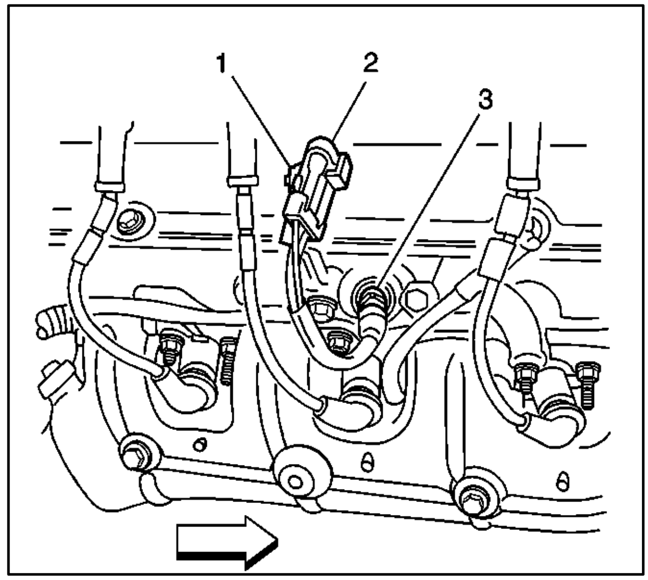
Important: While the learn procedure is in progress, release the throttle immediately when the engine starts to decelerate. The engine control is returned to the operator and the engine responds to throttle position after the learn procedure is complete.

8. Follow throttle application instructions on Tech 2.
9. Immediately release the throttle when fuel cut-off is reached.
10. The scan tool displays Learn Status: Learned this ignition. If the scan tool does NOT display this message and no additional DTCs set, refer to *Symptoms – Engine Mechanical*. If a DTC is set, refer to Diagnostic Trouble Code (DTC) List for the applicable DTC that set.
11. Turn OFF the ignition for 30 seconds after the learn procedure is completed successfully.
12. It may happen that the Tech 2 resets during the cranking phase of crankshaft position system variation learning procedure. This will prevent the procedure from being completed. One of two things can be done to bypass the problem of the Tech 2 resetting:
    - 12.1. Ignore the step to turn off the ignition after the engine was started, and continue to the next steps. Pay close attention to the commands concerning depressing the brake pedal.
    - 12.2. If "12.1" does not solve the problem, an external 12-volt power source for the Tech 2 is required. The external power source will prevent the Tech 2 from resetting, and consequently losing its step position in the variation learning sequence.

Notice: Make sure that the ground terminal of the external battery is securely connected to vehicle ground before the Tech 2 is turned on. Do not use the 110-volt AC adapter as the external source. Failure to adhere to the above cautions can cause damage to the Tech 2, PCM, TCM, and/or ABS module.

Engine Coolant Temperature (ECT) Sensor Replacement

Removal Procedure



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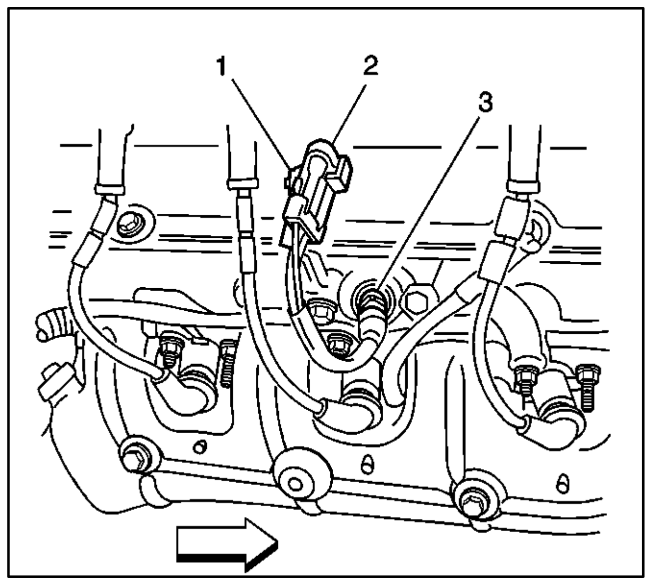
Notice: Use care when handling the coolant sensor. Damage to the coolant sensor will affect the operation of the fuel control system.

1. Turn OFF the ignition.
2. Drain the cooling system below the level of the ECT sensor. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Disconnect the ECT electrical connector (2).
4. Remove the ECT electrical connector from the bracket (1).
5. Remove the ECT sensor (3).

Installation Procedure



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Notice: Use care when handling the coolant sensor. Damage to the coolant sensor will affect the operation of the fuel control system.

Notice: Replacement components must be the correct part number for the application. Components requiring the use of the thread locking compound, lubricants, corrosion inhibitors, or sealants are identified in the service procedure. Some replacement components may come with these coatings already applied. Do not use these coatings on components unless specified. These coatings can affect the final torque, which may affect the operation of the component. Use the correct torque specification when installing components in order to avoid damage.

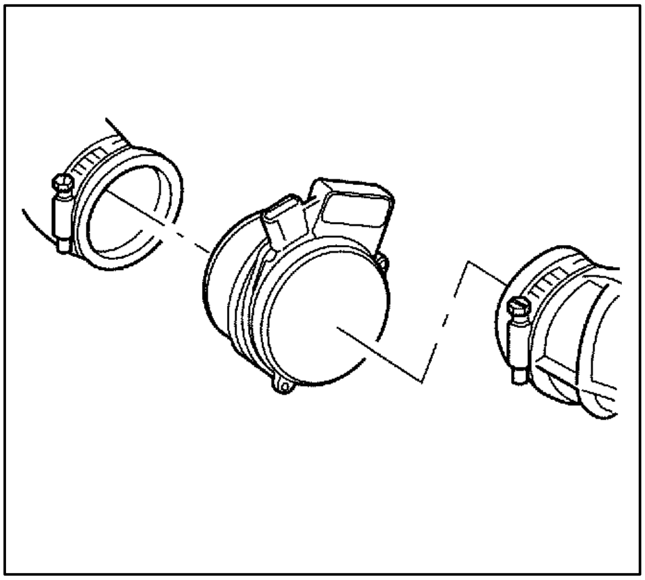
1. Coat the threads with sealer P/N 9985253 or equivalent.

Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the ECT sensor (3).

   Tighten

   Tighten the ECT sensor to 20N·m (15 lb ft).
3. Connect the ECT electrical connector to the bracket (1).
4. Connect the ECT harness connector (2) to the ECT sensor (3).
5. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.



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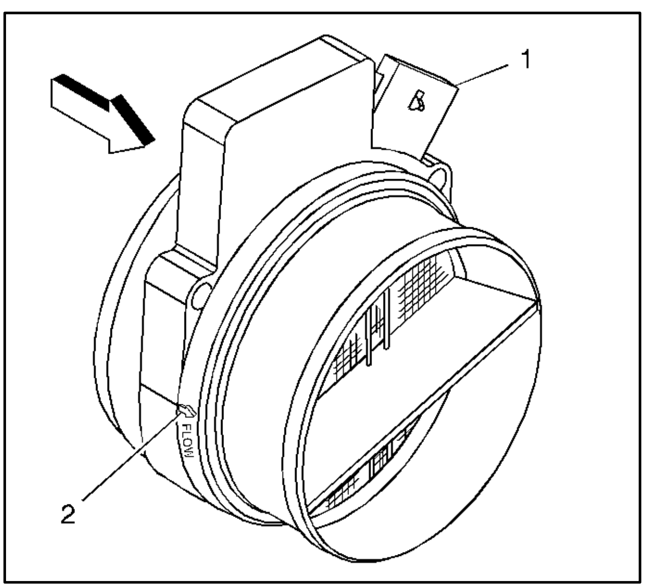
Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor Replacement

Removal Procedure

Important: Take care when handling the mass air flow/ intake air temperature (MAF/IAT) sensor. Do not dent, puncture, or otherwise damage the honeycell located at the air inlet end of the MAF/IAT. Do not touch the sensing elements or allow anything including cleaning solvents and lubricants to come in contact with them. Use a small amount of a non-silicone based lubricant, on the air duct only, to aid in installation. Do not drop or roughly handle the MAF/IAT sensor.

1. Remove the fastener securing the air intake duct to the upper fan shroud.
2. Loosen the clamps at the MAF/IAT sensor and at the throttle body.
3. Remove the air intake duct from the MAF/IAT sensor and the throttle body.
4. Disconnect the MAF/IAT sensor electrical connector.
5. Loosen the clamp securing the MAF/IAT sensor to the air cleaner housing.
6. Remove the MAF/IAT sensor from the air cleaner assembly.



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Installation Procedure

Important: The embossed arrow on the MAF/IAT sensor indicates the proper air flow direction. The arrow must point toward the engine.

1. Locate the air flow direction arrow (2) on the MAF/IAT sensor.

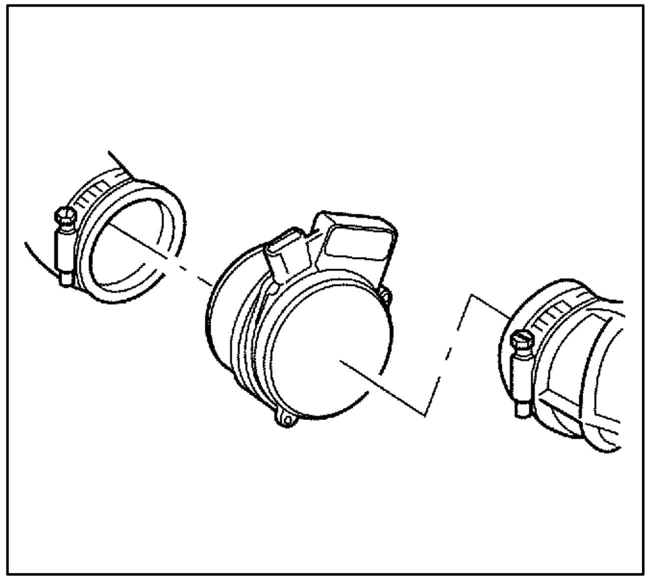
2. Install the MAF/IAT sensor on to the air cleaner housing with the connector up. Make sure that the tabs of the MAF/IAT sensor are properly aligned with the adapter to the air cleaner.
3. Tighten the clamp securing the MAF/IAT sensor to the air cleaner housing.
4. Connect the MAF/IAT electrical connector.
5. Install the air intake duct to the MAF/IAT sensor and the throttle body.
6. Install the fastener securing the air intake duct to the upper fan shroud.

Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

7. Tighten the clamps at the MAF/IAT sensor and at the throttle body.

   Tighten

   Tighten the air intake duct clamps to 4 N·m (35 lb in).

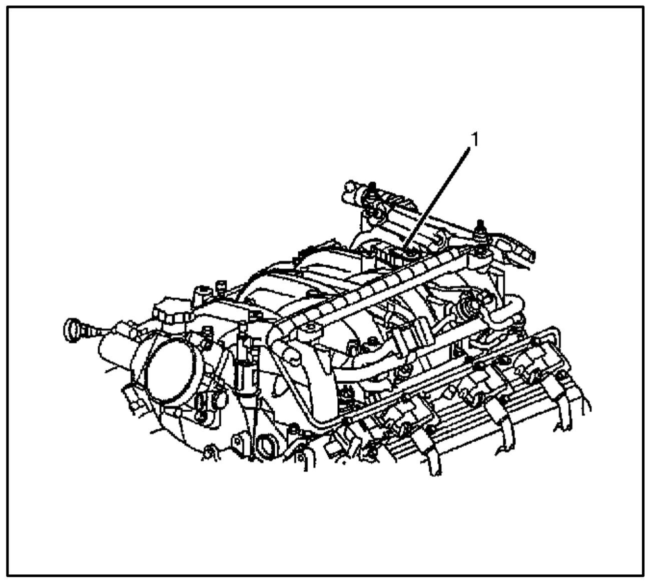


WRK64021

Manifold Absolute Pressure (MAP) Sensor Replacement

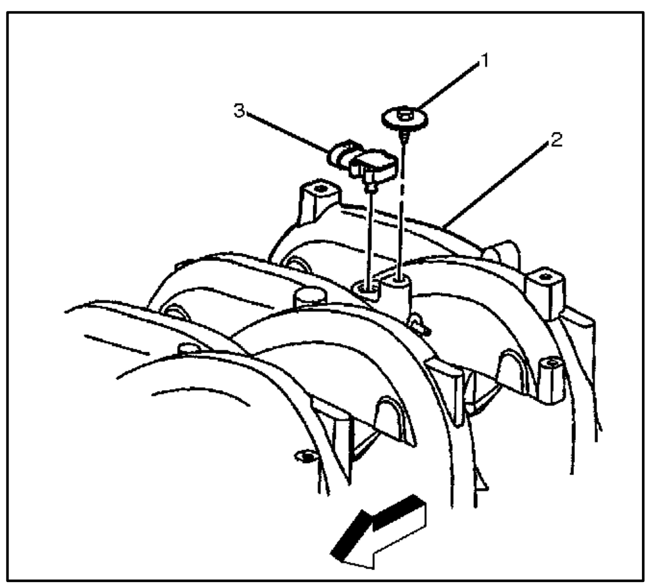
Removal Procedure

1. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (1).

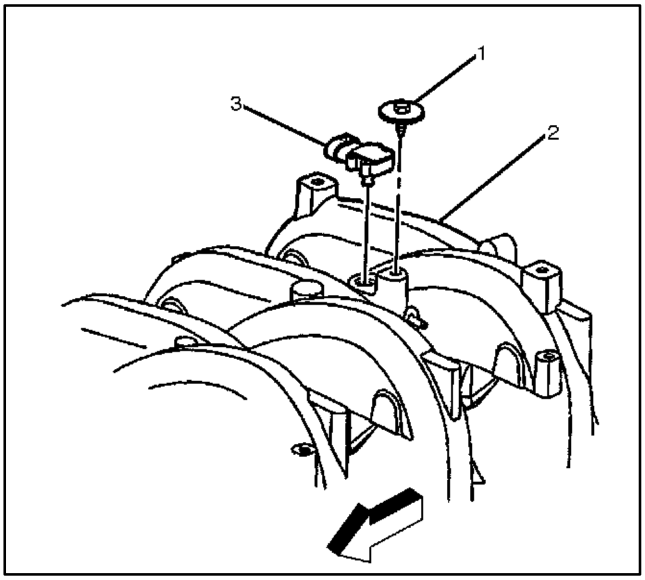


WRK64007

2. Remove the MAP sensor retaining bolt and washer (1).
3. Remove the MAP sensor (3) from the intake manifold (2).
4. Inspect the MAP sensor seal for wear or damage and replace as necessary.



WRK64008



WRK64008

Installation Procedure

Important: Lightly coat the MAP sensor seal with rubber lubricant part number 9985770 before installing the sensor. The lubricant should be applied with a sponge or a brush. To prevent blockage, avoid dipping the sensor port directly into the lubricant.

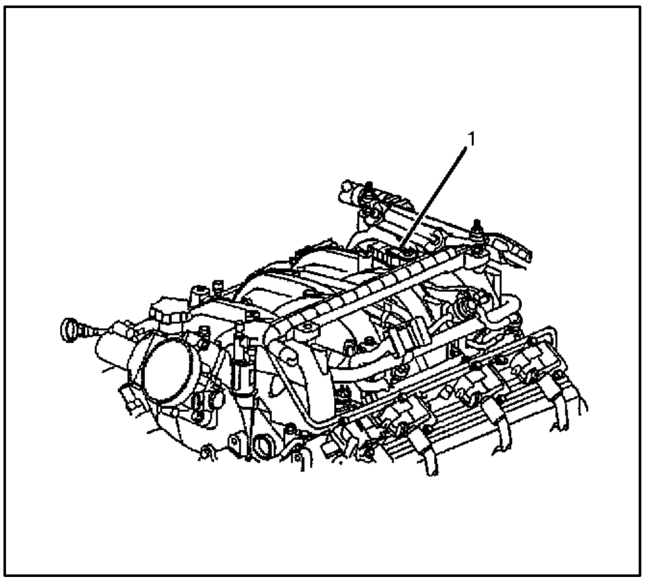
1. Install the MAP sensor (3).

Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the MAP sensor retaining bolt and washer (1).

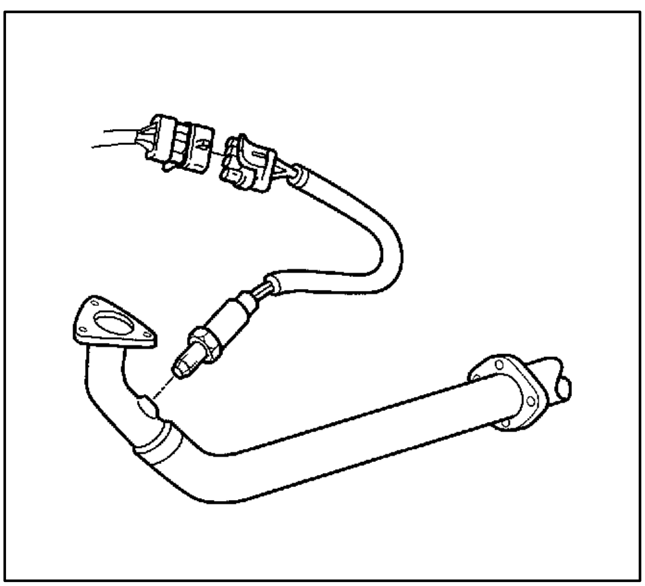
   Tighten

   Tighten the fastener to 12 N·m(106 in/lb).



WRK64007

3. Connect the MAP sensor electrical connector (1).



WRK66001

Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1

Tools Required

J 39194-B Heated Oxygen Sensor Wrench

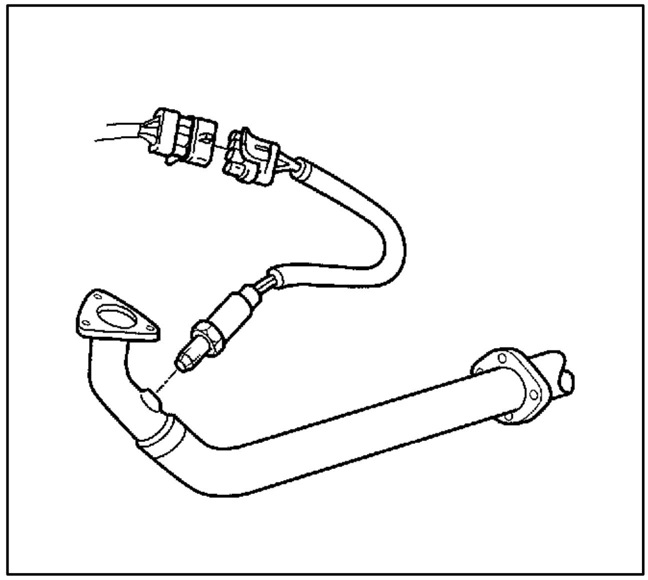
Notice: Refer to HO2S Pigtail Notice in Cautions and Notices.

Removal Procedure

Important: The heated oxygen sensor may be difficult to remove when the engine temperature is below 48°C (120°F). Excessive force may damage the threads in the exhaust manifold or exhaust pipe. It may be necessary to lower the exhaust system to gain sufficient access to a HO2S and/or it's connector.

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the HO2S electrical connector.

3. Using the *J 39194-B* loosen the heated oxygen sensor.
4. Carefully back out the heated oxygen sensor.



WRK66001

Installation Procedure

Important: A special anti-seize compound is used on the heated oxygen sensor threads. The compound consists of graphite suspended in fluid and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will already have the compound applied to the threads. If a sensor is removed from an engine and if for any reason is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

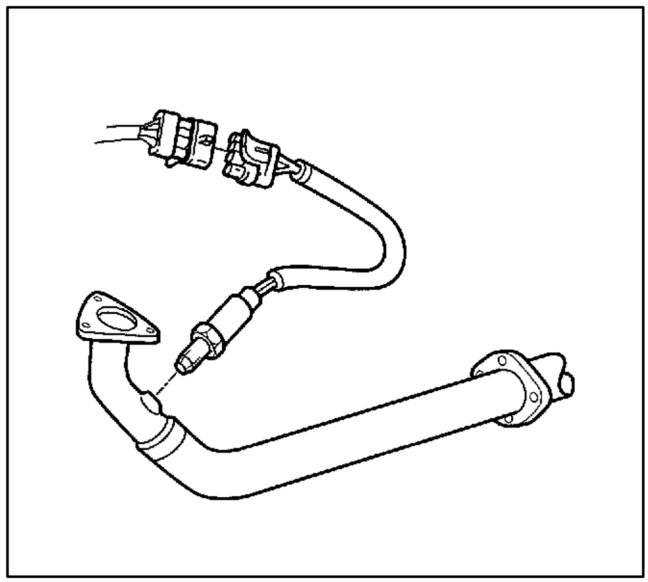
1. Coat the threads of the heated oxygen sensor with anti-seize compound P/N 12377953, or equivalent if necessary.

Notice: Refer to Fastener Notice in Cautions and Notices.

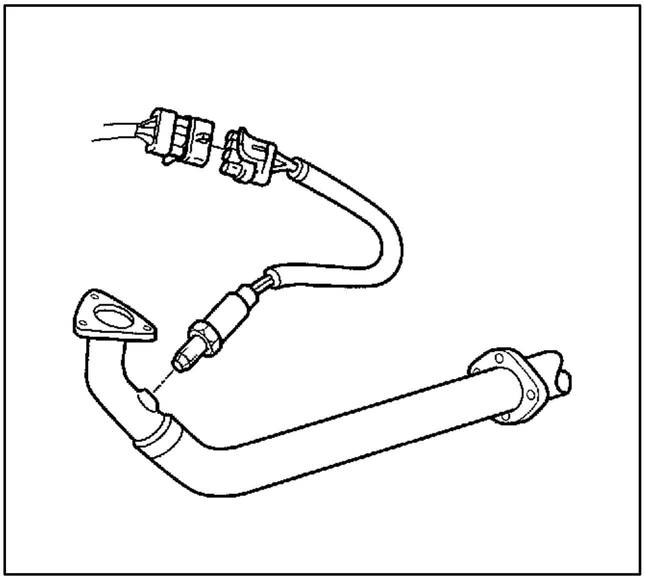
2. Using the *J 39194-B* install the heated oxygen sensor.

   Tighten

   Tighten the HO2S to 41 N·m (30 lb ft).

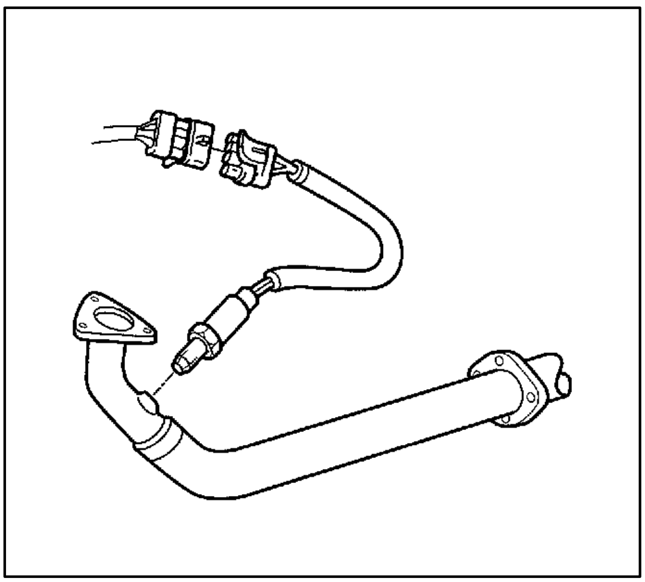


WRK66001



WRK66001

3. Connect the HO2S electrical connector.
4. Lower the vehicle.



WRK66001

Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1

Tools Required

J 39194-B Heated Oxygen Sensor Wrench

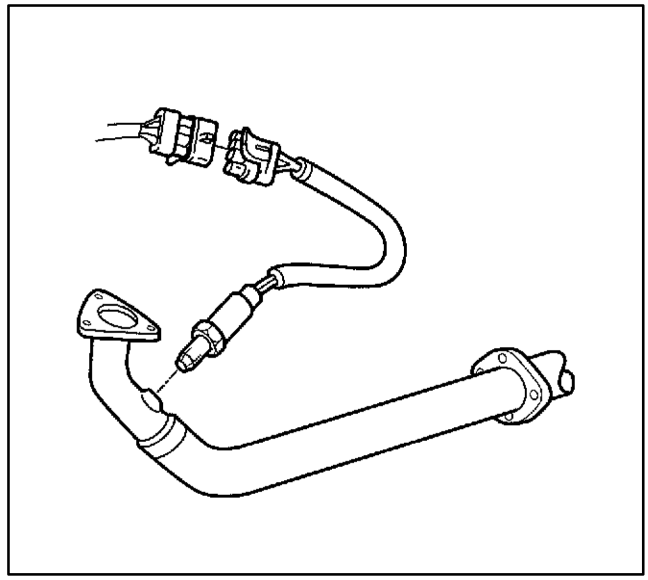
Notice: Refer to HO2S Pigtail Notice in Cautions and Notices.

Removal Procedure

Important: The heated oxygen sensor may be difficult to remove when the engine temperature is below 48°C (120°F). Excessive force may damage the threads in the exhaust manifold or exhaust pipe. It may be necessary to lower the exhaust system to gain sufficient access to a HO2S and/or it’s connector.

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the HO2S electrical connector.

3. Using the *J 39194-B* loosen the heated oxygen sensor.
4. Carefully back out the heated oxygen sensor.



WRK66001

Installation Procedure

Important: A special anti-seize compound is used on the heated oxygen sensor threads. The compound consists of graphite suspended in fluid and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will already have the compound applied to the threads. If a sensor is removed from an engine and if for any reason is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

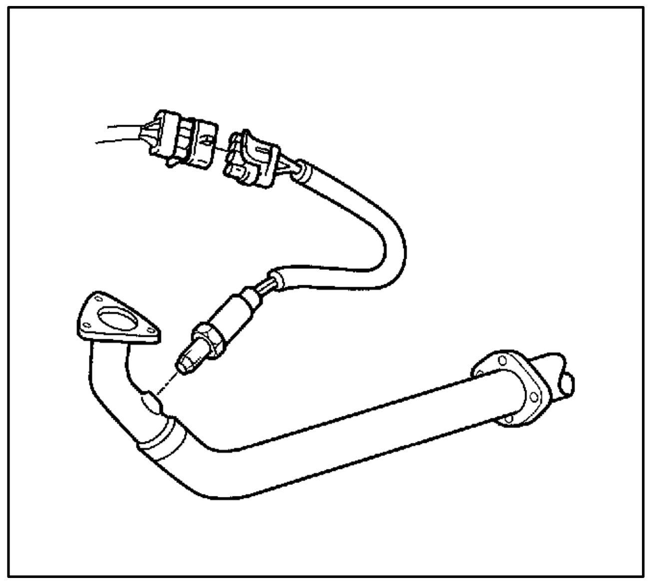
1. Coat the threads of the heated oxygen sensor with anti-seize compound P/N 12377953, or equivalent if necessary.

Notice: Refer to Fastener Notice in Cautions and Notices.

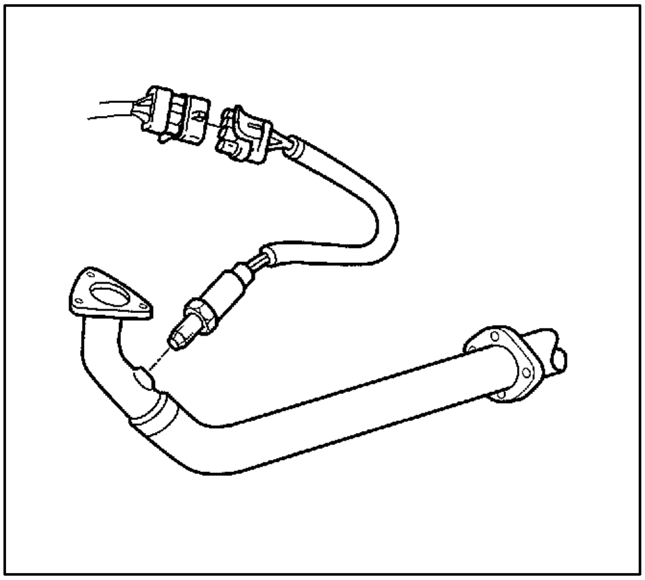
2. Using the *J 39194-B* install the heated oxygen sensor.

   Tighten

   Tighten the HO2S to 41 N·m (30 lb ft).

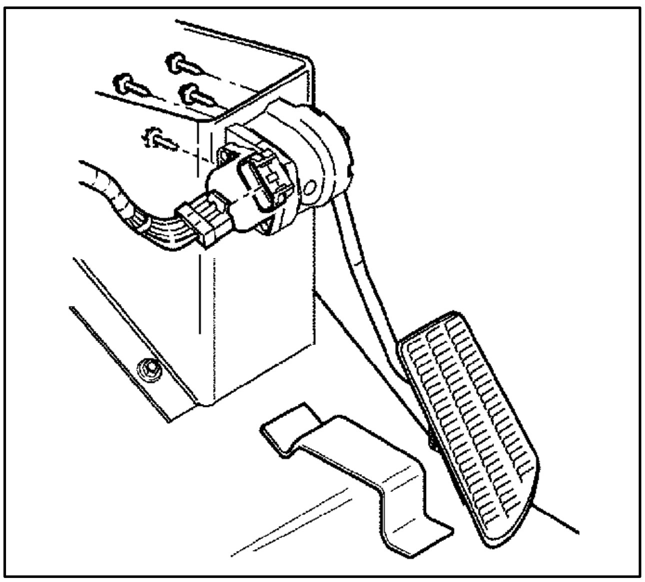


WRK66001



WRK66001

3. Connect the HO2S electrical connector.
4. Lower the vehicle.



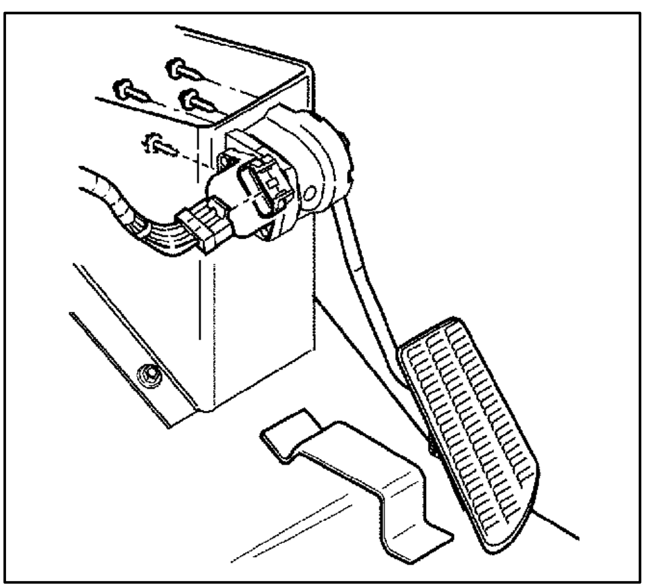
WRK64027

Accelerator Pedal Position (APP) Sensor Replacement

Removal Procedure

Notice: Refer to Handling Electronic Throttle Control Notice in Cautions and Notices.

1. Remove the left instrument panel (IP) lower closeout insulator panel.
2. Disconnect the APP sensor harness connector.
3. Remove the accelerator pedal mounting bolts. Remove the accelerator pedal.



WRK64027

Installation Procedure

1. Install the accelerator pedal to the steering column support bracket.

Notice: Refer to the Fastener Notice in Cautions and Notices.

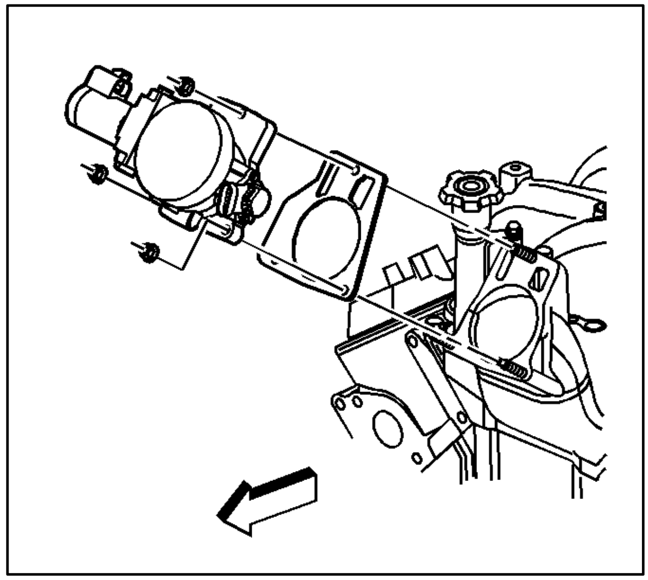
2. Install the accelerator pedal mounting bolts.

   Tighten

   Tighten the accelerator pedal mounting bolts to 20 N·m (15 lb ft).
3. Connect the APP sensor harness connector.
4. With the vehicle not in reduced engine power, turn ON the ignition with the engine OFF. Test for proper throttle opening and closing range by operating the accelerator pedal and monitoring the throttle angles using a scan tool. The accelerator pedal should operate freely without binding between full closed throttle and wide open throttle (WOT).

Throttle Body Assembly Replacement

Removal Procedure


470760

Notice: Handle the electronic throttle control components carefully. Use cleanliness in order to prevent damage. Do not drop the electronic throttle control components. Do not roughly handle the electronic throttle control components. Do not immerse the electronic throttle control components in cleaning solvents of any type.

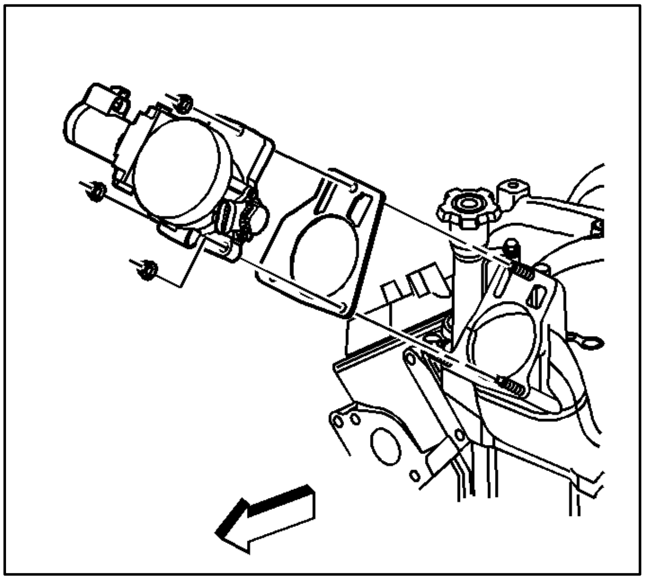
1. An 8 digit part identification number is stamped on the throttle body casting. Refer to this number if servicing, or part replacement is required.
2. Remove the air induction assembly.

Important: Cover or plug any openings when servicing the throttle body in order to prevent possible contamination.

3. Disconnect the throttle actuator motor harness connector.
4. Disconnect the TP sensor harness connector.
5. Remove the throttle body attaching nuts.

Important: Do not reuse the throttle body gasket. Install a new gasket during assembly.

6. Remove the throttle body and the gasket.
7. Discard the throttle body gasket.



470760

Installation Procedure

1. Install a new throttle body gasket.
2. Install the throttle body assembly.

Notice: Refer to Fastener Notice in Cautions and Notices.

Important: Always use a torque wrench in order to obtain the proper torque.

3. Install the throttle body attaching nuts.

   Tighten

   Tighten the throttle body nuts to 10 N·m (89 lb in).

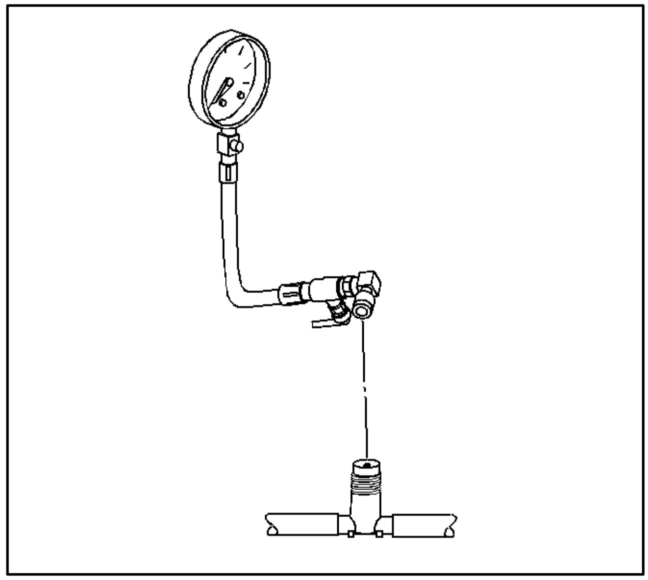
Important: Ensure that the electrical connector to throttle body motor and the connector seal are properly installed and not damaged.

4. Connect the TP sensor harness connector.
5. Connect the throttle actuator motor harness connector.
6. Install the air induction assembly.
7. With the vehicle not in reduced engine power, turn ON the ignition with the engine OFF. Inspect for complete throttle opening and closing positions. Use a scan tool to monitor the throttle angles while operating the accelerator pedal to open and close the throttle. The accelerator pedal should operate freely without binding between full closed throttle and wide open throttle
8. Start the engine.

Fuel Pressure Relief Procedure

Caution: Relieve the fuel system pressure before servicing fuel system components in order to reduce the risk of fire and personal injury.

After relieving the system pressure, a small amount of fuel may be released when servicing the fuel lines or connections. In order to reduce the chance of personal injury, cover the damper and the fuel line fittings with a shop towel before disconnecting. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.



180378

Tools Required

J 34730-1A Fuel Pressure Gauge

1. Turn the ignition OFF.
2. Disconnect the negative battery cable in order to avoid possible fuel discharge if an accidental attempt is made to start the engine. Refer to *Battery Negative Cable Disconnect/Connect Procedure (Single Battery) Battery Negative Cable Disconnect/Connect Procedure (Auxiliary Battery)* in Engine Electrical.
3. Loosen the fuel filler cap in order to relieve the fuel tank vapor pressure.
4. Connect the *J 34730-1A* to the fuel pressure valve. Wrap a shop towel around the fitting while connecting the gauge in order to avoid spillage.
5. Install the bleed hose of the gauge into an approved container.
6. Open the valve on the gauge to bleed the system pressure. The fuel connections are now safe for servicing.
7. Drain any fuel remaining in the gauge into an approved container.

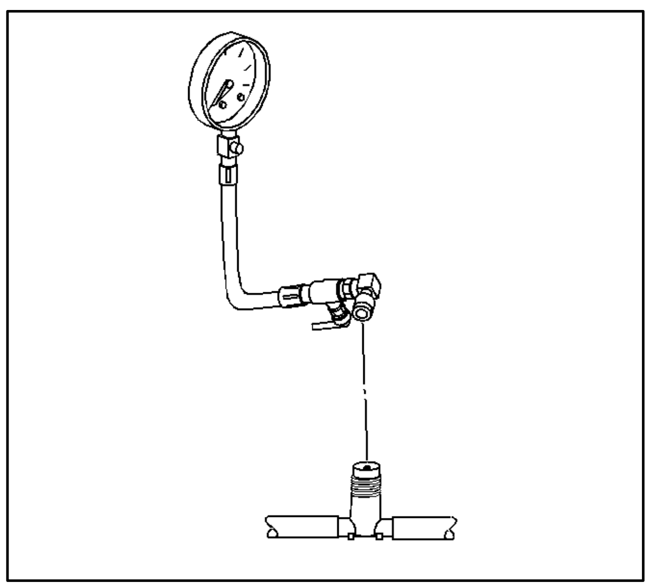
Fuel Pressure Gage Installation and Removal

Installation Procedure

Caution: Refer to Gasoline/Gasoline Vapors Caution in Cautions and Notices.

Caution: Refer to Fuel Gage Leak Caution in Cautions and Notices.

Notice: Refer to Clean All Connections In Order to Avoid Contamination in Cautions and Notices.

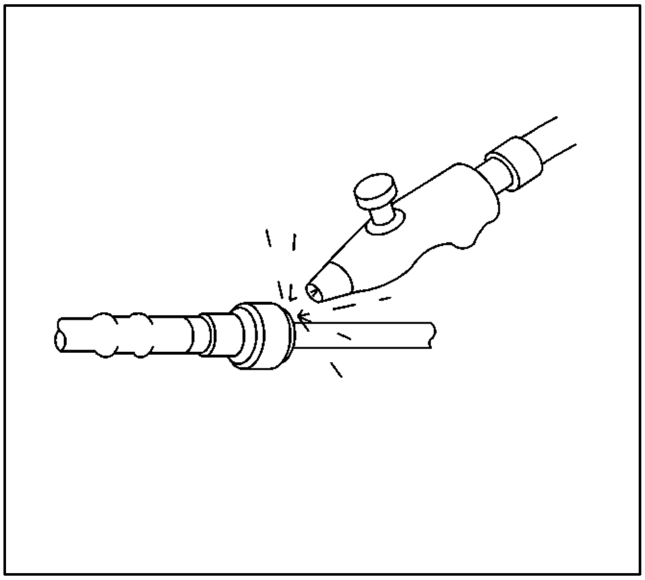


180378

1. Install the *J 34730-1A* fuel pressure gage to the fuel pressure service connection, located on the fuel rail.
2. Turn ON the ignition.

Caution: Refer to Fuel Storage Caution in Cautions and Notices.

3. Place the bleed hose of the fuel pressure gage into an approved gasoline container.
4. Open the bleed valve on the fuel pressure gage in order to bleed the air from the fuel pressure gage.
5. Command the fuel pump ON with a scan tool.
6. Close the bleed valve on the fuel pressure gage.
7. Inspect for fuel leaks.



12776

Quick Connect Fitting(s) Service (Metal Collar)

Tool Required

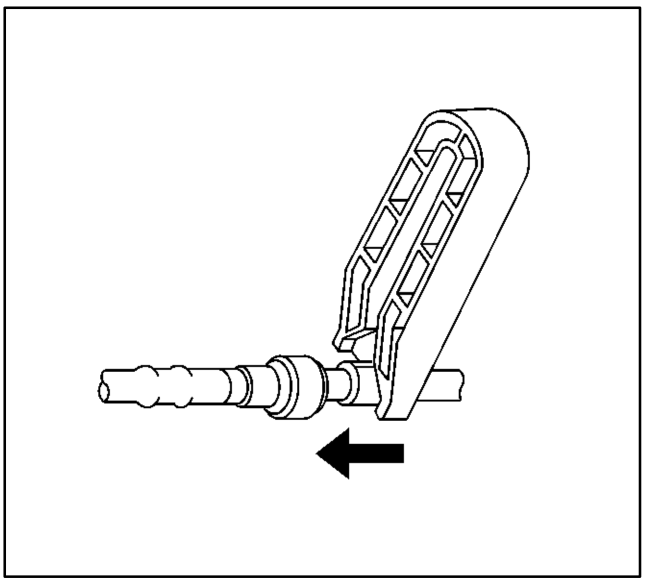
J 37088-A Fuel Line Quick-Connect Separator Tool Set

Removal Procedure

1. Relieve the fuel system pressure before servicing any fuel system connection. Refer to *Fuel Pressure Relief Procedure*.
2. Remove the retainer from the quick-connect fitting.

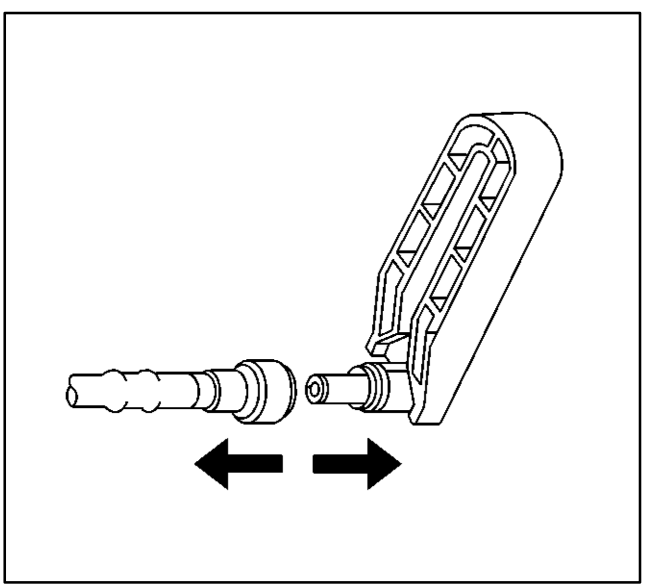
Caution: Refer to Safety Glasses and Compressed Air Caution in Cautions and Notices.

3. Blow dirt out of the fitting using compressed air.



12780

4. Choose the correct tool from the *J 37088-A* for the size of the fitting. Insert the tool into the female connector, then push inward in order to release the locking tabs.



12782

5. Pull the connection apart.

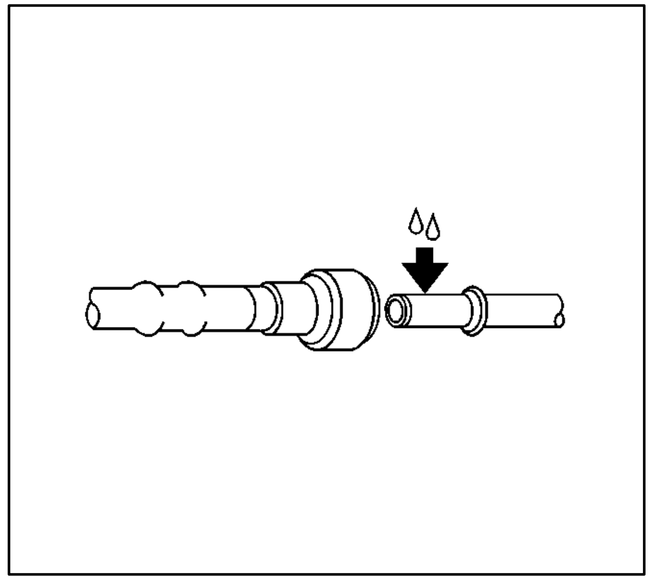
Notice: Refer to Quick-Connect Fittings Notice in Cautions and Notices.

6. Use a clean shop towel in order to wipe off the male pipe end.
7. Inspect both ends of the fitting for dirt and burrs. Clean or replace the components as required.

Installation Procedure

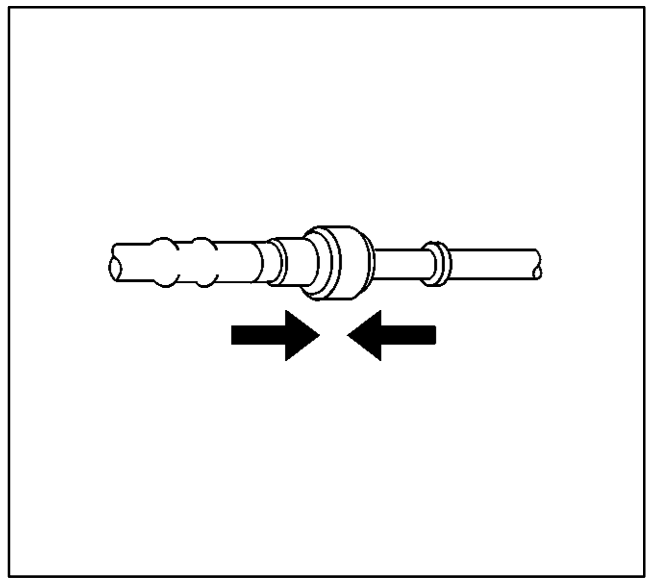
Caution: Refer to Fuel Pipe Fitting Caution in Cautions and Notices.

1. Apply a few drops of clean engine oil to the male pipe end.



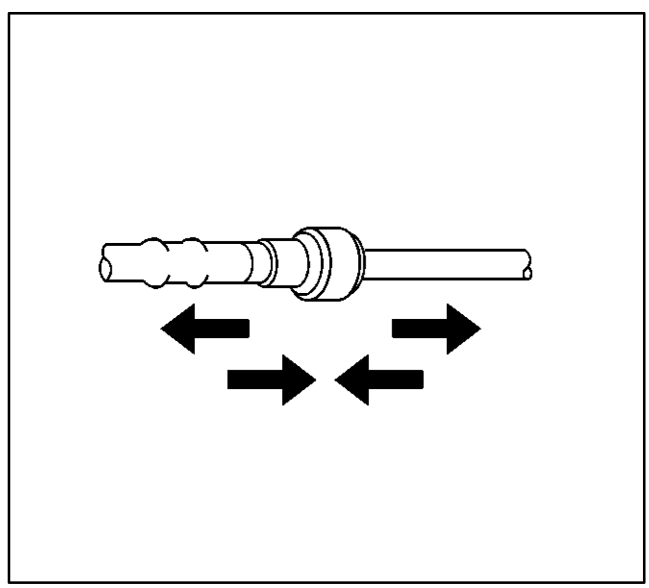
12784

2. Push both sides of the fitting together in order to snap the retaining tabs into place.



12786

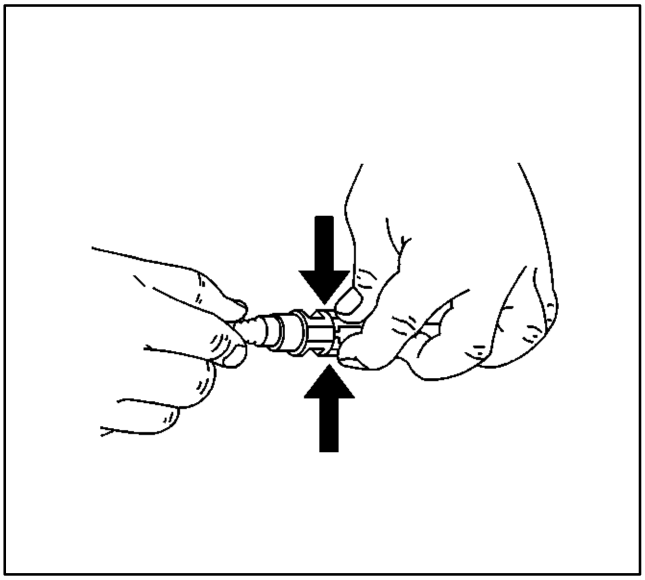
3. Once installed, pull on both sides of the fitting in order to make sure the connection is secure.
4. Install the retainer to the quick-connect fitting.



12787

Quick Connect Fitting(s) Service (Plastic Collar)

Removal Procedure

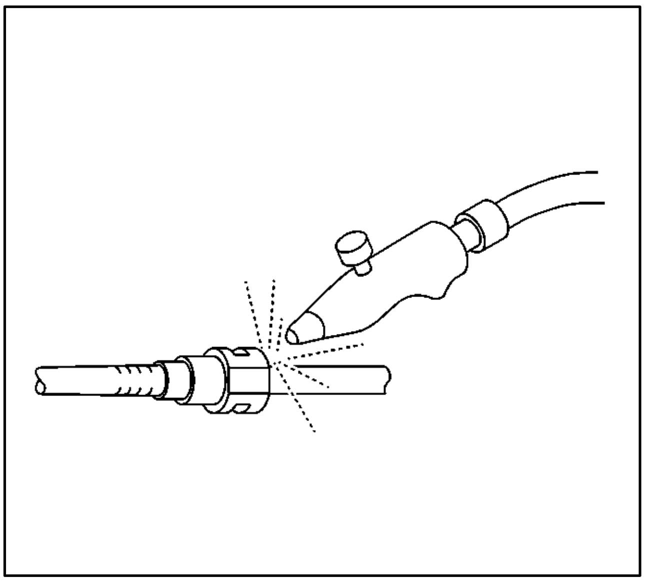


12777

1. Relieve the fuel system pressure before servicing any fuel system connection. Refer to *Fuel Pressure Relief Procedure*.

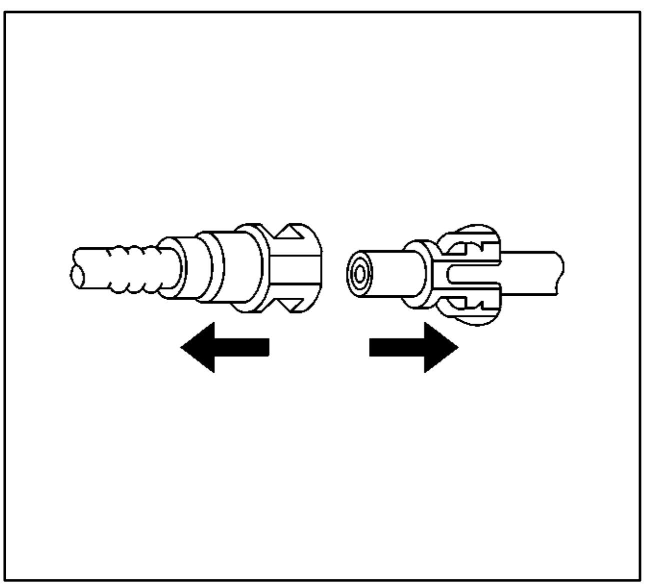
Caution: Refer to Safety Glasses and Compressed Air Caution in Cautions and Notices.

2. Using compressed air, blow any dirt out of the quick-connect fitting.



155410

3. Squeeze the plastic retainer release tabs.



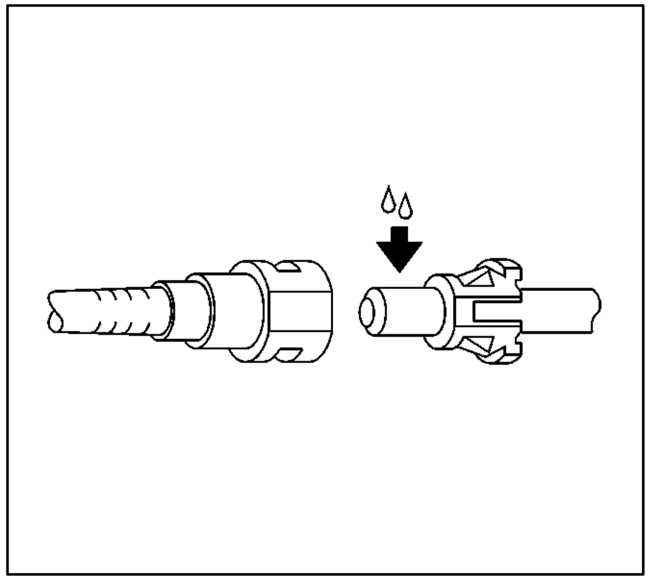
12778

4. Pull the connection apart.

Installation Procedure

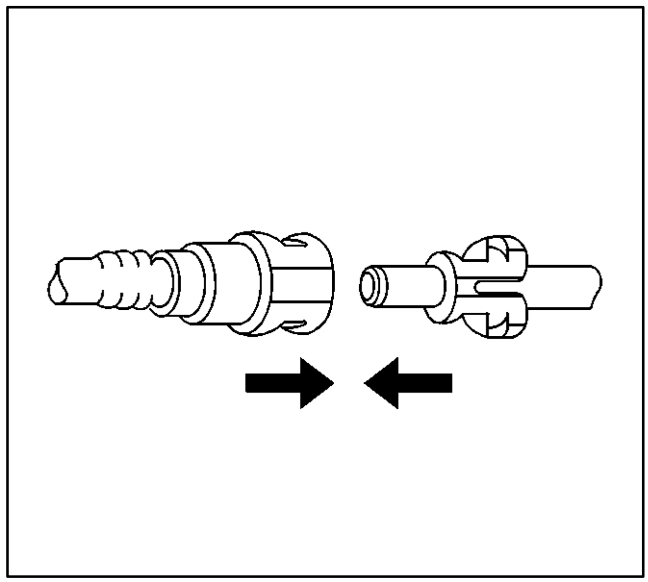
Caution: Refer to Fuel Pipe Fitting Caution in Cautions and Notices.

1. Apply a few drops of clean engine oil to the male fuel pipe end.



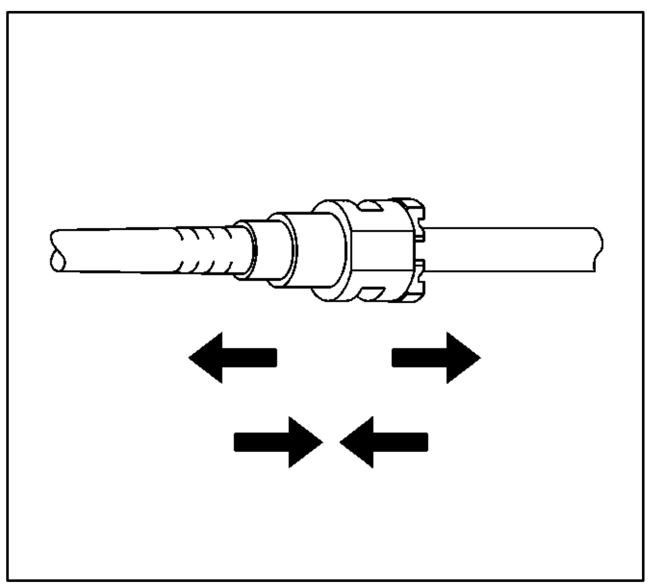
155425

2. Push both sides of the quick-connect fitting together in order to cause the retaining tabs to snap into place.



21855

3. Once installed, pull on both sides of the quick-connect fitting in order to make sure the connection is secure.

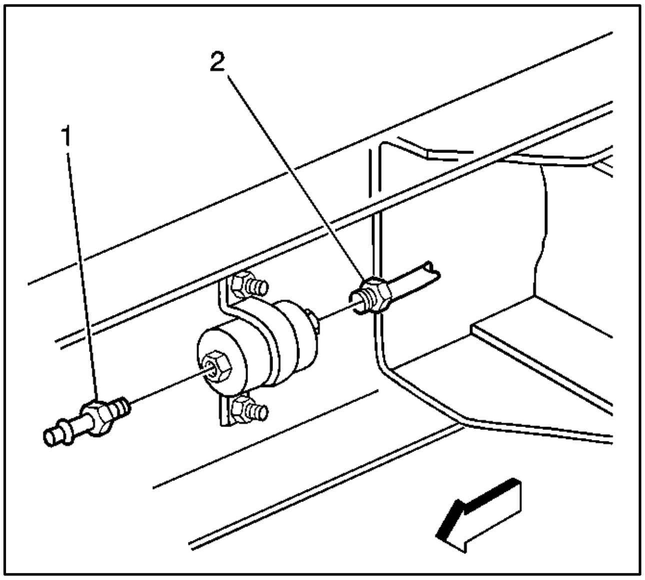


155399

Fuel Filter Replacement

Removal Procedure

1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief Procedure.*
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle*.
3. Remove the fuel feed and return pipes (1, 2) at the filter

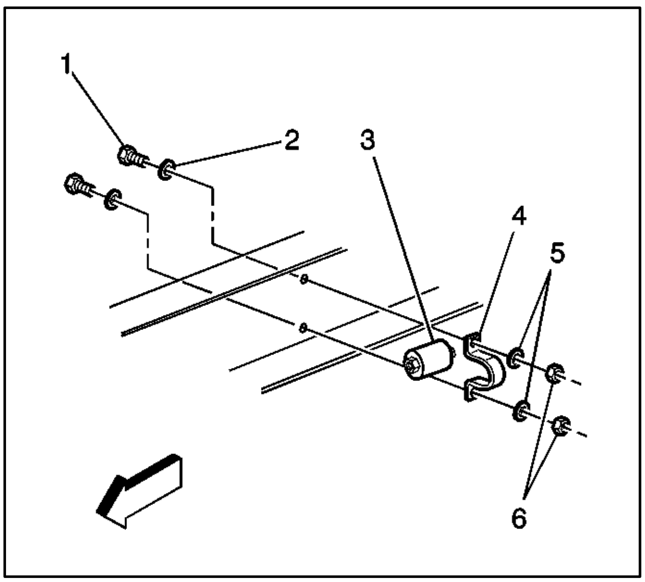


747226

4. Remove the fuel filter clamp (4) from the filter (3).

Important: If the fuel filter is plugged, inspect the fuel tank internally and clean if necessary. Refer to *Fuel System Cleaning.*

5. Inspect the fuel filter.



747225

Installation Procedure

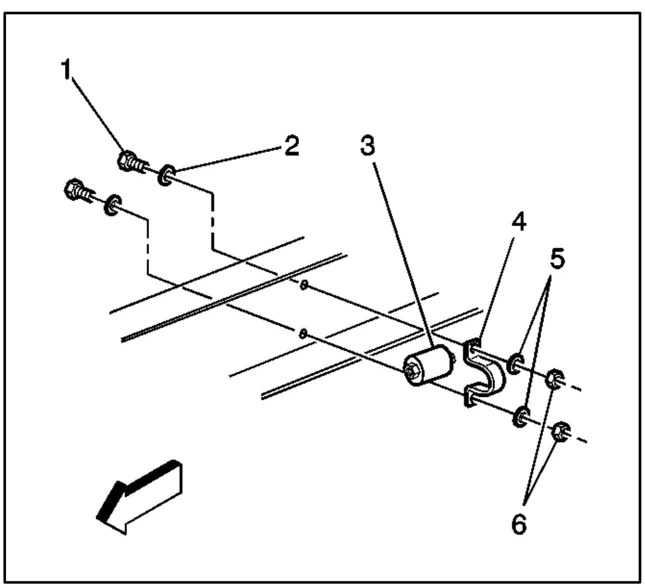
1. Remove the protective caps from the new filter.
2. Install the fuel filter clamp (4) on to the fuel filter (3).
3. Install the fuel filter retaining bolts (1) with flat washers (2) through the frame rail and fuel filter clamp (4).

Notice: Refer to Fastener Notice in Cautions and Notices.

4. Install the flat washers (5) and nuts (6) while aligning the fuel filter.

   Tighten

   Tighten the retaining nuts to 22.5 N·m (17 lb ft).

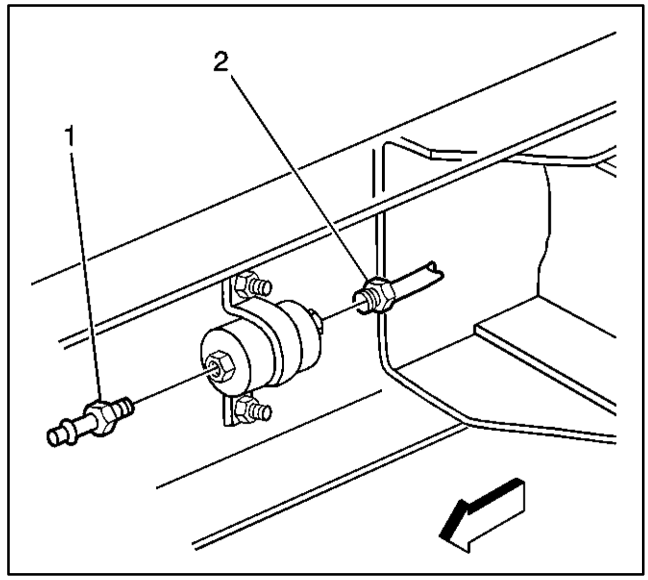


747225

5. Install the fuel feed and return pipes (1, 2) to the fuel filter.

   Tighten

   Tighten the fuel pipe nuts to 27 N·m (20 lb ft).
6. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle.*
7. Connect the negative battery cable.
8. Inspect for fuel leaks using the following procedure:
   8.1. Turn ON the ignition, with the engine OFF for 2 seconds.
   8.2. Turn OFF the ignition for 10 seconds.
   8.3. Turn ON the ignition, with the engine OFF.
   8.4. Inspect for fuel leaks.



747226

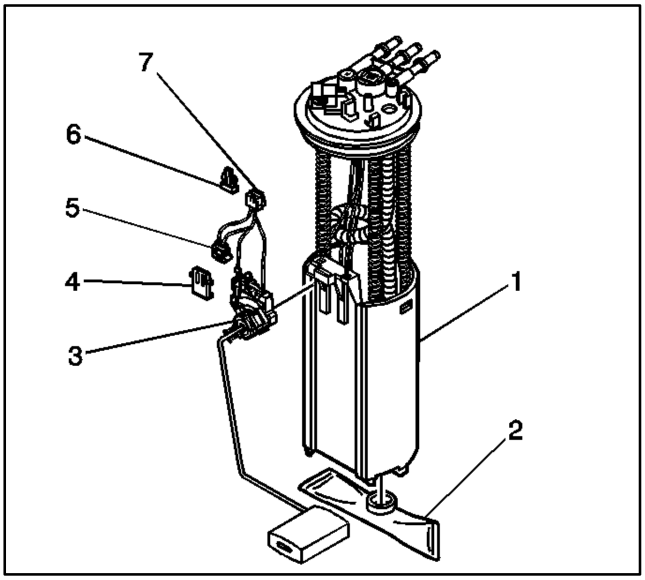
Fuel Tank Draining Procedure

Caution: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

1. Remove the fuel fill cap.
2. Use a hand operated pump device in order to remove the fuel through the fuel filler pipe.

Fuel Tank Replacement

Refer to *Fuel Tank Replacement (Motorhome)* and *Fuel Tank Replacement (Commercial)* in the WCC Service Manual.

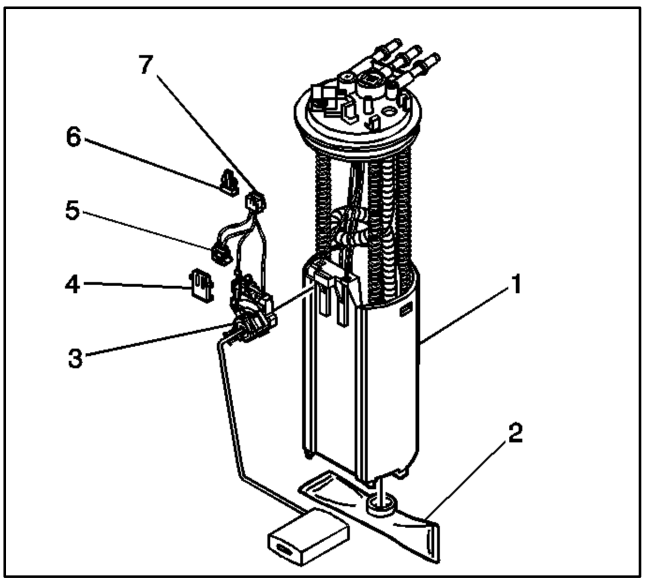


751369

Fuel Level Sensor Replacement

Removal Procedure

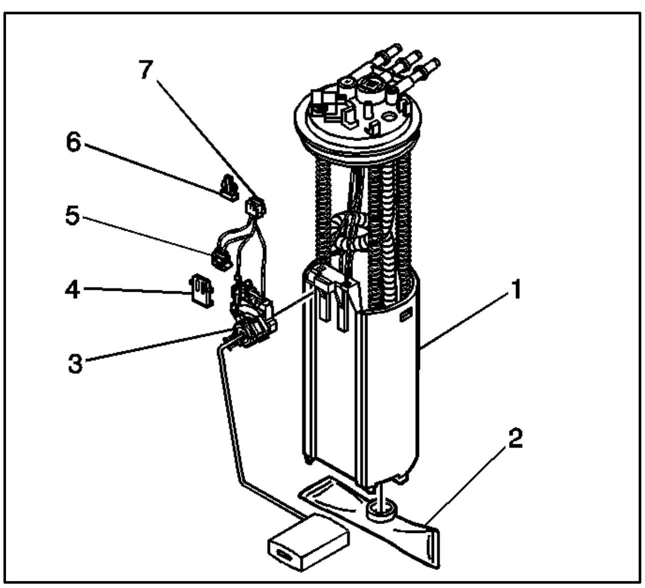
1. Remove the fuel tank. Refer to *Fuel Tank Assembly Replacement.*
2. Remove the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.
3. Disconnect the fuel pump electrical connector (5).
4. Remove the fuel level sensor electrical connector retaining clip (6).
5. Disconnect the fuel level sensor electrical connector (7) from under the fuel sender cover.
6. Remove the fuel level sensor retaining clip (4).
7. Squeeze the locking tangs and remove the fuel level sensor (3).



751369

Installation Procedure

1. Install the fuel level sensor (3).
2. Install the fuel level sensor retaining clip (4).
3. Connect the fuel level sensor electrical connector (7).
4. Connect the fuel level sensor electrical connector retaining clip (6).
5. Connect the fuel pump electrical connector (5).
6. Install the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement.*
7. Install the fuel tank. Refer to *Fuel Tank Assembly Replacement.*



751369

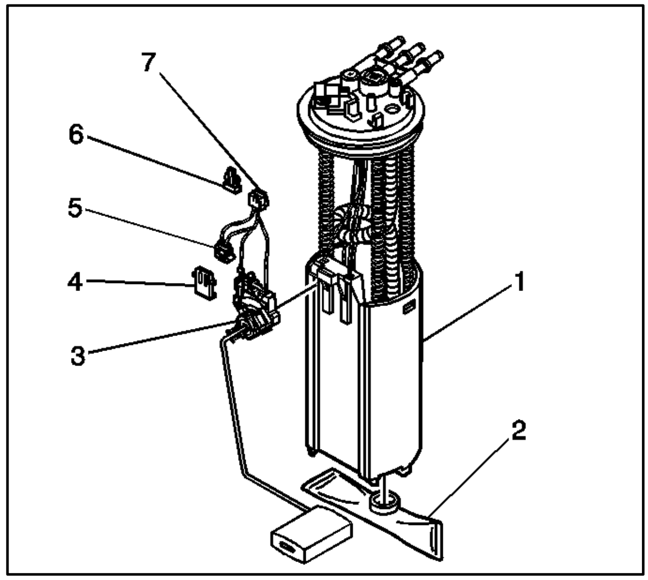
Fuel Strainer Replacement

Removal Procedure

1. Remove the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement.*
2. Note the position of the fuel strainer (2) on the fuel sender.
3. Support the fuel sender assembly with one hand and grasp the strainer (2) with the other hand.
4. Pull the strainer off the fuel sender. Discard the strainer after inspection.
5. Inspect the strainer. Replace a contaminated strainer and clean the fuel tank.

Installation Procedure

1. Install a new fuel strainer (2) in the same position as noted during disassembly. Push the strainer on the bottom of the fuel sender until the strainer is fully seated.
2. Install the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.

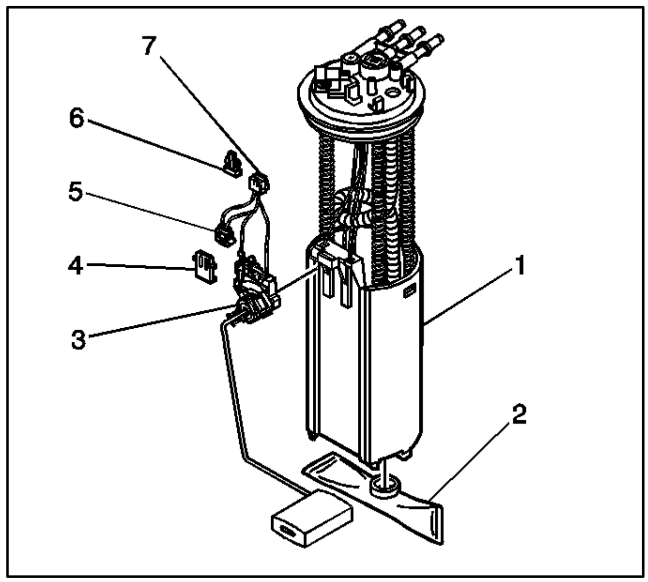


751369

Fuel Tank Pump Module Replacement

Removal Procedure

1. Remove the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.
2. Note the position of the fuel strainer (2) on the fuel sender.
3. Support the fuel sender assembly with one hand and grasp the strainer (2) with the other hand.
4. Pull the strainer off the fuel sender. Discard the strainer after inspection.
5. Inspect the strainer. Replace a contaminated strainer and clean the fuel tank.
6. Disconnect the fuel pump electrical connector (5).
7. Remove the electrical connector retaining clip (6) from the fuel level sensor.
8. Disconnect the sensor electrical connector (7) from under the fuel sender cover.
9. Remove the fuel level sensor retaining clip (4).
10. Squeeze the locking tangs and remove the fuel level sensor (3).



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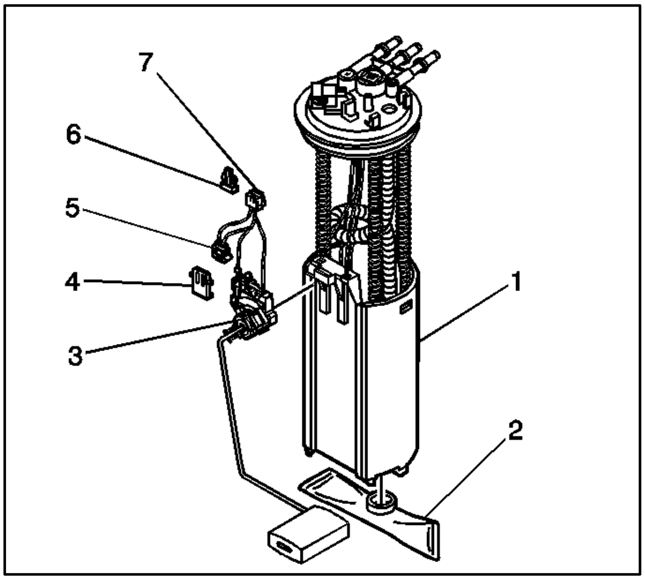


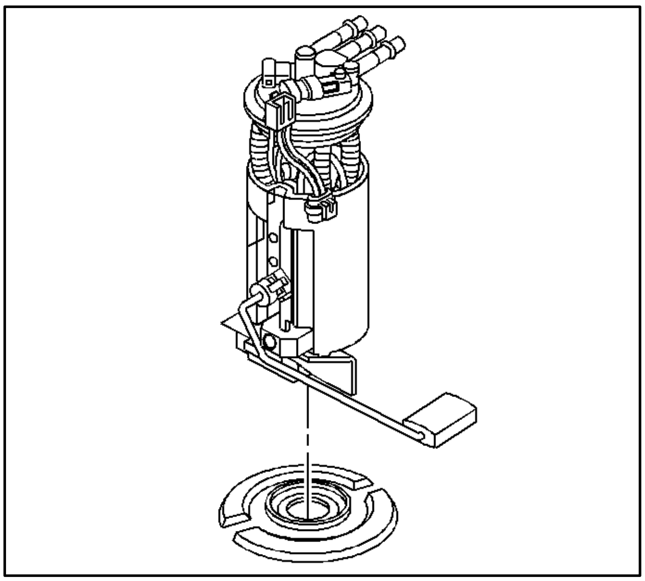
751369

Installation Procedure

1. Install the fuel level sensor (3).
2. Install the sensor retaining clip (4).
3. Connect the electrical connector (7) to the fuel level sensor.
4. Connect the electrical connector retaining clip (6) to the fuel level sensor.
5. Connect the fuel pump electrical connector (5).

Important: Always install a new fuel strainer when replacing the fuel tank fuel pump module.

6. Install a new fuel strainer (2) in the same position as noted during disassembly. Push the strainer on the bottom of the fuel sender until the strainer is fully seated.
7. Install the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.



331709

Fuel Sender Assembly Replacement

Removal Procedure

Tools Required

J 39765 Fuel Sender Lock Nut Wrench

1. Remove the fuel tank. Refer to *Fuel Tank Replacement*

Notice: Do Not handle the fuel sender assembly by the fuel pipes. The amount of leverage generated by handling the fuel pipes could damage the joints.

2. Remove the fuel sender assembly retaining ring using the *J 39765*.

Caution: Drain the fuel from the fuel sender assembly into an approved container in order to reduce the risk of fire and personal injury. Never store the fuel in an open container.

3. Remove the fuel sender assembly and the seal. Discard the seal.
4. Clean the fuel sender sealing surfaces.

Installation Procedure

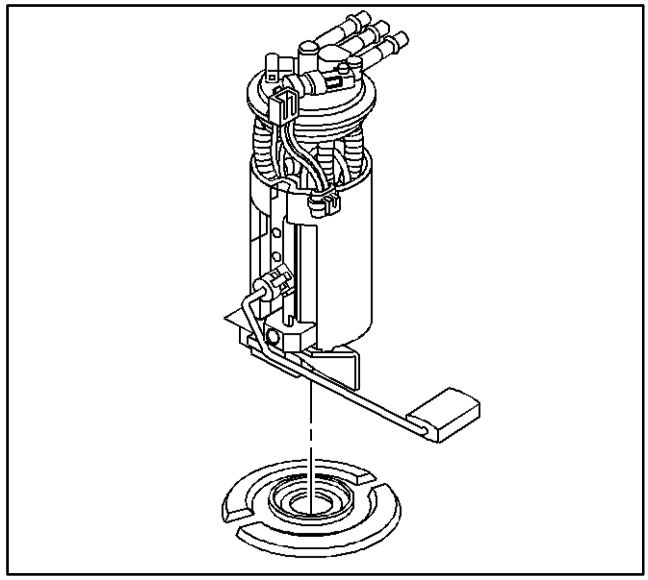
Caution: In order to reduce the risk of fire and personal injury that may result from a fuel leak, always replace the fuel sender gasket when reinstalling the fuel sender assembly.

Important: The fuel strainer must be in a horizontal position when the fuel sender is installed in the tank. When installing the fuel sender assembly, assure that the fuel strainer does not block full travel of the float arm.

1. Install the new seal on the fuel tank.

Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the fuel sender assembly into the fuel tank.
3. Install the fuel sender assembly retaining ring using the *J 39765*.
4. Install the fuel tank. Refer to *Fuel Tank Replacement* .



331709

Fuel Hose/Pipes Replacement – Filter to Engine

Refer to *Fuel Hose/Pipes Assembly (Motorhome Pipes)* and *Fuel Hose/Pipes Assembly Replacement (Commercial)* in the WCC Service Manual.

Fuel System Cleaning

Fuel Tank Cleaning

Important:

Only use oil free compressed air to blow out the fuel pipes.

Inspect the fuel tank internally and clean the fuel tank if you find a plugged fuel filter.

Caution: Refer to Battery Disconnect in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief Procedure*.
3. Drain the fuel tank. Refer to Fuel Tank Draining Procedure.
4. Remove the fuel tank. Refer to *Fuel Tank Replacement*
5. Remove the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.
6. Inspect the fuel pump strainer. Replace a contaminated strainer and inspect the fuel pump.
7. Inspect the fuel pump inlet for dirt and debris. Replace the fuel pump if you find dirt or debris in the fuel pump inlet.

Important: When flushing the fuel tank, handle the fuel and water mixture as a hazardous material. Handle the fuel and water mixture in accordance with all applicable local, state, and federal laws and regulations.

8. Flush the fuel tank with hot water.
9. Pour the water out of the fuel sender assembly opening. Rock the tank to be sure that removal of the water from the tank is complete.
10. Install the fuel sender assembly. Refer to *Fuel Sender Assembly Replacement*.
11. Install the fuel tank. Refer to *Fuel Tank Replacement*
12. Refill the fuel tank.
13. Install the fuel filler cap.
14. Connect the negative battery cable.
15. Inspect for leaks:
    - 15.1. Turn ON the ignition for 2 seconds.
    - 15.2. Turn OFF the ignition for 10 seconds.
    - 15.3. Turn ON the ignition.
    - 15.4. Inspect for fuel leaks.

Fuel Pressure Connection Valve Replacement

Removal Procedure

1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief Procedure*.
2. Clean the area around the fuel pressure connection with GM X-30A or equivalent.
3. Remove the fuel pressure connection core (2) using a standard valve core removal and installation tool.

Installation Procedure

1. Install the fuel pressure connection core assembly (2) using a standard valve core removal and installation tool.
2. Tighten the fuel filler cap.
3. Connect the negative battery cable.
4. Inspect for leaks.

4.1. Turn ON the ignition for 2 seconds.

4.2. Turn OFF the ignition for 10 seconds.

4.3. Turn ON the ignition.

4.4. Inspect for fuel leaks.

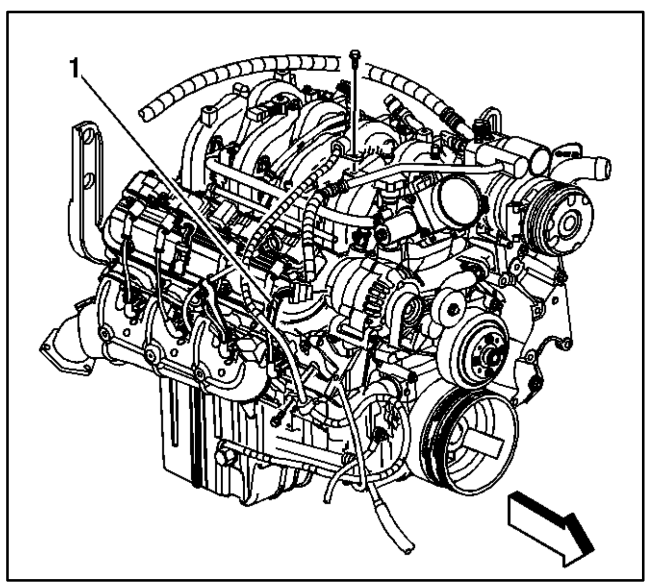
5. Install the fuel pressure connection valve cap (1).

Fuel Rail Assembly Replacement

Removal Procedure

Important: An eight digit identification number is located on the fuel rail assembly. Refer to this model identification number if servicing or part replacement is required.

1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief Procedure*.
2. Before removal, clean the fuel rail assembly with a spray type engine cleaner, GM X-30A or equivalent, if necessary. Follow the package instructions. Do not soak fuel rails in liquid cleaning solvent.
3. Disconnect the generator harness connector (1).



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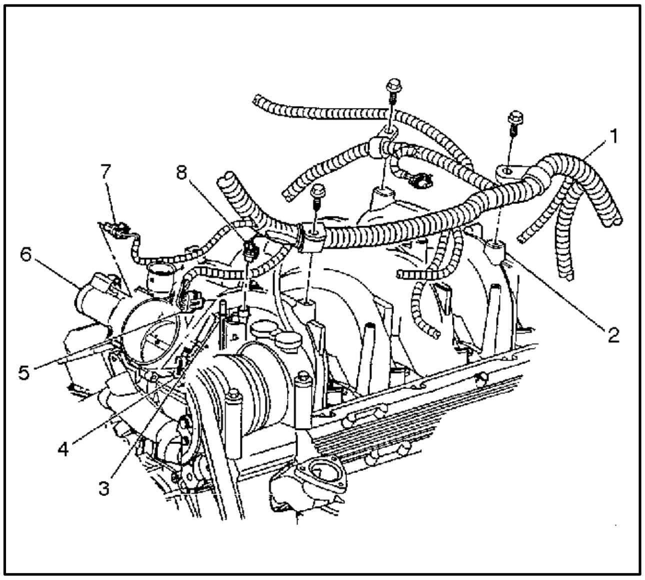

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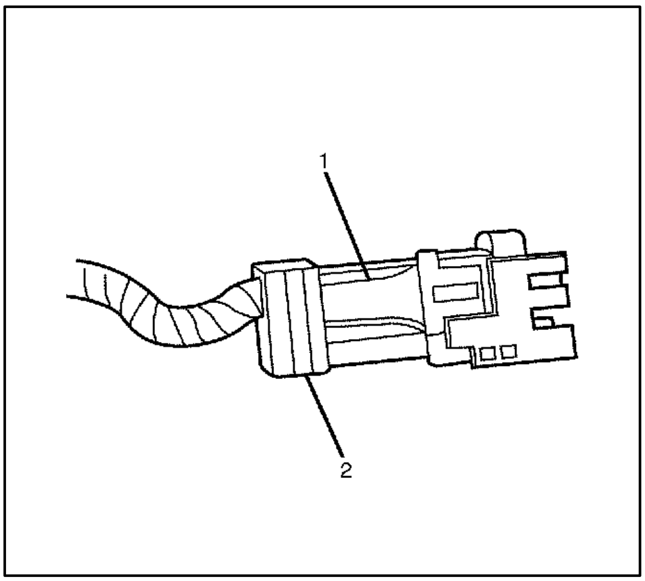
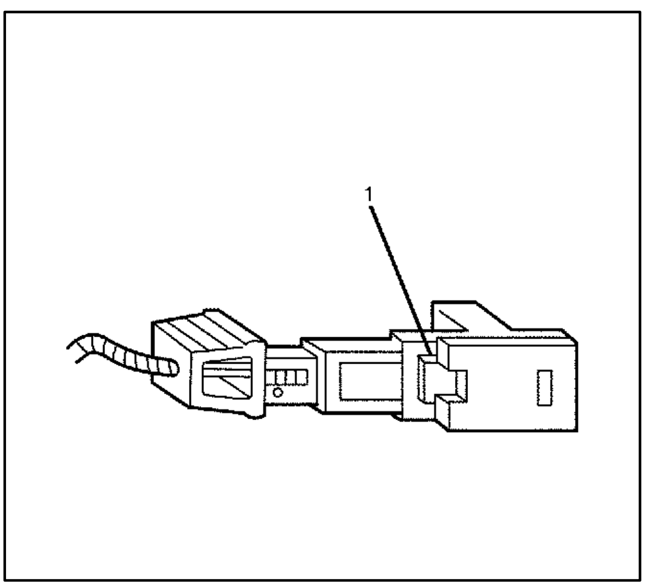
4. Disconnect the EVAP purge valve harness connector (4).
5. Disconnect the throttle position (TP) sensor harness connector (2).
6. Disconnect the electronic throttle control (ETC) harness connector (3).
7. Remove the upper engine wire harness bracket studs and position the upper engine wire harness aside.



WRK64012

8. Identify the connectors to their corresponding injectors to ensure correct sequential injector firing order after reassembly.
9. Pull the top portion (2) of the injector connector up. Do not pull the top portion of the connector past the top of the white portion (1).



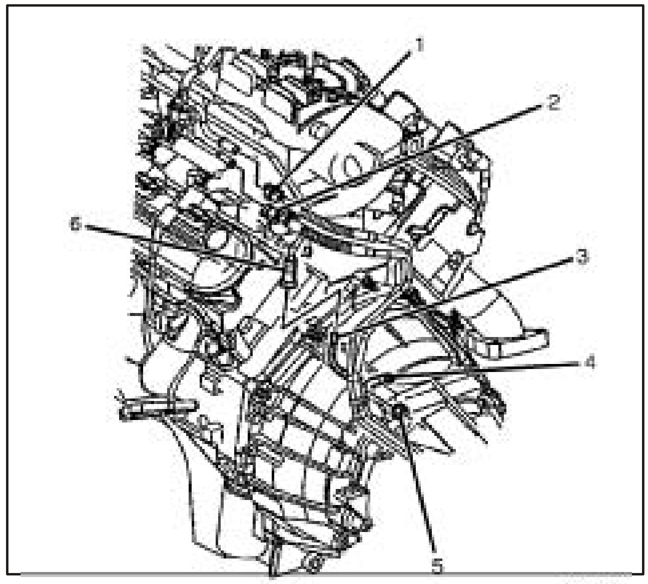
WRK64013

10. Push the tab (1) on the lower side of the injector connector in order to release the connector from the injector.
11. Repeat *step 9* and *step 10* for each injector connector.

Notice:

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

12. Disconnect the fuel feed pipe and return pipes (1, 2) from the fuel rail.



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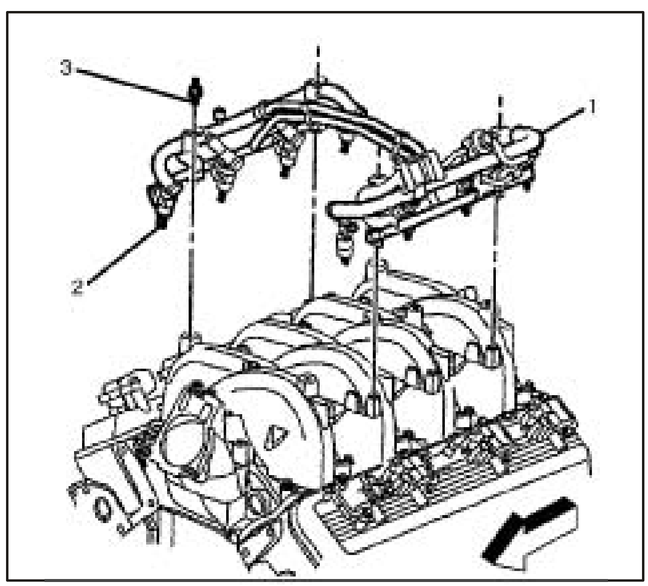
13. Remove the fuel rail attaching bolts (3).
14. Remove the fuel rail assembly (1).



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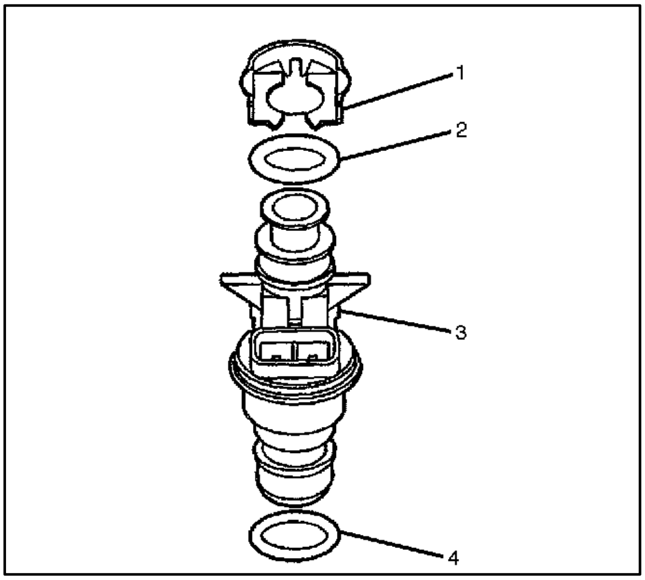

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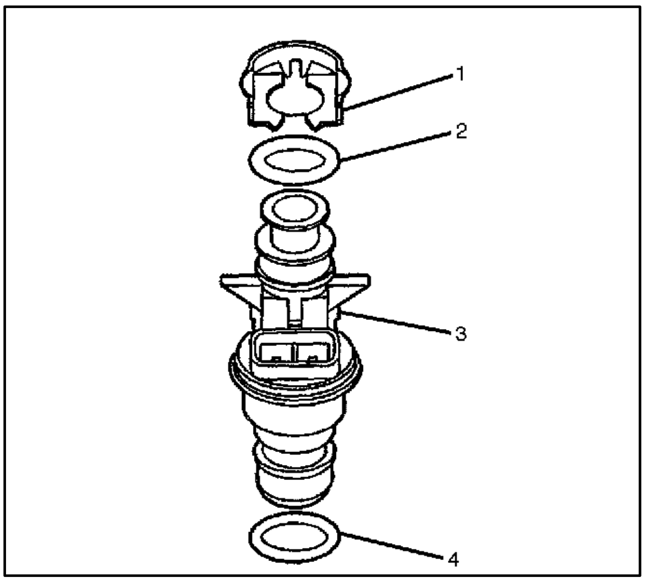
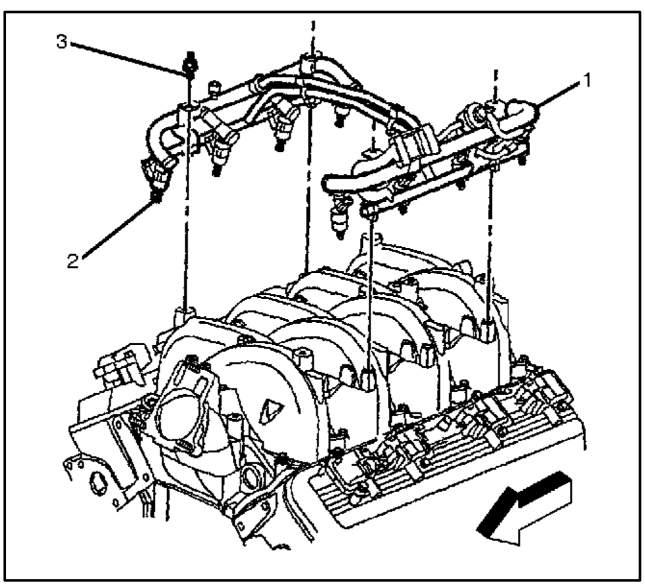
16. Remove the injector lower O-ring seal (4) from the spray tip end of each injector (3).
17. Discard the O-ring seals.



WRK64017

Installation Procedure

1. Lubricate the new lower injector O-ring seals (4) with clean engine oil.
2. Install the new O-ring seals (4) on the spray tip end of each injector (3).



WRK64016

3. Install the fuel rail assembly to the intake manifold.
4. Apply a 5 mm (0.020 in.) band of GM P/N 12345382 thread lock or equivalent, to the threads of the fuel rail bolts.

Notice: Refer to Fastener Notice in Cautions and Notices.

5. Install the fuel rail attaching bolts.

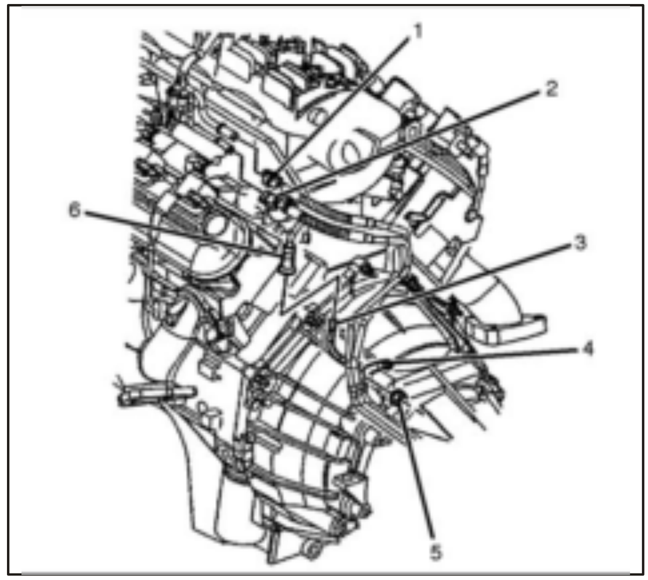
   Tighten

   Tighten the bolts to 12 N·m (106 lb in).

6. BLANK
7. Connect the fuel feed pipe (1) and the return pipe (2) to the fuel rail.
8. Connect the injector electrical connectors.

Install each connector on the proper injector in order to ensure correct sequential injector firing order.

Rotate the injectors as required in order to avoid stretching the wire harness.

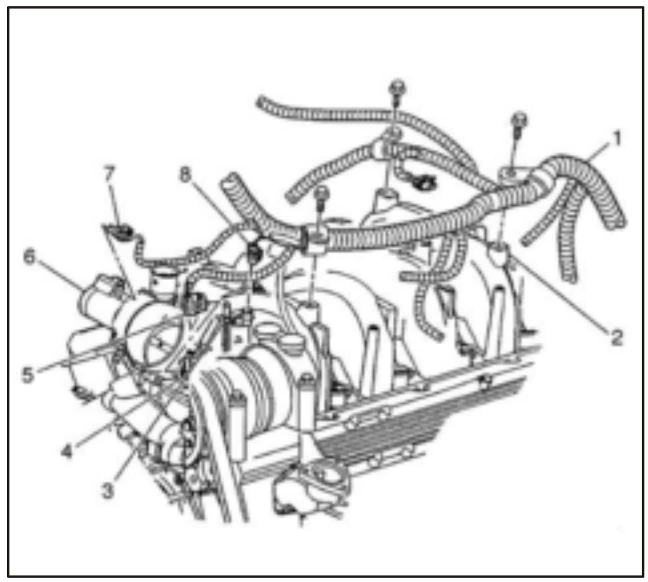


WRK64014

9. Install the upper engine wire harness bracket.
10. Install the retainer studs to the upper engine wire harness.

    Tighten

    Tighten the studs to 10 N·m (89 lb in).
11. Reconnect the EVAP purge valve harness connector (8).
12. Reconnect the throttle position sensor harness connector (5).
13. Reconnect the electronic throttle control harness connector (7).



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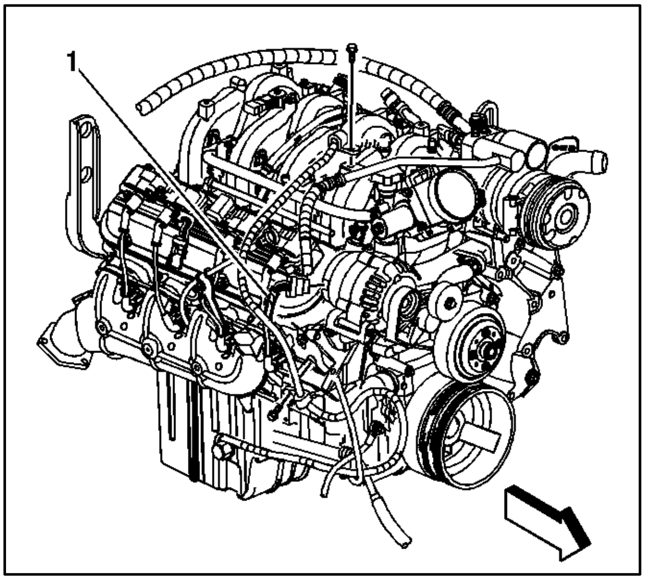

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14. Reconnect the generator harness connector (1).
15. Tighten the fuel filler cap.
16. Connect the negative battery cable. Refer to *Battery Cable Replacement* in the WCC Service Manual.
17. Inspect for leaks.
    17.1. Turn the ignition ON for 2 seconds.
    17.2. Turn the ignition OFF for 10 seconds.
    17.3. Turn the ignition ON.
    17.4. Inspect for fuel leaks.

Fuel Injector Replacement

Removal Procedure

Tools Required

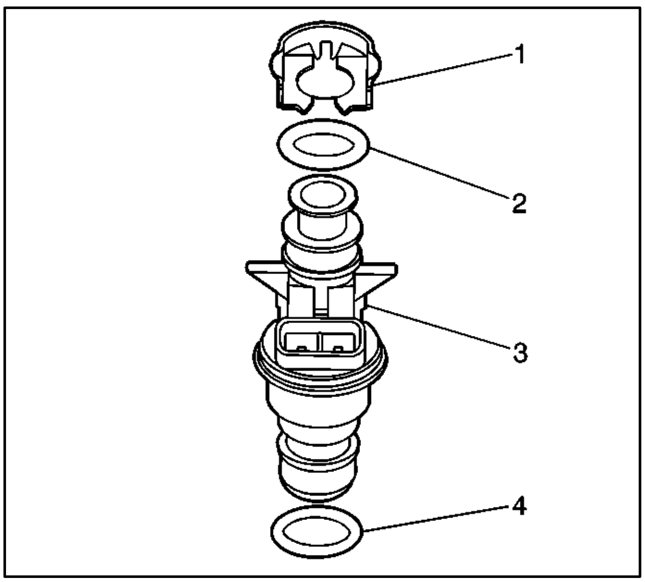
J 43013 Fuel Injector Assembly Removal Toll

Notice: Refer to Fuel Injector Notice in Cautions and Notices.

Important: The engine oil may be contaminated with fuel if the fuel injectors are leaking.

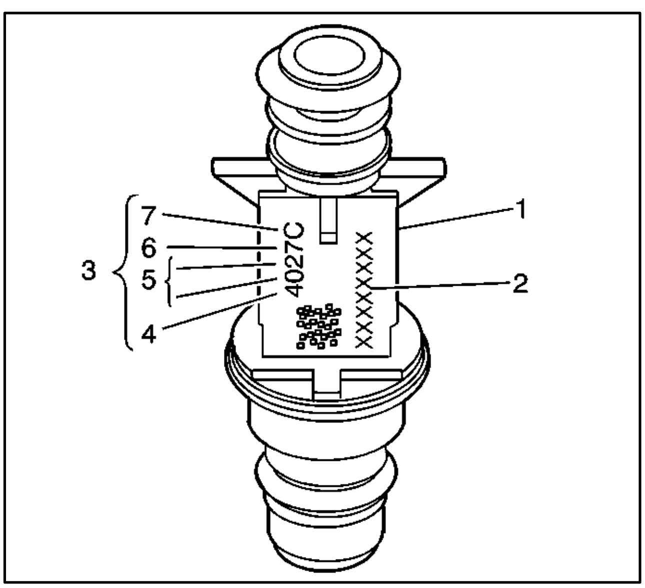
1. Remove the fuel rail assembly. Refer to *Fuel Rail Assembly Replacement*.

2. Remove the injector retainer clip (4).
3. Insert the fork of *J 43013* the fuel injector assembly removal tool between the fuel rail pod and the 3 protruding retaining clip ledges. Use a prying motion while inserting the tool in order to force the injector out of the fuel rail pod.



351185

4. Discard the injector retainer clip (1).
5. Remove the injector O-ring seals (2, 4) from both ends of the injector. Discard the O-ring seals.



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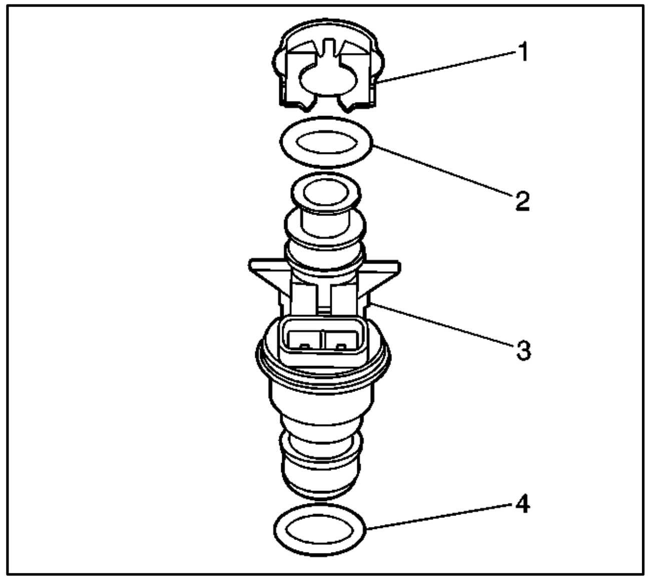
Installation Procedure

Important: When ordering new fuel injectors, be sure to order the correct injector for the application being serviced.

The fuel injector assembly (1) is stamped with a part number identification (2). A four digit build date code (3) indicates the month (4), day (5), year (6), and the shift (7) that built the injector.

1. Lubricate the new injector O-ring seals (2, 4) with clean engine oil.
2. Install the new injector O-ring seals on the injector.
3. Install a new retainer clip (1) on the injector.



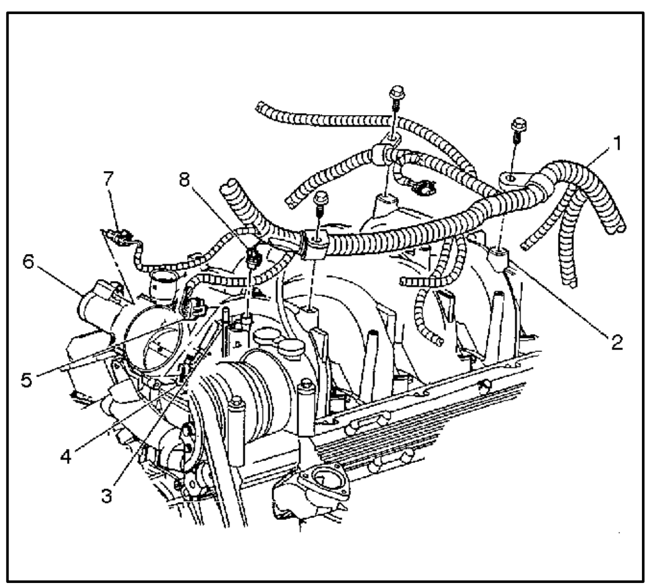
351185

4. Push the fuel injector (5) into the fuel rail injector socket with the electrical connector facing outwards. The retainer clip (4) locks on to a flange on the fuel rail injector socket.
5. Install the fuel rail assembly. Refer to *Fuel Rail Assembly Replacement.*

Evaporative Emission (EVAP) Canister Purge Valve Replacement

Removal Procedure

1. Disconnect the evaporative emission (EVAP) canister purge valve harness connector (8).



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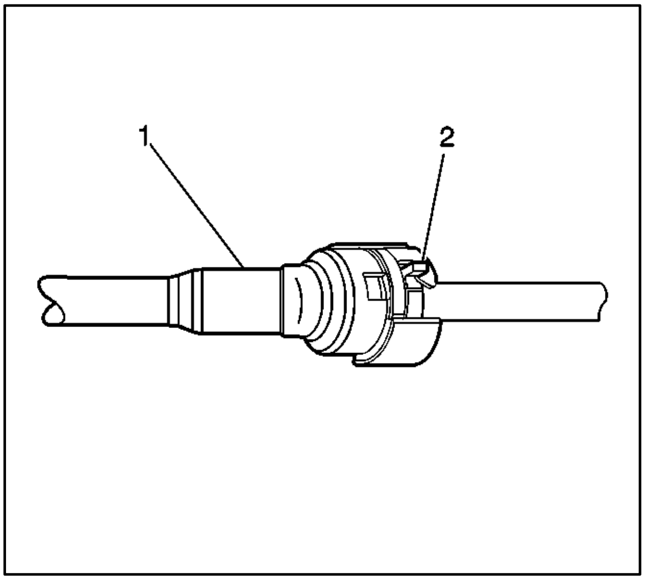
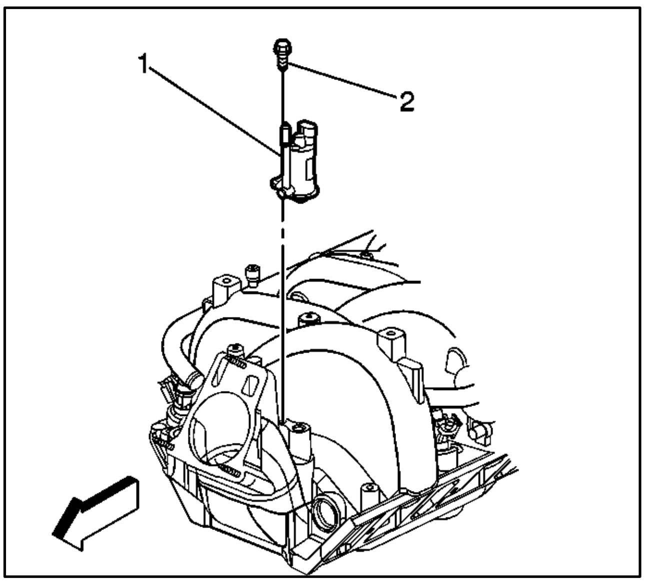


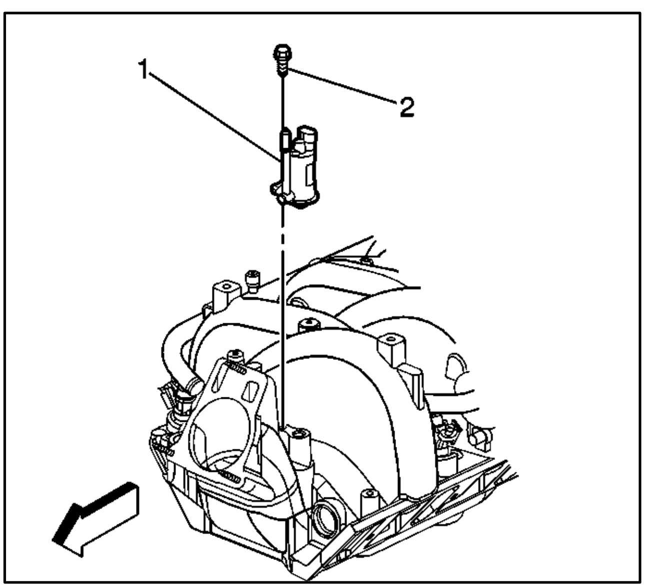
695582

2. To disconnect the EVAP purge pipe connector (1), slide the retaining tab (2) to the release position and separate the connection.



693633

3. Disconnect the EVAP purge pipe connector from the EVAP canister purge valve.
4. Remove the EVAP canister purge valve retaining bolt (2).
5. Remove the EVAP canister purge valve (1).



693633

Installation Procedure

1. Position the EVAP canister purge valve (1) on the intake manifold.

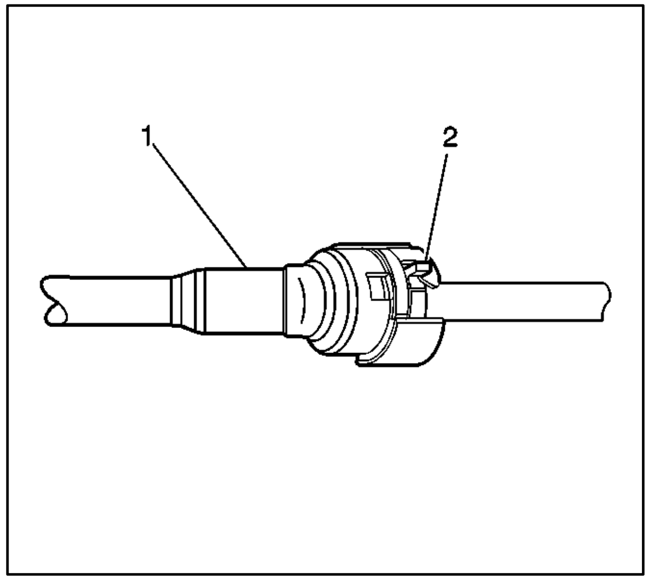
Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the EVAP canister purge valve retaining bolt (2).

   Tighten

   Tighten the EVAP purge valve retaining bolt to 10 N·m (89 lb in).

3. To connect the purge pipe connector (1), press the components together in order to snap the tab (2) in place.
4. Connect the purge pipe to the EVAP canister purge valve.



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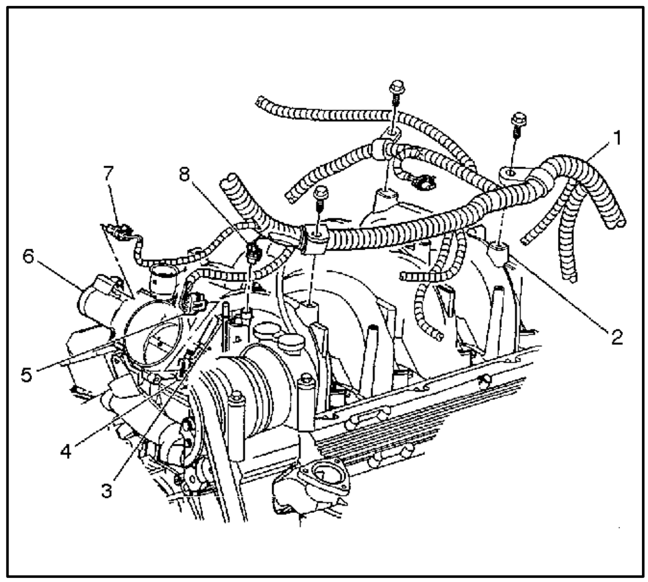
5. Connect the EVAP canister purge valve harness connector (8).



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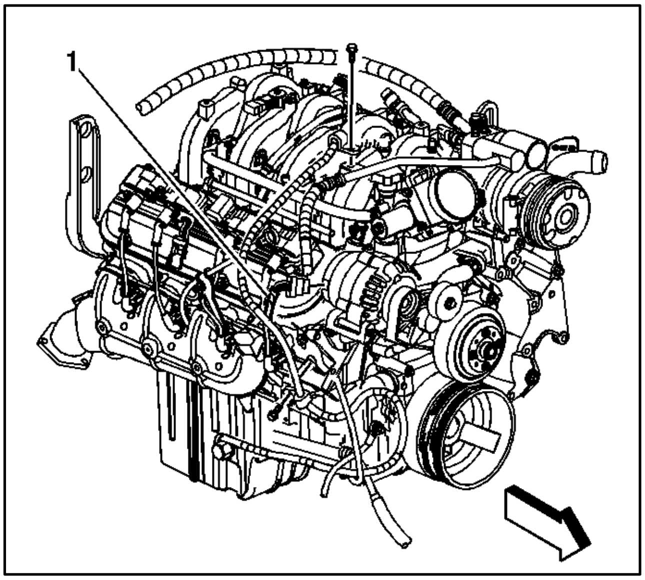
Evaporative Emission (EVAP) Canister Vent Valve Replacement

Refer to *EVAP Vent Valve Replacement* in Engine Controls – 8.L in the WCC Service Manual.

Evaporative Emission (EVAP) Hoses/Pipes Replacement – Engine

Removal Procedure



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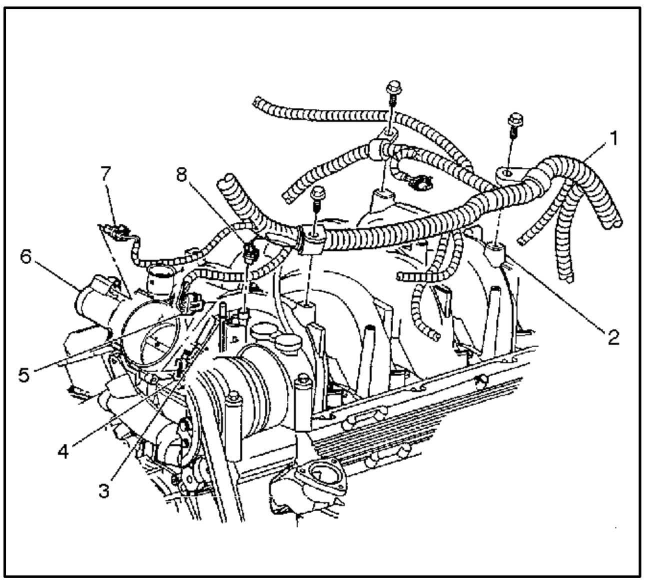
1. Disconnect the generator harness connector (1), if necessary.



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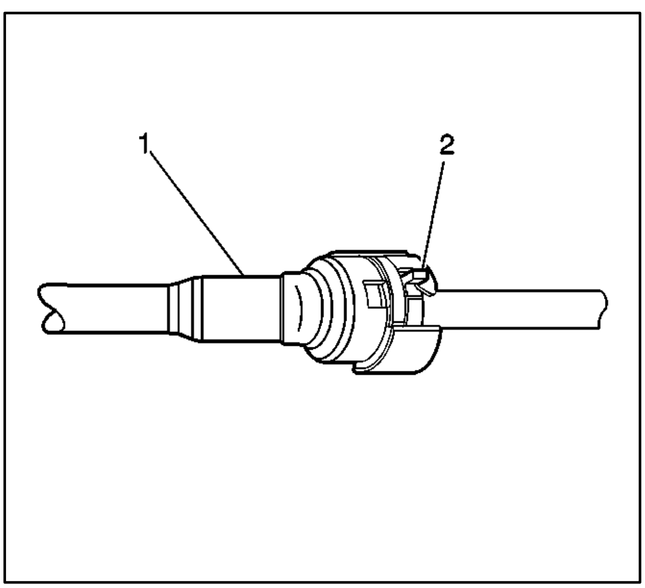
2. Disconnect the throttle position (TP) sensor harness connector (5) , if necessary.
3. Disconnect the fuel injection harness multi-way connector, if necessary.



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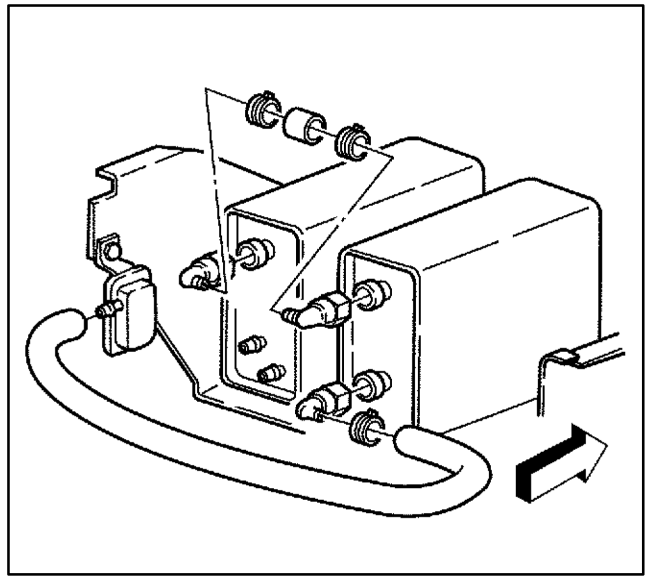
4. Disconnect the engine purge pipe from the EVAP canister purge valve. To disconnect the EVAP purge pipe connector (1), slide the retaining tab (2) to the release position and separate the connection.

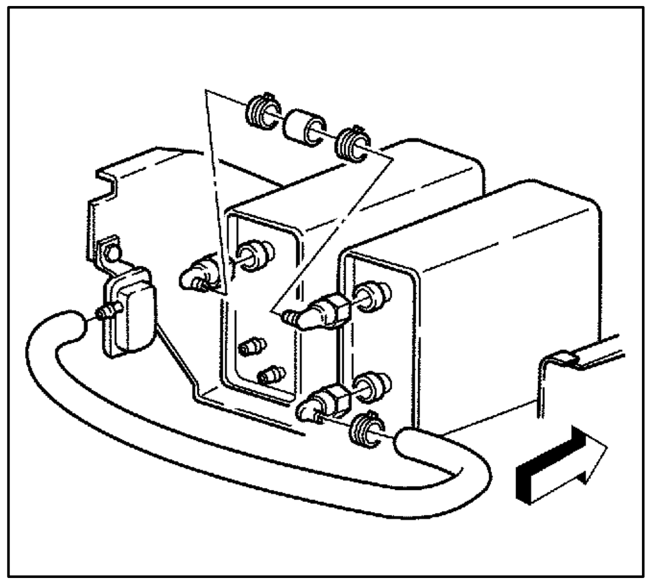
5. Disconnect the EVAP purge pipe from the EVAP canister.
6. Remove the EVAP engine purge pipe from the vehicle.



WRK64045

Installation Procedure

1. Position the EVAP purge pipe to the EVAP canister and EVAP canister purge valve.
2. Connect the EVAP purge pipe to the EVAP canister.



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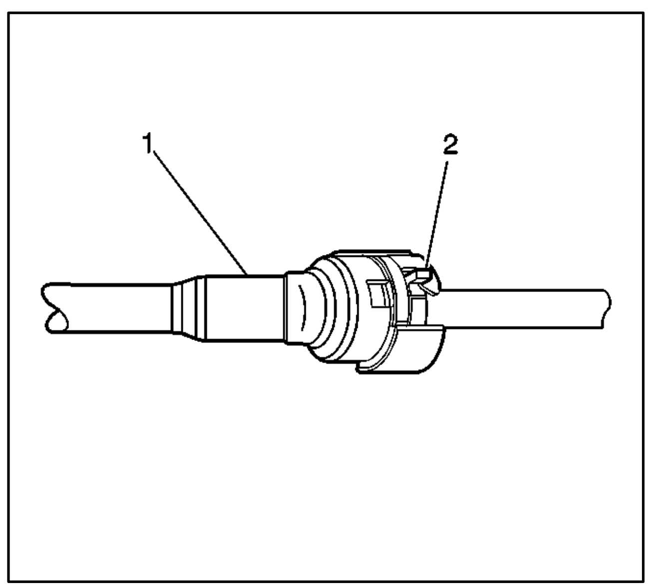
3. Connect the EVAP purge pipe (1) to the EVAP canister purge valve (2).



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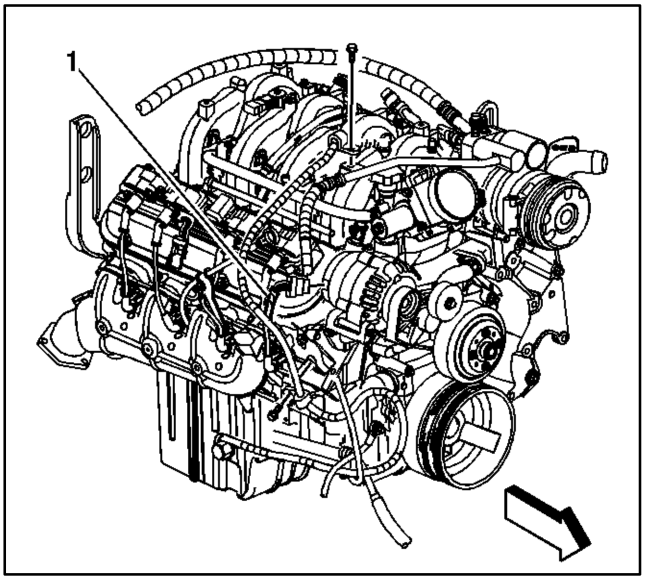

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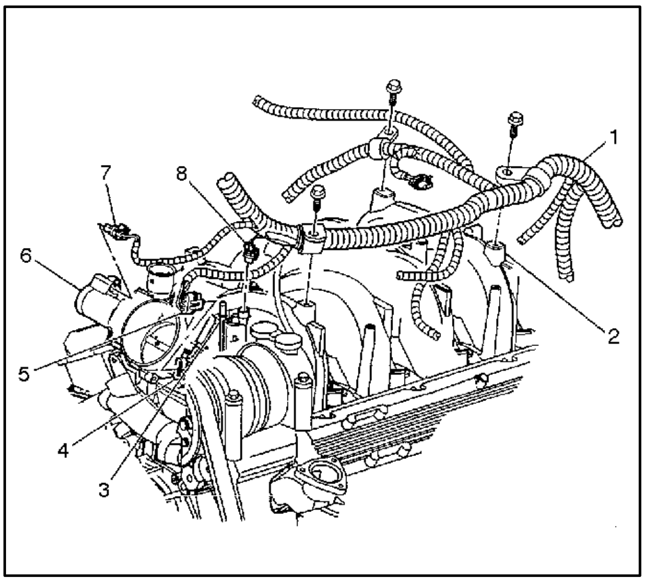
4. Connect the generator harness connector (1), if necessary.



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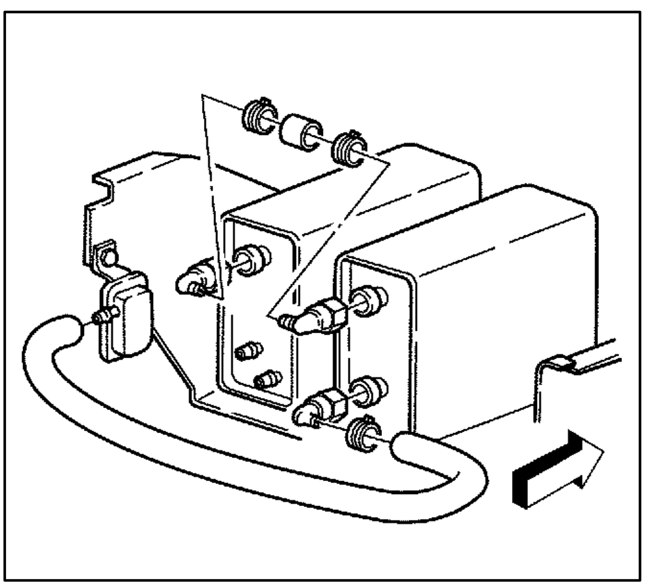
5. Connect the TP sensor harness connector (5), if disconnected.
6. Connect the fuel injector harness multi-way connector, if disconnected.



WRK64045

Evaporative Emission (EVAP) Canister Replacement

Removal Procedure

1. Disconnect the evaporative emission (EVAP) vent hose from the EVAP canister.
2. Disconnect the EVAP purge pipe and the pipe to the fuel tank vapor pipe from the EVAP canister.
3. Remove the EVAP vent valve from the EVAP canister bracket.
4. Remove the EVAP canister bracket nut.
5. Remove the EVAP canister from the EVAP canister bracket.

Installation Procedure

1. Install the EVAP canister into the EVAP canister bracket.

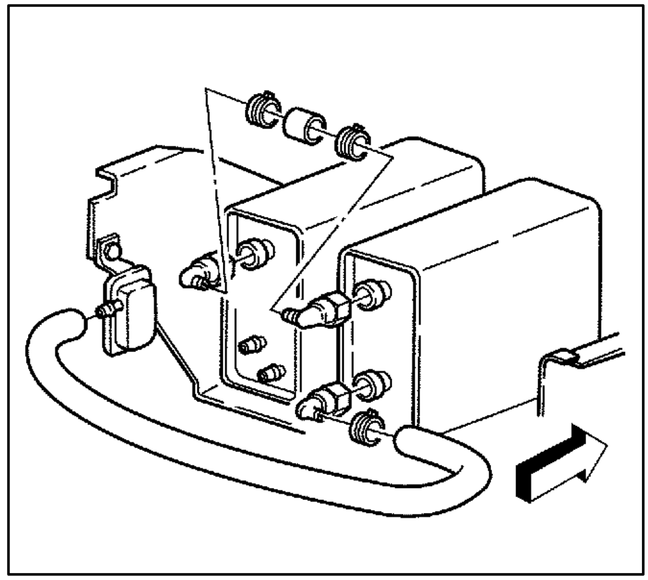
Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the EVAP canister bracket nut.

   Tighten

   Tighten the nut to 5 N·m (44 lb in).

3. Install the EVAP vent valve to the canister bracket.
4. Connect the EVAP purge pipe and the fuel tank vapor pipe to the EVAP canister.
5. Connect the EVAP vent hose to the EVAP canister.



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Evaporative Emission (EVAP) System Cleaning

Tools Required

J 41413 EVAP Pressure/Purge Diagnostic Station

Inspection Procedure

Notice: Refer to Clean, Dry, Low Pressure Gas Source Notice in Cautions and Notices.

Important: Proceed with the following procedure only when performing a purge valve replacement.

1. Turn OFF the ignition.
2. Remove the evaporative emission (EVAP) canister purge valve. Refer to Evaporative Emission (EVAP) Canister Purge Valve Replacement.
3. Lightly tap the EVAP canister purge valve on a hard surface.
4. Inspect for carbon particles exiting either of the vacuum ports.
   - If contamination is found during the inspection procedure. Replace the EVAP canister purge valve and continue with the cleaning procedure.
   - If no contamination is found continue with the published service procedure.

Cleaning Procedure

1. Connect the *J 41413.*
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the EVAP canister. Refer to *Evaporative Emission (EVAP) Canister Replacement*.
4. Turn OFF the main valve on the EVAP pressure/purge diagnostic station.
5. Disconnect the hose from the diagnostic station pressure regulator.
6. Using a section of vacuum hose, connect one end onto the diagnostic station pressure regulator.
7. Connect the other end of the vacuum hose to the canister side of the purge pipe.
8. Turn ON the main nitrogen cylinder valve and continue to discharge nitrogen for 15 seconds.
9. If the nitrogen does not dislodge the carbon particles, replace the purge pipe. Refer to Evaporative Emission (EVAP) Hoses/Pipes Replacement – Engine.
10. Return the *J 41413* to its original condition.

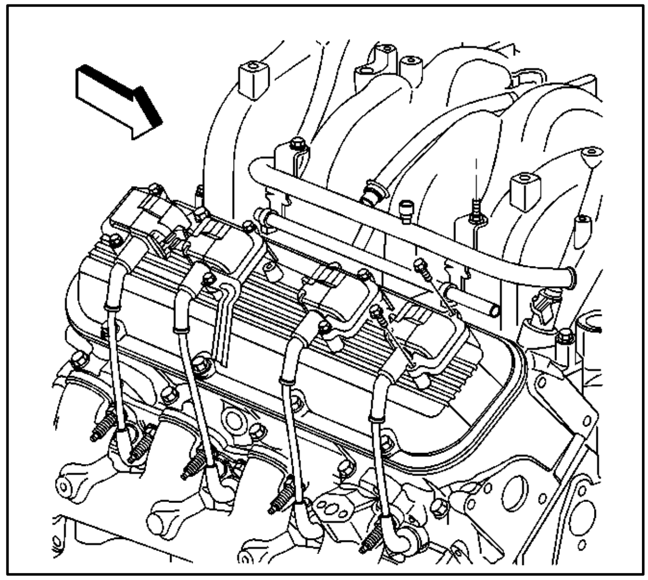
Important: The EVAP canister must be replaced if contamination is found.

11. Install a new EVAP canister. Refer to *Evaporative Emission (EVAP) Canister Replacement*.
12. Lower the vehicle.
13. Install a new EVAP canister purge valve. Refer to *Evaporative Emission (EVAP) Canister Purge Valve Replacement.*
14. Return to the published service procedure.

Ignition Coil(s) Replacement

Removal Procedure

1. Disconnect the spark plug wires at the ignition coils. Refer to *Spark Plug Wire Replacement.*
2. Disconnect the ignition coil harness connector.
3. Remove the ignition coil mounting bolts.
4. Remove the ignition coil.



703554

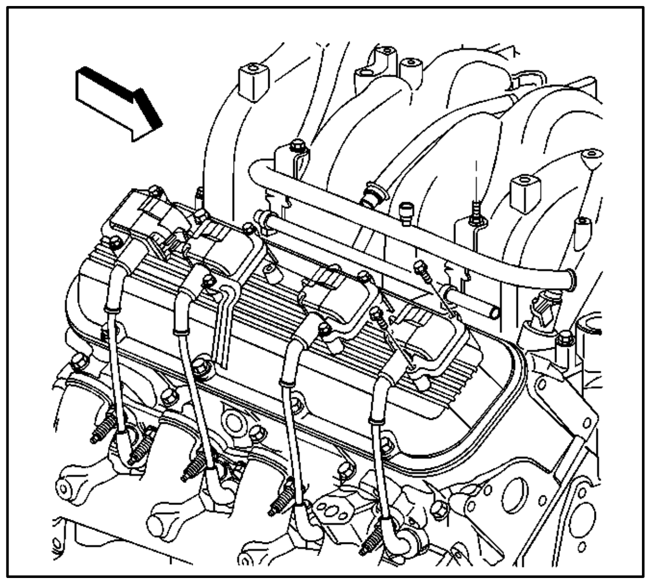
Installation Procedure

1. Install ignition coil.

Notice: Refer to Fastener Notice in Cautions and Notices.

2. Install the ignition coil mounting bolts.

   Tighten
   Tighten the ignition coil mounting bolts to 12 N·m (106 lb in).
3. Connect the ignition coil harness connector.
4. Connect the spark plug wires at the ignition coils. Refer to *Spark Plug Wire Replacement.*



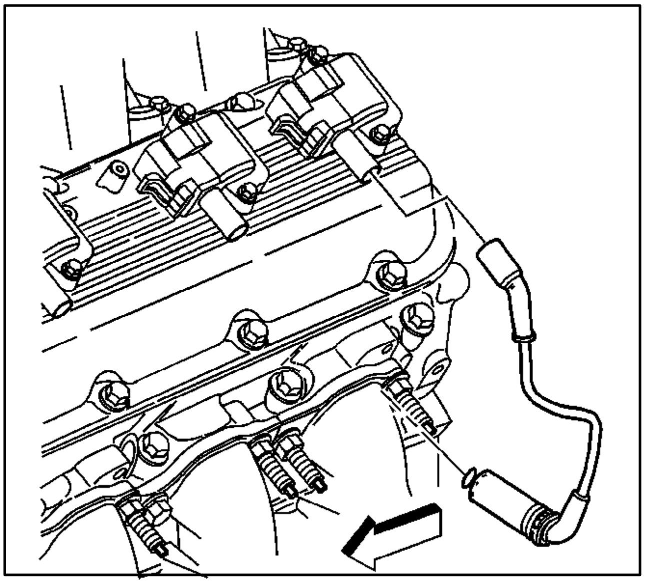
703554

Spark Plug Wire Inspection

Spark plug wire integrity is vital for proper engine operation. A thorough inspection will be necessary to accurately identify conditions that may affect engine operation. Inspect for the following conditions:

1. Correct routing of the spark plug wires—Incorrect routing may cause cross-firing.
2. Any signs of cracks or splits in the wires
3. Inspect each boot for the following conditions:
   - Tearing
   - Piercing
   - Arcing
   - Carbon tracking
   - Corroded terminal

If corrosion, carbon tracking or arcing are indicated on a spark plug wire boot or on a terminal, replace the wire and the component connected to the wire.

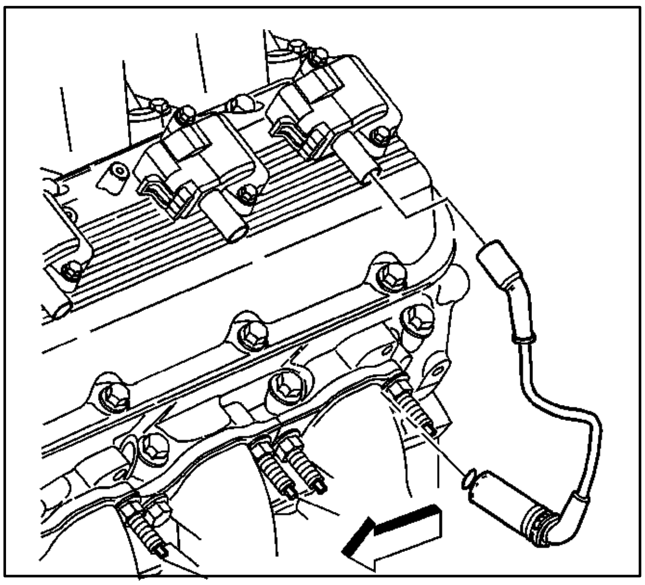


470666

Spark Plug Wire Replacement

Removal Procedure

1. Disconnect the spark plug wire at each spark plug.
   - Twist each spark plug 1/2 turn.
   - Pull only on the boot in order to remove the wire from each spark plug.
2. Disconnect the spark plug wire from the ignition coil.
   - Twist each spark plug boot 1/2 turn.
   - Pull only on the boot in order to remove the wires from the ignition coil.



470666

Installation Procedure

1. Install the spark plug wires at the ignition coil.
2. Install the spark plug wire to each spark plug.
3. Inspect the wires for proper installation:
   - Push sideways on each boot in order to inspect the seating.
   - Reinstall any loose boot.

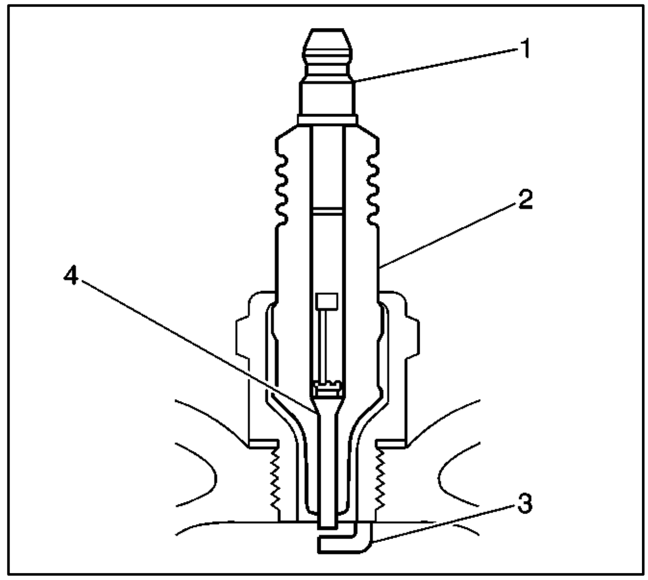
Spark Plug Inspection

Spark Plug Usage

- Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to *Ignition System Specifications* for the correct spark plug.
- Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
  – Spark plug fouling—Colder plug
  – Pre-ignition causing spark plug and/or engine damage—Hotter plug

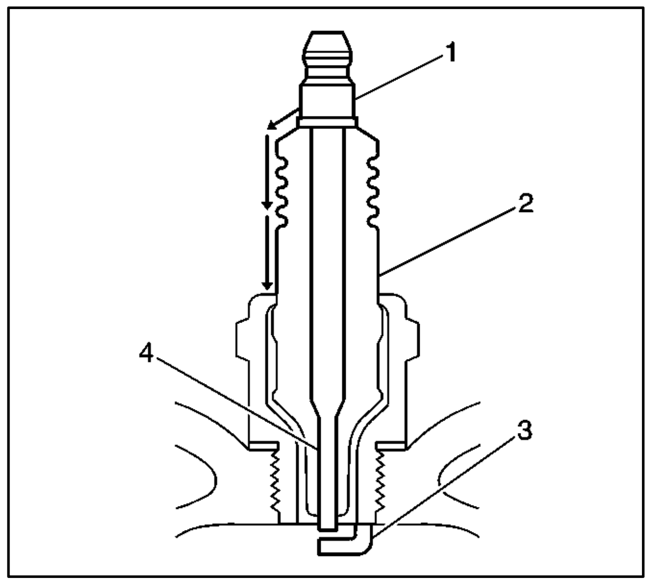
Spark Plug Inspection

- Inspect the terminal post (1) for damage.
  - Inspect for a bent or broken terminal post (1).
  - Test for a loose terminal post (1) by twisting and pulling the post. The terminal post (1) should NOT move.



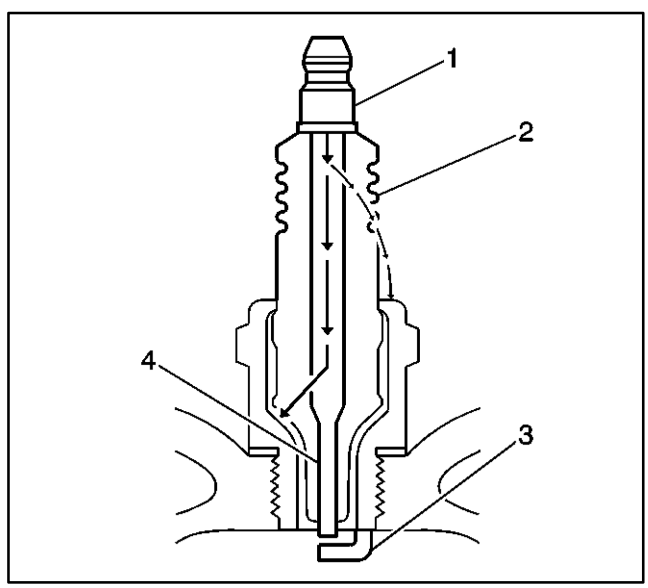
622530

- Inspect the insulator (2) for flashover or carbon tracking, soot. This is caused by the electrical charge traveling across the insulator (2) between the terminal post (1) and ground. Inspect for the following conditions:
  - Inspect the spark plug boot for damage.
  - Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant, or water. A spark plug boot that is saturated causes arcing to ground.

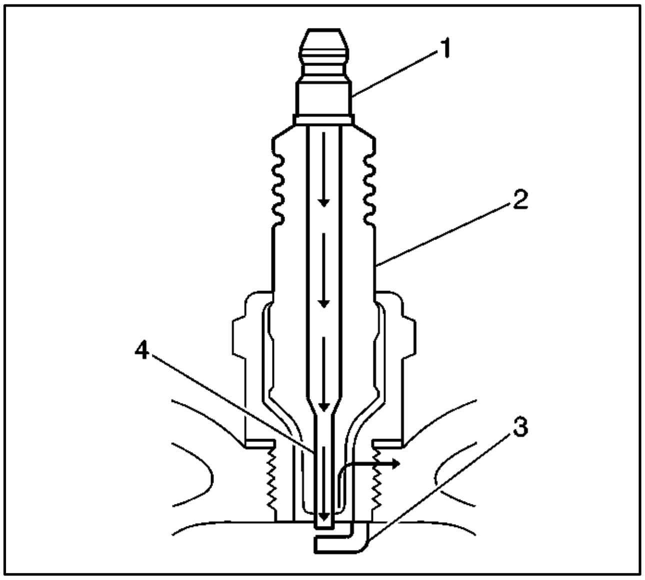


622529

- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).



622528



622527

- Inspect for evidence of improper arcing.
  - Measure the gap between the center electrode (4) and the side electrode (3) terminals. Refer to Ignition System Specifications. An excessively wide electrode gap can prevent correct spark plug operation.
  - Inspect for the correct spark plug torque. Refer to *Ignition System Specifications.* Insufficient torque can prevent correct spark plug operation. An over torqued spark plug causes the insulator (2) to crack.
  - Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
  - Inspect for a broken or worn side electrode (3).
  - Inspect for a broken, worn, or loose center electrode (4) by shaking the spark plug.
    - A rattling sound indicates internal damage.
    - A loose center electrode (4) reduces the spark intensity.
  - Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
  - Inspect for worn or missing platinum pads on the electrodes (3, 4), if equipped.
  - Inspect for excessive fouling.
  - Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

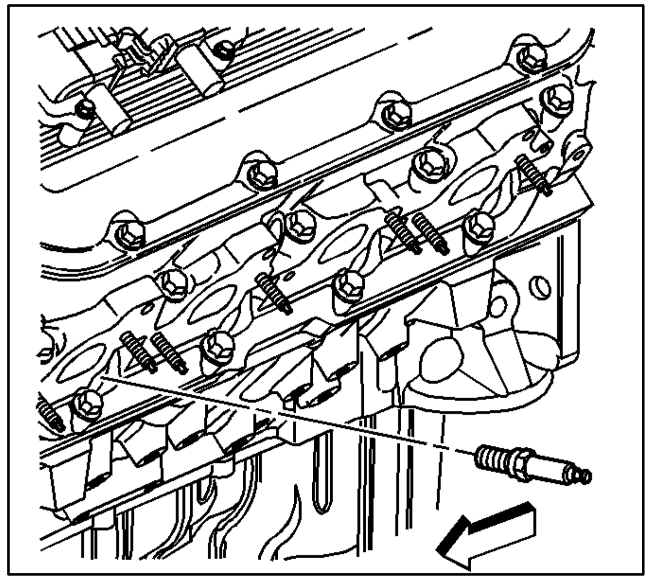
Spark Plug Visual Inspection

- Normal operation—Brown to grayish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives.
- Carbon fouled—Dry, fluffy black carbon, or soot caused by the following conditions:
  - Rich fuel mixtures
    - Leaking fuel injectors
    - Excessive fuel pressure
    - Restricted air filter element
    - Incorrect combustion
  - Reduced ignition system voltage output
    - Weak coils
    - Worn ignition wires
    - Incorrect spark plug gap
  - Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off.

Deposit fouling—Oil, coolant, or additives that include substances such as silicone, very white coating, reduces the spark intensity. Most powdery deposits will not effect spark intensity unless they form into a glazing over the electrode.

Spark Plug Replacement

Removal Procedure

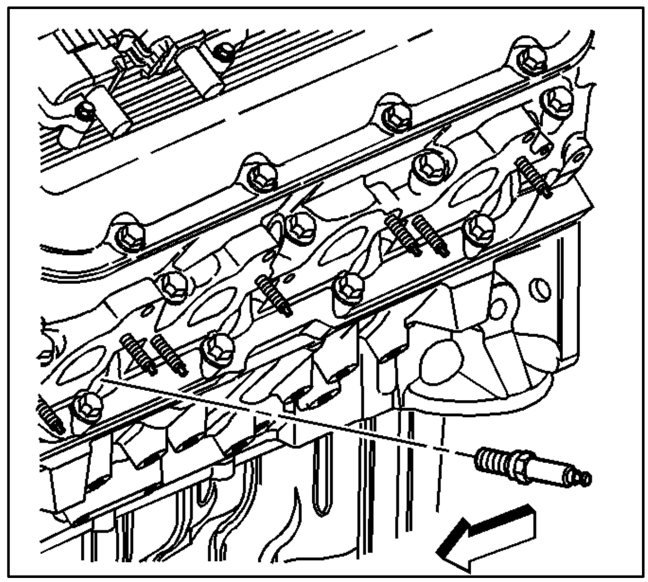


470690

Exhaust manifold shown removed for clarity.

1. Remove the spark plug wires. Refer to *Spark Plug Wire Replacement*.
2. Loosen each spark plug one or two turns.
3. Brush or air blast away any dirt from around the spark plugs.
4. Remove the spark plugs one at a time and place each plug in a tray marked with the corresponding cylinder numbers.

Installation Procedure



470690

1. Properly position each spark plug washer.
2. Inspect each spark plug gap. Adjust each plug as needed.

Specification

Spark plug gap: 1.524 mm (0.060 in)

Notice: Refer to Fastener Notice in Cautions and Notices.

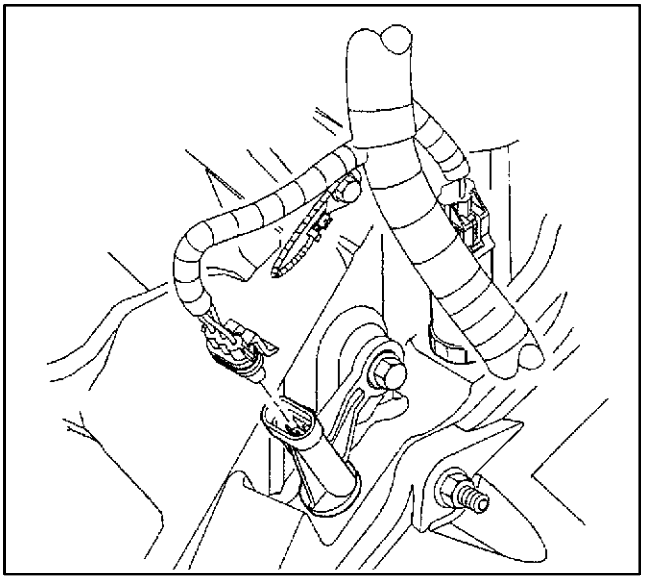
3. Install the spark plugs.

   Tighten

   For (IRON Head-all Subsequent Installations) tighten the spark plugs to 20 N·m (15 lb ft).

   For new iron heads tighten the spark plugs to 30 N·m (22 lb ft).

4. Install the spark plug wires. Refer to *Spark Plug Wire Replacement.*



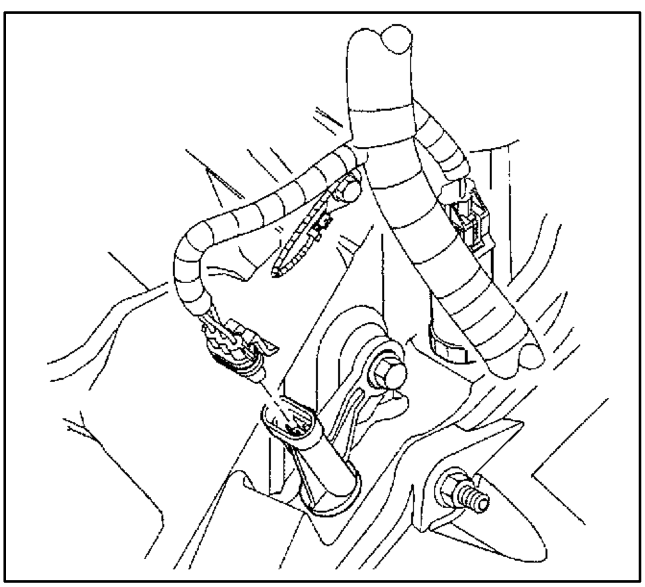
WRK64056

Crankshaft Position (CKP) Sensor Replacement

Removal Procedure

Important: Care must be taken when removing the crankshaft position (CKP) sensor. Twist the sensor to break the O-ring seals loose. When removing the sensor, pull the sensor straight out of the engine block at the same angle the sensor was installed. Failure to be careful may result in sensor damage.

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the crankshaft position (CKP) sensor harness connector at the CKP sensor.
3. Remove the fuel line bracket and retaining bolt. Refer to *Fuel Hose/Pipes Replacement – Filter to Engine.*
4. Use penetrating oil and allow to soak around the CKP sensor before removing the sensor.
5. Remove the CKP sensor retaining bolt.
6. Prior to removal of the CKP sensor, rotate the sensor back and forth.
7. Remove the CKP sensor at the same angle that you install it at.



WRK64056

Installation Procedure

Important: Inspect the CKP sensor O-ring for wear or damage. If a problem is found, replace the O-ring. Lubricate the new O-ring with engine oil before installing.

1. Install the CKP sensor at the same angle as you removed it.

Notice: Refer to Fastener Notice in Cautions and Notices.

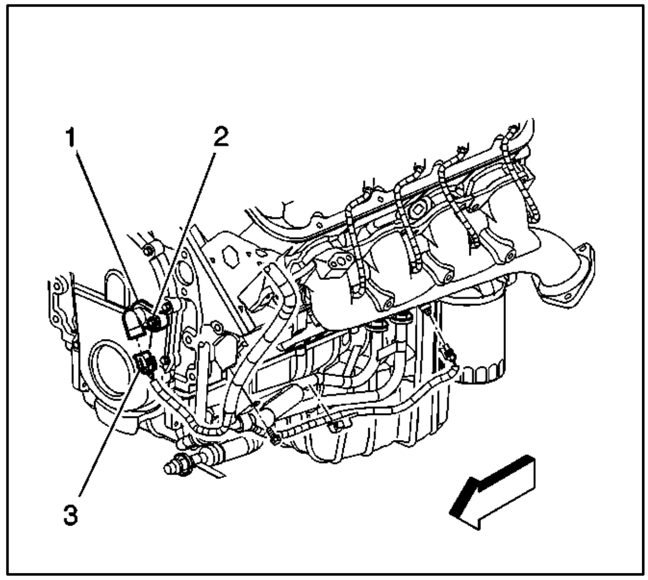
2. Install the CKP sensor retaining bolt.

   Tighten

   Tighten the bolt to 12 N·m (106 lb in).
3. Connect the CKP sensor harness connector.
4. Install the fuel line bracket and retaining bolt. Refer to *Fuel Hose/Pipes Replacement – Filter to Engine.*
5. Lower the vehicle.
6. Perform the CKP system variation learn procedure. Refer to *CKP System Variation Learn Procedure.*

Camshaft Position (CMP) Sensor Replacement

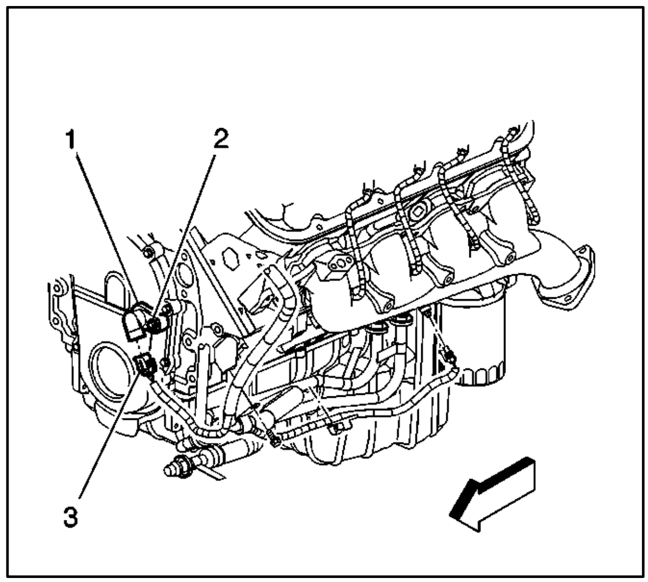
Removal Procedure



690593

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the camshaft position (CMP) sensor harness connector (3) at the CMP sensor (1).
3. Remove the CMP sensor retaining bolt (2).
4. Remove the CMP sensor (1).
5. Inspect the CMP sensor for wear, cracks, or leakage if the sensor is not being replaced.

Installation Procedure



690593

Important: Inspect the CMP sensor O-ring for wear or damage. If a problem is found, replace the O-ring. Lubricate the new O-ring with engine oil before installing.

1. Install the CMP sensor 1).

Notice: Refer to Fastener Notice in Cautions and Notices.

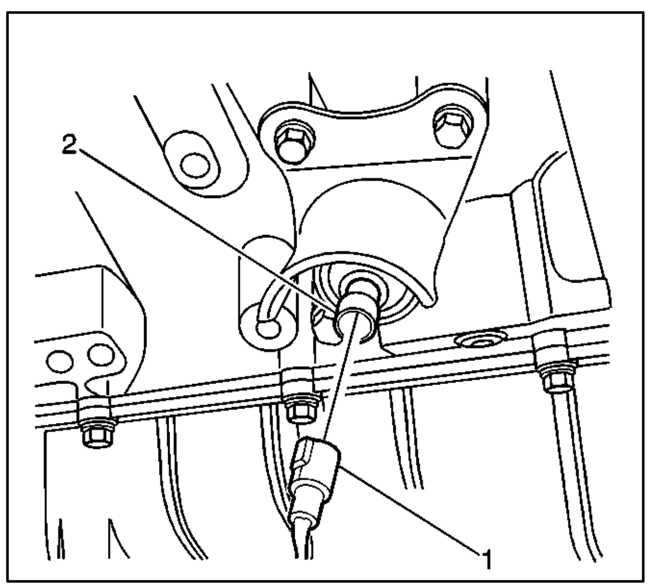
2. Install the CMP sensor retaining bolt (2).

   Tighten

   Tighten the bolt to 12N·m(106 lb in).
3. Connect the CMP sensor harness connector (3).
4. Install the steering linkage shield, if equipped.
5. Lower the vehicle.

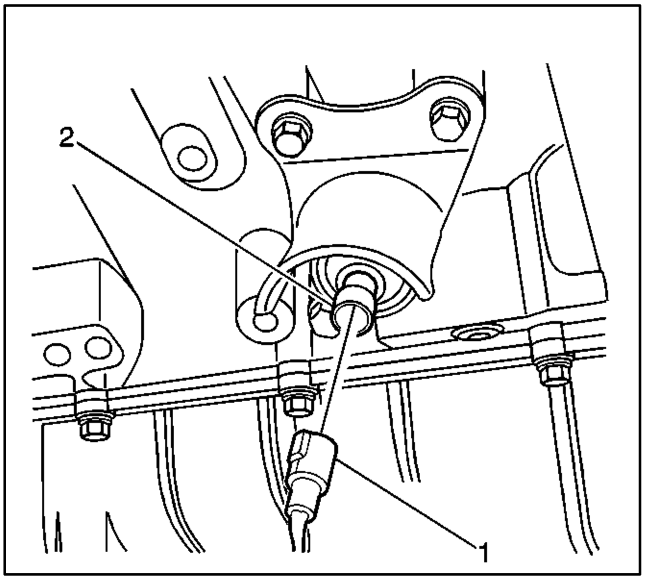
Knock Sensor (KS) 1 Replacement

Removal Procedure



678815

1. Raise the vehicle if necessary. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the wiring harness connector (1) from the knock sensor (2).
3. Remove the knock sensor (2) from the engine block.



678815

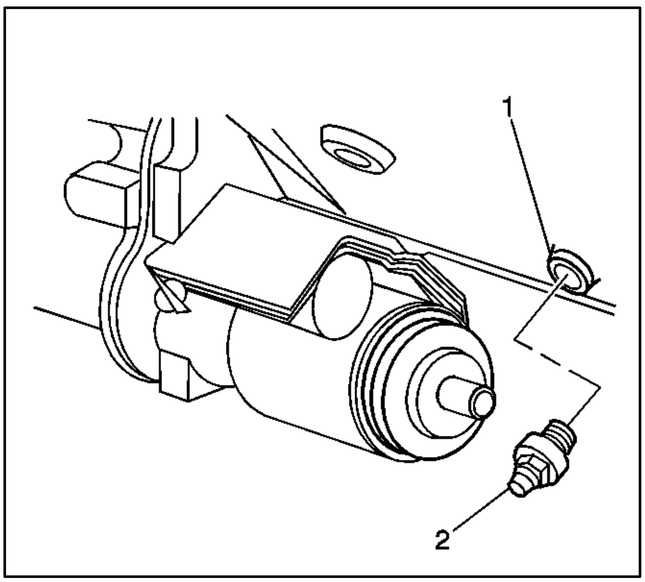
Installation Procedure

Notice: Refer to Fastener Notice in Cautions and Notices.

1. Install the knock sensor (2) into the engine block.

   Tighten

   Tighten the knock sensor to 20 N·m (15 lb ft).
2. Connect the knock sensor harness connector (1) to the knock sensor (2).

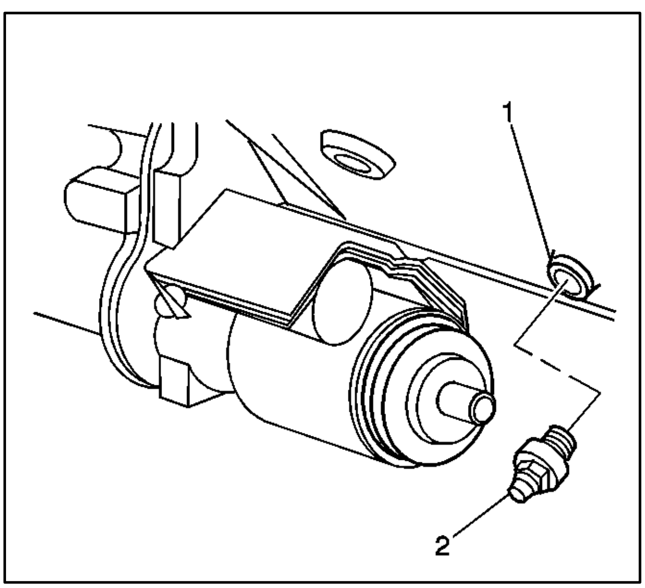


20272

Knock Sensor (KS) 2 Replacement

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the wiring harness connector from the knock sensor (2).
3. Remove the knock sensor (2) from the engine block (1).



20272

Installation Procedure

Notice: Refer to Fastener Notice in Cautions and Notices.

1. Install the knock sensor (2) into the engine block (1).

   Tighten

   Tighten the knock sensor to 20 N·m (15 lb ft).
2. Connect the harness connector to the knock sensor (2).

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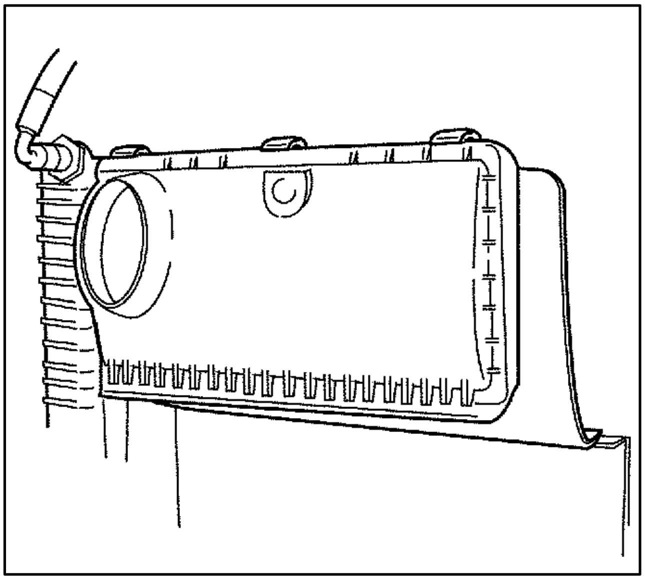
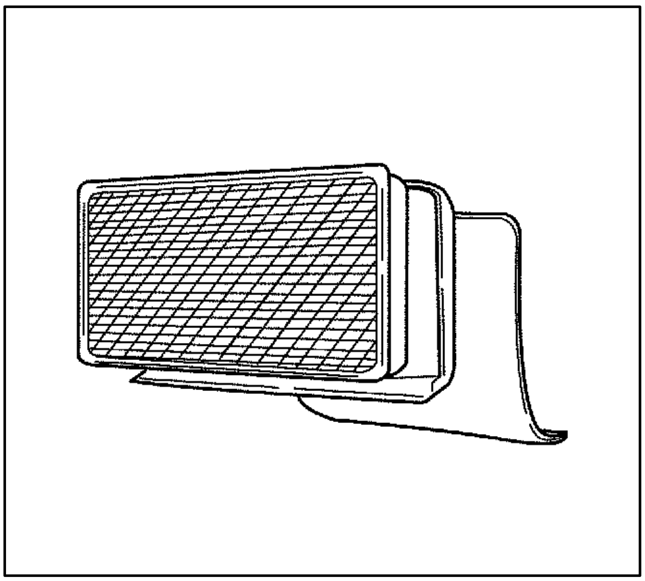
Air Cleaner Element Replacement

Removal Procedure



WRK64001

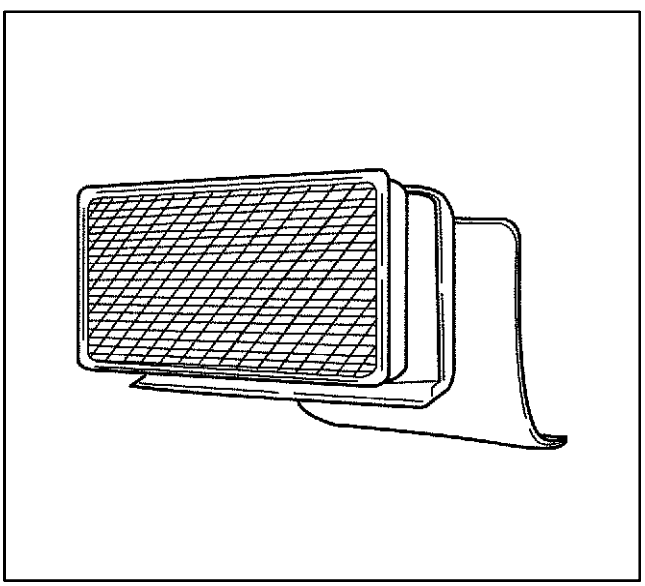
1. Unhook the fasteners securing the air cleaner assembly cover.
2. Move the cover out of the way.



WRK64003

3. Remove the air cleaner filter element from the air cleaner assembly body.

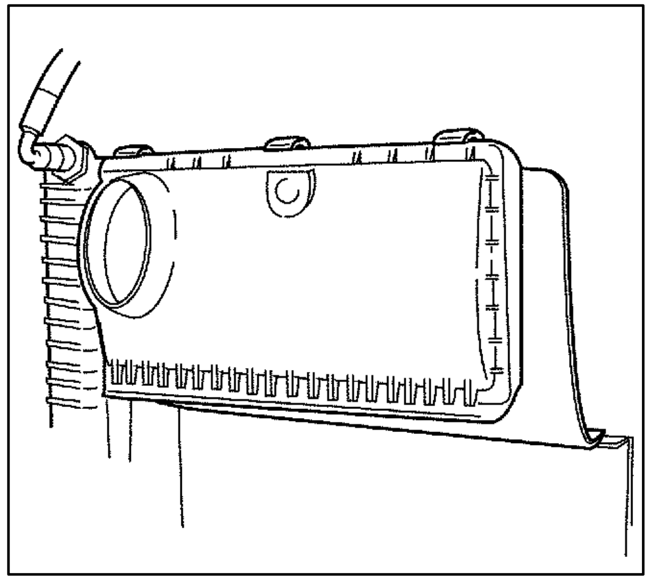
Installation Procedure



WRK64003

1. Install the air cleaner filter element into the air cleaner assembly body.

2. Install the cover onto the air cleaner assembly body
3. Secure the air cleaner assembly cover in place with the fasteners.

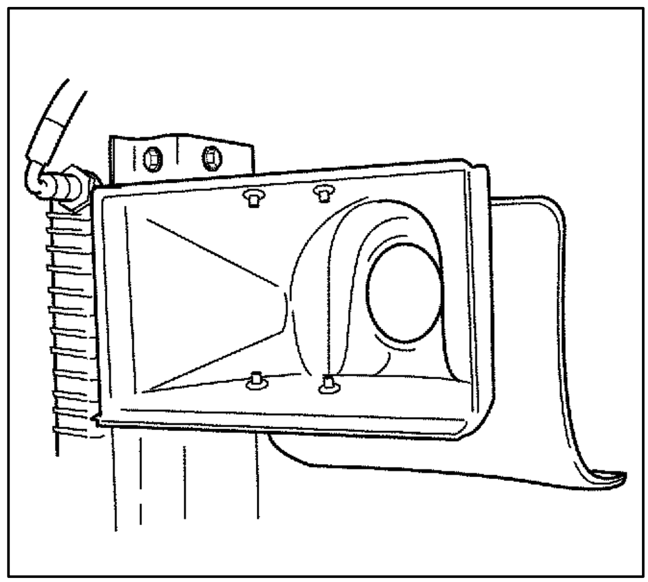


WRK64001

Air Cleaner Assembly Replacement

Removal Procedure

1. Remove the MAF/IAT sensor and the intake duct from the air cleaner assembly cover. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.
2. Remove the air cleaner filter element. Refer to *Air Cleaner Element Replacement* in this supplement.
3. Remove the air cleaner assembly retaining bolts and the air cleaner assembly body.



WRK64002

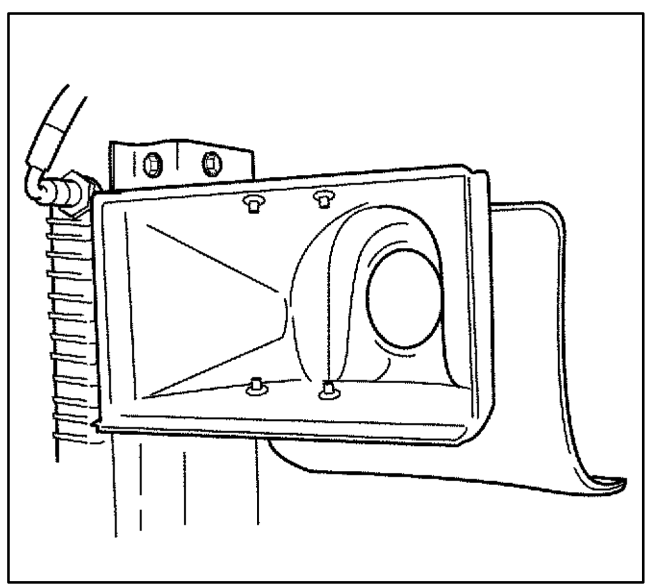
Installation Procedure

Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

1. Install the air cleaner assembly body and the air cleaner assembly retaining bolts.

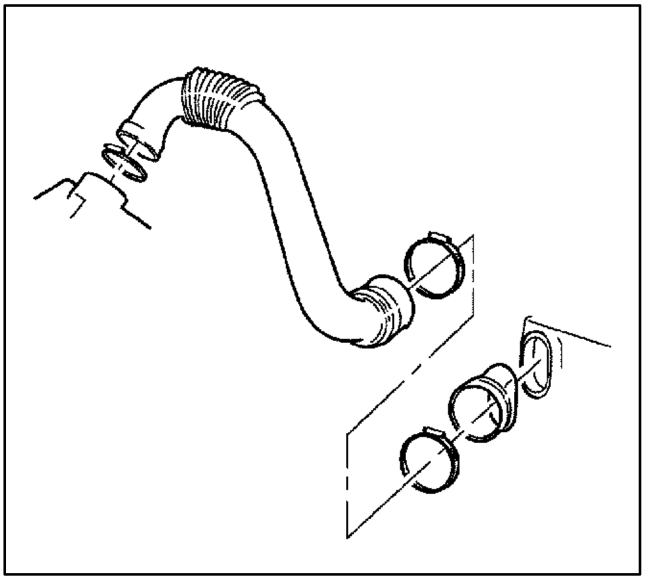
   Tighten

   Tighten the air cleaner assembly bolts to 9 N·m (80 lb in).
2. Install the air cleaner filter element. Refer to *Air Cleaner Element Replacement* in this supplement.
3. Install the MAF/IAT sensor and the air intake duct from the air cleaner assembly cover. Refer to *Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Replacement* in this supplement.



WRK64002

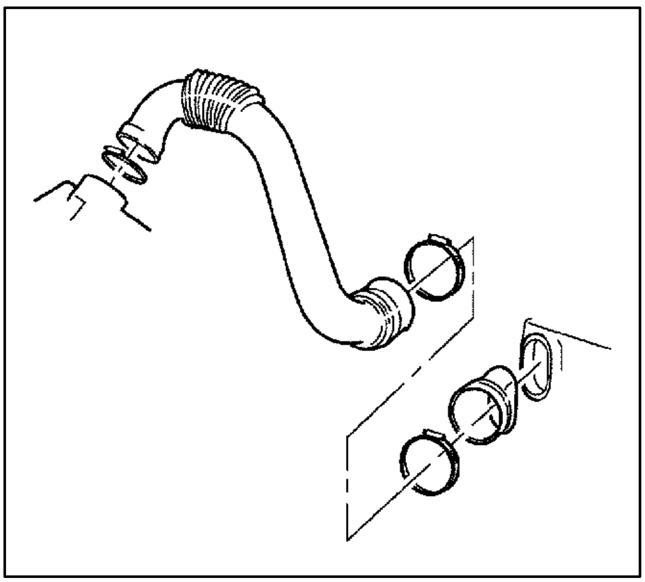
Air Intake Duct Replacement (8.1L)



WRK22006

Removal Procedure

1. Remove the fastener securing the air intake duct to the upper fan shroud.
2. Loosen the clamps at the MAF/IAT sensor and the throttle body and remove the air intake duct.
3. Remove the air intake duct and clamps from the MAF/IAT sensor and the throttle body and remove the air intake duct.



WRK22006

Installation Procedure

1. Install the clamps and air intake duct to the MAF/IAT sensor and the throttle body.
2. Install the fastener securing the air intake duct to the upper fan shroud.

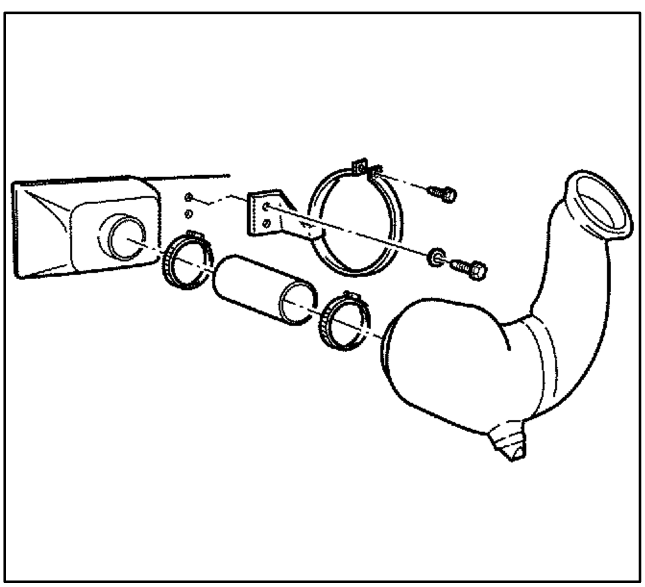
Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

3. Tighten the clamps at the MAF/IAT sensor and at the throttle body.

   Tighten

   Tighten the air intake duct clamps to 4 N·m (35 lb in).

Outside Air Duct and Bracket Replacement



WRK54049

Removal Procedure

1. Loosen the hose clamps at the air cleaner assembly inlet flange and the outside air duct outlet flange.
2. Remove the outside air duct bracket clamp screw.
3. Spread the bracket clamp and remove the outside air duct, hose, and hose clamps.
4. If necessary, remove the outside air duct bracket screws and washers and remove the bracket.

Installation Procedure

Notice: Refer to Fastener Notice in Cautions and Notices in the WCC Service Manual.

1. If removed, install the outside air duct bracket, washers, and screws.

   Tighten

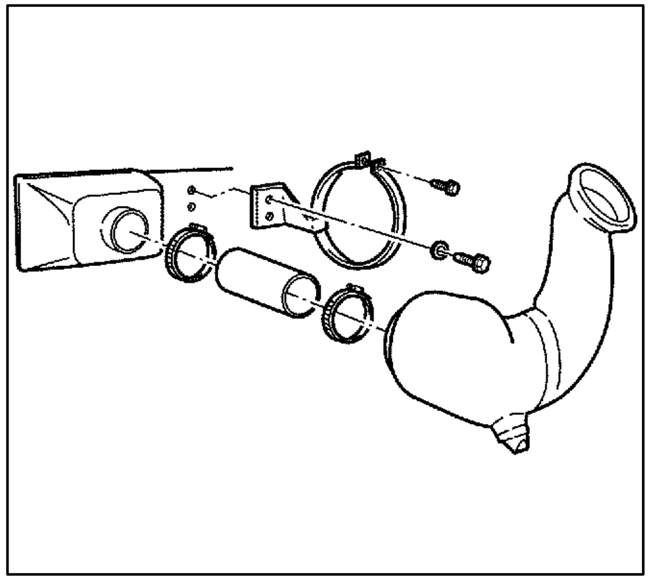
   Tighten the screws to 10 N·m (89 lb in).
2. Install the outside air duct, hose clamps, and hose to the outside air duct bracket and the air cleaner assembly inlet flange.
3. Install the outside air duct bracket clamp screw.

   Tighten

   Tighten the screw to 3.4 N·m (30 lb in).
4. Position the hose clamps on the hose at the air cleaner assembly inlet flange and the outside air duct outlet flange.

   Tighten

   Tighten the hose clamps to 4 N·m (35 lb in).



WRK54049

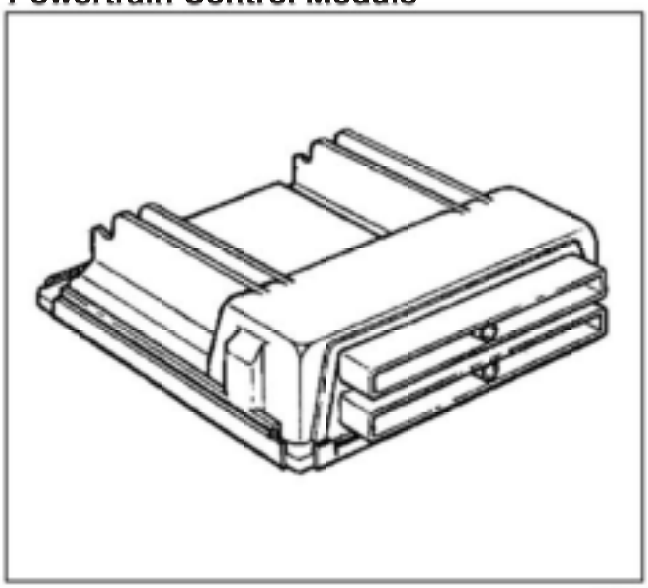
Description and Operation

Powertrain Control Module (PCM) Description

The powertrain control module (PCM) is designed to maintain exhaust emission levels while maintaining excellent driveability and fuel efficiency. The PCM controls the following operations:

- The fuel control
- The ignition control (IC)
- The knock sensor (KS) system
- The automatic transmission shift functions
- The cruise control enable
- The generator
- The evaporative emissions (EVAP) purge
- The A/C clutch control
- The vehicle maximum speed control
- The idle engine speed control
- The max engine speed control
- The diagnostic functions
- The auxiliary fan control

Powertrain Control Module



187237

The powertrain control module (PCM) is located in the engine compartment.

The PCM constantly monitors the information from various sensors and controls the systems that affect vehicle performance and emissions. The PCM also performs the diagnostic functions for those systems. The PCM can recognize operational problems and alert the driver through the malfunction indicator lamp (MIL) when a malfunction has occurred. When a malfunction is detected, the PCM stores a diagnostic trouble code (DTC) which helps to identify problem areas. This is done to aid the technician in making repairs.

The PCM supplies either 5.0 or 12.0 volts to power various sensors and switches. This is done through resistances in the PCM. The resistance is so high in value that a test lamp does not illuminate when connected to the circuit. In some cases, even an ordinary shop voltmeter does not give an accurate reading because the voltmeters resistance is too low. Therefore, a DMM with a minimum of 10 mega ohms input impedance is required to ensure accurate voltage readings.

The PCM controls output circuits such as the fuel injectors, the idle air control (IAC), and the cooling fan relays by controlling the ground or the power feed circuit through transistors or a device called an output driver module (ODM).

Torque Management

Torque management is a function of the PCM that reduces engine power under certain conditions. Torque management is performed for the following reasons:

- To prevent over-stressing the powertrain and driveline components
- To prevent damage to the vehicle during certain abusive maneuvers

The PCM monitors the following sensors and engine parameters in order to calculate engine output torque:

- The air and fuel ratios
- The mass air flow (MAF) sensor
- The manifold absolute pressure (MAP) sensor
- The intake air temperature (IAT) sensor
- The spark advance
- The engine speed
- The engine coolant temperature (ECT) sensor
- The AC clutch status

The PCM monitors the torque converter status, the transmission gear ratio, and the engine speed in order to determine if torque reduction is required. The PCM retards the spark as appropriate to reduce engine torque output if torque reduction is required. The PCM also shuts OFF the fuel to certain injectors in order to reduce the engine power in the case of an abusive maneuver.

The following are instances when engine power reduction is likely to be experienced:

- During transmission up shifts and downshifts
- When the clutch pedal is released too quick under a heavy load When the driver is performing harsh or abusive maneuvers such as shifting into gear at high throttle angles or shifting the transmission from reverse to drive to create a rocking motion

The driver is unlikely to notice the torque management actions in the first 2 instances. The engine power output is moderate at full throttle in the other cases.

The PCM calculates the amount of spark retard necessary to reduce the engine power by the desired amount. The PCM disables the fuel injectors for cylinders 1, 4, 6, and 7 in the case of an abusive maneuver.

PCM Function

The PCM supplies a buffered voltage to various sensors and switches. The PCM controls most components with electronic switches which complete a ground circuit when turned ON.

Use of Circuit Testing Tools

Do not use a test lamp in order to diagnose the powertrain electrical systems unless specifically instructed by the diagnostic procedures. Use the *J 35616-A* Connector Test Adapter Kit whenever diagnostic procedures call for probing any connectors.

Basic Knowledge Required

Without a basic knowledge of electricity, it will be difficult to use the diagnostic procedures contained in this section. You should understand the basic theory of electricity and know the meaning of voltage (volts), current (amps) and resistance (ohms). You should understand what happens in a circuit with an open or a shorted wire. You should be able to read and understand a wiring diagram.

PCM Service Precautions

The PCM is designed to withstand normal current draws associated with vehicle operations. Avoid overloading any circuit. When testing for opens or shorts, do not ground any of the PCM circuits unless instructed. When testing for opens or shorts, do not apply voltage to any of the PCM circuits unless instructed. Only test these circuits with a DMM while the PCM connectors remain connected.

Aftermarket (Add-On) Electrical And Vacuum Equipment

Aftermarket, add-on electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicles electrical or vacuum systems. No allowances have been made in the vehicle design for this type of equipment.

Notice: Do not attach add-on vacuum operated equipment to this vehicle. The use of add-on vacuum equipment may result in damage to vehicle components or systems.

Notice: Connect any add-on electrically operated equipment to the vehicle's electrical system at the battery (power and ground) in order to prevent damage to the vehicle.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicles electrical system such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain problem is to eliminate all aftermarket electrical equipment from the vehicle. If the problem still exists, diagnose the problem in the normal manner.

Electrostatic Discharge Damage

Notice: In order to prevent possible Electrostatic Discharge damage to the PCM, Do Not touch the connector pins or the soldered components on the circuit board.

Electronic components used in the control systems are often designed in order to carry very low voltage. Electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to some electronic components. There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges can cause damage. Therefore, it is important to use care when handling and testing electronic components.

Engine Controls Information

The driveability and emissions information describes the function and operation of the powertrain control module (PCM).

The engine controls information contains the following:

- Component locations
- Wiring diagrams
- PCM terminal end view and terminal definitions
- Diagnostic (OBD) System Check – Engine Controls
- Diagnostic trouble code (DTC) tables

The component system includes the following items:

- Component and circuit description
- On-vehicle service for each sub-system
- Functional checks and diagnostic tables

The DTCs also contain diagnostic support information containing circuit diagrams, circuit or system information, and helpful diagnostic information.
Maintenance Schedule

Maintenance Schedule

Refer to the WCC Maintenance Schedule of the appropriate service category for the maintenance that the owner or technician should perform in order to retain emission control performance.

Visual and Physical Underhood Inspection

Important: This visual and physical inspection is very important. Perform the inspection carefully and thoroughly.

Perform a careful visual and physical underhood inspection when performing any diagnostic procedure or diagnosing the cause of an emission test failure. This can often lead to repairing a problem without further steps. Use the following guidelines when performing a visual and physical inspection:

- Inspect all vacuum hoses for the following conditions:
  - Correct routing

  - Pinches
  - Cuts
  - Disconnects
- Inspect all wires in the engine compartment for the following conditions:
  - Proper connections
  - Burned or chafed spots
  - Pinched wires
  - Contact with sharp edges
  - Contact with hot exhaust manifolds

Basic Knowledge Of Tools Required

Important: Lack of basic knowledge of this powertrain when performing diagnostic procedures could result in incorrect diagnosis or damage to powertrain components. Do not attempt to diagnose a powertrain problem without this basic knowledge.

A basic understanding of hand tools is necessary in order to effectively use this information.

Primary System Based Diagnostics

There are primary system-based diagnostics which evaluate the system operation and their effect on vehicle emissions. The primary system-based diagnostics are listed below, with a brief description of the diagnostic functionality.

Oxygen Sensor Diagnosis

Diagnose the fuel control heated oxygen sensors (HO2S) for the following conditions:

- Slow response
- Response time, time to switch R/L or L/R
- Inactive signal, output steady at bias voltage—Approximately 450 mV
- Signal fixed high
- Signal fixed low

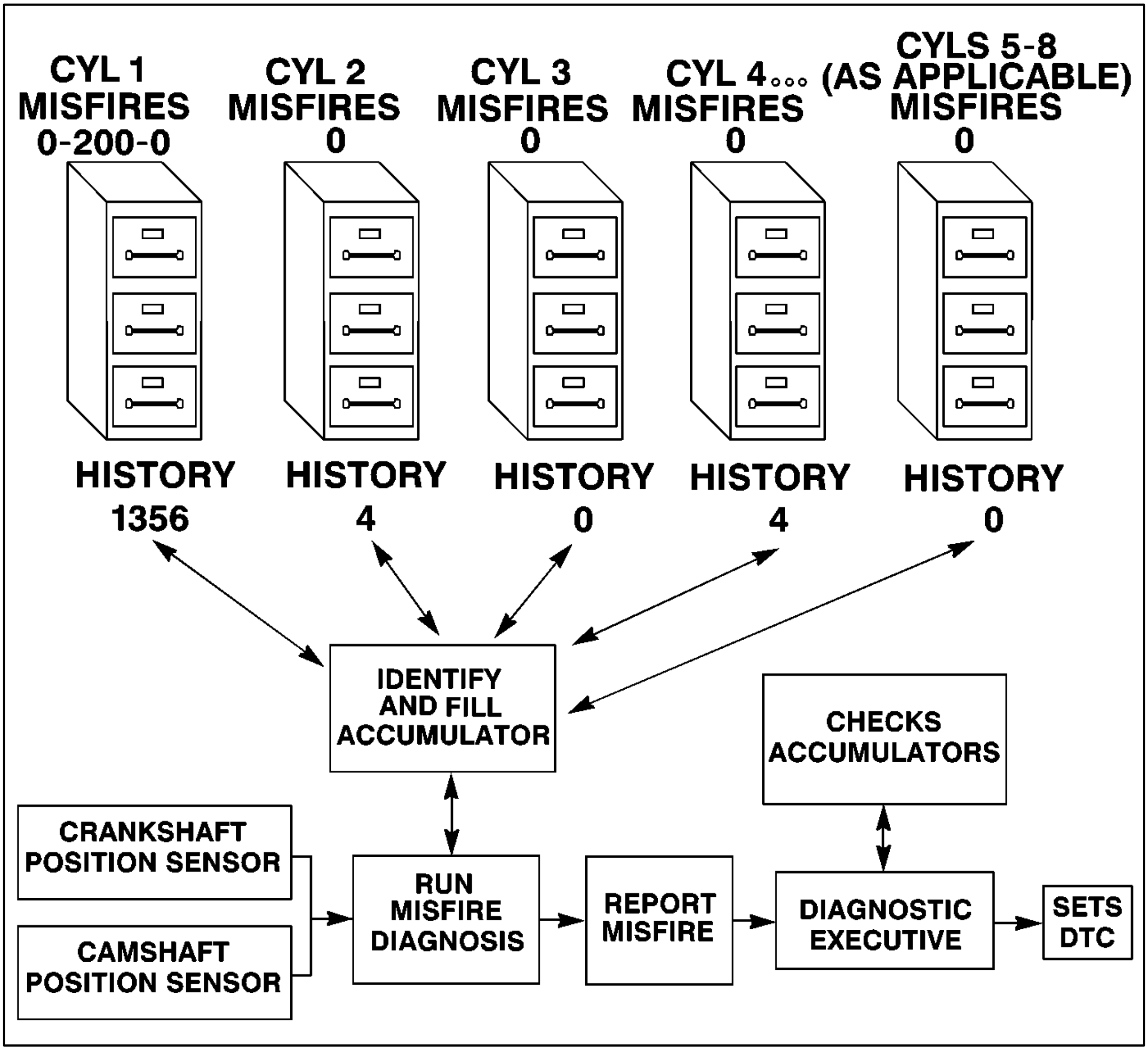
Misfire Monitor Diagnostic Operation

The misfire monitor diagnostic is based on crankshaft rotational velocity, aka reference period, variations. The PCM determines crankshaft rotational velocity using the crankshaft position (CKP) sensor and camshaft position (CMP) sensor. When a cylinder misfires, the crankshaft slows down momentarily. By monitoring the crankshaft and camshaft position sensor signals, the PCM can calculate when a misfire occurs.

For a non-catalyst damaging misfire, the diagnostic is required to monitor a misfire present for between 1,000-3,200 engine revolutions.

For catalyst damage misfire, the diagnostic responds to the misfire within 200 engine revolutions.

Rough roads may cause false misfire detection. A rough road applies sudden torque variations to the drive wheels and drivetrain. This torque can intermittently decrease the crankshaft rotational velocity.



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Whenever a cylinder misfires, the misfire diagnostic counts the misfire and notes the crankshaft position at the time the misfire occurred.

A current and a history misfire counter is maintained for each cylinder. The misfire current counters, Misfire Cur 1-8, indicate the number of firing events out of the last 200 cylinder firing events which were misfires. The misfire current counters displays real time data without a misfire DTC stored. The misfire history counters, Misfire Hist 1-8, indicate the total number of cylinder firing events which were misfires. The misfire history counters display 0 until the misfire diagnostic has failed and a DTC P0300 is set. Once the misfire DTC sets, the misfire history counters will be updated every 200 cylinder firing events. The Misfire counters graphic illustrates how these misfire counters are maintained.

When crankshaft rotation is erratic, the PCM detects a misfire condition. Because of this erratic condition, the data that is collected by the diagnostic can sometimes incorrectly identify which cylinder is misfiring. The misfire counters graphic shows there are misfires counted from more than one cylinder. Cylinder 1 has the majority of counted misfires. In this case, the misfire counters would identify cylinder 1 as the misfiring cylinder. The misfires in the other counters were just background noise caused by the erratic rotation of the crankshaft. If the number of accumulated misfires is sufficient for the diagnostic to identify a true misfire, the diagnostic will set DTC P0300–Misfire Detected. The illustration depicts an accumulation in the history buffers.

If two cylinders in sequential firing order are both misfiring, the first misfiring cylinder will accumulate misfires in its buffer, but the second misfiring cylinder will not. This is because the PCM compares a misfiring cylinder with the cylinder 90 degrees prior to it in the firing order. Therefore the PCM would be comparing crankshaft speed of the second misfiring cylinder to an already suspect cylinder. The PCM however, will be able to detect both misfiring cylinders after the engine exceeds 2,000 RPM. This is because the PCM then starts to compare misfires to the opposing cylinder rather than the previous cylinder in the firing order.

Use Techline® equipment to monitor the misfire counter data on applicable vehicles. Knowing which specific cylinders misfire can lead to the root cause. Using the information in the misfire counters identifies which cylinders are misfiring. If the counters indicate cylinders number 1 and 4 misfired, look for a circuit or component common to both cylinders.

The misfire diagnostic may indicate a fault due to a temporary fault not necessarily caused by a vehicle emission system malfunction. Examples include the following items:

- Contaminated fuel
- Running out of fuel
- Fuel fouled spark plugs
- Basic engine fault

Comprehensive Component Monitor Diagnostic

Comprehensive component monitoring diagnostics are required to monitor emissions-related input and output powertrain components.

Input Components

The PCM monitors the input components for circuit continuity and out-of-range values. This includes performance checking. Performance checking refers to indicating a fault when the signal from a sensor does not seem reasonable, such as a throttle position (TP) sensor that indicates high throttle position at low engine loads or manifold absolute pressure (MAP) voltage. The input components may include, but are not limited to, the following sensors:

- Vehicle speed sensor (VSS)
- Mass air flow (MAF) sensor
- Intake air temperature (IAT) sensor
- Crankshaft position (CKP) sensor
- Knock sensor (KS)
- Throttle position (TP) sensor
- Engine coolant temperature (ECT) sensor
- Camshaft position (CMP) sensor
- Manifold absolute pressure (MAP) sensor

In addition to the circuit continuity and rationality check, the ECT sensor is monitored for its ability to achieve a steady state temperature to enable Closed Loop fuel control.

Output Components

Diagnose the output components for the proper response to PCM commands. Components where functional monitoring is not feasible will be monitored for circuit continuity and out-of-range values, if applicable.

Output components to be monitored include, but are not limited to, the following circuits:

- The evaporative emission (EVAP) system
- The AC relay, if so equipped
- The vehicle speed sensor (VSS) output
- The malfunction indicator lamp (MIL) control
- The cruise control enable

Wiring Harness Service

Replace the wire harnesses with the proper part number replacement.

Consider the low amperage and voltage levels utilized in the powertrain control systems. Make the best possible bond at all splices. Use rosin-core solder in these areas.

Molded-on connectors require complete replacement of the connector. Splice a new connector into the harness. Replacement connectors and terminals are listed in Group 8.965 in the Standard Parts Catalog.

For wiring repair, refer to the appropriate procedures in Wiring Systems.

Connectors and Terminals

In order to prevent shorting between opposite terminals, use care when probing a connector and when replacing terminals. Damage to the components could result.

Always use jumper wires between connectors for circuit checking.

Never probe through Weather—Pack seals.

The *J 35616-A* Connector Test Adapter Kit, or the equivalent, contains an assortment of flexible connectors used to probe terminals during diagnosis.

Fuse remover and test tool BT-8616 is used for removing a fuse and to adapt the fuse holder to a DMM for diagnosis.

Open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor, or in the wiring harness, may temporarily correct the open circuit. Oxidized or loose connections may cause intermittent problems.

Be certain of the type of connector and terminal before making any connector or terminal repair. Weather-Pack and Com-Pack III terminals look similar, but are serviced differently.

Service Programming System (SPS) Description

Service Programming System (SPS)

The service programming system (SPS) allows a technician to program a control module through the data link connector (DLC). The information transfer circuit that is used at the DLC is the same serial data circuit used by the scan tool for retrieving diagnostic trouble codes (DTCs), displaying data, clearing DTCs, etc. This procedure offers the ability to install software/calibrations matched to a particular vehicle.

This also allows one type of control module to be used across different vehicle platforms and engine combinations. The following is a list of control modules that are programmable:

- The powertrain control module (PCM)
- The engine control module (ECM)
- The vehicle control module (VCM)

Types of Programmable Memory

EEPROM: Electrically erasable programmable read only memory—This type of memory allows selected portions of memory to be programmed while other portions remain unchanged.

Certain learned values reside in EEPROM. The following information resides in EEPROM:

- The vehicle identification number (VIN)
- The crankshaft variation learned position
- The software/calibrations identification numbers
- The control module security information

Flash Memory: Flash read only memory—Flash memory has increased memory storage capacity. During programming, all information within memory is erased, and then replaced with entirely new information.

Most control modules have both types of memory. The software/calibrations reside in the flash memory.

Service Programming Methods

The three methods of programming a control module and the proper tools for each method are as follows:

- Remote Programming:
  – The Tech 2® and the Techline® Terminal
  – The control module installed in the vehicle
- Pass Through Programming:
  – The Tech 2® or other scan tools, Techline® Terminal or a personal computer equipped with General Motors Corporation authorized programming software—The Tech 2® or other scan tools are used as an interface between the vehicle and the Techline® Terminal or a personal computer.
  – The control module installed in the vehicle.
- Off-Board Programming (Vehicle NOT available):
  – The Tech 2®, Techline® Terminal, and Off Board Programming Adapter
  – The control module NOT installed in a vehicle

Before Programming a Control Module

Important: Do NOT program an existing control module with the identical software/calibration package. This procedure is not a short cut to correct a driveability condition. This is an ineffective repair. A control module should only be programmed when the following occurs:

- When a service procedure instructs you to replace the control module. The service part control module does not contain operating software or calibrations.
- General Motors Corporation releases an updated software/calibration package.

Ensure the following conditions are met before programming a control module:

- Vehicle system voltage:
  – There is no charging system concern. All charging system concerns must be repaired before programming a control module.
  – Battery voltage is greater than 12 volts but less than
  – 16 volts. The battery must be charged before programming the control module if the battery voltage is low.
  – A battery charger is NOT connected to the vehicles battery. Incorrect system voltage or voltage fluctuations from a battery charger, may cause programming failure or control module damage.
  – Turn OFF or disable any system that may put a load on the vehicles battery.
    - Daytime running lights (DRL). Applying the parking brake, on most vehicles, disables the DRL system. Refer to the Owners manual.
    - Heating, ventilation, and air conditioning (HVAC) systems
    - Engine cooling fans, etc.
- The ignition switch is in the proper position. The scan tool prompts you to turn ON the ignition, with the engine OFF. Do NOT change the position of the ignition switch during the programming procedure, unless instructed to do so.
- All tool connections are secure:
  – RS-232
  – The connection at the DLC is secure.
  – The voltage supply circuits
- DO NOT disturb the tool harnesses while programming. If an interruption occurs during the programming procedure, programming failure or control module damage may occur.
- If you are performing the pass-through programming procedure using a notebook computer without the power cord, ensure the internal battery is fully charged.

After Programming a Control Module

The powertrain may operate slightly different after a control module software/calibration update. Operating the powertrain through various driving conditions allows the control module to re-learn certain values. The control module must re-learn the following after a software/calibration update:

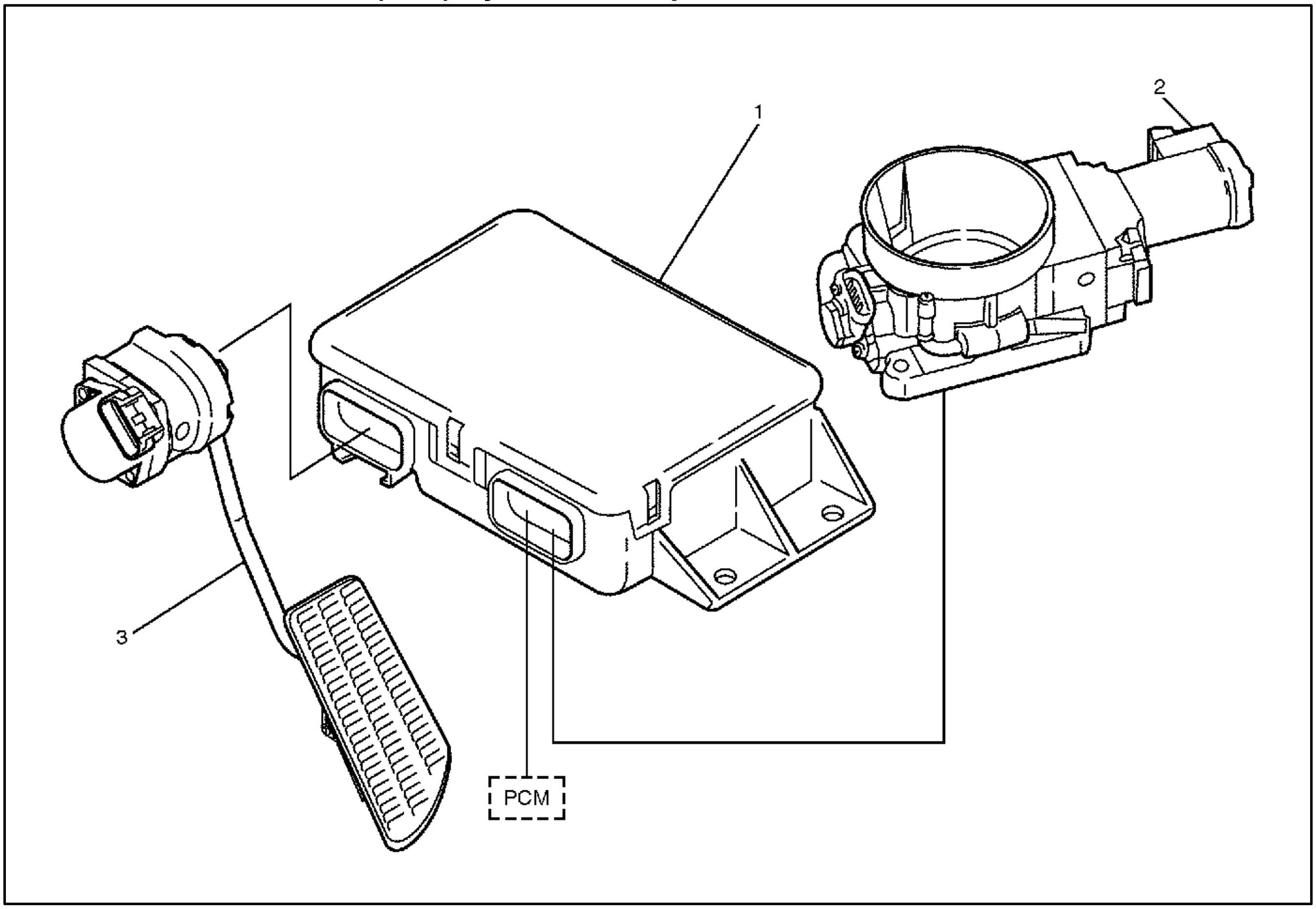
- Fuel trim correction
- Idle air control learned position
- Automatic transmission shift adapts

Other learned values only re-learn by doing a service procedure.

If a control module is replaced the following service procedures must be performed:

- The crankshaft variation learn procedure, if applicable.
- The Idle Learn Procedure, if applicable
- The Idle Learn Procedure, if applicable
- The Inspection/Maintenance Complete System Set Procedure
- The Vehicle Theft Deterrent Password Learn Procedure, if applicable
- The TP sensor learn procedure, if applicable

Throttle Actuator Control (TAC) System Description



Legend

(1) Throttle Actuator Control (TAC) Module

(2) Throttle Body Assembly

(3) Accelerator Pedal Position (APP) Sensor

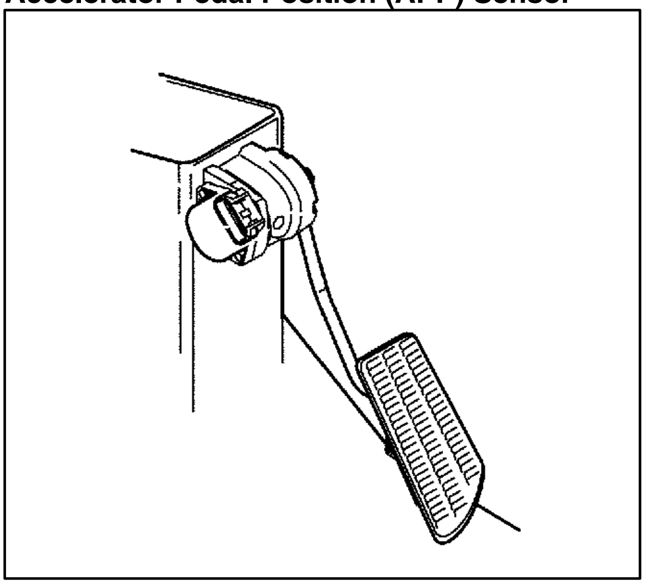
The throttle actuator control (TAC) system uses vehicle electronics and components to calculate and control the position of the throttle blade. This eliminates the need for a mechanical cable attachment from the accelerator pedal to the throttle body. This system also performs the cruise control functions as well.

The TAC system components include the following:

- The accelerator pedal position (APP) sensor
- The throttle body
- The throttle actuator control (TAC) module
- The powertrain control module (PCM)

Each of these components interface together to ensure accurate calculations and control of the throttle position.

Accelerator Pedal Position (APP) Sensor



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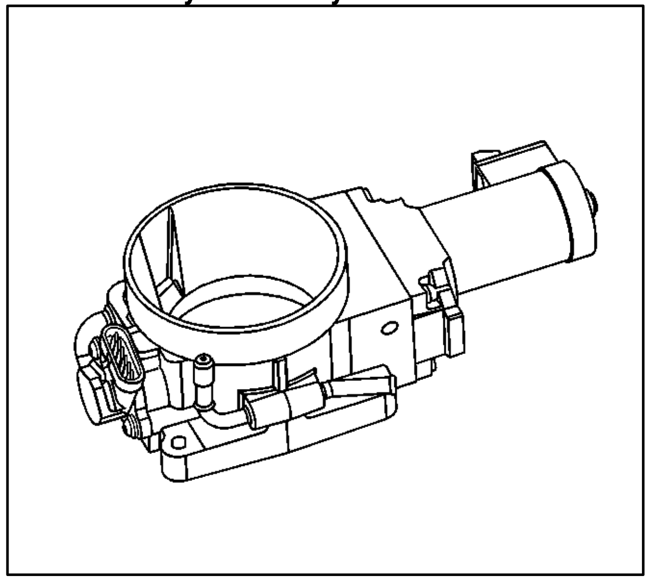
The accelerator pedal position (APP) sensor is mounted on the accelerator pedal assembly. The APP is actually 3 individual accelerator pedal position sensors within one housing. Three separate signal, low reference, and 5-volt reference circuits are used to connect the APP and the TAC module. The APP sensor 1 voltage should increase as the accelerator pedal is depressed, from below 1 volt at 0 percent pedal travel to above 2 volts at 100 percent pedal travel. APP sensor 2 voltage should decrease from above 4.0 volts at 0 percent pedal travel to below 2.9 volts at 100 percent pedal travel. APP sensor 3 voltage should decrease from above 3.8 volts at 0 percent pedal travel to below 3.1 volts at 100 percent pedal travel.

Throttle Body Assembly



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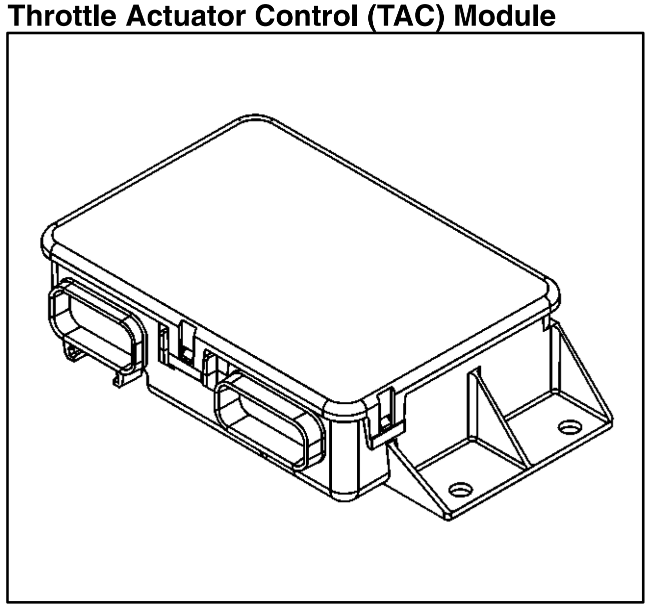
The throttle body for the TAC system is similar to a conventional throttle body with a couple of exceptions. One exception being the use of a motor to control the throttle position instead of a mechanical cable. The other exception is the new design throttle position (TP) sensor. The TP sensor mounts on the side of the throttle body opposite the throttle actuator motor. The TP sensor is actually 2 individual TP sensors within one housing. Separate signal, low reference, and 5-volt reference circuits are used to connect the TP sensors and the TAC module. The TP sensor 1 signal voltage increases as the throttle opens, from around 1.0 volt at 0 percent throttle to above 3.5 volts at 100 percent throttle. TP sensor 2 signal voltage decreases as the throttle is opened, from around 3.8 volts at 0 percent throttle to below 1 volt at 100 percent throttle.

Throttle Actuator Control (TAC) Module



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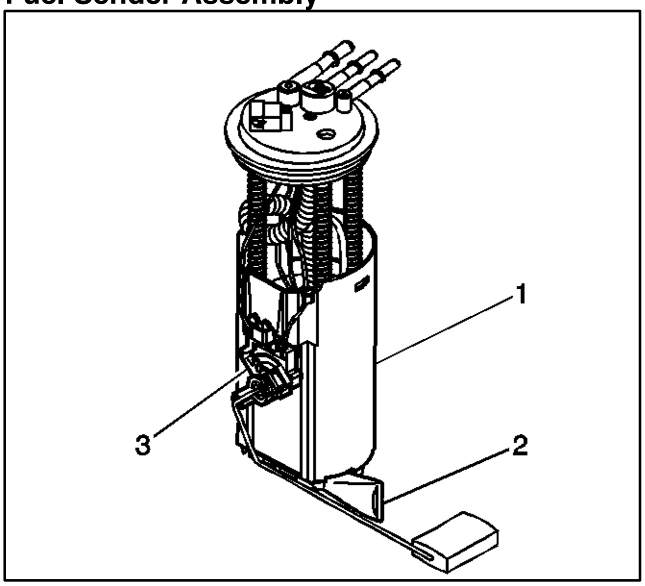
The TAC module is the control center for the electronic throttle system. The TAC module and the PCM communicate via a dedicated redundant serial data circuit. The TAC module and the PCM monitor the commanded throttle position and compare the commanded position to the actual throttle position. This is accomplished by monitoring the APP and the TP sensor. These 2 values must be within a calibrated value of each other. The TAC module also monitors each individual circuit of the TP sensor and the APP to verify proper operation.

Fuel System Description

Fuel System Overview

The fuel tank stores the fuel supply. An electric fuel pump is located in the fuel tank with the fuel sender assembly. The electric fuel pump sends fuel through an in-line fuel filter to the fuel rail assembly. The fuel pump provides fuel at a higher rate of flow than is needed by the fuel injectors. The fuel pressure regulator keeps fuel available to the injectors at a regulated pressure. A separate pipe returns unused fuel to the fuel tank.

Fuel Sender Assembly



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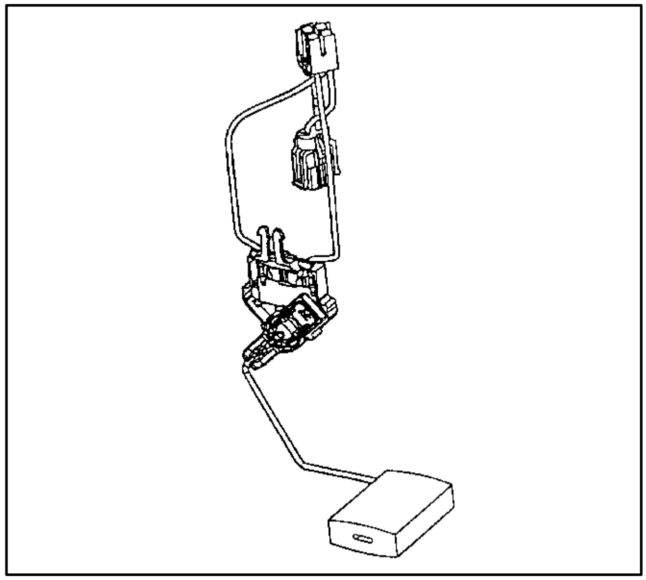
The fuel sender assembly consists of the following major components:

- The fuel tank fuel pump module (1)
- The fuel strainer (2)
- The fuel level sensor (3)

Fuel Level Sensor



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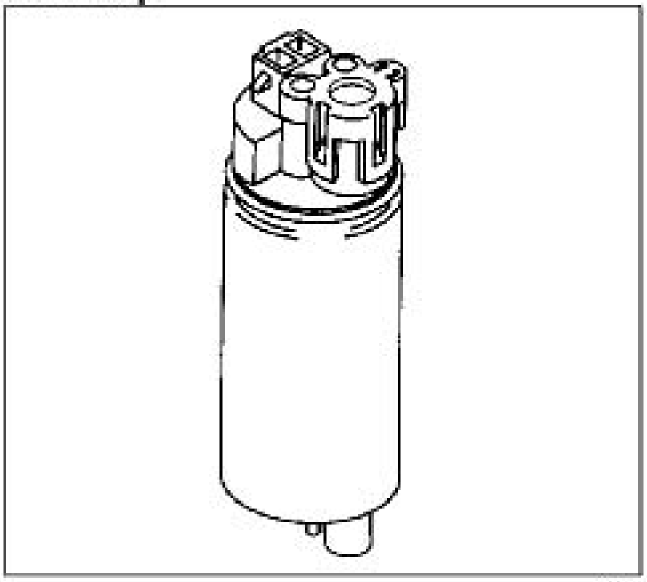
The fuel level sensor consists of a float, a wire float arm, and a ceramic resistor card. The position of the float arm indicates the fuel level. The fuel level sensor contains a variable resistor which changes resistance in correspondence with the amount of fuel in the fuel tank. If the vehicle is equipped with dual fuel tanks, the fuel balance module monitors the fuel level in both tanks. The powertrain control module (PCM) sends the fuel level information via the class II circuit to the instrument panel (IP) cluster. This information is used for the IP fuel gauge. The PCM also monitors the fuel level input for various diagnostics.

Fuel Pump



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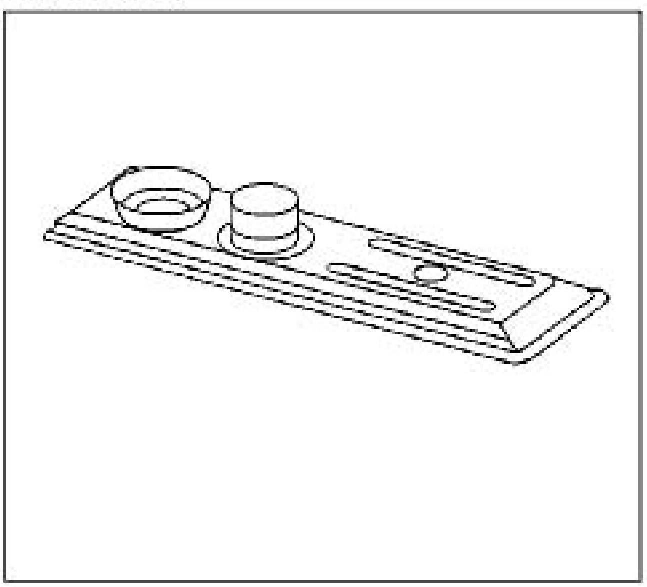
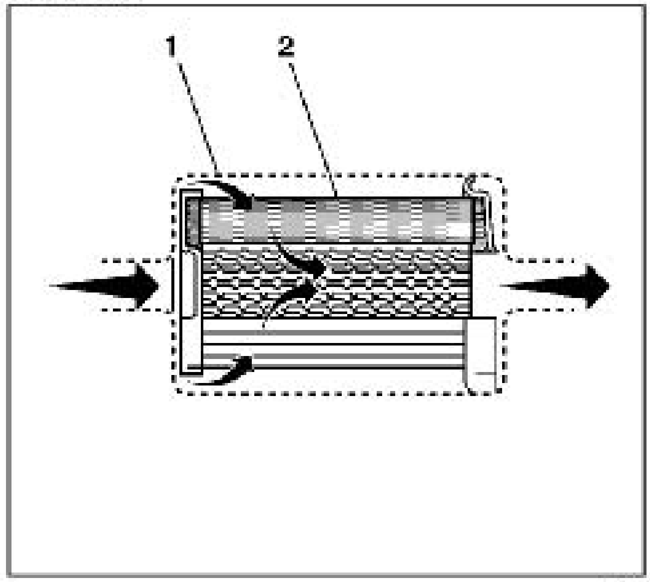
The fuel pump is mounted in the fuel sender assembly reservoir. The fuel pump is an electric high pressure pump. The fuel pump provides fuel at a higher rate of flow than is needed by the fuel injectors. Excess fuel from the fuel rail assembly returns to the fuel tank through the fuel return pipe. The fuel pump delivers a constant flow of fuel to the engine even during low fuel conditions. The PCM controls the electric fuel pump operation through a fuel pump relay. The fuel pump flex pipe acts to dampen the fuel pulses and noise generated by the fuel pump. The fuel pressure regulator is mounted in the assembly reservoir

Fuel Strainer



The fuel strainer attaches to the lower end of the fuel sender. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick fuel. The fuel strainer is self-cleaning and normally requires no maintenance. Fuel stoppage at this point indicates that the fuel tank contains an abnormal amount of sediment or water.

Fuel Filter



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The fuel filter is located on the fuel feed pipe, between the fuel pump and the fuel injectors. The paper filter element (2) traps particles in the fuel that may damage the fuel injection system. The filter housing (1) is made to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature. There is no service interval for fuel filter replacement. Replace a restricted fuel filter.

Fuel Feed and Return Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel rail assembly. The fuel return pipe carries fuel from the fuel rail assembly back to the fuel tank. The fuel pipes consist of 2 sections:

- ? The rear fuel pipe assemblies are located from the top of the fuel tank to the chassis fuel pipes. The rear fuel pipes are constructed of nylon.
- The chassis fuel pipes are located under the vehicle and connect the rear fuel pipes to the fuel rail pipes. These pipes are constructed of steel.

Nylon Fuel Pipes

Nylon pipes are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature. There are 3 sizes of nylon pipes used: 3/8 in. ID for the fuel feed, 5/16 in. ID for the fuel return, and 1/2 in. ID for the vent. Heat resistant rubber hose or corrugated plastic conduit protect the sections of the pipes that are exposed to chafing, high temperature, or vibration.

Nylon fuel pipes are somewhat flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes kink and restrict the fuel flow. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Take special care when working on a vehicle with nylon fuel pipes.

Quick-Connect Fittings

Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

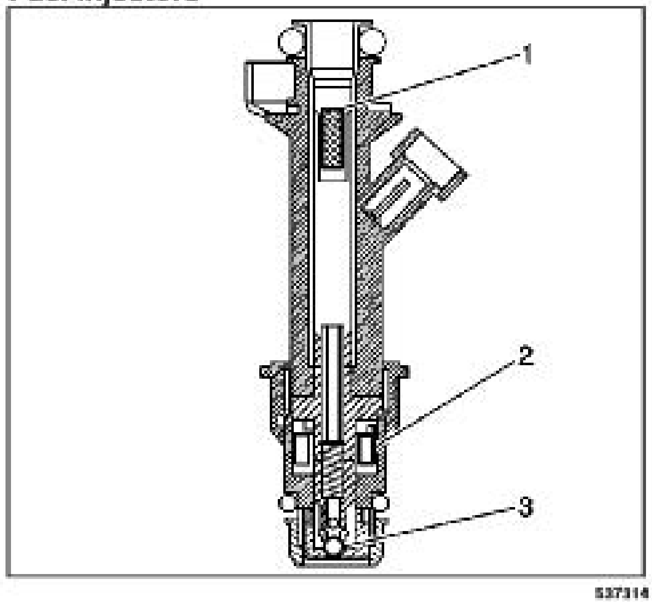
Fuel Pipe O-Rings

O-rings seal the connections in the fuel system. Fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.

The fuel rail assembly attaches to the engine intake manifold. The fuel rail assembly performs the following functions:

- Positions the fuel injectors in the intake manifold
- Distributes fuel evenly to the fuel injectors

Fuel Injectors



The Multec 2 fuel injector assembly is a solenoid device, controlled by the PCM, that meters pressurized fuel to a single engine cylinder. The PCM energizes the high-impedance (12.0 ohms) injector solenoid (2) to open a normally closed ball valve (3). This allows fuel to flow into the top of the injector, past the ball valve, and through a director plate at the injector outlet. The director plate has four machined holes that control the fuel flow, generating a spray of finely atomized fuel at the injector tip. Fuel from the injector tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber. This fine atomization improves fuel economy and emissions.

Fuel Metering Modes of Operation

The powertrain control module (PCM) monitors voltages from several sensors in order to determine how much fuel to give the engine. The PCM controls the amount of fuel delivered to the engine by changing the injector pulse width. The fuel is delivered under one of several modes.

Starting Mode

When the ignition is first turned ON, the PCM energizes the fuel pump relay for 2 seconds. This allows the fuel pump to build pressure in the fuel system. The PCM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), mass air flow (MAF) , manifold absolute pressure (MAP), and throttle position (TP) sensors. The system stays in starting mode until the engine speed reaches a predetermined RPM.

Clear Flood Mode

If the engine floods, clear the engine by pressing the accelerator pedal down to the floor and then crank the engine. When the throttle position (TP) sensor is at wide open throttle, the PCM reduces the injector pulse width in order to increase the air to fuel ratio. The PCM holds this injector rate as long as the throttle stays wide open and the engine speed is below a predetermined RPM. If the throttle is not held wide open, the PCM returns to the starting mode.

Run Mode

The run mode has 2 conditions called Open Loop and Closed Loop. When the engine is first started and the engine speed is above a predetermined RPM, the system begins Open Loop operation. The PCM ignores the signal from the heated oxygen sensor (HO2S). The PCM calculates the air/fuel ratio based on inputs from the engine coolant temperature , mass air flow, manifold absolute pressure, and throttle position sensors. The system stays in Open Loop until meeting the following conditions:

- Both HO2S have varying voltage output, showing that they are hot enough to operate properly.
- The ECT sensor is above a specified temperature.
- A specific amount of time has elapsed after starting the engine.

Specific values for the above conditions exist for each different engine, and are stored in the electrically erasable programmable read-only memory (EEPROM). The system begins Closed Loop operation after reaching these values.

In Closed Loop, the PCM calculates the air/fuel ratio (injector on-time) based upon the signal from various sensors, but mainly from the HO2S. This allows the air/fuel ratio to stay very close to 14.7:1.

Acceleration Mode

When the driver pushes on the accelerator pedal, air flow into the cylinders increases rapidly. To prevent possible hesitation, the PCM increases the pulse width to the injectors to provide extra fuel during acceleration. This is also known as power enrichment. The PCM determines the amount of fuel required based upon the throttle position, the coolant temperature, the manifold air pressure, the mass air flow, and the engine speed.

Deceleration Mode

When the driver releases the accelerator pedal, air flow into the engine is reduced. The PCM monitors the corresponding changes in throttle position, manifold air pressure, and mass air flow. The PCM shuts off fuel completely if the deceleration is very rapid, or for long periods, such as long, closed-throttle coast-down. The fuel shuts off in order to prevent damage to the catalytic converters.

Battery Voltage Correction Mode

When the battery voltage is low, the PCM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

Fuel Cutoff Mode

The PCM cuts off fuel from the fuel injectors when the following conditions are met in order to protect the powertrain from damage and improve driveability:

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal.
- This prevents flooding or backfiring.
- The engine speed is too high, above red line. The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle coast down—This reduces emissions and increases engine braking.
- During extended deceleration, in order to prevent damage to the catalytic converters

Short Term Fuel Trim

The short term fuel trim values change rapidly in response to the HO2S signal voltages. These changes fine tune the engine fueling. The ideal fuel trim values are around 0 percent. A positive fuel trim value indicates that the PCM is adding fuel in order to compensate for a lean condition.

When the PCM determines that the short term fuel trim is out of the operating range, a fuel trim diagnostic trouble code (DTC) will set.

Long Term Fuel Trim

The long term fuel trim is a matrix of cells arranged by RPM and manifold absolute pressure (MAP). As the engine operating conditions change, the PCM will switch from cell to cell. The PCM uses the value stored in the active long term fuel trim cell to calculate the injector pulse width.

The PCM also monitors the short term fuel trim while in any given cell. If the short term fuel trim is far enough from 0 percent, the PCM will change the long term fuel trim value. Once the long term fuel trim value is changed, the short term fuel trim should change back toward 0 percent. If the mixture is still not correct, the short term fuel trim will continue to have a large deviation from the ideal 0 percent. In this case, the long term fuel trim value will continue to change until it reaches it's limit. If the mixture is not corrected by the short term and long term fuel trim at their limits, a fuel trim diagnostic trouble code (DTC) will set.

Under the conditions of power enrichment, the PCM sets the short term fuel trim to 0 percent until power enrichment is no longer in effect. This is done so the Closed Loop factor and the long term fuel trim will not try to correct for the power enrichment condition.

Evaporative Emission (EVAP) Control System Description

EVAP System Operation

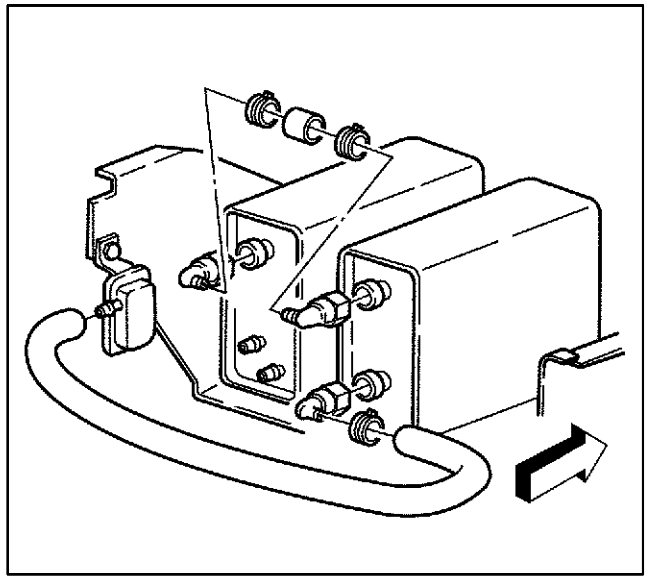
The evaporative emission (EVAP) control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank (due to pressure in the tank), through the vapor pipe, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent pipe and EVAP air inlet to atmosphere. The EVAP canisters store the fuel vapors until the engine is able to use them. At an appropriate time, the powertrain control module (PCM) will command the EVAP purge valve open, allowing engine vacuum to be applied to the EVAP canister. Fresh air will be drawn through the EVAP air inlet and vent pipe to the EVAP canisters. Fresh air is drawn through the EVAP canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge pipe and EVAP purge valve into the intake manifold to be consumed during normal combustion.

EVAP System Components

The EVAP system is made up of the following components:

- The EVAP canister purge valve
- The EVAP canister
- The fuel fill neck/fill cap
- The fuel tank
- The EVAP air inlet
- The EVAP vapor pipe
- The EVAP vent pipe
- The EVAP purge pipe

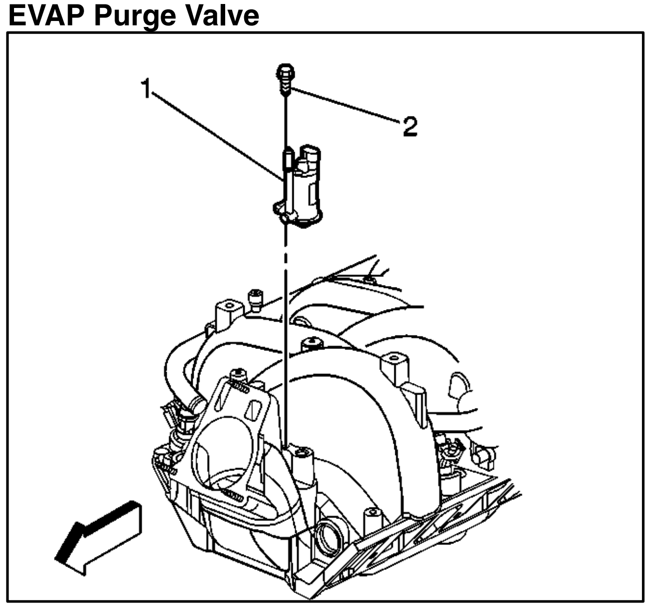
EVAP Canisters



WRK64045

Each EVAP canister is a sealed unit with 3 ports. Each canister is filled with carbon pellets used to absorb and store fuel vapors. Fuel vapor is stored in the canister until the powertrain control module (PCM) determines that the vapor can be consumed in the normal combustion process.

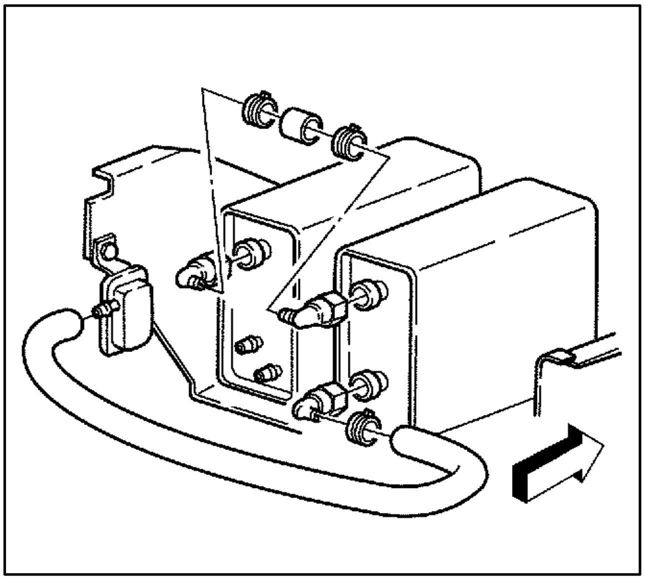
EVAP Purge Valve



693633

The EVAP purge valve controls the flow of vapors from the EVAP system to the intake manifold. This normally closed valve is pulse width modulated by the PCM to precisely control the flow of fuel vapor to the engine. The valve will also be opened during some portions of the EVAP testing, allowing engine vacuum to enter the EVAP system

EVAP Air Inlet.



WRK64045

The EVAP air inlet filters air entering the EVAP canister.

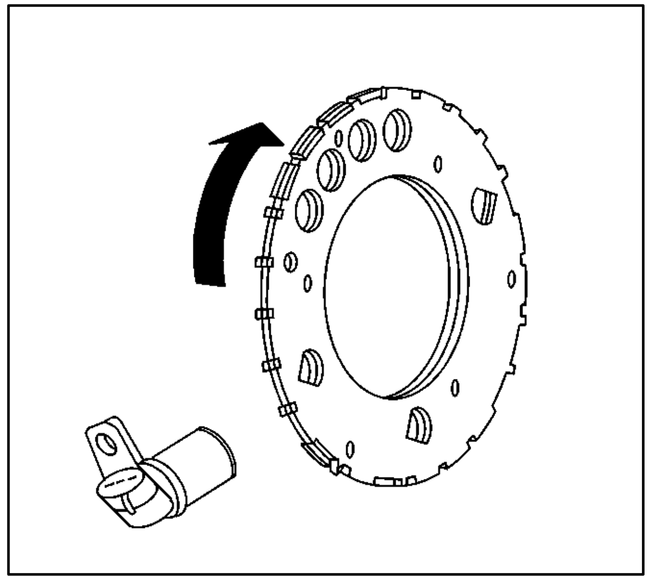
Electronic Ignition (EI) System Description

Ignition System Overview

The ignition system consists of the following components or circuits:

- The 8 ignition secondary wires
- The 8 ignition coils
- The 8 ignition control (IC) circuits
- The camshaft position (CMP) sensor
- The camshaft reluctor wheel
- The crankshaft position (CKP) sensor
- The crankshaft reluctor wheel
- The related connecting wires
- The powertrain control module (PCM)

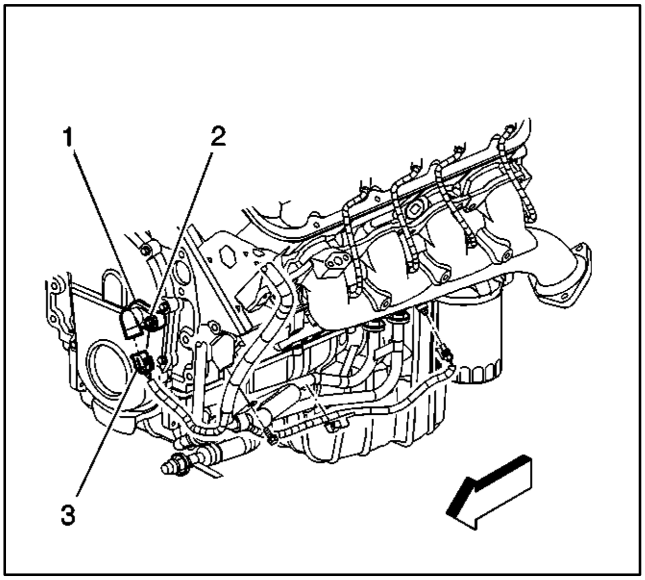
Crankshaft Position Sensor and Reluctor Wheel



65872

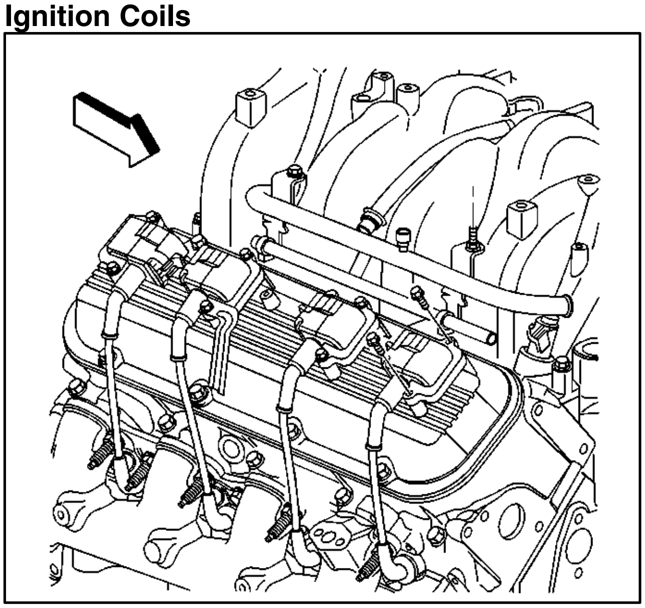
The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 24X reluctor wheel. The reluctor wheel is mounted on the rear of the crankshaft. The 24X reluctor wheel uses 2 different width notches that are 15 degrees apart. This pulse width encoded pattern allows cylinder position identification within 90 degrees of crankshaft rotation. In some cases this can be achieved within 45 degrees of crankshaft rotation. The reluctor wheel also has dual track notches that are 180 degrees out of phase, this design allows for quicker starts and accuracy. The CKP sensor also outputs a 4x signal for spark control, misfire diagnosis, tachometer output, and fuel control. All CKP signals are output as a digital square waveform.

Camshaft Position Sensor

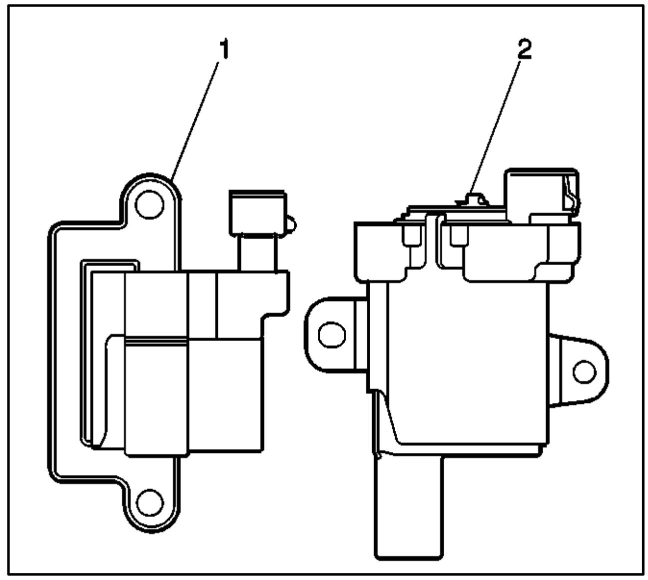


The camshaft position (CMP) sensor works in conjunction with 1X reluctor wheel mounted at the rear of the camshaft. The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 24X CKP sensor signal for quicker starting. The PCM will detect an increase in the mass airflow (MAF) sensor signal when the engine starts. The CMP signals are output as a digital waveform.

Ignition Coils



The ignition system on this vehicle features a multiple coil configuration and is known as coil near plug. There are two styles of ignition coil assemblies (1,2). The engine could have either style. The ignition coil mounting bracket is attached to the rocker cover (3).



The 8 ignition coils are individually mounted above each cylinder on the rocker covers. The coils are fired sequentially. There is an ignition control (IC) circuit for each ignition coil. The 8 ignition control circuits are connected to the PCM. The PCM triggers each ignition coil individually and makes all timing decisions. The ignition coils are supplied with the following circuits:

- The ignition 1 voltage circuit
- The ignition control circuit
- The ground circuit
- The reference low circuit

The ignition 1 voltage circuits are fused separately for each bank of the engine. The 2 fuses also supply the power for the injectors for that bank of the engine. Each coil is serviced separately.

This system puts out very high ignition energy for plug firing. Less energy is lost to ignition wire resistance because the ignition wires are much shorter than in a conventional ignition system.

Circuits Affecting Ignition Control

To properly control ignition timing, the PCM relies on the following information:

- The engine load, manifold pressure, or vacuum
- The atmospheric barometric pressure
- The engine temperature
- The intake air temperature
- The crankshaft position
- The engine speed (RPM)

The ignition control (IC) system consists of the following components:

- The ignition coils
- The 24X crankshaft position sensor
- The powertrain control module (PCM)
- All connecting wires

The ignition control utilizes the following to control spark timing functions:

- The 24X signal—The 24X crankshaft position sensor sends a signal to the PCM. The PCM uses this signal to determine crankshaft position. The PCM also utilizes this signal to trigger the fuel injectors.
- The ignition control (IC) circuits—The PCM uses these circuits to trigger the ignition coils.

Noteworthy Ignition Information

There are important considerations to point out when servicing the ignition system. The following noteworthy information will list some of these to help the technician in servicing the ignition system.

- The ignition coils secondary voltage output capabilities are very high, more than 40,000 volts. Avoid body contact with ignition high voltage secondary components when the engine is running or personal injury may result.
- The 24X crankshaft position (CKP) sensor is the most critical part of the ignition system. If the sensor is damaged so that pulses are not generated, the engine does not start.
- The CKP sensor clearance is very important. If the interrupter ring is bent or damaged in any way, the CKP sensor may be destroyed. Extreme care must be exercised during removal and installation procedures.
- The ignition timing is not adjustable. There are no timing marks on the crankshaft balancer or the timing chain cover.
- Be careful not to damage the secondary ignition wires or boots when servicing the ignition system. Rotate each boot in order to dislodge the boot from the plug or coil tower before pulling the boot from the spark plug or the ignition coil.

Powertrain Control Module (PCM)

The PCM is responsible for maintaining proper spark and fuel injection timing for all driving conditions. To provide optimum driveability and emissions, the PCM monitors input signals from the additional following components in calculating ignition control (IC) spark timing:

- The engine coolant temperature (ECT) sensor
- The intake air temperature (IAT) sensor
- The mass air flow (MAF) sensor
- The trans range inputs from the transmission range switch (PRND)
- The throttle position (TP) sensor
- The vehicle speed sensor (VSS)

Knock Sensor (KS) System Description

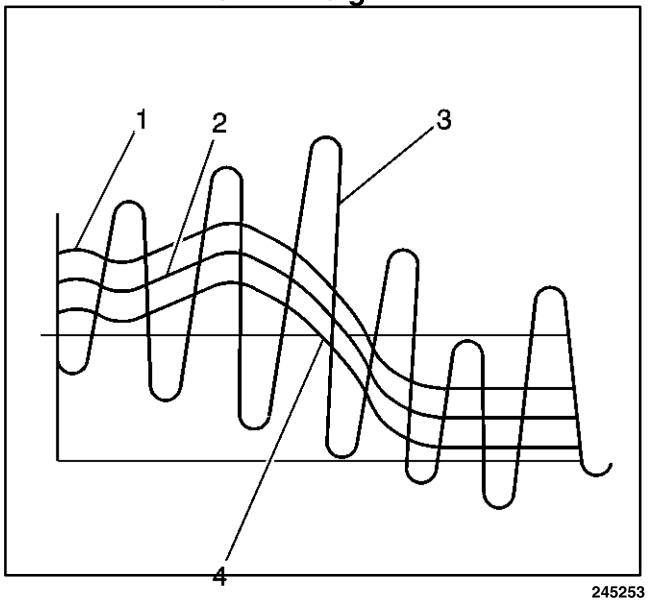
Purpose

To control spark knock (detonation), a knock sensor (KS) system is used. This system is designed to retard spark timing when excessive spark knock is detected in the engine. The KS system allows the engine to use maximum spark advance for optimal driveability and fuel economy under all operating conditions.

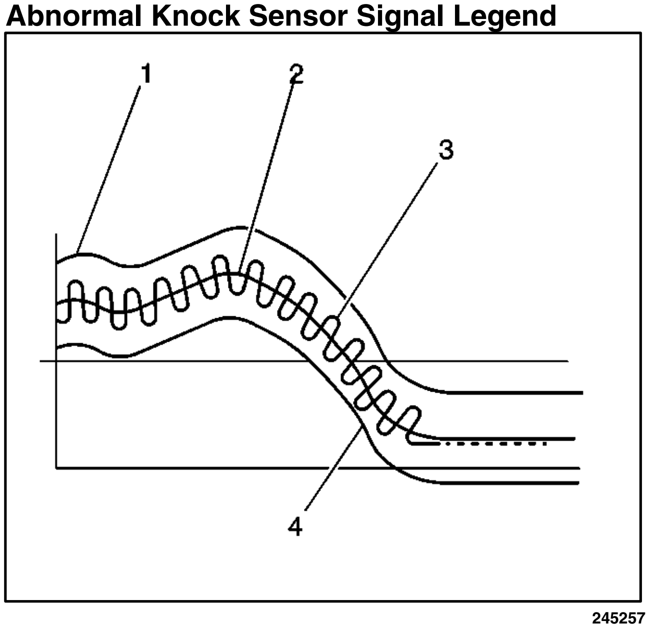
Operation

The powertrain control module (PCM) uses a knock sensor to detect abnormal vibration in the engine (detonation/spark knock). Mounted on the engine block, the knock sensor produces an AC voltage signal at all engine speeds and loads. The PCM then adjusts the spark timing based on the amplitude and frequency of the KS signal. The PCM uses the KS signal to calculate an average voltage. Then, the PCM assigns a voltage range above and below the average voltage value. The PCM checks the KS and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should vary outside the assigned voltage range as shown in the NORMAL KS figure. If the PCM detects a KS signal within the assigned voltage range as shown in the ABNORMAL figure the applicable diagnostic trouble code (DTC) will be set.

Normal Knock Sensor Signal



Abnormal Knock Sensor Signal Legend



Legend

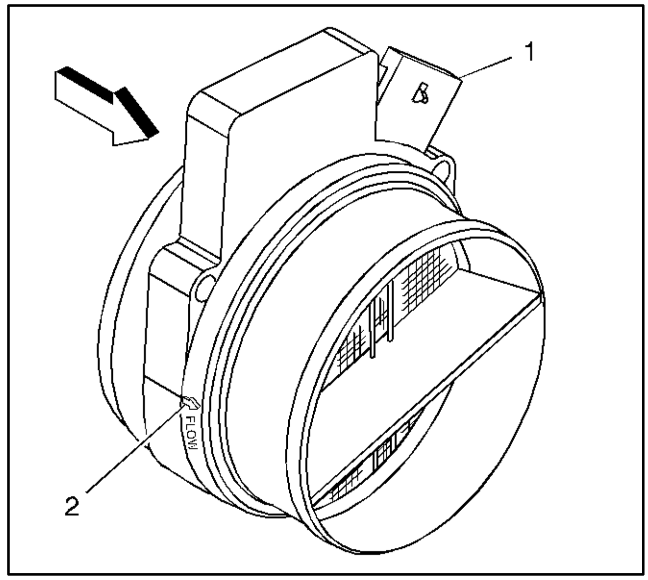
(1) Upper fail region
(2) Knock sensor calculated average
(3) Knock sensor signal
(4) Lower fail region

BLANK

Air Intake System Description

Air Induction Components

The air cleaner assembly is remotely mounted. The air intake system draws outside air through the side of the air cleaner assembly and filter element of the forward mounted air cleaner. The air is then routed through the mass air flow (MAF) sensor and then into the throttle body to the intake manifold. The air is then directed into the intake manifold runners, through the cylinder heads and into the cylinders.



359112

If the mass air flow (MAF) sensor is installed backwards, the system will go rich. An arrow (2) cast into the plastic portion of the sensor indicates proper air flow direction. The arrow must point toward the engine.

Special Tools and Equipment

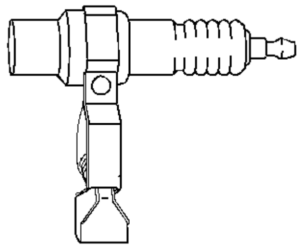
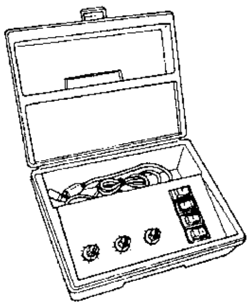
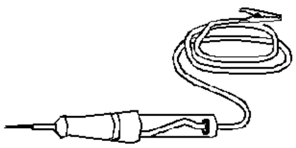
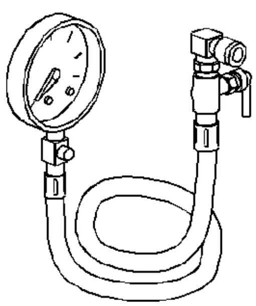
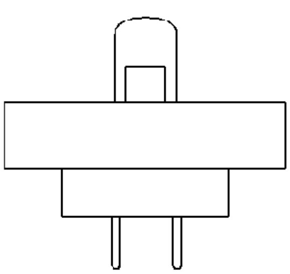
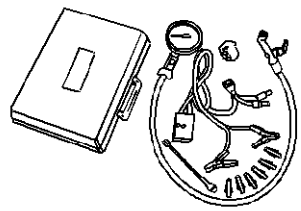
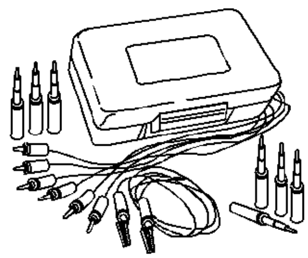
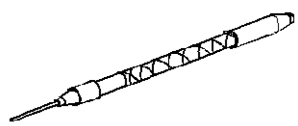
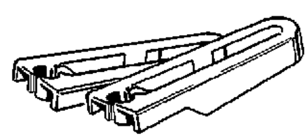
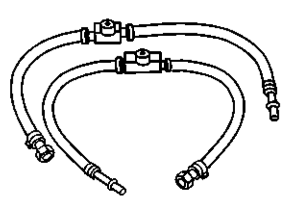
Illustration	Tool Number/ Description
 5381	J 26792 Spark Tester
 9194	J 33431-B Signal Generator and Instrument Panel Tester
 5382	J 34142-B Test Lamp
 5389	J 34730-1A Fuel Pressure Gauge
 5390	J 34730-2C Injector Test Light (EFI Lite)
 5377	J 34730-E Fuel Pressure Gauge Kit
 8917	J 35616-A Connector Test Adapter Kit
 5395	J 35689-A Metri-Pack Terminal Kit
 12366	J 37088-A Fuel Line Quick Connect Separator
 13541	J 37287 Inlet and Return Fuel Line Shut-off Adapters

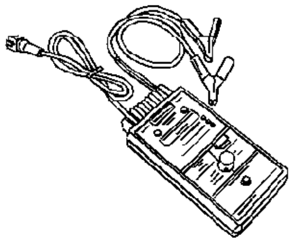
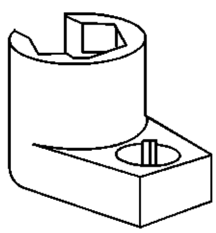
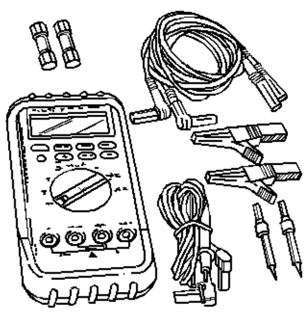
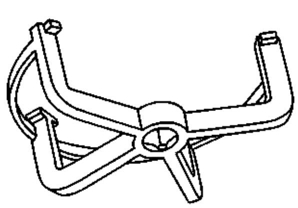
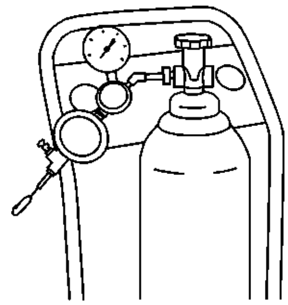
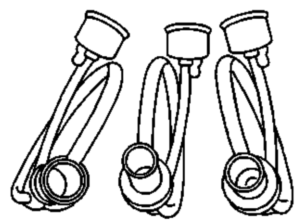
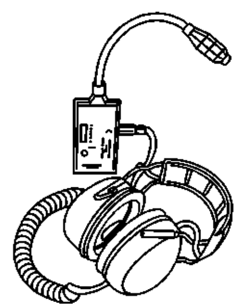
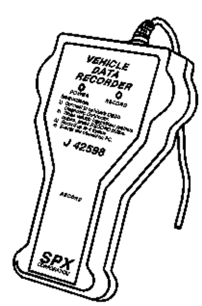
Illustration	Tool Number/ Description
 5380	J 39021 Fuel Injector Coil and Balance Tester
 17342	J 39194-B Heated Oxygen Sensor Wrench
 3430	J 39200 Digital Multimeter
 16891	J 39765 Fuel Sender Locknut Wrench

Illustration	Tool Number/ Description
 227620	J 41413 EVAP Pressure/Purge Diagnostic Station
 679126	J 41415 Gas Cap Forward/Filler Neck Kit (3)
 69758	J 41416 Ultrasonic Leak Detector
 624560	J 42598 Vehicle Data Recorder

Engine Exhaust

Specifications

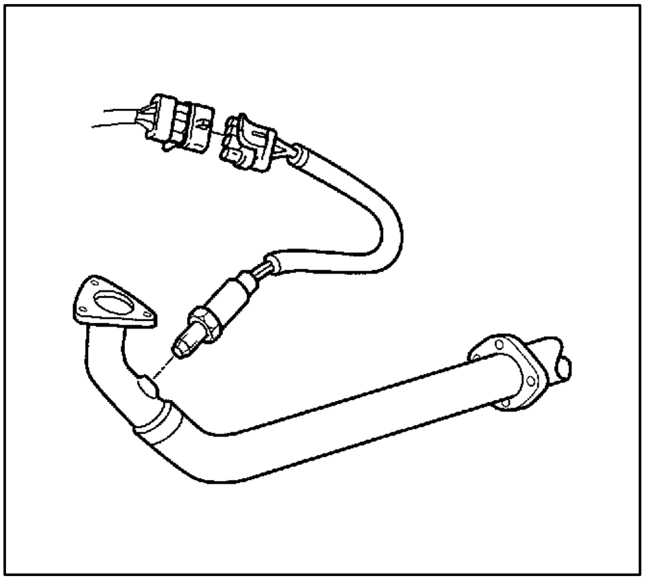
Fastener Tightening Specifications

Application	Specification	
	Metric	English
Catalytic Converter Flange Nut	85 N·m	63 lb ft
Exhaust Manifold Center Bolt	35 N·m	26 lb ft
Exhaust Manifold Nut	16 N·m	12 lb ft
Exhaust Pipe to Manifold Flange Nut	65 N·m	48 lb ft
Exhaust Muffler Clamp Nut	40 N·m	30 lb ft
Exhaust Pipe Clamp Nut	40 N·m	30 lb ft
Intermediate Exhaust Pipe Flange Nut	85 N·m	63 lb ft
Oxygen Sensor	45 N·m	33 lb ft

Repair Instructions

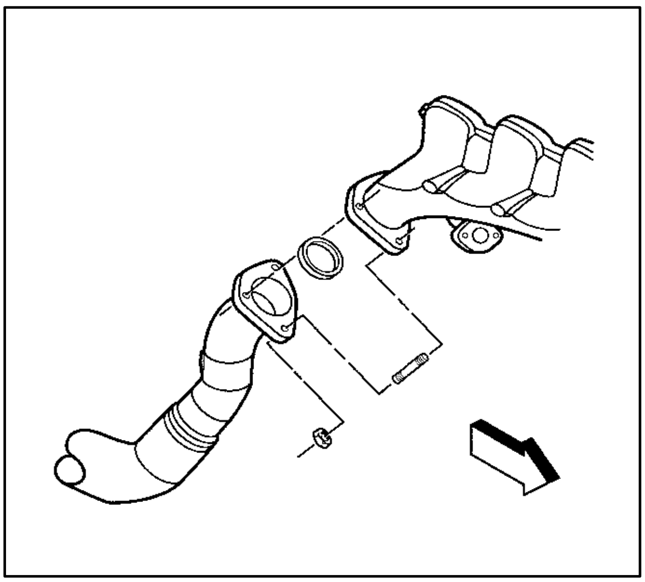
Exhaust Seal Replacement (8.1L)

Removal Procedure



WRK66001

1. Disconnect the O2 sensor electrical connector from the wiring harness.
2. Remove the O2 sensor from the exhaust pipe.



WRK66002

3. Remove the exhaust pipe flange nuts from the exhaust manifold.
4. Remove the exhaust pipe flange nuts from the catalytic converter.
5. Remove the exhaust pipe from the exhaust manifold.
6. Remove the exhaust manifold gasket from the manifold.

Installation Procedure

1. Install the exhaust manifold gasket to the manifold.
2. Install the exhaust pipe to the exhaust manifold.

Notice: Refer to *Fastener Notice* in Cautions and Notices in WCC Service Manual.

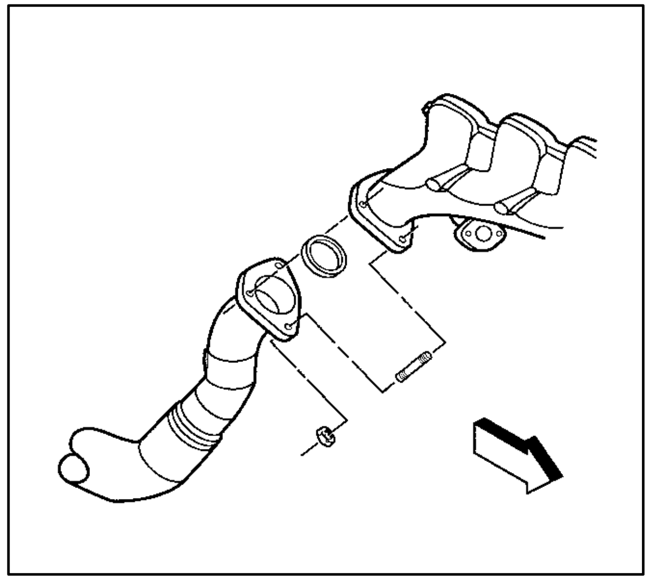
3. Install the exhaust pipe flange nuts to the catalytic converter.
4. Install the exhaust pipe flange nuts to the exhaust manifold.

   Tighten

   Tighten the exhaust pipe flange nuts to 65 N·m (48 lb ft).
5. Install the O2 sensor to the exhaust pipe.
   5.1. Apply anti-seize compound GM P/N 1233377953 or equivalent to the threads of the old oxygen sensor.

   Tighten

   Tighten the O2 sensor to 45 N·m (33 lb ft).
6. Connect the O2 sensor electrical connector to the wiring harness.

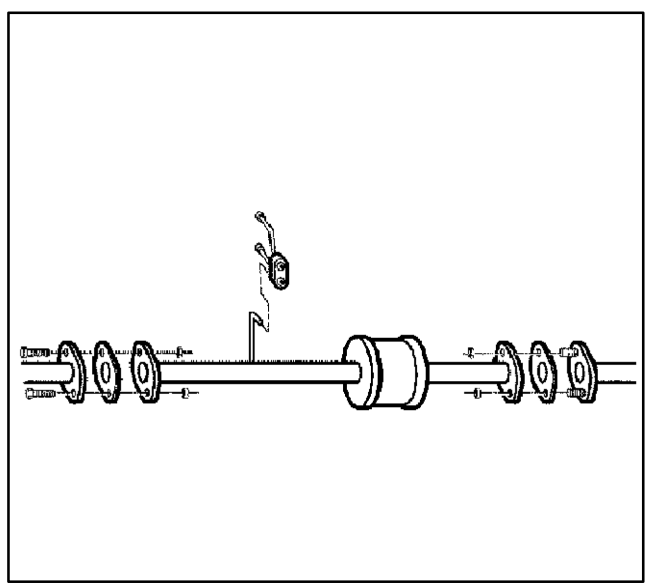


WRK66002

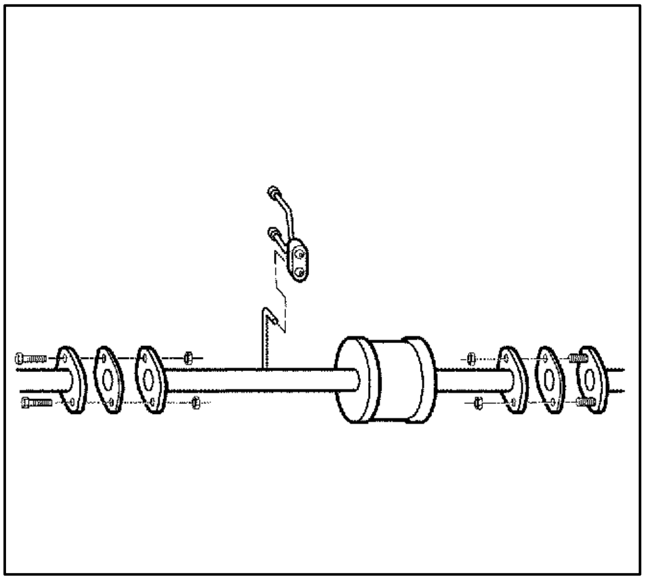
Catalytic Converter Replacement (8.1L)

Removal Procedure

1. Remove the flange nuts and gasket at the front of the catalytic converter.
2. Remove the flange nuts at the back of the catalytic converter.
3. Remove the catalytic converter from the exhaust hanger and remove converter and gasket from the exhaust pipe.



WRK66004



WRK66004

Installation Procedure

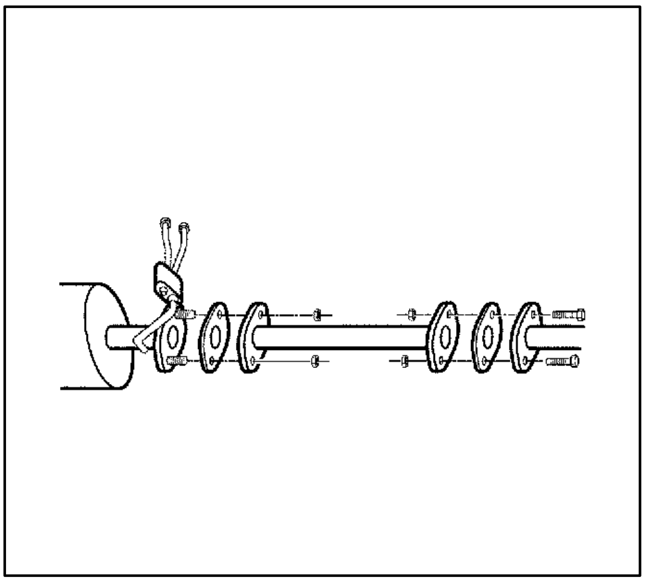
1. Install the catalytic converter to the exhaust hanger and install gasket and converter to the exhaust pipe.

Notice: Refer to *Fastener Notice* in Cautions and Notices in WCC Service Manual.

2. Install the flange nuts at the back of the catalytic converter.
3. Install the gasket and flange nuts at the front of the catalytic converter.

   Tighten

   Tighten the flange nuts to 85 N·m (63 lb ft).

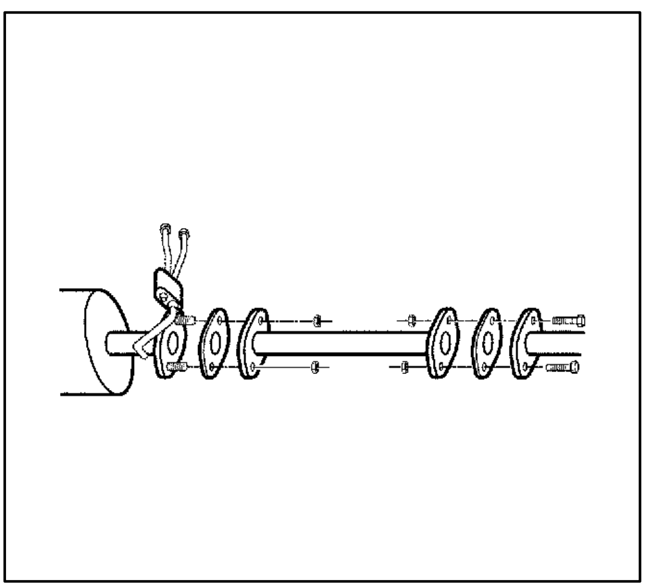


WRK66003

Exhaust Pipe Replacement (Intermediate) (8.1L)

Removal Procedure

1. Remove the flange nuts at the back of the catalytic converter.
2. Remove the flange nuts from the front of the muffler and remove the intermediate pipe and gaskets.



WRK66003

Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices in WCC Service Manual.

1. Install the intermediate pipe and gaskets and install the flange nuts to the front of the muffler.
2. Install the flange nuts at the back of the catalytic converter.

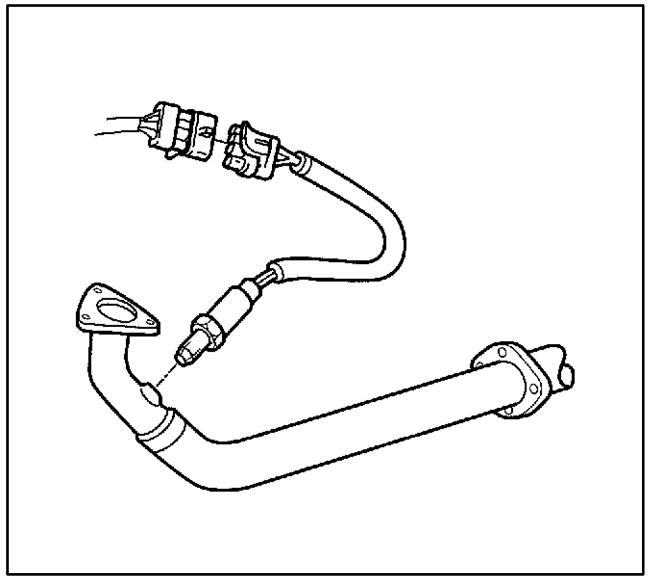
   Tighten

   Tighten the intermediate pipe flange nuts to 85 N·m (63 lb ft).

Exhaust Pipe Replacement (Front) (8.1L)

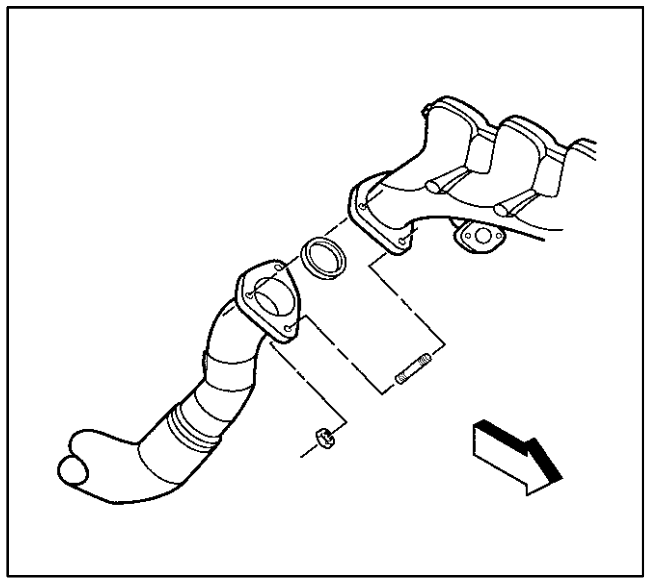
Removal Procedure

1. Disconnect the O2 sensor electrical connector from the wiring harness.
2. Remove the O2 sensor from the exhaust pipe.



WRK66001

3. Remove the exhaust pipe flange nuts from the exhaust manifold.
4. Remove the exhaust pipe flange nuts from the catalytic converter.
5. Remove the exhaust pipe and gaskets from the exhaust manifold and catalytic converter.



WRK66002

Installation Procedure

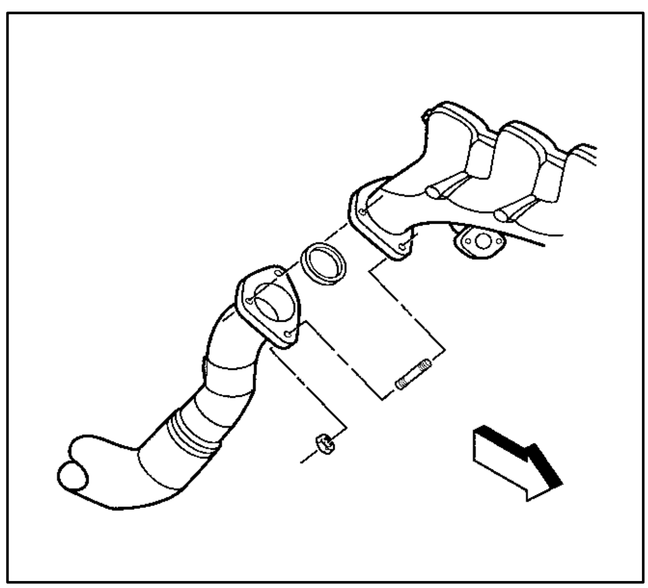
1. Install the exhaust pipe and gaskets to the exhaust manifold and catalytic converter.

Notice: Refer to *Fastener Notice* in Cautions and Notices in the WCC Service Manual.

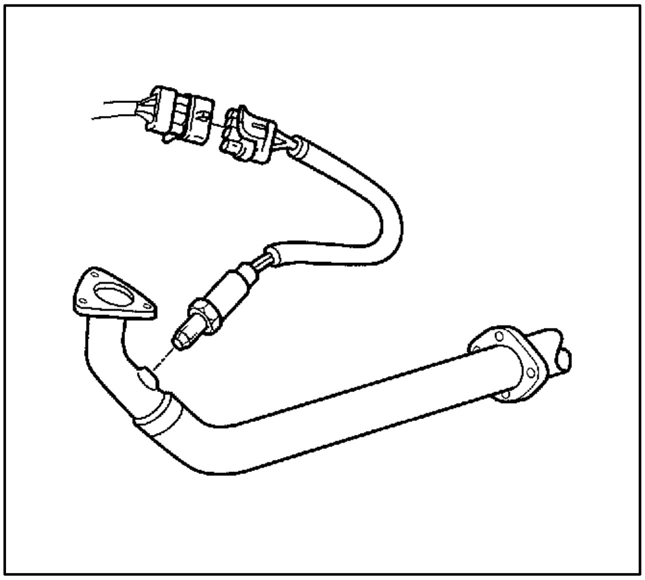
2. Install the exhaust pipe flange nuts to the catalytic converter.
3. Install the exhaust pipe flange nuts to the exhaust manifold.

   Tighten

   - Tighten the exhaust pipe to manifold flange nuts to 65 N·m (48 lb ft).
   - Tighten the catalytic converter flange nuts to 85 N·m (63 lb ft).



WRK66002

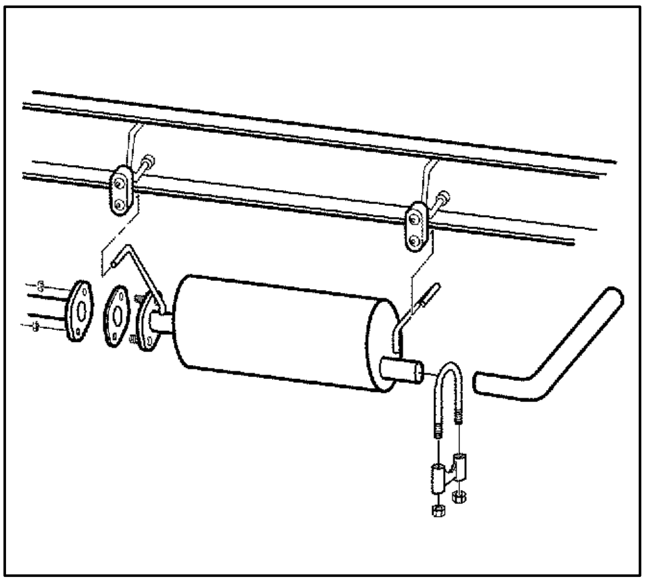


WRK66001

4. Install the O2 sensor to the exhaust pipe.
   4.1 Apply anti-seize compound GM P/N 1233377953 or equivalent to the threads of the old oxygen sensor.

   Tighten

   Tighten the oxygen sensor to 45 N·m (33 lb ft).
5. Connect the O2 sensor electrical connector to the wiring harness.

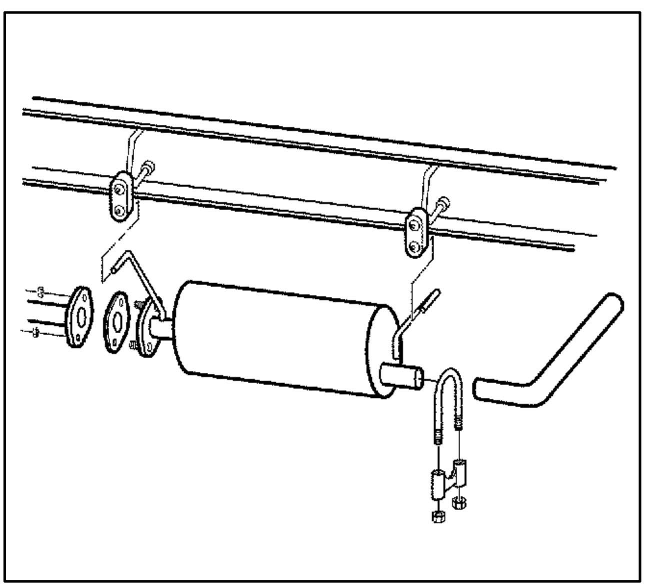


WRK66006

Muffler Replacement (8.1L)

Removal Procedure

1. Remove the flange nuts from the front of the muffler and the intermediate exhaust pipe, and remove the gasket.
2. Remove the clamp from the rear of the muffler and the tailpipe.
3. Remove the tailpipe from the muffler.
4. Disconnect the muffler from the exhaust hangers.



WRK66006

Installation Procedure

1. Connect the muffler to the exhaust hangers.
2. Install the tailpipe to the muffler.

Notice: Refer to *Fastener Notice* in Cautions and Notices in WCC Service Manual.

3. Install the clamp and the clamp nuts to the tailpipe and the rear of the muffler.
4. Install the gasket and flange nuts to the front of the muffler.

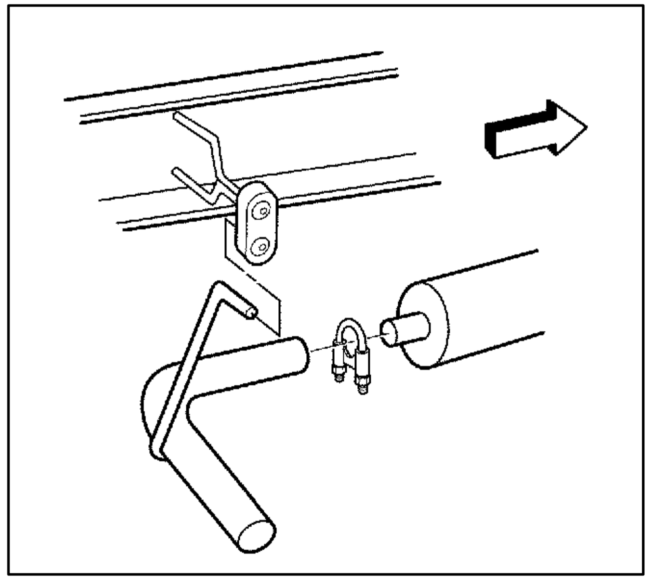
   Tighten

   - Tighten the flange nuts to 85 N·m (63 lb ft).
   - Tighten the clamp nuts to 40 N·m (30 lb ft).

Tailpipe Replacement (8.1L)

Removal Procedure

1. Remove the clamp from the rear of the muffler and the tailpipe.
2. Disconnect the tailpipe from the hanger and remove the tailpipe.



WRK66005

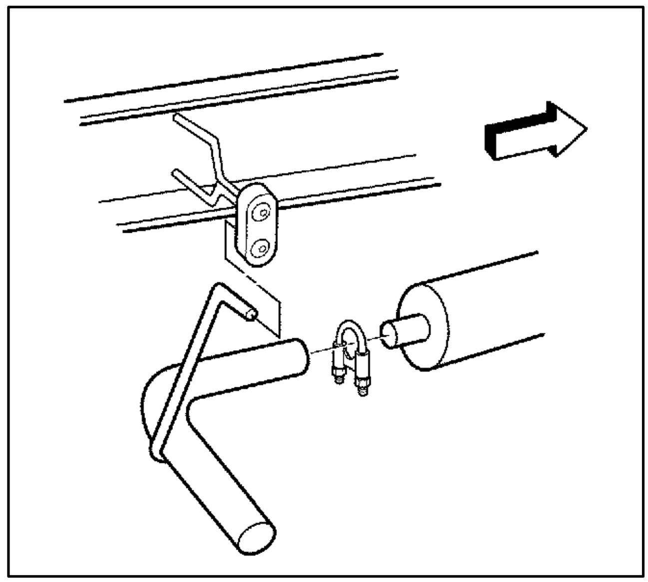
Installation Procedure

1. Connect the tailpipe to the hanger and install to the muffler.

Notice: Refer to *Fastener Notice* in Cautions and Notices in WCC Service Manual.

2. Install the tailpipe clamp and clamp nuts to the tailpipe and the rear of the muffler.

   Tighten
   Tighten the clamp nuts to 40 N·m (30 lb ft).



WRK66005

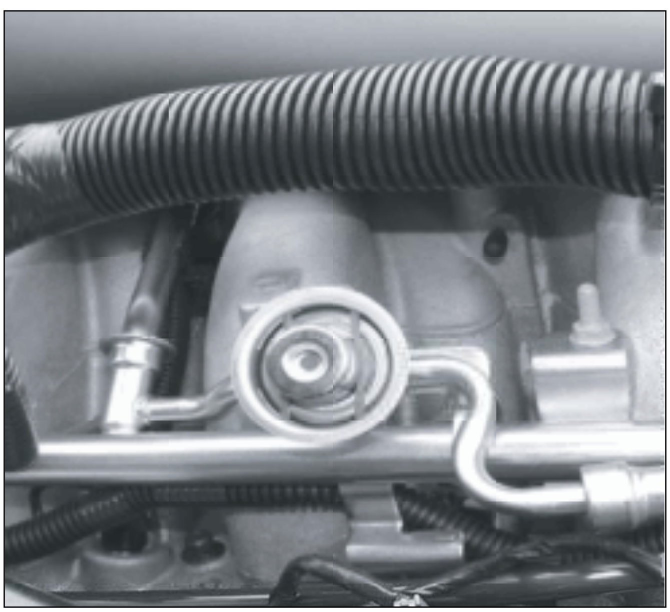
FUEL SYSTEM

FUEL SUPPLY SYSTEM

The fuel supply system has been updated to meet the more stringent OBD II requirements. Starting in the 2004 model year the fuel rail mounted fuel pressure regulator has been eliminated along with the vacuum control line and the fuel return line to the tank. Fuel pressure regulation is now controlled solely by the regulator which is part of the in-tank fuel pump module. This new system is known as a “returnless” fuel system. On systems using a return line from the rail, the fuel is heated by the engine and returns to the tank resulting in increased fuel (HC) vapors in the system. Eliminating the extra vapor allows the EVAP system to be sized accordingly.

The returnless system uses a higher fuel pressure to maintain sufficient fuel quantity at the injectors. Fuel system service remains virtually unchanged from previous model years.

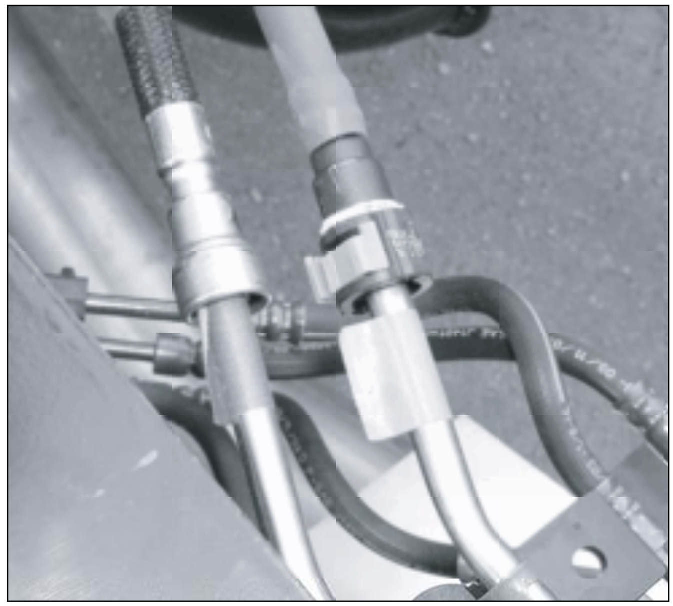
The fuel rail is equipped with a pulsation dampner to elimnate fuel wave pulsations created by the rapid cycling of the fuel injectors. The dampner and fuel rail are serviced as an assembly. Follow all safety precautions and warnings whenever opening fuel pressure lines.



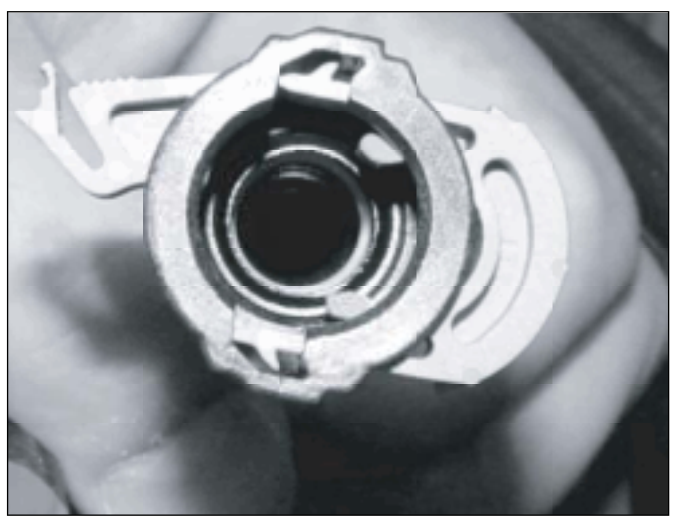
Pulsation dampner.

Fuel Lines

The fuel lines are now constructed of stainless steel to further reduce the fuel permasbility rate to atmosphere in order to meet the new LEV II requirements. Damaged lines should be replaced as special procedures are required to properly service these lines. Standard flare procedures may cause the line to fracture in the flare and result in leakage. Compression style fittings should be used if repair is absolutely necessary.



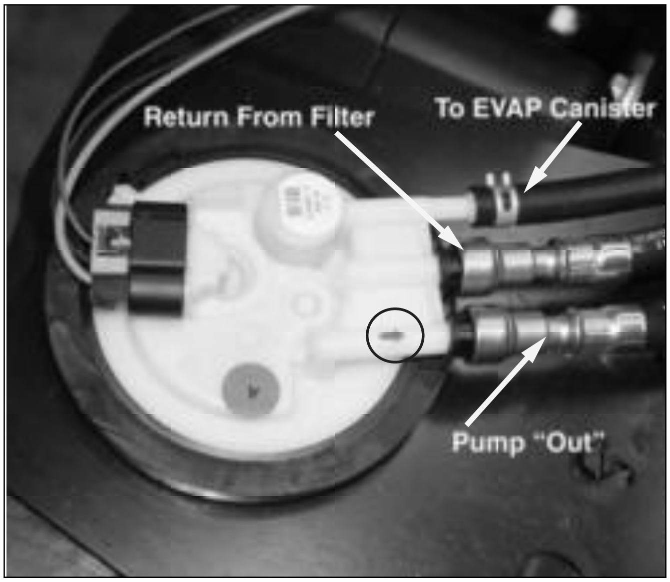
Fuel line connections.



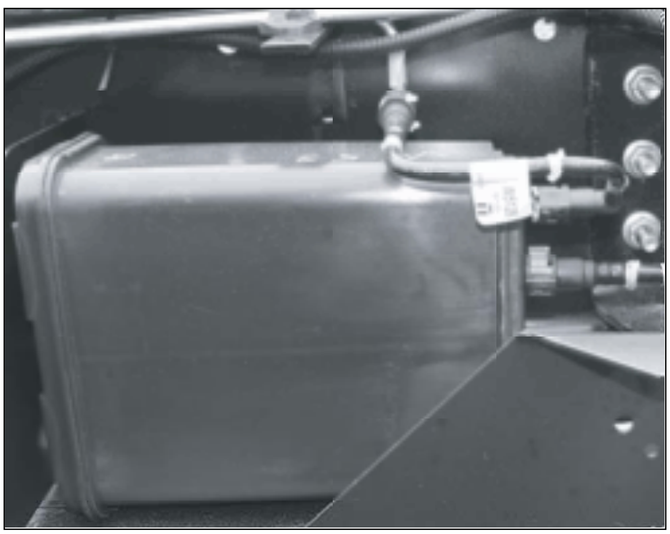
Safety lock must be unlatched before disconnecting the fuel line.

Fuel Pump Module

The fuel pump module is redesigned to accomodate the nes returnless system.



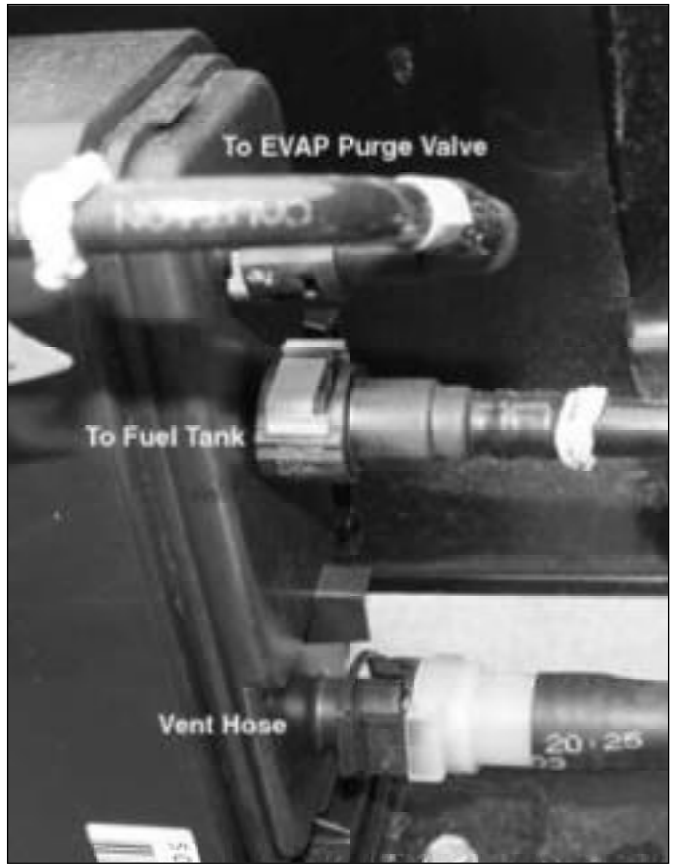
Fuel pump module fuel and vapor line connections.



Redesigned EVAP canister.

EVAP SYSTEM

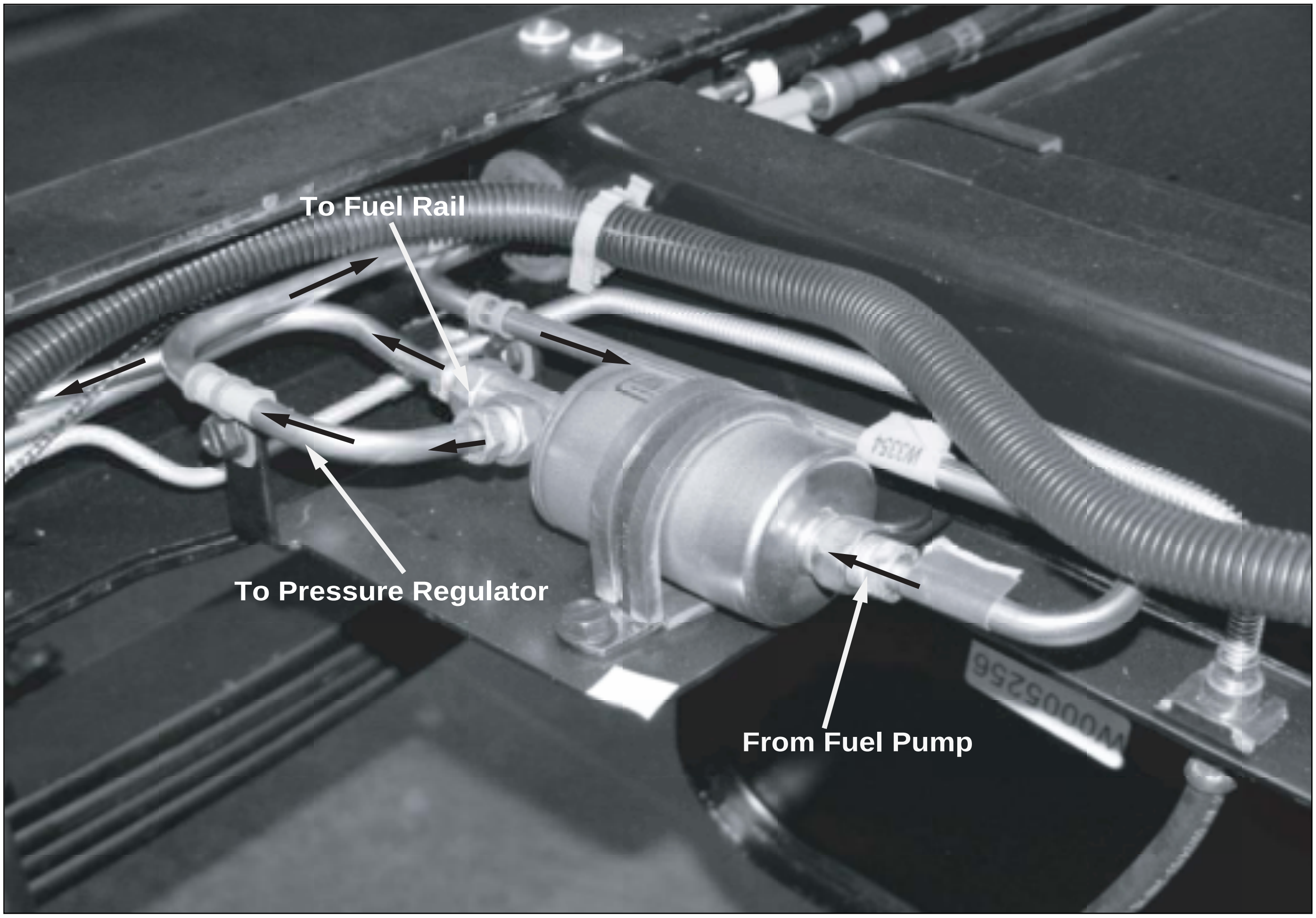
The EVAP canisters have been redesigned to meet the new EVAP emissions requirements. Depending on emission requirements, the chassis may have one or two EVAP canisters installed.



Canister vapor and vent connections.

Fuel Filter

The fuel filter has been remounted to accomodate the new returnless fuel system. The filter is frame mounted to maintain ease of service.



Fuel filter mounting and line routing.

Fuel Tanks

The fuel tanks have been redesigned to meet the new FMCSA regulations which require an aluminum label containing the applicable manufacturing information. The diesel fuel tanks have a new rollover vent valve as well.

ISB4/ISB^{e}
Electronic Interface
Application Technical Package

Cummins Inc.
1460 National Road
Columbus, Indiana 47201

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1 FEATURES

1.1 TECHNICAL PACKAGE INTRODUCTION

This ISB4/ISB^e Electronic Interface Application Technical Package contains the technical information needed to apply the electronic features of the ISB4/ISB^e engines to OEM vehicles. The features for the ISB4/ISB^e engines are listed below. Unless specifically noted in this document the information applies to both engines. Those items specific to the ISB4 or ISB^e are noted in parenthesis with the appropriate electronic interface application.

1.2 ABOUT THE ISB4/ISB^e ENGINES

The ISB4/ISB^e family of engines is the replacement for the B series in truck and bus applications. These engines are one liter per cylinder models with high-pressure common rail electronic fuel systems, 4 valves per cylinder and a rear gear train.

1.3 AUTOMOTIVE FEATURES

- 12 or 24 Volt Operation
- Accelerator Control - Interlock
- All Speed Governor
- Analog Throttle with Idle Validation
- ASG - Switchable Droop
- Auxiliary Speed Control
- Battery Voltage Monitor
- Cab Switchable Governor
- Cruise Control
- Diagnostic Fault Detection and Processing
- Diagnostics - VSS Fault Detection
- Dual Potentiometer Throttle
- Electronic Fan Clutch
- Engine Protection - Calibratible Derates
- Engine Protection - Coolant Temperature
- Engine Protection - Derates
- Engine Protection - Intake Manifold Temperature
- Engine Protection - Low Coolant Level
- Engine Protection - Oil Pressure
- Engine Protection - Overspeed Protection
- Engine Protection - Shutdown
- Engine Protection - Shutdown Override
- Engine Warmup Protection - Max RPM
- Engine/Exhaust Brake/Driveline Retarder Control
- Fan Clutch Control
- Fuel Heater Control
- Gear Down Protection
- Grid Heater Control
- J1587 Data Link
- J1939 Data Link
- J1939 Multiplexing
- Low Idle - Adjustable
- Low Idle - Idle Shutdown
- Low Idle - Switchable
- Maintenance Monitor
- Min/Max (Automotive) Governor
- MPG/GPH Monitor
- Multi-level Security
- PowerTrain Protection (Torque Control)
- PTO
- Remote Throttle

- Road Speed Governor
- Starter Lockout
- Switchable Torque
- Switched Max Operating Speeds
- Tachometer Output Signal
- Throttle Activated Diagnostic
- Throttle Control - Limp Home
- Transmission Shift Modulation
- Trip Information Log
- Two Speed Axle
- Vehicle Acceleration Rate Limiter
- Vehicle Anti-Theft Protection
- Vehicle Speed Input
- VSS Anti Tamper
- Water in Fuel Warning

Note: Once the OEM has identified the Features and Parameters that will be selected and programmed for implementation in a given vehicle, Cummins Inc. strongly suggests that a Vehicle/Feature Interaction Analysis be performed on the system.

2 FUNCTIONAL OPERATION

2.1 ACCELERATOR INTERLOCK

The Accelerator Interlock Feature is intended to keep the engine at idle speed by using an interlock switch that is usually attached to the vehicle door. Most buses use this feature to disable the accel pedal and PTO operation while the bus door is open; thus the engine remains idle while the door remains open.

The Accelerator Interlock applies to the main accelerator input *and* the Remote Throttle.

Note: This feature can be overridden with the Remote PTO feature.

2.2 AUXILIARY PROTECTION SYSTEM

The ISB4/ISB^e engines are also equipped with an auxiliary protection system as an optional feature. However this feature is not available for European calibration. This system is capable of monitoring up to two input parameters (1 Temperature, 1 Pressure) and logs diagnostic faults when an over or under normal operating range condition occurs. This system is capable of applying derates to engine torque and/or engine speed and/or engine shutdown when these parameters exceed a customer programmable threshold.

The ECM also keeps an electronic data log of time of occurrence, elapsed times, extreme pressures and extreme temperatures when the system detects an out-of-range condition. See OEM Temperature/Pressure Sensor descriptions in Section 3 for more details.

2.3 BATTERY VOLTAGE MONITOR

This feature warns the operator by turning on the warning Lamp when the battery voltage is either above or below the normal range for the alternator. An optional feature of the battery voltage monitor will automatically increase idle speed to 800RPM, if the battery voltage falls below an unacceptable limit while the engine is idling Once Battery voltage reaches an acceptable value, the idle speed will decrease back to the engine's normal idling speed in decrements of 50 rpm. This feature can be enabled by the programming tools.

2.4 CAB SWITCHABLE GOVERNOR

The Cab Switchable Governor allows the operator to choose between an automotive type Min/Max governor and a variable speed governor via a switch or the Cummins service tool. The ECM will not change governors except at a zero throttle condition. This feature is often utilized to choose a different governor for Remote Throttle.

2.5 CRUISE CONTROL

Cruise control has three modes: off, standby and active. The *off* position of the enable switch disables cruise control. The standby mode occurs when the operator switches the cruise control on/off switch to the *on* position. The operator can then achieve the active mode by enabling the set switch after accelerating to the desired road speed. Once the system is in the active mode, the accelerator pedal can be used to increase the speed beyond the cruise control set speed (up to the high idle engine governor speed or to the road speed governor limit). When the pedal is released, cruise control will remain active when vehicle speed reaches the previously set speed. Enabling the Cruise Control feature disables the Engine or Exhaust Brakes (unless Engine or Exhaust Brake/Cruise Control Interaction is selected -see below).

Cruise control is deactivated and returns to the standby mode in several ways: the brake pedal is depressed, the engine speed (rpm) drops below 1000 revolutions per minute, the vehicle speed drops below 48 kilometer/30 miles per hour or the parking brake is activated. Manual transmissions can also deactivate cruise via the clutch switch or by placing the transmission into neutral. Initiating either of these cruise control deactivation modes will cause a cruise control deactivated Engine or Exhaust Brake to become active again.

To return to active mode if cruise is in standby mode, the operator must enable either the set or the resume switch. Momentary enabling of the set switch will establish a new set speed at the current vehicle speed. Momentary enabling of the resume switch will return cruise control to the previously established cruise speed.

The coast feature of the coast switch is used to *decrease* the vehicle speed and establish a new lower cruise speed. By holding the coast switch closed, the vehicle speed decreases until the switch is released; the speed at release becomes the new cruise control set speed. 1.6-kilometer/1mile-per-hour decrements can be achieved by bumping (briefly enabling) the coast switch.

The accel feature of the accel switch is used to increase the vehicle speed and establish a new higher cruise speed. By holding this switch closed, the vehicle speed increases until the switch is released; the speed at release becomes the new cruise control set speed. 1.6-kilometer/1-mile-per-hour increments can be achieved by bumping the accel switch up to the programmed maximum cruise control speed.

With the use of programming tools, the customer has the option to change switch functions from set/coast and resume/accelerate to set/accelerate and resume/coast. See Table 7-42-3 on page 13 for feature priority.

2.6 CRUISE CONTROL GOVERNOR TAILORING

Using programming tools, the customer can also tailor the cruise control governor by setting the upper and lower droops. Adding droop to the cruise control governor may enhance fuel economy under certain conditions.

2.7 DIAGNOSTICS

ISB4/ISB^e engines have both an on board diagnostic mode and an off board data link connection. With the vehicle key switch on, the engine not cranking or running, and the diagnostic mode activated via the test switch or the throttle, the system is in the on board diagnostic mode. In this mode, the red and amber indicator lamps light and remain lighted if there is no active fault. If there is an active fault, the red lamp flashes in a sequence of pulses to indicate that specific fault code. For offboard diagnostics the data link is active when the vehicle key switch is on.

2.7.1 ON BOARD DIAGNOSTICS

The ISB4/ISB^e engines have a built-in diagnostic capability which alerts the operator of a system problem while the engine is running by illuminating one of the required indicator lamps. The warning lamp, when lit, warns the operator of an active component or system fault. While it denotes a failure has happened, the vehicle can be operated. The vehicle should be serviced to solve the problem but the situation is not considered an emergency. A lighted Stop Lamp indicates a major ISB4/ISB^e engine problem and the vehicle should be stopped as soon as safely possible.

Note: The Stop Lamp will be flashed in scenarios where engine protection shutdown or idle shut down are about to shut the engine down.

The engine protection system uses an indicator lamp to alert the operator of a coolant temperature high, intake manifold temperature high, oil pressure low, or coolant (water) level low condition. The lamp will turn on at the occurrence and then begin blinking after a period of time. This blinking operation is to warn the operator that the condition has been active for a period of time or else the pressure or temperature condition has become worse and engine shutdown is about to occur if the shutdown feature has been enabled.

Note: The engine protection faults defined above will turn on the Warning and Stop lamps depending on the severity of the fault detected with the exception of the coolant level engine protection which will turn on the Maintenance Lamp.

In addition to alerting the operator of system faults, the lamps are used in the diagnostic operation. The diagnostic mode begins when the vehicle key is on, the engine is not running, and the diagnostic mode is activated. The Warning Lamp flashes at the beginning of a fault code sequence, the Stop Lamp flashes the code for the active fault and the Warning Lamp again flashes to separate the previous Stop Lamp sequence from the next one.

2.7.2 Offboard Diagnostics

The data link is activated when the key switch is on regardless of whether the engine is running or not. The data link is used with tools offered by Cummins. The data link also provides information, formatted in accordance with the recommended SAE standard, to additional data logging equipment such as electronic dashboards and other onboard recording devices. This data link is compatible with the SAE Recommended Practices J1939, J1587 and J1708. Refer to Chapter 6 for details about the diagnostic mode recall.

2.8 ENGINE PROTECTION SYSTEM

The ISB4/ISB^{e}engines are equipped with an engine protection system as a standard feature. This system monitors four engine parameters: coolant level, coolant temperature, oil pressure, intake manifold temperature and unintended fueling diagnostics and derates the engine when one or more of those parameters goes out of range. The Engine Protection system can impose a torque derate, engine speed derate and possible engine shutdown in progressive order.

The ECM also keeps an electronic data log of time of occurrence, elapsed times, extreme pressures and extreme temperatures when the system detects an out-of-range condition. See Section 6 for the list of logged data displayed by the programming tools.

2.8.1 Torque Derate

If one or more of the engine parameters goes out of range the Engine Protection system will decrease the maximum torque output of the engine. The engine torque will decrease if the parameter remains out of range. A dash lamp will be illuminated. The torque derate is imposed until the engine parameters return to normal range or a speed derate is imposed.

2.8.2 Speed Derate

If one or more of the engine parameters continues out of range the Engine Protection system will decrease maximum engine speed. The maximum engine speed will decrease if the parameter remains out of range. A dash lamp will flash. The speed derate is imposed until the engine parameter returns to torque derate range or engine shutdown occurs (if enabled).

2.8.3 Engine Protection Shutdown

If the customer chooses the Engine Protection system can impose an engine shutdown if out of range parameters persist. The dash lamp will continue to flash. An Engine Protection shutdown can be delayed using the Engine Protection Override Switch. The engine may be restarted after an Engine Protection shutdown. After the engine is restarted it will be limited to the maximum torque and/or speed derate levels of the out-of-range parameter until the engine parameters return to normal.

Note: The engine protection shutdown can be activated or deactivated using the programming tools.

2.9 ENGINE WARM-UP PROTECTION

The purpose of the feature is to delay engine acceleration to prevent internal damage, such as rod bearing and turbo bearing failures. This is accomplished by limiting engine speed at start-up until adequate oil pressure is achieved and maintained. During engine warm-up the following inputs are ignored:

1. Throttle pedal
2. Remote Throttle
3. PTO
4. Remote PTO
5. Datalink control/speed inputs

The feature is triggered when the vehicle key switch is cycled and vehicle speed is 0.

2.10EXHAUST BRAKE

The Exhaust Brake helps slow the vehicle when activated by restricting exhaust flow to generate back pressure against the pistons during the exhaust stroke. Optimum braking power is achieved at high engine speed. Activating the Exhaust Brake Switch in the cab enables the Exhaust Brake. When the switch is activated, the ECM activates the brake when the conditions in Table 2-1 are met.

Table 2-1 Conditions Required to Activate Exhaust Brake

FUNCTION	CONDITION
Exhaust Brake Switch	ON
Engine Speed	Greater than 1000 RPM
Throttle Position	Released or 0%
Clutch Pedal	Released or Switch Indicates Off
PTO	Inactive
Cruise Control (Service Tool Selectable)	Inactive or Vehicle Speed greater than set speed

2.10.1 Exhaust Brake/Cruise Control Interaction

This interaction can be selected using the field service tool. When selected this feature allows the exhaust brake to engage while in cruise control. This will only occur when the vehicle speed is a customer programmable value above the cruise set speed and the Exhaust Brake Switch is ON.

2.10.2 Exhaust Brake / Automatic Transmission Interaction

Some automatic transmissions allow performance to help optimize exhaust brake operation. When the exhaust brake becomes active the transmission will change to lower gears to increase engine speed. Check with the transmission OEM for this operation and interfacing.

2.10.3 Exhaust Brake / Driveline Retarder

Some automatic transmissions offer a driveline retarder to aid engine braking when an exhaust brake is not present. The Driveline Retarder is essentially a brake on the driveline. When the transmission offers this capability the operating conditions are the same as listed in Table 2-1.

2.11FAN CLUTCH CONTROL

The ISB4/ISB^{e} engines are equipped with a fan clutch control as a standard feature. When the engine coolant or intake manifold temperatures reach a predetermined limit the fan clutch turns on. Fan operation is prevented when the engine is not running. Using the service tool, the OEM can direct the ECM to provide battery voltage to turn the fan on (default) or to provide battery voltage to turn the fan off (some fan clutches are designed to run continuously unless battery voltage is applied to stop the fan). When the coolant or intake manifold temperatures fall below a limit, the ECM will turn the fan off.

Default conditions which activate the fan:

-High coolant temperatures
-High intake manifold temperatures
-Coolant temperature sensor out of range high
-Coolant temperature sensor out of range low
-Intake Manifold temperature sensor out of range high
-Intake Manifold temperature sensor out of range low

Optional conditions which activate the fan:

-High air conditioner refrigerant pressure
-Service tool request
-Manual fan switch activation

-Datalink using SAE J1939 PGN - 57,344 (for more information see Table 7-4 on page 115)

Since the coolant and intake manifold temperature sensors are required for the ISB4/ISB^e fuel control functions of the engines, the OEM does not need to supply temperature sensors to perform this function.

The Variable Fan can be either an On-Off type fan which the % fan engagement request is converted into an On or Off request, or a High-Low-Off. In the High-Low-Off the % fan engagement request is converted into a High, Low or Off request and the fan is forced to go through a low speed for a minimum time, if High is requested from Off.

Note: The OEM does need to enable the AC pressure switch input via the programming tools and supply a normally closed air conditioner refrigerant pressure switch if A/C pressure input is to be included in the fan control algorithms. Similarly, the Manual override switch must be enabled via tools and a normally closed manual override switch must be installed if the OEM wants the operator to have manual fan override control.

2.12 GEAR DOWN PROTECTION

Gear down protection is optional on the ISB4/ISB^e products and can be enabled using programming tools. Gear down protection encourages fuel efficient operation by limiting vehicle speed in lower gears. Based on the transmission's top two gear ratios, gear down protection can determine if the vehicle is operating in a lower gear; and, if so, limits the maximum vehicle speed to the values selected with programming tools. The maximum vehicle speed in one gear down from top gear can be programmed for both heavy and light engine loads. This allows a driver to downshift when climbing a hill without a derate in vehicle speed for being one gear down from top gear. This feature is usually used in heavier vehicle applications with transmissions that have greater than 6 forward gears.

For example, with the following settings a driver can climb a hill at 55mph (88kph) in one gear down from top gear and not be limited to 60mph (96kph) in that gear until returning to light load cruising conditions.

Note: The Gear Down vehicle speed limit can not be greater than the RSG value.

Table 2-2 Gear Down Protection Example

Parameter	Programmed Value (kph)
Maximum vehicle speed in top gear	60mph (96kph)
Maximum vehicle speed one gear down-heavy engine load	60mph (96kph)
Maximum vehicle speed one gear down-light engine load	55mph (88kph)

2.13 FUEL HEATER CONTROL

An optional Fuel Heater can be used in the ISB4/ISB^e engines to avoid “clouding” of diesel fuel. This clouding is the result of the wax (paraffin) in the fuel solidifying. The Fuel heater Controller controls the fuel heater based on intake manifold temperature. This feature takes intake manifold temperature to derive a fuel heater input temperature value and compares it to calibratible limits. Based on the result, the ECM commands a relay on or off. This relay controls the fuel filter/heater assembly.

Below a set temperature, the heater will be commanded on; above a set temperature, the heater will be commanded off.

2.14 GRID HEATER CONTROLS

Grid heaters are required in the ISB4 engines and can be used in the ISB^e engines. They are used to aid starting and reduce smoke during cold ambient conditions. There are two phases of intake air heat operation: preheat (after key-on and before cranking) and postheat (just after a successful engine start).

The intake air heater is used in starting during cold temperatures and to reduce white smoke after such a start. The intake air heaters or grid heaters are controlled from relays via the ECM. The amount of time the grid heaters stay on in the preheat cycle is a function of the measured temperatures at key on. Preheat time increases with colder temperatures.

A Wait to Start Lamp, also controlled by the ECM, is illuminated while the grid heaters are active to indicate the driver should not crank the engine.

During cranking, the intake air heater is turned off to allow maximum current to be used by the starter. The postheat phase starts after successful engine start and the grid heaters are cycled on a schedule based on the measured temperatures. The postheat cycle time will increase with colder temperatures.

The OEM is responsible for the mounting and wiring of the relays to the grid heaters and battery (+). Refer to Sections 3 and 5 for design and sourcing information and voltage sourcing options.

2.15IDLE SHUTDOWN

The ISB4/ISB^e products offer an optional idle shutdown feature using programming tools. When enabled, this function will automatically shut an engine off after a period of engine idle time with no driver input. The ECM will monitor the throttle, clutch, vehicle speed, and service brake for inactivity and the engine speed for an idle condition. The amount of time the ECM will allow at idle before engine shutdown is determined with the programming tools. The engine can be restarted by cycling the key switch.

Note: An Idle shutdown will flash the amber Warning Lamp to warn the user of imminent engine shutdown. The Warning Lamp will flash 30 seconds prior to an idle shutdown. During the 30 seconds, a driver can override the idle shutdown timer by changing the clutch, brake, or throttle position, if idle shutdown override is active.

Also selectable by programming tools is whether idle shutdown is active in PTO mode. If idle shutdown is activated for PTO mode, the engine will shut down after the specified amount of time while in PTO. If idle shutdown is deactivated for PTO mode, then the engine will not shut down while in PTO mode.

If the road speed equals 0 and if idle shutdown is turned on, then the idle shutdown timer is started, even if the brake, clutch, or throttle pedal is depressed. If a change of state occurs in the brake, clutch, or throttle pedal, the idle shutdown timer will be reset and restarted.

If this feature is turned on and if Coolant Temperature is less than a calibratable threshold, then the idle shutdown times will not be started until the coolant temperature exceeds the threshold.

2.16INFORMATION LOG

The following parameters are displayed in the trip information section of the programming tools.

- CUMULATIVE DATA

  Total Fuel Used
  Total Idle Fuel Used
  Total Engine Hours
  Total ECM Hours
  Total Average Engine Load

- TRIP SINCE LAST RESET

  Fuel Used
  Hours
  Average Fuel Rate
  Trip Max Engine Speed
  Trip Average Engine Load
  Trip ECM Hours

- IDLE SINCE LAST RESET

Fuel Used
Hours

- PTO SINCE LAST RESET

Fuel Used
Hours
Percent Usage

- BRAKE UTILIZATION SINCE LAST RESET

Number of Sudden Decelerations

- INSTANTANEOUS DATA

MPG
Fuel Rate

2.17KEY SWITCH ON

Four vehicle key switch phases govern the operation of the ISB4/ISB^e systems:

- Key switch on, diagnostic test switch off, engine not cranking or running
- Key switch on, diagnostic test switch on, engine not cranking or running
- Key switch on, engine cranking
- Key switch on, engine running

With the key switch on, the diagnostic test switch off and the engine not cranking or running, the electronic control module (ECM) performs diagnostic and status operations. It reads the logic inputs from the brake, clutch and cab switches and analog inputs from sensors such as the engine coolant temperature sensor and the manifold boost pressure sensor. During this phase, the data link is active.

Additionally if the key switch is turned on but the diagnostic switch remains off, the indicator lamps (Warning, Stop, Maintenance Lamp, and Wait to Start) illuminate for approximately two seconds and then go off in given order, one after the other, to verify they are working and wired correctly. This is part of the normal operation of the power-up sequence. When cold starting algorithms are activated, the Wait To Start Lamp will remain on until grid heaters have timed out. If an active fault is present, one of the remaining lamps will remain illuminated, determined by the type of fault being sensed. When engine maintenance is needed the maintenance lamp will flash upon engine power up.

When the diagnostic test switch is turned on, the Stop and Warning indicator lamps light and remain illuminated if there is no active fault. If there is an active fault, the Stop Lamp flashes in a sequence of pulses to indicate the specific fault code. Further discussion of diagnostic operations is found in the Diagnostics Section.

The ISB4/ISB^e engine electronic subsystems and the starter motor are independent of each other. During the cranking phase, with the key switch in the start position, the ECM commands all of the fuel needed to start the engine. The throttle pedal has no effect while cranking the engine.

Note: The feature discussions in this section have many customer programmable parameters that can be used to optimize the ISB4/ISB^e engine electronics to best suit each customer’s needs. All customer programmable parameters can be modified with programming tools.

2.18Limp Home Throttle Operation

Most conditions have the engine speed controlled by the operator via the throttle pedal. The throttle pedal sends position information to the ECM by two means. The primary way is a potentiometer that sends a low voltage signal iforming the ECM of the throttle position. There are two complimentary switches to indicate either the throttle pedal is in an idle position or an above idle position. If the throttle potentiometer circuit fails, the engine speed can still be controlled via Limp Home Throttle feature. This feature was developed to allow the vehcile operator to “limp” the vehicle for service.

When this feature is active it allows fueling greater than the idle governor, but significantly less than normal operation. Limp Home Throttle takes throttle pedal position information from the idle validation switches. When the throttle pedal is in a released position idle is detected and the engine is governed to idle engine speed. When the throttle pedal is pressed the engine speed will begin to ramp up at a constant rate. During Limp Home Throttle operation fueling is limited, so the highest engine speed is greatly effected by the amount of load on the engine. Once the pedal is returned to idle position the engine will return to idle. The return to idle is immediate.

2.19 LOW IDLE SPEED ADJUSTABILITY

The low engine idle speed (rpm) can be adjusted between 700 and 800 RPM with a two-position momentary increment/decrement switch. This function permits the operator to adjust the idle speed up or down in increments of 25 rpm by enabling the switch. When this adjustment occurs, a new low engine idle speed is established and is saved when the key switch is turned off. This switch function can be disabled with a service tool adjustment.

Low idle can be adjusted with programming tools if switches are not available.

2.20 MAINTENANCE MONITOR

The ISB4/ISB^e engine includes a maintenance monitor feature. This feature indicates to the operator when engine maintenance is required. The maintenance monitor is defaulted to off. Using programming tools, the customer can activate the maintenance monitor feature by choosing the manual method of determining the oil change interval. The automatic interval calculates based on values for the miles driven. With the manual method, the customer inputs the miles for the oil change interval. The maintenance monitor feature also allows for extended oil change intervals when the operator is using such products as Premium Blue 2000. Programming tools can be used to display the percent of the current interval that has been consumed.

When engine maintenance is needed, the Maintenance Lamp will flash upon ECM power up.

The maintenance monitor can be reset using programming tools or by performing the following sequence:

1. Key on.
2. Hold throttle at 100%.
3. Tap the brake 3 times
4. Release the throttle and brake.
5. Hold the throttle at 100%, again.
6. Tap the brake 3 more times.
7. Release the throttle and brake.
8. The Warning Lamp will flash 3 quick flashes signifying the request has been made.

Note: Under most circumstances other than resetting the Maintenance Monitor data following each maintenance event, no action is required on the part of the operator. The Maintenance Monitor feature will start in the Automatic Mode, and will set the longest possible maintenance interval. Without any adjustment, it will automatically compensate for stressful operating conditions, and give the operator the maximum safe interval.

Note: The operator may choose to use special lubricating oils. In the manual mode of operation, when the OEM inserts an appropriate multiplication factor into the Oil Change Interval Factor with a service tool, the algorithm will automatically adjust all the interval thresholds.

Note: The Maintenance Monitor will flash the warning indicator at a programmable percentage of the maintenance interval to provide advance notice. This advanced notice can be modified or eliminated by the customer.

2.21 MULTILEVEL SECURITY

The ISB4/ISB^e engines have an ECM that is Password Protected. The correct Master Password or Function Password must be entered before changing a password or changing any information in the ECM. The

Multilevel security feature provides the OEM this capability for multiple levels of users. This capability allows the programmable memory of the ECM to operate secure from unauthorized corruption. Multilevel Security helps reduce the risk of unauthorized clearing of information in the ECM, thus insuring integrity of customer data residing in the ECM.

Note: Refer to Section 6.3.6.2 or the appropriate service tool users manual for more detailed information.

Note: The original factory default setup is no passwords required.

2.22 POWER TAKEOFF (PTO) GOVERNOR

The PTO governor controls the engine at a constant customer-selectable speed (rpm) regardless of engine load. This feature is standard on the ISB4/ISB^{e} product and the PTO functions are enabled via the same switches used for cruise control operation. It can be disabled using programming tools.

When the PTO feature is selected via the cruise on/off switch, the PTO governor goes to standby mode. PTO allows the operator to set and control the engine speed using the cruise set and resume switches. PTO will return to standby mode when the vehicle speed is more than a customer programmable limit, or when the brake or clutch is pressed. The PTO vehicle speed limit is defaulted to10 kilometer/6 miles per hour. The Maximum PTO vehicle speed is limited to the minimum Cruise Control Speed. If Cruise Control is disabled the customer can select any vehicle speed limit between 0 and 30 mph (48 kph) using programming tools.

Once PTO is in standby mode, either the set switch or the resume switch will move PTO into the active mode. Enabling the set switch will cause the engine to idle at a Cummins preprogrammed default set speed of 850 rpm. This engine speed can be reprogrammed using the programming tools. By enabling the resume switch the engine will go to a second programmable preset speed.

The PTO minimum, set, resume, maximum, and remote PTO engine speeds can be programmed by the programming tools from low idle to 2500 rpm. Actual PTO operation will be limited by the low idle set speed and the high idle governor. Maximum PTO speed will be limited to the programmed rpm for maximum engine speed without a vehicle speed sensor if this option is enabled. The throttle pedal's effect on PTO operation is customer programmable. The customer can choose to have the throttle override the PTO governor or to have no effect. The throttle pedal can override the remote PTO set speed as well as cab PTO when the customer chooses to enable this function.

Depressing the brake and/or clutch pedals disables the PTO governor for *cab activated PTO* unless the customer programs the Brake PTO Disable and/or Clutch PTO Disable to “No” using programming tools. If a parking brake switch is wired to the ECM, the customer can select an option of disabling the cab PTO when parking brake is not set. This option can be selected using programming tools. Remote PTO is unaffected by the brake, clutch and parking brake switchs.

While in PTO mode, the coast switch is used to decrease the engine speed. By holding the switch closed for more than one second the engine speed is ramped down. When the switch is released a new lower PTO set speed is established.

The accel switch can be used to ramp the engine speed up by holding the switch closed. When the switch is released, it establishes a new higher rpm set speed. This speed is limited by the maximum PTO speed adjusted by the service tool but is programmable to the user's choice. Unlike cruise control, there is no incremental bumping up or down in PTO, only ramping.

A third PTO set speed can be provided in the cab enabling the set and resume switches simultaneously. OEMs will need to provide an independent switch for set and another switch for resume to implement this function in the cab and in order to maintain the preset PTO speed select for set and resume described above.

Remote PTO is also an available option, if the OEM provides a normally open Remote PTO switch. This switch will override the cab PTO switches. Cab throttle and remote throttle are also overridden by remote PTO activation unless “throttle override in PTO” is enabled. The programming tools can enable up to 5 different preset speeds for Remote PTO. All of these set speeds are defaulted to 950 rpm unless adjusted by programming tools. The preset speeds are selected by closing the remote PTO switch once for the first PTO set point, twice for the second PTO set point, and so on up to the fifth available preset PTO speed/setpoint. This must be done quickly, or PTO will be disengaged. The remote PTO mode is deactivated by any one of the following events: setting the remote PTO switch to the off position, a vehicle speed greater than the programmable limit, a vehicle speed sensor fault, or an engine shutdown. See Table 2-3 for feature priority. If the remote PTO is deactivated and the cab PTO is left active the vehicle will return to the cab PTO set speed.

Note: The Remote PTO maximum and minimum engine speeds cannot be set above or below the PTO programmed maximum or minimum engine speeds.

Note: The Remote PTO does not have the ability to have brake or clutch interaction (kick the vehicle out of Remote PTO when the brake or clutch is engaged.).

Application Note:

It is possible to remote mount the cruise switches (typically in cab) that are also used for standard PTO, allowing an application to remotely control the engine throughout the PTO operating range. If the switches are remote mounted they should be waterproofed.

Table 2-3 Feature Switch Setting Hierarchy (See **Notes : Next Page**)

MODE	**OFF**	**ON**	**REMOTE PTO @ Speed**	**REMOTE THROTTLE @ Some Speed**	**CAB THROTTLE**	**SET**	**COAST**	**RESUME**	**ACCEL**	**AFTER ACCEL PEDAL**	**AFTER CLUTCH OR BRAKE**
Exampled: PTO	Off	Standby	Remote PTO Overrides PTO	**8**.Remote Throttle Overrides if above PTO	**4.**Override or No Effect	Establish *"set"PTO rpm**-950 Default	Decrease & set or ramp PTO down	Default to 2nd set speed	Establish higher rpm up to Max PTO	No Effect or resume set speed	Customer Programmable
REMOTE PTO	Off	**4**.Active Remote PTO # Speeds	**4.**Remote PTO # speeds	Remote Throttle # speeds	**4.**Override or No Effect	Not Active	Not Active	Not Active	Not Active	No Effect	No Effect
CRUISE CONTROL	Off	Standby	No Effect	No Effect	Standby	Establish mph (kph)	Decelerate & set or bump down	Last set speed	Accelerate & set or bump up	Resume cruise mph (kph)	7.Deactivated
ACCEL INTERLOCK	Off	Not Active	**1**.Remote PTO # speeds	**1.**Accel Override	Cab Throttle	Not Active	Not Active	Not Active	Not Active	Active	Not Active
Engine or Exhaust BRAKE	Off	**5**. Standby	Remote PTO # speeds	Remote Throttle # speeds	Cab Throttle	**2**.Not Active	**2**.Not Active	**2**.Not Active	2.Not Active	**3** Active	**3.**Active
REMOTE THROTTLE	Off	**6**. Standby	Remote PTO Overrides RT	Remote Throttle# speeds	Cab Throttle	Active	Active	Active	Active	Resume Remote Throttle	No Effect

*Read the body of this table vertically. It shows how various features affect or override other features. The various modes of vehicle operation that the features can be affected by are shown horizontally across the top.

Example: Examine PTO. Reading horizontally across from PTO to see how the various Modes affect the PTO Feature. Each Mode is underlined.

PTO Example cont.: Off Mode is Off.

- Switching the PTO Mode to On places the PTO on Standby Mode.
- Turning on the Remote PTO while PTO is on will cause PTO to be overridden by the Remote PTO and cut off.
- Switching on the Remote Throttle while PTO is on allows Remote Throttle to override PTO only if it's throttle setting is above the PTO set speed and PTO/Remote Throttle programming allows it per Note 8.
- The Cab Throttle can override PTO or have no effect dependent upon the customer enabling override as indicated by Note 4. Per Note 1 this table assumes the default condition with PTO - Throttle override not enabled.
- Enabling the Cruise Control (C/C) Set while PTO is on locks PTO to the programmed Set switch speed.
- Enabling the C/C Coast mode while in PTO decreases the PTO speed.
- Enabling the C/C Resume bumps the PTO to the PTO Resume set speed.
- Next, depressing the Accelerator will increase the PTO up to the Max PTO programmed rpm.
- After Accel. Pedal depression there is no affect or the PTO resumes at its set speed dependent upon whether or not PTO set speed has been exceeded.
- Lastly, just as Note4 illustrates, Clutching and Braking can be programmed to have no effect on PTO or to override PTO, dependent upon the programming.

1. **Note:** The Accel Interlock does not disable the PTO, or the Remote PTO. But the remote throttle is interlocked by this feature.
2. **Note:** Cruise Control (C/C) has a higher control priority than the Engine or Exhaust Brake; However if the C/C and Engine or Exhaust Brake Interaction is enabled, Engine or Exhaust Brake will automatically come on if C/C cruise speed is overshot by a customer programmable amount.
3. **Note:** This table assumes Engine or Exhaust Brake/Cruise Control interaction is programmed off. When Engine or Exhaust Brake/Cruise Control Interaction is programmed on, when the vehicle speed nears the cruise set speed the Engine or Exhaust Brake will automatically disengage.
4. **Note:** Multiple set speeds are customer programmable, (For remote PTO this is selected by enabling remote PTO switch multiple times).
5. **Note:** The Engine or Exhaust Brake activates if all of the following conditions are true: 0% throttle, the clutch pedal is not depressed, PTO and Cruise Control are inactive, and the engine speed is > 1000 rpm.
6. **Note:** To engage the Remote Throttle the controlling Potentiometer must start off from idle after Remote Throttle Enable.
7. **Note:** If Cruise Resume is enabled Cruise Control set speed will resume after a clutch depression, after a brake depression the Cruise Control goes into Standby.
8. **Note:** Ability to have Throttle Override (Up to a Customer programmable speed) is customer programmable

2.23 POWER TRAIN PROTECTION

The Power Train Protection option limits the engine torque as a function of the transmission gear ratio. This reduction in engine torque or speed output can increase the durability of driveline components and assist the engine in meeting many application specifics. The ability to manage the input torque to the transmission also serves as a means of controlling the maximum propshaft and drive axle torque levels. All transmissions have some nominal input torque rating, the absolute capacity of individual gear ratios will generally vary, with one or more ratios often having a considerable safety margin. Power train protection must be enabled by the customer.

The torque limits are imposed based on gear ratio, a switch torque input, and the maximum torque that the rear axle can handle. All of these items must be selected or enabled by the customer that wants to implement power train protection. Torque Limits are allowed for up to four gears and gear ratios are also customer programmable.

Note: The customer must also select the manner in which the higher torque limit is achieved, as a direct function of gear ratio or only after the vehicle has "Lugged Back" in the higher gear.

In gear ratios which ultimately have a torque capacity which exceeds the nominal input limit of a given transmission, this gear ratio based torque control feature enables higher levels of input torque. Another benefit of this feature is the ability to enable higher peak levels of performance to be reached without the introduction of new higher capacity power train components.

Note: All of the values shown in Table 2-9, Table 2-10 and Table 2-11 are examples of customer provided values.

Table 2-4 Gear Ratio and Torque Limit

Trans. Gear Ratio	Max. Torque Limit
>= 15:1	1250 ft/lbs
>=2.6:1	1450 ft/lbs
>=1.35:1	1550 ft/lbs
>=1:1	1650 ft/lbs

Table 2-5 Max Switched Torque Limit

Switched Torque	Switched Speed
1050	1400 ft/lbs

Table 2-6 Max Torque Allowed by Axle

Axle Torque Limit
3000 ft/lbs

2.24REMOTE THROTTLE

The Remote Throttle is an optional analog throttle input for applications where remote control of the engine is required. Remote Throttle controls the engine when the Remote Throttle Switch is set On and the feature is Enabled. Engine control returns to the Primary Throttle when the Remote Throttle Switch is set Off. Remote Throttle functions with the same governor as the Primary Throttle. **Unlike Primary Throttle, the Remote Throttle does not employ idle validation switches.** The OEM may choose to enable or disable the Remote Throttle feature using the service tool. It is possible to remote mount the remote switches (typically in cab). If the switches are remote mounted they should be waterproofed.

The specifications for this signal is detailed in CES 14118. See Table 2-1 on page 2-4 for feature priority.

2.25ROAD SPEED GOVERNOR

The road speed governor is a basic feature of the ISB4/ISB^{e}systems which allows the owner to set the maximum vehicle speed via the programming tools. Using programming tools, the customer can also tailor the road speed governor, like the cruise control governor, by setting the upper and lower droops. The road speed and cruise control governors can have different droop settings. Lower droop is unavailable in the European market.

2.25.1 Smart RSG

Smart RSG allows the user to update the Road Speed Governor while driving. The Road Speed Governor can be adjusted by using the cruise control increment or decrement switch whenever cruise control on/off switch is off. Foot on control allows the operator to update Road Speed Governor as well. The Road Speed Governor is incremented 1.6 kilometer/1 mile per hour each time the cruise increment switch is engaged. The Road Speed governor is decremented 1.6 kilometer/1 mile per hour each time the cruise decrement switch is engaged.

NOTE: Smart RSG cannot be set greater than maximum Road Speed limit.

2.25.2 RSG Increment / Decrement Values

The road speed governor can be calibrated to increment or decrement to any value between 0-10 MPH / 0 - 16.1 KPH when the respective increment or decrement switch is pressed. This makes it possible to have an increment / decrement of other convenient values such as 1.0 MPH / 1.61 KPH, 0.5 MPH / 0.8 KPH, 0.62 MPH / 1 KPH or 0.31 MPH / 0.5 KPH.

2.25.3 Switched RSG

This optional feature can be enabled using a Cummins service tool. Currently this feature is only available for the European Market. (In some markets this feature is known as Application Speed Limiter.)

Switched RSG allows the user to program a second independent Road Speed limit via Cummins Service tool. This allows the user to select a different Road Speed Governor for the current driving conditions. This feature requires a separate dash mounted switch that will allow the user to change from the current road speed governor to the second road speed governor.

The maximum vehicle speed determined by the Switched RSG will have priority when the cruise control is being used. For instance if cruise is used after Switched RSG is activated, the vehicle will be limited to the speed of the second road speed governor while in cruise.

2.25.4 RSG ‘Set’

This optional feature can be enabled using a Cummins service tool. Enabling this tool also enables Kick-down Throttle. Currently this feature is only available for the European Market. (In some markets this feature is known as Adjustable Speed Limiter.)

The RSG ‘Set’ function allows the driver to set the road speed governor in a similar fashion to a set of the cruise control. The first press of the Cruise Set switch after a toggle of the Cruise On/Off switch to the off position will set the road speed governor to the current vehicle speed. Using RSG Set offers the driver several advantages such as a intuitive interface, easy adjustment of coarse changes in the road speed governor, throttle control of the road speed governor and an infinitely variable road speed governor that is no longer limited by the pre-set increment / decrement values. RSG set can be used with Switched RSG provided the set speed is greater than the minimum cruise speed and less than the Switched RSG speed.

2.25.5 Kick-down Throttle

This optional feature can be enabled using a Cummins service tool. Enabling this tool also enables RSG “Set”. Currently this feature is only available for the European Market. (In some markets this feature is known as Adjustable Speed Limiter.)

The kick-down throttle allows a driver to override the road speed governor and reset it to the maximum road speed limit. When installed, the physical kick-down throttle implements a detente that limits full throttle pedal travel by a small amount. Under normal conditions, a driver can depress the throttle up to the detente throttle position and the road speed governor will limit the vehicle. If encountering a circumstance that requires additional speed such as a long grade or a panic situation, a driver can depress the throttle to the kick-down position, and the road speed governor will change to the maximum road speed limit (determined by Switched RSG). When the throttle is released from the kick-down position, the previous road speed governor setting will be restored automatically.

2.25.6 Switched RSG Low Speed Application

This optional feature can be enabled using a Cummins service tool. Currently this feature is only available for the European Market.

A special version of Switched RSG can be used in conjunction with low speed applications (e.g. refuse) to limit the speed of the vehicle when someone is standing on the rear platform. Instead of a dash-mounted switch, an outboard switch is connected to the rear platform of a refuse truck. When someone is standing on the rear platform, the refuse truck will be able to detect it via the switch and limit the truck to a very low speed via the second road speed governor. The speed of the second road speed governor is programmed via the Cummins Service Tool. Also note that the second road speed governor can be set below the minimum cruise road speed only when the low speed RSG option is enabled.

2.26STARTER LOCKOUT

Starter Lockout prevents the starter motor from being engaged if the engine has already been started, and there is no need for cranking. This is to prevent unnecessary wear on the starter motor.

2.27SWITCHED MAX OPERATING SPEEDS

The ISB4/ISB^e engines provide the option of switching between two maximum engine speeds for the high speed governor (HSG). This can be achieved by using a two position switch.

2.27.1 Two Position Switch

When the switchis open, the HSG defaults to the standard operating speed, typically used during normal driving. When the switch is closed, the HSG is limited to a customer selectable isochronously governed speed.

2.28TACHOGRAPH (ISB^e)

For use with European customers, the CM800 has tachograph compatibility. This optional input accepts speed signals from EEC Tachographs, such as VDO Kienzle KTCO 1318 or equivalent tachograph models. The CM800 also supports a J1939 based digital tachograph unit, such as digital J1939 based VDO Kienzle MTCO 1324 or equivalent tachograph models, which are connected to J1939 system buss.

2.29TACHOMETER OUTPUTS

See Recommended Practice RP123. This signal must be connected to the tachometer by the OEM harness. The tachometer signal duty cycle is 50% and the frequency varies with engine speed. The number of pulses per revolution is 12 US / 16.55 European.

2.30TRANSMISSION SHIFT MODULATION (Analog Torque) LOAD SIGNAL

Transmission Shift Modulation, also referred to as Analog Torque, allows the OEM to create an analog signal (pulse width modulated) whose duty cycle is proportional to: absolute engine torque, engine torque at speed or throttle percent (or the inverse of any one of these). The intended use of the analog signal is to control a transmission. This signal can also be configured as a kickdown signal where the signal is either Vbatt (12 or 24 volts) or open depending on the load. The minimum signal is at 5% duty cycle, and the maximum signal is at 95% duty cycle. The frequency is a calibratible option. Typical frequency is 125 Hz.

2.31TWO SPEED AXLE (Rear Axle Ratio)

The Two Speed Axle (Rear Axle Ratio) feature is designed for vehicles used in tow speed rear axle ratio applications. Vehicles with a Rear Axle Ratio Switch installed, and the Two Speed Axle feature enabled (via Cummins tools) will have one rear axle ratio associated with an Open Rear Axle Ratio Switch, and another rear axle ratio associated with Rear Axle Ratio Switch.

As mentioned above, the Two Speed Axle feature is programmable. There are three programmable parameters;

- Two Speed Rear Axle - used to enable or disable the Two Speed Axle feature.

- Rear Axle Ratio (Rear Axle Ratio Low) - used by vehicles in single-speed rear axle ratio or two-speed axle ratio applications. In two-speed real axle ratio applications, this is the rear axle ratio with the lower numeric value.

- Two Speed Rear Axle Ratio (Rear Axle Ratio High) - used by vehicles in two-speed rear axle ratio applications only. This is the rear axle ratio with the higher numeric value (the Two Speed Rear Axle Ratio parameter should be set to greater than or equal to Rear Axle Ratio parameter).

Note: The OEM must use the service tool to enable the feature and to indicate the second (2nd) axle ratio.

2.32VEHICLE ACCELERATION RATE LIMITER (Rate Management)

This feature regulates engine torque output based on vehicle acceleration and predefined acceleration limits. The engine acceleration limits are calculated and vary based on vehicle acceleration, gear ratio and a customer selectable level of acceleration limiting.

2.33VEHICLE ANTI-THEFT PROTECTION

Vehicle Anti-theft Protection provides the operator with a method to lock engine operation until a programmed password is entered. Up to six passwords can be programmed for the electronic system to accommodate a vehicle with multiple operators. The operator of the vehicle must enter one of the six passwords to lock engine operation. Likewise, if locked, the operator must input one of the six passwords before the engine can be started or operated. With the correct password the ECM will lock or unlock engine operation in less than 1 second. The passwords are entered into the Road Relay or service tool.

The ECM can still be accessed for data download during locked engine operations.

This feature can be set to engage automatically or manually. Unlocking is always manual. The engine can be locked while in idle or with the key on but the engine not running. If the engine is locked in idle, the ECM will shut down the engine if a significant change in load occurs (such as attempting to engage the clutch to move the vehicle). The keyswitch must be on to unlock an engine.

Note: At least one password must be programmed before the engine operation can be locked.

Note: Passwords can be deleted from use as long as one password remains if the feature is enabled.

Note: Even if the Anti-Theft Protection auto-lock option is turned on, the Anti-Theft protection will not automatically lock the engine if the engine unintentionally stalls out.

Note: If an incorrect password has been entered then the operator must wait a programmable amount of time before trying to re-enter the correct password.

Note: This feature is only compatible with Road Relay 4.0 or later.

2.34VEHICLE SPEED SENSOR (VSS) ANTI - TAMPERING

Vehicle Speed Sensor Anti - Tampering provides the customer with a method to;

- Detect any attempts made to tamper with the VSS signal seen by the ECM.
- To alert the driver that the ECM has detected a loss of signal from the vehicle speed sensor.

2.35WATER-IN-FUEL WARNING

The Water-In-Fuel (WIF) sensor is a mandatory OEM supplied sensor for the Bosch HPCR fuel system. The sensor must be in the OEM supplied water separator. The sensor can either be connected through the OEM wiring harness as outlined in teh Engine Controls Technical Package and wiring diagram or it can be connected directly to a dash WIF light as long as the indicator is calibrated correctly. The use of the WIF sensor minimizes water damage to fuel system components.

The ECM will blink the Maintenance Lamp when water is detected by the sensor. When the Maintenance Lamp flashes, the vehicle driver/maintainer should drain the water from the water/fuel separator. Once the water has been drained and the WIF sensor detects only fuel, the ECM will stop flashing the Maintenance Lamp.

3 SYSTEM COMPONENTS

3.1 ELECTRIC CONTROL MODULE

The ECM is the control center of the ISB4/ISB^e electronic system. The ECM determines the desired timing and fueling quantity and it controls the fuel system in order to achieve it.

On some applications, it may be necessary to remote mount the control module due to foul conditions with accessory drives e.g. large capacity power steering pumps. For these applications, options have been released for an extended wiring harness and remote mount control module.

The ECM has three connector ports: Port A for the sensor portion of the engine harness, Port B for the OEM harness, and Port C for the Injectors. Ports A & C come with connectors and the harness supplied with the engine.

To ensure that the ECM and its mating connectors meet their durability requirements, the wiring harness must be secured to a point at the same vibration level as the ECM, so that relative motion between the ECM and mating connectors is eliminated. All branches of the harness from the ECM must be secured and the fixing point must be no greater than 100 millimeters from the point where the wires exit the ECM connector backshells.

Note: The connector and harness for port B are supplied by the OEM to link the OEM switches and sensors discussed in Section 4 with the ECM.

The ECM has reverse polarity protection.The fuses and or circuit breakers will trip during reverse battery conditions and prevent damage to the ECM.

The ISB4/ISB^e Electronic Control Module has the ability to operate properly for both 12.0 and 24.0 volt battery systems with only a calibration change. However some features may be impacted with the change. The following components will have different load impedances in 12 Vdc versus 24 Vdc vehicle battery systems **based on your selection**:

1. Exhaust Brake solenoid for the ISB4/ISB^e engine,
2. Lamps,
3. Fan clutch,
4. Intake air heater elements, and wiring.
5. Relays used to route battery (+) to the intake air heater elements.
6. OEM Drivers

The ECM output to these components are not current controlled by the ECM, but rather by the impedance of these components. The use of 12.0 volt parts for a 24.0 volt battery system will cause an over-current condition for these components when activated. The ECM is designed to shut an output off if an over-current condition is detected.

Note: Refer to the ISB4/ISB^e wiring diagram in Figure 4-2-Figure 4-3 for OEM requirements. This drawing is appropriate for both 12 VDC and 24 VDC systems.

Note: All four battery + and - wires are included in the OEM harness.

Figure 3-1: Electronic Control Module

3.2 HARNESSES

The ISB4/ISB^e system uses wiring harnesses with one 89-pin connector (connector B), one 36-pin connector (connector A), and one 16-pin connector (connector C) for ECM inputs and outputs. The engine harness (connector A) and cylinder harness (connector C) come with the engine.

Note: The OEM harness and the ECM Vehicle connector (Connector B) must be supplied by the OEM and is described in Chapter 4.

3.3 ENGINE POSITION SENSOR

Often referred to as the EPS, this Variable Reluctance Sensor measures engine position in order to provide timing data to the electronic control module via connector A. It is mounted on the gear plate, between the compressor and fuel pump mounting facing forward to a cam gear.

3.4 ENGINE SPEED SENSOR

Often referred to as the ESS, this Variable Reluctance sensor measures engine speed from teeth located on a crank shaft mounted tone wheel at the front of the engine. It is mounted on the engine block and detects uniformly spaced, machined surfaces on the tonewheel.

3.5 INTAKE MANIFOLD PRESSURE/AIR TEMPERATURE SENSOR

The combined manifold boost pressure/temperature sensor is connected to the air intake manifold and monitors manifold pressure and temperature. The ECM uses the measured air temperature for engine protection, grid heater control and fan clutch control, while using the Boost Pressure data for Air/Fuel Control.

3.6 COOLANT TEMPERATURE SENSOR

The Coolant Temperature Sensor, mounted in the cylinder head near the thermostat, is a sensor which provides engine coolant temperature data to the ECM. This data is used for Fuel Injection Timing and Engine Protection purposes. The ECM will log a diagnostic fault code, illuminate a warning lamp and derate the maximum engine power when the temperature rises above specific limits.

3.7 OIL PRESSURE/TEMPERATURE SENSOR (OPTIONAL)

The combined Oil Pressure/Temperature Sensor is located on the engine in the oil filter head. The ECM uses the measured engine oil pressure and temperature for engine protection and engine warmup protection. The ECM will log a diagnostic fault, illuminate a warning lamp and derate the maximum engine power when the pressure falls below predetermined low pressure limits for engine protection. Engine warmup protection limits engine speed to idle until proper oil pressure is detected.

3.8 OIL PRESSURE SWITCH

Starting MY04 the ISB4/ISB^e is equiped with a Oil Pressure switch. This is in place of the Oil Pressure / temperature sensor, which is now optional. The ECM will still log a diagnostic fault, illuminate a warning lamp and derate the maximum engine power when the pressure falls below predetermined low pressure limits for engine protection. Engine warmup protection limits engine speed to idle until proper oil pressure is detected.

3.9 RAIL PRESSURE SENSOR

The Rail Pressure Sensor, mounted on the fuel rail, is a sensor which provides fuel pressure data to the ECM for pressure regulator control and fueling calculations.

3.10 AMBIENT AIR PRESSURE SENSOR

The Ambient Air Pressure Sensor, contained within the CM800, is a sensor which provides data used for Air/Fuel Control and Altitude Derate capabilities. Due to its location, this sensor is not accessible for servicing.

3.11 FUEL TEMPERATURE SENSOR (PRE MY04 ENGINES)

The Fuel Temperature Sensor, located in the fuel filter housing, provides data used by the Fuel Heater Control.

3.12 OEM COMPONENTS

Refer to the Components section (Section 5) for a more detailed description of the components that must be provided by the OEM. Part Description and Part Application statements are included for each component as well as electrical, mechanical, functional and environmental characteristics.

Also refer to the ISB4/ISB^e wiring diagram in Figure 4-2 for OEM requirements.

3.13 CONTACTS AND CONNECTORS

Reference wiring diagram Figure 4-2 for the following discussions.

The ISB4/ISB^e engine requires that all switch contacts (exercised surfaces) must be gold flashed for durability regardless of the location. Slip rings (if required in an application) should also be gold flashed material. Ring terminals may be either solder dipped or tin plated.

Chassis-mounted connectors should be environmentally sealed and, at a minimum, be tin plated. In the cab area, tin plating should be on wire-to-wire and wire-to-switch interconnectors.

The circuit between the throttle pedal, bulkhead connector, and the ECM Vehicle connector must have gold-plated or tin-plated brass connector pins to reduce risk of long-term throttle signal degradation.

Sensor signals from the components connected to the ECM are low voltage and low current. Because of this special care must be taken in selecting circuitry components, primarily termination systems and connectors used in the complete circuit, so that system reliability is achieved and maintained.

Signal returns should be tied directly to the signal return pin on the ECM. It is recommended that impedance of the signal return path be kept to less than 100 milliohms for maximum noise margins and maximum system performance

Signal supplies should be tied directly to the signal supply pin on the ECM. It is recommended that impedance of the signal supply path be kept to less than 100 milliohms for maximum noise margins and maximum system performance.

Note: Switch circuits on the ISB4/ISB^e engines must be electrically isolated from OEM wiring. Do not connect any of the ISB4/ISB^e switches to anything except the ISB4/ISB^e switch supply or return.

3.14 OEM HARNESS AND HARNESS ROUTING

The OEM harness with Bosch Vehicle connector is needed to link the OEM sensors and switches to the electronic control module for vehicle and driver interfaces. The ECM Vehicle connector is an 89-pin plug, keyed to the OEM receptacle of the ECM. The minimum size wiring requirement for sensors, switches and lamps on the harness is 22 AWG stranded wire covered with GXL (or equivalent) insulation and the maximum is 20 AWG stranded wire covered with GXL (or equivalent) insulation. The minimum size wiring requirement for power pins, battery + and - is 14 AWG stranded wire covered with GXL (or equivalent) insulation, with a maximum length of 15 feet.

Unused large terminal cavities of the OEM connector must be filled to prevent moisture intrusion. Small term cavities have a sealing membrane that does not require additional measures so long as the integrity of the seal is intact.

Note: Harness wiring may be composed of TXL if the proper connector seal size is used. The connector seal for the 89 pin connector is not optional.

There are certain circuits in the system that require wires twisted at a rate of one twist per inch to minimize electromagnetic interference. There are eight circuits that require twisted pairs, J1708/J1587 datalink, Water In Fuel Sensor, OEM Temperature Sensor, Switched Max Operating Speed, Vehicle Speed, Tachograph (ISB^e) and Tachometer (High side or Low side). There are four circuits that require twisted triplets, Throttle, Idle Validation Switches, Remote Throttle, and OEM Pressure. Wiring for the J1939 should use SAE compliant cabling. Wherever possible, wires associated with the OEM harness should be routed physically close to metals grounded by battery (-) to minimize electromagnetic interferences with other electronic subsystems in the vehicle.

Proper wiring as described above allows current return path for various components on the engine and also supplies RF noise shunt to the engine ECM. It is recommended that a braided ground wire with a minimum width of 1 inch be attached to the back of the upper engine block just above the flywheel housing. Other ground attach locations are more susceptible to increased impedance or more severe corrosion caused by dissimilar metal electrolysis.

3.15 VEHICLE KEY SWITCH

The OEM-supplied vehicle key switch requires input from the vehicle battery. The key switch signals its on/off status to the ECM through a direct line from the key switch to pin B39 on the ECM interface connector. That line must not have power interrupts during cranking. Additionally, it must be on an independently fused line at 5-amps. It is preferred that this line not share power with other devices. However if exclusive line use is not possible then any inductive devices sharing power must provide fly back suppression. Short circuits in any other vehicle accessory must not cause this line to lose power.

When the key switch is switched from On to Off, the voltage at the key switch input to the ECM must decay to below 0.8 volts within 40 milliseconds. The voltage level at the key switch shall not be allowed to go below ground.

3.16 VEHICLE SPEED SENSOR

This is a variable reluctance sensor that provides vehicle speed information. It does so by measuring the rotational speed of the transmission output shaft. The ECM then computes the vehicle speed from this information, using programmed differential gearing and tire size data. This sensor shall be electrically isolated from other devices on the vehicle.

The vehicle speed sensor should be wired to the electronic control module with the correct polarity. Therefore, the positive lead from the VSS should be connected to pin B74 of the ECM Vehicle connector and the signal return should be connected to pin B56. The vehicle speed sensors wire should be twisted as identified in Section 3.13 on page 22 for twisted pair. Vehicle speed information can also be received by way of the ECM communications data link or a tachograph. Air gap between the sensor magnet and target teeth on the gear of the transmission output shaft should be controlled within 0.22-mm0.009” and 1.14-mm0.045” to allow proper detection of very slow vehicle speeds. Care should be taken in wire routing from the Vehicle Speed Sensor to the speedometer and from the Vehicle speed sensor to the ECM to minimize noise coupling into sensitive ECM vehicle speed conditioning circuitry. Failure in routing or twisting of vehicle speed sensor leads can lead to false vehicle speed detection that will interfere with cruise control, PTO, and other vehicle speed dependent functions.

NOTE: The Vehicle Speed Sensor interface (pins B74 and B56) support the VR sensor only. This means that the signal on these pins should resemble a digital waveform with both positive and negative peaks, with zero crossing. The interface does not support a non-zero crossing signal.

NOTE: See Appendix B for Cummins Disclaimer on using its ECM data for purposes of setting the Cumulative Odometer Value.

NOTE: If Vehicle Speed lost error is active at Key Off then power down time for the ECM is extended by 60 seconds.

3.17 TACHOGRAPH INPUT (ISB^e)

For use with European customers, the CM800 has tachograph compatibility. This optional input accepts speed signals from EEC Tachographs, such as VDO Kienzle KTCO 1318 or equivalent tachograph models. The signal input is connected to pin B57, while the return should be connected to pin B54. The Tachograph Input wires should be twisted as identified in Section 3.13 on page 22 for a twisted pair.

The CM800 also supports a J1939 based digital tachograph unit, such as digital J1939 VDO Kienzle MTCO 1324 or equivalent tachograph models, which is connected to the J1939 system buss.

3.18 OEM TEMPERATURE SENSOR

An optional feature is an OEM Temperature input. This thermistor type sensor, supplied by the OEM, can be used for an application specific (via DO option) protection feature. For example, the OEM can specify for the engine to derate torque, engine speed, or shut down when limits have been exceeded. In addition, the information provided by this sensor can be broadcast across the J1939 datalink. The input signal for this sensor should be connected to pin B88 of the OEM Connector, whereas the return should be spliced to pin B32. The OEM Temperature sensor wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

Note: This feature is not available on the European version of ISB4/ISB^e.

3.19 OEM PRESSURE SENSOR

An optional feature is an OEM Pressure input. This sensor, supplied by the OEM, can be used for an application specific (via DO option) protection feature. For example, the OEM can specify for the engine to derate torque, engine speed, or shut down when limits have been exceeded. In addition, the information provided by this sensor can be broadcast across the J1939 datalink. The supply voltage to the sensor is on pin B68, and the return on pin B32. The signal input is to be connected to pin B82. The OEM Pressure sensor wires should be twisted as identified in Section 3.28 for twisted triplet.

3.20 STARTER LOCKOUT RELAY

An optional feature is an output at pin B46 which is wired to a relay to interrupt the starter solenoid circuit in order to implement the starter lockout feature. When implemented this feature protects the starter motor and flywheel from damage due to inadvertent engagement. The supply for the relay should be connected to pin B01.

3.21 TACHOMETER INTERFACE

An OEM-supplied tachometer in the cab receives an output signal from the ECM. The signal has a low level range of 0 to 0.5 volts and a high level range of 4V to battery voltage. The duty cycle of the tachometer signal is fixed at 50%. The signal is compatible with ATA/TMC Recommended Practice RP-123.

3.21.1 High Side

The output signal is provided by the ECM at pin B37 of the ECM Vehicle connector. The tachometer return line should be referenced to pin B02. The Tachometer Interface wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

3.21.2 Low Side

The output signal is provided by the ECM at pin B49 of the ECM Vehicle connector. The tachometer supply line should be referenced to Battery Supply. The Tachometer Interface wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

3.22 ACCELERATOR PEDAL ASSEMBLY

An ISB4/ISBe engine supports two kinds of throttle pedals.

3.22.1 Throttle Pedal with Idle Validation switches

The throttle control of an ISB4/ISB^{e} engine is designed to provide a voltage signal to the control module proportional to the throttle pedal position.

The ECM provides power and ground to these components and observes their return signals to take proper action. For the Throttle pedal with Idle Validation switches, the OEM must supply the throttle position and idle validation signals to the ECM according to the performance specifications (see CES 14118).

The 5-volt supply to the assembly is connected at pin B55, throttle position input is connected at pin B83 and the return at pin B81 of the OEM interface connector. The wires must be electronically isolated from the other wires in the OEM harness and should be a twisted triplet, as identified in Section 3.28. This includes accelerator pedal manufacturers that have a pigtail extending out of the throttle pot.

The connections for the idle validation switch are made through the OEM harness Vehicle connector. The normally open contact (at idle position) is connected to pin B73. The normally closed contact (at idle position) is connected to pin B72. The switch return is connected to pin B19. The wires must be electronically isolated from the other wires in the OEM harness and should be a twisted triplet, as identified in Section 3.28.

3.22.2 Dual Potentiometer Throttle Pedal (MY04 and beyond)

A dual potentiometer throttle pedal as the name suggests will provide to the ECM two signals. The ECM provides power and ground to these components and observes the signals to take proper action. For the Dual Potentiometer Throttle Pedal, the OEM must supply the ECM with the two signals, according to the performance specifications (see CES 14118).

The connectons for the first signal is made through the OEM harness Vehicle connector Pin B83 and the connection for the second signal is made through the OEM harness Vehicle connector Pin B84. The wires must be electronically isolated from the other wires in the OEM harness and should be a twisted triplet, as identified in Section 3.28. This includes accelerator pedal manufacturers that have a pigtail extending out of the throttle pot.

Note: The sensor signals from this component are low voltage and low current. Because of this, special care must be taken in selecting circuitry components, primarily termination systems and connectors used in the complete circuit, so that system reliability is achieved and maintained.

3.23 EXHAUST BRAKE CONTROL

The Exhaust Brake control is designed to be compatible with exhaust brake systems available in the industry. The operator enables the Exhaust Brake via an On/Off switch. This switch connects the input on pin B20 to the battery voltage bus on pin B08. The Exhaust Brake signal should be connected at pin B11 and the Exhaust Brake return should be connected to pin B04 of the vehicle connector.

3.23.1 Exhaust Brake Wiring with Manual Transmissions

The diagram below shows how a typical wiring schematic for a vheicle with a manual transmission.

Note: The exhaust brake output has capability to supply up to 2 Amps to an air solenoid.

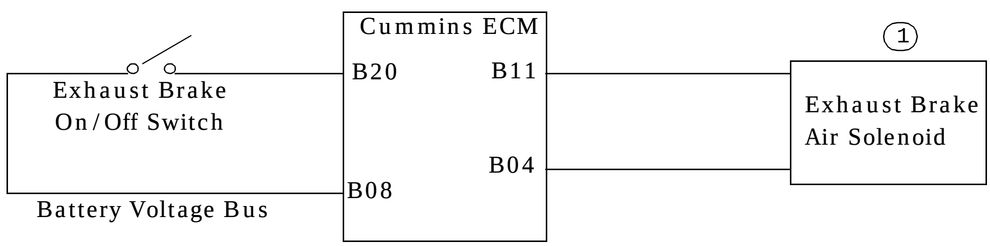


Figure 3-2: Exhaust Brake Wiring with Manual Transmission

Notes:

1) A relay does not have to be used to power the exhaust brake air solenoid unless the solenoid requires more than 2 amps to hold the exhaust brake valve closed. The ECM's exhaust brake circuit can only supply up to 2 amps.

3.23.2 Exhaust Brake Wiring with Allison AT, MT Transmissions

The diagram below shows exhaust brake wiring for Allison AT, MT transmissions or other non-electronic transmissions. Note that the lockup clutch pressure switch connects pin B62 to the battery supply bus pin B08 when pressure exceeds 40 psi.

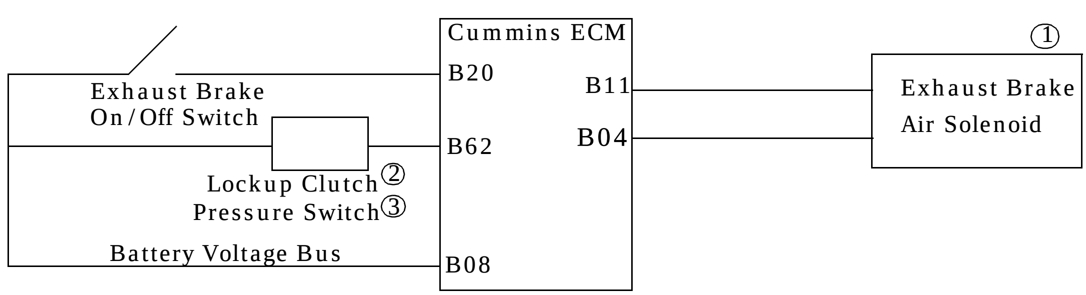


Figure 3-3: Exhaust Brake Wiring w/Allison AT & MT Transmission or other Non-Electronic Transmissions

Notes:

1) A relay does not have to be used to power the exhaust brake air solenoid unless the solenoid requires more than 2 amps to hold the exhaust brake valve closed. The ECM's exhaust brake

circuit can only supply up to 2 amp.

2) This pressure sensor is mounted in a 1/8” NPT port that is located on the left side of the transmission (if looking at the flex plate (front) end of the transmission above the oil pan. There will probably be two 1/8” NPT ports at this location - the lockup pressure port will be the one closest to the front (flex plate) of the transmission. A 40 psi, normally open switch should be used (switch open below 40 psi and closed above 40 psi).

3) For transmissions without lockup capability (e.g. Allison AT transmissions), the lockup clutch pressure switch is not required, but the clutch switch signal wire (from pin B62) must be wired to pin B08. This allows the exhaust brake to function correctly.

3.23.3 Exhaust Brake Wiring with Allison MD Transmission

The diagram below shows exhaust brake wiring for Allison MD transmissions.

Note: The exhaust brake output has capability to supply up to 2 Amps to an air solenoid.

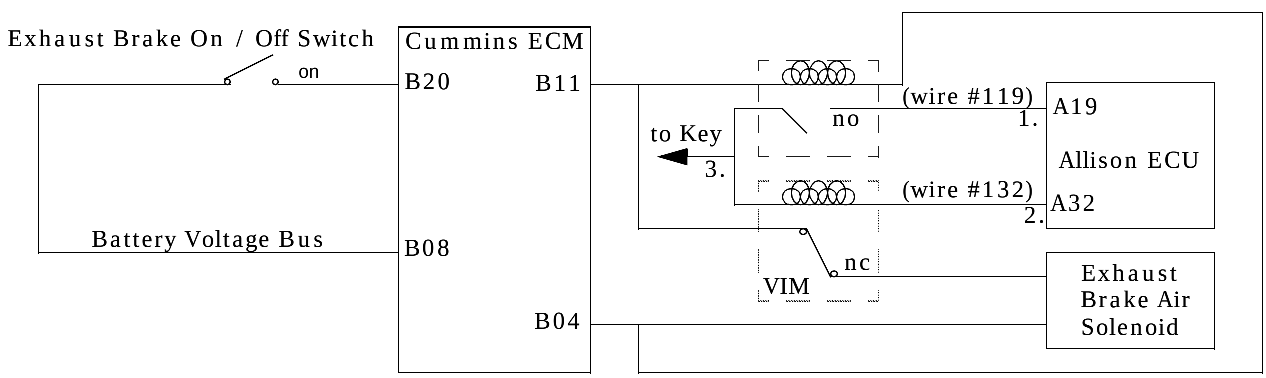


Figure 3-4: Exhaust Brake Wiring w/Allison MD Transmission

Notes:

1) If using the Allison wiring harness, the wire going to pin A19 will be wire number 119.

2) If using the Allison wiring harness, the wire going to pin A32 to the Allison relay will be wire number 132.

3) If using the Allison VIM relay, then keyswitch power will already be supplied to the exhaust brake relay from the VIM assembly. Therefore, it does not need to be supplied separately as shown in the diagram above.

4) The exhaust brake air solenoid through pin B11 must draw less than 2 Amps current for this wiring scheme. Otherwise battery power, rather than Cummins ECM power, will be needed to power the exhaust brake air solenoid.

6) The Pull-in current for the new relay coil must be 0.5 amperes or less due to the amperage requirements of the exhaust brake solenoid and related wiring.

3.23.4 Typical rewire Installation of Vehicle Exhaust Brake Systems connecting to the Allison MD Transmission: with Allison VIM.

1. OEMs connecting to the Allison MD Transmission need to purchase a relay which meets or exceeds the following minimum requirements:

12/24 Vdc Single pole relay, Normally Open
Coil Pull-in of < 0.5 amps
Max Pull-in Voltage 8.5 Vdc
Contact Current 10 milliamps
Operating Temperature Range: -40 to 100 °C

2. Connect the 12/24Vdc power supply to the "normally open" contact of the relay.

3. Connect the opposite end of this relay contact to the Allison transmission wire #119 or pin 3 of the Allison ECU.

4. Connect one wire of the two coming from the Cummins ECM pin B11 to the coil side of the relay, and the opposite side of the coil to ECM pin B04.

5. Connect the second wire from the Cummins ECM Vehicle connector pin B11 to pin E2 of the Allison VIM.

6. Connect the Cummins ECM Vehicle connector pin B20 to the dash mounted switch which will activate the Exhaust Brake. Note in some installations there is a prewired #N15 white wire and # 1435D black wire connected to other wires which must be disconnected before completing Rewire Installation steps 6 and 7.

7. Connect the opposite side of the dash board Exhaust Brake switch to the switch return on ECM pin B08.

8. Connect the Cummins ECM Vehicle connector pin B62 to the battery voltage bus on pin B08.

9. Connect pin D2 of the Allison VIM to the red input of the Exhaust Brake Air Solenoid. Note in some installations a red wire runs from the solenoid to the front of the vehicle, and a black wire is prewired to ground the Exhaust Brake Air Solenoid. If this prewired condition is found the red wire must be disconnected from the front of the vehicle before it can be connected to the Exhaust Brake Air Solenoid.

10. Connect the Exhaust Brake Air Solenoid to the system ground.

11. The diagram shown in Figure 3-4 on page 27 provides the system schematic.

3.24 DRIVELINE RETARDER CONTROL

As mentioned in Section 3.13 on page 22, the ISB4/ISB^e system is compatible with the Driveline Retarder feature of the Allison AT545 transmission. The 'Exhaust Brake Driver' outputs of the ECM shall be used to activate the Driveline Retarder Solenoid. The driver output is located on pin B11, while the return should be spliced to pin B04.

Note: This driver is capable of continuously driving a maximum of 2 Amps.

3.25 REMOTE THROTTLE ASSEMBLY

The remote throttle assembly provides an input for use in applications where remote control of the engine is required. The Remote Throttle On/Off Input switch is connected to pin B21 of the ECM Vehicle connector and is activated by shorting the input to pin B08 of the ECM Vehicle connector. The 5-volt supply to the remote throttle assembly is connected at pin B68 of the OEM interface connector. The input is connected at pin B85 and the return at pin B50.

The remote throttle assembly can use a Variable Speed Governor if appropriately wired instead of an automotive governor. The OEM has the option to allow for throttle and remote throttle override of the remote PTO via a tool selectable parameter. This option is defaulted off unless specifically selected by the OEM. To meet the conditions of CES 14118, the total resistance Rt of the remote throttle feature shall be equal to 2.5k ohms.

The Remote Throttle must comply with CES 14118. With a 5Vdc supply, Idle voltage must be 0.5 Volts +/- 0.25Vdc. The Wide Open Throttle voltage must be 3.75 volts +/- 0.25Vdc. The Remote Throttle wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

Note: Cummins policy dictates that under no circumstances shall the vehicle be driven while the remote throttle is under operation. The Remote Throttle feature is to be used for stationary applications only. No idle validation logic exists in the remote throttle feature.

3.26 TRANSMISSION SHIFT MODULATION SIGNAL

This output signal indicates the load on the engine. Two general types of signal, depending on the application, are used to indicate the operating load on the engine. The signal is either a PWM with a duty cycle indicating percentage of load, or a kick down signal which indicates that the load has exceeded a threshold.

In the PWM signal mode the signal is proportional or inversely proportional to the selected load signal. In the kick down signal mode the signal is a discrete which is either high or low depending on the load signal relative to a threshold. This function is for configuration purposes and allows the setting of the proper transmission type with the programming tool.

Decreasing PWM% Duty Cycle = 95% - 0.9 x (Throttle%).

Increasing PWM% Duty Cycle = 5%+ 0.9 x (Throttle%)

Note: Transmission Shift Modulation Signal is connected at Pin B36 of the OEM interface connector. The negative side of this signal must be connected at Pin B2.

Note: This signal operates with Allison and Aisin A581 transmissions.

Table 3-1: Transmission Shift Modulation Signals

TYPE of SIGNAL
1.) PWM proportional to Increasing Throttle. (*PTO/Cruise Operation)
2.) PWM proportional to Decreasing Throttle (*PTO/Cruise Operation)
3.) Engine Speed
4.) Kick-Down Signal (Vbatt, 100% PWM) w/ Programmable Thresholds Kick-Down / Deactivate Kick -down
5.) 80 / 65 default
6.) 70 / 55
7.) 60 /45

*During PTO and Cruise Control Operation the ECM utilizes the Torque -vs- Speed map to calculate a PWM signal which would be proportional to the equivalent throttle needed at the same speed and fuel conditions.

3.27 COOLANT LEVEL SENSOR

The coolant level sensor provides digital input that detects two states: in-coolant, out-of-coolant. Coolant Level High input is available on pin B59 and the Coolant Level Low input on pin B78 of connector A. The sensor supply is connected to pin B68 and the return is connected to pin B50.

Note: Care must be taken to adequately locate, and position the sensor such that it is submerged in coolant under all conditions except the low coolant condition.

The engine protection system uses an indicator lamp to alert the operator of a coolant (water) level low condition. The lamp will turn on at the occurrence and then begin flashing the Stop lamp after a period of time. This flashing operation is to warn the operator that the condition has been active for a period of time or that the condition has become worse and engine shutdown is about to occur (if the shutdown feature has been enabled).

3.28 WATER IN FUEL SENSOR

This mandatory sensor alerts the operator when the fuel system water collector is full. Removing excess water from the fuel system prevents fuel system damage. The OEM may provide wiring from the WIF sensor to the ECM Vehicle connector pins B87 and B32. The Water In Fuel sensor wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

Table 3-2: WIF Sensor Performance Requirements

Condition	Sensor Resistance
No Water	> 52 Kohm
Water Detected	52K ---> 300 ohms
Sensor Failed	< 300 ohms

3.29 FUEL HEATER INTERFACE

The Fuel Heater is located on the Filter Head, and is used to heat the fuel prior to entering the High Pressure Pump. Under very cold temperatures the fuel can gel and wax, reducing the capabilities of the engine. See Table 4 below for Fuel Heater details for both the 12 Volt and 24 Volt options. The Fuel Heater Electrical Connections in Figure 3-5 on page 30 are provided to aid the OEM in wiring to the Fuel Heater.

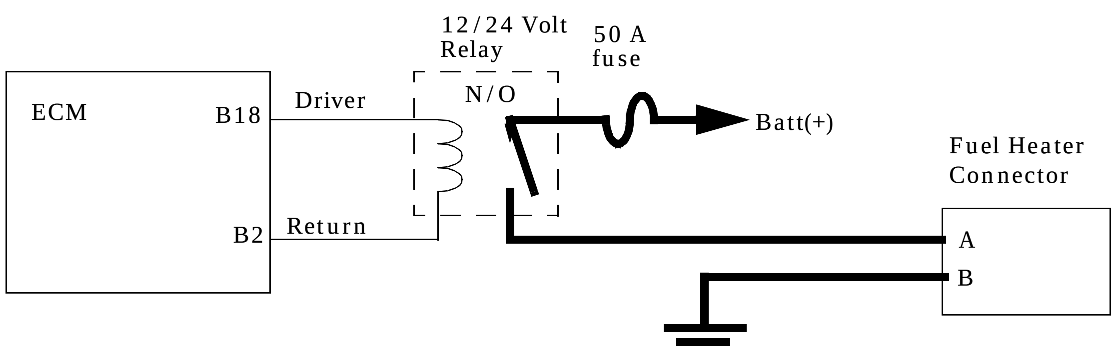


Figure 3-5: Fuel Heater Electrical Connections

Table 3-3: 12 and 24 Volt Fuel Heater Details

	12 V	24 V
Power	300 W	345 W
Current	25 A	15 A
Temperature Rise	5-6 C	6-7 C
Recommended Fuse Size	50	50

3.30 GRID - INTAKE AIR HEATER RELAYS

The intake air heater system is used to aid in starting during cold temperatures and to reduce white smoke after such a start. The 12V system consists of two heater elements which are controlled by the

ECM via two high current relays. The 24V system consists of one heater element controlled by the ECM via one high current relay.

Note: The installer is responsible for sourcing and mounting the grid heater power relays under-hood in a location free of road splash and also for routing battery connections through the relay contacts to the two (2) grid heaters which are shipped with the engines. The Intake air heater relays <u>must</u> not be mounted on engine.

Since significant power is routed to the grid heaters, the gauge of the wire should be at least 2 AWG for the 12 V DC grid heater since each of the grid heating elements require 105 Amps during the heating cycle. The gauge of the wire from the grid heater relays to the grid heater elements also need to be at least 2 AWG to carry the required current. Fuses, fuseable links, or circuit breakers set to 125 amps are advocated for the grid heating elements. Refer to Figure Figure 3-7 on page 32 for a layout of the 12 V and 24 V grid heater system layout. The positive battery cable and grid heater wiring is 2 AWG for the 24 V grid heater. The 24 V DC grid heater subsystem is shown in Figure 3-7 on page 32. The 24 V DC heater relay is connected to pin B16 of the OEM interface connector. The relay return is connected to pin B4. The ECM can source up to 2 amps to turn this relay on. The switch contact of this relay must carry the current from battery (+) to the grid heating elements. Only one relay is required to drive both grid heaters on 24 V DC systems since the grid heaters are wired in series.

There are two phases of intake air heater operation: preheat (at key-on) and postheat (after a successful engine start). The preheat phase also controls the wait-to-start lamp to signify to the driver when it is appropriate to begin cranking the engine. In order to allow maximum current to be used by the starter, the heater elements are de-energized during cranking. The amount of time to stay in preheat and postheat is determined by the temperature measured at key-on. Once the Grid Heater postheat cycle terminates for time or vehicle speed conditions, then the grid heaters will not come back on unless the keyswitch has been cycled from off to on. The heater relays are connected to pins B16 and B17 of the ECM Vehicle connector. Both relay returns are spliced into pin B4. The ECM can source up to 2 amps to turn on each of these relays. The switch contacts of these relays must carry the current from battery (+) to the grid heating elements. The grid heating elements draw 105 amps each nominally.

A Grid Heater Systems layout is shown in Figure 3-7 on page 32. In addition, refer to Table 3-4 on page 31 and Figure 3-6 on page 32 for Grid Heater Electrical Connections.

Table 3-4: Grid Heater Electrical Connection Table

Heater Application	Terminal A	Terminal B	Terminal C
12 Volt (Parallel)	12 Volt (+)	12 Volt (-)	12 Volt (+)
24 Volt Option 1 (Series)	24 Volt (+)	Isolated Structural Bolt	24 Volt (-)
24 Volt Option 2 (Series)	24 Volt (-)	Isolated Structural Bolt	24 Volt (+)

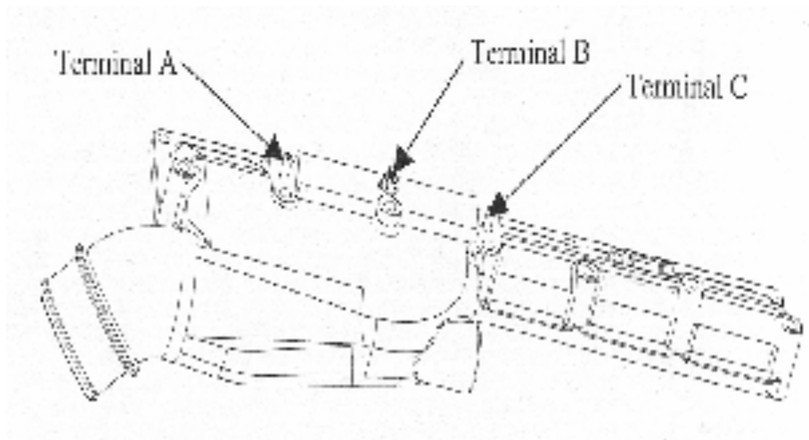


Figure 3-6: Grid Heater Electrical Connections

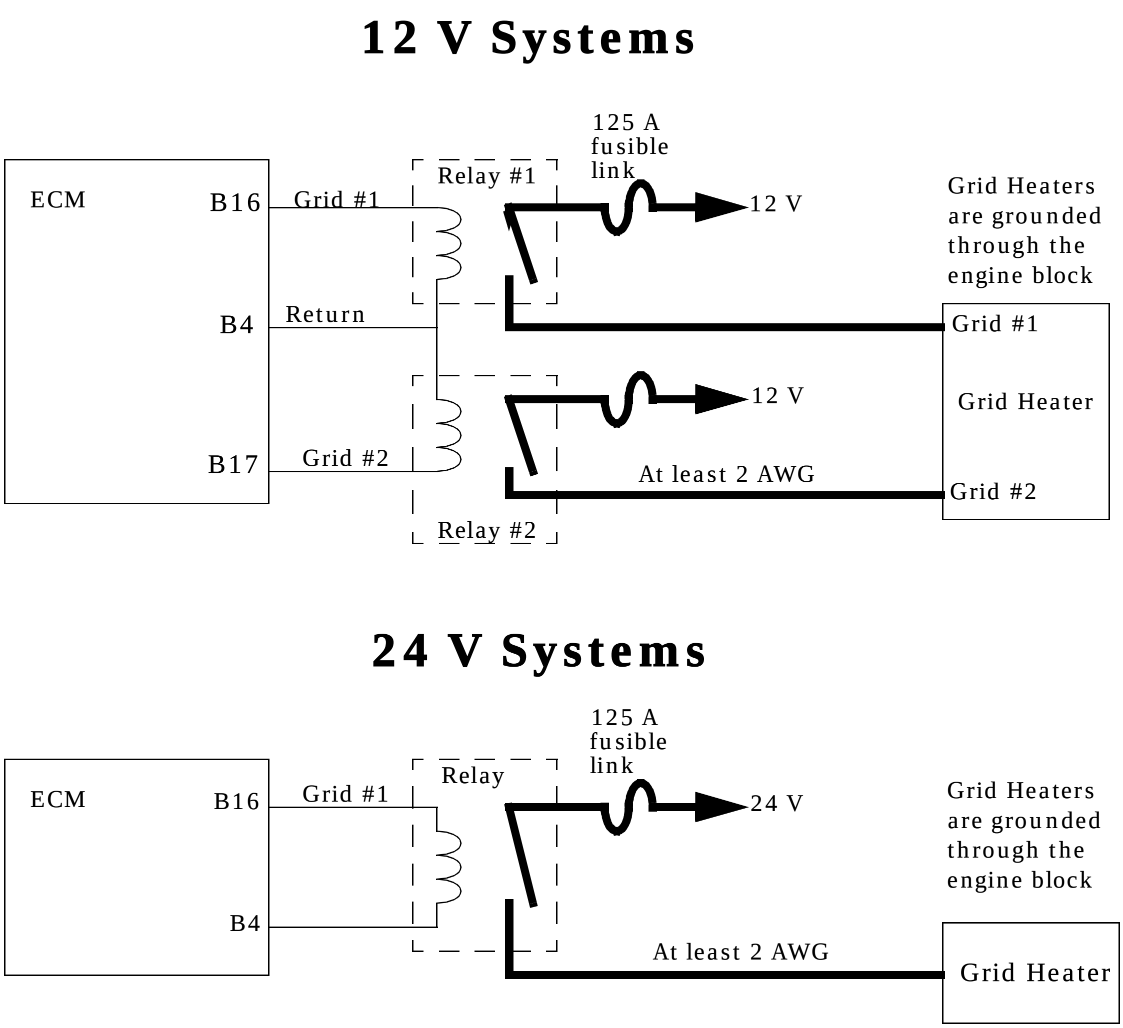


Figure 3-7: Grid Heater Systems Layout

3.31 SERVICE BRAKE SWITCH

A switch in the brake system detects the application of the service or trailer brakes to disable cruise control or PTO. The switch is normally closed, shorting the brake switch input on pin B80 to the battery voltage bus on pin B08 of the ECM Vehicle connector, when brakes are not applied. The switch must be located so that the application of either the service or the trailer brake opens the switch contacts. Parking brakes application must not activate this switch. The OEM can also source their own switch providing it meets guidelines in Section 5.

3.32 PARKING BRAKE SWITCH

A switch in the parking brake system detects the application of the parking brake to disable cruise control or PTO. The switch is normally closed, shorting the parking brake switch input on pin B27 to the battery voltage bus on pin B08 of the ECM vehicle connector, when parkign brake is not applied. The switch must be located so that the application of the parking brake opens the switch contacts. Service brake application must not activate this switch.

3.33 CLUTCH PEDAL SWITCH

The clutch pedal uses a switch to disable cruise control or PTO. As the clutch pedal is depressed, the switch opens the circuit. When the switch circuit is open, cruise control or PTO is deactivated. Applications with manual transmissions without a clutch pedal will require wiring such that the clutch switch circuit is always closed. Applications with automatic transmissions should leave B62 not connected. The clutch switch shorts the clutch switch input on pin B62 to the battery voltage bus on pin B08 of the ECM Vehicle connector. The OEM can also source their own switch providing it meets guidelines in Section 5.

3.34 CRUISE CONTROL / PTO SWITCHES

Refer to ISB4/ISB^{e} Functional Operation for a detailed description of cruise control operation (Section 3.13 on page 22) and PTO operation Section 3.13 on page 22.

3.34.1 Cruise / PTO - On/Off Switch

This is a single pole, single throw switch that will enable either Cruise Control or PTO (depending on vehicle speed), by shorting pin B76 to the battery voltage bus on pin B08 of the ECM Vehicle connector.

When the vehicle is moving or at a speed greater than a tool selectable miles per hour (30 mph (48 kph) = default, programmable from 20 mph (18.64 kph) to 70 mph (112,65 kph), by closing the switch the operator can enable cruise control.

When the vehicle is stopped or at a speed less than tool selectable miles per hour (6 mph/9.7 kph = default, programmable from 0 to 30 mph/48 kph). closing the on/off switch enables PTO.

Opening this switch will disable both Cruise Control and PTO regardless of the vehicle speed.

3.34.2 Cruise / PTO - Set-Resume Switches

This is a two-position momentary switch that is either toggled or held to activate it. Its normal rest position is in the center.

3.34.2.1 Vehicle in Cruise

The operator sets the cruise control speed by momentarily toggling the switch to the set position. Once cruise speed is set, the operator can reduce road speed by holding the switch on in the coast position and coasting to a lower speed. This position of the switch can also be used to bump to a lower speed at 1 mph (1.6 kph) decrements per bump. The set/coast position of the switch is connected at pin B60 of the ECM Vehicle connector. When the switch is activated, it shorts the input to pin B08 of the ECM Vehicle connector.

Once cruise control speed has been established, the resume switch is used to bring the vehicle back to the set cruising speed following the application of the clutch or the brake. This is done by momentarily toggling the switch resume position. The operator can increase road speed by holding the switch in the accelerate position. When the driver releases the switch, that speed is the new cruise control set speed. This position of the switch can also be used to bump to a higher speed at 1 mph (1.6 kph) increments per bump. The resume/accelerate position of the switch is connected at pin B61 of the ECM Vehicle connector. When the switch is activated, it shorts the input to pin B08 of the ECM Vehicle connector.

3.34.2.2 Vehicle in PTO

When the vehicle is stopped or at a speed less than tool selectable miles per hour (6 mph/9.7 kph = default, programmable from 0-30 mph/48 kph), the on/off switch enables PTO. The set and resume switches bring the engine speed to the rpm programmed with tools. The coast switch ramps the engine speed down and establishes a new set speed when released. The accelerate switch ramps the rpm to a higher speed up to the maximum programmed limit. While in PTO mode, the throttle can override the PTO if programmed as described in Section 2, page 11.

3.34.2.3 Cruise Control Switch Reconfiguration

The switch for set and resume can have its configurations reversed to suit the OEM or the end user. By changing an adjustable parameter with tools, the functions of the switches can be changed. Set/coast becomes set/accelerate so that the set position can be used to accelerate to a higher cruise speed or bumped up in increments. Resume/accelerate becomes resume/coast so that the resume position can be used to decelerate to a lower cruising speed or bumped down in decrements. If the configuration is changed the pin numbers of the switches remain as stated above.

3.35 DIAGNOSTIC TEST SWITCH

A single pole, single throw switch connected to pin B79 of the OEM interface connector, acts as an on/off switch for onboard diagnostics and must be mounted in an accessible cab location. Care should be taken when locating this switch in the cab so that it can not be turned on accidentally. Instead of a switch, a special mating connector called a shorting plug employing a jumper wire can be used to enable the diagnostic mode. When the diagnostic mode is turned on all active fault codes will be flashed out on the Stop and Warning Lamps. The diagnostic mode is enabled by closing the switch between pins B79 and B08.

Optionally, the throttle input can be used to trigger the onboard diagnostic mode. With the key on, but the engine not running, cycle the throttle to full throttle and back to idle three times. Start the engine or key off to stop the diagnostic mode.

3.36 IDLE/DIAGNOSTIC INCREMENT/DECREMENT SWITCH

The low idle/diagnostic increment/decrement switch is a dual-function switch. It is a two-position momentary switch installed on the vehicle dashboard that adjusts the low idle speed. It is also used during onboard diagnostics to move through the diagnostic fault code list when the diagnostic test mode is turned on. Optionally, the throttle input can be used to step through the fault code list in diagnostic mode; cycle the throttle to full throttle and back to idle to step to the next active fault code. The increment switch connects to pin B-61, the decrement switch connects to pin B60 of the OEM interface connector. Each switch input is activated by shorting to B8 of the ECM Vehicle connector. The default step size for incrementing/decrementing the low idle speed is 25 RPM.

3.37 FAN CLUTCH INTERFACE

The fan clutch output provides control based on both coolant temperature, intake manifold temperature, a/c pressure and manual switch input. The fan clutch driver circuit is capable of driving the fan clutch directly up to 6 amps. A relay should be used for fan clutches requiring more than 6 amps. Fan clutch inductance needs to be 176 mH or less for proper operation. The fan should be wired to pin B5 of the ECM Engine connector with the ground wired to pin B10 of the ECM Engine connector.

Note: The Fan Clutch Interface can be configured for a VBatt on system or a VBatt off system via Cummins service tool.

3.37.1 Manual Override Fan Clutch Switch

This is a single pole, single throw switch, that can override the automatic fan control to turn on the fan. This optional toggle switch is normally closed so that the fan will run if the switch is opened or if the circuit fails open. Since this requires the switch to be present for normal fan control, the optional manual fan feature must be enabled via a service tool after the normally closed switch is installed. The programmable parameter is manual fan switch input (yes/no). The connection from the ECM to the manual override fan clutch switch will be through pin B22 on the 89-pin Vehicle connector. The switch is activated by opening the connection to the battery voltage bus on pin B08 of the ECM Vehicle connector.

3.37.2 Air Conditioner Pressure Switch

The optional air conditioner pressure switch can be monitored in order to control the AC system pressure by activating the engine cooling fan. The switch is normally closed so that the fan will run when the switch is opened by AC pressure or the circuit fails open. Since this requires the switch to be present for normal fan control, the optional AC Pressure feature must be enabled via a service tool after the normally closed switch is installed. The service tool programmable parameters that affect the feature are: air conditioner switch input (yes/no), max fan-on time for AC pressure switch (in 0 - 180 seconds).

The air conditioning pressure switch is attached to pin B23 and is normally closed to pin B08 of the ECM Vehicle connector. When air conditioning system pressure increases enough to open the OEM supplied pressure switch, the engine cooling fan will engage. The engine cooling fan will remain engaged for the predetermined time set by the customer.

3.38 ACCELERATOR INTERLOCK SWITCH

This optional input is used to prevent acceleration during some critical vehicle process. Some examples include bus doors, engine doors, operator not in seat or parking brakes engaged. The engine will remain at idle when pin B38 is shorted to the battery voltage bus on pin B08. This feature applies to both primary Throttle *and* the Remote Throttle.

Note: This feature can be overridden with the Remote PTO feature.

3.39 TWO SPEED AXLE SWITCH

This optional switch input signals the ECM when the operator changes axle ratios so the ECM can adjust vehicle speed and speed governing. The OEM must install this switch when a two speed axle is installed. The OEM must also enable this feature and set the two axle ratios with the programming tools. This switch connects the input on pin B41 to pin B50. While the switch is in the ‘open’ position, the axle is expected to be in LOW gear. Conversely, while the switch is in the ‘closed’ position, the axle is expected to be in HIGH gear.

3.40 CAB SWITCHABLE GOVERNOR SWITCH

This optional switch input selects between an automotive type Min/Max governor and a variable speed governor. The ECM will not change governors except at a zero throttle condition. This feature is often utilized to choose a different governor for Remote Throttle.This normally open switch connects the input on pin B77 to pin B08.

3.41 POWERTRAIN PROTECTION TORQUE LIMIT SWITCH

This optional switch input limits the engine torque as a function of the transmission gear ratio. This normally open switch connects the input on pin B40 to pin B50.

Note: For more details on this function see Section 2.40.

3.42 SWITCHED MAX OPERATING SPEEDS

This optional input changes maximum engine speed for the high speed governor (HSG). This feature requires a two or three position switch. See table below for position and voltage values. Input for this feature is Pin B89 and the reference is B32

Table 3-5: Voltages at B89.

Switch Position	2 Position Switch
Position 1	5V
Position 2	0V

3.43 SWITCHED RSG

This optional switch input allows the user to switch between two Road Speed Governor set points. This normally open switch connects pin B25 to pin B8.

3.44 ENGINE PROTECTION OVERRIDE SWITCH

This optional switch input allows the user to prevent an impending Engine Protection shutdown. This feature allows the operator to delay engine shutdowns when a condition more critical than engine damage exists during the engine shutdown warning period. This normally open switch connects pin B26 to pin B8.

3.45 INDICATOR LAMPS

The ISB4/ISB^e system uses four indicator lamps: Stop Lamp, Warning Lamp, Maintenance Lamp, and Wait to Start Lamp. When the keyswitch is turned ON the indicator lamps illuminate, in approximately two seconds they go off, one after the other, to verify they are working and wired correctly.

Location of the lamps in the cab area is critical as is luminosity in the daytime; the driver must be able to see them clearly from driving position. The Warning Lamp is connected to pin B64 and pin B28. The Stop Lamp is connected to pin B47, Maintenance Lamp connected to pin B63, Wait to Start Lamp connected to pin B29 and they all share supply connected to pin B8.

3.46 DATA LINKS

3.46.1 J1939 Data Links

While the diagnostic test switch described above is for onboard diagnostics, the J1939 data link is used to communicate offboard diagnostics. The data link may also be used to provide information to data logging equipment and electronic dashboards. The J1939 datalink may be used in integrated vehicle controls such as automated transmissions and traction control systems where information is shared between these vehicle systems and the Cummins engine for integrated vehicle control. Refer to Section 7 for a complete listing of J1939 messages and functionality available in ISB4/ISB^e electronically controlled engines.

The J1939 data link is connected to the ECM through two lines. The inverted data link is on pin B52 and the noninverted data link is on pin B53. The wires must be electrically isolated from any other wires in the harness and should meet specifications called out in SAE J1939/11.

The J1939 shield is connected to pin B51.

3.46.2 J1939 Data-link Backbone

The OEM is responsible for providing the J1939 “backbone” or “spline” harness per SAE J1939/11 if the OEM vehicle has additional J1939 electronic systems. Refer to Figure 3-8 on page 37. The ISB4/ISB^e engine ECM acts as one of 30 possible nodes on the J1939/11 data-link bus. The J1939/11 datalink bus can be up to 40 meters in length and must have 120 ohm external termination resistors at the ends (enclosing all J1939 nodes) of the data-link bus.

Since programming and servicing of the engine electronic system can be accomplished through the J1939 or J1708/1587 data link, easy access is required. Industry standards dictate connector type and locations for service access to the data link. SAE J1939/13 defines the hardware requirement for accessing the data link used with electronically controlled engines. Other industry standardization organizations call out service tool connector types and connector locations. ISO 11783 part 2 is a document that defines these industry standards. Several industries look to these organizations to define their individual market's needs.

The intent of this Cummins requirement is simply to provide an easily accessible service data link connection point that will allow for proper servicing of all components and connectors in the engine electronic control system.

To comply to the intent of the above mentioned industry standards, Cummins **requires** the following:

NOTE: Cab Connector Type - The SAE J1939/13 -Defined 9-pin connector with J1939 and J1587/1708 is required for servicing or programming the vehicle.

NOTE: Installation of any Cummins engine is to adhere to the appropriate industry standard for data link accessibility, service tool connector type, and connector location. If an industry standard is not available for a specific application, then the OEM must follow connector and connector location recommendations called out in SAE J1939/13.

NOTE: If the furthest component (i.e. sensor) in the engine control system is greater than 10 feet (3.3 meters) from the standardized data link location, an easily accessible engine compartment data link connection point must be designed into that application in addition to the in-cab connector.

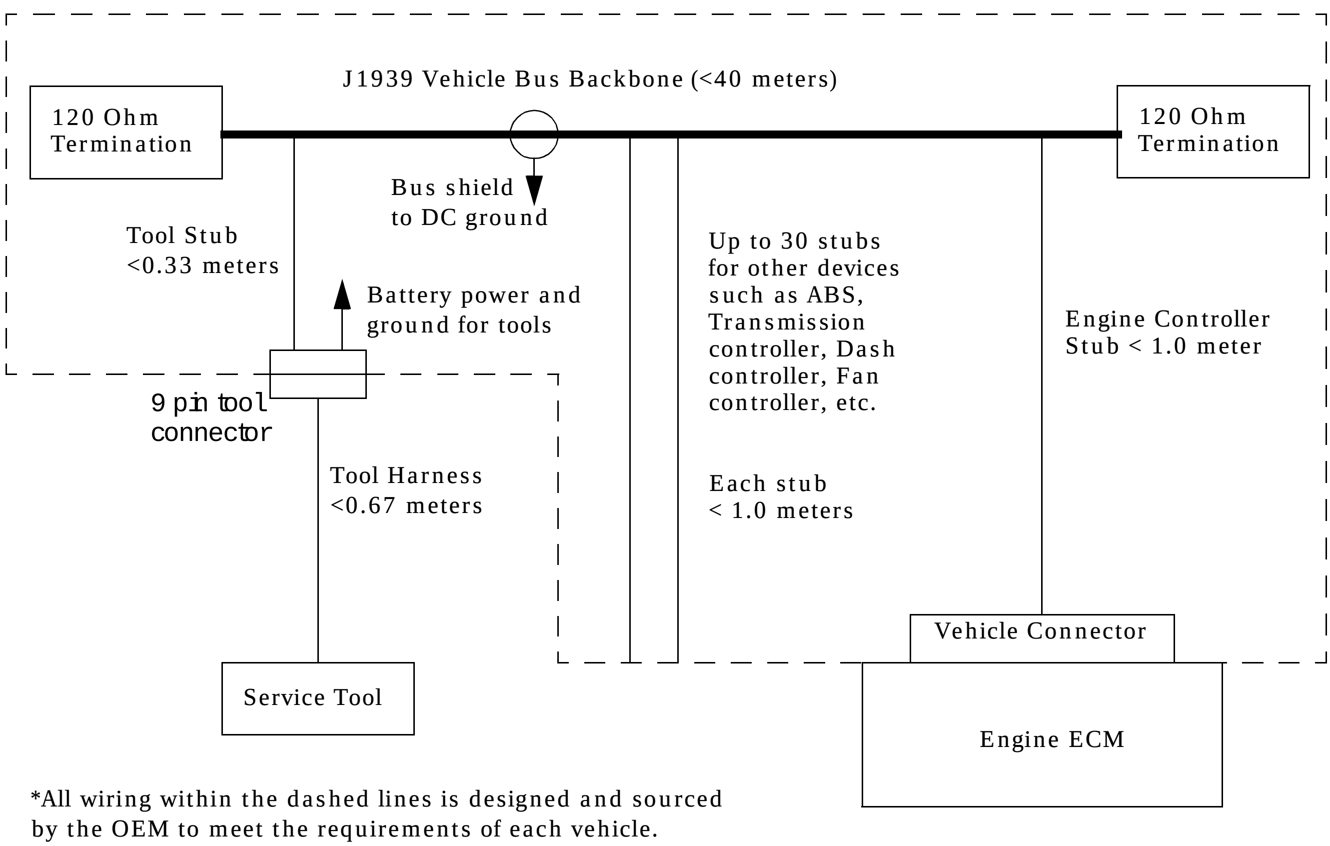


Figure 3-8: OEM supplied J1939 backbone harness

3.46.3 J1587 Data-link

The J1587 inverted data link is on pin B30 and the noninverted data link is on pin B31 of the OEM interface connector. Refer to Section 7, ECM Serial Communications for J1587 data link information.

Note: Cummins ISB4/ISB^{e} electronically controlled engines do not support SAE J1922 (MIDS 69

through 86 are not supported).

The data link is available through a connection on the OEM harness. The wiring diagram in Section 4 for the OEM harness shows connector configurations compatible with the guidelines for J1587 connector. The SAE J1587 data-links wires should be twisted as identified in Section 3.13 on page 22 for twisted pair.

3.47 BLOCK HEATER OPTION

Cummins offers 750 watt block coolant immersed heaters at either 120 or 240 VAC for ISB4/ISB^e Engines. Electrical plugs for 120 or 240 VAC are supplied with this option. This block heater is not thermostatically controlled and operates as long as plugged in to VAC source. The OEM does not supply any wiring to the ECM for this option.

3.48 OTHER RECOMMENDATIONS

3.48.1 ECM to Vehicle Connection Procedure

The following elements are requirements for connecting ECM power to vehicle power:

1. All ECM power and I/O connections must be made prior to connecting the vehicle batteries (Must Not Hot Plug the ECM).

2. The Battery (-) connection must be made prior to the Battery (+) connection

3. Key switch must not be turned ON prior to connecting and energizing the ECM with the batteries.

4. The ECM should not be powered from a source outside of the vehicle chassis, unless using a device specifically approved by Cummins.

3.48.2 Data Link Device Power Connections

1. When connecting devices and/or diagnostic tools to the ECM via the J1939 or J1708 datalink the devices must have a common connection with the ECM Battery (-).

2. Device power supply grounds must be tied together when separate power supplies are used.

3.48.3 Vehicle Welding Recommendations

Vehicle welding can be performed providing battery connections to the ECM are disconnected. The battery connections to the ECM should be removed for arc welding for any vehicle location. Ground return for arc welding can not be connected to any of the sensors, wiring harnesses, or to the ECM on the engine during the welding process. Direct welding of any electronic engine component must NOT be attempted.

Note: Use CAUTION! Attach the welder ground cable no more than 0.61 meters [2 feet] from the part being welded. Do not connect the ground cable of the welder to the ECM. Welding on the engine or engine mounted components is not recommended.

3.48.4 Engine Painting Recommendations

Care should be taken that all electrical mating connectors are connected prior to engine paint. If connectors on the engine harness or the OEM harness are not connected, then these connectors should be masked off during the paint process.

The ECM data plate must also be masked during paint processes. Once painting is complete all paint masking materials must be removed.

Note: Use CAUTION! Battery connections to the ECM must be removed during electrostatic painting processes. Disconnect both the positive (+) and the negative (-) battery cables from the battery before painting on the vehicle.

3.48.5 Engine Jump Start Recommendations

The electrical system is capable of standard jump-starting procedures.

Note: Use CAUTION! Jump starting voltage should not exceed 36 volts. Jump starting or battery charging cables should never be connected to any part of the electronic control system. This may damage the electronic control system parts such as the ECM, Sensors, and Harnesses.

3.48.6 Vehicle Battery Disconnection Recommendations

Vehicle battery disconnection should only be performed by the following process to insure no false diagnostics are logged and that the engine ECM is properly disconnected. Using CAUTION, disconnect the positive (+) battery cable. The positive battery cable should always be disconnected first when the battery needs to be disconnected.

Table 3-6: CM800 Output Current Capabilities

Output Name	Pin #	Current Capability	Driver Type	Reference
Starter Lockout Driver	B46	300 milliAmps	Low Side	Vbatt
Grid Heater Driver #1	B16	2 Amps	High Side	B04
Grid Heater Driver #2	B17	2 Amps	High Side	B04
Exhaust Brake	B11	2 Amps	High Side	B04
Fan Clutch	B05	6 Amps	High Side	B10
Analog Torque	B36	2 Amps	High Side	B02
Fuel Heater	B18	2 Amps	High Side	B02
High Side Tachometer	B37	2 Amps	High Side	B02
Low Side Tachometer	B49	70 milliAmps	Low Side	Vbatt

4 ELECTRONIC INTERFACE

4.1 ELECTRICAL WIRING

4.1.1 OEM & Engine Wiring Harnesses

The following 3 pages are normally viewed as one 17 x 22 drawing. For practical purposes they have been broken down into 3 sections to fit into this document. Below is the legend, page 41 shows the B connector and page 42 shows the A and C connectors.

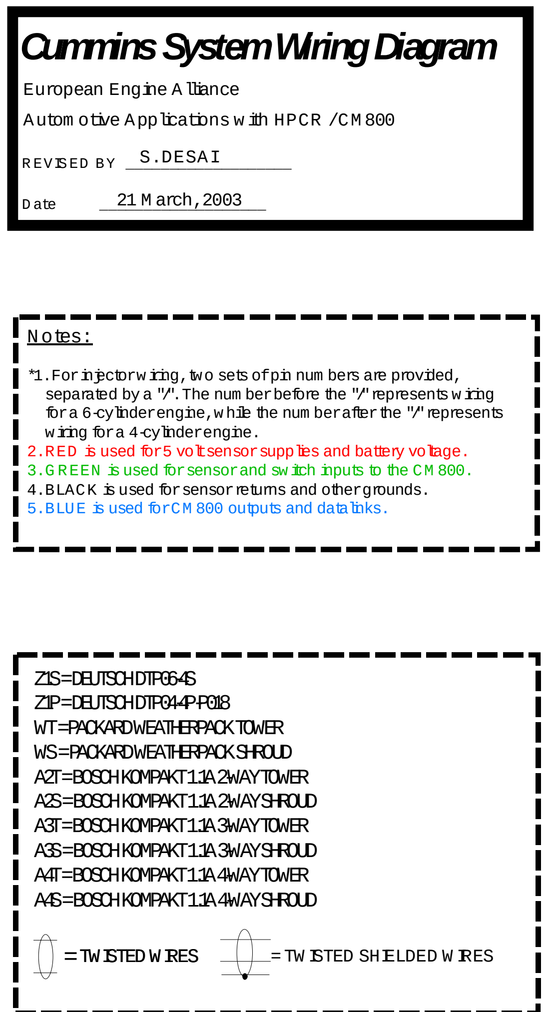


Figure 4-1: Legend for Wiring Diagram

OEM HARNESS

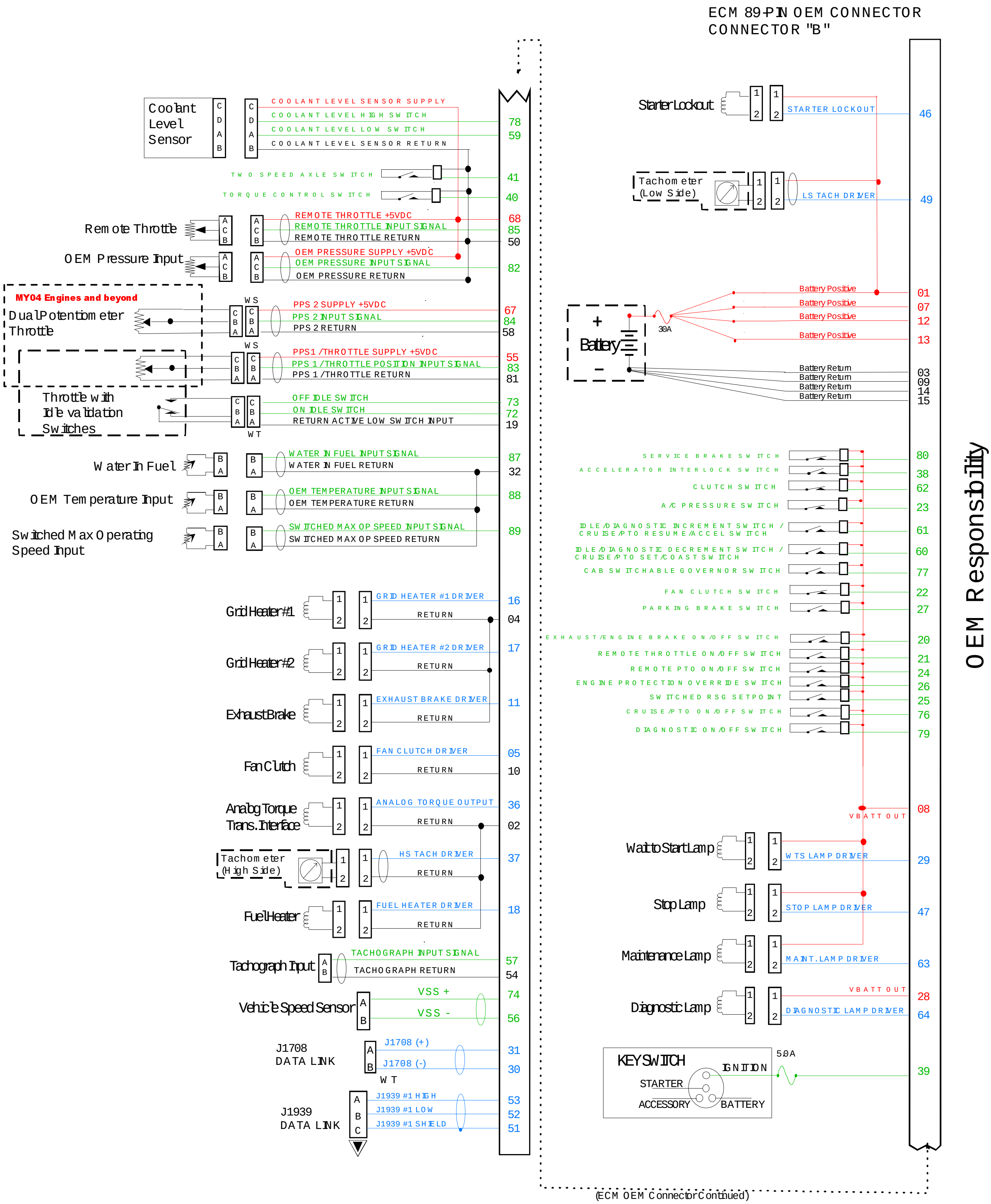


Figure 4-2: ISB4/ISB^e Wiring Diagram (OEM Connector B)

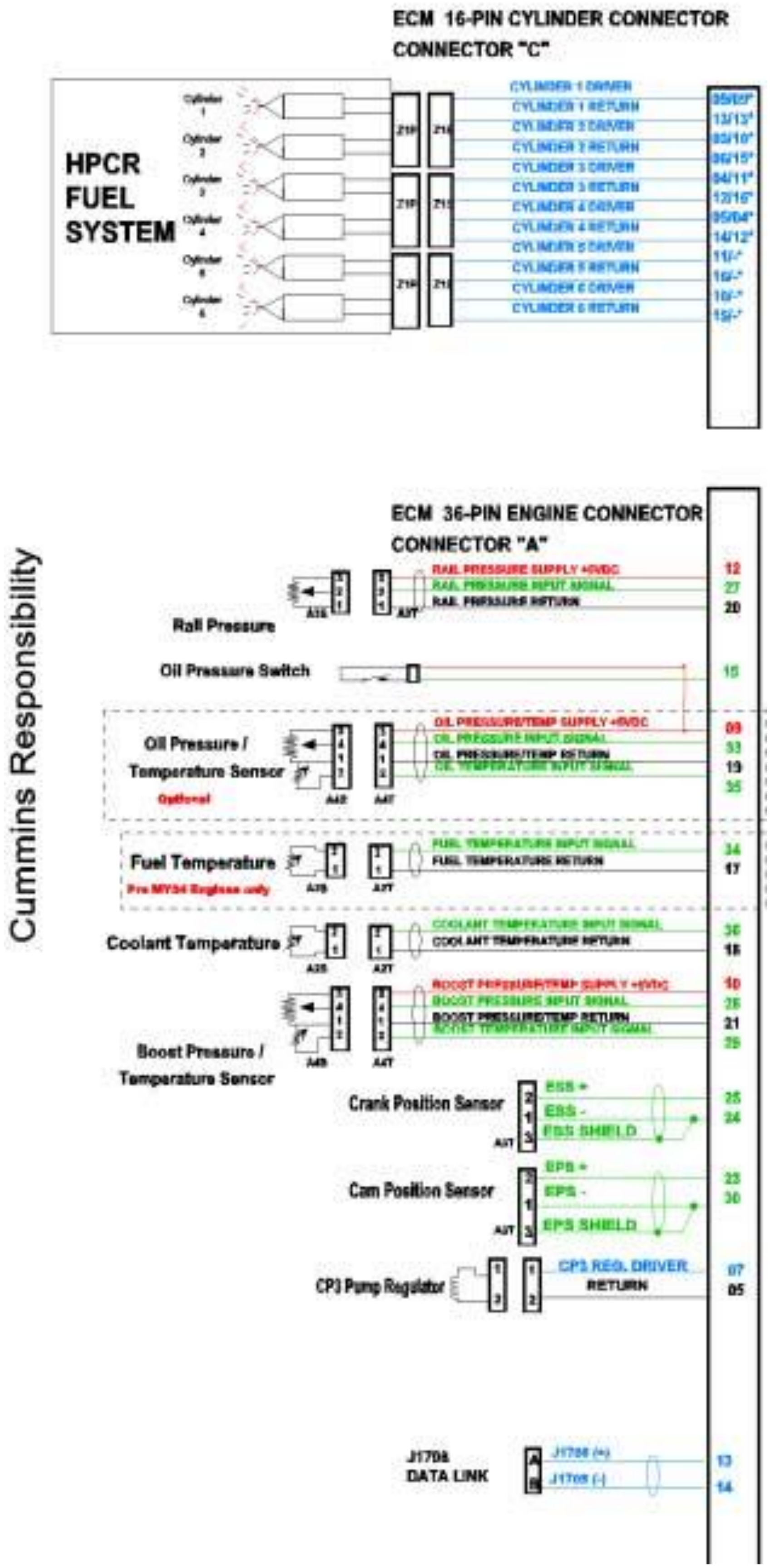


Figure 4-3: ISB4/ISB^{e} Wiring Diagram (Connectors C and A)

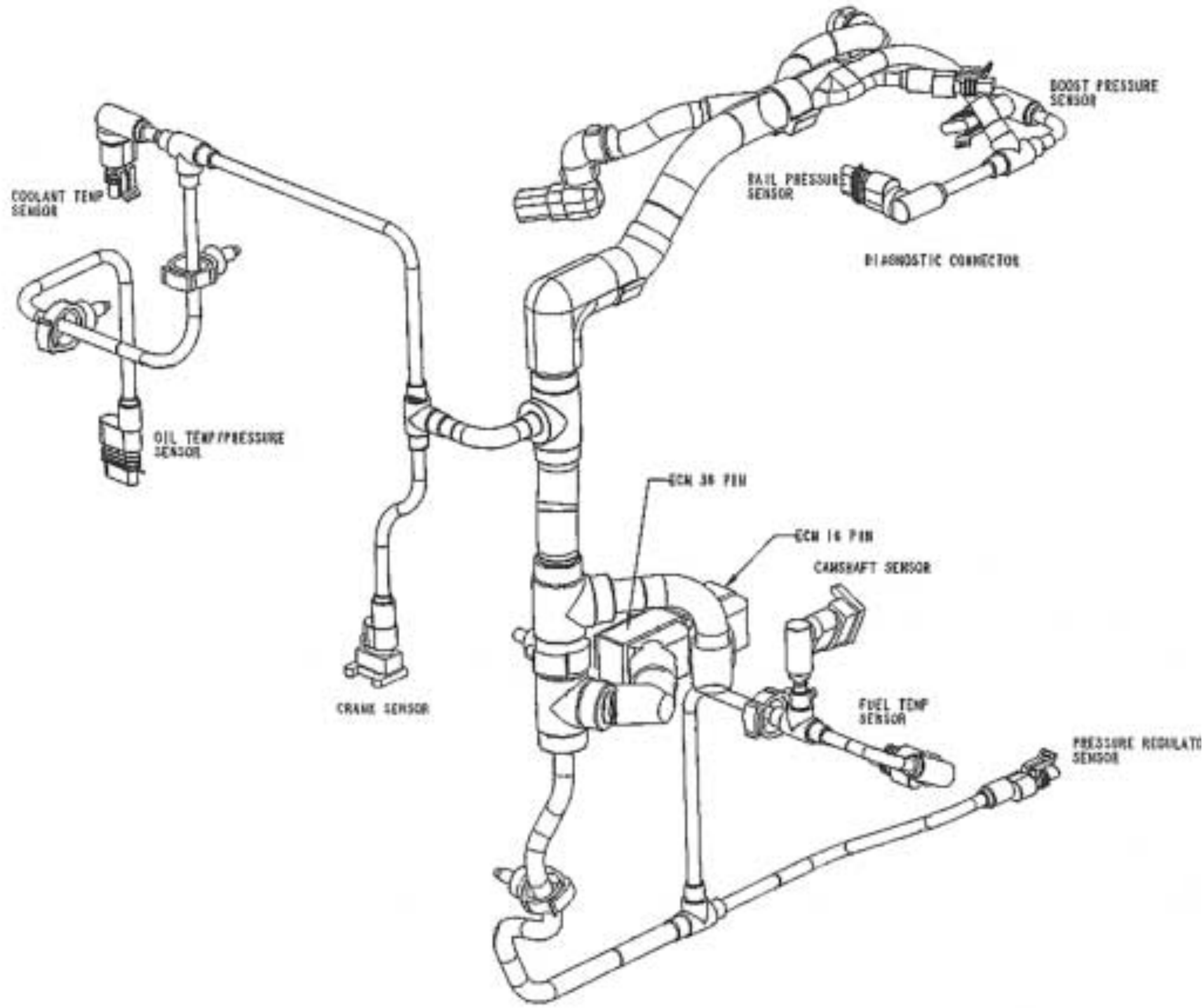


Figure 4-4: 4 Cylinder Engine Harness

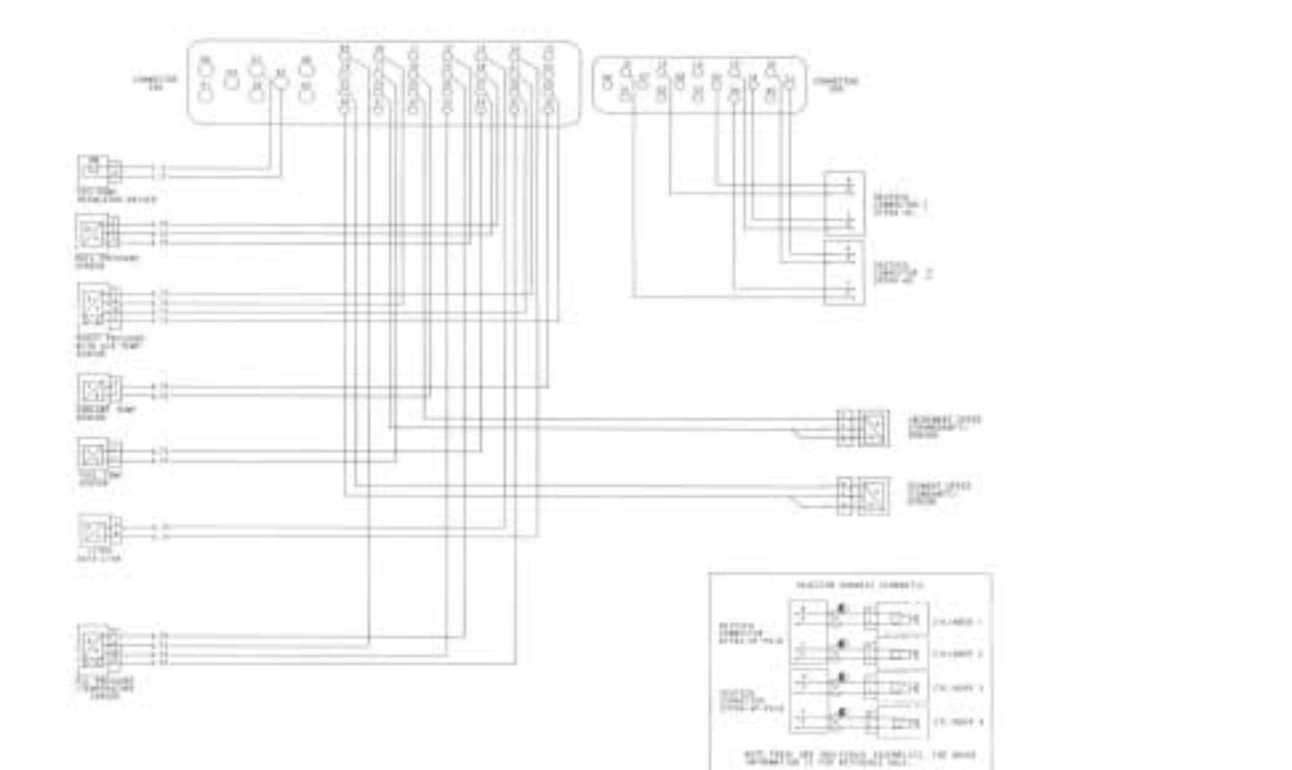


Figure 4-5: 4 Cylinder Engine Harness Schematic

Table 4-1: 4 Cylinder Engine Harness Connection List

CCT No	End A	Cav No.	End B	Cav No.	Wire Col	Size MM2	Description
1	ECM300	1					
2	ECM300	2					
3	ECM300	3					
4	ECM300	4	DC2	1	White / Brown Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 4
5	ECM300	5					
6	ECM300	6					
7	ECM300	7					
8	ECM300	8					
9	ECM300	9	DC1	4	Red / Green Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 1
10	ECM300	10	DC1	1	Red / Brown Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 2
11	ECM300	11	DC2	4	White / Green Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 3
12	ECM300	12	DC2	2	White / Orange Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 4
13	ECM300	13	DC1	3	Red / Yellow Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 1
14	ECM300	14					
15	ECM300	15	DC1	2	Red / Orange Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 2
16	ECM300	16	DC2	3	White / Yellow Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 3
17	ECM200	1					
18	ECM200	2					
19	ECM200	3					
20	ECM200	4					
21	ECM200	5	CP3PR	2	Brown / White Stripe	1.5	CP3 PUMP REGULATOR GROUND
22	ECM200	6					
23	ECM200	7	CP3PR	1	Brown / Purple Stripe	1.5	CP3 PUMP REGULATOR DRIVER
24	ECM200	8				0.75	OIL PRESSURE / TEMP SUPPLY
25	ECM200	9	OP / T	3	Purple / Yellow Stripe	0.75	BOOST PRESSURE SEN-SOR SUPPLY
26	ECM200	10	BPS	3	Brown / Yellow Stripe		
27	ECM200	11					
28	ECM200	12	RPS	3	Green / Yellow Stripe	0.75	RAIL PRESSURE SENSOR SUPPLY
29	ECM200	13	J1708	A		0.75	SAE J1708+
30	ECM200	14	J1708	B		0.75	SAE J1708-
31	ECM200	15					
32	ECM200	16					

Table 4-1: 4 Cylinder Engine Harness Connection List

CCT No	End A	Cav No.	End B	Cav No.	Wire Col	Size MM2	Description
33	ECM200	17	FTS	1	Yellow / Red Stripe	0.75	FUEL TEMP SENSOR GROUND
34	ECM200	18	CTS	1	Yellow / Brown Stripe	0.75	COOLANT TEMP SENSOR GROUND
35	ECM200	19	OP / T	1	Purple / Brown Stripe	0.75	OIL PRESSURE / TEMP GROUND
36	ECM200	20	RPS	1	Green / Brown Stripe	0.75	RAIL PRESSURE SENSOR GROUND
37	ECM200	21	BPS	1	Brown	0.75	BOOST PRESSURE SEN-SOR GROUND
38	ECM200	22					
39	ECM200	23	CAMPS	2	Blue		CAM POSITION SENSOR
40	ECM200	24	CRNKPS	1	Blue		CRANK POSITION SEN-SOR GROUND
41	ECM200	25	CRNKPS	2	Red		CRANK POSITION SEN-SOR
42	ECM200	26					
43	ECM200	27	RPS	2	Green / Orange Stripe	0.75	RAIL PRESSURE SENSOR
44	ECM200	28	BPS	4	Brown / Green Stripe	0.75	BOOST PRESSURE SEN-SOR
45	ECM200	29	BPS	2	Brown / Orange	0.75	BOOST AIR TEMP
46	ECM200	30	CAMPS	1	Red		CAM POSITION SENSOR GROUND
47	ECM200	31					
48	ECM200	32					
49	ECM200	33	OP / T	4	Purple / Green Stripe	0.75	OIL PRESSURE SENSOR
50	ECM200	34	FTS	2	Yellow / Blue Stripe	0.75	FUEL TEMP SENSOR
51	ECM200	35	OP / T	2	Purple / Orange Stripe	0.75	OIL TEMP SENSOR
52	ECM200	36	CTS	2	Yellow / Orange Stripe	0.75	COOLANT TEMP SENSOR

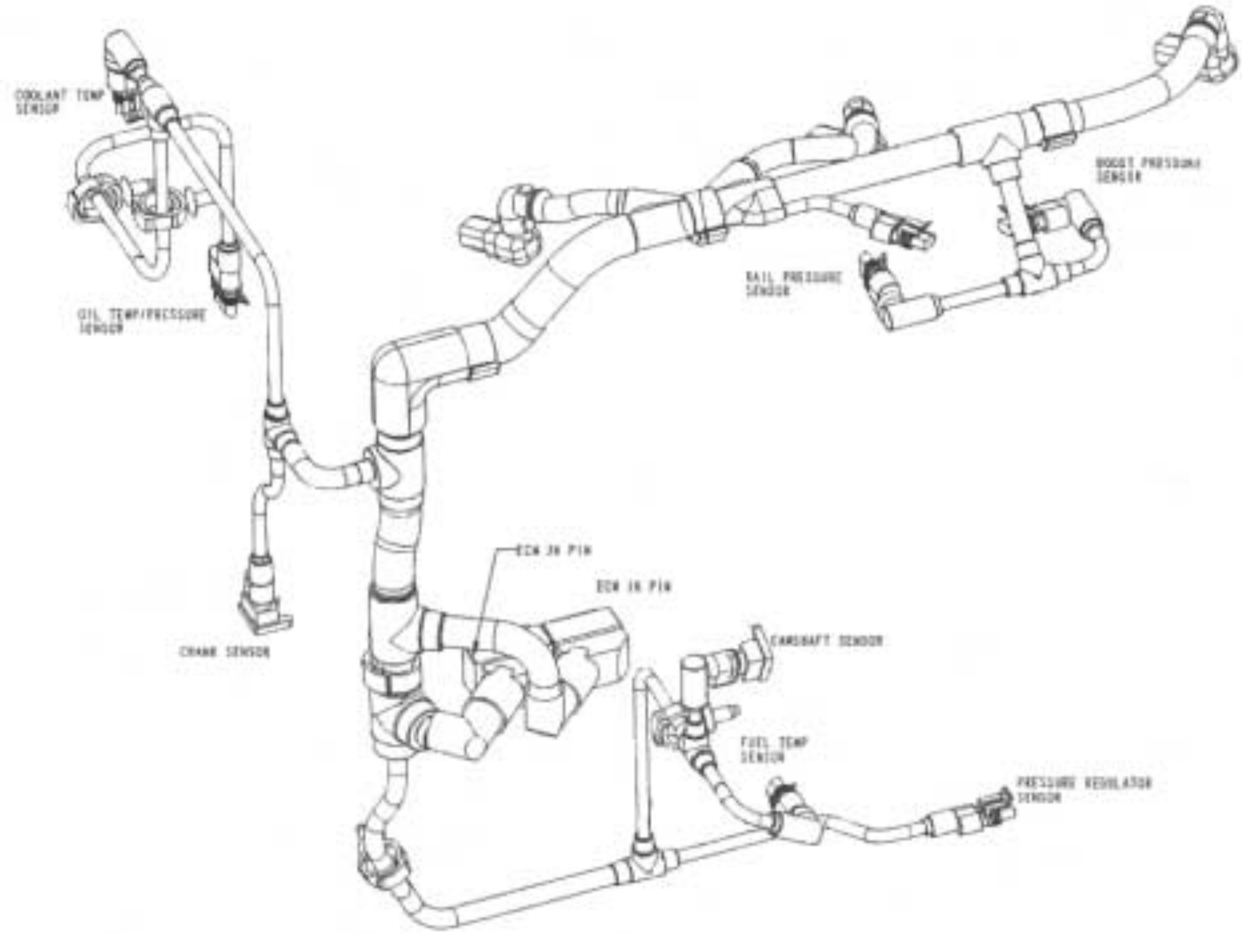


Figure 4-6: 6 Cylinder Engine Harness

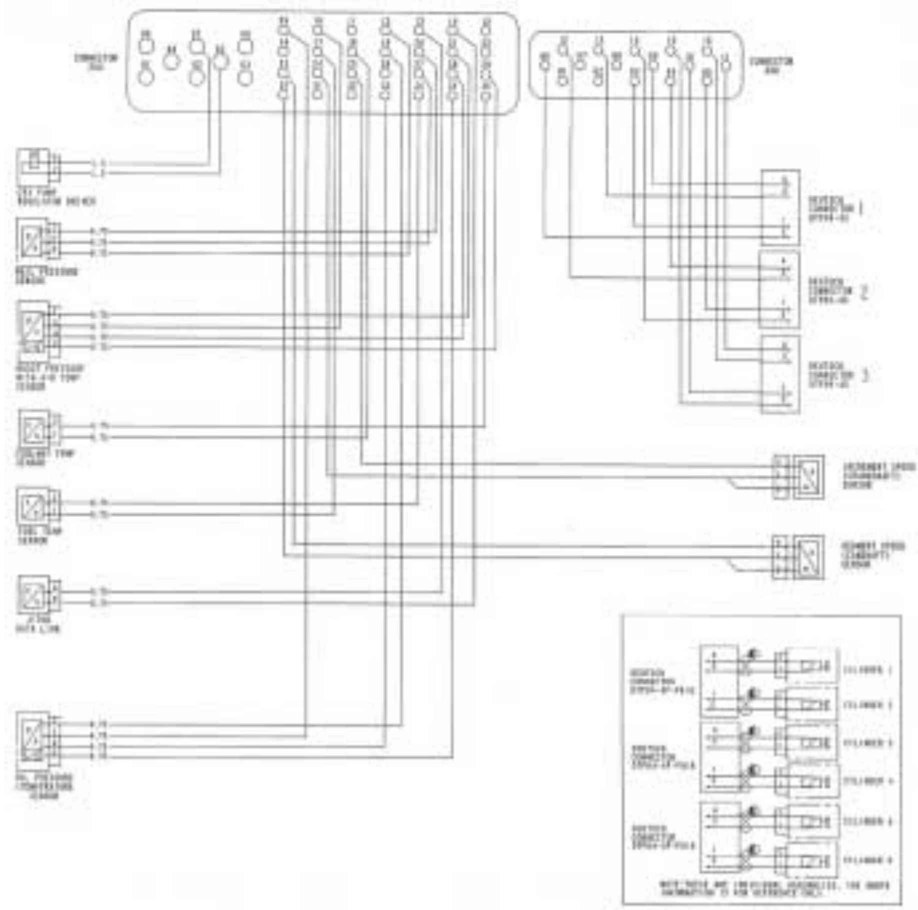


Figure 4-7: 6 Cylinder Wiring Schematic

Table 4-2 6 Cylinder Engine Harness Connection List

CCT No	End A	Cav No.	End B	Cav No.	Wire Col	Size MM2	Description
1	ECM300	1					
2	ECM300	2					
3	ECM300	3	DC1	1	Red / Blue Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 2
4	ECM300	4	DC2	4	White / Purple	2.5	DEUTSCH CONNECTOR 2 CYL 3
5	ECM300	5	DC2	1	White / Blue Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 4
6	ECM300	6	DC1	2	Red / White Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 2
7	ECM300	7					
8	ECM300	8					
9	ECM300	9	DC1	4	Red / Green Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 1
10	ECM300	10	DC3	1	Blue / Brown Stripe	2.5	DEUTSCH CONNECTOR 3 CYL 6
11	ECM300	11	DC3	4	Blue / Green Stripe	2.5	DEUTSCH CONNECTOR 3 CYL 5
12	ECM300	12	DC2	3	White / Red Stripe	2.5	DEUTSCH CONNECTOR 2 CYL 3
13	ECM300	13	DC1	3	Red / Yellow Stripe	2.5	DEUTSCH CONNECTOR 1 CYL 1
14	ECM300	14	DC2	2	White	2.5	DEUTSCH CONNECTOR 2 CYL 4
15	ECM300	15	DC3	2	Blue / Orange Stripe	2.5	DEUTSCH CONNECTOR 3 CYL 6
16	ECM300	16	DC3	3	Blue / Yellow Stripe	2.5	DEUTSCH CONNECTOR 3 CYL 5
17	ECM200	1					
18	ECM200	2					
19	ECM200	3					
20	ECM200	4					
21	ECM200	5	CP3PR	2	Brown / White Stripe	1.5	CP3 PUMP REGULATOR GROUND
22	ECM200	6					
23	ECM200	7	CP3PR	1	Brown / Purple Stripe	1.5	CP3 PUMP REGULATOR DRIVER
24	ECM200	8					
25	ECM200	9	OP / T	3	Purple / Yellow Stripe	0.75	OIL PRESSURE / TEMP SUPPLY
26	ECM200	10	BPS	3	Brown / Yellow Stripe	0.75	BOOST PESSURE SENSORE SUPPLY
27	ECM200	11					
28	ECM200	12	RPS	3	Green / Yellow Stripe	0.75	RAIL PRESSURE SENSOR SUPPLY
29	ECM200	13	J1708	A		0.75	SAE J1708+
30	ECM200	14	J1708	B		0.75	SAE J1708-
31	ECM200	15					

Table 4-2 6 Cylinder Engine Harness Connection List

CCT No	End A	Cav No.	End B	Cav No.	Wire Col	Size MM2	Description
32	ECM200	16					
33	ECM200	17	FTS	1	Yellow / Purple Stripe	0.75	FUEL TEMP SENSOR GROUND
34	ECM200	18	CTS	1	Yellow / Brown Stripe	0.75	COOLANT TEMP SENSOR GROUND
35	ECM200	19	OP / T	1	Purple / Brown Stripe	0.75	OIL PRESSURE / TEMP GROUND
36	ECM200	20	RPS	1	Green / Brown Stripe	0.75	RAIL PRESSURE SENSOR GROUND
37	ECM200	21	BPS	1	Brown	0.75	BOOST PRESSURE SEN-SOR GROUND
38	ECM200	22					
39	ECM200	23	CAMP S	2	Blue		CAM POSITION SENSOR
40	ECM200	24	CRNK PS	1	Blue		CRANK POSITION SEN-SOR GROUND
41	ECM200	25	CRNK PS	2	Red		CRANK POSITION SEN-SOR
42	ECM200	26					
43	ECM200	27	RPS	2	Green / Ornage Stripe	0.75	RAIL PRESSURE SENSOR
44	ECM200	28	BPS	4	Brown / Green Stripe	0.75	BOOST PRESSURE SEN-SOR
45	ECM200	29	BPS	2	Brown / Orange Stripe	0.75	BOOST AIR TEMP
46	ECM200	30	CAMP S	1	Red		CAM POSITION SENSOR GROUND
47	ECM200	31					
48	ECM200	32					
49	ECM200	33	OP / T	4	Purple / Green Stripe	0.75	OIL PRESSURE SENSOR
50	ECM200	34	FTS	2	Yellow / Blue Stripe	0.75	FUEL TEMP SENSOR
51	ECM200	35	OP / T	2	Purple / Orange Stripe	0.75	OIL TEMP SENSOR
52	ECM200	36	CTS	2	Yellow / Orange Stripe	0.75	COOLANT TEMP SENSOR

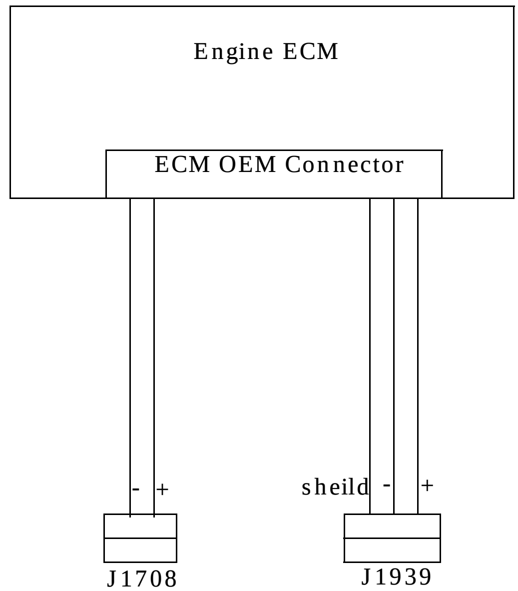


Figure 4-8: *Sample* ISB4/ISBe OEM DATALINK Harness Section

Table 4-3: Current Usage

Operation Condition	Fan Clutch Solenoid	Warning Lamps & PWMs	Grid Heater **Note 6** (24 VDC)	Exhaust Brake	CP3 Pump	HPCR Fuel System **Note 2**	ECM Internal Power	Total Supply Current Required
1. Key Switch Off	0	0	0	0	0	0	0.02	0.02
2. Key Switch On Engine Not Running	0	3	213 (106)	0	2	1	1	220 (110) **Note 3**
2. Engine Cranking	2	3	0	0	2	2	1	10
Idle Only	2	3	213 (106)	0	2	1	1	222 (115) **Note3**
Engine Braking	2	3	0	2.0	2	0	1	10
100% Power	2	3	0	0	2	2	1	10

1 ECM Cranking is incremental to starter current.
2 Currents represents worst case at peak torque RPM and full load.
3 Represents current demanded from heating elements + ECM relay drive current.
4 Worse case current draws under normal conditions are listed.
5 Values represent all engines unless indicated in (), which in this table represents 24V applications.

4.2 PARTS LIST FOR OEM HARNESS INTERFACES TO ENGINE CONTROLLER

Qty	P/N	Description
OEM Connector		
1	1-928-404-195	Bosch 89 pin connector body
1	1-928-404-196	Backshell - EDC7 89-way connector
17	1-928-498-063	BSK 2.8 gold-plated terminals and
17	1-928-300-600	1.5-2.5 mm wire seals
72	1-928-498-003	BMK 0.6 gold-plated terminal

Note: Assembly instructions for the connectors are available via your Bosch dealer.

Qty	P/N	Description
Fuel Heater Connector		
1	15300027	2-position (Packard) weatherpack tower
1	15300014	TPA
1	15300030	Connector seal
2	12077413	10-12 AWG terminals (TIN)
2	12015193	10 AWG wire seals

4.3 ISB4/ISB^e Engine Pins

Table 4-4: ISB4/ISB^e Engine A Connector

Engine Connector		
Pin Number	**Generic Name**	**Cummins Automotive**
A5	Source #10 Ground	CP3 Pump Regulator Driver Return
A7	Source #10	CP3 Pump Regulator Driver
A9	Active #6 Supply	Oil Pressure/Temp Sensor Supply (Pre MY04 engines) Oil Pressure Switch supply (MY04 and beyond)
A10	Active #2 Supply	Boost Pressure/Temp Sensor Supply
A12	Active #1 Supply	Rail Pressure Sensor Supply
A13	Spare Pin	J1708+ Datalink
A14	Spare Pin	J1708- Datalink
A15	Active High Switch	Oil Pressure Switch
A17	Passive #1 Ground	Fuel Temperature Return (Pre MY04 engines)
A18	Passive #2 Ground	Coolant Temperature Return
A19	Active #6 Ground	Oil Pressure/Temp Return (Pre MY04 engines
A20	Active #1 Ground	Rail Pressure Return
A21	Active #2 Ground	Boost Pressure/Temp Return
A22	Spare Pin	Return Spare analog Pressure Input
A23	VR #2	Cam Position Sensor +
A24	VR #1 Ground	Crank Position Return -
A25	VR #1	Crank Position Sensor +
A27	Active #1	Rail Pressure Sensor
A28	Active #2	Boost Pressure Sensor
A29	Passive #3	Boost Air Temperature Sensor
A30	VR #2 Ground	Cam Position Return -
A33	Active #6	Oil Pressure Sensor (Pre MY04 engines)
A34	Passive #1	Fuel Temperature Sensor (Pre MY04 engines)
A35	Passive #5	Oil Temperature Sensor (Pre MY04 engines)
A36	Passive #2	Coolant Temperature Sensor

Table 4-5: ISB4/ISB^{e} Engine B Connector

OEM Connector		
Pin Number	**Generic Name**	**Cummins Automotive**
B1	V+ Battery	Battery Positive
B2	Source #7/8/9 Ground	Return for Analog Torque Output, High Side Tachometer and Fuel Heater
B3	V Battery Return	Battery Negative
B4	Source #1/2/4 Ground	Return for Grid Heater Relays and Exhaust Brake
B5	Source #6	Fan Clutch Driver
B7	V+ Battery	Battery Positive
B8	VBattery for Lamps/Switches	Dedicated VBattery Output for Active-High Switches and Lamp Pullups, except Diag-nostic Lamp
B9	V Battery Return	Battery Negative
B10	Source #6 Ground	Fan Clutch Return
B11	Source #4	Exhaust Brake Driver
B12	V + battery	Battery Positive
B13	V + battery	Battery Positive
B14	V Battery Return	Battery Negative
B15	V Battery Return	Battery Negative
B16	Source #1	Grid Heater #1 Driver
B17	Source #2	Grid Heater #2 Driver
B18	Source #9	Fuel Heater Driver
B19	Digital Low- Side Switch Ground	Return Active Low Switch Input
B20	Digital #22	Exhaust Brake On/Off Switch
B21	Digital #23	Remote Throttle On/Off Switch
B22	Digital #14	Fan Clutch Switch
B23	Digital #25	A/C Pressure Switch
B24	Digital #24	Remote PTO On/Off Switch
B25	Digital #26	Switched RSG Limit Switch
B26	Digital #16	Engine Override Protection Switch
B27	Digital #15	Parking Brake Switch

OEM Connector		
Pin Number	**Generic Name**	**Cummins Automotive**
B28	VBattery for Lamp #6	Dedicated VBattery output for Diagnostic Lamp Pullup
B29	Sink Dr. (Lamp) #2	Wait to Start Lamp Driver
B30	ISO-L/J1708B	Alternate SAE J1708- Connection
B31	ISO-K/J1708A	Alternate SAE J1708+ Connection
B32	Passive #4/6/7/8 Ground	Return for WIF Sensor, OEM Temperature Sensor, and Switched Max Operating Speed Input
B36	Source #7	Analog Torque Output
B37	Source #8	Tachometer (High Side) Driver
B38	Digital #13	Accelerator Interlock Switch
B39	Key Switch	Key Switch
B40	Digital #10	Torque Control Switch
B41	Digital #17	Two Speed Axle Switch
B42	Digital #18	Spare Switch Input (Active Low)
B46	Sink Dr. (Lamp) #1	Starter Lockout Driver
B47	Sink Dr. (Lamp) #3	Stop Lamp Driver
B49	Sink Dr. (Signal) #1	Tachometer (Low Side) Driver
B50	Active #8/9 Ground	Return for Remote Throttle and OEM Pressure Sensor
B51	CAN 1 Shield	J1939 #1 Shield
B52	CAN #1/L	J1939 1 Low
B53	CAN #1/H	J1939 1 High
B54	Tachography Ground	Return for Tachograph
B55	Active #4 Supply	Sampled Throttle / Dual Potentiometer Pedal Input #1 Supply +5VDC
B56	VR #4 Ground	Vehicle Speed Sensor -
B57	Hall #2	Tachograph Input Signal
B58	Active #7 Ground	Return for Dual Potentiometer Throttle Input # 2
B59	Digital #6	Coolant Level Low Switch
B60	Digital #9	Idle/Diagnostic Decrement Switch/ Cruise/PTO/Set/Coast Switch

OEM Connector		
Pin Number	**Generic Name**	**Cummins Automotive**
B61	Digital #8	Idle/Diagnostic Increment Switch/Cruise/PTO/Resume/Accel Switch
B62	Digital #5	Clutch Switch
B63	Sink Dr. (Lamp) #4	Maintenance Lamp Driver
B64	Sink Dr. (Lamp) #6	Diagnostic Lamp Driver
B67	Supply #5	Dual Potentiometer Pedal Input #2 Supply +5VDC
B68	Active #8/9 Supply	Supply for Remote Throttle, OEM Pressure Sensor and Coolant Level Sensor
B72	Digital #1	Idle Validation On Idle Switch
B73	Digital #3	Idle Validation Off Idle Switch
B74	VR #4	Vehicle Speed Sensor +
B76	Digital #4	Cruise/PTO On/Off Switch
B77	Digital #11	Cab Switchable Governor Switch
B78	Digital #12	Coolant Level High Switch
B79	Digital #7	Diagnostic On/Off Switch
B80	Digital #3	Service Brake Switch
B81	Active #4 Ground	Sampled Throttle / Dual Potentiometer Pedal Input #1 Return
B82	Active #9	OEM Pressure Input Signal
B83	Active #4	Sampled Throttle Input / Dual Potentiometer Pedal Input #1
B84	Active #7	Dual Potentiometer Pedal Input # 2
B85	Active #8	Remote Throttle Input Signal
B87	Passive #6	Water in Fuel Analog Input
B88	Passive #7	OEM Temperature Input Signal
B89	Passive #8	Switched Max Operating Speed Input (Analog In)

Table 4-6: ISB4/ISB^e Engine C Connector

Cylinder Connector		
Pin Number	**Generic Name**	**Cummins Automotive**
C3	Injector #2/-*	Injector #2/-Driver
C4	Injector #3/4*	Injector #3/4 Driver
C5	Injector #4/-*	Injector #4/- Driver
C6	Injector #2/-* Return	Injector #2/- Return
C9	Injector #1/1*	Injector #1/1* Driver
C10	Injector #6/2*	Injector #6/2 Driver
C11	Injector #5/3*	Injector #5/3 Driver
C12	Injector #3/4* Return	Injector #3/4 Return
C13	Injector #1/1* Return	Injector #1/1 Return
C14	Injector #4/-* Return	Injector #4/- Return
C15	Injector #6/2* Return	Injector #6/2 Return
C16	Injector #5/3* Return	Injector #5/3 Return

5 CONNECTORS, SENSORS AND SWITCHES

5.1 CONNECTORS

5.1.1 OEM Connector

Drawing Number: N/A

Specifications: 10674 Source Approval Method
10012 Approved Source List
14130 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

The 89-pin Bosch Connector system utilizes (72) BMK0.6 terminals and (17) BSK2.8 terminals. It has an environmentally sealed, hard-shell connector. The plug is keyed to fit the mating module header and is secured to the ECM using a self contained lever mechanism.

PART APPLICATION

The OEM connector is used as an integral part of an electronic control module for the wiring harness interface. Cavity plugs should be inserted in any unused cavities.

Throttle, power, keyswitch, cruise control, brake and clutch switch and other vehicle switch inputs and indicator lamp, outputs are connected to the ECM through this connector.

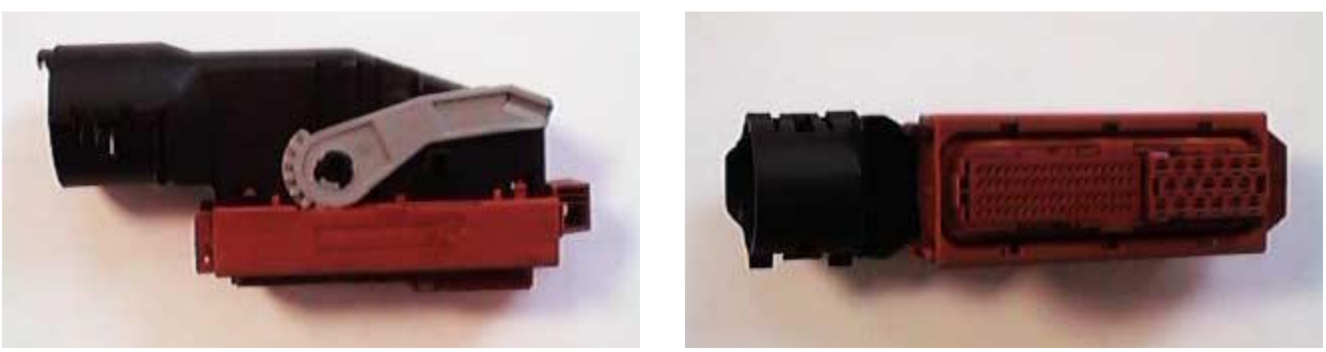


Figure 5-1: OEM Connector

OEM Connector Plug
BOSCH P/N: 1 928 404 195

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

<u>Environmental Information</u>	
Operating Temperature Range:	-40 to +140 °C [-40 to +284 °F]
Storage Temperature Range:	-40 to +140 °C [-40 to +284 °F]
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; on engine
<u>Small Pins</u>	
Current Rating:	2 AMPS
Terminals:	Gold plated
Connector Terminals:	BMK 0.6
Cable Cover :	BOSCH P/N: 1 928 404 196
Wire Size:	0.5 - 0.75 mm^2 (20-22 AWG)
Part Number:	BOSCH P/N: 1 928 498 003
<u>Large Pins</u>	
Current Rating:	6 AMPS
Connector Terminals:	BSK 2.8
Terminals:	Gold plated
Wire Size:	0.5 - 1.0 mm^2 (18-20 AWG)
Part Number:	BOSCH P/N: 1 928 498 062
Wire Size:	1.5 - 2.5 mm^2 (14-18 AWG)
Part Number:	BOSCH P/N: 1 928 498 063
Cavity Plugs:	BOSCH P/N: 1 928 300 601

Note: Assembly instructions for the connectors are available via your Bosch dealer.

CUMMINS SUPPLIER

Bosch
TBD
Bosch Distributor
TBD

5.1.2 Fan Clutch Connector

Drawing Number: N/A

Specifications: 10674 Source Approval Method
10012 Approved Source List
14130 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

Packard 2-position weather pack tower. The in-line connectors are environmentally sealed, have positive-locking hard shells and are used on both wiring harnesses and devices employing pigtail wiring. Low signal levels as well as those carrying significant current levels are accommodated. The units employ convoluted silicone wire seals and connector seals.

PART APPLICATION

Sealed tower and shroud connectors are useful in severe environments ranging from under hood to on chassis.

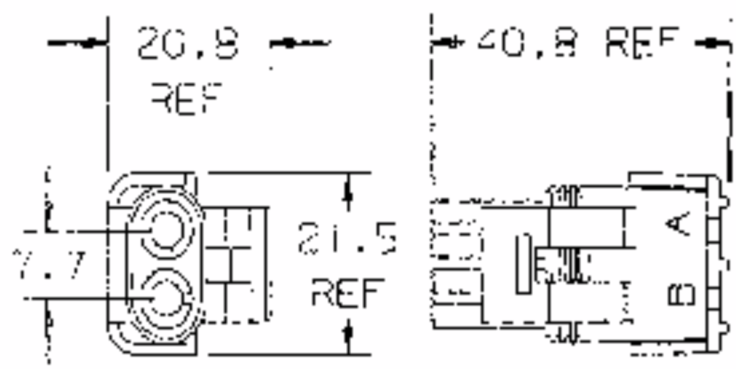


Figure 5-2: Fan Clutch Connector

Fan Clutch Connector
Packard P/N: 1201-0973

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	15 µA minimum; voltage = 0.02 volts 7.5A maximum; voltage = 500 volts
Low Level Contact Resistance:	Less than 10 milliohms @ 50 millivolts
Silicone Cable Seals:	18 AWG wire
Terminals:	Gold plated or tin-plated brass
Lubricant:	Lubriplate DS-ES (optional)
Operating Temperature Range:	-40 to +125 °C [-40 TO +257 °F]
Storage Temperature Range:	-40 to +150 °C [-40 to +302 °F]
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; under-hood

CUMMINS SUPPLIER

Packard Electric
P.O. Box 431
Warren, OH 44486
Telephone: 216-373-2121

5.1.3 Fuel Heater Connector

Drawing Number: N/A

Specifications:
10674 Source Approval Method
10012 Approved Source List
14130 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

Packard 2-position Metri-pak Series. The in-line connectors are environmentally sealed, have positive-locking hard shells and are used on both wiring harnesses and devices employing pigtail wiring. Low signal levels as well as those carrying significant current levels are accommodated. The units employ convoluted silicone wire seals and connector seals.

PART APPLICATION

Sealed tower and shroud connectors are useful in severe environments ranging from under hood to on chassis.

A

PART NO:	**15300027**
DESCRIPTION:	Connector Assembly 2F
SIZE:	29.9L x 25.0H x 25.2W
COLOR:	Black
MATERIAL:	PA66 HS IM
TERMINALS:	See Page 80
SEALS/PLUGS:	See Page 80, 81

B

PART NO:	**15300014**
DESCRIPTION:	TPA
NUMBER REQ.:	1
COLOR:	Blue
MATERIAL:	PA6

Figure 5-3: Fuel Heater Connector

Fuel Heater Connector
Packard P/N: 1530 0027

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	15 µA minimum; voltage = 0.02 volts 7.5A maximum; voltage = 500 volts
Low Level Contact Resistance:	Less than 10 milliohms @ 20 millivolts
Silicone Cable Seals:	18 AWG wire
Terminals:	Gold plated or tin-plated brass
Lubricant:	Lubriplate DS-ES (optional)
Operating Temperature Range:	-40 to +125 °C [-40 TO +257 °F]
Storage Temperature Range:	-40 to +150 °C [-40 to +302 °F]
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road, on engine

CUMMINS SUPPLIER

Packard Electric
P.O. Box 431
Warren, OH 44486
Telephone: 216-373-2121

5.1.4 Coolant Level Connector

Drawing Number: N/A
Specifications: 10,674 Source Approval Method
10,012 Approved Source List
14,130 Performance Standard
14,232 General Environmental Testing and Performance Standard

PART DESCRIPTION

Packard 4-position weather pack tower. The in-line connectors are environmentally sealed, have positive-locking hard shells and are used on both wiring harnesses and devices employing pigtail wiring. Low signal levels as well as those carrying significant current levels are accommodated. The units employ convoluted silicone wire seals and connector seals.

PART APPLICATION

Sealed tower and shroud connectors are useful in severe environments ranging from under hood to on chassis. A lubricant applied to the mating surfaces of the terminals is recommended to preclude fretting corrosion terminals.

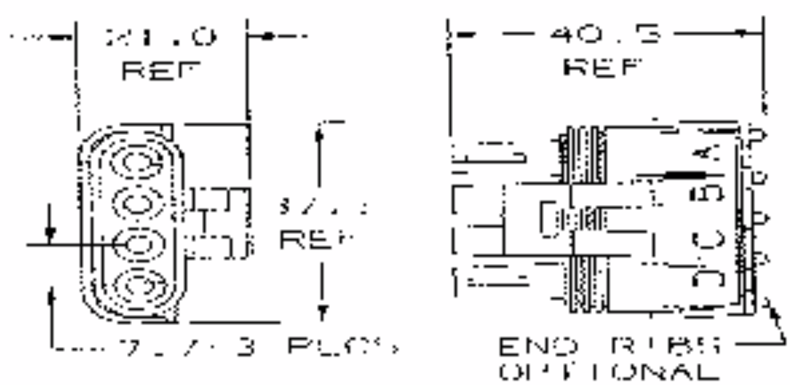


Figure 2-4 Coolant Level Connector

Coolant Level Connector
Packard P/N: 1201 5797

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	15 mA minimum; voltage = 0.02 volts 7.5A maximum; voltage = 500 volts
Low Level Contact Resistance:	Less than 10 milliohms
Number of Circuits Accommodated:	4 circuits
Silicone Cable Seals:	18 AWG wire
Terminals:	Gold plated or tin-plated brass
Lubricant (optional):	Lubriplate DS-ES
Operating Temperature Range:	-40 to +125 ×C [-40 TO +257 °F]
Storage Temperature Range:	-40 to +150 ×C [-40 to +302 °F]
Environment:	B/C/L/Heavy-duty truck, industrial, off road, under hood

CUMMINS SUPPLIER

Parkard Electric
P.O. Box 431
Warren, OH 44486
1-800-722-5273

5.1.5 J1939 Tool Connector

Drawing Number: N/A

Specifications: 10674 Source Approval Method
10012 Approved Source List
14130 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

Deutsch 3-position connector plug as per SAE J1939 specifications. This part consists of three major parts. The description of those parts are as follows:

Plug: This plug connects the backbone to a node on the backbone side. The connector consists of a 3-way Deutsch DT series plug which requires a locking insert. The Plug uses gold-plated sockets.

Receptacle: The receptacle connects a node to the backbone on the node side. The connector consists of a 3-way Deutsch DT series receptacle and requires a wedge lock. The receptacle uses gold-plated pins.

Termination Receptacle Hardware: Each end of the backbone uses a Termination Receptacle. This connector is pre-assembled and consists of a Deutsch DT04-3P receptacle, W3S (orange) wedge lock, gold-plated pins, cavity plugs and a 120-ohm resistor.

PART APPLICATION

Used for J1939 datalink tools and devices.

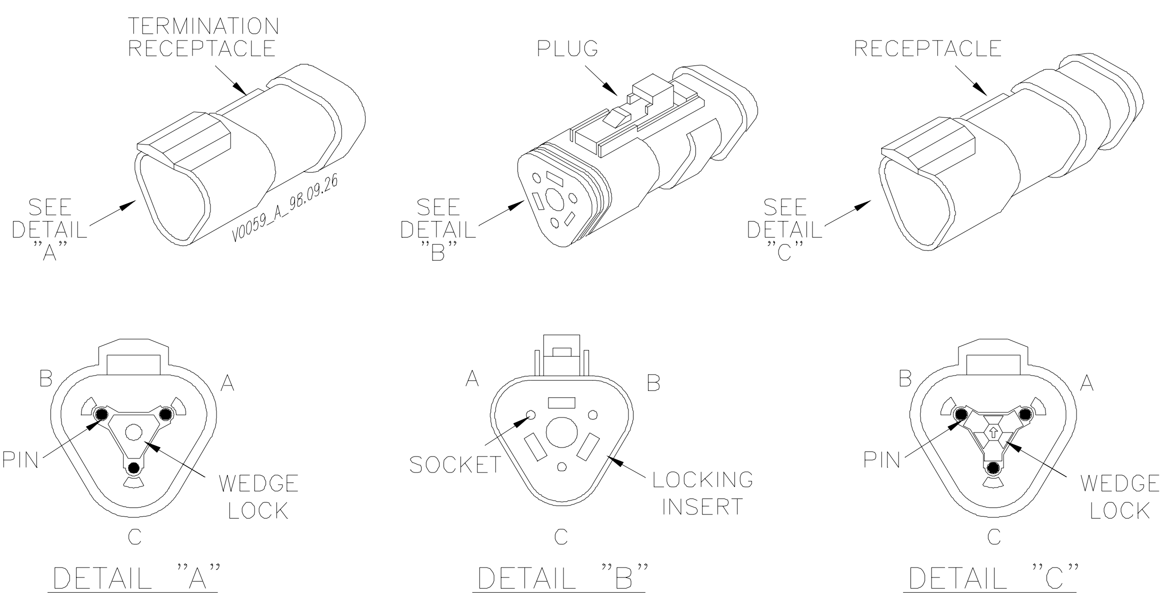


Figure 5-5: J1939 Tool Connector

J1939 Tool Connector
Deutsch P/N: DT06-3S-E008

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	15 µA minimum; voltage = 0.02 volts 7.5A maximum; voltage = 500 volts
Low Level Contact Resistance:	Less than 10 milliohms
Number of Circuits Accommodated:	3 circuits
Conductor Sizes:	18 AWG
Operating Temperature Range:	-50 to +125 °C [-58 to +257 °F]
Storage Temperature Range:	-50 to +150 °C [-58 to +302 °F]
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; under hood

CUMMINS SUPPLIER

Deutsch
Industrial Products Division
37140 Industrial Avenue
Hemet, CA 92343
Telephone: 714-929-1200

Table 5-1:J1939 Tool Connector Part List

Part Name	Manufacturer	Manufacturer Part #	Cummins Part #
Plug	Deutsch	DT06-3S-E008	3659400
Plug Terminal Reel	Deutsch	1062-16-0144	3658430
Locking Insert	Deutsch	W3S (orange(	3616472
Receptacle	Deutsch	DT04-3P-E008	3659369
Receptacle Pin Reel	Deutsch	1060-16-0144	3658431
Wedge Lock	Deutsch	W3P (orange)	3616471
Termination Receptacle	Deutsch	DT04-3P-_006	3942041

5.1.6 9 PIN Datalink Tool Connector

Drawing Number: N/A

Specifications: 10674 Source Approval Method
10012 Approved Source List
14130 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

A 9 Pin Datalink connector is optional for connecting to a diagnostic tool. Deutsch 9-position HD10 series connector plug as per SAE specifications. This connector can be located in the vehicle cab and/or the engine compartment.

PART APPLICATION

This connector mates to a service tool.

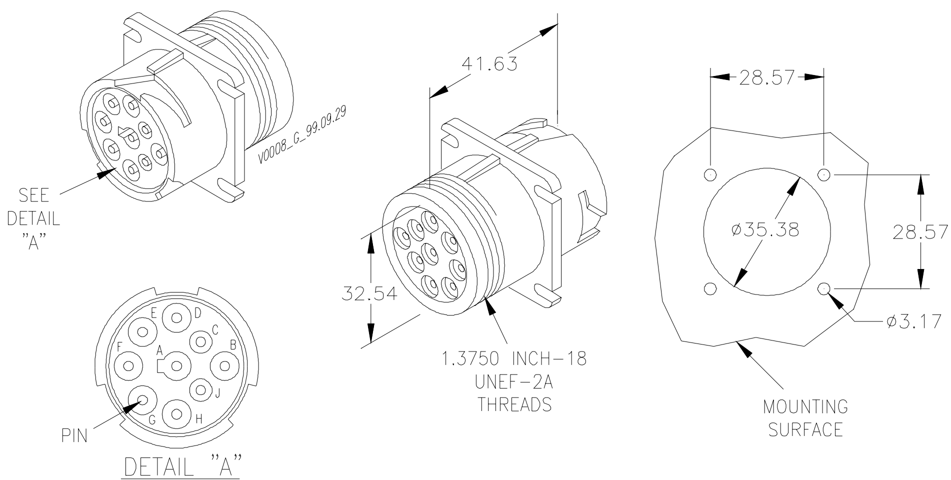


Figure 5-6: 9 PIN Datalink Tool Connector

Table 5-2:9-Pin J1939 Datalink Connector Parts List

Item	Manufacturer	Manufacturer Part No.	Cummins Part No.
Connector Shell	Deutsch	HD10-9-1939P	3658643
Terminal Reel - Pin	Deutsch	0460-202-1631/Solid Terminals	3658462
Terminal Reel - Pin	Deutsch	1060-16-0144/S&F Terminals	3658431
Captive Dust Cap	Deutsch	HDC 16-9	3825184

9 PIN DATALINK TOOL CONNECTOR
Deutsch P/N: HD10-9-1939P

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	15 µA minimum; voltage = 0.02 volts 7.5A maximum; voltage = 500 volts
Low Level Contact Resistance:	Less than 10 milliohms
Number of Circuits Accommodated:	9 circuits
Silicone Cable Seals:	14 to 18 AWG wire
Terminals:	Gold plated.
Lubricant:	Lubriplate DS-ES
Operating Temperature Range:	-55 to +125 °C [-67 TO +257 °F]
Storage Temperature Range:	-55 to +125 °C [-67 to +257 °F]
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; under hood

NOTE: Size 16s socket contact Deutsch PN 1062-14-0144 can be used for 14 AWG wires.

CUMMINS SUPPLIER

Deutsch
Industrial Products Division
37140 Industrial Avenue
Hemet, CA 92343
Telephone: 714-929-1200

5.2 SENSORS

5.2.1 Vehicle Speed Sensor (Variable Reluctance Magnetic Pickup)

PART DESCRIPTION

This sensor is a single pole piece, dual output variable reluctance magnetic pickup in which each output is physically isolated from the other. The output swings positive when the target approaches, passes through zero when the target and pole piece are coincident, and then swings negative when the target leaves. Voltage amplitude is a function of gap, target size and angular velocity.

PART APPLICATION

This sensor is mounted through the transmission case and senses passing teeth from a 16-tooth or optional 11-tooth gear. Each revolution of the gear produces 16 or 11 cycles of quasi-sinusoidal voltage. The sensor responds down to 1 mph (1.6 kph) which is 31 rpm of the 16-tooth speedometer gear shown in the accompanying illustration. At the time of installation, the sensor is to be hand turned until it touches the target, then backed off one-half turn and the jam nut tightened. The sensor is polarity sensitive and a sharp positive-to-negative transition is accomplished by using the white lead wire as the positive reference and the black wire as the negative reference.

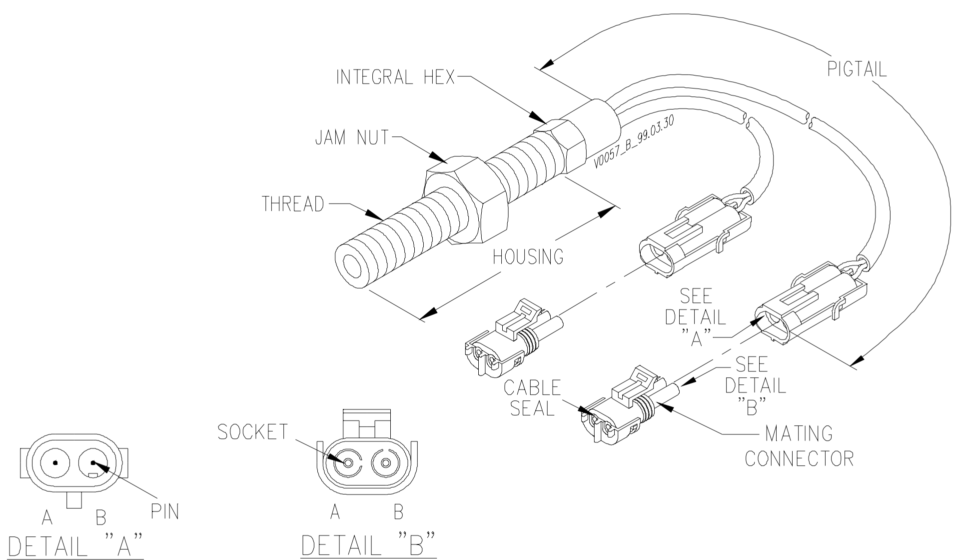


Figure 5-7: Vehicle Speed Sensor

Variable Reluctance Magnetic Pickup
Wabash P/N

KEY CHARACTERISTICS AND APPLICATION CONSIDERATIONS

Output Voltage:	400 mVpp min @ 31 rpm; 80 Vpp max @ 2480 rpm using transmission speedometer gear shown above
Electrical Load:	20k ohms minimum, 47k ohms typical
Coil-to-Coil Intercapacitance:	350 pF maximum
DC Resistance:	1.5k ohms maximum
Recommended Air Gap:	1/2 turn equals 0.76 mm (0.03 in)
Hex Size	3/4 in hex
Thread Size:	3/4-16 UNF
Installation Torque:	34 ±7 N•m [25 ±5 ft•lbs]
Operating Temperature Range:	-40 to +125 °C [-40 to +257 °F]
Storage Temperature Range:	-40 to +150 °C [-40 to +302 °F]
Connector:	2 Packard Electric Weather Pack P/N 1201 0973 shrouds P/N 1208 9040 Terminals; P/N 1201 5323 seals
Mating Connector:	2-way towers with female terminals
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; on engine/transmission

CUMMINS SUPPLIER

Wabash Technologies
1375 Swan Street
P.O. Box 829
Huntington, IN 46750-0829
Telephone: 219 356-8300

5.3 PRESSURE SWITCHES

5.3.1 Brake Switch

Drawing Number:

Specifications: 10638 Source Approval Method
14104 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

This normally closed single pole, single throw (SPST) plunger design limit switch is rated for one million switch cycles. It has an actuation force of 4.17 N [0.937 lbs] (15 ounces) and the total plunger movement is 4.928 mm [0.1938 in]. The recommended switch actuation is 3.175 mm [0.1249 in] to avoid undesirable bottoming out. An elastomeric sealing boot keeps harsh abrasives from damaging the plunger body and guide. Gold contacts make the switch reliable for low voltage and current switching.

PART APPLICATION

The signal from the brake pressure is used to disable cruise control and PTO operations. It is mounted directly, or with a T-fitting, into the low pressure control side of the truck's pneumatic brake system. When the brake pedal is actuated or the trailer brake is applied, the pneumatic pressure rises from 0 psig to 90 psig. An open circuit to the control module, whether by this switch or a wiring circuit failure, will disable the cruise control function. This switch is qualified for under-the-dashboard mounting only. A molded rubber boot is recommended for use with the mating connector.

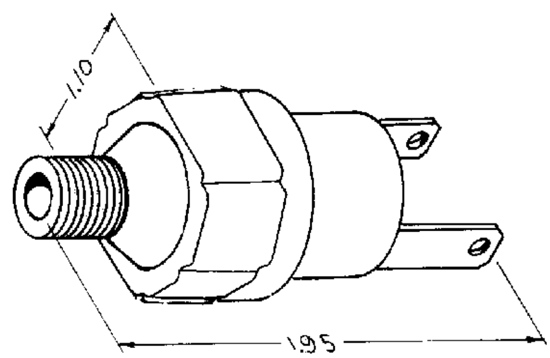


Figure 5-8: Pressure Switch

Brake Switch
Fasco Industries P/N: 1749-2134

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Contact Requirements:	10 µA minimum current through contacts; 2A maximum
Prime Accuracy:	±2 psig
Switch Threshold:	4 psig
Proof Pressure:	150 psig
Thread Size:	1/8 NPTF external
Terminals:	Two 6.35 mm [.250 in]
Installation Torque:	34 N•m [25 ft•lbs] maximum
Durability:	1,000,000 cycles
Operating Temperature Range:	-40 to +85 °C [-40 to +185 °F]
Storage Temperature Range:	-40 to +125 °C [-40 to +257 °F]
Mating Connector:	2 Packard Electric 56 Series P/N 0628 8905 shells with P/N 0296 5141 female spade terminals
or:	AMP P/N 15419-1 shell with P/N 154718-3 terminals
or:	Custom-molded rubber boot connector from: National Industries P.O. Box 3528 Montgomery, AL 36109
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab

CUMMINS SUPPLIER

FASCO Controls Corporation
1100 Airport Road
Shelby, NC 28150-3699
Telephone: 704 637-2298

5.4 SWITCHES AND SWITCH ASSEMBLIES

5.4.1 Rotary Clutch Switch Assembly

Drawing Number: **N/A**

Specifications: 10641 Source Approval Method
14107 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

The clutch switch assembly is comprised of a rotary switch, lever and rod assembly and a switch bracket. The rotary switch is a normally closed single pole, single throw switch that is designed to exceed one million switch cycles. Gold contacts make it reliable for low voltage and current switching. The shaft is 7.87 millimeters [0.309 in] in diameter. At the open position, actuation torque is 1.34 N•m [0.988 ft•lbs] (190 inch-ounces). Total mechanical travel is 40 degrees of maximum rotation with 35 degrees of maximum pretravel and 3 degrees of differential travel. The ruggedness of this switch allows it to be used in high vibration environments.

PART APPLICATION

The device can be mounted both in the cab or under the cab. The rod is cut or bent to fit the top or front side of the clutch arm so that the clutch rest position has the switch in the closed-circuit mode. As the clutch pedal is depressed, the linkage arm will move and the spring preload in the switch will cause the rod to follow and open the switch circuit. When mounted under the cab, a shield should be added to prevent direct road splash on the rotary shaft area.

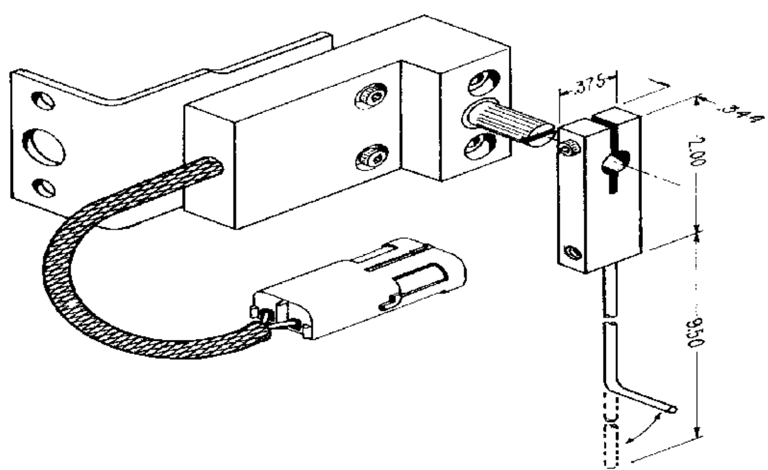


Figure 5-9: Rotary Clutch Assembly

Rotary Clutch Switch Assembly

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	10 µA ±1 @ 5V ±0.25
Voltage Maximum:	16V
Voltage Drop:	Not to exceed 0.20V 10mA
Pretravel to Switch Point:	0.762 mm [0.030 in]
Overtravel Past Switch Point:	0.280 mm [0.110 in]
Recommended Set Point:	0.229 mm [0.090 in]
Durability:	1,000,000 cycles
Switch Contact:	Gold plated
Wire Size:	18 AWG
Operating Temperature:	-40 to +85 °C [-40 to +185 °F]
Storage Temperature:	-40 to +150 °C [-40 to +302 °F]
Connector:	Packard Electric Weather Pack P/N 1201 0973 shroud P/N 1208 9040 gold plated or tin-plated brass terminals P/N 1201 5323 seals
Mating Connector:	Packard Electric Weather Pack P/N 1201 5792 2-way tower P/N 1203 4051 female gold plated or tin-plated brass terminals P/N 1201 5323 seals
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab, on frame

CUMMINS SUPPLIERS

Switch: *Telemecanique*
2002 Bethel Road
Westminster, MD 21157
Telephone: 216-373-2121

Lever Kit, Bracket: *Cummins After Market*
Memphis Distribution Center
4155 Quest Way
Memphis, TN 38112

5.4.2 Optional Levered Clutch or Brake Switch

Drawing Number: N/A

Specifications: 10641 Source Approval Method
14107 Performance Standard
14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

The clutch or brake switch assembly is comprised of a levered switch and a switch bracket assembly. The levered switch is a normally opened single pole, single throw switch that is designed to achieve one million switch electrical cycles. Silver/ Copper/ Nickel contacts (sealed contacts) make it reliable for low voltage and current switching. The shaft is 82.804 millimeters [3.260 in] in length. At the closed position, actuation force is 0.695 N [0.1562 lbs] (2.5 ounces). The ruggedness of this switch allows it to be used in high vibration environments.

PART APPLICATION

The device can be mounted both in the cab or under the cab. The rod is mounted to fit the top or front side of the clutch or brake arm so that the clutch or brake rest position has the switch in the open-circuit mode. As the clutch or brake pedal is depressed, the linkage arm will move and the spring preload in the switch will cause the rod to follow and open the switch circuit. When mounted under the cab, a shield should be added to prevent direct road splash on the levered shaft area.

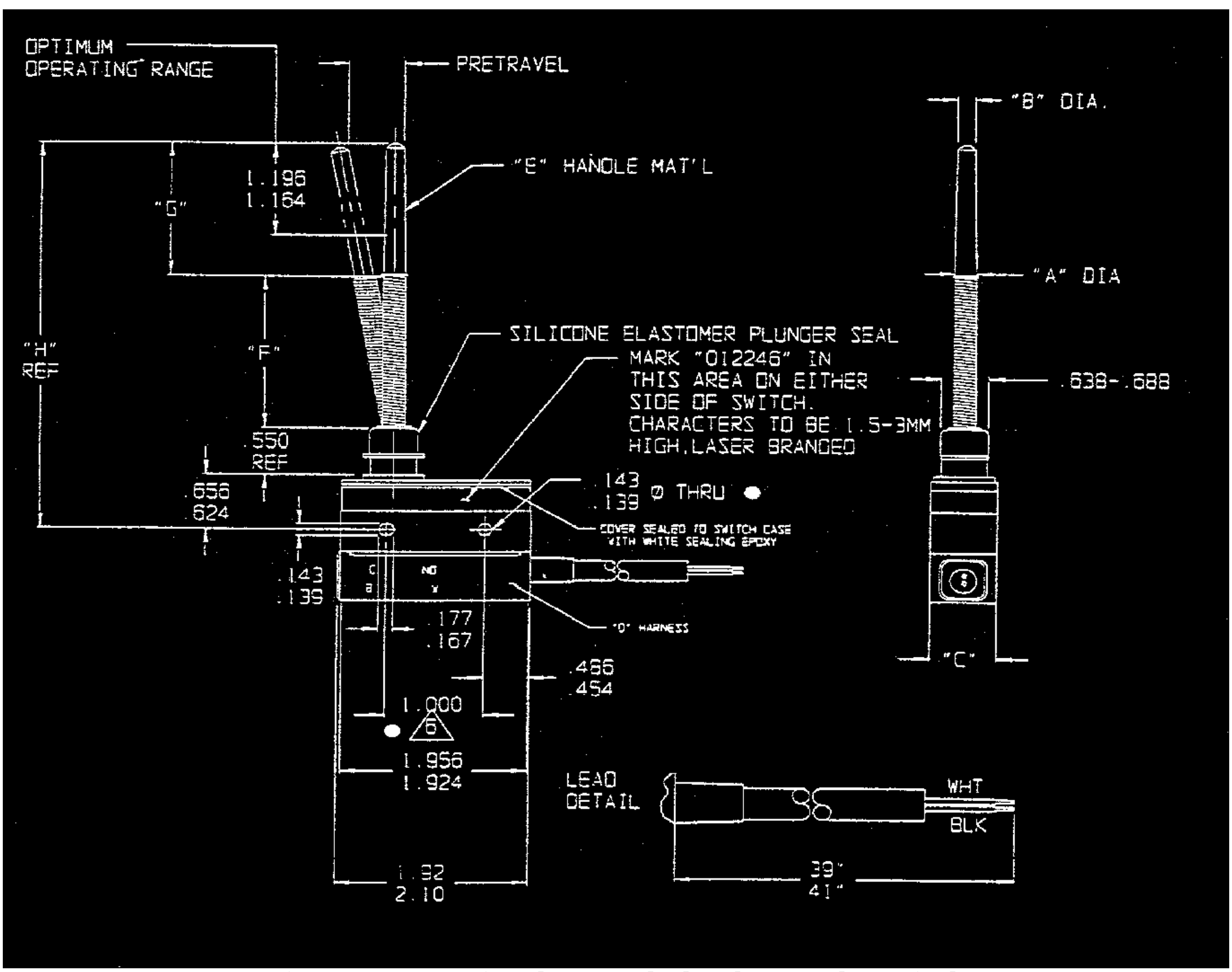


Figure 5-10: Optional Levered Clutch or Brake Switch

Optional Levered Clutch or Brake Switch

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	10A @ 8-30 VDC
Voltage Maximum:	250V
Voltage Drop:	0 VDC closed (normally open)
Pretravel to Switch Point:	12.7 mm [0.500in]
Overtravel Past Switch Point:	
Recommended Set Point:	29.972 mm [1.18 in]
Durability (Mechanical Life):	1,000,000 cycles
Switch Contact:	Silver over Copper over Nickel
Wire Size:	16 AWG
Operating Temperature:	-40 to +85 °C [-40 to +185 °F]
Storage Temperature:	-40 to +150 °C [-40 to +302 °F]
Connector:	
Mating Connector:	
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab, on frame

CUMMINS SUPPLIERS

Switch: *Jacobs Vehicle Systems*
22 East Dudley Town Road
Bloomfield, CT 06002
Telephone 860 243-1441

Lever Kit, Bracket: *Cummins After Market*
Memphis Distribution Center
4155 Quest Way
Memphis, TN 38112

5.4.3 Optional Clutch or Brake Switch

Drawing Number: 3612523

Specifications: 10642 Source Approval Method
14108 Performance Standard
14113 General Environmental and Performance Testing Standard

PART DESCRIPTION

This normally closed single pole, single throw (SPST) plunger design limit switch is rated for one million switch cycles. It has an actuation force of 4.17 N [0.937 lbs] (15 ounces) and the total plunger movement is 4.928 mm [0.1938 in]. The recommended switch actuation is 3.175 mm [0.1249 in] to avoid undesirable bottoming out. An elastomeric sealing boot keeps harsh abrasives from damaging the plunger body and guide. Gold contacts make the switch reliable for low voltage and current switching.

PART APPLICATION

The limit switch may be chosen as an optional clutch or brake switch instead of the rotary clutch switch assembly. It is mounted on the bell housing of the transmission and is operated by an actuating bracket attached to the bell crank. The slim packaging of this harsh environment plunger switch allows it to be easily mounted for limit switch application. Two mounting holes 5.08 mm [0.199 in] in diameter accommodate number 10 capscrews for bracket compatibility. The actuators that impinge on the plunger should be adjusted to the specified range of the switch.

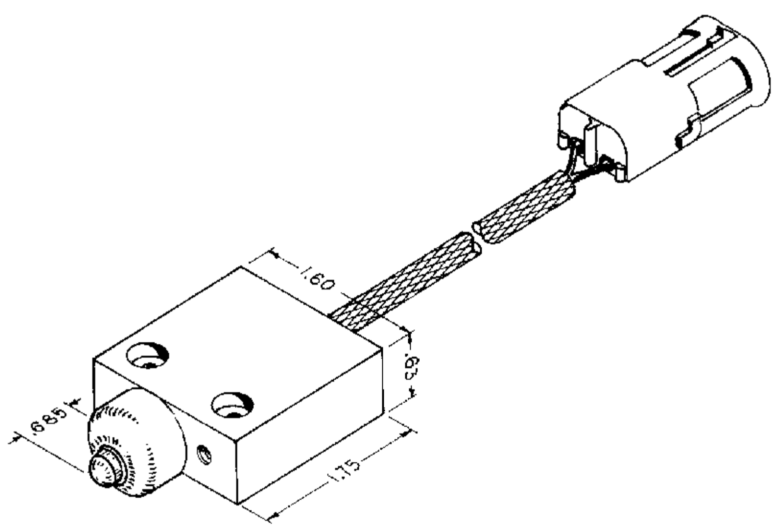


Figure 5-11: Optional Clutch or Brake Switch

Optional Clutch or Brake Switch

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	10 µA ±1 @ 5V ±0.25
Output:	Inductive load of 2.7 ohms @ 50 mH
Voltage:	16 Vdc maximum
Supply Voltage:	5V
Voltage Drop:	Not to exceed 0.20 V @ 10 mA
Pretravel to Switch Point:	1.626 mm [0.0639 in]
Overtravel to Switch Point:	3.175 mm [0.1249 in]
Actuation Force:	4.17 N [0.937 lbs] (15 ounces)
Wire Size:	18 AWG
Durability:	1,000,000 cycles
Installation Torque:	2.83 N•m [25.0 in-lbs]
Switch Contact:	Gold plated
Operating Temperature Range:	-40 to +125 °C [-40 to +257 °F]
Storage Temperature Range:	-40 to +150 °C [-40 to +302 °F]
Mounting:	Two 5.08 mm [0.200 in] diameter holes; 24.9 mm [1.73in] center-to-center
Connector:	Packard Electric Weather Pack P/N 1201 0973 shroud P/N 1208 9040 gold plated or tin-plated brass terminals P/N 1201 5323 seals
Mating Connector:	Packard Electric Weather Pack P/N 1201 5792 2-way tower P/N 1203 4051 female gold plated or tin-plated brass terminals P/N 1201 5323 seals
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; on engine, harsh environment

CUMMINS SUPPLIER

Telemecanique, Inc.
103 Broadway
Bedford, OH
Telephone 410 581-2000

5.4.4 Toggle Switches

Cutler Hammer P/N: 8956K639 Single Pole, Single Throw

8956K638 Two-momentary, Maintain-center-off
8956K640 Two-pole, Three Position

Drawing Number: 8956K639 Single Pole, Single Throw
8956K638 Two-momentary, Maintain-center-off
8946K1023 Two-pole, three-position

Specifications: N/A

PART DESCRIPTION

These toggle switches employ gold-plated rocker contacts and standard 17.5-millimeter [0.687-inch], long rounded-metal bat handles. The toggle switches are mounted on the instrument panel and have 6.35 mm [0.250 in] blade terminals at the rear for push-on harness connections. The connector terminals should be gold plated.

PART APPLICATION

The single pole, single throw (SPST) switches are used as the on/off switches for cruise control, power takeoff, Exhaust Brake and diagnostics. A two-momentary, maintain-center-off switch is used for set/coast and resume/acceleration for cruise control and power takeoff. An additional two-momentary, maintain-center-off switch controls the increase or decrease of the low idle adjustment as well as sequencing through the fault codes in the diagnostic mode.

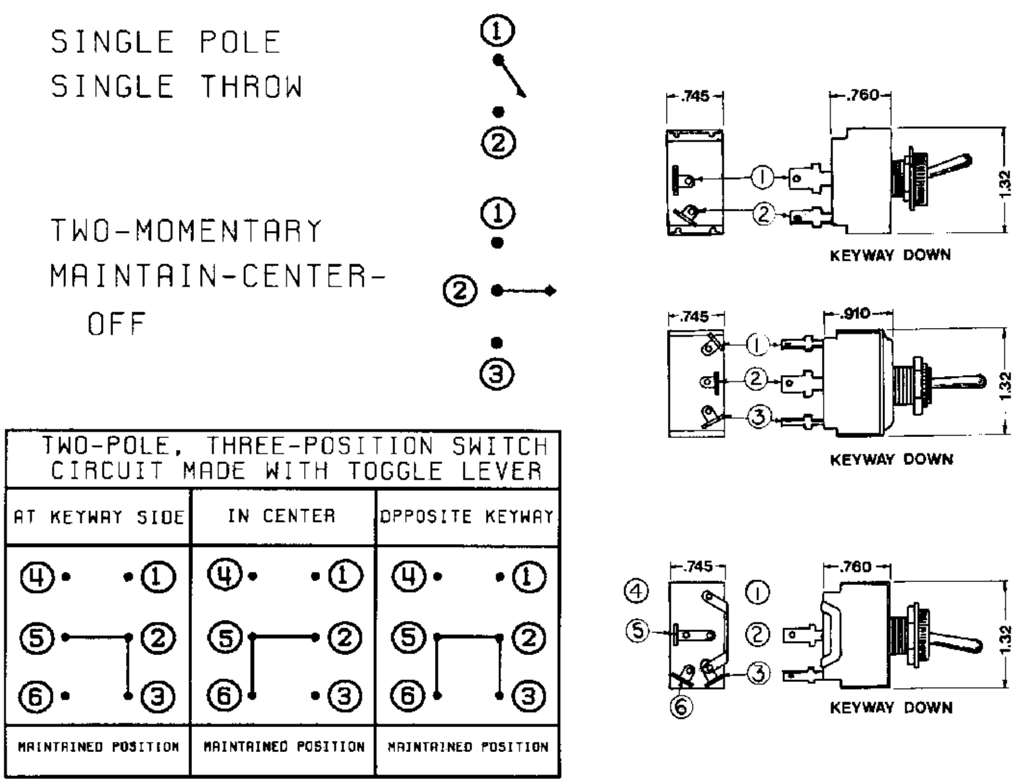


Figure 5-12: Toggle Switches

Toggle Switches

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	10µA minimum, 6A maximum
Durability:	10,000 cycles at 10 mA contact current
Operating Temperature Range:	-40 to + 85 °C [-40 to +185 °F]
Storage Temperature Range:	-40 to +125 °C [-40 to + 257 °F]
Mating Connector:	Packard Electric 56 Series P/N 1205 2978 connector body with P/N 0296 5141 female gold-plated spade terminals
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab

CUMMINS SUPPLIER

Cutler-Hammer Products
Eaton Corporation
310 West Lake Street
Elmhurst, IL 60126
Telephone

5.4.5 Radiator Coolant Level Switch

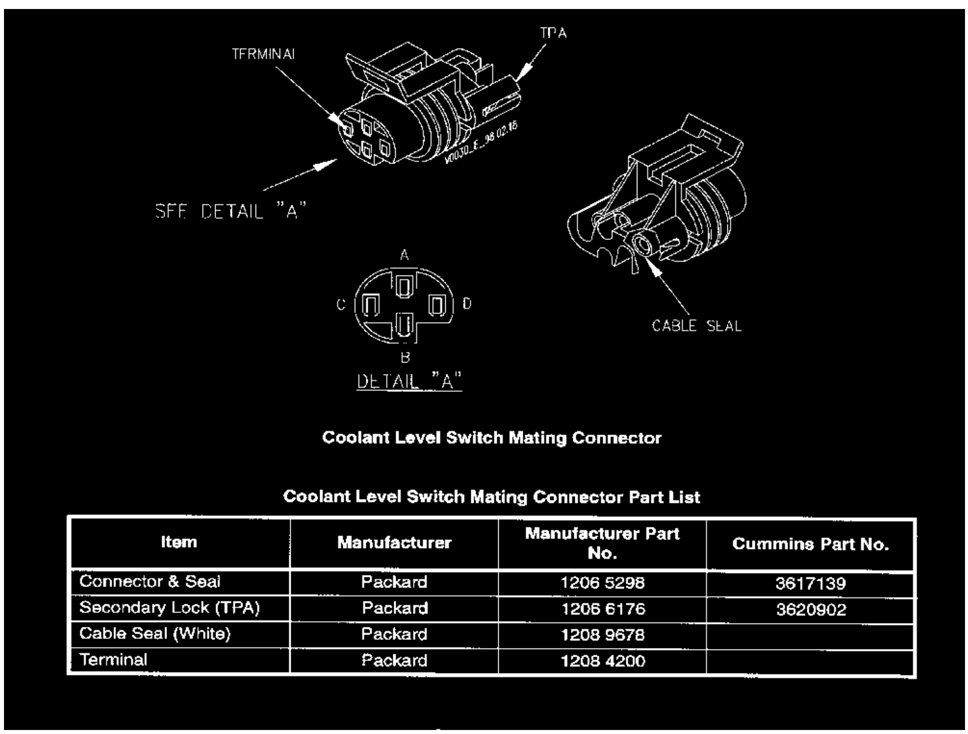
Packard P/N:	1206 5298
Drawing Number:	3612521 (Reference Only)
Specifications:	10657 Source Approval Method
	14121 Performance Standard
	14113 General Environmental Testing and Performance Standard

PART DESCRIPTION

This device monitors the coolant level in the upper reservoir of the radiator and provides a warning when coolant is being lost. It is an electronic switch which operates on the electrostatic or capacitance sensing principle. The probe of the component extends into the liquid and produces a change in electrical capacitance when liquid displaces the air immediately surrounding the probe. The change is converted within the component into an on/off solid-state switch closure and indicates the absence or presence of liquid. The probe is electrically insulated providing a slick, non-fouling surface as well as good electrical characteristics to prevent electric current flow through the liquid.

PART APPLICATION

The radiator coolant level switch is designed to be installed in the top of the radiator tank by the OEM. The tank requires a 1/4 NPT boss to locate the switch at the switching level desired.



Coolant Level Switch Mating Connector Part List

Item	Manufacturer	Manufacturer Part No.	Cummins Part No.
Connector & Seal	Packard	1206 5298	3617139
Secondary Lock (TPA)	Packard	1206 6176	3620902
Cable Seal (White)	Packard	1208 9678	
Terminal	Packard	1208 4200	

Figure 5-13: Radiator Coolant Level Switch

Radiator Coolant Level Switch
Robertshaw P/N: 85927-C1

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Supply Voltage:	+5V ±0.25V
On State:	3.5 Vdc minimum
Off State:	0.5 Vdc maximum
Load Resistance:	510 ohms ±5%
Case Isolation:	100 megohms
Response Time:	5 seconds maximum
Installation Torque:	34 ±7 N•m [25 ±5 ft•lbs]
Coolant:	Water, ethylene glycol (including corrosion/ scale inhibitors)
Operating Temperature:	-40 to +125 °C [-40 to +257 °F]
Storage Temperature Range:	-40 to +150 °C [-40 to +302 °F]
Mating Connector:	4-way integral shell with female tin-plated brass terminals
Environment:	Heavy-duty/Mid-range truck, industrial, off road; radiator mounted

CUMMINS SUPPLIERS

Robertshaw Controls Company
2318 Kingston Pike
P.O. Box 400
Knoxville, TN 37901-0400
Telephone: 423 546-0550

5.4.6 Remote Throttle/Remote PTO Switch

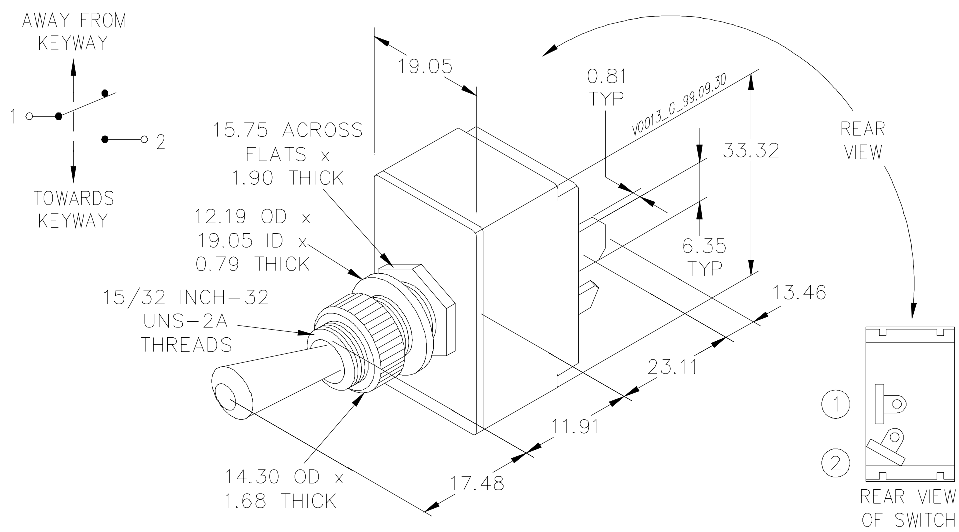
P/N:
Drawing Number:
Specifications: Source Approval Method
Performance Standard
General Environmental Testing and Performance Standard

PART DESCRIPTION

This switch is a two position toggle switch. As with other remote switches this must be a waterproof switch.

PART APPLICATION

This switch enables and disables the Remote Throttle feature. When enabled the Remote Throttle controls the engine with the same governor as the primary throttle.



Remote Throttle/Remote PTO Switch
P/N: 8956K639 Single Pole, Single Throw

KEY CHARACTERISTICS AND APPLICATION REQUIREMENTS

Current Rating:	10µA minimum, 6A maximum
Durability:	10,000 cycles at 10 mA contact current
Operating Temperature Range:	-40 to + 85 °C [-40 to +185 °F]
Storage Temperature Range:	-40 to +125 °C [-40 to + 257 °F]
Mating Connector:	Packard Electric 56 Series P/N 1205 2978 connector body with P/N 0296 5141 female gold-plated spade terminals
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab

CUMMINS SUPPLIERS

Cutler-Hammer Products
Eaton Corporation
310 West Lake Street
Elmhurst, IL 60126

5.5 LAMPS

5.5.1 Fault Lamps

Warning lamp
Stop lamp
Maintenance Lamp
Wait to Start Lamp

Specification: SAE Recommended Practice J1211

PART DESCRIPTION

These fault lamps are 12/24-volt incandescent. The Warning Lamp can have the word “warning” printed on it and Stop Lamp the word “stop”. These lamps will only be activated when the key switch is turned on and the current system condition exists.

PART APPLICATION

A Warning Lamp is required in the ISB4/ISBe system. It alerts the operator when a component or system fault is detected and signals the beginning of the code sequence during onboard diagnostics. The Stop Lamp is required during truck operation to signal a major system fault. During onboard diagnostics it flashes the codes which represent any faults detected by the ECM. A Maintenance Lamp is required to alert the driver to an out-of-range condition of the engine fluids.

The Wait To Start Lamp is require to alert the driver the system requires the cold start aids to ensure a proper start.

The terminals should be at a minimum tin-plated brass. The lamps are to be of adequate luminosity and mounted on the instrument panel in such a location as to be easily seen by the vehicle operator.

KEY SPECIFICATIONS AND APPLICATION REQUIREMENTS

Max Lamp Current:	300 mA @ 14/28V
Suggested Luminosity:	2 candlepower minimum
Max Voltage:	36 Volt (during jump start)
Terminals:	Tin-plated brass
Environment:	Heavy-Duty/Mid-Range truck, industrial, off road; in cab

CUMMINS SUPPLIER

Cutler-Hammer Products
Eaton Corporation
310 West Lake Street
Elmhurst, IL 60126

5.6 RELAYS AND RELAY ASSEMBLIES

5.6.1 Grid Heater Power Relays

White Rodgers P/N: 120-105111-5
Phone Number: (219) 583-4459

KEY CHARACTERISTICS

Coil:	
Max Pull-in Voltage:	10.5/21 vdc
Coil Resistance:	16 ohm
Max Battery Vdc:	16/32 vdc
Max Hold-in Voltage:	8.5/17 vdc
Contacts:	
Continuous Current Rating:	100 Amps
Inrush Current Rating:	400 Amps
Contact Material:	Silver (85%) Cd (15%)
Terminal:	5/16 - 24 (.388 minimum length)
Mounting Position:	Coil leads up or horizontal

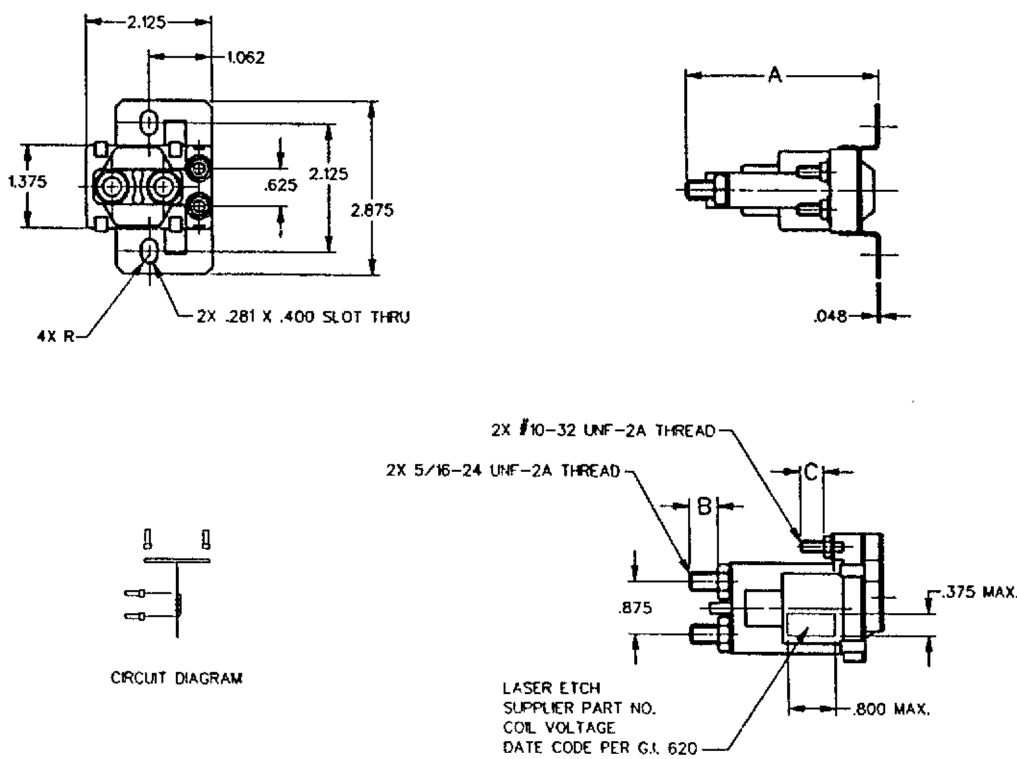


Figure 5-14: High Power Relay (Note: Drawing shown for form features only.)

5.6.2 Fuel Heater Relay

Potter & Brumfield P/N: VF28-65F14-Z03
KEY CHARACTERISTICS

Coil:	
Operate Voltage:	3.0 to 7.2 VDC
Release Voltage:	1.2 to 4.2 VDC
Coil Resistance:	90 Ohms +/- 10%
Equivalent Resistance:	80 Ohms +/- 10%
Contacts:	
Maximum Break Current:	40A @ 14 VDC Resistive
Max Continuous Current:	30 Amp max
Contacts Material:	Silver plated, over Nickel, SPDT, sealed

Siemens
200 S. Richland Creek Dr.
Princeton, IN 47671 (
Telephone: 812 386-1000

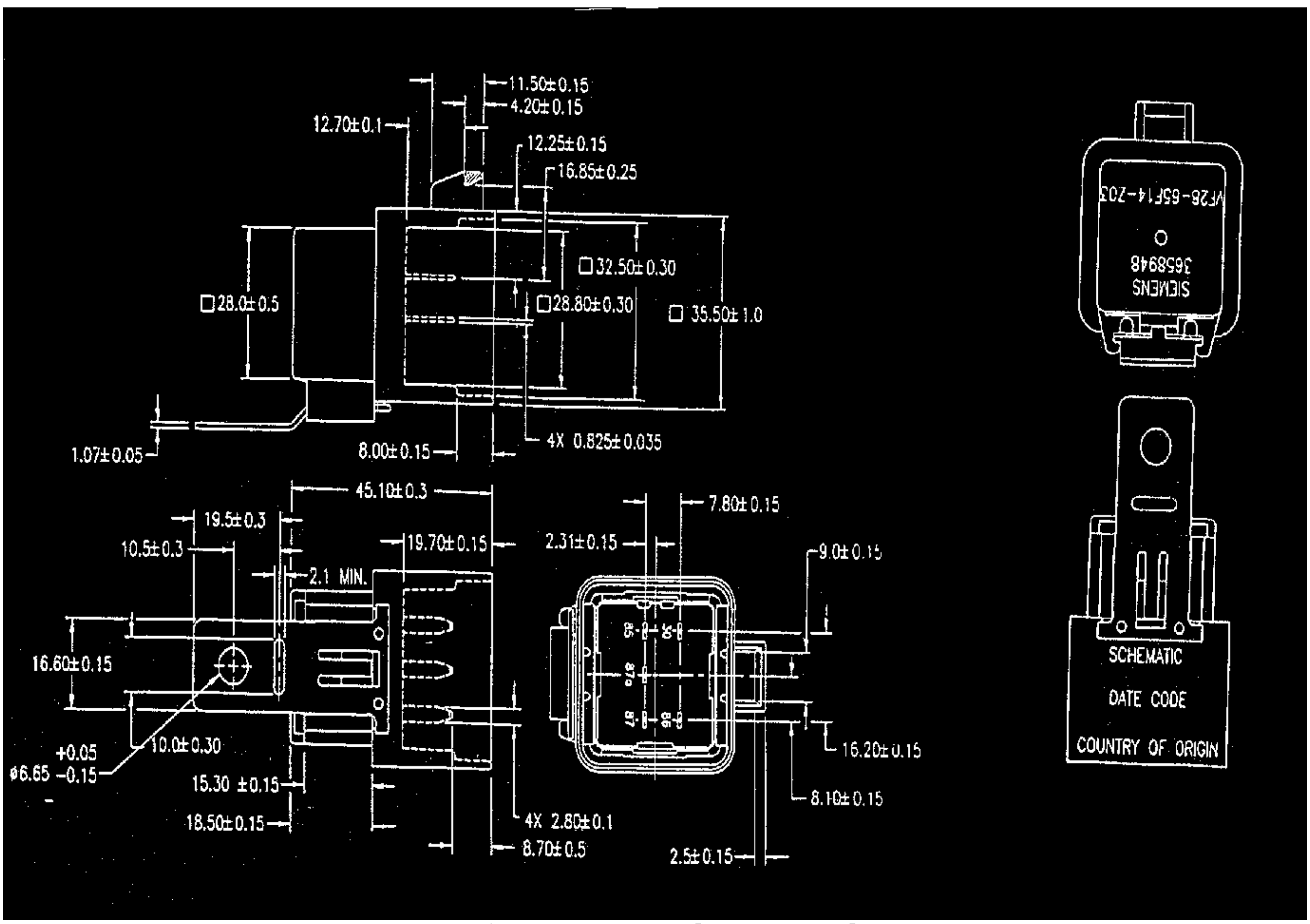


Figure 5-15: Fuel Heater Relay

5.7 COMPONENT SOURCES

Vendor Part No.	Component	Sources
Various	In-line connector	Packard Electric
737-8	Sensor, vehicle speed	Bosch
N/A	Sensor, accelerator position assembly	Williams Controls, Bendix-Allied, Econocruise
1749-2134	Switch, brake pressure	FASCO
N/A	Switch, clutch, rotary	Telemecanique
1749-2134	Limit switch, plunger	Telemecanique
8956K639	Switch, SPST	Cutler-Hammer
8956K638	Switch, 2-momentary, maintain center off	Cutler-Hammer
8956K1023	Switch, 2-pole, 3-position	Cutler-Hammer
5TF2LAB4	Lamp, amber	Cutler-Hammer
5TFLRB4	Lamp, red	Cutler-Hammer
N/A	Dual lamp housing	Cutler-Hammer
N/A	Single lamp housing	Cutler-Hammer
N/A	Warning/Stop lens	Cutler-Hammer
N/A	EPS/Wait lens	Cutler-Hammer
120-105111-5	Grid Heater Relays	White Rodgers
85927-C1	Switch, Radiator Coolant Level	Robertshaw Controls Co.
VF28-65-F14-Z03	Fuel Heater Relay	Potter & Brumfield

5.8 ELECTRONIC THROTTLE INTERFACE, CES 14118

See your Cummins Representative for a copy of the electronic throttle interface specification.

5.9 MIDRANGE ACCELERATOR PEDAL ASSEMBLY INSTALLATION RECOMMENDATIONS

5.9.1 Introduction

The following Installation Recommendations for the Midrange accelerator pedal assembly are offered as a guide to achieve a reliable and durable pedal assembly installation into a vehicle chassis environment. These recommendations are to provide the design engineer with foresight into the selection of this critical component of the Midrange electronic subsystem.

The specifications for the critical electrical interface between the OEM's vehicle system and the Midrange engine control system are found in the document Testing Method and Performance Standard 14118, Midrange Accelerator Pedal Assembly.

6 DIAGNOSTICS

Advanced diagnostics are included to make the ISB4/ISB^{e} engines straight forward to repair and service.

- Onboard Diagnostics
  - Extensive fault detection fault capability within the ECM
  - Flash out of fault codes
  - Fault lamps located on the cab dash to indicate warning/stop
  - Maintenance Lamp
  - Maintenance Monitor

- Offboard Diagnostics
  - INSITE: a windows-based PC service tool for Cummins electronic engines. It is used to help troubleshoot and repair ISB4/ISB^{e} engines.
  - Generic Scan Tools: the ISB4/ISB^{e} module will support generic scan tools via J1587 and J1939 public datalink communications per CES 14601.

6.1 ONBOARD DIAGNOSTICS

6.1.1 Fault Detection

Faults are records of system problems detected while the engine is running. If a problem is currently detected, a fault is logged in memory and a snapshot of engine parameters is logged. In addition, certain faults may illuminate the Warning Lamp, the Stop Lamp, or the Maintenance Lamp depending on the severity of the active fault.

For full list of fault codes please see Table 7-6.

6.1.2 Flash Out of Fault Codes

To flash out fault codes, the key switch is turned on and the engine is not cranking or running and the diagnostic mode is activated. If no active faults exist, the Stop and Warning Lamps will remain on without flashing. However, if active fault codes exist the diagnostic mode is enabled. The ECM will begin to flash out fault codes by first turning on the Warning Lamp. The Warning Lamp will turn off and the ECM will begin flashing the Stop Lamp in a sequence to represent the active fault code number. As the fault code is flashed short pauses will occur to indicate the completion of a digit. The Warning Lamp will turn on to indicate the beginning of a fault code. The ECM will continue to flash a fault until the user uses the idle increment or idle decrement switch to change to a new fault if present. The ISB4/ISB^{e} control system use three and four digit fault codes. The diagnostic mode will remain active until either the diagnostic switch is turned off or the engine is started.

6.2 OFFBOARD DIAGNOSTICS

6.2.1 Fault Information Management

INSITE lets the user display both active and inactive fault codes and erase only inactive fault codes from within the ECM. INSITE also provides engine monitoring and special diagnostic test capabilities.

6.2.1.1 Display Fault Codes and Fault Information

Faults recorded in the memory of the ECM can be displayed on INSITE. Fault information for the first and most recent occurrence are displayed.

- Fault Information Displayed
  - ECM run time
  - Cummins fault code
  - Parameter identifier (PID) or Subsystem Identifier (SID) or Suspect parameter number (SPN) and Failure Mode Identifier (FMI)
  - Fault Status (active/inactive)
  - Number of occurrences-counts
  - Snapshot data
  - Engine protection data

- ECM time at which fault occurred
- Lamp action

6.2.1.2 Erase Fault Codes

INSITE can erase all inactive fault codes and associated fault information from the ECM memory.

6.2.1.3 Save Fault Codes and Data

INSITE can save fault code information and engine protection data using the "Save Job Image" command. The "Save Job Image" command saves all information in all the dialogue boxes for the connected electronic control module (ECM) to a Paradox database. This "job image" is a snapshot of all the information related to a job at a specific point in time, including adjustable parameters, fault information, and so on. Job data can be viewed by selecting the "Open" command. Select the job image number in the paradox database of "Previously Stored Job Images".

Job data can also be imported and exported between INSITE stations. This allows the user the ability to transfer job images between mobile units (laptop computers) and stationary units (desktop computers). Some reasons for transferring data are shop records maintenance and print capability. Job data can be printed using the "Print" command.

6.2.2 Monitor Mode

The monitor functions as a set of gauges which allow the service technician to check basic information about engine performance while the engine is running. The screen displays engine variables, listed below, that are then monitored during engine operation while on the shop floor, on the Dynomometer or during road testing.

- % Fuel
- % Throttle
- Accelerator Type
- Air Conditioner Pressure Switch
- Ambient Air Pressure
- Battery Voltage
- Boost Pressure
- Cab Switchable Governor
- Calibration Software Phase
- Cam Sensor Engine Speed
- Clutch Switch
- Coolant Level
- Coolant Temperature
- Crank Sensor Engine Speed
- Cruise/PTO Status Switch
- Cruise/PTO Switch
- Cruise Set/Resume Switch
- Diagnostic Switch
- Door Interlock Switch
- Electronic Fuel Control Actuator Current
- Electronic Fuel Control Actuator Duty Cycle
- Engine Brake Switch
- Engine Governor Type
- Engine Oil Pressure
- Engine Oil Pressure Signal Voltage
- Engine Oil Temperature
- Engine Speed
- Exhaust Brake
- Fan Clutch % On
- Fuel Heater
- Fuel Rail Pressure
- Fuel Rail Pressure Signal

- Fuel Temperature (on pre MY04 engines)
- Gear Ratio
- Gear-Down Protection State
- HPCR Fuel Setpoint
- Idle Adjustment Switch
- Intake Air Heater #1
- Intake Air Heater #2
- Intake Manifold Temperature
- J1939 Broadcast
- J1939 Engine Control Source
- J1939 Engine Control Status
- J1939 Retarder Control Source
- J1939 Retarder Control Status
- J1939 Stop Broadcast Source Address One
- J1939 Stop Broadcast Source Address Two
- J1939 Stop Broadcast Source Address Three
- Key Off
- Key Switch
- Manual Fan Clutch Switch
- OEM Pressure
- OEM Temperature
- Power Train Protection Torque Limit
- PTO Validation
- Remote Switch
- Remote Throttle %
- Remote Throttle Switch
- Selected Throttle Control
- Service Brake Switch
- Switched Maximum Operating Speed Switch
- Throttle Signal Voltage
- Throttle Status (Idle Validation)
- Torque Limit Switch
- Total ECM Time (Keep on Time)
- Total Engine Hours (Engine Run Time)
- Two Speed Axle Switch
- User Fueling State
- Vehicle Acceleration Rate
- Vehicle Speed
- Water in Fuel Status

6.2.3 ECM Data Plate Information

Table 6-1: Minimum Required Data Plate Layout

Name of Field	Units
Engine MAKE	N/A
Engine MODEL	N/A
Engine Serial #	N/A
Engine Build Date	N/A
Engine CPL	N/A
Peak Torque Low Range	FT-LBS
Peak Torque High Range	FT-LBS

Name of Field	Units
Peak Torque RPM Low Range	RPM
Peak Torque RPM High Range	RPM
Governed Speed Low Range	RPM
Governed Speed High Range	RPM
Horsepower Low Range	HP
Horsepower High Range	HP
Horsepower RPM Low Range	RPM
Horsepower RPM High Range	RPM
Fuel Code/Pump Part Number	N/A
Percent Torque Rise	N/A
Peak Torque Rise	N/A
Peak Torque	FT-LBS
Peak Torque RPM	RPM
Governed Speed	RPM
Advertised Horsepower	HP
Advertised HP RPM	RPM
Module Identifier	N/A
ECM Part #	N/A
ECM Serial #	N/A
ECM Voltage Low Range	V
ECM Voltage High Range	V
ECM Code	N/A
Engine Calibration Time/Date Stamp	N/A
SC Option #	N/A
DO Option #	N/A
Other Options	N/A
Calibration Voltage Low Range	V
Calibration Voltage High Range	V
OEM Name	N/A
OEM Vehicle or Equipment Model	N/A
Vehicle Identification Number or Equipment Serial Number	N/A
Vehicle or Equipment Year	N/A

Name of Field	Units
Customer Name	N/A
Location	N/A
Unit Number	N/A
SC File B P/N 1	N/A
SC File B P/N 2	N/A
SC File B P/N 3	N/A
SC File B P/N 4	N/A
SC File B P/N 5	N/A
SC File B P/N 6	N/A
DO File B P/N 1	N/A
DO File B P/N 2	N/A
Module Hardware Manufacturing Date Code	N/A
Governor Type	N/A

6.2.4 Performance Tests

INSITE performs the following tests on ISB4/ISB^e systems:

- Single Cylinder Cutout Test
  - Enter cylinder number to cut out
  - Restore fueling to cut out cylinder
- Set up for Dynometer
  - Utilize ECM feature test hooks
  - Perform dyno/vehicle test without control system interference.
- J1939 Control Datalink Enable/Disable
  - J1939 Lock-in Mode
  - Allows the user to disable all J1939 control to the ECM
  - Used for diagnostics
- Intake Air Heater Override Test
- Fan Clutch Override Test
- Fuel System Leakage Test
- Fuel Pump Test

6.2.5 Special Functions

INSITE performs the following special functions:

- Display Audit Trail
  - ECM time
  - INSITE S/W serial number
  - Tool serial number
  - Parameters changed
- Display Datalogger (Different than User Data Logger)
  - Record engine parameters over a period of time
  - Record various trigger points
  - Record sampling rates
  - Save parameters to file for analysis
- View J1939 control information

- Display what 5 devices last controlled the ECM
- ECM Calibration
  - Function is contained in ESDN on INSITE

6.2.6 INSITE and ECM Security

6.2.6.1 Password Security

Cummins has devised a multi-level security plan to help limit any inappropriate use of the INSITE software. The software is serialized, and the serial number is written into the ECM audit trail if the software has been used to modify the ECM contents.

In order to use the software to communicate and change an ECM, a software "token" must be present when the software attempts to communicate with an ECM and the registration password must be entered. The registration password is unique to each serialized token diskette and must be obtained from Cummins Information Management System (IMS). On ECM-password protected modules, the user must also know the ECM password(s). Refer to 6.3.6.2 Multi-Level Security.

This token may be installed onto the computer hard disk from the INSITE Security Key diskette or left on the diskette. With the token present and validated, the computer can communicate with the ECM. The token may be moved to a different computer using the correct INSITE Security Key diskette. This transfer disables ECM communication on the first computer and enables it on the second computer. The software on the first computer can still be used for reference purposes after the token has been removed.

Another level of security is user passwords. System administrators can assign full or limited access to individual users. Each user can be limited access with unique user passwords. The following functions can be turned ON or OFF for specific users:

- act as system administrator
- calibrate an ECM
- modify parameters and features
- clear faults
- reset engine protection data
- reset J1939 information
- reset trip information
- reset maintenance monitor
- change ECM passwords
- import data
- modify emissions

6.2.6.2 Multi-Level Security

The multi-level security feature provides more flexibility for securing functions in the programmable memory of the ECM. This capability will:

1. Reduce the risk of unauthorized program memory changes that can compromise the performance of the engine.

2. Reduce the risk of unauthorized clearing of information in the ECM, thus insuring integrity of customer data residing in the ECM.

Levels affected with **passwords**:

1. **ECM Master Password** locks out the following:

   a. Feature Selection & Parameter Adjustment

   b. Calibration Transfers to the ECM

   c. Resetting Engine Protection Data

   d. Resetting Trip Information Data

e. Resetting the Maintenance Monitor

f. Changing the Adjustment & Reset Password

2. **Adjustment Password** locks out the following:

   a. Feature Selection and Parameter Adjustment

   b. Calibration Transfers to the ECM

3. **Reset Password** locks out the following:

   a. Resetting Engine Protection Data

   b. Resetting Trip Information Data

   c. Resetting the Maintenance Monitor

6.2.7 Fault Information System (FIS)

The FIS provides computerized troubleshooting capabilities. Diagnostics are performed in an interactive manner with the service technician responding to prompts displayed. Prompts are requests to make observations or perform certain tests.

The FIS includes symptom trees, control system specs, tools listing for controls system, and theory of operation for controls components.

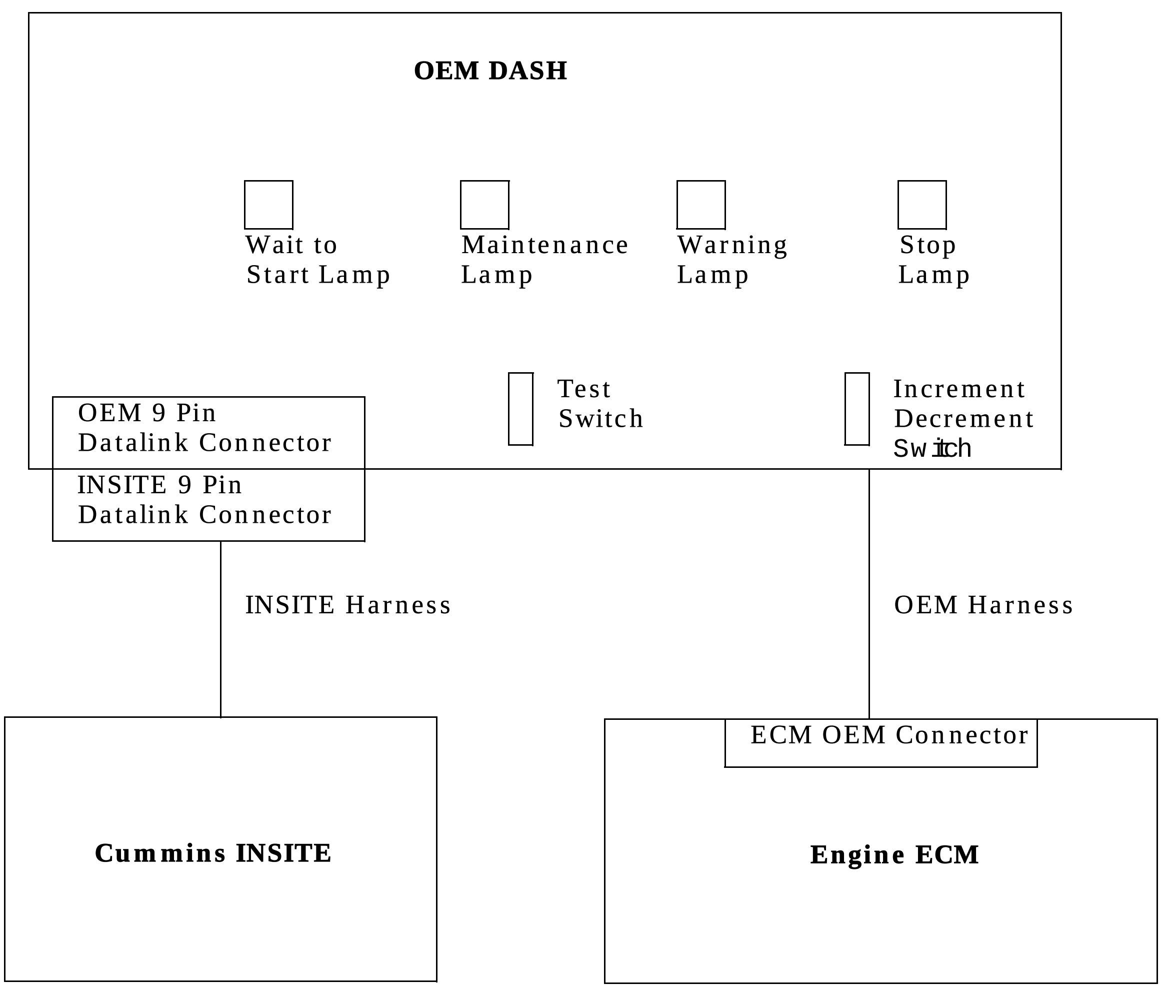


Figure 6-1. Service Tools for ISB4/ISB^e Engines

7 ELECTRONIC CONTROL MODULE SERIAL COMMUNICATIONS

7.1 Introduction

Serial Communications provide the means for electronic devices on the vehicle to interact with each other. Some typical functions performed are sharing of sensor data, sharing of calculated information, allowing subsystems (e.g. Engine, Transmission etc.) to influence each others operation, communication of subsystem operation state. Serial Communications also provide a means for on and offboard diagnostic work to be done.

This document, together with the SAE specifications listed below, contains the information required to apply the data link to vehicle applications. The intended utilization is to transmit and receive vehicle-related status, sensor and diagnostics information. The data links follow the recommended practices listed below:

SAE J1587	(March, 1996 plus 1/97 addendum) - Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy Duty Vehicle Applications.
SAE J1708	Physical Layer (October, 1993) - Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications.
SAE J1939	Recommended Practice for Serial Control and Communications Network (Class C) For Truck and Bus Applications Top Level Document (Jan. 31, 1994, Rev. 2)
SAE J1939/11	Recommended Practice for Serial Control and Communications Network (Class C) For Truck and Bus Applications Physical Layer (May 7, 1994)
SAE J1939/12	Physical Layer (working draft is ISO 11783 Part 2, May 1997) - Operates at 250K bits/sec, linear bus with twisted quad cable.
SAE J1939/13	Off-board Diagnostic Connector (January, 1997) - Specifies 9-pin Deutsch that will provide a connection to J1939, J1587, a second CAN network for implements, unswitched power and ground.
SAE J1939/21	Recommended Practice For Serial Control and Communications Network (Class C) For Truck And Bus Applications Data Link Layer (June 23, 1994)
SAE J1939/71	Recommended Practice For Serial Control And Communications Network (Class C) For Truck And Bus Applications Application Layer (Aug. 1994)
SAE J1939/73	Application Layer (October, 1998) - Diagnostics, defines capability required to perform diagnostics on J1939 - strategy to identify the least repairable subsystem that failed, how it failed, read and clear diagnostics fault codess, communication of diagnostic lamp status and providing a variety of parameters for monitoring by the service tool.
SAE J1939/81	Network Management (Novemeber, 1996)

The communication functions implemented are as follows:

Data Requests	Another device requests information from the electronic control module
Broadcasts	Messages sent without request with a predetermined time between updates
Data Writes	Devices with data that must be written to the electronic control module

J1939 communication support is discussed in detail in section 7.3.

7.1.1 Hardware Implementation

The Cummins ISB4/ISB^e ECMs have been designed with two serial communications ports. The first port provides access to the SAE J1587 network, while the second port provides access to the SAE J1939 network.

The first port is fully compatible with SAE J1708; it is assumed that it will be attached to SAE J1587 compatible onboard devices such as dashboard controllers and vehicle information systems.

The second port is fully compatible with SAE J1939/11 and supports the power train control, info sharing, diagnostic, and proprietary functions of J1939.

7.2 J1587 SERIAL COMMUNICATIONS

7.2.1 Introduction

SAE J1587 is a J1708 based network which operates at 9600 baud. It supports information sharing, diagnostics and proprietary communications. The network can have a maximum of 20 node connections at a given time.

7.2.2 Message Priority

The message priority for all SAE J1587 communications specified in this document is priority 3.

7.2.3 Communications Requests

7.2.3.1Data Requests

The SAE J1587 specification has two request-for-parameter identification types. The first is parameter identifier 0 (PID 0) which requests data from all units on the bus for that parameter; the bus consists of all devices on the data link communicating with the ECM. The second is PID 128 which requests data only from the specific unit addressed by the format. (See SAE J1587 PID 0 and PID 128 for details.) Both are implemented in ISB4/ISB^e. The data request works with any message identifier (MID) with an assigned unit number of 128 or above as specified. The message identifier for the ECM is 128.

The list of the PIDs available for request are given in Table 7-1 on page 108 and the parameter specifications are given in Table 7-2 on page 109. Scaling and bit maps for the above parameters are as defined in the January 1994 version of SAE J1587 specification except where otherwise specified.

7.2.3.2Broadcasts

A broadcast is a message sent without request with a predetermined time between updates. The acceptable range of time between updates is 0.1 to 25.5 seconds and in increments of 0.1 second. The calibration contains broadcasted parameter identifiers, the names of the parameters to be sent and the time between updates.

The Cummins standard broadcast PID and timing information are defined in TableTitle: Table 7-1: PIDs Supported on J1587 . Any parameter identifier that is available by request can be broadcast with the exception of PID 192 (multisection parameter). Broadcasts requiring multiple packets are fully acceptable and functional. The limit on the number of J1587 broadcast PIDs is 40.

7.2.3.3Data Writes

Parameters are written into the ECM if the MID is authorized by Cummins and if the PID is authorized for that MID. The data written may be transmitted by a broadcast. The available, authorized data writes are given in Table 7-3 on page 110.

7.2.4 Integrity

7.2.4.1 Error Detection

The error detection is implemented by the following constraints:

- A message packet received with a bad checksum is ignored.
- A message length greater than 21 ASCII characters is ignored.
- An unauthorized MID or authorized MID with an invalid PID is ignored for data write functions.
- An unauthorized PID is ignored in the packet.

7.2.4.2 Collision Avoidance

Collision avoidance is performed by hardware, software and system design. Added hardware that gives enhanced collision avoidance is the start-bit-detect logic, a sign of a high-to-low transition. It indicates when a message has started after an idle line has been detected. This has an advantage over the typical universal asynchronous receiver transmitter (UART) that indicates only when a full character has been received. It is required to have a start-bit-detect in order to meet SAE J1708 access time constraints. Collision avoidance can also be assured by the vehicle network system designer. The equal distribution of message priorities, the minimization of information sent, the utilization of broadcast instead of data request and the packing of PIDs in message packets all reduce the number of collisions. (See section 7.2.4.2 for the effect of collisions on bus utilization.)

7.2.5 Operational Notes

7.2.5.1 Packing PIDs and Data

It is preferred that multiple PIDs and data be packed in single message packets if possible. The Cummins ISB4/ISBe ECMs can handle messages that contain up to 21 ASCII characters. Some received messages may require multiple message responses. Packing the information in as few messages as possible reduces the amount of overhead associated with message handling.

Messages requiring PID data greater than 21 ASCII characters are formatted in the PID 192 format. Information requests such as trip recorder data and component identification require the PID 192 format.

7.2.5.2 Normal Data Transfer

The normal transfer of information should be through the broadcast; request for data should be used for occasional-use items only. This saves bus utilization time which is a limited resource.

If the ECM is not processing a broadcast and a request for data occurs, the ECM will service the request for data before it services the broadcast, should one occur. However, a broadcast-in-process is responded to before a request for data is serviced. No message data is lost in either case.

7.2.5.3 Bus Utilization

As mentioned in Section 7.2.5.2, bus utilization time is a limited resource and the SAE bus can be saturated by excessive use. An allocation of time for broadcast and data request and for response must be set for each module.

For the ECM broadcast, the bus utilization is calculated as follows:

U = bus utilization = B/N

Where:

N = baud rate/number of bits per character
= 9600/10 = 960

RA = access bytes + MID byte = 3.0 (assumes two tries, winning half the time)

C#	=	number of collisions. This number is dependent on the number of units on the bus with equal priority, the size of the message and the total number of messages to be transmitted on the bus.
Ct	=	collision bytes = re-access bytes * number of collisions = RA * C#
B	=	number of bytes broadcasted per second
	=	B1 + B2 + B3 + Ct
B1	=	bytes for access *maximum broadcast rate
	=	2 * 10
		Note: 20 bits (two transmission bytes) are approximately equal to the access time plus the priority time. This assumes only one packet per broadcast.
B2	=	bytes for overhead of each packet * maximum broadcast rate = 2 * 10 (overhead is the MID and checksum)
B3	=	total number of bytes broadcasted (byte count * update frequency * number of PIDs rate)

For example, for the following table:

PID	Parameter Description	Bytes	Broadcast Rate
190	Engine Speed	3	00.1 sec
091	Percent Throttle	2	00.1 sec
183	Fuel Rate	3	00.2 sec
102	Boost Pressure	2	01.0 sec
002	Status Word 1	2	01.0 sec
110	Engine Coolant Temperature	2	01.0 sec
086	Cruise Control Set MPH	2	10.0 sec

B3	=	3 *10*1 + 2*10*1 + 3*5*1 + 2*1*3 + 2*0.1*1
	=	71.2 for the above table
Ct	=	3 (assuming one collision per second)
		For the above example, with only two similar devices on line, the collision rate is one per minute. With a third device on line, which is not respecting SAE access times, the collision rate is one per second.

For the above example, the utilization is calculated as follows (assuming three devices are on line):

B	=	B1 + B2 + B3 + Ct = the number of bytes broadcasted
	=	20 + 20 + 71.2 + 3.0
	=	114.2
U	=	B/N = 114.2/960 = utilization
	=	11.89% utilization

The number of collisions increases with the number of units on the bus and the amount of information transferred. The vehicle manufacturer and other users must avoid adding devices that do not follow SAE access constraints. These devices may significantly increase the number of collisions and the utilization of the bus. In addition, caution should be taken in adding aftermarket products to the bus because these devices may cause bus operation problems if they are not strictly compatible with SAE J1587 and J1708. Any added device should be approved by the vehicle manufacturer.

The managing of a vehicle data bus network is not a simple task if the bus is used near its full capacity. It is recommended that either a statistical analysis and/or a software simulation be employed to analyse the total vehicle bus.

7.2.5.4 Message Identifier Usage

The ECM reserves the following list of MIDs for the J1708 serial communications port.

MID	Description
0 - 7	**Available in ISB4/ISB^e product**
69 - 86	**Not available in ISB4/ISB^e product**
128	Used for all SAE J1587 communications from the ECM
129 - 253	Reserved for all SAE J1587 applications

The percent of bus utilization calculated for broadcast data of the Cummins device using MID 128 is found in Section 7.2.5.3.

MIDs 129 - 253 are as defined by SAE J1587. See Table 7-3 on page 110 for MIDs that are available for authorized data writes. The ECM will respond to requests from any of the MIDs in the range of 129-253.

7.2.6 More Detail on PIDs

The SAE J1587 specification does not contain all the information on PIDs 2, 3 and 193. Cummins has provided the following detailed definitions:

7.2.6.1 PID 2 - Status Word 1

Bit 1 - Boost Pressure	0 = OK	1 = Exceeds Limits
Bit 2 - Oil Pressure*	0 = OK	1 = Exceeds Limits*
Bit 3 - Engine Speed	0 = OK	1 = Exceeds Limits
Bit 4 - Coolant Temperature	0 = OK	1 = Exceeds Limits
Bit 5 - Oil Temperature*	N/A	Not available
Bit 6 - Throttle	0 = OK	1 = Exceeds Limits
Bit 7 - Amber Lamp	0 = Off	1 = On
Bit 8 - Red Lamp	0 = Off	1 = On

Note: Limits are engine limits, not sensor limits.

7.2.6.2 PID 3 - Diagnostic Status

Bit 1 - Idle Increment on Control Panel	0 = Off	1 = On
Bit 2 - Idle Decrement on Control Panel	0 = Off	1 = On
Bit 3 - Test Mode Switch on Control Panel	0 = Off	1 = On

7.2.6.3 PID 193 - Diagnostic Table

This PID calls for any fault codes that are stored in a fault buffer. The format is as follows:

Position	Character	Description	Notes
1	128	Message identifier for engine control	
2	193	Parameter ID for diagnostic table	(1)
3	0 or K	Zero if no faults have occurred or K which is the number of fault codes which follow	(2)
N	Fault Number	The diagnostic number/code as noted in the table below	(3)
Last	CS	Checksum of message packet	

This information is available only on request.

(1) Diagnostic codes are defined only as they apply to troubleshooting. These are listed in Table 7-6 on page 18 by fault number, Cummins code, SAE J1587 diagnostic PID or subsystem identifier (SID), and the SAE J1587 failure mode identifiers (FMI).

(2) If there are more than 17, then PID 192 will be used.

. (3) N can be 4 to 17 depending on the number of faults. Each fault number is one byte in length. The most significant bit is set to 1 indicating an active fault or set to 0 indicating an inactive fault.

7.2.6.4PID 194 - Transmitter System Diagnostic Code and Occurrence Count Table

The following list is the Cummins definition and description of the SAE J1587 and J1939 failure modes identifiers.

FMI	Cummins Description
0	*Data Valid but Above Normal Operational Range - Most Severe Level*

The signal communicating information is within a range which is defined acceptable and valid, but the real world condition is above what would be considered normal by the predefined limits for that particular measure of the real world condition (region e of signal range definition).

1 *Data Valid but Below Normal Operational Range - Most Sever Level*

The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal by the predefined limits for that particular measure of the real world condition (region d of signal range definition).

2 *Data Erratic, Intermittent or Incorrect*

Erratic or intermittent data includes all measurements that change at a rate that is not considered possible in the real world condition and must be caused by improper operation of the measuring device or its connection to the module. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

Incorrect data includes any data not received and any data that is exclusive of the situations covered by FMIs 3, 4, 5, and 6 below. Data may also be considered incorrect if it is inconsistent with other information collected or known about the system.

3 *Voltage Above Normal or Shorted to **High** Source*

a. A voltage signal, data or otherwise, is above the predefined limits that bound the range (Region g of the signal range definition). Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

b. Any signal external to an electronic control module whose voltage remains at a high level when the ECM commands it to low. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

4 *Voltage Below Normal or Shorted to **Low** Source*

a. A voltage signal, data or otherwise, is below the predefined limits that bound the range (Region f of the signal range definition). Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

b. Any signal external to an electronic control module whose voltage remains at a low level when the ECM commands it to high. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

5 *Current Below Normal or Open Circuit*

a. A current signal, data or otherwise, is below the predefined limits that bound the range (Region f of the signal range definition). Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

b. Any signal external to an electronic control module whose current remains off when the ECM commands it on. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

6 *Current Above Normal or Grounded Circuit*

a. A current signal, data or otherwise, is above the predefined limits that bound the range (Region g of the signal range definition). Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

b. Any signal external to an electronic control module whose current remains on when the ECM commands it off. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

7 *Mechanical System Not Responding or Out of Adjustment*

Any fault that is detected as the result of an improper mechanical adjustment or an improper response or action of a mechanical system that, with a reasonable confidence level, is not caused by an electronic or electrical system failure.

8 *Abnormal Frequency or Pulse Width or Period*

Abnormal frequency is defined as any frequency or PWM signal that is outside the predefined limits which bound the signal range for frequency or duty cycle (outside Region b or the signal definition).- To be considered in cases of FMIs 4 and 5. Also, if the signal is an ECM output, any signal whose frequency or duty cycle is not consistent with the signal which is emitted. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

9 *Abnormal Update Rate*

Any failure that is detected when receipt of data via the data link bus or as input from a smart actuator or smart sensor is not at the update rate expected or required by the ECM (outside Region c of the signal range definition). Any error that causes the controller not to send information at the rate required by the system.

10 *Abnormal Rate of Change*

Any data, exclusive of the abnormalities covered by FMI2, that is considered valid but whose data is changing at a rate that is outside the predefined limits that bound the rate of change for a properly functioning system (outside Region c of the signal range definition).

11 *Root Cause Not KNown*

It has been detected that a failure has occurred in a particular subsystem but the exact nature of the fault is not known. Broadcast of data value is stopped. Default value is returned upon request via PID/SID.

12 *Bad Intelligent Device or Component*

Inconsistency of data indicates that a device with some internal intelligence, such as a controller, module, smart sensor or smart actuator, is not properly functioning. This data may be internal to a module or external from a data link message or from various system responses. Broadcast of data value is stopped. Default value is returned upon request via PID/SID. This error is to include all internal controller faults that cannot be caused by connections or systems external to the controller.

13 *Out of Calibration*

14 *Special instructions*

15 *Reserved for assignment by the SAE Data Format Subcommittee (J1587 only)*

Note: The J1587 has only the above mentioned FMI's. The following FMI's apply only to the J1939.

15 *Data Valid but Above Normal Operating Range - Least Severe Level*

16	*Data Valid but Above Normal Operating Range - Moderately Severe Level*
17	*Data Valid but Below Normal Operating Range - Least Severe Level*
18	*Data Valid but Below Normal Operating Range - Moderately Severe Level*
19	*Received Network Data in Error*
20-30	*Reserved for SAE Assignment*
31	*Not Available or COndition Exists*

7.2.6.5 PID 243 - Component Identification

The component identification is presented in PID 192 format. The form is as follows:

Packet 1

80,CO,11,F3,20,1F,MK,MK,MK,MK,2A,EM,EM,EM,EM,EM,EM,EM,EM,CS

Packet 2

80,CO,11,F3,21,EM,EM,2A,SN,SN,SN,SN,SN,SN,SN,SN,SN,SN,SN,CS

Packet 3

80,CO,04,F3,22,SN,SN,CS

Where

80	= Engine MID
CO	= PID 192 label
11	= Packets 1 and 2 data byte count
F3	= MID 243 label
20	= Upper nibble = last packet number = Lower nibble = present packet number for packet
1F	= Total message length
MK	= ASCII characters of engine make
2A	= ASCII for "*" This is used as a data field terminator.
EM	= ASCII characters of engine model
CS	= Checksum
21	= Upper nibble = last packet number = Lower nibble = present packet number for packet
04	= Packet 3 data byte count
22	= Upper nibble = last packet number = Lower nibble = present packet number for packet
SN	= ASCII engine serial numbers

7.2.7 Bus Utilization for J1587 Standard Broadcast Data

Bus utilization for J1587 standard broadcast data in Table 7-1: PIDs Supported on J1587 :

B3 = number of message bits (assume one active fault)
B3 = 2*10*2 + 3*10*1 + 2*5*2 + 3*5*1 + 2*1*9 + 3*1*2 + 5*1*1 + 2*0.1*1 + 3*0.1*2 + 5*0.1*2 + 3*5*1 + 2*10*1
= 40 + 30 + 20 + 15 + 18 + 6 + 5 +.2 +.6 + 1 + 15 + 20
= 170.8

B2 = packet overhead
= 2*10 + 2*1 = normal packet frequency + 2nd packet frequency
= 22

B1 = access overhead
= 22

Ct = collision bytes
= 3 (assuming one collision per second)

Bus Utilization = (B1 + B2 + B3 + Ct)/960
= (170.8 + 22 + 22 + 3)/960
= 217.8/960 = 0.227

Bus Utilization = 22.7%

7.2.8 Assumptions and Definitions For FMIs

1. Data: Any information pertaining to physical conditions that is communicated to an electronic module in the form of voltage, current, PWM signals or data streams.

2. Real World: Mechanical parameters or operating conditions that can be measured in the form of voltage, current, PWM signals, data streams, etc.

3. Signal Range Definitions:

```
|------------------------------a-----------------------------------|

|------f----|-----d-----|---------c----------|-------e------|------g------|

|--------------------b-----------------------|
```

Region a: Total signal input range possible that can be seen by an electronic module.

Region b: Total signal range physically possible as defined by an application.

Region c: Range defined as normal for a given real world measurement.

Region d: Range defined as critically below what is considered normal for the given world measurement.

Region e: Range defined as critically above what is considered normal for the given real world measurement.

Region f: Range which is low outside the range of what is considered physically possible for a given system, indicating a short to a low source has occurred.

Region g: Range which is high outside the range of what is considered physically achievable.

Table 7-1: PIDs Supported on J1587

PID	Parameter Description	Bytes (Includes PID)	Broadcast Rate	Notes
044	Attention / Warning Lamp Status	2	1.0 sec or on state change of the lamp	
045	Inlet Air Heater Status	2	1.0 sec	
071	Idle Shutdown Timer Status	2	1.0 sec	
074	Maximum Road Speed Limit	2	On Request	
084	Road Speed	2	0.1 sec	
085	Cruise Control Status	2	0.2 sec	
086	Cruise Control Set Speed	2	On Request	
087	Cruise Control High Set Limit Speed	2	On Request	
088	Cruise Control Low Set Limit Speed	2	On Request	
089	Power Takeoff Status	2	1.0 sec	
091	Percent Accelerator Pedal Position	2	0.1 sec	
092	Percent Engine Load	2	0.1 sec	
097	Water In Fuel Indicator	2	10 sec	
100	Oil Pressure	2	1.0 sec	
102	Boost Pressure	2	1.0 sec	
105	Intake Air Temperature	2	1.0 sec	
110	Engine Coolant Temperature	2	1.0 sec	
121	Engine Retarder Status	2	On Request	
128	Component Specific Parameter Request	3	On Request	
137	Aux Pressure Sensor (OEM Pressure)	3	On Request	
166	Rated Engine Power	3	On Request	
168	Volts (Battery)	3	1.0 sec	
174	Fuel Temperature	3	On Request	
175	Oil Temperature	3	1.0 sec	
182	Trip Fuel	3	10.0 sec	
183	Fuel Rate	3	On Request	
184	Instantaneous MPG	3	0.2 sec	
185	Average Fuel Economy	3	On Request	
187	PTO Set Speed	3	10.0 sec	
188	Idle Engine Speed	3	On Request	
189	Rated Engine Speed	3	On Request	
190	Engine Speed	3	0.1 sec	
192	Multisection Parameter	Variable	As Needed	

Table 7-1: PIDs Supported on J1587

PID	Parameter Description	Bytes (Includes PID)	Broadcast Rate	Notes
194	Transmitter System Diagnostic Code and Occurrence Count Table	Variable	1.0 sec	(2)(4)
196	Diagnostic Data Request/Clear Count	Variable	On Request	
197	Connection Management	Variable	On Request	
198	Connection Mode Data Transfer	Variable	On Request	
222	Anti-Theft Status Report	Variable	On Request	
234	Software Identification	Variable	On Request	
235	Total Idle Hours	5	On Request	
236	Total Idle Fuel Used	5	On Request	
237	Vehicle Identification Number	Variable	On Request	
243	Component Identification Parameter	Variable	On Request	
244	Trip Distance	5	10.0 sec	
245	Total Vehicle Distance (See Appendix B)	5	10.0 sec	
247	Total Engine Hours	5	On Request	
248	Total PTO Hours	5	On Request	
250	Total Fuel Used	5	On Request	
252	Date	4	On Request	
254	Escape	Variable	On Request	
441	Auxiliary Temperature #1	4	On Request	

(1) The present SAE specification does not contain all the required application information.
(2) Cummins PID 194 messages include occurrence count when requested. When PID 194 is broadcast, the fault count information is not included.
(3) This PID is available for systems which were designed before the availability of PID 194. PID 194 should be used for new products.
(4) Active faults are broadcast at the rates specified in the J1587 document. Inactive faults are only available on request.

NOTE: Table 7-2, which follows, contains the specifications for engine and vehicle data used by the ECM.

Table 7-2: J1587 Parameter Specifications

PID	Parameter	Resolution	Accuracy	Sample Rate	Filtered Data	Time Constant
74	Maximum Road Speed	0.5 mph	--	--	No	--
84	Road Speed	0.5 mph	--	0.04 s	Yes	0.7 s
86	Cruise Control Set Speed	0.5 mph	--	100 ms	No	--
87	Cruise Control High Limit	0.5 mph	--	--	No	--

Table 7-2: J1587 Parameter Specifications

PID	Parameter	Resolution	Accuracy	Sample Rate	Filtered Data	Time Constant
88	Cruise Control Low Limit	0.5 mph	--	--	No	--
91	Throttle	0.4%	± 5%	0.02 s	Yes	0.02 s
92	Percent Engine Load	0.5%	± 10%		No	
100	Oil Pressure (1)	0.5 psi	± 1.0 psi	0.02 s	Yes	0.02 s
102	Boost Pressure	0.125 psi	± 0.5 psi	0.02 s	Yes	0.02 s
105	Intake Manifold Air Temp (1)	1.0 °F	±5 °F	0.02 s	Yes	0.02 s
110	Engine Coolant Temperature (2)	1.0 °F	±6 °F	0.02 s	Yes	0.02 s
175	Engine Oil Tempera-ture	0.25°	--	.040	Yes	--
164	Fuel Rail Pressure	1/256 mpg	--	.010	Yes	--
168	Battery Voltage	1/8 V		0.04 s	Yes	0.04 s
183	Fuel Rate (1)	4.34 E-6	TBD	0.2 s	No	--
184	Instantaneous MPG	1/256 mpg		0.2 s	No	
185	Average MPG	1/256 mpg		0.2 s	Yes	Complex
187	PTO Reference	0.25 rpm	±1 rpm		No	--
188	Idle Engine Speed	0.25 rpm	±1 rpm	--	No	
189	Maximum Engine Speed	0.25 rpm	±1 rpm	--	No	
190	Engine Speed	0.25rpm	±1 rpm	0.02 s	No	
247	Total Engine Hours	0.05 hours		0.2 s	No	--

(1)For temperature readings, sensor response time to a step change from 0 to 100 °C (32 to 212 °F) is 10 to 30 seconds.
(2)This is the engine speed reference, not the rotational speed of the PTO device.

Table 7-3: Available Authorized Data Writes

PID	Parameter Description	Bytes	MIDs Notes
195 (1)	Diagnostic Data	N	154, 172,
	Request/Clear Count		141, 180, 182

(1) Cummins supports PID 195, Request Counts Be Cleared, for all diagnostic codes on the device with the given MID function. This occurs when bits 7 and 8 or the diagnostic code character are set to 0 and 1 (binary) respectively. Reference SAE J1587 for a more detailed description of PID 195. The ECM acknowledges an authorized PID 195 request with a PID 196.

7.3 J1939 SERIAL COMMUNICATIONS

7.3.1 Introduction

SAE J1939 datalink is a high speed network for vehicles which operates at 250K baud. It is capable of supporting control, information sharing, diagnostics, multiplexing and proprietary communications. The J1939 (physical layer) datalink uses a differential line driver circuit and allows a maximum bus length of 40 meters. The network can have a maximum of 30 node connections at a given time.

7.3.2 Hardware Implementation

The port is fully compatible with SAE J1939/11 and supports the power train control, info sharing, diagnostic, and proprietary functions of J1939.

A list of supported messages has been included in Table 7-1 on page 108. Cummins has identified five categories of J1939 capability. They are: (1) Powertrain Control, (2) Information Sharing, (3) Diagnostics, (4) Multiplexing and (5) Proprietary Communications. The information presented in Table 7-1 on page 108 covers the Powertrain Control and Information Sharing, Diagnostics, and Proprietary Communications (current level of support) capabilities of the product.

7.3.3 Messages Supported on J1939

Cummins has identified six categories of J1939 capability. They are:

(1). Powertrain Control (PT)

The powertrain control category comprises of parameters exchanged between the engine and devices such as transmission, ASR and ABS.

(2). Information Sharing (IS)

This category has parameters pertaining to general engine operation. These parameters can be broadcast as well as be provided upon request from a remote system. For example - engine coolant temperature, engine oil pressure etc.

(3). Diagnostics (DG)

This category comprises of parameters that are used to convey fault information, have capability to command system tests, access test results, clear active and inactive diagnostic trouble codes and access emissions related active diagnostic trouble codes separately from other diagnostic trouble codes (DTCs).

(4). Multiplexing (MX)

What is Multiplexing - J1939 Multiplexing is sending or receiving of input and output control commands using J1939 datalink instead of individual hard wires. The enables for multiplex parameters are service trims and can be adjusted with VEPS. The source address from which the parameter is multiplexed is also VEPS trimmable. Please refer to 1377 - 9804 - J1939 Multiplexing of Inputs and Outputs (Interface Specification) for details.

All parameters that help accomplish multiplexing fall in this category.

(5). General (G)

All other non-proprietary J1939 requirements that are not covered in the other 5 categories are grouped under General. For example - Acknowledgment (ACK/NACK), Transport Protocol.

(6). Service/Proprietary (SP)

This category comprises J1939 messages which can be used to convey proprietary information. For example - PGN for Proprietary A.

The Table 3, below lists all J1939 PGNs and parameters that are supported on CM550/CM554 for ISB, ISC and ISL engine platforms. Please read the following notes in order to understand the contents of the table.

Notes To Aid Understanding of Table 3:

1). Column one lists the SAE defined PGN names. Also, SA/DA refers to the Source Address/Destination Address and listing of SAE defined PGN numbers is given. As an example, the combination of PGN 00000 - TSC1 and Trans(3)/Engine(0) should be interpreted as TSC1 is sourced from the Transmission (J1939 address 3) and received by Engine (J1939 address 0). Also note that any PGN can be requested by any source with a J1939 address. Where this is not true, the specific addresses have been listed.

Some PGNs are not completely defined in SAE J1939 -71 and -73. They are denoted with a superscripted asterisk "*". Please refer to the notes at the end of the table for details.

2). Column 2 lists the update rate of the PGN in CM800

3). Column 3 indicates which Cummins defined category the parameter falls in. Please note that there are cases where the parameter may belong to more than one category. For example - Parameter "engine Derate Switch" belongs to both IS/MX. Also read Note 6.

4). Column 4 lists the parameters within the PGN.

5). Column 5 describes parameter support for ISB^E and ISB4. *TX* means that the parameter is transmitted from the engine, *RX* means that the engine receives the parameter, an entry *no* means that the parameter is not supported. Support of a J1939 parameter listed as both *TX/RX*, means the following:

under a non-multiplexed case, the parameter value is transmitted (TX) from Engine

under a multiplexed case, the parameter value is received (RX) by Engine

The broadcast of certain J1939 Parameters shall be dependent upon the override trims for those parameters. These trims can only be changed (enabled/disabled) prior to the powerup sequence. When the overrides have been enabled. J1939 Parameters for those System Names shall be broadcast with N/A (11_2 for switches & FF_{16} for analog values.)

Note: Multiplexing - If the hardwire is still attached to the ECM for that particular switch/sensor and the parameter is set to be multiplexed, then the ECU will ignore the hardwire input.

Table 7-4: Messages Supported on J1939

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J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Electronic Engine Controller #1 -EEC1 Engine (0)/ None PGN - 61444	0.02 s	PT PT PT PT PT	1) Engine Torque Mode 2) Drivers demand engine - percent torque 3) Actual Engine - percent torque 4) Engine Speed 5) Source Address of controlling device for engine control	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx
Electronic Engine Controller #2 -EEC2 Engine (0)/ None PGN - 61443	0.05 s	PT PT/MX PT/MX PT PT/MX	1) AP kick down switch 2) AP low idle switch 3) Accelerator pedal (AP) position 4) Percent load at current speed 5) Remote Accelerator	1) Tx 2) Tx/Rx 3) Tx/Rx 4) Tx 5) Tx/Rx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Electronic Engine Controller #3 -EEC3 Engine (0)/ None PGN - 65247	0.25 s	PT PT PT	1) Nominal friction-percent torque 2) Engine's desired operating speed 3) Engine's operating speed asymmetry adjust	1) Tx 2) Tx 3) Tx
Torque/Speed Control #1 - TSC1 Trans.(3) / Engine (0) ABS(11) / Engine (0) ASR(33) / Engine (0) PGN - 00000	0.01s	PT PT PT	1) Override control mode priority 2) Desired speed control conditions 3) Override control mode A) Override disabled (00) B) Speed control (01) a) desired speed b) desired speed control conditions C) Torque control (10) a) desired torque b) desired speed control conditions D) Speed/torque limit control (11) a) speed and torque limit b) desired speed control conditions	1) Rx 2) see 3 - B,C,D 3) Rx A) Rx B) Rx a) Rx b) Rx C) Rx a) Rx b) no D) Rx a) Rx b) no
Torque/Speed Control #2 - TSC1 Trans.(3) / Exh Retarder (41) / Eng Retarder (15) ABS(11) / Exh Retarder(41) / Eng Retarder (15) ASR(33) / Exh Retarder(41) / Eng retarder (15) PGN - 00000	0.05 s	PT PT PT	1) Override control mode priority 2) Desired speed control conditions 3) Override control mode A) Override disabled (00) B) Speed control (01) a) desired speed b) desired speed control conditions C) Torque control (10) a) desired torque b) desired speed control conditions D) Speed/torque limit control (11) a) speed limit b) torque limit c) desired speed control conditions	1) Rx 2) see 3 - B,C,D 3) Rx A) no B) no a) no b) no C) Rx a) Rx b) no D) Rx a) no b) Rx c) no
Proprietary B (EPA Torque, Speed and Timing Message) Engine (0) / Service Tool (249,250) PGN - 65504	On Request	SP SP SP	1) Engine Speed 2) Output Torque 3) Encrypted Timing	1) Tx 2) Tx 3) Tx
Electronic Transmission Controller #1 - ETC1 Trans (3) / Engine (0) PGN - 61442	0.01s	PT PT PT PT PT PT PT PT	1) Shift in progress 2) Torque converter lockup engaged 3) Driveline engaged 4) Output shaft speed 5) Percent clutch slip 6) Progressive shift disable 7) Momentary engine overspeed enable 8) Input Shaft Speed	1) Rx 2) Rx 3) Rx 4) Rx 5) no 6) Rx 7) Rx 8) no

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Electronic Transmission Controller #2 - ETC2 Trans (3) / Engine (0) PGN - 61445	0.01s	 PT	1) Selected gear 2) Actual gear ration 3) Current gear 4) Transmission requested range 5) Transmission current range	1) no 2) Rx 3) no 4) no 5) no
Electronic Retarder Controller #1 - ERC1 Exh Retarder(41) / Eng Retarder (15) / None PGN - 61441	0.1s	PT PT	1) Retarder Status a) Retarder enable - shift assist switch b) Retarder enable - brake assist switch c) Engine/Retarder torque mode 2) Actual Retarder - percent torque 3) Intended Retarder percent torque 4) Engine Coolant load increase 5) Source address of controlling device for retarder control	1) Tx a) no b) Tx c) Tx 2) Tx 3) no 4) no 5) no
Engine Configuration Message Engine(0) / None PGN - 65251	5.0 s / 10% chg	PT PT PT PT PT PT PT PT PT PT PT PT PT PT PT PT PT PT	1) Engine Speed at idle, point 1 2) Percent torque at idle, point 1 3) Engine speed at point 2 4) Percent torque at point 2 5) Engine speed at point 3 6) Percent torque at point 3 7) Engine speed at point 4 8) percent torque at point 4 9) Engine speed at point 5 10) Percent torque at point 5 11) Engine speed at high idle, point 6 12) Gain (KP) of endspeed governor 13) Reference engine torque 14) Maximum momentary engine override speed, point 7 15) Maximum momentary engine override time limit 16) Requested speed control range lower limit 17) Requested speed control range upper limit 18) Requested torque control range lower limit 19) Requested torque control range upper limit	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx 6) Tx 7) Tx 8) Tx 9) Tx 10) Tx 11) Tx 12) no 13) Tx 14) Tx 15) Tx 16) Tx 17) Tx 18) Tx 19) Tx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB[E]
Retarder Configuration Message Exh Retarder (41) / Eng Retarder (15) / None PGN - 65249	5.0 s	PT PT PT PT PT PT PT PT PT PT PT PT PT PT	1) Retarder location 2) Retarder type 3) Retarder control method 4) Retarder speed at idle, point 1 5) Percent torque at idle, point 1 6) Maximum retarder speed, point 2 7) Percent torque at maximum speed, point 2 8) Retarder speed at point 3 9) Percent torque at point 3 10) Retarder speed at point 4 11) Percent torque at point 4 12) Retarder speed at peak torque, point 5 13) Percent torque at peak torque, point 5 14) Reference retarder torque	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx 6) Tx 7) Tx 8) Tx 9) Tx 10) Tx 11) Tx 12) Tx 13) Tx 14) Tx
Cab Message #1 Any / Any PGN - 57344	1.0s	IS/ MUX	1) Requested percent fan speed	1) Tx / Rx
Fuel Economy Engine (0) /None PGN - 65265	1.0 s	IS IS IS	1) Fuel Rate 2) Instantaneous fuel economy 3) Average fuel economy 4) Throttle Position	1) Tx 2) Tx 3) Tx 4) no
Cruise Control/Vehicle Speed Engine (0) / None On Board Vehicle Controller / Engine(0) PGN - 65265	0.1 s	IS/Mx IS IS IS/MX IS/MX IS/MX IS/MX IS/MX IS/MX IS/ MX IS/MX IS IS IS IS/MX IS/MX IS/MX	1) Parking brake switch 2) Two speed axle switch 3) Wheel based vehicle speed 4) Clutch switch 5) Brake switch 6) Cruise control enable switch 7) Cruise control active 8) Cruise control accelerate switch 9)Cruise control resume switch 10) Crusie control coast switch 11) Cruise control set switch 12) Cruise control set speed 13) Crusie control state 14) PTO state 15) Engine test mode 16) Idle Inc Switch 17)Idle Dec Switch	1) Tx/Rx 2) Tx 3) Tx 4) Tx/Rx 5) Tx/Rx 6) Tx/Rx 7) Tx/Rx 8) Tx/Rx 9) Tx/Rx 10) Tx/Rx 11) Tx/Rx 12) Tx 13) Tx 14) Tx 15) Tx/Rx 16) Tx/Rx 17) Tx/Rx
Reset Service Tool (249,250) / Engine (0) PGN - 56832	As Needed	SI SI	1) Trip Reset 2) Service Component to Reset	1) Rx 2) Rx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Diagnostic Message #13 Any / Engine (0) PGN - 57088	As Needed	DG	1) Stop_Start_Broadcast 2) Hold Signal	1) Rx 2) Rx
DM7 Any / Engine (0) PGN - 58112	As Needed	DG	1) Test Identifier	1) Rx
Acknowledgement Messagec Engine (0) / Any PGN - 59392	As Needed	G	1) Control Byte (identifies ACK or NACK) 2) PGN being requested	1) Tx 2) Tx
Request PGN Any / Engine(0) PGN - 59904	As Neededt	G	1) PGN being requested	) Rx
Transport Protocol-Data Transfer Any / Engine(0) Any / Exh Retarder (41) /Eng Retarder (15) Engine (0) / Any PGN - 60160	As Needed	G	1) Sequence Number 2) Packeted Data	1) Tx/Rx 2) Tx/Rx
Transport Protocol-Data Transfer Any / Engine(0) Any / Exh Retarder (41) /Eng Retarder (15) Engine (0) / Any Exh Retarder (41) / Eng Retarder (15) / Any PGN - 60416	As Needed	G	1) Control Byte, identifies CM message type 2) Total Message Size, number of bytes 3) Total Number of Packets 4) Parameter Group Number of packeted message	1) Tx/Rx 2) Tx/Rx 3)Tx/Rx 4) Tx/Rx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Proprietary A Engine (0) / Service Tool (249,250) Service Tool (249,250) / Engine (0) PGN - 61184	As Needed	SP	1) Proprietary information, manufacturer specific	1) Tx/Rx
EBC1 Engine (0)/None Instument Cluster (23) / Engine (0) Management Computer (39) / Engine (0) PGN - 61441	0.1s	 IS/MX IS/MX IS/MX IS/MX IS/MX	1) EBS Brake Switch 2) ABS Active 3) ASR Brake Control Active 4) ASR Engine Control Active 5) Brake Pedal Position 6) Traction Control Override Switch 7) ASR “Hill Holder” Switch 8) ASR Offroad Switch 9) ABS Offroad Switch 10) Remote accelerator enable switch 11) Auxiliary engine shutdown switch 12) Engine derate switch 13) Accelerator Interlock Switch 14) Engine Retarder Selection 15) ABS/EBS Amber Warning State 16) EBS Red Warning State 17) ABS Fully Operational 18) Source Address for COntrolling Brake Control	1) no 2) no 3) no 4) no 5) no 6) no 7) no 8) no 9) no 10) Tx/Rx 11) Tx/Rx 12) Tx/Rx 13) Tx/Rx 14) Tx/Rx 15) no 16) no 17) no 18) no
Fan Drive Engine (0) / None PGN - 65226	1.0 st	IS IS	1) Estimated Percent Fan Speed Fan drive state	1) Tx 2) Tx
Service Engine (0) / Service Tool (249,250) PGN - 65216	On Request	SP	1) Service Component Identification 2) Service Distance 3) Service Component Identification 4) Service Delay/Calendar Time Based 5) Service Component Identification 6) Service Delay/Operational Time Based	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx 6) Tx
DM1 - Active Diagnostic Trouble Codes Engine (0) / None PGN - 65226	1.0 s	DG DG DG DG DG	1) Malfuntion Indicator Lamp Status 2) Red Stop Lamp Status 3) Amber Warning Lamp Status 4) Protect Lamp Status 5) Diagnostic Trouble Code (s)	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx
DM2 - Previously Active Diagnostic Trouble Engine (0) / None PGN - 65227	On Request	DG DG DG DG DG	1) Malfuntion Indicator Lamp Status 2) Red Stop Lamp Status 3) Amber Warning Lamp Status 4) Protect Lamp Status 5) Diagnostic Trouble Code (s)	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^{E}
DM3 Engine (0) / None PGN - 65228	On Request	DG	1) Diagnostic Data Clear/Reset of Previously DTCs	1) Rx
DM4 - Freeze Frame Parameters Engine (0) / None PGN - 65229	On Request	DG DG DG DG DG DG DG DG	1) Freeze Frame Length 2) Diagnostic Trouble Code 3) Engine Torque Mode 4) Boost 5) Engine speed (MSB, 31.5 RPM/bit) 6) Engine Percent Load 7) Engine Coolant Temperature 8) Vehicle Speed 9) Manufacturer Specific Information	1) Tx 2) Tx 3) no 4) Tx 5) Tx 6) Tx 7) Tx 8) Tx 9) Tx
DM5 - Diagnostic Readiness Engine (0) / None PGN - 65230	On Request	DG DG DG DG DG DG	1) Active Trouble Codes 2) Previously Active DIagnostic Trouble Codes 3) OBD Compliance 4) Continuously Monitored System Status 5) Non-Continuously Monitored System Support 6) Non-Continuously Monitored System Status	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx 6) Tx
DM8 - Test Results for Non-Continuously Monitored Systems Engine (0) / None PGN - 65232	On Request	DG	1) Test Identifier 2) Test Type / Component Identifier 3) Test Value 4) Test Limit Maximum 5) test Limit Minimum	1) Tx 2) no 3) Tx 4) no 5) no
DM10 - Non-Continuously Monitored Systems Test ID Support Engine (0) / None PGN - 65234	On Request	DG	1) Test ID	1) Tx
Software Identification Engine (0) / Any PGN - 65242	On Request	IS	1) Number of Software Identification Fields 2) Software Identifications (n) a) Module part Number b) Module serial number c) Calibration data date stamp d) Software Phase designation e) Module identifier f) Application identifier	1) Tx 2) Tx a) Tx b) Tx c) Tx d) Tx e) Tx f) Tx
Idle Operation Engine(0) / Any PGN - 65244	On Request	IS IS	1) Total Idle Fuel Used 2) Total Idle Hours	1) Tx 2) Tx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^{E}
Vehicle Distance Engine(0) / None PGN - 65248	On Request	IS IS	1) Trip Distance 2) Total Vehicle Distance (See Appendix B)	1) Tx 2) Tx
Shutdown Engine(0) / None PGN - 65252	5.0	IS IS IS IS IS IS IS IS IS IS IS IS IS IS	1) Idle Shutdown Timer State 2) Idle Shutdown Timer Override 3) Idle Driver Alert Mode 4) Idle Shutdown 5) Idle Shutdown Timer Function 6) Refrigerant High Pressure Switch 7) Refrigerant Low Pressure Switch 8) A/C High Pressure Fan Switch 9) Wait to Start Lamp 10) Engine Protection System Timer State 11) Engine Protection System Timer Override 12) Engine Protection System Approaching Shutdown 13) Engine Protection System has Shutdown Engine 14) Engine Protection System Configuration	1) Tx 2) Tx 3) Tx 4) Tx 5) Tx 6) no 7) no 8) Tx/Rx 9) Tx 10) Tx 11) no 12) Tx 13) Tx 14) Tx
Engine Hours, Revolutions Engine (0)/None PGN - 65253	On Request	IS IS	1) Total Engine Hours 2) Total Engine Revolutions	1) Tx 2) Tx
Vehicle Hours Engine (0) / None PGN - 65255	On Request	IS	1) Total vehicle hours 2) Total Power Takeoff Hours	1) Tx 2) Tx
Fuel Consumption Engine (0) / None PGN - 65257	On Request	IS IS	1) Trip Fuel 2) Total Fuel Used	1) Tx 2) Tx
Component Identification Engine (0) / None PGN - 65259	On Request	IS IS IS IS	1) Make 2) Model 3) Serial Number 4) Unit Number	1) Tx 2) Tx 3) Tx 4) Tx
Vehicle Identification Engine (0) / None PGN - 65260	On Request	IS	1) Vehicle Identification Number	1) Tx

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB^E
Cruise Control/Vehicle Speed Setup Engine (0) / None PGN - 65261	On Request	IS IS IS	1) Maximum Vehicle Speed Limit 2) Cruise Control High Set Limit Speed 3) Cruise Control Low Set Limit Speed	1) Tx 2) Tx 3) Tx
Engine Temperature Engine (0) /None PGN - 65262	1.0	IS IS IS	1) Engine Coolant Temperature 2) Fuel Temperature 3) Engine Oil Temperature 1 4) Turbo Oil Temperature 5) Engine Intercooler Temperature 6) Engine Intercoolar Thermostat Opening	1) Tx 2) Tx 3) Tx 4) no 5) no 6) no
Engine Fluid Level/ Pressure Engine (0) / None PGN - 65263	0.5	IS IS IS	1) Fuel Delivery Pressure 2) Extended Crankcase Blowby Pressure 3) Engine Oil Level 4) Engine Oil Pressure 5) Crankcase Pressure 6) Coolant Pressure 7) Coolant Level	1) Tx 2) no 3) no 4) Tx 5) no 6) Tx 7) no
PTO - Power Takeoff Information Engine (0) / None PGN - 65264	0.1 s	 IS IS/Mx IS/Mx IS/Mx IS/Mx IS/Mx IS/Mx	1) Power Takeoff Oil Temperature 2) Power Takeoff Speed 3) Power Takeoff Set Speed 4) Remote PTO Variable Speed Control Switch 5) Remote PTO Preprogrammed Speed Control Switch 6) PTO Enable Switch 7) PTO Accelerate Switch 8) PTO Resume Switch 9) PTO Coast/Decelerate Switch 10) PTO Set Switch	1) no 2) no 3) Tx 4) no 5) Tx/Rx 6) Tx 7) Tx/Rx 8) Tx/Rx 9) Tx/Rx 10)Tx/Rx
Ambient Conditions Engine (0) / None PGN - 65269	0.1 s	IS	1) Barometric Pressure 2) Cab interior Temperature 3) Ambient Air Temperature 4) Air Inlet Temperature 5) Road Surface Temperature	1)Tx 2) no 3) no 4) no 5) no
Inlet/Exhaust Conditions Engine (0) / None PGN - 65270	0.5 s	 IS IS	1) Particulate Trap Inlet Pressure 2) Boost Pressure 3) Intake Manifold Temperature 4) Air Inlet Pressure 5) Air Filter Differential Pressure 6) Exhaust Gas Temperature 7) Coolant Filter Ddifferential	1) no 2) Tx 3) Tx 4) no 5) no 6) no 7) no
Vehicle Electrical Power Engine (0) / None PGN - 65271	1.0 s	 IS	1) Net Battery Current 2) Alternator Current 3) Alternator Potential (voltage) 4) Electrical Potential (voltage) 5) Battery Potential (Voltage), Switched	1) no 2) no 3) no 4) Tx 5) no

J1939 Message Name SA/DA PGN #	Update Rate	Use	Parameters	ISB4, ISB[E]
Water In Fuel Indicator Engine (0) / None PGN - 65279	1.0 s	IS	1) Water In Fuel Indicator bit	1) Tx
TCO1 Any / Engine(0) PGN - 65132	0.05	 PT PT	1) Driver recognize 2) Driver 2 working state 3) Driver 1 working state 4) Overspeed 5) Driver 1 card 6) Driver 1 time related states 7) Driver 2 card 8) Driver 2 time related states 9) Direction indicator 10) Tachograph performance 11) Handling information 12) System event 13) Tachograph output shaft speed 14) Tachograph vehicle speed	1) no 2) no 3) no 4) no 5) no 6) no 7) no 8) no 9) no 10) no 11) no 12) no 13) Rx 14) Rx

Notes on Superscripted PGN* used in Table 3:

(1)The SAE J1939 specification does not contain all the information on PGNs 65229, 65259 and 65260.
(2)Only able to reset the Engine Oil.
(3)Non-conforming to J1939/21 SAE Specification.
(4)Non-conforming to J1939/71 SAE Specification.
(5)The Request PGN is actually received with the DM3 PGN in the data field.
(6)When Cruise Control/PTO Set or Resume Switches are used to activate Coast or Accelerate Switches, the Set or Resume Switches will no longer activate during a broadcast while the Resume or Accelerate Switches are active.
(7)Note: Via PGN - 61441 the OEM is capable of initiating an Engine Shutdown by commanding it over the J1939 datalink.

Cummins has provided the following detailed definitions:
PGN 65229 - Diagnostic Message DM4
A freeze frame is defined as the list of recorded parameters at the time a diagnostic trouble code was captured. The freeze frame record for each diagnostic trouble code contain the SAE defined required parameters first and then any manufacturer-specific information.
Byte 1:Freeze Frame Length
Bytes 2-5:Diagnostic Trouble Code (4 bytes)
Byte 6:Engine Torque Mode set to FF_{16} - not available
Byte 7:Boost
Bytes 8-9:Engine Speed
Byte 10:Engine% Load
Byte 11:Engine Coolant Temperature
Bytes 12-13:Vehicle Speed
Bytes 14-74:Manufacturer Specific Information - Please refer to Table 4
Note: The following illustrates the message format for when there are more than one freeze frame.
Given:a=freeze frame length
b=required parameters
c=manufacturer specific freeze frame information

Message form will be as follows: a,b,c,a,b,c,a,b,c,...etc. The transport protocol of J1939 -21 will have to be used to send freeze frames because they are more than 8 data bytes. The maximum message size limit is 1785 bytes.

7.4 Fault Codes

Table 7-5: FAULT CODES FOR ISB4/ISB^{e} ENGINES

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FMI	SPN	FMI			
111	Red	S254	12	629	12	ECM internal hardware error.	Possible no effect or engine may run rough or not start.	ECM General Hardware Error
122	Yellow	P102	3	102	3	High voltage detected at intake manifold pressure sensor signal pin.	Engine will derate to no-boost fueling.	Intake Manifold Pressure Sensor Circuit - Failed High
123	Yellow	P102	4	102	4	Low voltage detected at intake manifold pressure sensor signal pin.	Engine will derate to no-boost fueling.	Intake Manifold Pressure Sensor Circuit - Failed Low
131	Yellow	P091	3	91	3	High voltage detected at throttle position signal pin.	Engine idles when idle validation switch indicates idle and ramps up to a default set speed when the idle validation switch indicates off-idle.	Accelerator Position Sensor Circuit - Failed High
132	Yellow	P091	4	91	4	Low voltage detected at throttle position signal pin.	Engine idles when idle validation switch indicates idle and ramps up to a default set speed when the idle validation switch indicates off-idle.	Accelerator Position Sensor Circuit - Failed Low
133	Yellow	P029	3	974	3	High voltage detected at remote throttle position signal pin.	Engine may not respond to remote throttle input.	Remote Throttle Position Sensor - Failed High
134	Yellow	P029	4	974	4	Low voltage detected at throttle position signal pin.	Engine may not respond to remote throttle input.	Remote Throttle Position Sensor Circuit - Failed Low
135	Yellow	P100	3	100	3	High voltage detected at oil pressure signal pin.	Default value used for oil pressure.	Oil Pressure Sensor Circuit - Failed High

Fault Code	Lamp	J1587 PID/SID	J1587 FMI	J1939 SPN	J1939 FMI	Fault Description (Reason)	Fault Effect	Fault Code Title
141	Yellow	P100	4	100	4	Low voltage detected at oil pressure signal pin.	Default value used for oil pressure.	Oil Pressure Sensor Circuit - Failed Low
143	Yellow	P100	1	100	18	Oil pressure signal indicates oil pressure below the low engine protection limit.	Power and/or speed derate and possible engine shutdown if engine protection shutdown feature is enabled.	Oil Pressure - Engine Protection - Fueling Derate
144	Yellow	P110	3	110	3	High voltage detected at coolant temperature signal pin.	Default value used for coolant temperature. No engine protection for coolant temperature.	Coolant Temperature Sensor Circuit - Failed High
145	Yellow	P110	4	110	4	Low voltage detected at coolant temperature signal pin.	Default value used for coolant temperature. No engine protection for coolant temperature.	Coolant Temperature Sensor Circuit - Failed Low
146	Yellow	P110	0	110	0	Coolant temperature signal indicates coolant temperature has exceeded the engine protection limit.	Power derate and possible engine shutdown if engine protection shutdown feature is enabled.	Coolant Temperature - Engine Protection - Fueling Derate
151	Red	P110	0	110	16	Coolant temperature signal indicates coolant temperature has exceeded the engine protection limit.	Power and/or speed derate and possible engine shutdown if engine protection shutdown feature is enabled.	Coolant Temperature - Engine Protection - Speed Derate
153	Yellow	P105	3	105	3	High voltage detected at intake manifold temperature signal pin.	Default value used for intake manifold temperature. No engine protection for IMT.	Intake Manifold Temperature Sensor Circuit
154	Yellow	P105	4	105	4	Low voltage detected at intake manifold temperature signal pin.	Default value used for intake manifold temperature. No engine protection for IMT.	Intake Manifold Temperature Sensor Circuit
155	Red	P105	0	105	0	Intake manifold air temperature signal indicates intake manifold air temperature is above the engine protection limit.	Power and/or speed derate and possible engine shutdown if engine protection shutdown feature is enabled.	Intake Manifold Temperature Sensor - Engine Protection - Speed Derate

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FMI	SPN	FMI			
187	Yellow	S232	4	1080	4	Low voltage detected on the ECM voltage supply line to fuel rail pressure and exhaust pressure sensors.	Possible low power.	Sensor Supply B - Low Voltage Error (Rail)
212	Yellow	P175	3	175	3	High voltage detected at the oil temperature signal pin.	No engine protection for oil temperature	Oil Temperature Sensor Circuit - Failed High
213	Yellow	P175	4	175	4	Low voltage detected at the oil temperature signal pin.	No engine protection for oil temperature	Oil Temperature Sensor Circuit - Failed Low
221	Yellow	P108	3	108	3	High voltage detected at ambient air pressure signal pin.	Engine power derate.	Ambient Air Pressure Sensor Circuit - Failed
227	Yellow	S232	3	1080	3	High voltage detected on the ECM voltage supply line to fuel rail pressure and exhaust pressure sensors.	Possible low power.	Sensor Supply B - High Error
234	Red	P190	0	190	0	Engine speed signal indicates engine speed has exceeded the overspeed limit.	Fuel injection disabled until engine speed falls below the overspeed limit.	Engine Overspeed Circuit Error
235	Yellow	P111	1	111	1	Coolant level signal pin indicates coolant level is low.	Power and/or speed derate and possible engine shutdown if engine protection shutdown feature is enabled.	Engine Coolant Level - Engine Protection - Fueling & RPM Derate
238	Yellow	S232	4	620	3	Low voltage detected on the ECM voltage supply line to the oil pressure sensor.	Default value used for oil pressure sensor connected to this +5 VDC supply and no engine protection for oil pressure.	Sensor Supply C - Low Voltage Error
239	Yellow	S232	3	620	3	High voltage detected on the ECM voltage supply line to the oil pressure sensor.	Default value used for oil pressure sensor connected to this +5 VDC supply and no engine protection for oil pressure.	Sensor Supply C - High Voltage Error

Fault Code	Lamp	J1587 PID/SID	J1587 FMI	J1939 SPN	J1939 FMI	Fault Description (Reason)	Fault Effect	Fault Code Title
241	Yellow	P084	2	84	2	Vehicle speed signal has been lost.	Engine speed limited to “Maximum Engine Speed without VSS”. Cruise control, gear-down protection and the road speed governor will not work. Trip information data that is based on mileage will beincorrect.	Vehicle Speed Signal Lost
261	None	P174	0	174	16	High fuel temperature has been detected. Voltage signal at the fuel temperature signal pin indicates fuel temperature above 71o C [160o F].	Calibration dependent progressive power derate and engine shutdown with increasing time after alert. (80^{O}C)	Fuel Temperature - Engine Protection - Fueling Derate
263	Yellow	P174	3	174	3	High voltage detected at the fuel temperature sensor signal pin.	Default value used for fuel temperature. Possible low power. No engine protection for fuel temperature.	Fuel Temperature Sensor CircuitFuel Temperature - Engine Protection - Fueling Derate
265	Yellow	P174	4	174	4	Low voltage detected at the fuel temperature sensor signal pin.	Default value used for fuel temperature. Possible low power. No engine protection for fuel temperature.	Fuel Temperature Sensor CircuitFuel Temperature - Engine Protection - Fueling Derate
266	None	P174	0	174	0	Fuel temperature signal indicates fuel temperature has exceeded the engine protection limit.	Power derate and possible engine shutdown if engine protection shutdown feature is enabled. (90^{O}C)	Fuel Temperature - Engine Protection - Speed Derate
269	Red	S217	2	1195	2	Engine RPM is detected when Vehicle Antitheft is active.	Engine may not start.	Information Fault
271	Red	S151	4	1347	4	Short circuit detected on the fuel pump regulator circuit.	Engine may shutdown from low fuel rail pressure.	Fuel Pump Regulator - Short Circuit
272	Red	S151	3	1347	3	Open circuit or short cicuit to ground detected on the fuel pump regulator circuit.	Fuel rail pressure high and regulated by DBV.	Fuel Pump Regulator - Open or Short Circuit

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FM I	SP N	F MI			
285	Yel-low	S231	9	639	9	J1939 Mux system device not responding; will return to default settings	Some mux features may not function.	J1939 Mux Error
287	Red	P91	0	91	19	J1939 Mux Accelerator pedal Sensor Error	Limp Home Throttle will control engine speed	Muxed Throt-tle Error
291	Red	S248	9	625	9	Immobilizer not commu-nicating.	Engine may not start.	Immobilizer feature error
311	Yel-low	S001	6	651	6	Short circuit detected in injector bank 1 circuit. For a 6 cylinder engine bank 1 is cylinders 1, 5, and 3. For a 4 cylinder, bank 1 is cylinders 1 and 3.	Low power as a result of cylinders not firing.	Injector Bank 1 Circuit Error
321	Yel-low	S004	6	654	6	Short circuit detected in injector bank 2 circuit. For a 6 cylinder engine bank 2 is cylinders 6, 2, and 4. For a 4 cylinder, bank 2 is cylinders 2 and 4.	Low power as a result of cylinders not firing.	Injector Bank 2 Circuit Error
322	Yel-low	S001	5	651	5	No current detected at No. 1 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #1 circuit.	Possible misfire on cyl-inder 1. Engine may run rough.	Cylinder #1 Circuit Error
323	Yel-low	S005	5	655	5	No current detected at No. 5 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #5 circuit.	Possible misfire on cyl-inder 5. Engine may run rough.	Cylinder #5 Circuit Error
324	Yel-low	S003	5	653	5	No current detected at No. 3 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #3 circuit.	Possible misfire on cyl-inder 3. Engine may run rough.	Cylinder #3 Circuit Error

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/SID	FMI	SPN	FMI			
325	Yellow	S006	5	656	5	No current detected at No. 6 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #6 circuit.	Possible misfire on cylinder 6. Engine may run rough.	Cylinder #6 Circuit Error
329	Red	S233	14	1077	14	Rail pressure cannot maintain ECM command.	HPCR Leakage - Engine Protection - Rail Pressure & RPM derate.	HPCR Leakage Error
331	Yellow	S002	5	652	5	No current detected at No. 2 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #2 circuit.	Possible misfire on cylinder 2. Engine may run rough.	Cylinder #2 Circuit Error
332	Yellow	S004	5	654	5	No current detected at No. 4 injector driver or return pin when the voltage supply at the harness is on. -OR- High resistance detected on injector #4 circuit.	Possible misfire on cylinder 4. Engine may run rough.	Cylinder #4 Circuit Error
341	Red	S254	12	629	12	Memory in ECM has been corrupted.	Possible no effect or engine may run rough or not start.	ECM Flash Memory Fault
352	Yellow	S232	4	1079	4	Low voltage detected on the ECM voltage supply line to boost pressure, oil level, OEM pressure, and coolant level sensors as well as the remote throttle.	Default value used for sensors connected to this +5 VDC supply and possible default to idle speed. Low power may occur because fueling defaulted to no boost fueling. Also possible loss of engine protection for the sensors.	Sensor Supply A - Low Voltage Error
381	Yellow	S237	11	626	11	Error detected in cold start aid relay 1 enable circuit.	The intake air heater #1 may be ON or OFF all of the time or is damaged.	Intake Air Heater #1 Circuit Error
382	Yellow	S237	11	626	11	Error detected in cold start aid relay 2 enable circuit.	The intake air heater #2 may be ON or OFF all of the time or is damaged.	Intake Air Heater #2 Circuit Error

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FM I	SP N	F MI			
386	Yel-low	S232	3	107 9	3	High voltage detected on the ECM voltage supply line to boost pressure, oil level, OEM pressure, and coolant level sen-sors as well as the remote throttle.	Default values used for sensors connected to this +5 VDC supply and possible default to idle speed. Low power may occur because fueling defaulted to no boost fueling. Also possible loss of engine protection for the sen-sors.	Sensor Supply A - High Voltage Error
389	Yel-low	S033	11	647	11	Error detected on fan clutch circuit.	The fan clutch may be on or off all the time or is damaged.	Fan Clutch Cir-cuit Error
392	Yel-low	S029	11	107 3	11	Error detected at engine/exhaust brake circuit	Engine brake driver 2 cannot be activated.	Engine/ Exhaust Brake Circuit Error
415	Red	P100	1	100	1	Oil pressure signal indi-cates oil pressure below the very low engine pro-tection limit.	Power and/or speed derate and possible engine shutdown if engine protection shutdown feature is enabled.	Oil Pressure - Engine Protection - Speed Derate
418	Main-ten-ance	P97	0	97	15	Water detected in water/ fuel separator	Possible fuel system damage	Water in Fuel
422	Yel-low	P111	2	111	2	Voltage detected simul-taneously on both the coolant level high and low signal pins...OR...no voltage detected on either pin.	No engine protection for coolant level.	Coolant Level Sensor Circuit Error
426	None	S231	2	639	2	Communication between the ECM and another device on the J1939 datalink has been lost.	None on performance. J1939 devices may not operate.	J1939 Datalink Circuit Error
427	None	S231	9	639	3	Communication between the ECM and another device on the J1939 datalink has been lost.		J1939 Datalink Circuit Error
429	Yel-low	P97	4	97	4	Water In Fuel sensor circuit failed.	Loss of Water In Fuel detection.	Water in Fuel Sensor - Failed Low

Fault Code	Lamp	J1587 PID/SID	J1587 FMI	J1939 SPN	J1939 FMI	Fault Description (Reason)	Fault Effect	Fault Code Title
431	Yellow	S230	2	558	2	Idle validation signals indicate no voltage detected simultaneously on both idle and off-idle pins.	No effect on performance, but loss of idle validation.	Idle Validation Switch Circuit Error
432	Red	S230	13	558	13	Idle validation signal indicates the throttle is at the idle position when the throttle position signal indicates the throttle is not at the idle position ...OR...Idle validation signal indicates the throttle is not at the idle position when the throttle is at the idle position.	Engine may only idle.	Accelerator Pedal Circuit Error
433	Yellow	P102	2	102	2	Intake manifold pressure signal indicates intake manifold pressure is high when other engine parameters (i.e., speed and load) indicate intake manifold pressure should be low.	Engine may derate to no-boost fueling.	Intake Manifold Pressure Sensor Circuit Error
434	Yellow	S251	2	627	2	All data gathered by the ECM since the last key-on (i.e., faults, trip information data, etc.) was not stored to permanent memory at the last key-off.	None on performance. Fault code table, trip information data and maintenance monitor data may be inaccurate.	Unswitched Battery Supply Circuit
441	Yellow	P168	1	168	18	Voltage detected at ECM power supply pins indicates low ECM supply voltage.	Engine may die or run rough.	Unswitched Battery Supply - Low Voltage Error
442	Yellow	P168	0	168	16	Voltage detected at ECM power supply pins indicates ECM supply voltage is above the maximum system voltage level.	None on performance.	Unswitched Battery Supply Circuit - High Voltage Error
449	Red	P094	0	94	16	Fuel pressure signal indicates that fuel pressure has exceeded the maximum limit for the given engine rating.	Engine may shutdown.	Fuel Pressure Too High

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FM I	SP N	F MI			
451	Yel-low	P157	3	157	3	High voltage detected at fuel pressure sensor signal pin.	Power and/or speed derate.	Fuel Pressure Sensor Circuit - Failed High
452	Yel-low	P157	4	157	4	Low voltage detected at fuel pressure sensor signal pin.	Power and/or speed derate.	Fuel Pressure Sensor Circuit - Failed Low
488	Yel-low	P105	0	105	16	Intake manifold air tem-perature signal indicates intake mani-fold air temperature is above the engine protec-tion limit.	Power derate and possi-ble engine shutdown if engine pro-tection shutdown feature is enabled.	Intake Manifold Temperature - Engine Protec-tion - Fueling Derate
551	Yel-low	S230	4	558	4	Idle validation signals on pins indicate no volt-age detected on either pin.	Engine may only idle.	Idle Validation Switch Circuit
596	Yel-low	P167	0	167	16	The control system has detected a high voltage output from the alterna-tor.	None on performance.	Alternator - High Voltage
597	Yel-low	P167	1	167	18	The control system has detected a low voltage output from the alterna-tor.	None on performance. Idle speed may be increased if enabled.	Alternator - Low Voltage
598	Red	P167	1	167	1	The control system has detected a very low volt-age output from the alternator.	None on performance. Idle speed may be increased if enabled.	Alternator - Very Low Voltage
689	Yel-low	P190	2	190	2	No engine speed detected at the ECM for the crankshaft speed sensor.	Engine can run rough. Possible poor starting capability.	Engine Speed Signal Error
731	Yel-low	S064	7	723	7	The engine speed sig-nals from the crank-shaft and camshaft speed sensor do not match.	Engine can run rough. Possible poor starting capability.	Engine Posi-tion Signal Mis-match
753	Yel-low	S064	2	723	2	Engine position signal from the camshaft and crankshaft engine posi-tion sensors do not match up.	Low power, rough idle, or possible white smoke.	Engine Speed Signal Error

Fault Code	Lamp	J1587		J1939		Fault Description (Reason)	Fault Effect	Fault Code Title
		PID/ SID	FM I	SP N	F MI			
768	Yel-low	S009	11	923	11	Error detected in the Analog Torque Driver pin.	Cannot control Trans-mission.	Analog Torque Circuit Error
778	Yel-low	S064	2	723	2	No engine speed detected at the ECM for the camshaft.	Possible poor starting capability.	Engine Speed Sensor Circuit Error
997	None	S0	11	0	11	Injection duration exceeded limit.	None on performance.	Injection error.
998	None	S0	11	0	11	Pilot injection duration exceeded beginning of main injection.	Pilot injection is dis-abled.	Audible engine tone change.
1139	Yel-low	S1	7	651	7	Injector Cylinder #1 - Mechanical System NOT responding properly or Out of Adjustment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1141	Yel-low	S2	7	652	7	Injector Cylinder #2 - Mechanical System NOT responding properly or Out of Adjustment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1142	Yel-low	S3	7	653	7	Injector Cylinder #3 - Mechanical System NOT responding properly or Out of Adjustment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1143	Yel-low	S4	7	654	7	Injector Cylinder #4 - Mechanical System NOT responding properly or Out of Adjustment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1144	Yel-low	S5	7	655	7	Injector Cylinder #5 - Mechanical System NOT responding properly or Out of Adjustment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1145	Yel-low	S6	7	656	7	Injector Cylinder #6 - Mechanical System NOT responding properly or Out of Adjustment.	None; Engine already derated due to FC329.	Internal cylin-der leak.
1146	Yel-low	S1	7	651	7	Unknown Injector Cylin-der - Mechanical System NOT responding prop-erly or Out of Adjust-ment.	Engine runs roughly, may produce white smoke and may not run.	Internal cylin-der leak.
1417	Yel-low	S254	12	629	12	Module will not shut-down at key off.	The ECM will cause bat-tery drain if engine is not run for an extended period of time.	ECM Shutdown Fault

Fault Code	Lamp	J1587 PID/SID	J1587 FMI	J1939 SPN	J1939 FMI	Fault Description (Reason)	Fault Effect	Fault Code Title
1478	Yellow		11		31	Error detected at Starter Lockout circuit.	Starter Lockout feature does not operate properly.	Starter Lockout Error
2185	Yellow	S232	3	620	3	Throttle supply voltage higher than normal.	Limp Home Throttle active.	Throttle Supply shorted high
2186	Yellow	S232	4	620	4	Throttle supply voltage lower than normal.	Limp Home Throttle active.	Throttle Supply shorted low
2197		P441	11	441	11	OEM temperature out-of-range has been detected. Voltage signal at OEM temperature signal pin indicates OEM temperature beyond OEM specified threshold.	Calibration dependent progressive power derate and engine shutdown with increasing time after alert.	OEM Temperature - Engine Protection - Fueling Derate
2212	Yellow		4		4	Error detected in fuel heater circuit.	The fuel heater may be ON or OFF all of the time or is damaged.	Fuel Heater Circuit Error - Low
2215	Yellow	P094	1	94	18	Fuel rail pressure signal indicates that fuel pressure is consistently lower than commanded fuel pressure.	Possible low power or no effect.	Fuel Rail Pressure Low Error
2216	Yellow	P094	0	94	16	Fuel rail pressure signal indicates that fuel pressure is consistently higher than commanded fuel pressure.	Possible low power or no effect.	Fuel Rail Pressure High Error
2217	Yellow	S240	11	628	31	ECM software error internal to the module.	Possible no effect or engine may run rough or not start.	ECM Software Error
2559	Yellow	S0	11	1482	11	Loss of 1939 communication between the ECM and transmission ECU.	Engine power derate & default transmission shift points.	1939 communication lost between ECM and transmission ECU.

8 OFF ENGINE MOUNTED GUIDELINES

This section provides installation guidelines for the CM800 electronic control module when used in applications where the control module is mounted off-engine

8.1 TEMPERATURE RESISTANCE

8.1.1 Operating - High Temperature

The CM800 is designed to consume up to 30 Watts. To ensure proper heat dissipation when the CM800 is operating at maximum power, the ECM can be mounted in any of the following three configurations:

- In free air, cooled by natural convection, with a maximum surrounding air temperature of 60 degrees Celsius.
- In free air, cooled by forced convection at 3 meters per second air flow, with a maximum surrounding air temperature of 80 degrees Celsius.
- Mounted on a heat sink capable of maintaining a maximum CM800 baseplate temperature of no greater than 85 degrees Celsius, with a maximum surrounding air temperature of 105 degrees Celsius.

8.1.2 Non-operational Storage Temperature

The maximum steady-state storage temperature for the ECM is +105^{o}C for short periods (up to 30 minutes) a temperature of up to +125^{o}C is permissable.

8.1.3 Operating - Low Temperature

The ECM is protected against low temperatures down to severity level defined below. ECM mounted off-engine must be in a location where the minimum surrounding air temperatures are greater than or equal to this severity level.

Standards:DIN-IEC 68-2-2 and DIN 40 046

Temperature:-40^{o}C

Operation Mode:Continuous operation

8.2 CLIMATE AND CHEMICAL RESISTANCE

The ECM is protected against climate and chemical resistance stresses as defined below. ECMs mounted off-engine must be in a location where the ECM will not be exposed to climates and chemicals not listed herein.

8.2.1 Humidity

8.2.2 Industrial Climates

Standards:DIN 50 018 - KW 2.0 S

Operation Mode:Passive

8.2.3 Salt Mist

Standards:IEC 68-2-52-Kb

Operation Mode:Passive

8.2.4 Chemical Resistance

The ECM is resistant to the following checmicals:

Diesel fuel	Engine oil
Rapeseed oil (100%)	Hydraulic fluid
Degreasing fluid	Steam Cleaning Solution (5% hydrochloric acid)
Water and Oil based paint	Antifreeze (Ethylene Glycol)
Brake Fluid	Window washing fluid
Beverages (cola/coffee)	Ether
Urea Notrogen	NPK Fertilizer
Propylene Glycol	Power Steering Oil
Ammonium Hydroxide Fog (20% aqueous solutio)	

8.3 MECHANICAL RESISTANCE

8.3.1 Vibration

The ECM is resistant to damage caused by reasonable levels of vibration. However, the ECM must be installed in a position where the vibration levels in any axis will not exceed the levels defined below:

Frequency range:10 to 3000 HZ

Accleration density:10Hz = 0.085 g^2/Hz

89 Hz = 1.43 g^2/Hz

105 HZ = 0.211 g^2/Hz

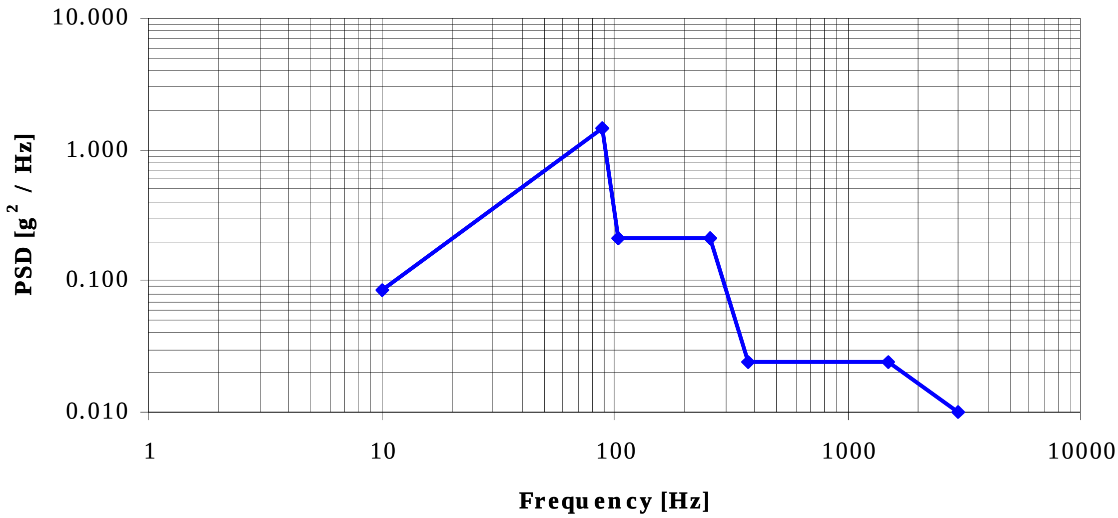
260 Hz = 0.211 g^2/Hz

378 = 0.024 g^2/Hz

1500 Hz = 0.024 g^2/Hz

3000 Hz = 0.01 g^2/Hz

Figure 8-1: Summary of Vibration



8.3.2 Mechanical Shock

The ECM is resitant to damage frommechanical shocks as defined below. The ECM must be installed in a location where it will not be exposed to mechanical shocks in excess of these limits.

Standards:DIN IEC 68-2-27 and DIN 40 046 sh. 7

shock acceleration:1000 m/s^2

Duration of nominal shock:6 milliseconds

Shock form:Sinusoidal

8.4 PROTECTION AGAINST WATER / DUST INGRESS

The CM800 is resistant against ingress of splashing water and solid objects such as dirt. However, the ECM should be installed in a location where it will not be exposed to immersion in water.

8.5 HARNESS LENGTH / IMPEDANCE

To ensure proper system operation, there are requirements for the maximum harness length and impedance. To achieve proper starting and subsequent operation, the total harness length from the CM800 to the injectors should not exceed 5 meters, with a maximum impedance from the ECM to the injector of 120 milohms per injector wire.

8.6 HARNESS ATTACHMENT

To ensure that the ECM and its mating connectors meet their durability requirements, the wiring harness must be secured to a point at the same level as the ECM, so that relative motion between the ECM and mating connectors is eliminated. All branches of the harness from the ECM must be secured and the fixing point must be no greater than 100 millimeters from the point where the wires exit the ECM connector backshells.

9 ENVIRONMENTAL SPECIFICATIONS

The ISB4/ISB^e engines have a wide variety of applications each with distinct duty cycles and operating environments. High volume applications are primarily automotive and medium duty trucks. The following section provides the environmental conditions which the engines electronic components were designed to meet.

9.1 ELECTRONIC COMPONENTS ENVIRONMENT

The ISB4/ISB^e ECM is a microprocessor based assembly which monitors and controls engine functions. The ISB4/ISB^e ECM is shown in Figure 9-1 on page 137. The ISB4/ISB^e ECM is designed to operate with either 12 or 24 volts DC. The operating voltage for the 24 volts ECM has a nominal voltage of 28 volts. The 12 volt operating ECMs have a nominal voltage of 14 volts. The ISB4/ISB^e ECM is designed to be mounted on the engine. Due to the relative harshness of that vicinity the ISB4/ISB^e electronic components are designed and tested to survive the ranges of Table 9:1 as well as the following environments:

Storage Temperature: -40 °C - 125 °C

Operating Temperature:-40 °C - 105 °C (Ambient Air Temperature)

Vibration: As measured on engine and accelerated for life expectancy in tests.

The engine environment causes a unique vibration profile for each axis. Horizontal is measured along the axis of the crankshaft. The Vertical axis is measured along the direction of the pistons. The specific vibration conditions which the ECM is designed to operate within is shown in Figure 8-1 on page 135.

Table 9:1 Environmental, Mechanical, Electrical Ranges

PARAMETER	RANGE
Mounting Flange Temperature (Temperature inside ECM cooler)	-40 to 85 °
Humidity	0 - 100%RH
Random Vibration	See Table 8-2 10 to 3000 Hz
Mechanical Shock	0 to 100G
Battery Voltage: CM800	6.0 VDC to 32.0 VDC

Figure 9-1: Electronic Control Module

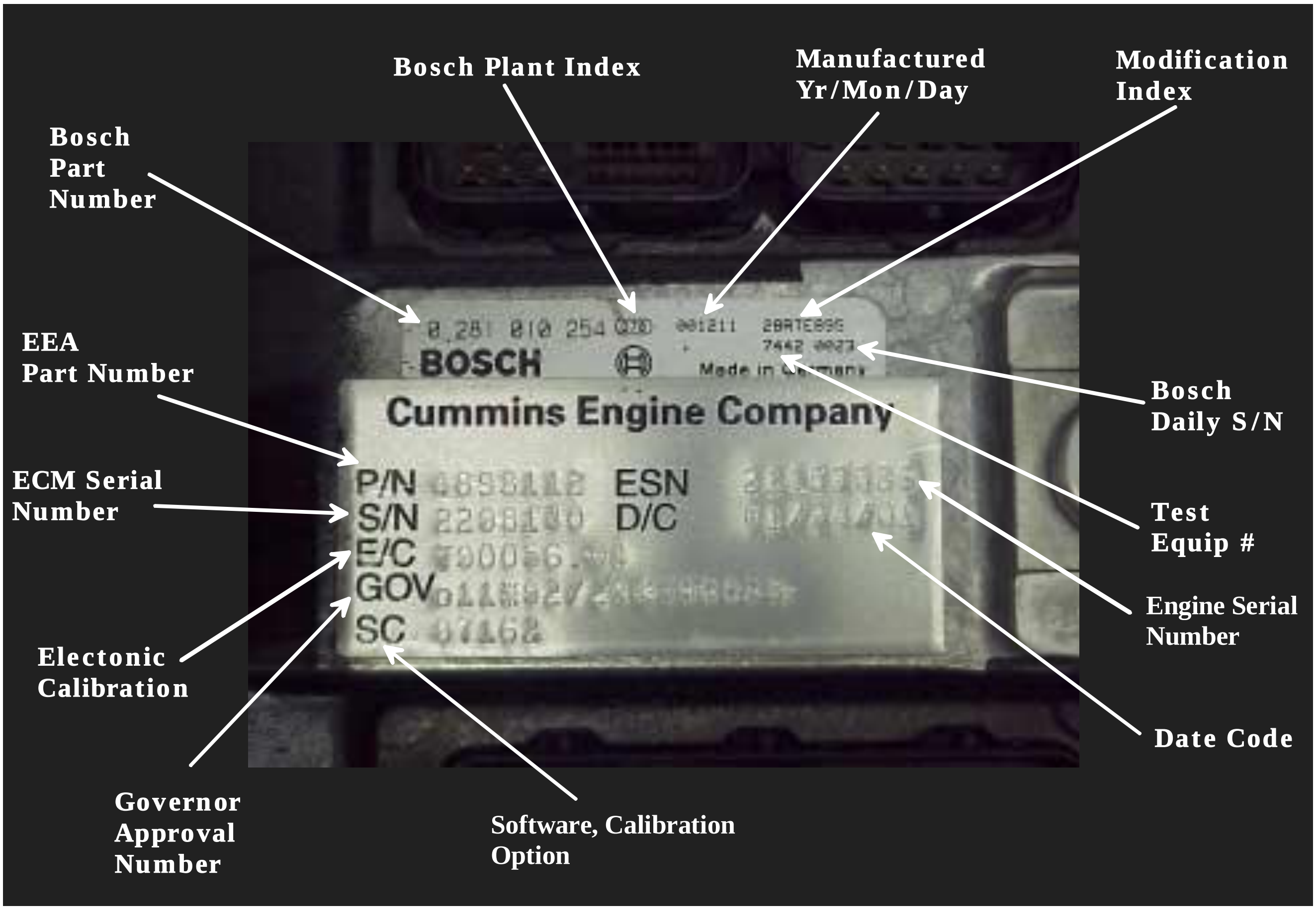


Figure 9-2: Close up of ECM Label

Table 9:2 Vibration Break Points - All Axes

Frequency	Level	
Hz	G^2/Hz	Test Level
10	0.255	(1.7 x GRMS)
89	4.3	
105	0.635	
260	0.635	
378	0.074	
1500	0.074	
3000	0.01	
GRMS Total:		

Susceptibility: 14khz to 10Ghz @ 100V/M

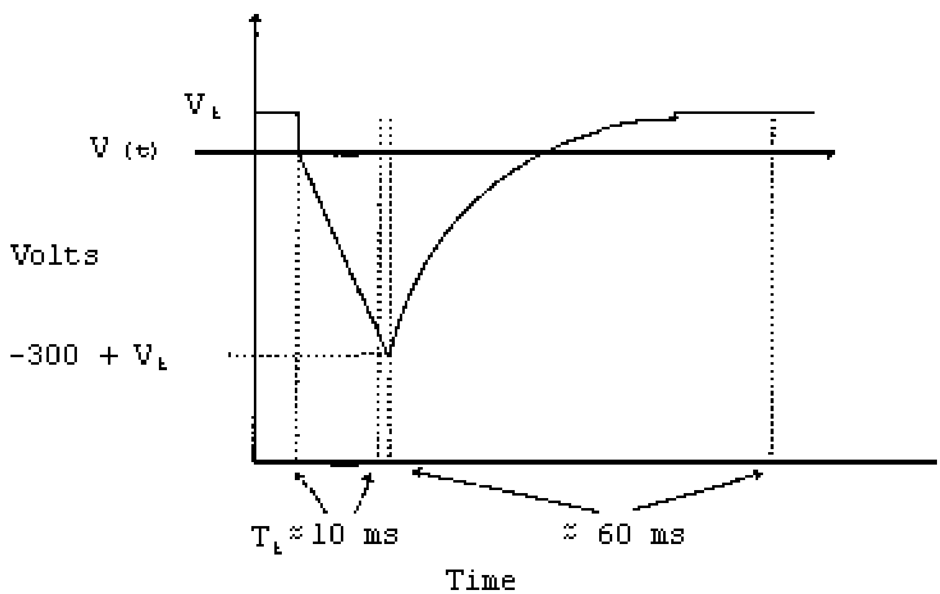


Figure 9-3: Inductive Load Switching #1

The transient pulses to which the ECM has been subjected and demonstrated to operate are shown in Table 9:3 thru Table 9:12 and Figure 9-3 thru Figure 9-11.

Table 9:3 Inductive Load Switching #1

Parameter	24 Volt System
Vs	-600
Vr	28V
t	27ms
Tr	2ms
Ri	4.7 ohms

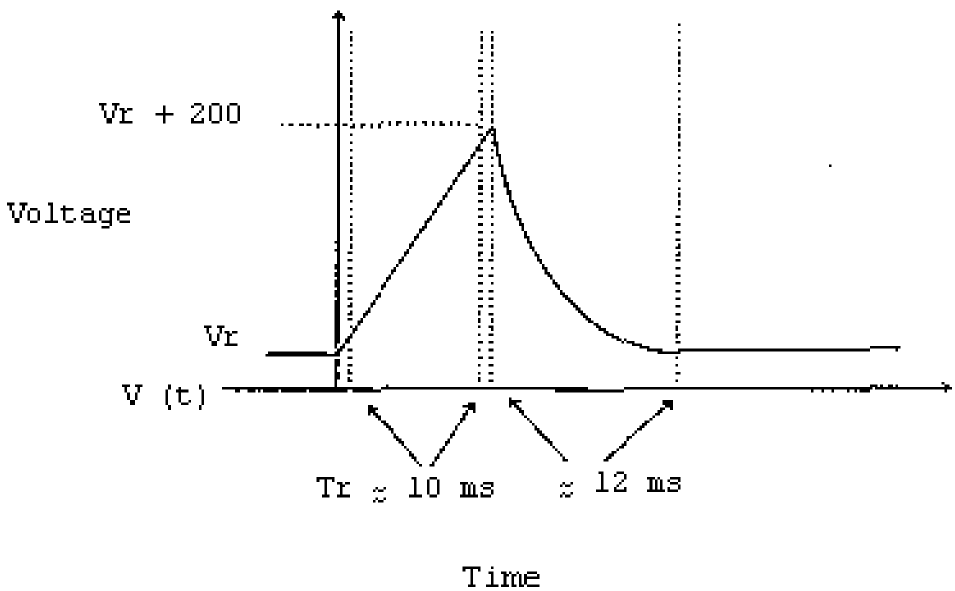


Figure 9-4: Inductive Load Switching #2

Table 9:4 Inductive Load Switching #2

Parameter	24 Volt System
Vs	100
Vr	28V
t	5.5ms
Tr	0.05ms
Ri	4.7 ohms

Table 9:5 Inductive Key Off Switching #1

Parameter	24 Volt System
Vs	-300
Vr	28V
T	2ms
T1	5s
T2	200ms
Ri	4 ohms

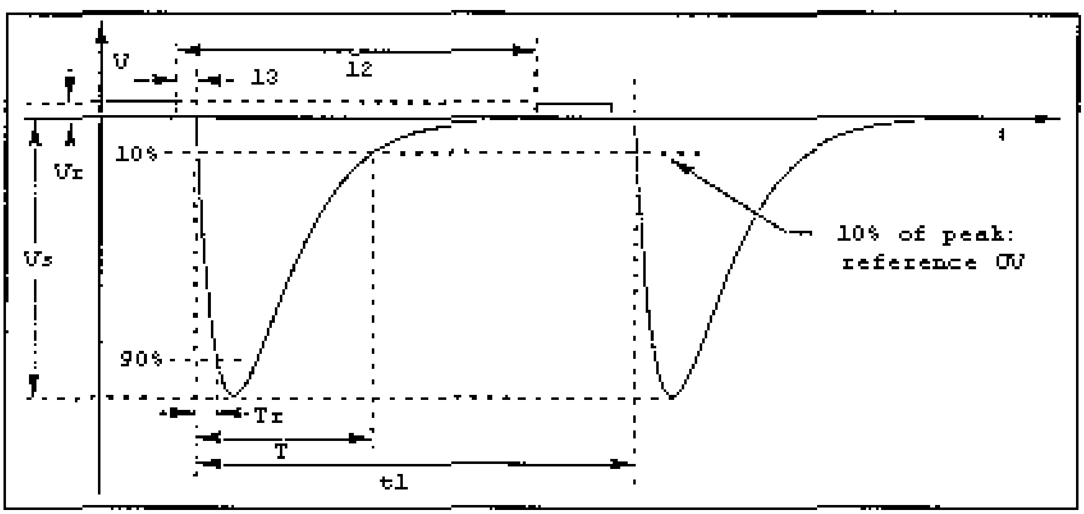


Figure 9-5: Inductive Key Off Switching #1

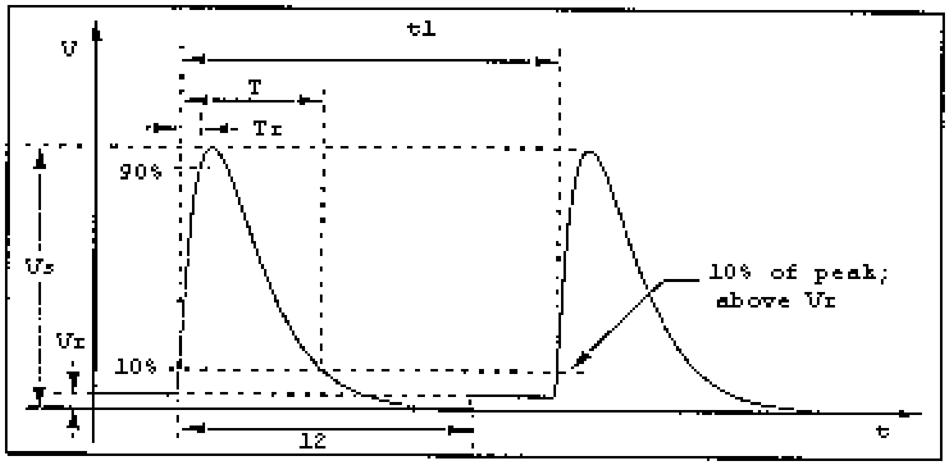


Figure 9-6: Inductive Key Off Switching #2

Table 9:6 Inductive Key Off Switching #2

Parameter	24 Volt System
Vs	200
Vr	28V
T	2ms
T1	5s
T2	200ms
Ri	4 ohms

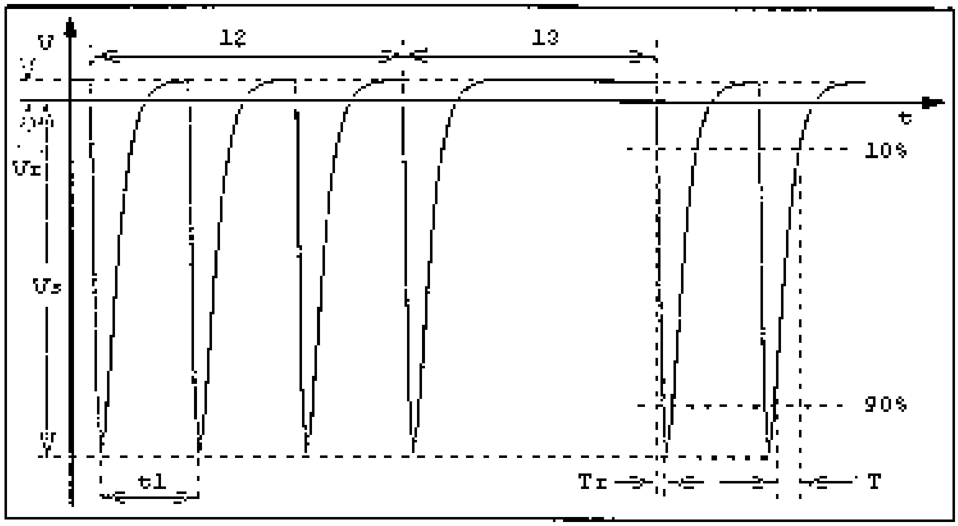


Figure 9-7: Switching Spikes #1

Table 9:7 Switching Spikes #1

Parameter	24 Volt System
Vs	-400V
Vr	28V
Ri	50 ohms

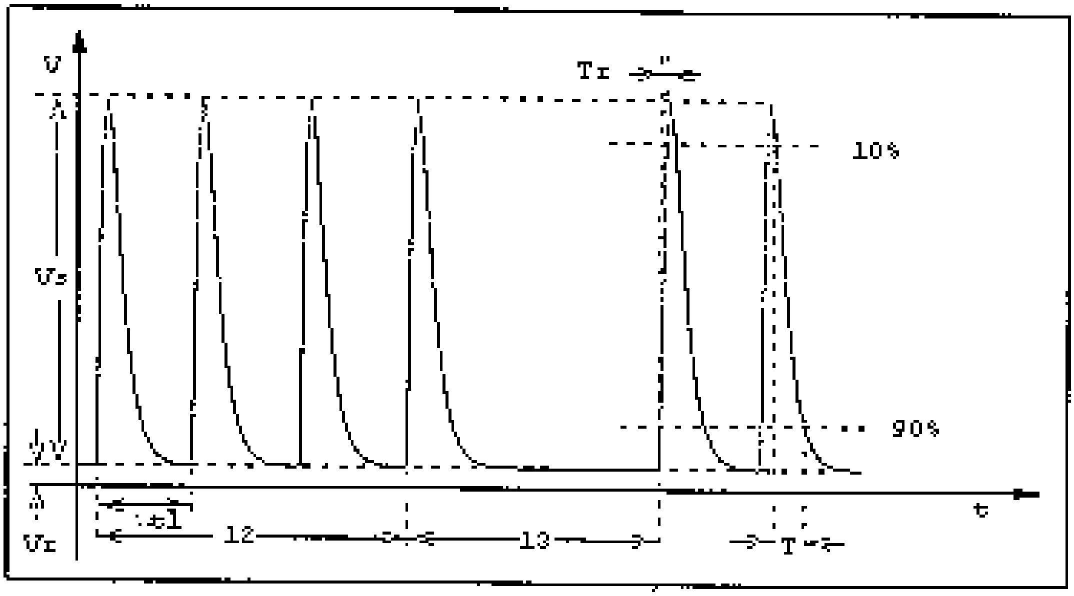


Figure 9-8: Switching Spikes #2

Table 9:8 Switching Spikes #2

Parameter	24 Volt System
Vs	400V
Vr	28V
Ri	50 ohms

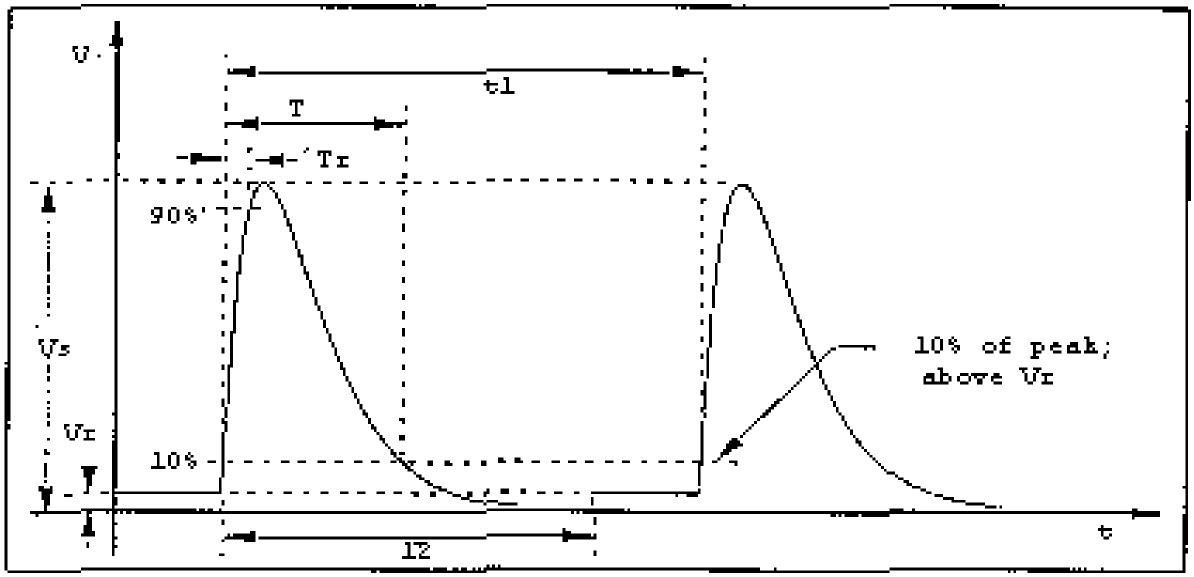


Figure 9-9: Mutual Coupling

Table 9:9 Mutual Coupling

Parameter	24 Volt System
Vs	100V
Vr	0V
Vbatt	28V
T	10usec
Tr	<3usec
t1	100msec
R	5 ohms
L	7 ft

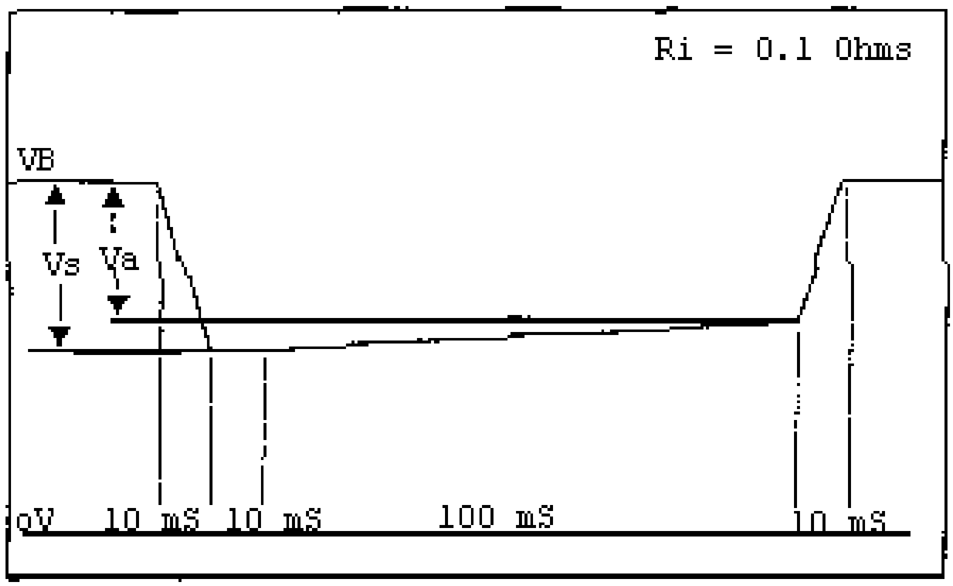


Figure 9-10: Starter Motor Engagement

Table 9:10 Starter Motor Engagement

Parameter	24 Volt System
Vs	-6V
Va	-5V

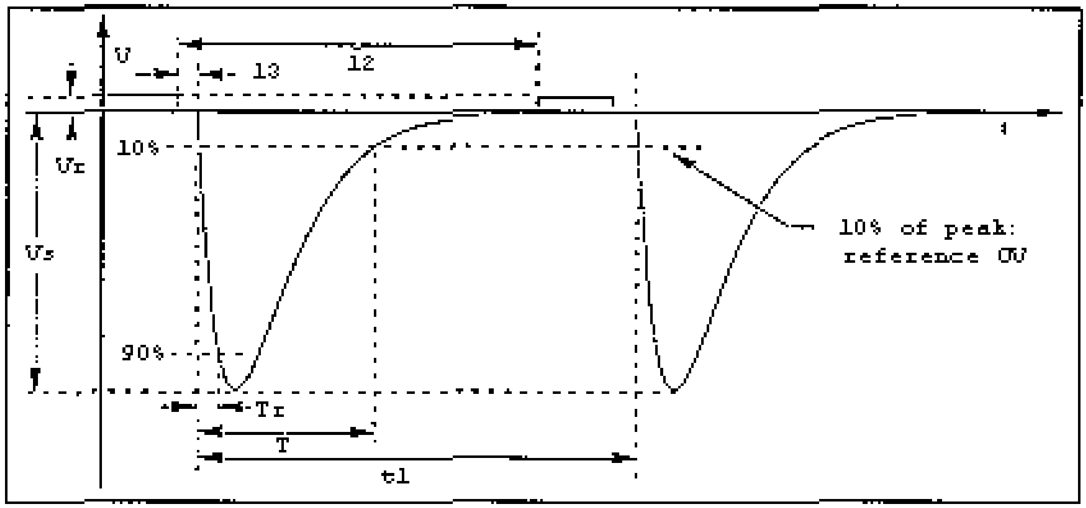


Figure 9-11: Field Decay Transient

Table 9:11 Alternator Field Decay

Parameter	24 Volt System
Vs	-120V
Vr	24V
Tr	<20ms
R	2 ohms
T	100ms

Load Dump: The Load Dump represents a transient pulse which is between +80 and 200 Volts at 300 msec. duration, that can be caused by a disconnection in the line between the alternator and battery, allowing stored energy within the alternator to dissipate throughout the remaining connected equipment. Table 9:12 shows the open circuit waveform parameters which are illustrated in Figure 9-12.

Table 9:12 Waveform Parameters

Waveform	Vr	Vs	Tr	T	R
1	28V	100	<10ms	480ms	2.0 ohms
2	28V	200V	<10ms	400ms	8 ohms

The ECM is designed to withstand this type of disruptive transient when supplied as the waveform represented in Figure 9-12.

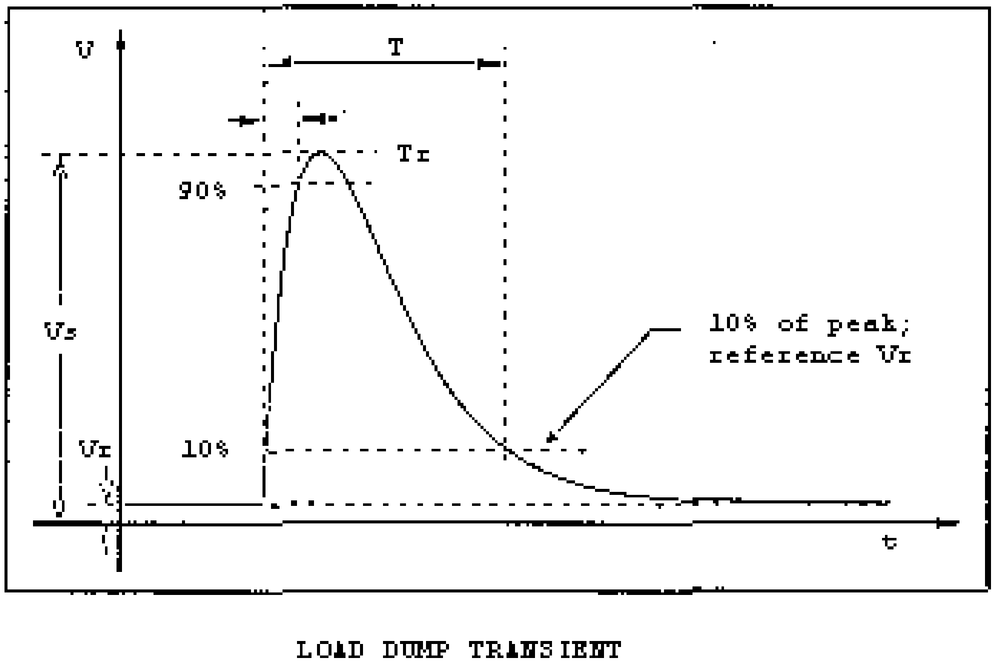


Figure 9-12: Load Dump

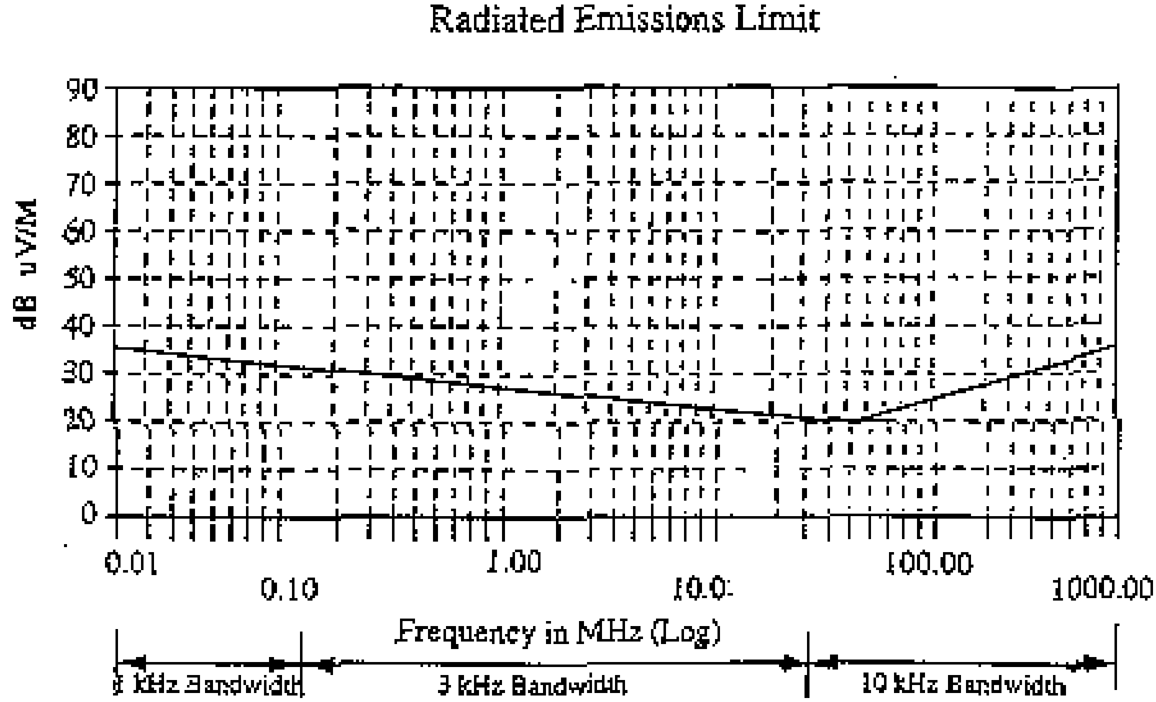


Figure 9-13: Radiated Emissions

Radiated Emissions:-see Figure 9-13

Note: Vehicle designs anticipating large transients outside the limits listed in the above Environmental Section should pursue additional transient suppression in their vehicle designs. This is highly recommended to insure that the energy levels depicted in the figures are not exceeded.

Note: The above Emission Limit Figure represents target emissions, actuals are not available at this time.

10 REVISION HISTORY

Rev Level 000 - 12/1998 - Original document for the ISB4/ISB^e OEM / engine interface. By Tom Fletcher

Rev Level 001 - 5/1999 - Updated and changed documentation to reflect changes to the ISB4/ISB^E OEM / engine. By Wanda WIlliams

Rev Level 002 - 9/2000 - Updated and changed documet to reflect current changes to the ISB4/ISB^E OEM / engine. By Wanda WIlliams

Rev Level 003 - 4/2001 - Updated feature list in section 1. Also alphabetized section 1 and 2. Checked formatting for consistency. Verified the interaction between PTO/Accelerator Interlock (none) in section 2.1. Added that Temp Sensor is not available for ISB^e to section 2.2. Clarified ramp increment for Batterry Voltage Momitor in Section 2.3. Updated conditions and Datalink information in section 2.11. Noted that Grid Heater is required for ISB4 but optional for ISB^E in section 2.13. Updated section 2.24, clarifying selection between Smart and Switched RSG. Section 2.25 was revised to include 2 and 3 position switch. Updated section 2.26 to include VDO info and reference number. Updated section 2.32 to show that WIF is mandatory but application may be engine or dash mounted. Added comment to clarify 12/24 volt operation in section 3.1. Verified interaction between cruise and park brake in section 3.31. Updated wiring diagrams and added harness drawings to section 4. Updated information in section 5. Updated data plate information and monitor mode information in section 6. Updated PID and datalink messages in section 7. Added a new Section 8 to include Off Engine mounted guidelines. Previous section 8 is now section 9. Added this change revision in preparation to putting this document on the vob.

Rev Level 004 - 8/2001 - Updated Section 2.18 to reflect calibrations for Low Idle Speed moved up to 700. Sections 3.26, 3.38 and 3.40 updated to reflect correct pin numbers for Coolant Level Sensor, Two Speed Axle Switch and Powertrain Protection Torque. Also updated rev level for the entire document. These changes implemented per PRCR numbers 43686 and 43446. Wanda Williams.

Rev Level 005 - 9/2001 - Updated section 2.24 to reflect current Euro RSG information. Updated Table 7-1: PIDs Supported on J1587. Updated rev level for entire document. These changes implemented per PRCR numbers 44203 and 43898.

Rev Level 006 - 05-02-02 - Updated Section 2 by adding functional operation data for Fuel Heater, Section 2-13. Updated Section 2.20 Maintenance Monitor to show that this is defaulted to off but can be activated manually. Added Euro Tachometer values to Section 2.28. Updated Section 2.26 Switched Max Operating Speed to reflect this is a TWO position switch only, not a three position. In Section 3.15 Vehicle Speed Sensor, wiring information was updated. In Section 3.22.3 Exhaust Brake wiring with Allison MD transmission, the figure showed the clutch switch incorrectly. This was corrected and a Note was deleted to make this correct. These changes were done per prcr #'s 41125, 41525,46405, 45743, 28490 and 46156. In addition rev level for the entire document and the Table of Contents was updated. Changes were done by Wanda Williams with information provided by Sahil Desai.

Rev Level 007 - 06-14-02 - Updated Section 2 with corrections to the Switched RSG section. Updated Section 7 with PIDs corrections and corrected Fault Code table. ALso added note of reference to a new Appendix B which is an odometer disclaimer. Updated PGN table to include the same reference to Appendix B as well as adding Rx to the PGN data for PGN # 61443. In addition rev level and cross references and table of contents were updated. These changes and corrections were made per prcr #'s 48450, and 48624 by Wanda WIlliams.

Rev Level 008 - 08-23-02 - Updated section 5 to include the addition of Cooling Level Sensor information. ALso updated PID tables and Fault Code Tables in section 7. These updates were made per prcr #48450 by Wanda Williams.

Rev Level 009 - 08-30-02 - Section 3.4.7.1 ECM to Vehicle Connection Procedure, and Section 3.4.7.2 Data Link Device Power Connections were added. The documents was reformated with a font acceptable by Acrobat Distiller. Reformated the cross references. Marked (in color) all the changes to the technical package since Rev 4. Rev 4 was the last version released to OEMs. These changes and corrections were made per prcr # 49791 by Sahil Desai.

Rev Level 010 - 11-12-02 - Marked all changes in Rev 009 with Blue color. Made changes to the Fuel Heater Connector part numbers, and added Fuel Heater fuse recommendations. These changes were made per PRCR # 50610 by Sahil Desai.

Rev Level011 - 03-25-03 - Updated the Fuel Heater Feature description to note that it is now optional. Added Starter Lockout and VSS Anti Tamper Feature description. Included information on the wiring diagram to indicate that the Fuel Temperature Sensor is not offered on the ISB4/ ISBe engines starting MY04. Added Oil Pressure Switch and Dual Potentiometer Throttle wiring in the wiring diagram. Changes made via PRCR #50197, PRCR #50259.

Rev Level012 - 06-20-03 - Updated Table 7-1: PIDs Supported on J1587 to reflect current production. Addition of PIDs 86, 121, 128, 174, 183, 185, 196, 197, 198, 222, 236, 245, 254, and 441. Change made via PRCR #53457 by Julie Hull.

ACRONYMS and ABBREVIATIONS

Acronym	Description
AC	Alternating Current
A/D	Analog-to-Digital (converter)
AFC	Air-Fuel Control
APS	Accelerator Pedal Sensor assembly
ASA	American Standards Association
ASG	All Speed Governor
ATA	American Trucking Associations, Inc.
AWG	American Wire Gauge
bhp	Brake horsepower
Bit	Least divisible unit of information (binary)
Byte	Group of eight adjacent bits treated as a unit
CC	Cruise Control
CECO	Cummins Engine Company, Inc.
CS	Checksum
CTC	Cummins Technical Center
DC	Direct Current
DPDT	Double Pole, Double Throw
DV	Design Verification (test)
ECI	Electronically Controlled Injection
ECM	Electronic Control Module
ECHO	High Pressure Common Rail Software Development Team
EEPROM	Electrically Erasable Programmable Read Only Memory
EFC	Electronic Fuel Control
EMI	Electromagnetic Interference
EPROM	Electrically Programmable Read Only Memory
EPS	Engine Position Sensor
ESDN	Electronic Software Database and Network
ESP	Electronic Smart Power
ESS	Engine Speed Sensor
FMEA	Failure Mode & Effects Analysis
FMI	Failure Modes Identifiers
FMVSS	Federal Motor Vehicle Safety Standard
FSO	Fuel Shutoff (valve)
GND	Ground (reference for voltage measurements)
Hg	Mercury
hp	Horsepower
HPCR	High Pressure Common Rail
HSG	High Speed Governor
Hz	Hertz
ISC	Intermediate Speed Control
LSI	Large Scale Integration (circuit)
LSG	Low Speed Governor

Acronym	Description
µA	Microamp (0.00000x) (unit of electrical current)
mA	Milliamp (0.00x) (unit of electrical current)
MEOST	Multiple Environment Over-Stress Testing
mH	Millihenry
MID	Message Identifier
Mil-spec	Military Specification
mph	Miles Per Hour (vehicle speed)
msec	Millisecond
MSI	Medium Scale Integration (circuit)
mVpp	Millivolts peak-to-peak
N/A	Not Applicable
NC	Normally Closed (switch)
NO	Normally Open (switch)
NPT	National Pipe Thread
NPTF	National Pipe Thread Fine
NTF	No Trouble Found
OAC	Optimized Aftercooler
o.d.	Outside Diameter
OEM	Original Equipment Manufacturer
OEM harness	Wiring harness used to connect the ECM to the vehicle
PC	Personal Computer
PDC	Cummins Parts Distribution Center
pF	Picofarad (unit of electrical capacitance)
PID	Parameter identifier
P/N	Part Number
psia	Pounds per square inch (absolute)
psig	Pounds per square inch (gage)
PTO	Power Takeoff
PV	Product Validation (test)
PWM	Pulse Width Modulator
RAM	Random Access Memory(read-write)
rms	Root mean square
ROM	Read Only Memory
rpm	Revolutions per minute (engine speed)
RSG	Road Speed Governor
SAE	Society of Automotive Engineers
SID	Subsystem Identifier
SPDT	Single Pole, Double Throw
SPST	Single Pole, Single Throw
SSI	Small Scale Integration
TBD	To Be Determined
TDC	Top Dead Center
TMC	The Maintenance Council of American Trucking Associations, Inc.

Acronym	Description
UART	Universal Asynchronous Receiver/Transmitter
UNF	Unified National Fine (threads)
Vbatt	Unswitched battery voltage
Vcc	Circuit supply voltage (usually +5 Vdc)
Vdc	Volts direct current
VIN	Vehicle Identification Number
VGT	Variable Geometry Turbocharger
VNT	Variable Nozzle Turbocharger (VGT)
VOM	Volt-Ohm Meter
Vpp	Voltage peak-to-peak
Vsensor	Reference voltage to sensor
VSG	Variable Speed Governor (Same as ASG)
VSS	Vehicle Speed Signal
WIF	Water In Fuel

Law Department

To all OEM' s, Distributors and Dealers

It has come to Cummins attention that some of our OEMs, Distributors and dealers may be using the total vehicle distance broadcasted by our engine ECM (via our standard protocol identifiers, for example and without limitation, PID 245 Total Vehicle Distance) as total vehicle miles for purposes of the vehicle odometer. This practice should cease immediately. Cummins does not authorize this practice, has never authorized this practice and will not authorize this practice in the future. You may incur significant legal liabilities if you utilize the total vehicle distance broadcasted by our engine ECM as the Cumulative Odometer Value ("Cumulative Odometer Value," means the actual, total miles recorded by the odometer).

The ECM is not designed to be the vehicle odometer. As you are aware, certain maintenance and repair practices can result in a modification to or "zeroing out" of the total vehicle distance broadcasted by the engine ECM. If you use the engine ECM' s broadcast to set the Cumulative Odometer Value and the ECM data is modified or "zeroed out," this may be considered an unlawful and potentially criminal act.

Installation of any device extraneous to the engine ECM or the installation of processes or procedures, by whatever means, that utilize the total vehicle distance broadcasted by our engine ECM for the purpose of setting the Cumulative Odometer Value may violate the Vehicle Information and Cost Savings Act of 1972, as amended, 49 U.S.C. Section 32701 et seq., and other state and federal laws and regulations. These statutes and regulations authorize the imposition of significant civil, financial and criminal penalties, including imprisonment.

Cummins disclaims any and all liability that may arise out of your decision,contrary to its position in this notice, to use the total vehicle distance broadcasted by our engine ECM as the Cumulative Odometer Value. Cummins expressly forbids the use of its ECM and ECM broadcasted data for purposes of setting the Cumulative Odometer Value.

If you have questions regarding the content of this notice or require further legal advice, please contact your legal counsel. Thank you.

Ron B Lannan	*Ric E Kleine*	*Miguel Rivera*
Executive Director Electronics Product Line	Executive Director Automotive Customer Engrg	Senior Counsel Law Department