

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor Bolt	50 N·m	37 lb ft
Air Cleaner Outlet Duct Clamp	8 N·m	71 lb in
Air Conditioning Compressor/Power Steering Pump Bracket Bolt	46 N·m	34 lb ft
Air Inlet Tube Nut	25 N·m	18 lb ft
Battery Cable Bracket Bolt	12 N·m	106 lb in
Battery Cable Bracket Nut	8 N·m	71 lb in
Bypass Pipe Bolt	25 N·m	18 lb ft
Camshaft Gear Bolt	234 N·m	173 lb ft
Camshaft Position Sensor Bolt	10 N·m	89 lb in
Camshaft Position Sensor Exciter Ring Bolt	9 N·m	80 lb in
Camshaft Thrust Plate Bolt	22 N·m	16 lb ft
Charged Air Cooler Bolt	21 N·m	15 lb ft
Charged Air Cooler Clamp	8 N·m	71 lb in
Connecting Rod Cap Bolt - Angular Tightening Method	1st Step 64 N·m	1st Step 47 lb ft
	2nd Step 30 degrees	2nd Step 30 degrees
	3rd Step 30 degrees	3rd Step 30 degrees
Coolant Pipe Bolt and Nut	25 N·m	18 lb ft
Coolant Tube to Water Pump Nut	25 N·m	18 lb ft
Cooling Fan Pulley	41 N·m	30 lb ft
Crankshaft Balancer Bolt	1st Step 100 N·m	1st Step 74 lb ft
	2nd Step 105 degrees	2nd Step 105 degrees
Crankshaft Bearing Cap Bolt	1st Step 98 N·m	1st Step 72 lb ft
	2nd Step 132 N·m	2nd Step 97 lb ft
	3rd Step 30 degrees	3rd Step 30 degrees
Crankshaft Bearing Cap Bolt - Angular Tightening Method	1st Step 100 N·m	1st Step 74 lb ft
	2nd Step 90 degrees	2nd Step 90 degrees
Crankshaft Bearing Cap Side Bolt	70 N·m	52 lb ft
Crankshaft Position Sensor Bolt	10 N·m	89 lb in
Crankshaft Position Sensor Spacer Bolt	10 N·m	89 lb in
Crossmember Bolt	100 N·m	74 lb ft

Cylinder Head M12 Bolt - Angular Tightening Method	1st Step 50 N·m	1st Step 37 lb ft
	2nd Step 80 N·m	2nd Step 59 lb ft
	3rd Step 60 degrees	
	4th Step 60 degrees	
Cylinder Head M8 Bolt	25 N·m	18 lb ft
Drive Belt Tensioner Pulley Bolt	50 N·m	37 lb ft
EGR to EGR Cooler Bolt	25 N·m	18 lb ft
EGR Bracket	25 N·m	18 lb ft
EGR Bracket Bolt	25 N·m	18 lb ft
EGR Bracket to Cooler Bolt	25 N·m	18 lb ft
Electrical Harness Bracket Bolt	10 N·m	89 lb in
Engine Block Coolant Plug	18 N·m	13 lb ft
Engine Block Ground Bolt	34 N·m	25 lb ft
Engine Mount Through Bolt to Frame	75 N·m	55 lb ft
Engine Mount to Block Bolts	58 N·m	43 lb ft
Engine Mount to Frame Bolt	65 N·m	48 lb ft
Engine Shield Bolt	20 N·m	15 lb ft
Exhaust Heat Shield Nut	10 N·m	89 lb in
Exhaust Manifold Bolt/Nut	57 N·m	42 lb ft
Exhaust Manifold Heat Shield Bolts	10 N·m	89 lb in
Exhaust Outlet Clamp	15 N·m	11 lb ft
Exhaust Outlet Heat Shield Bolts	10 N·m	89 lb in
Exhaust Pipe Bracket Nut	53 N·m	39 lb ft
Exhaust Pipe Clamp	53 N·m	39 lb ft
Exhaust Pipe Heat Shield Bolts	10 N·m	89 lb in
Exhaust Pipe to EGR Cooler Nuts	26 N·m	19 lb ft
Fan Pulley Bracket Bolt	50 N·m	37 lb ft
Flywheel Bolt - Angular Tightening Method	1st Step 79 N·m	1st Step 58 lb ft
	2nd Step 60 degrees	2nd Step 60 degrees
	3rd Step 60 degrees	3rd Step 60 degrees
Flywheel Housing Bolt	80 N·m	60 lb ft
Flywheel Housing to Upper Oil Pan Bolt	50 N·m	37 lb ft
Front Engine Cover Bolt	25 N·m	18 lb ft
Fuel Filter Bracket Bolt	30 N·m	22 lb ft
Fuel Injection Pipe Nut	41 N·m	30 lb ft
Fuel Injector Bracket Bolt	30 N·m	22 lb ft
Fuel Inlet Pipe Bracket Bolt	21 N·m	15 lb ft
Fuel Injection Pump Assembly to Cylinder Block Bolt	25 N·m	18 lb ft
Fuel Injection Pump to Bracket Bolt	28 N·m	20 lb ft

Fuel Injection Pump Drive Gear Nut	70 N·m	52 lb ft
Fuel Line Bracket Nut	21 N·m	15 lb ft
Fuel Temperature Sensor	22 N·m	16 lb ft
Fuel Pipes Bracket Bolt	25 N·m	18 lb ft
Fuel Pressure Relief Valve	100 N·m	74 lb ft
Fuel Rail Assembly Bolt	25 N·m	18 lb ft
Fuel Rail Balance Pipe Bolt	21 N·m	15 lb ft
Generator Bracket Bolt and Nut	50 N·m	37 lb ft
Generator Positive Cable Nut	9 N·m	80 lb in
Glow Plug	18 N·m	13 lb ft
Glow Plug Controller Bolt	10 N·m	89 lb in
Glow Plug Harness Bracket Bolt	10 N·m	89 lb in
Glow Plug Nut	2 N·m	18 lb in
Glow Plug Power Feed Nut	15 N·m	11 lb ft
Glow Plug Relay Assembly Bolt	10 N·m	89 lb in
Heater Outlet Pipe Bolt	25 N·m	18 lb ft
Heater Pipe Bolt	25 N·m	18 lb ft
Hood Hinge Bolt	25 N·m	18 lb ft
Idle Pulley Bolt	50 N·m	37 lb ft
Injector Bracket Bolt	23 N·m	16 lb ft
Intake Manifold Bolts/Nuts	25 N·m	18 lb ft
Oil Cooler Adapter Bolts	25 N·m	18 lb ft
Oil Cooler Adapter Nuts	25 N·m	18 lb ft
Oil Cooler Assembly Bolts	25 N·m	18 lb ft
Oil Cooler Adapter Stud	10 N·m	89 lb in
Oil Drain Plug	84 N·m	62 lb ft
Oil Fill Tube Bolt	25 N·m	18 lb ft
Oil Filter	24 N·m	18 lb ft
Oil Gallery Plugs	53 N·m	39 lb ft
Oil Level Indicator Tube Bolt	21 N·m	15 lb ft
Oil Level Sensor Bolt	10 N·m	89 lb in
Oil Level Sensor Harness Bolt	40 N·m	29 lb ft
Oil Pan Bolts/Nuts - Lower	10 N·m	89 lb in
Oil Pan Bolt - Upper	20 N·m	15 lb ft
Oil Pan Skid Plate Bolt	20 N·m	15 lb ft
Oil Pressure Sensor Unit	49 N·m	36 lb ft
Oil Pressure Relief Valve	39 N·m	29 lb ft
Oil Pump Bolt	21 N·m	15 lb ft
Oil Pump Driven Gear Nut	100 N·m	74 lb ft
Oil Pump Gear Cover Bolt	21 N·m	15 lb ft

Oil Pump Pipe and Screen Assembly Bolts and Nuts	25 N·m	18 lb ft
Piston Cooling Nozzle Eye Bolt	21 N·m	15 lb ft
Positive Cable Junction Block Bracket to Power Steering Pump Bolt	9 N·m	80 lb in
Positive Crankcase Ventilation Cover Screws	4 N·m	35 lb in
Positive Crankcase Ventilation Oil Separator Bracket Nut	25 N·m	18 lb ft
Power Steering Pump Bracket Bolt	50 N·m	37 lb ft
Power Steering Pump Bolt	50 N·m	37 lb ft
Rocker Arm Shaft Bracket Bolt	41 N·m	30 lb ft
Starter Motor Bolt	78 N·m	58 lb ft
Transmission Fill Tube Nut	18 N·m	13 lb ft
Thermostat Housing Bolts/Nuts	25 N·m	18 lb ft
Thermostat Cover Bolt	25 N·m	18 lb ft
Torque Converter Bolt	60 N·m	44 lb ft
Transmission Oil Cooler Clip Nut	9 N·m	80 lb in
Turbocharger Bolt	108 N·m	80 lb ft
Turbocharger Coolant Outlet Pipe Bracket Nut	10 N·m	89 lb in
Turbocharger Heat Shield Bolts	10 N·m	89 lb in
Turbocharger Oil Return Pipe Stud	10 N·m	89 lb in
Turbocharger Oil Supply Hose Eye Bolt	26 N·m	19 lb ft
Turbocharger Oil Return Pipe Bolts/Nuts	25 N·m	18 lb ft
Upper Oil Pan to Flywheel Housing Bolts	20 N·m	15 lb ft
Valve Adjusting Nut	22 N·m	16 lb ft
Valve Lifter Holdown Bracket Bolt	11 N·m	97 lb in
Valve Rocker Arm Cover Bolt - Lower	10 N·m	89 lb in
Valve Rocker Arm Cover Bolt - Upper	8 N·m (Two Times)	71 lb in (Two Times)
Water Outlet Bolts	25 N·m	18 lb ft
Water Pump Bolt	25 N·m	18 lb ft
Water Pump Inlet Pipe Bolts	25 N·m	18 lb ft

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
┆ Engine Type	90 degree V-8	
┆ Displacement	6.6 Liter	402 cu in
┆ RPO	LMM	
┆ Bore	103 mm	4.0551 in
┆ Stroke	99 mm	3.8976 in
┆ Compression Ratio	16.8:1	
┆ Engine Compression Test - Minimum	2069 KPa	300 psi
┆ Idle Speed	680 RPM	
┆ Firing Order	1-2-7-8-4-5-6-3	
Block		
┆ Cylinder Bore Diameter - Service Limits	103.11 mm	4.0594 in
┆ Cylinder Bore Diameter - Production Value	103.0-103.014 mm	4.0551-4.0557 in
┆ Cylinder Bore Out-of-Round - Production Value	0.015 mm	0.0006 in
┆ Cylinder Bore Taper - Production Value	0.015 mm	0.0006 in
Camshaft		
┆ Camshaft Bearing Inside Diameter - Service Limit	61.07 mm	2.4043 in
┆ Camshaft Bearing Inside Diameter - Production Value	61.00-61.03 mm	2.4016-2.4028 in
┆ Camshaft End Play - Service Limit	0.2 mm	0.0079 in
┆ Camshaft Journal Diameter - Service Limit	60.92 mm	2.3984 in
┆ Camshaft Journal Diameter - Production Value	60.932-60.962 mm	2.3990-2.4001 in
┆ Camshaft Lobe Lift - Exhaust - Production Value	5.907 mm	0.2326 in
┆ Camshaft Lobe Lift - Intake - Production Value	7.273 mm	0.2863 in
┆ Camshaft Runout - Service Limit	0.05 mm	0.0020 in
Cooling System		
┆ Capacity @ Engine RPM	270 L/min @ 3172 RPM	
┆ Thermostat Full Open Temperature	110 degrees C	230 degrees F
┆ Turbocharger Coolant Bypass Valve	60 degrees C	140 degrees F
Connecting Rod		
┆ Connecting Rod Bearing Clearance - Service Limit	0.10 mm	0.0039 in
┆ Connecting Rod Bearing Clearance - Production	0.036-0.077 mm	0.0014-0.0030 in

Value		
Connecting Rod Bore Diameter - Bearing End - Production Value	62.958-62.979 mm	2.4789-2.4795 in
Connecting Rod Bore Diameter - Pin End - Service Limit	34.53 mm	1.3594 in
Connecting Rod Bore Diameter - Pin End - Production Value	34.512-34.522 mm	1.3587-1.3591 in
Connecting Rod Length	163.0 mm	6.42 in
Connecting Rod Side Clearance - Service Limit	0.54 mm	0.0213 in
Connecting Rod Side Clearance - Production Value	0.31-0.49 mm	0.0122-0.0193 in
Crankshaft		
Connecting Rod Journal Diameter - Service Limit	62.88 mm	2.4756 in
Connecting Rod Journal Diameter - Production Value	62.902-62.922 mm	2.4764-2.4772 in
Crankshaft End Play - Service Limit	0.54 mm	0.0213 in
Crankshaft End Play - Production Value	0.04-0.205 mm	0.0016-0.0081 in
Crankshaft Main Bearing Clearance - Service Limit	0.14 mm	0.0055 in
Crankshaft Main Bearing Clearance - Production Value	0.039-0.070 mm	0.0015-0.0028 in
Crankshaft Main Journal Diameter - Service Limit	79.89 mm	3.1453 in
Crankshaft Main Journal Diameter - Production Value	79.905-79.925 mm	3.1459-3.1466 in
Crankshaft Runout - Service Limit	0.44 mm	0.0173 in
Crankshaft Runout - Production Value	0.05 mm	0.0020 in
Cylinder Head		
Surface Flatness - Block Deck - Service Limit	0.2 mm	0.0079 in
Surface Flatness - Block Deck - Production Value	0.075 mm	0.0030 in
Surface Flatness - Exhaust Manifold Deck - Production Value	0.1 mm	0.0039 in
Surface Flatness - Intake Manifold Deck - Production Value	0.1 mm	0.0039 in
Exhaust Manifold		
Surface Flatness- Production Value	0.3 mm	0.0118 in
Intake Manifold		
Surface Flatness - Production Value	0.3 mm	0.0118 in
Lubrication System		
Oil Capacity - with Filter	10 qt	9.5 L
Oil Capacity - without Filter	9.2 qt	8.7 L
Oil Pressure - Minimum- Hot - at idle	98 KPa	14 psi
Oil Pressure - Minimum - 1800 RPM	294 KPa	42 psi
Oil Relief Valve Opening Pressure	441 KPa	64 psi

Piston Cooling Jet Valve Opening Pressure	196 KPa	29 psi
Oil Pump		
Gear Shaft Outside Diameter - Drive - Service Limit	19.86 mm	0.7819 in
Gear Shaft Outside Diameter - Drive - Production Value	19.947-19.960 mm	0.7853-0.7858 in
Gear Shaft Outside Diameter - Driven - Service Limit	19.86 mm	0.7819 in
Gear Shaft Outside Diameter - Driven - Production Value	19.947-19.960 mm	0.7853-0.7858 in
Gear Shaft-to-Bushing - Service Limit Clearance	0.14 mm	0.0055 in
Gear-to-Cover Clearance - Drive/Driven - Service Limit	0.109 mm	0.0043 in
Gear-to-Cover Clearance - Drive/Driven - Production Value	0.064-0.109 mm	0.0025-0.0043 in
Gear-to-Housing Clearance - Drive/Driven - Service Limit	0.22 mm	0.0087 in
Gear-to-Housing Clearance - Drive/Driven - Production Value	0.125-0.221 mm	0.0049-0.0087 in
Piston Rings		
Piston Ring End Gap-First Compression Ring - Service Limit	1.37 mm	0.0539 in
Piston Ring End Gap-First Compression Ring - Production Value	0.3-0.45 mm	0.0118-0.0177 in
Piston Ring End Gap-Second Compression Ring - Service Limit	1.35 mm	0.0531 in
Piston Ring End Gap-Second Compression Ring - Production Value	0.50-0.65 mm	0.0197-0.0256 in
Piston Ring End Gap-Oil Control Ring - Service Limit	1.20 mm	0.0472 in
Piston Ring End Gap-Oil Control Ring - Production Value	0.15-0.35 mm	0.0059-0.0138 in
Piston Ring to Groove Clearance-First Compression Ring - Service Limit	0.26 mm	0.0102 in
Piston Ring to Groove Clearance-First Compression Ring - Production Value	0.08-0.17 mm	0.0030-0.0067 in
Piston Ring to Groove Clearance-Second Compression Ring - Service Limit	0.10 mm	0.0039 in
Piston Ring to Groove Clearance-Second Compression Ring - Production Value	0.01-0.03 mm	0.0004-0.0012 in
Piston Ring to Groove Clearance-Oil Control Ring - Service Limit	0.12 mm	0.0047 in
Piston Ring to Groove Clearance-Oil Control Ring - Production Value	0.01-0.03 mm	0.0004-0.0012 in
Pistons and Pins		
Piston-Piston Diameter	102.948-	

	102.960 mm	4.0531-4.0535 in
┆ Piston-Piston Pin Bore Diameter	34.504-34.512 mm	1.3584-1.3587 in
┆ Pin-Piston Pin Clearance to Piston Pin Bore - Service Limit	0.017 mm	0.0007 in
┆ Pin-Piston Pin Clearance to Piston Pin Bore - Production Value	0.004-0.017 mm	0.0002-0.0007 in
┆ Pin-Piston Pin Diameter - Service Limit	34.45 mm	1.3563 in
┆ Pin-Piston Pin Diameter - Production Value	34.495-34.5 mm	1.3581-1.3583 in
Starter		
┆ Rated Output	3.5 KW	
Valve System		
┆ Valves-Valve Face Angle - Production Value	45 degrees	
┆ Valves-Valve Face Width - Service Limit	2.5 mm	0.0984 in
┆ Valves-Valve Face Width - Production Value	2.1 mm	0.0827 in
┆ Valves-Valve Head Diameter - Exhaust	31.0 mm	1.22 in
┆ Valves-Valve Head Diameter - Intake	33.0 mm	1.30 in
┆ Valves-Valve Seat Angle	45 degrees	
┆ Valves-Valve Stem Diameter	7.0 mm	0.28 in
┆ Valves-Valve Stem Oil Seal Installed Height	6.05 mm	0.2382 in
┆ Valves-Valve Stem-to-Guide Clearance - Service Limit	0.20 mm	0.0079 in
┆ Valves-Valve Stem-to-Guide Clearance - Exhaust - Production Value	0.038-0.071 mm	0.0015-0.0028 in
┆ Valves-Valve Stem-to-Guide Clearance - Intake - Production Value	0.030-0.063 mm	0.0012-0.0025 in
┆ Valves-Valve Stem-to-Guide Clearance	0.20 mm	0.0079 in
┆ Valve Lifters/Push Rods-Push Rod Straightness	0.8 mm	0.0315 in
┆ Rocker Arms-Valve Rocker Arm Bore Diameter	22.010-22.035 mm	0.8665-0.8675 in
┆ Rocker Arms-Valve Rocker Arm Bore-to-Shaft Clearance - Service Limit	0.20 mm	0.0079 in
┆ Rocker Arms-Valve Rocker Arm Bore-to-Shaft Clearance - Production Value	0.010-0.056 mm	0.0004-0.0022 in
┆ Rocker Arms-Valve Rocker Arm Ratio - Exhaust	1.69:1	
┆ Rocker Arms-Valve Rocker Arm Ratio - Intake	1.36:1	
┆ Rocker Arms-Valve Rocker Arm Shaft Diameter - Service Limit	21.85 mm	0.8602 in
┆ Rocker Arms-Valve Rocker Arm Shaft Diameter - Production Value	21.979-22.000 mm	0.8653-0.8661 in
┆ Valve Springs-Valve Spring Free Length - Production Value	56.6 mm	2.2283 in
┆ Valve Springs-Valve Spring Installed Height - Production Value	41 mm	1.6142 in

Valve Springs-Valve Spring Load - Exhaust - Service Limit	275 N at 41 mm	61.8 lb at 1.61 in
Valve Springs-Valve Spring load - Exhaust - Production Value	315-363 N at 41 mm	71-81.6 lb at 1.61 in
Valve Springs-Valve Spring Load - Intake - Service Limit	306 N at 41 mm	68.8 lb at 1.61 in
Valve Springs-Valve Spring Load - Intake - Production Value	315-363 N at 41 mm	71-81.6 lb at 1.61 in

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Adhesives, Fluids, Lubricants, and Sealers

Application	Type of Material	GM Part Number	
		United States	Canada
Sealing Cup Plug	Loctite 272T or Equivalent	12345493	10953488
Upper Oil Pan to Cylinder Block	Sealant	12378521	88901148
Flywheel Housing to Cylinder Block	Sealant	12378521	88901148
Engine Front Cover to Cylinder Block	Sealant	12378521	88901148
Lower Oil Pan to Upper Oil Pan	Sealant	12378521	88901148
Crankshaft Bearing Side Cap Bolts	Sealant	12346004	10953480
Intake Manifold to Cylinder Head	Sealant	12378521	88901148
Camshaft Bearing	Engine Oil	12345634	993297
Rocker Arm Shaft	Engine Oil	12345634	993297
Valve Bridge Cap	Engine Oil	12345634	993297
Valve Stem Seal	Engine Oil	12345634	993297
Valve Lifter	Engine Oil	12345634	993297
Piston Ring	Engine Oil	12345634	993297
Crankshaft Bearing	Engine Oil	12345634	993297
Connecting Rod Bearing	Engine Oil	12345634	993297
Thrust Bearing	Engine Oil	12345634	993297
Camshaft Bearing	Engine Oil	12345634	993297
Camshaft	Engine Oil	12345634	993297
Connecting Rod Small End Bushing	Engine Oil	12345634	993297
Push Rod	Engine Oil	12345634	993297
Crankshaft Bearing Cap Bolt	Molybdenum Disulfide	1052948	992926
Lithium Grease	Lubricant	12346293	--
Parts Cleaner	Cleaner	12377981	10953463

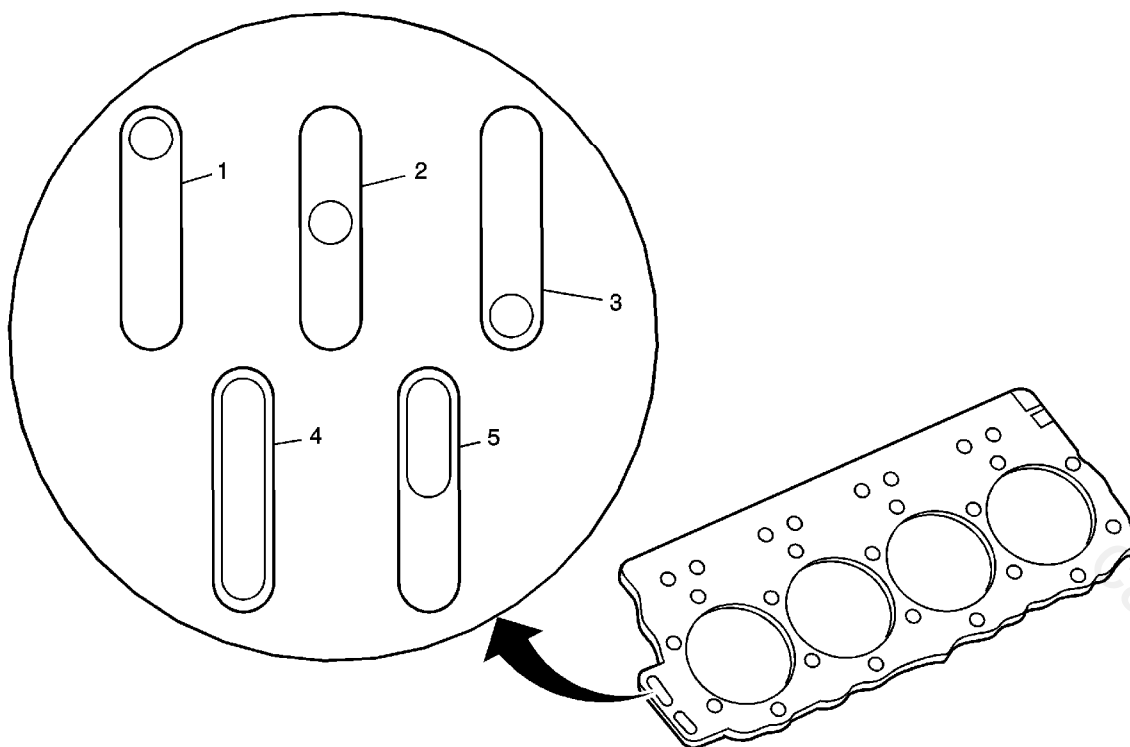
Connecting Rod Bearings Selection Specifications

Connecting Rod Bearing Grade

Connecting Rod Grade (Stamped on Connecting Rod)	Use This Bearing Color	Bearing Thickness		Oil Clearance	
		Metric (mm)	English (in)	Metric (mm)	English (in)
A	Green	2.007 - 2.013	0.0790 - 0.0793	0.037 - 0.076	0.0015 - 0.0030
B	Yellow	2.011 - 2.017	0.0792 - 0.0794	0.037 - 0.076	0.0015 - 0.0030

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Cylinder Head Gasket Selection Specifications



- (1) Grade A
- (2) Grade B
- (3) Grade C
- (4) Block Over-Bored
- (5) Block Over-Bored and Deck Milled

Cylinder Head Gasket Grade	Ti Max (Piston Projection)		Compressed Gasket Thickness	
	Metric (mm)	English (in)	Metric (mm)	English (in)
Grade A	0.223 - 0.274	0.0088 - 0.0108	0.90-1.00	0.0354-0.0394
Grade B	0.274-0.325	0.0108-0.0128	0.95-1.05	0.0374-0.0413
Grade C	0.325-0.376	0.0128-0.0148	1.00-1.10	0.0394-0.0433
Block Over-Bored 0.010-0.030 in (0.254-0.762 mm)	0.223-0.376	0.0088-0.0148	1.00-1.10	0.0394-0.0433
Block Over-Bored 0.010-0.030 in (0.254-0.762 mm) and Deck	0.4257-0.5777	0.0168-0.0228	1.25-1.35	0.0492-0.0532



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Crankshaft Bearing Selection Specifications

Cylinder Block Grade	Crankshaft Journal Grade	Identification Bearing Color	Oil Clearance	
			Metric (mm)	English (in)
1	1	Black	0.041- 0.068	0.0016- 0.0027
1	2	Brown	0.039- 0.065	0.0015- 0.0026
2	1	Blue	0.043- 0.070	0.0017- 0.0028
2	2	Black	0.041- 0.067	0.0016- 0.0027

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Valve Clearance Adjustment Specifications

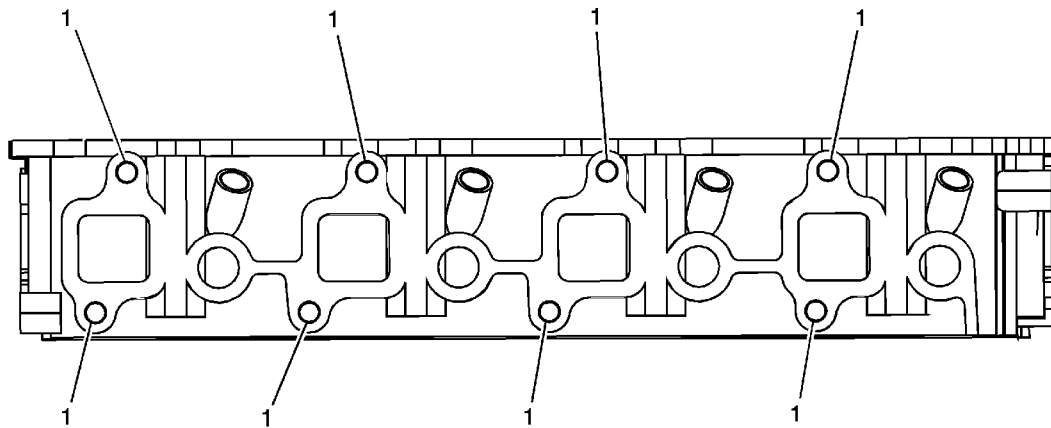
Cylinder		Adjust at No 1 Compression Stroke TDC		Adjust at No 1 Exhaust Stroke TDC	
Left Bank	Right Bank	Intake	Exhaust	Intake	Exhaust
--	1	X	X	--	--
2	--	--	X	X	--
--	3	X	--	--	X
4	--	--	--	X	X
--	5	X	--	--	X
6	--	X	--	--	X
--	7	--	X	X	--
8	--	--	X	X	--

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Thread Repair Specifications

Table 1:	Cylinder Head - Exhaust View
Table 2:	Cylinder Head - Intake View
Table 3:	Cylinder Head - Top View
Table 4:	Cylinder Head - Rear View
Table 5:	Cylinder Head - Front View
Table 6:	Intake Manifold - Right Side View
Table 7:	Intake Manifold - Left Side View
Table 8:	Oil Cooler
Table 9:	EGR Cooler - Rear View
Table 10:	EGR Cooler - Front View
Table 11:	EGR - Top View
Table 12:	Thermostat Housing - Top View
Table 13:	AC Bracket
Table 14:	Generator Bracket - Front View
Table 15:	Generator Bracket - Rear View
Table 16:	Generator Bracket - Side View
Table 17:	Engine Front Cover - Front View
Table 18:	Engine Front Cover - Side View
Table 19:	Engine Front Cover - Bottom View
Table 20:	Lower Rocker Arm Cover - Top View
Table 21:	Lower Rocker Arm Cover - Side View
Table 22:	Upper Rocker Arm Cover - Top View
Table 23:	Upper Rocker Arm Cover - Bottom View
Table 24:	Flywheel Housing - Rear View
Table 25:	Flywheel Housing - Top View
Table 26:	Flywheel Housing - Bottom View
Table 27:	Flywheel Housing - Right View
Table 28:	Flywheel Housing - Left View
Table 29:	Upper Oil Pan - Bottom View
Table 30:	Upper Oil Pan - Top View
Table 31:	Upper Oil Pan - Front View
Table 32:	Upper Oil Pan - Rear View
Table 33:	Upper Oil Pan - Side View

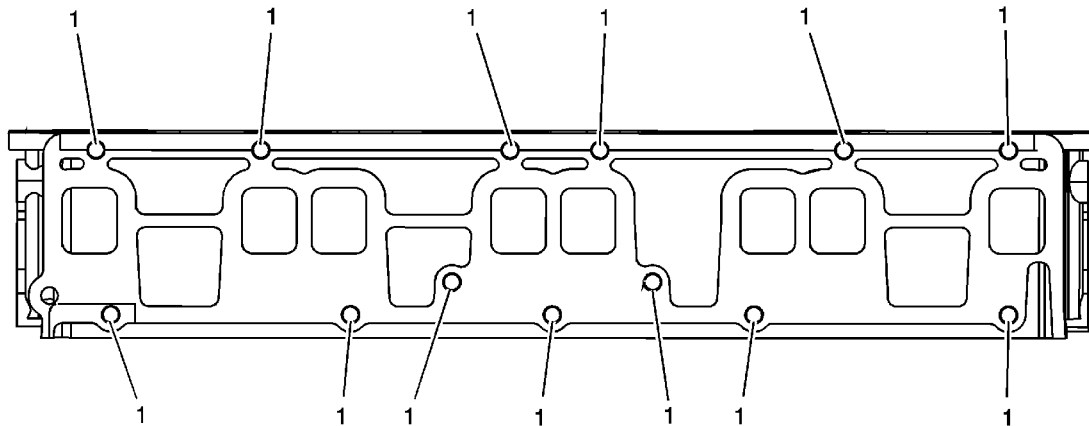
[Cylinder Head - Exhaust View](#)



Cylinder Head - Exhaust View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-215	25	0.985	21	0.827

Cylinder Head - Intake View

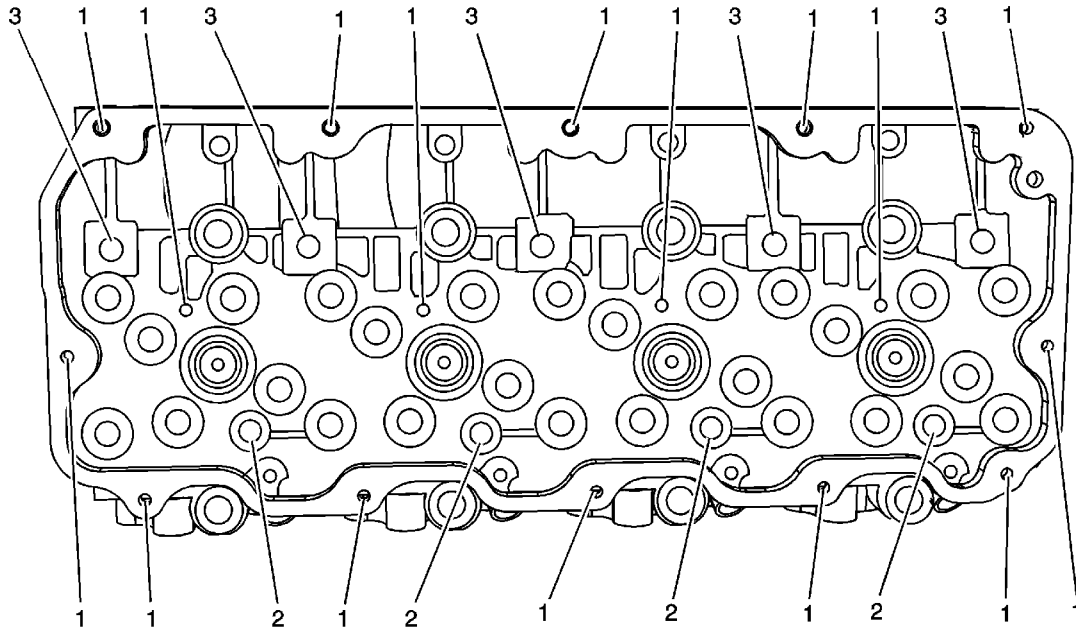


Cylinder Head - Intake View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)

1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	21	0.827	17	0.669
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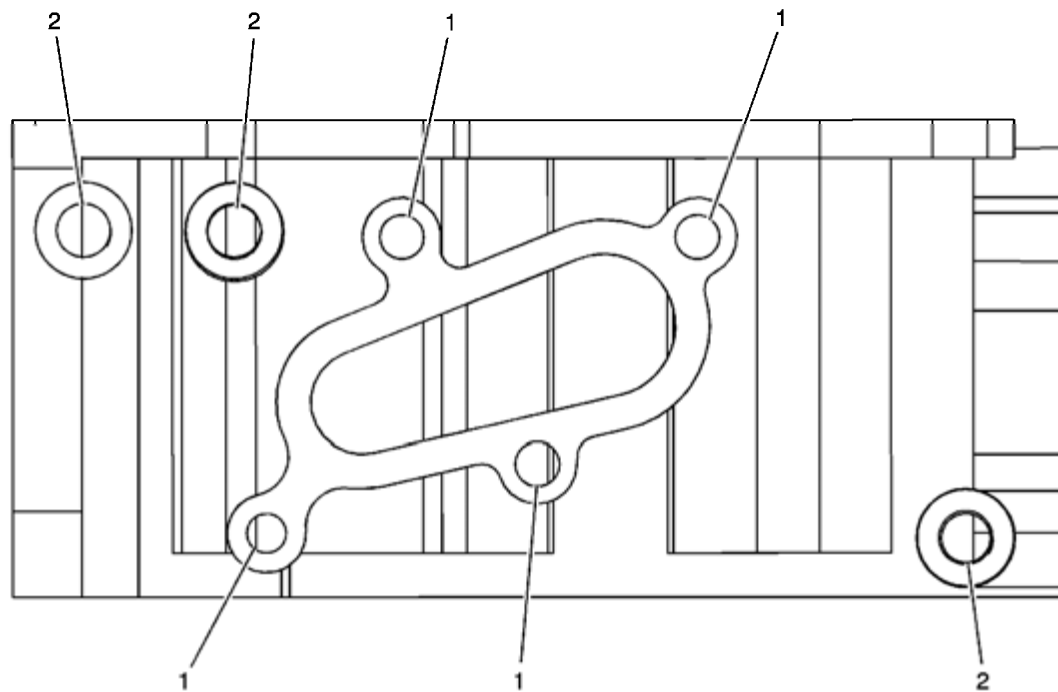
Cylinder Head - Top View



Cylinder Head - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 6 x 1.0	- 201	-202	N/A	- 203	-204	-205	17	0.669	13	0.512
2	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	26	1.024	20	0.788
3	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-215	26	1.024	20	0.788

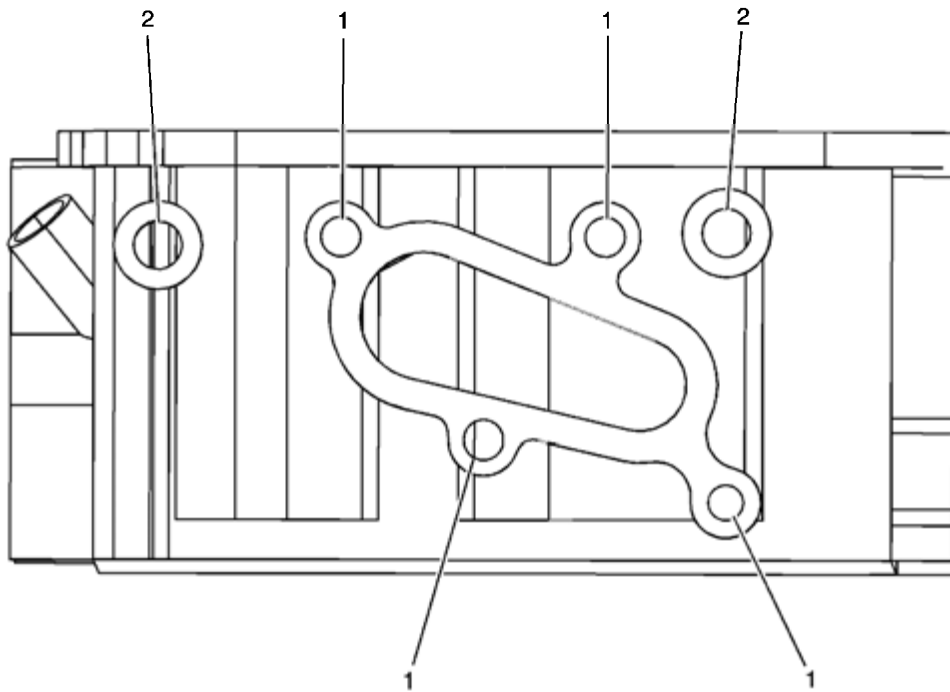
Cylinder Head - Rear View



Cylinder Head - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	17	0.669	13	0.512
2	M 10 x 1.5	-211	-212	N/A	-213	-214	-216	20	0.788	16	0.630

Cylinder Head - Front View



Cylinder Head - Front View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	17	0.669	13	0.512
2	M 10 x 1.5	-211	-212	N/A	-213	-214	-216	20	0.788	16	0.630

Intake Manifold - Right Side View

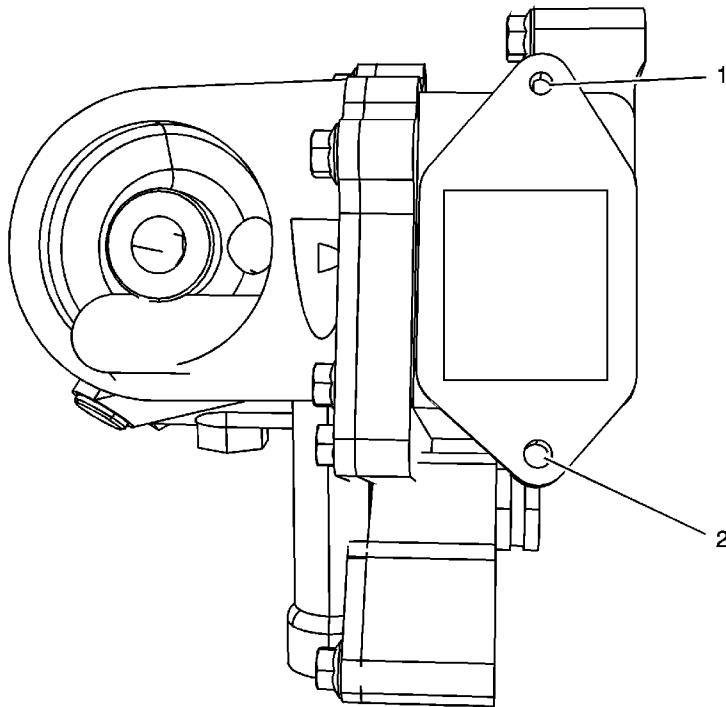


Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-415	16	0.630	13	0.512
2	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	
3	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	16	0.0630	12	0.472

[illegible]

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	
2	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	14	0.551	11	0.433
3	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	16	0.630	12	0.472

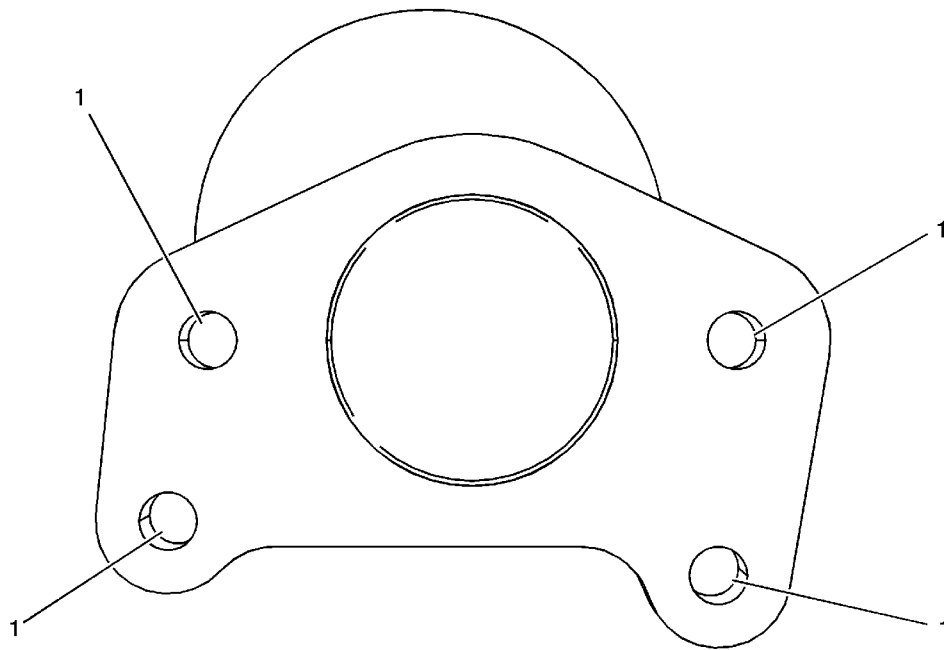
Oil Cooler



Oil Cooler

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	21	0.827	17	0.669
2	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	

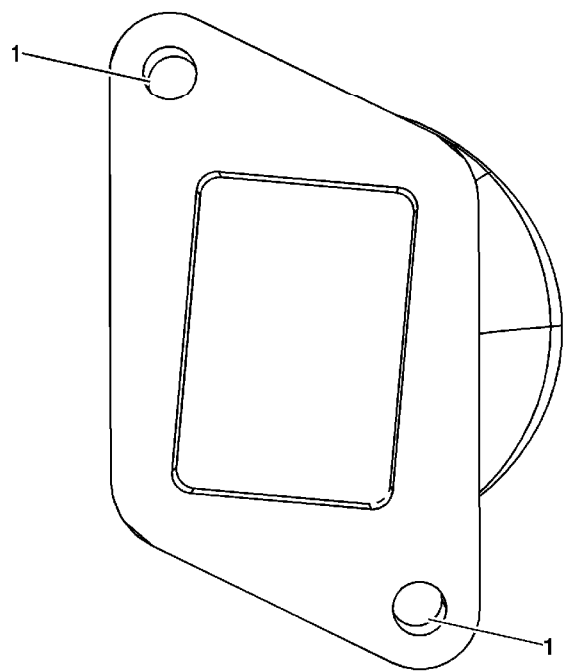
EGR Cooler - Rear View



EGR Cooler - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	

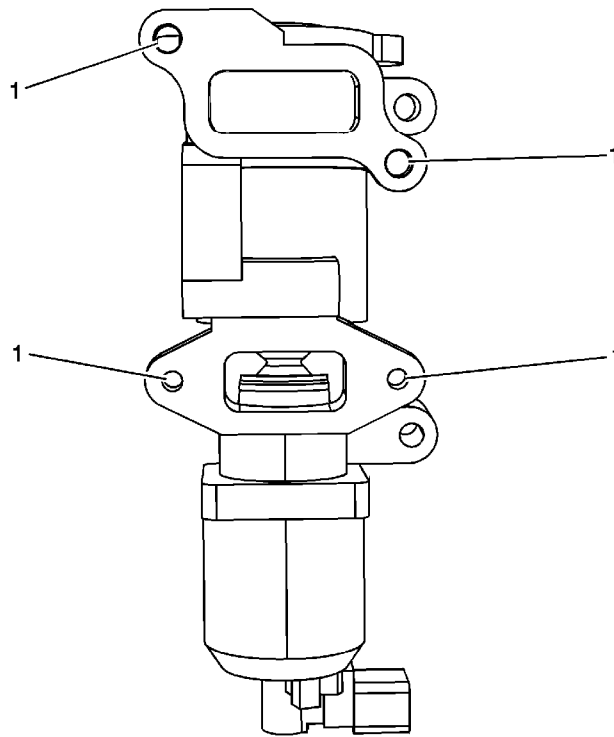
EGR Cooler - Front View



EGR Cooler - Front View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	THRU		THRU	

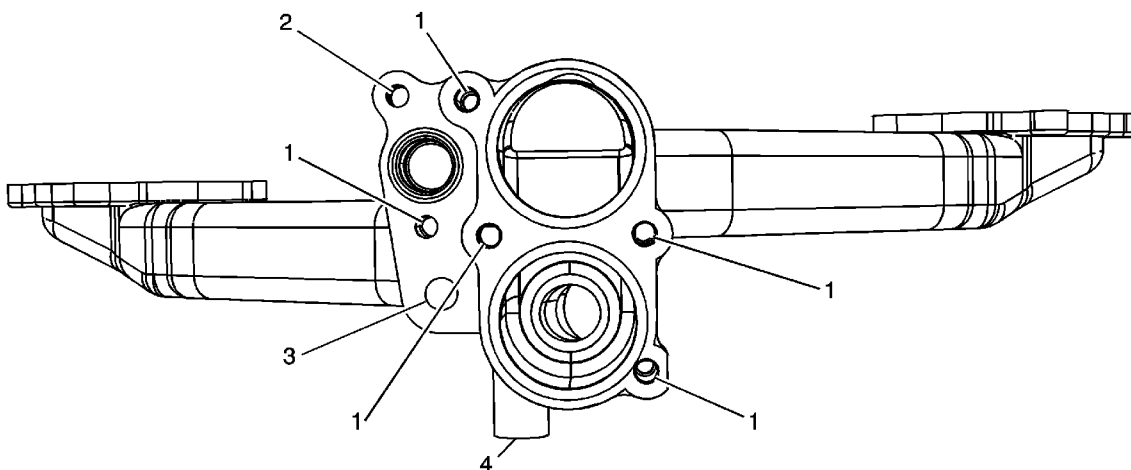
EGR - Top View



EGR - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	

Thermostat Housing - Top View

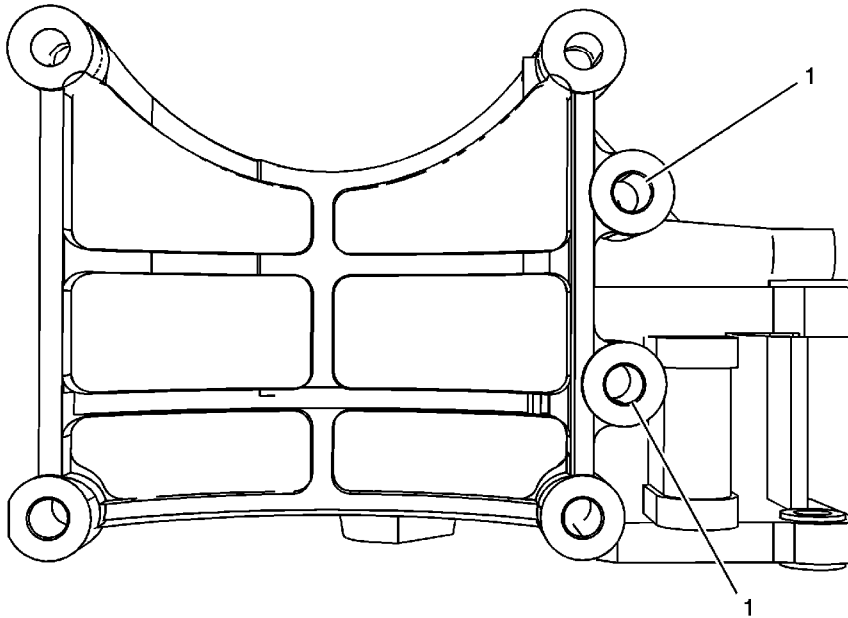




Thermostat Housing - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	21	0.827	17	0.669
2	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	THRU		THRU	
3	NPT 3/8	-2013	N/A	N/A	-294	-2015	-2016	THRU		THRU	
4	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	19	0.748	15	0.591

AC Bracket

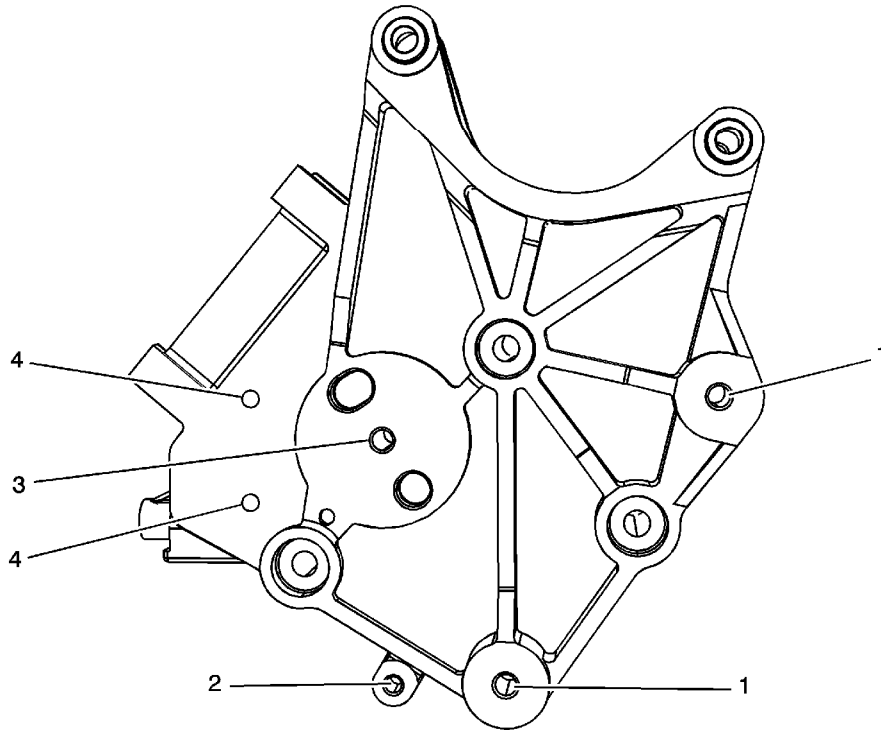


AC Bracket

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)

1	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-420	30	1.182	25	0.985
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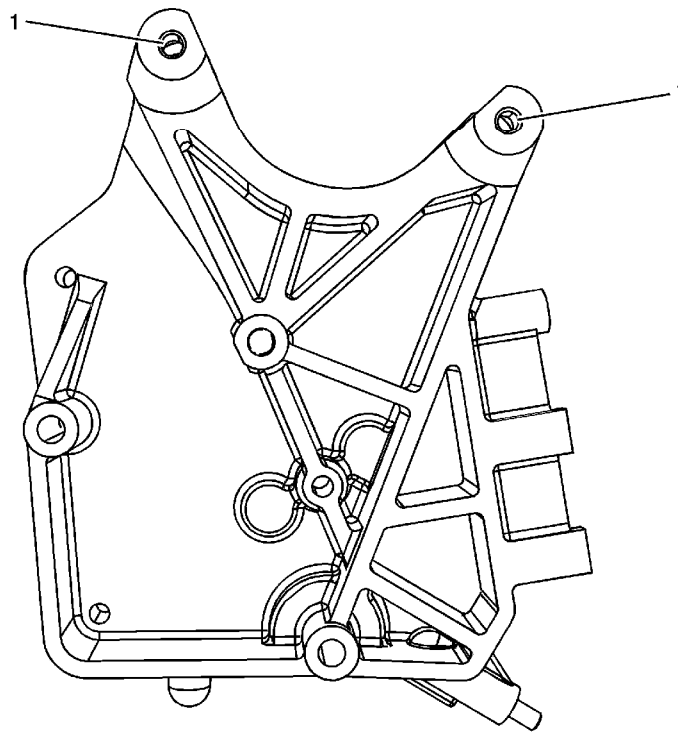
Generator Bracket - Front View



Generator Bracket - Front View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-215	THRU		THRU	
2	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-415	17	0.669	12	0.472
3	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-420	THRU		25	0.985
4	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	22	0.866	17	0.669

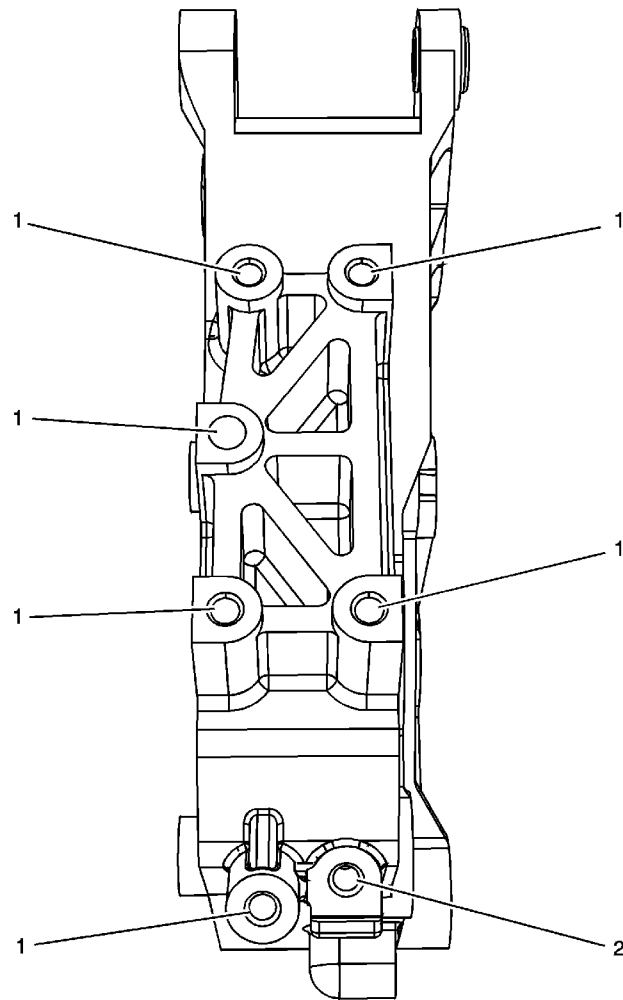
Generator Bracket - Rear View



Generator Bracket - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 10 x 1.5	- 211	-212	N/A	- 213	-214	-215	THRU		THRU	

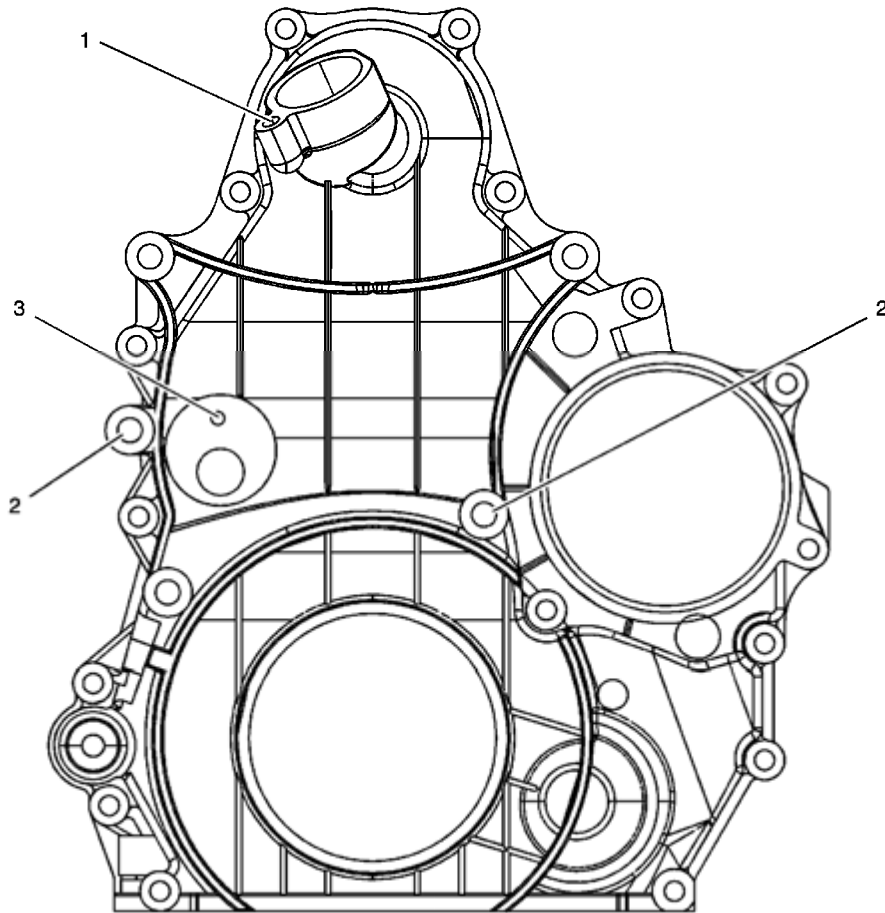
Generator Bracket - Side View



Generator Bracket - Side View

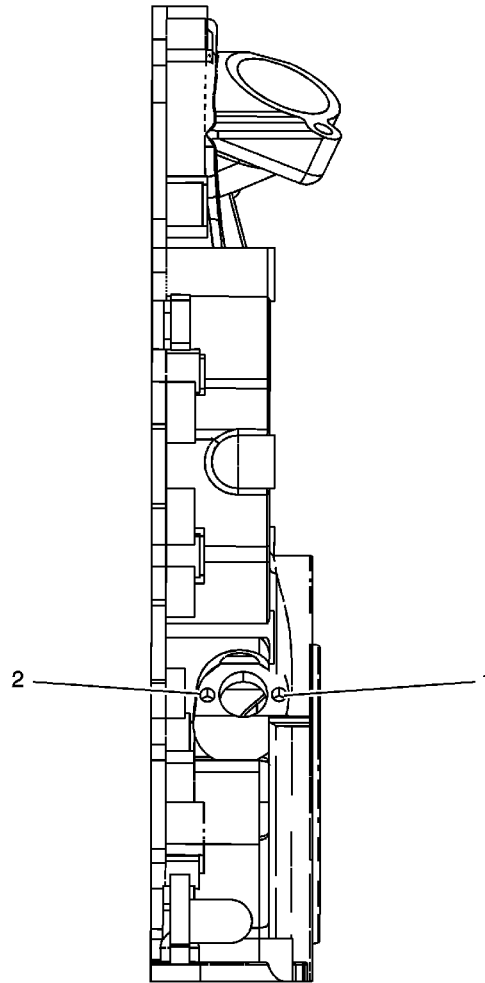
Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	22	0.866	17	0.669
2	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	17	0.669	12	0.472

Engine Front Cover - Front View

**Engine Front Cover - Front View**

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	19	0.748	15	0.591
2	M 10 x 1.5	-211	-212	N/A	-213	-214	-216	20	0.788	16	0.630
3	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	14	0.551	10	0.394

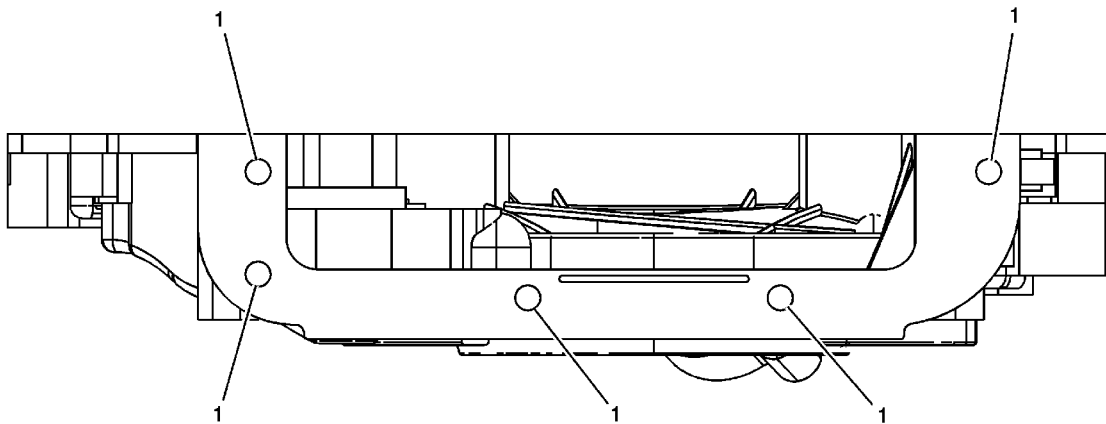
Engine Front Cover - Side View



Engine Front Cover - Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	14	0.551	10	0.394
2	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	THRU		10	0.394

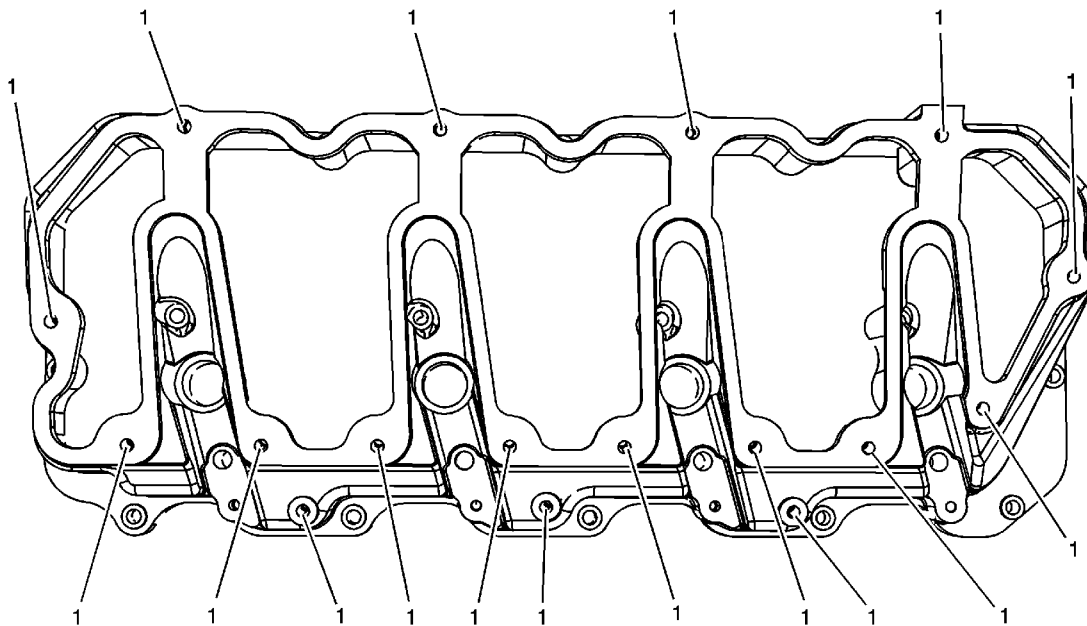
Engine Front Cover - Bottom View



Engine Front Cover - Bottom View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	17	0.669	13	0.512

Lower Rocker Arm Cover - Top View

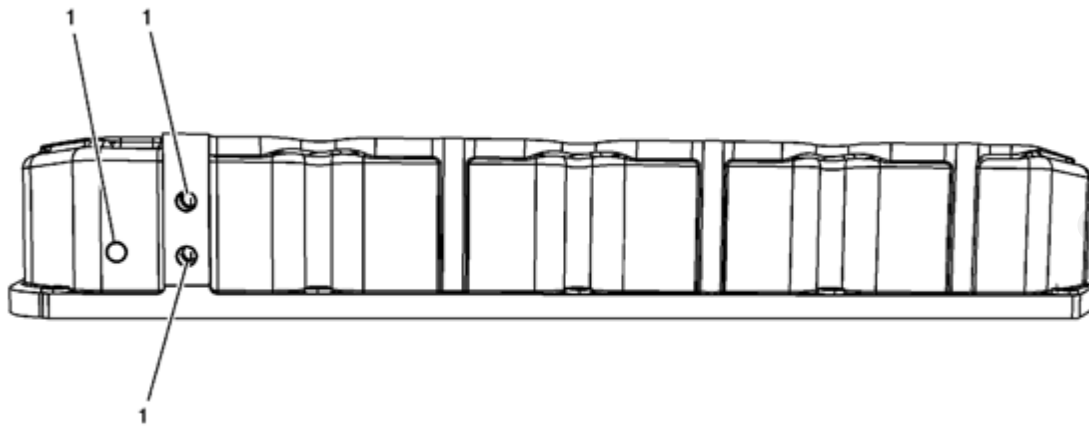




Lower Rocker Arm Cover - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 6 x 1.0	- 201	-202	N/A	- 203	-204	-205	18	0.709	15	0.591

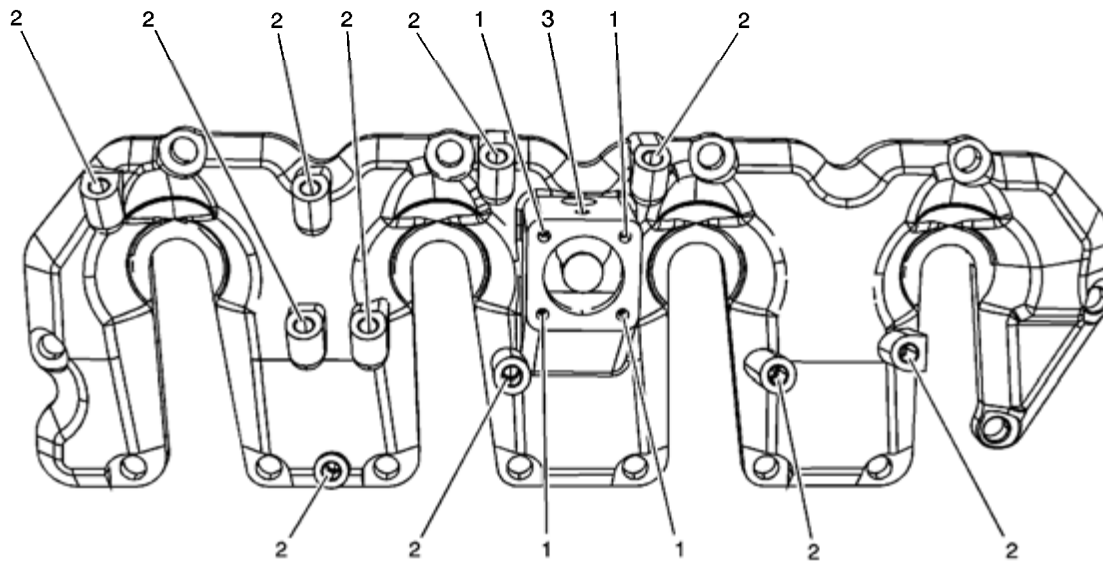
Lower Rocker Arm Cover - Side View



Lower Rocker Arm Cover - Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	21	0.827	17	0.669

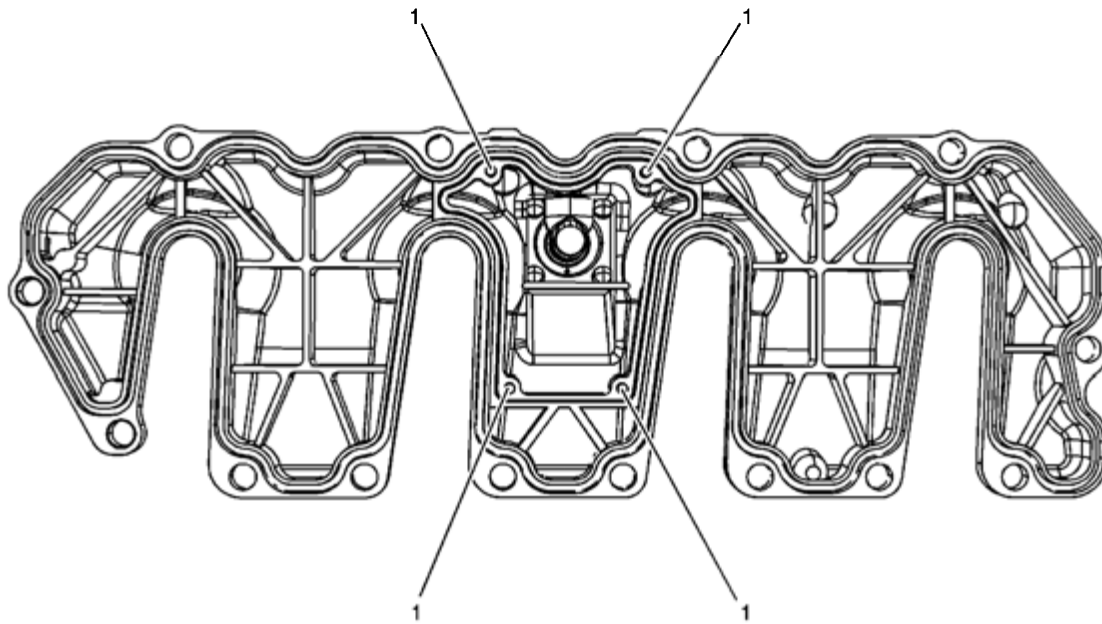
Upper Rocker Arm Cover - Top View



Upper Rocker Arm Cover - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 5 x 0.8	N/A	N/A	N/A	N/A	N/A	N.A	13	0.512	10	0.394
2	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	21	0.827	17	0.669
3	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	16	0.630	12	0.472

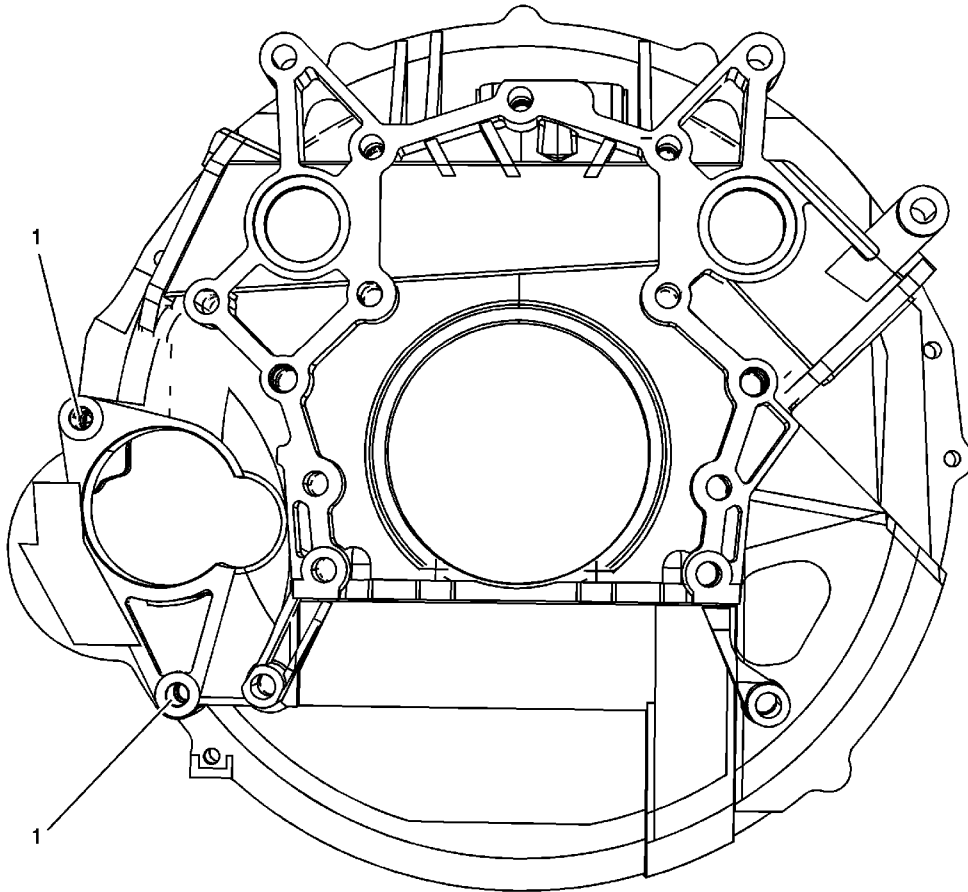
Upper Rocker Arm Cover - Bottom View



Upper Rocker Arm Cover - Bottom View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 5 x 0.8	N/A	N/A	N/A	N/A	N/A	N/A	13	0.512	10	0.394

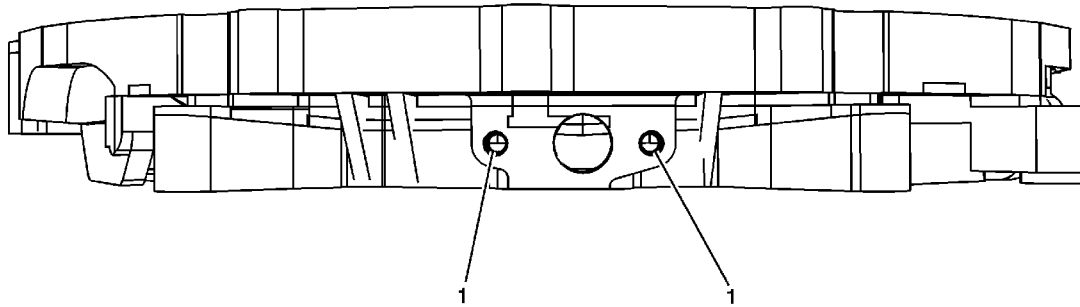
Flywheel Housing - Rear View



Flywheel Housing - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 12 x 1.75	- 856	-857	N/A	- 858	-859	-855	28	1.103	23	0.906

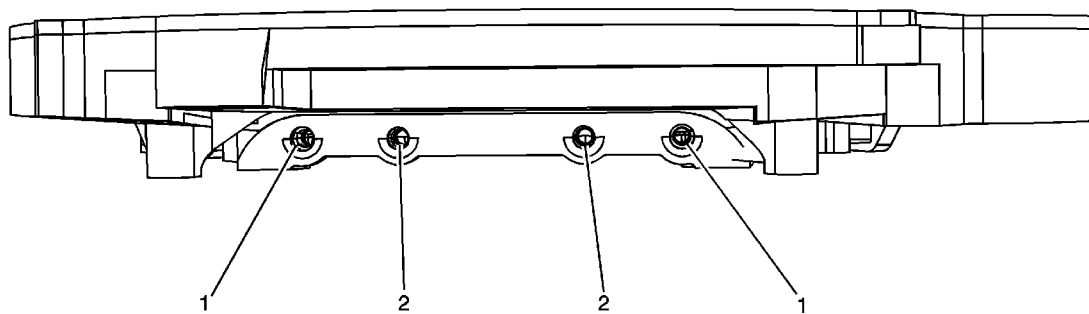
Flywheel Housing - Top View



Flywheel Housing - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	17	0.669	13	0.512

Flywheel Housing - Bottom View

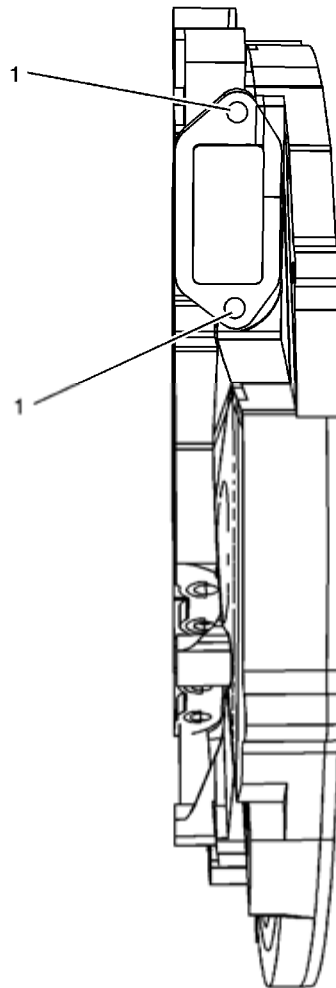


Flywheel Housing - Bottom View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)

1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	21	0.827	18	0.709
2	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	17	0.669	14	0.551

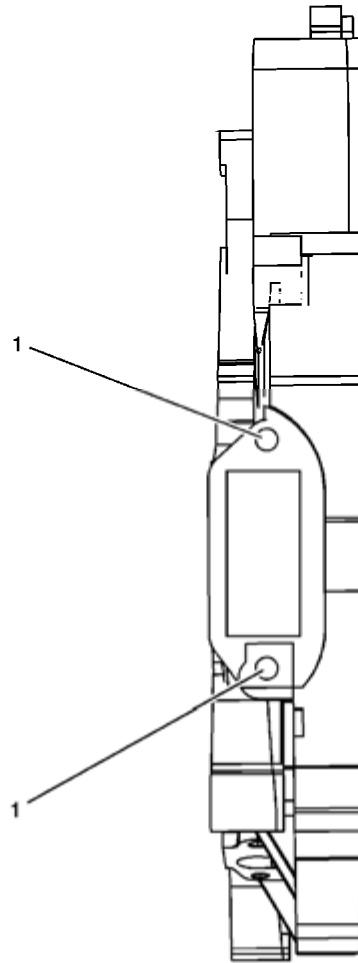
Flywheel Housing - Right View



Flywheel Housing - Right View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	- 206	-207	N/A	- 208	-209	-210	17	0.669	13	0.512

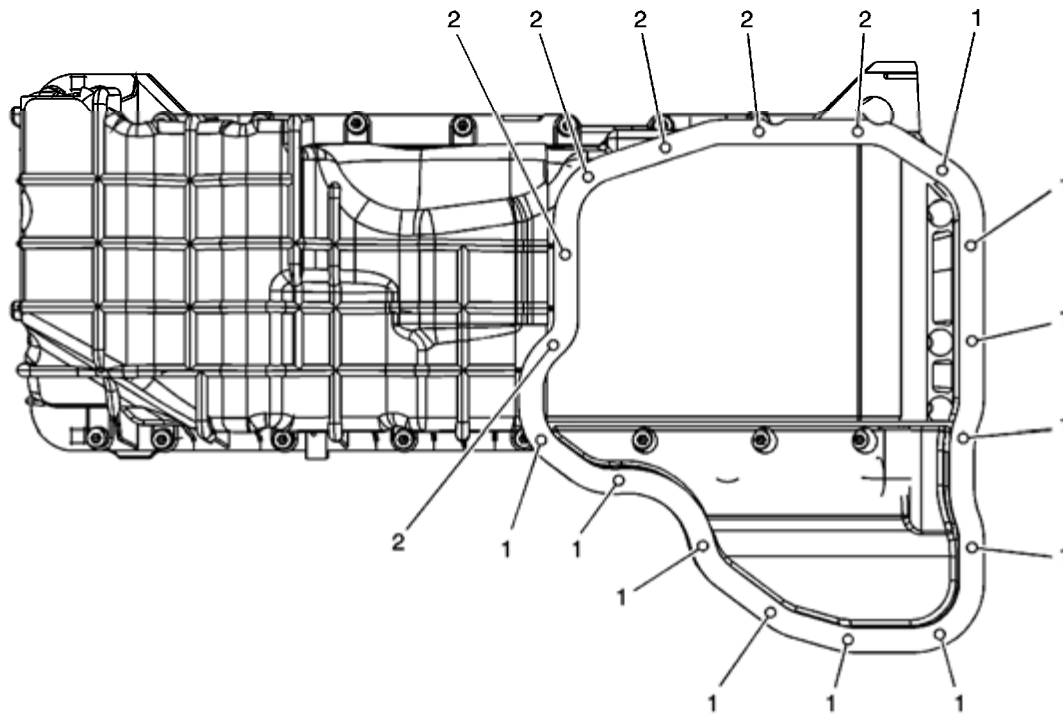
Flywheel Housing - Left View



Flywheel Housing - Left View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	17	0.669	13	0.512

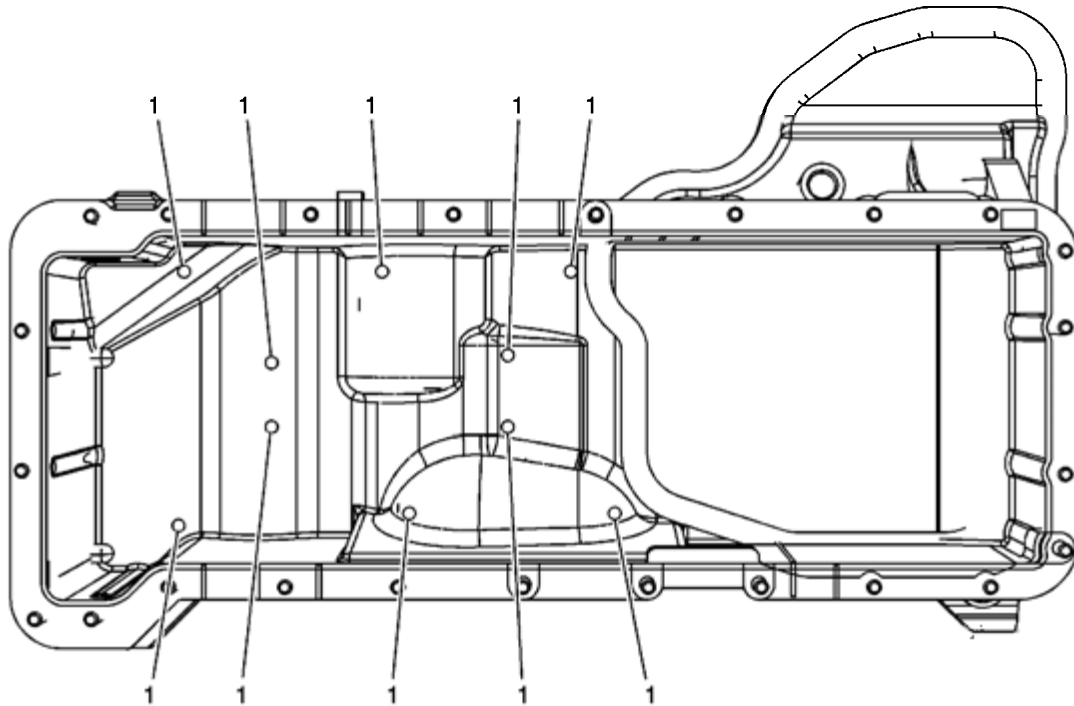
Upper Oil Pan - Bottom View



Upper Oil Pan - Bottom View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	THRU		THRU	
2	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	17	0.669	13	0.512

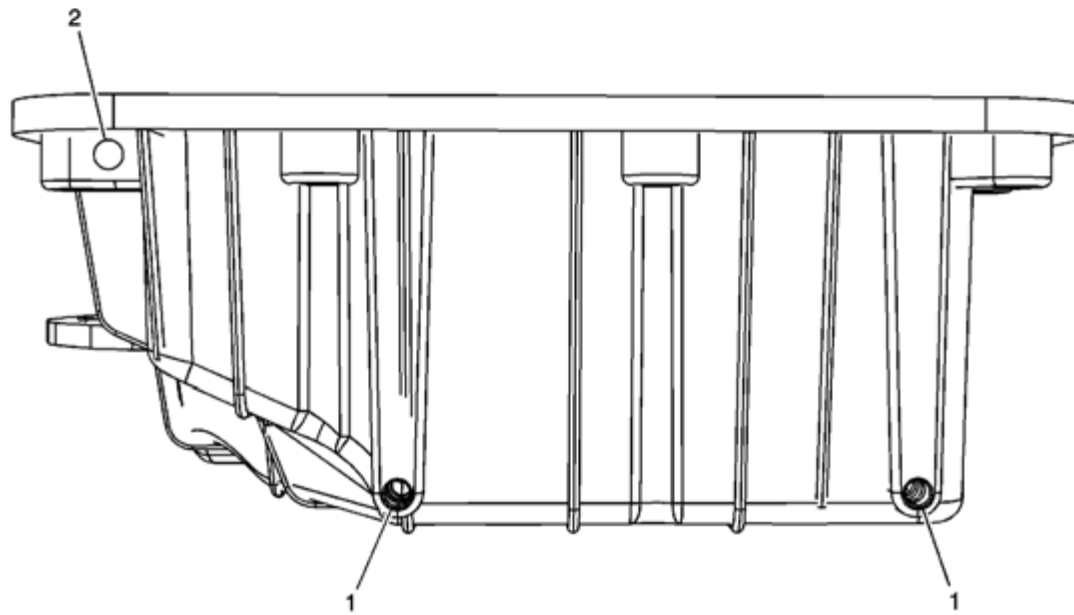
Upper Oil Pan - Top View



Upper Oil Pan - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	17	0.669	13	0.512

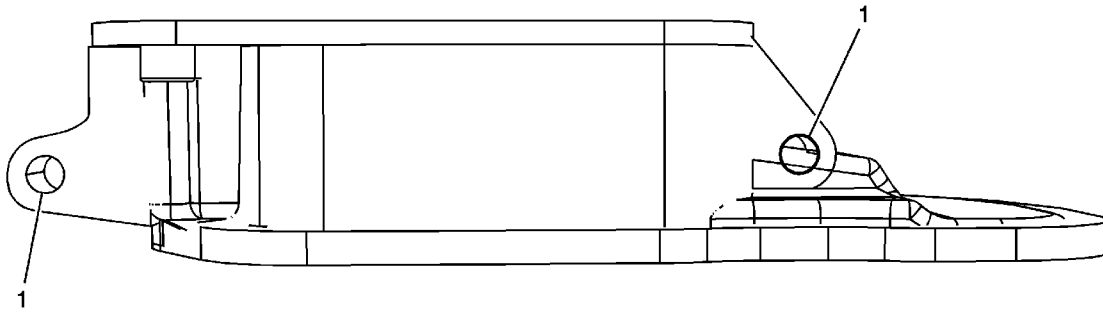
Upper Oil Pan - Front View



Upper Oil Pan - Front View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 6 x 1.0	-201	-202	N/A	-203	-204	-205	17	0.669	13	0.512
2	M 8 x 1.25	-206	-207	N/A	-208	-209	-210	21	0.827	17	0.669

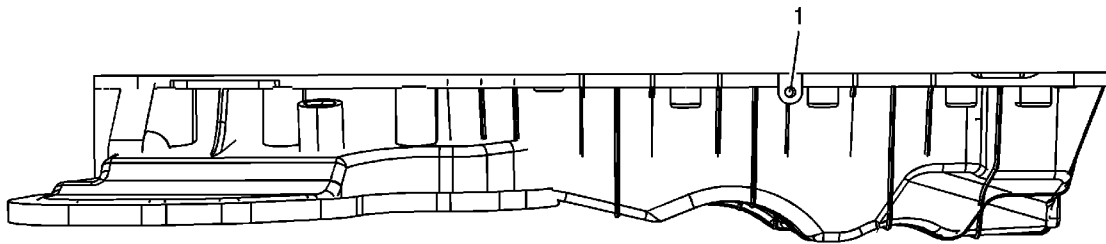
Upper Oil Pan - Rear View



Upper Oil Pan - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)
1	M 12 x 1.75	-856	-857	N/A	-858	-859	-855	22	0.866	16	0.630

Upper Oil Pan - Side View



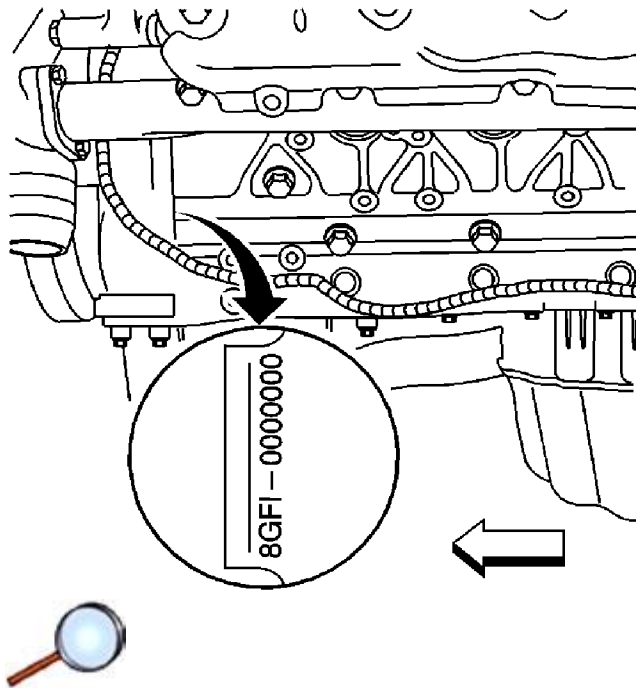
Upper Oil Pan - Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
								mm	(in)	mm	(in)

1	M 6 x 1.0	- 201	-202	N/A	- 203	-204	-205	17	0.669	13	0.512
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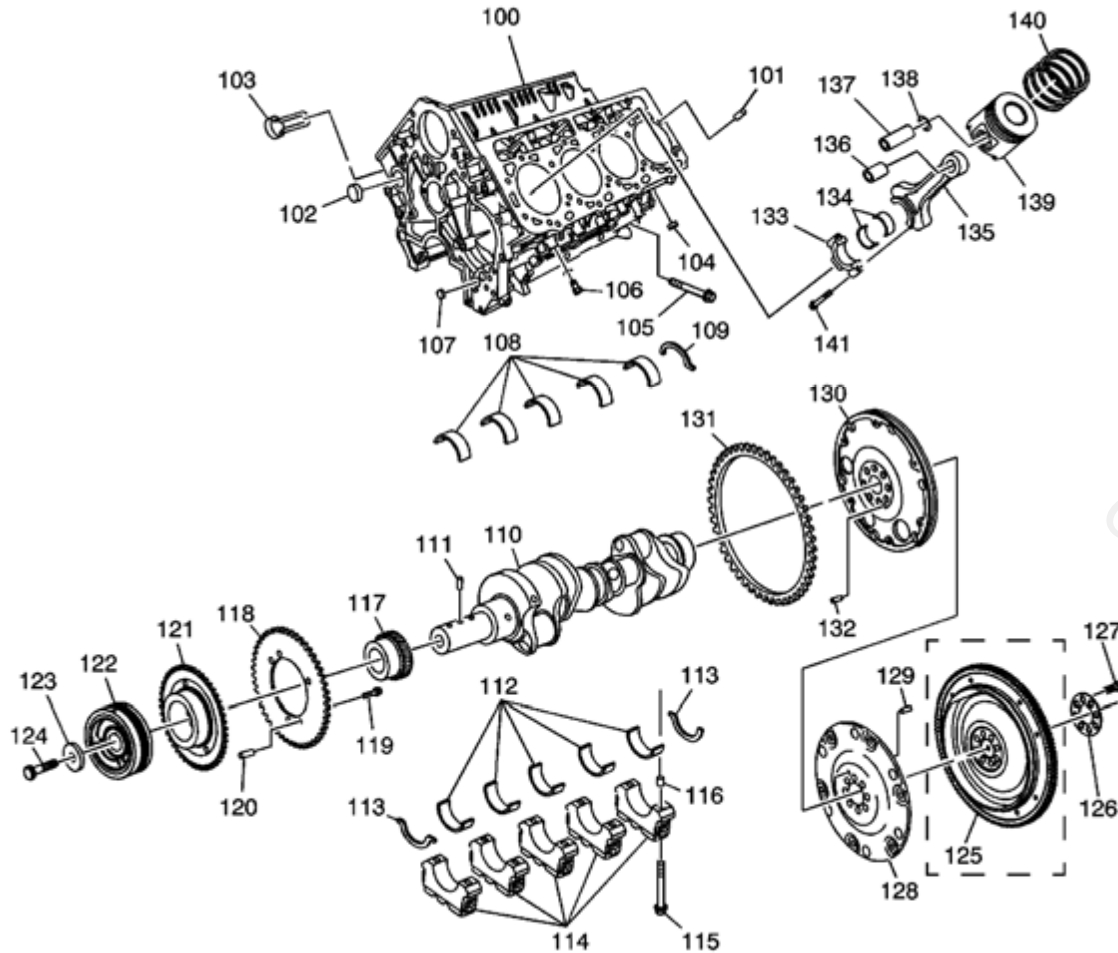
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Engine Identification



The engine identification tag is located on the left side of the block. It is on the front edge of the block.

Engine Block, Crankshaft, Piston

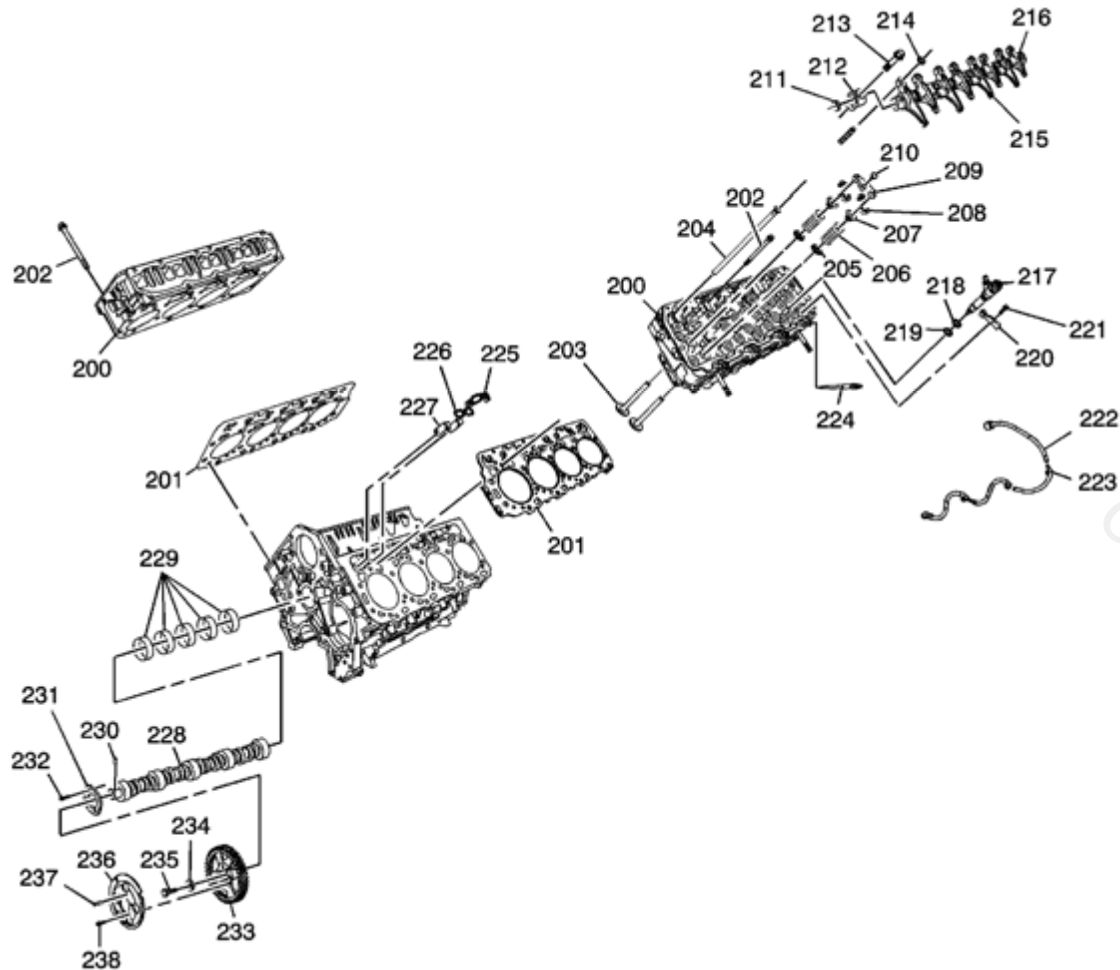


- (100) Engine Block
- (101) Dowel Pin
- (102) Engine Block Plug
- (103) Engine Block Heater
- (104) Engine Block Plug
- (105) Crankshaft Bearing Cap Bolt
- (106) Engine Block Plug
- (107) Engine Block Plug
- (108) Upper Crankshaft Bearings
- (109) Upper Thrust Bearing
- (110) Crankshaft

- (111) Crankshaft Pin
- (112) Lower Crankshaft Bearings
- (113) Lower Thrust Bearings
- (113) Lower Thrust Bearings
- (114) Crankshaft Bearing Cap
- (115) Crankshaft Bearing Cap Bolt
- (116) Dowel Pin
- (117) Crankshaft Gear
- (118) Crankshaft Position Sensor Exciter Ring
- (119) Crankshaft Position Sensor Exciter Ring Bolt
- (120) Crankshaft Position Sensor Exciter Ring Pin
- (121) Oil Pump Drive Gear
- (122) Crankshaft Balancer
- (123) Crankshaft Balancer Washer
- (124) Crankshaft Balancer Bolt
- (125) Flywheel - Manual Transmission
- (126) Flywheel Washer
- (127) Flywheel Bolt
- (128) Flywheel Plate
- (129) Dowel Pin
- (130) Flywheel - Automatic Transmission
- (131) Ring Gear
- (132) Dowel Pin
- (133) Connecting Rod Cap
- (134) Connecting Rod Bearings
- (135) Connecting Rod
- (136) Connecting Rod Bushing
- (137) Piston Pin
- (138) Piston Pin Retainer
- (139) Piston
- (140) Piston Rings
- (141) Connecting Rod Bolt

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Cylinder Head, Valves, Lifters, Timing Components, Camshaft

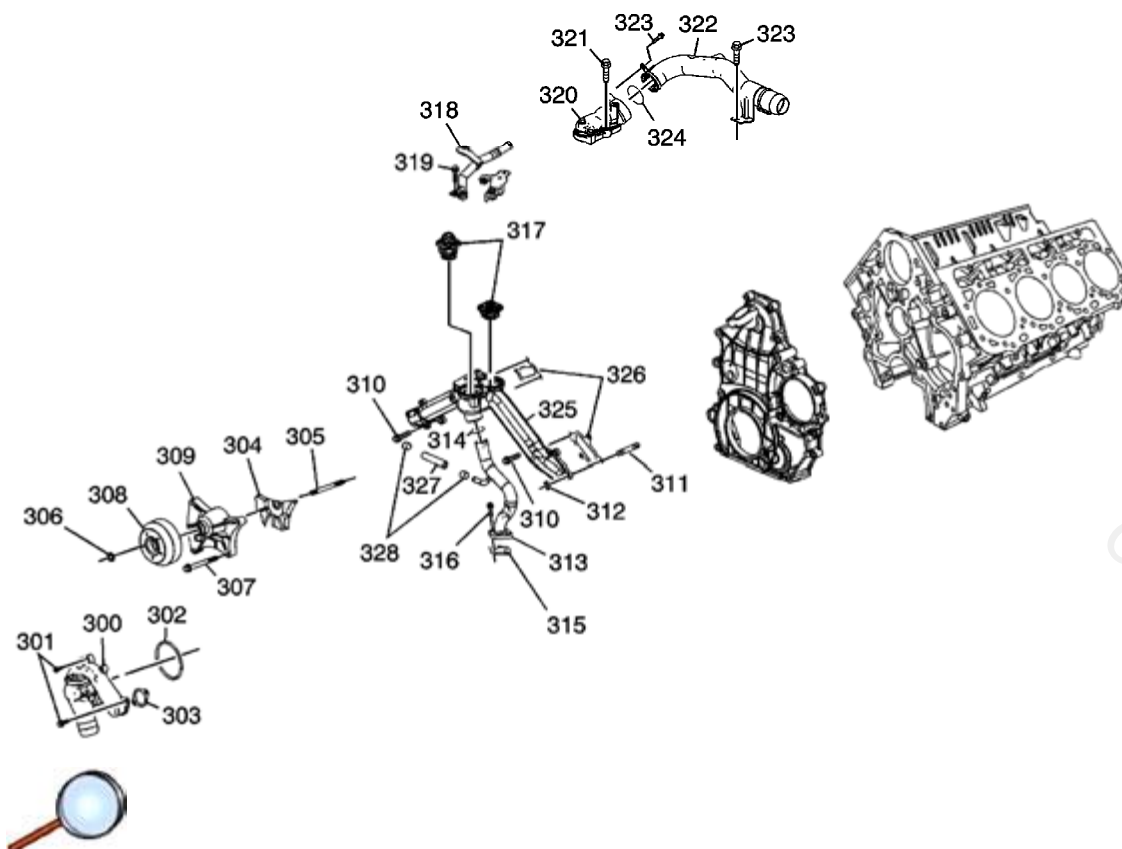


- (200) Cylinder Head
- (200) Cylinder Head
- (201) Cylinder Head Gasket
- (201) Cylinder Head Gasket
- (202) Cylinder Head Bolt
- (202) Cylinder Head Bolt
- (203) Exhaust Valve
- (204) Pushrod
- (205) Valve Spring Seat
- (206) Valve Spring
- (207) Valve Spring Retainer

- (208) Valve Key
- (209) Valve Bridge
- (210) Valve Bridge Pin
- (211) Rocker Arm Shaft Plug
- (212) Rocker Arm Shaft Mount
- (213) Rocker Arm Shaft Mount Bolt
- (214) Rocker Arm Shaft Assembly Lock Nut
- (215) Rocker Arm
- (216) Rocker Arm Shaft Assembly
- (217) Fuel Injector
- (218) Fuel Injector O-ring Seal
- (219) Fuel Injector Gasket
- (220) Fuel Injector Bracket
- (221) Fuel Injector Bracket Bolt
- (222) Fuel Return Pipe
- (223) Fuel Return Pipe Bolt
- (224) Glow Plug
- (225) Valve Lifter Guide Bracket
- (226) Valve Lifter Guide
- (227) Valve Lifter
- (228) Camshaft
- (229) Camshaft Bearings
- (230) Camshaft Pin
- (231) Camshaft Thrust Plate
- (232) Camshaft Thrust Plate Bolt
- (233) Camshaft Gear
- (234) Camshaft Gear Washer
- (235) Camshaft Gear Bolt
- (236) Camshaft Position Sensor Exciter Ring
- (237) Camshaft Position Sensor Exciter Ring Pin
- (238) Camshaft Position Sensor Exciter Ring Bolt

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Cooling, Water Pump



- (300) Water Pump
- (301) Water Pump Bolt
- (302) Water Pump O-ring Seal
- (303) Water Pump Gasket
- (304) Cooling Fan Pulley Insulator
- (305) Cooling Fan Pulley Stud
- (306) Cooling Fan Pulley Nut
- (307) Cooling Fan Pulley Bolt
- (308) Cooling Fan Pulley
- (309) Cooling Fan Pulley Bracket
- (310) Thermostat Housing Bolt
- (310) Thermostat Housing Bolt
- (311) Thermostat Housing Stud
- (312) Thermostat Housing Nut
- (313) Thermostat Bypass Pipe
- (314) Thermostat Bypass Pipe O-ring
- (315) Thermostat Bypass Pipe Gasket
- (316) Thermostat Bypass Pipe Bolt

- (317) Thermostat
- (318) Heater Pipe
- (319) Heater Pipe Bolt
- (320) Thermostat Cover
- (321) Thermostat Cover Bolt
- (322) Water Outlet
- (323) Water Outlet Bolt
- (323) Water Outlet Bolt
- (324) Water Outlet O-ring Seal
- (325) Thermostat Housing
- (326) Thermostat Housing Gasket
- (327) Thermostat Bypass Pipe Crossover Tube
- (328) Thermostat Bypass Pipe Crossover Tube Clamps

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Oil Pan, Pump, Filter, Tube

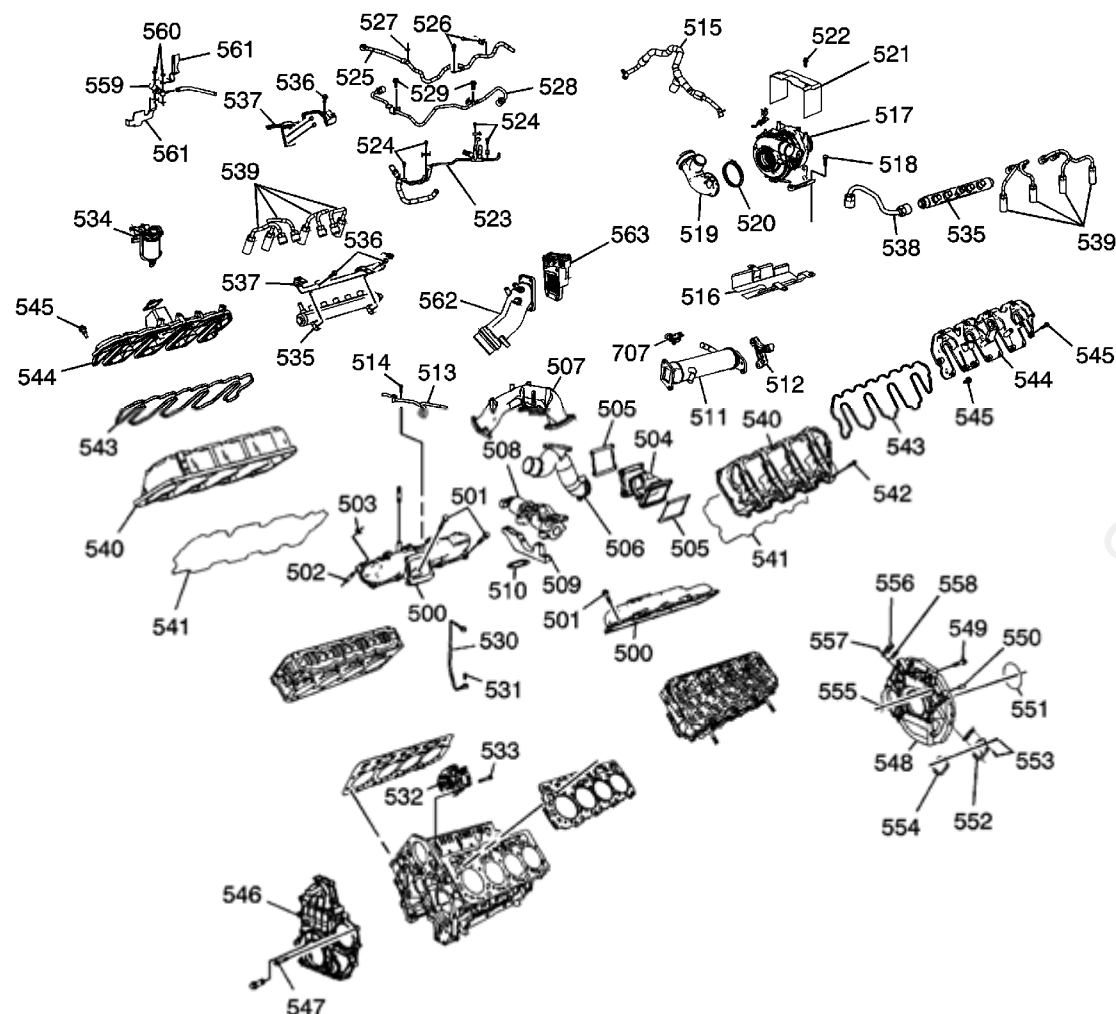


- (400) Oil Pump Housing
- (401) Oil Pump Cover
- (402) Oil Pump Cover Bolt
- (403) Oil Pump Drive Gear
- (404) Oil Pump Driven Gear
- (405) Oil Pump Gear
- (406) Oil Pump Gear Nut
- (407) Oil Level Indicator Tube
- (408) Oil Level Indicator Tube Bolt
- (409) Oil Level Indicator
- (410) Oil Level Indicator Tube O-ring

- (411) Oil Pump Pipe and Screen Assembly
- (412) Oil Pump Pipe and Screen Assembly Bolt
- (413) Oil Pump Pipe and Screen assembly Gasket
- (414) Upper Oil Pan
- (415) Upper Oil Pan Bolt
- (416) Lower Oil Pan
- (417) Lower Oil Pan Bolt
- (418) Oil Level Sensor
- (419) Oil Level Sensor Bolt
- (420) Oil Level Sensor Retainer
- (421) Oil Drain Plug
- (422) Engine Oil Cooler
- (423) Engine Oil Cooler O-ring
- (424) Engine Oil Cooler Bolt
- (424) Engine Oil Cooler Bolt
- (425) Oil Filter Adapter
- (426) Oil Filter
- (427) Oil Pressure Relief Valve Spring Cup
- (428) Oil Pressure Relief Valve Spring
- (429) Oil Pressure Relief Valve Spring Plug
- (430) Oil Cooler Tube
- (431) Oil Fill Tube
- (432) Oil Fill Tube Cap
- (433) Oil Fill Tube Bolt
- (434) Oil Fill Tube O-ring

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Intake Manifold, Rails, Covers



- (500) Intake Manifold
- (500) Intake Manifold
- (501) Intake Manifold Bolt
- (501) Intake Manifold Bolt
- (502) Intake Manifold Stud
- (503) Intake Manifold Nut
- (504) Intake Manifold Crossover
- (505) Intake Manifold Crossover Gasket
- (505) Intake Manifold Crossover Gasket
- (506) Intake Manifold Tube
- (507) Air Inlet Tube

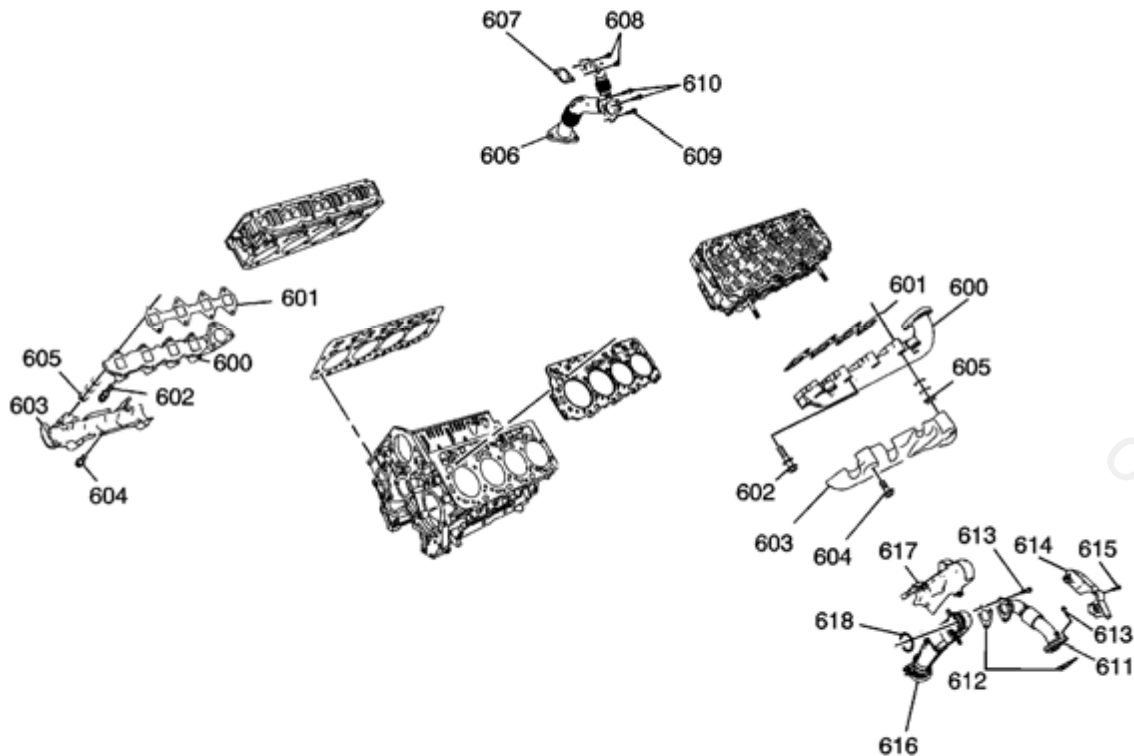
(508) EGR
(509) EGR Bracket
(510) EGR Gasket
(511) EGR Cooler
(512) EGR Cooler Bracket
(513) Fuel Pipe
(514) Fuel Pipe Bolt
(515) PCV Hose
(516) Lower Turbocharger Heat Shield
(517) Turbocharger
(518) Turbocharger Bolt
(519) Turbocharger Air Inlet
(520) Turbocharger Air Inlet Clamp
(521) Upper Turbocharger Heat Shield
(522) Upper Turbocharger Heat Shield Bolt
(523) Fuel Inlet Pipe Assembly
(524) Fuel Inlet Pipe Assembly Bolt
(524) Fuel Inlet Pipe Assembly Bolt
(525) Fuel Feed Pipe
(526) Fuel Feed Pipe Bolt
(527) Fuel Feed Pipe Nut
(528) Fuel Rail Balance Pipe
(529) Fuel Rail Balance Pipe Bolt
(530) Turbocharger Oil Supply Line
(531) Turbocharger Oil Supply Line Bolt
(532) Fuel Injection Pump
(533) Fuel Injection Pump Bolt
(534) Fuel Filter Assembly
(535) Fuel Rail
(535) Fuel Rail
(536) Fuel Rail Bolts
(536) Fuel Rail Bolts
(537) Fuel Rail Bracket
(537) Fuel Rail Bracket
(538) Fuel Injection Pump Pipe
(539) Injection Pipes
(539) Injection Pipes
(540) Lower Valve Rocker Arm Cover
(540) Lower Valve Rocker Arm Cover
(541) Lower Valve Rocker Arm Cover Gasket
(541) Lower Valve Rocker Arm Cover Gasket
(542) Lower Valve Rocker Arm Cover Bolt
(543) Upper Valve Rocker Arm Cover Gasket
(543) Upper Valve Rocker Arm Cover Gasket
(544) Upper Valve Rocker Arm Cover

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(544) Upper Valve Rocker Arm Cover
(545) Upper Valve Rocker Arm Cover Bolt
(545) Upper Valve Rocker Arm Cover Bolt
(545) Upper Valve Rocker Arm Cover Bolt
(546) Engine Front Cover
(547) Engine Front Cover Bolt
(548) Flywheel Housing
(549) Flywheel Housing Bolt
(550) Dowel Pin
(551) Crankshaft Rear Oil Seal
(552) Flywheel Housing Oil Cooler Adapter
(553) Flywheel Housing Oil Cooler Adapter Bolt
(554) Flywheel Housing Oil Cooler Adapter Gasket
(555) Flywheel Housing O-ring
(556) Flywheel Housing Cover
(557) Flywheel Housing Cover Bolt
(558) Flywheel Housing Cover Gasket
(559) Fuel Schrader Valve
(560) Fuel Schrader Valve Nuts
(561) Fuel Schrader Valve Bracket
(561) Fuel Schrader Valve Bracket
(562) Intake Pipe
(563) Intake Heater
(707) Turbocharger Boost Sensor

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Exhaust Manifolds, EGR, Air

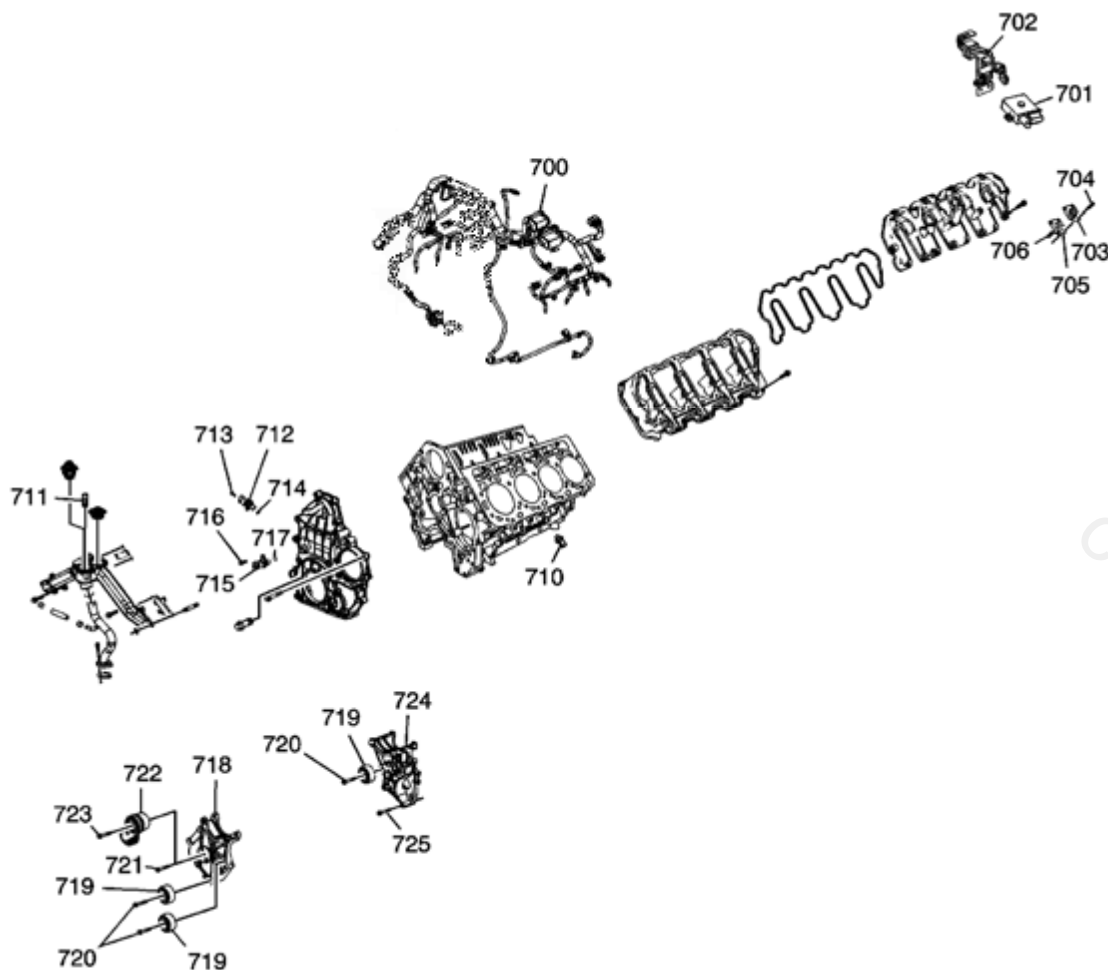


- (600) Exhaust Manifold
- (600) Exhaust Manifold
- (601) Exhaust Manifold Gasket
- (601) Exhaust Manifold Gasket
- (602) Exhaust Manifold Bolt
- (602) Exhaust Manifold Bolt
- (603) Exhaust Manifold Heat Shield
- (603) Exhaust Manifold Heat Shield
- (604) Exhaust Manifold Heat Shield Bolt
- (604) Exhaust Manifold Heat Shield Bolt
- (605) Exhaust Manifold Nut

- (605) Exhaust Manifold Nut
- (606) Exhaust Pipe
- (607) Exhaust Pipe Gasket
- (608) Exhaust Pipe Bolt
- (609) Exhaust Pipe Stud
- (610) Exhaust Pipe Nut
- (611) Exhaust Crossover Pipe
- (612) Exhaust Crossover Pipe Gasket
- (613) Exhaust Crossover Pipe Bolt
- (613) Exhaust Crossover Pipe Bolt
- (614) Exhaust Crossover Pipe Heat Shield
- (615) Exhaust Crossover Pipe Heat Shield Bolt
- (616) Exhaust Outlet Adapter
- (617) Exhaust Outlet Heat Shield
- (618) Exhaust Outlet Adapter Clamp

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Miscellaneous, Sensors, Ignition, Vacuum Hoses, Electrical



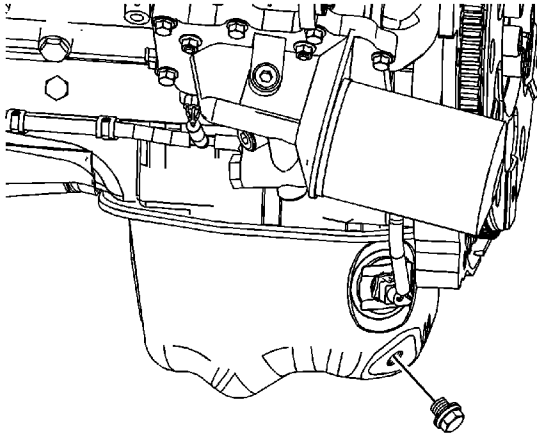
- (700) Engine Wiring Harness
- (701) Glow Plug Controller
- (702) Glow Plug Controller Bracket
- (703) PCV Cover
- (704) PCV Cover Bolt
- (705) PCV Diaphragm
- (706) PCV Spring
- (710) Oil Pressure Sensor
- (711) Coolant Temperature Sensor
- (712) Crankshaft Position Sensor
- (713) Crankshaft Position Sensor Bolt

(714) Crankshaft Position Sensor O-ring
(715) Camshaft Position Sensor
(716) Camshaft Position Sensor Bolt
(717) Camshaft Position Sensor O-ring
(718) Generator Mounting Bracket
(719) Idler Pulley
(719) Idler Pulley
(719) Idler Pulley
(720) Idler Pulley Bolt
(720) Idler Pulley Bolt
(721) Generator Mounting Bracket Bolt
(722) Drive Belt Tensioner
(723) Drive Belt Tensioner Bolt
(724) Power Steering Pump Bracket
(725) Power Steering Pump Bracket Bolt

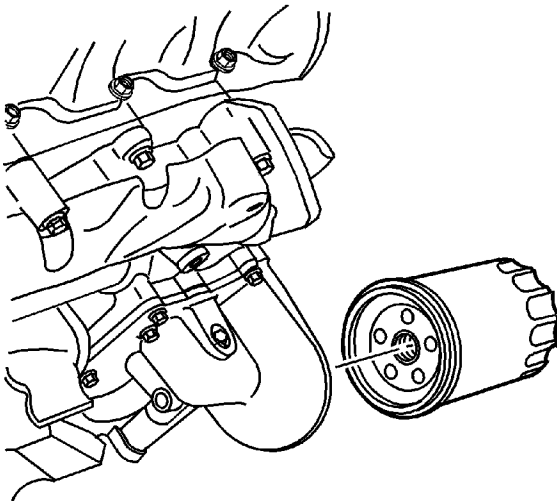
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Engine Oil and Oil Filter Replacement

Removal Procedure



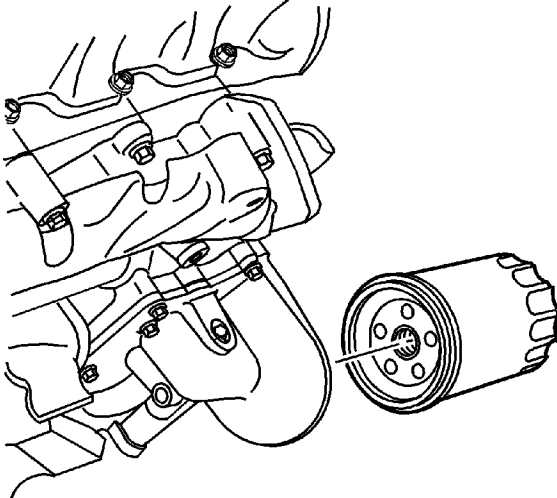
1. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
2. Position a suitable drain pan under the oil pan drain plug.
3. Remove the oil drain plug.
4. Allow the oil to drain completely.
5. Clean and inspect the oil pan drain plug, replace if necessary.
6. Clean and inspect the oil pan drain plug sealing surface, replace the oil pan if necessary.
7. Wipe any remaining oil from the drain plug hole and reinstall the oil pan drain plug until snug.





8. Position a suitable drain pan under the oil filter
9. Remove the oil filter.
10. Ensure that the oil filter gasket is still on the old oil filter, if not remove the oil filter gasket from the adapter.

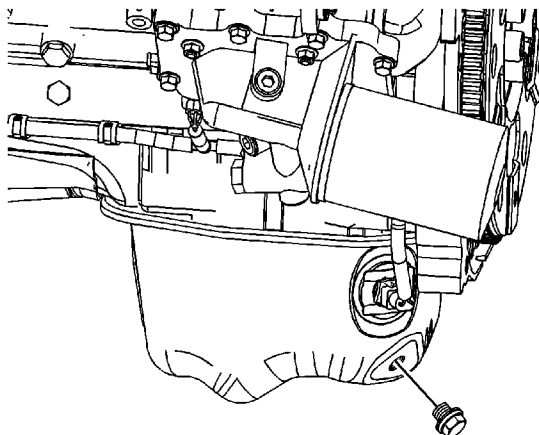
Installation Procedure



1. Apply clean engine oil to the NEW oil filter gasket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the NEW oil filter and tighten after contact plus 1 to 1¼ turn.

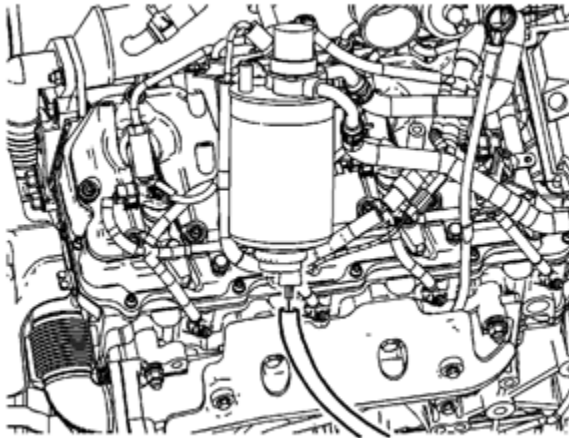




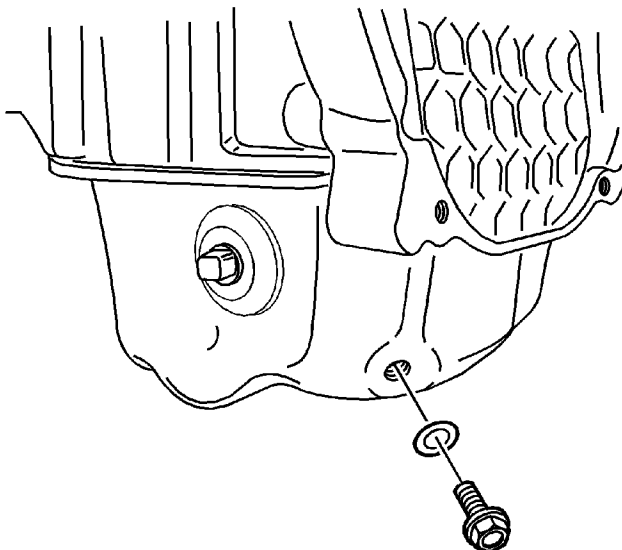
3. Tighten the oil pan drain plug to **84 N·m (62 lb ft)**.
4. Remove the oil drain pan from under the vehicle.
5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to [Approximate Fluid Capacities](#) and [Fluid and Lubricant Recommendations](#).
7. Start the engine.
8. Inspect for oil leaks after engine start up.
9. Turn off the engine and allow the oil a few minutes to drain back into the oil pan.
10. Remove the oil level indicator from the oil level indicator tube.
11. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
12. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.
13. Again, remove the oil level indicator from the oil level indicator tube keeping the tip of the oil level indicator down.
14. Check the level of the engine oil on the oil level indicator.
15. If necessary, adjust the oil level by adding or draining oil.
16. Check for oil leaks.

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Draining Fluids and Oil Filter Removal

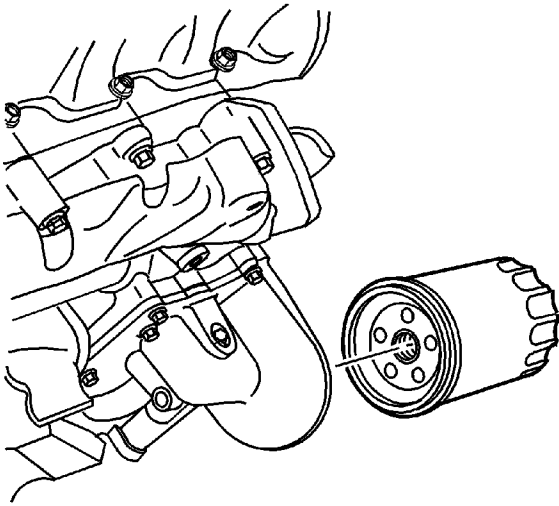


1. Drain the fuel from the fuel filter.
 - 1.1. Attach drain tube to fuel filter drain tap.
 - 1.2. Place open end of drain tube into a suitable container.
 - 1.3. Open fuel filter drain, and allow fuel to drain.
 - 1.4. Close fuel filter drain.
 - 1.5. Remove drain tube.
 - 1.6. Properly dispose of used fuel.

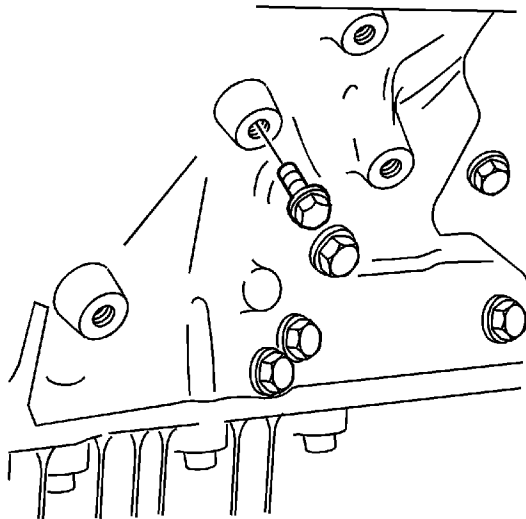




2. Remove the oil drain plug and gasket, and allow engine oil to drain.
3. Discard the oil drain plug gasket.

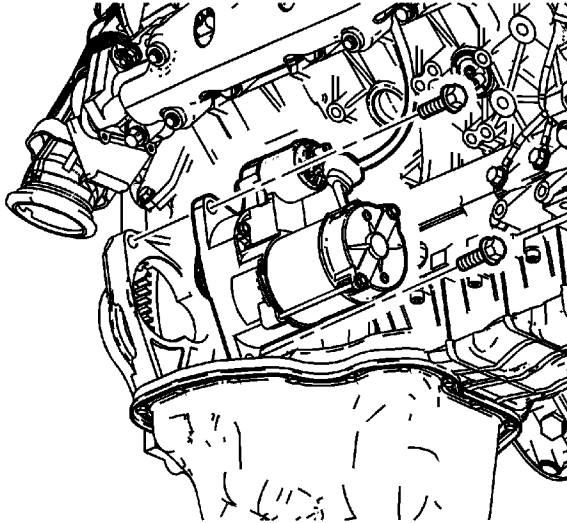


4. Remove the oil filter.



5. Remove the engine block coolant plugs, and allow coolant to drain.

Starter Removal



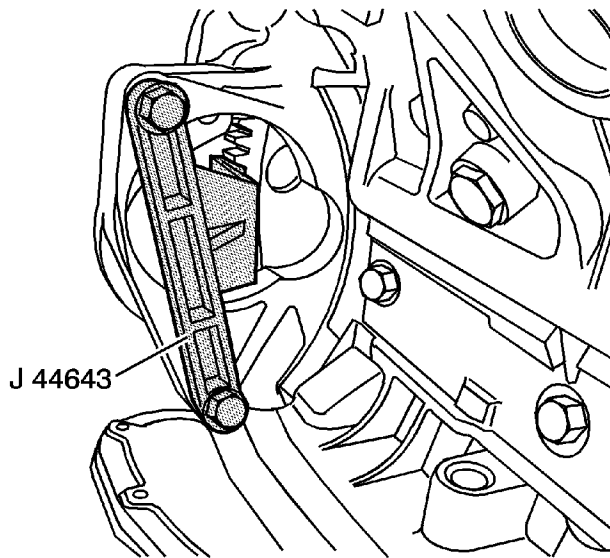
1. Remove the starter motor bolts.
2. Remove the starter motor assembly.

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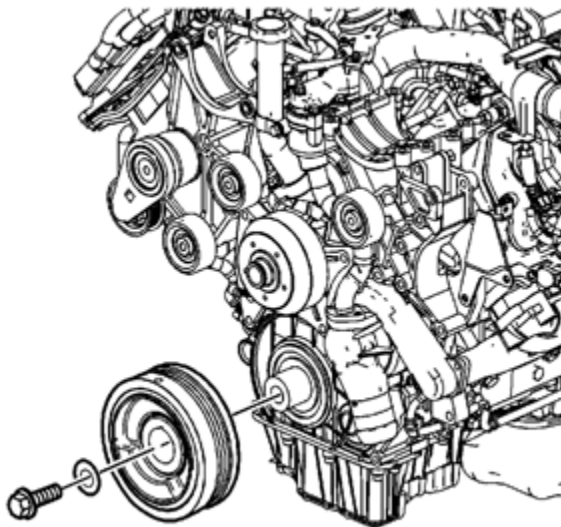
Crankshaft Balancer Removal

Tools Required

[J 44643](#) Flywheel Hold Tool



1. Install [J 44643](#) to lock the flywheel.



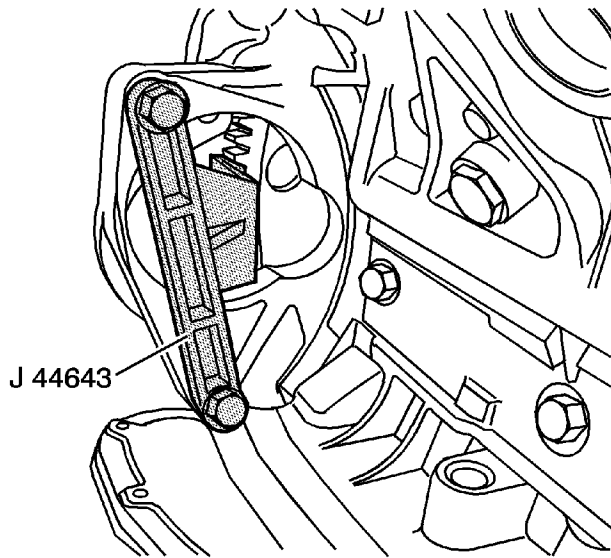
2. Remove the crankshaft balancer bolt.
3. Remove the crankshaft balancer.

Engine Flywheel Removal (Manual Transmission)

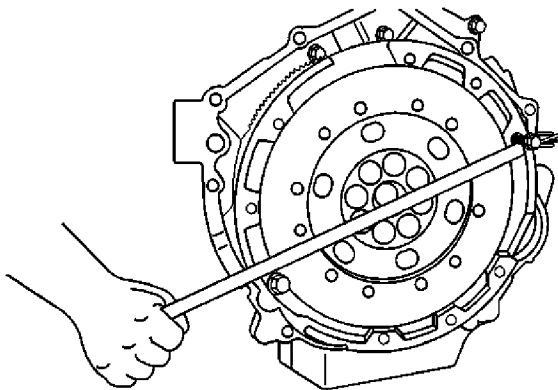
Special Tools

J 44643 Flywheel Hold Tool

For equivalent regional tools, refer to [Special Tools](#).

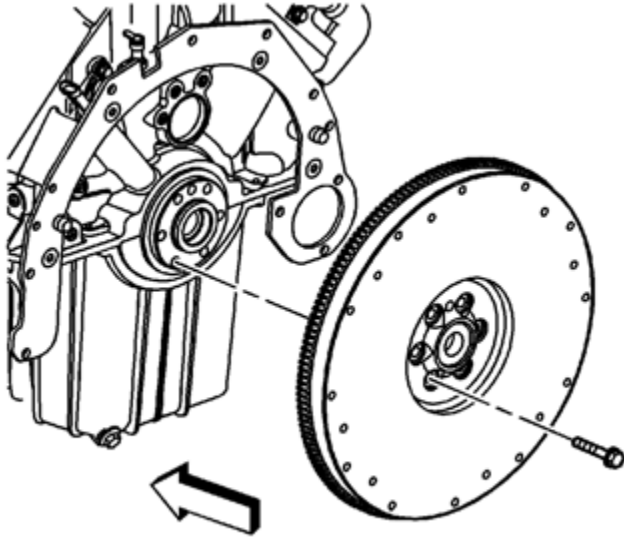


1. Install the J 44643 tool to the starter opening in order to hold the flywheel.



Note: Do not use the clutch pressure plate bolts. Use a bolt of the correct thread and a length that protrudes enough to use a pry bar.

2. Install two bolts into the clutch pressure plate mounting holes 180 degrees apart.
3. Using a long pry bar, turn the secondary ring of the dual mass flywheel clockwise until the flywheel mounting bolts can be accessed. It may require to turn the secondary ring past the bolt holes in order to compensate the spring tension.



4. Remove the flywheel mounting bolts and discard.
5. Remove the J 44643 tool .

Warning: When removing, handling or installing this component wear protective gloves. The sharp edges on the component may be very sharp and may cause injury.

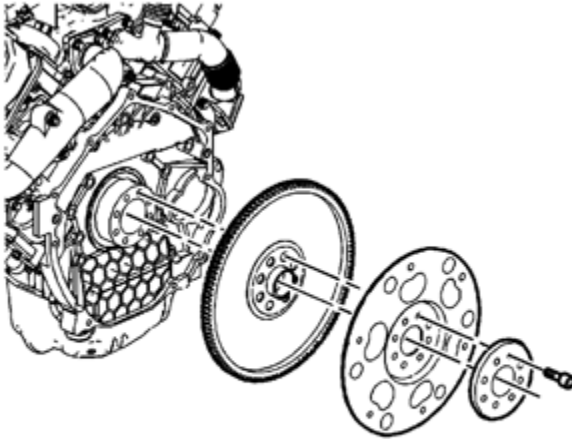
6. Remove the flywheel.

Engine Flywheel Removal (Automatic Transmission)

Special Tools

J 44643 Flywheel Hold Tool

For equivalent regional tools, refer to [Special Tools](#).

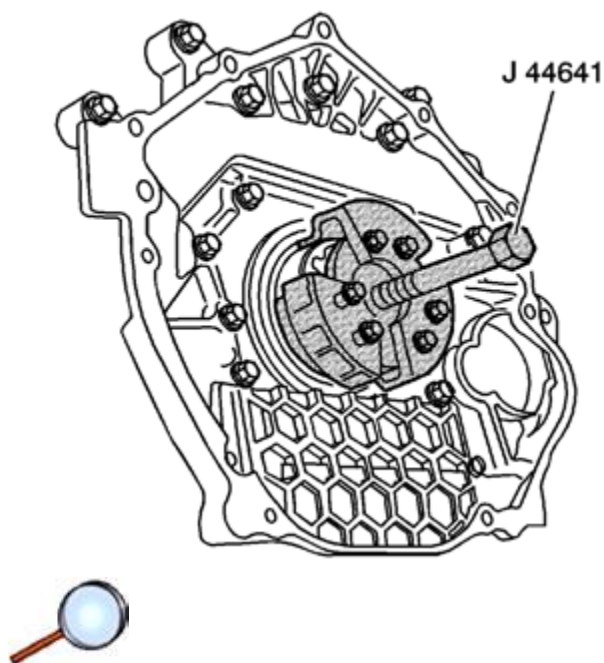


1. Remove the flywheel mounting bolts and discard.
2. Remove the flywheel washer.
3. Remove the J 44643 tool .
4. Remove the flywheel assembly.

Crankshaft Rear Oil Seal Removal

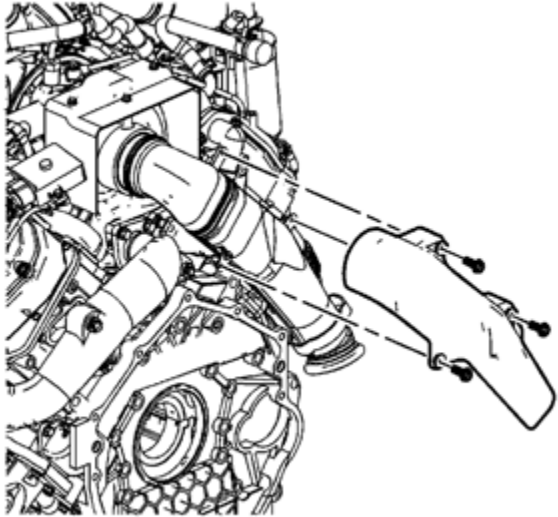
Tools Required

[J 44641](#) Crankshaft Rear Oil Seal Remover

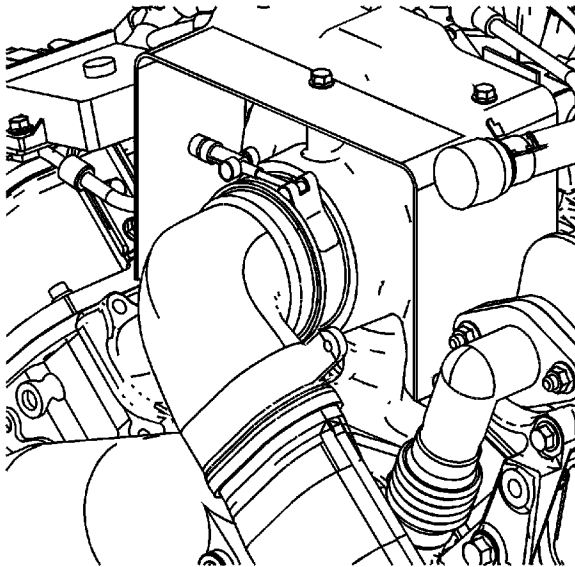


1. Install the button of [J 44641](#) into the crankshaft.
2. Press the jaws of [J 44641](#) into the felt portion of the seal far enough to engage the inner lip of the seal.
3. While holding the jaws of [J 44641](#) tightly to the seal's inner sleeve, tighten the jaw bolts.
4. Remove the crankshaft rear oil seal using the [J 44641](#).

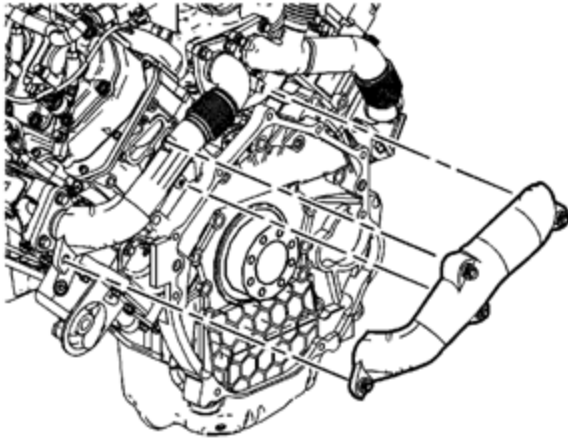
Exhaust Outlet Removal



1. Remove the exhaust outlet heat shield bolts.
2. Remove the exhaust outlet heat shield.
3. Remove the exhaust outlet to right exhaust pipe bracket bolt.



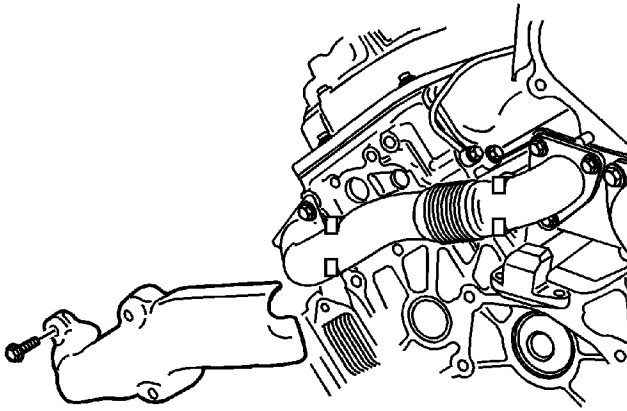
4. Loosen the exhaust outlet holding clamp.



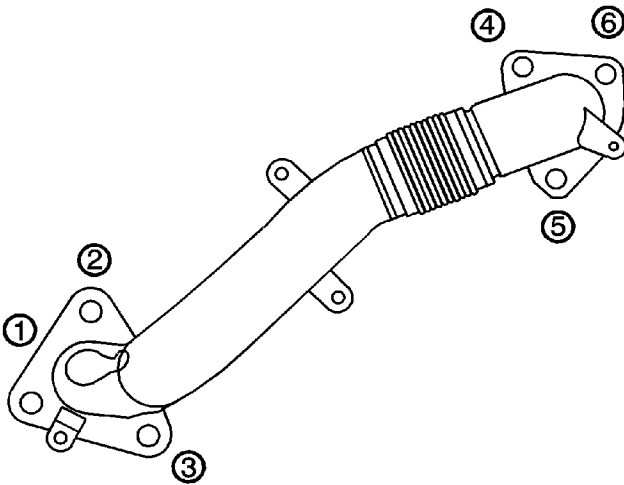
5. Remove the exhaust outlet.

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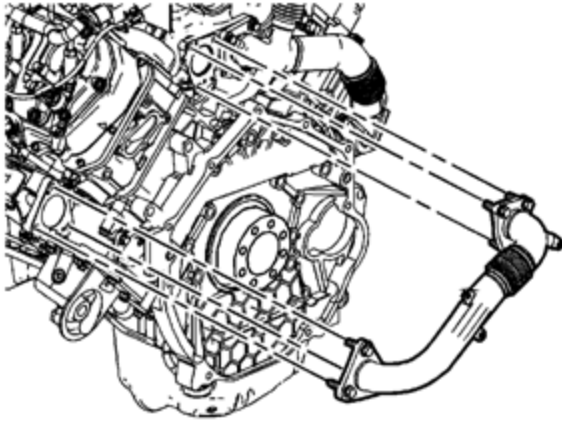
Exhaust Pipe Removal - Left Side



1. Remove the left exhaust pipe heat shield bolts.
2. Remove the left exhaust pipe heat shield.



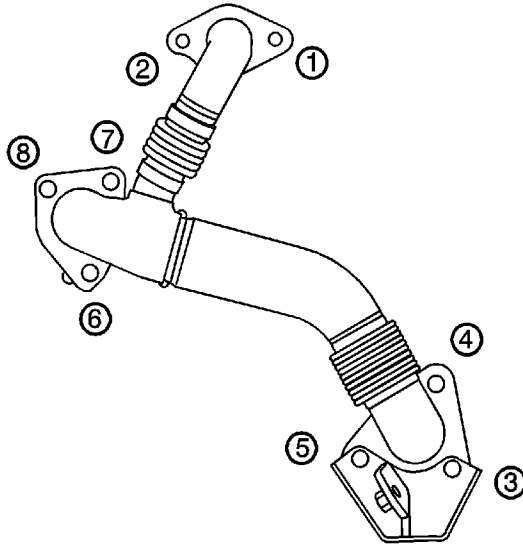
3. Remove the exhaust pipe bolts in the proper sequence.



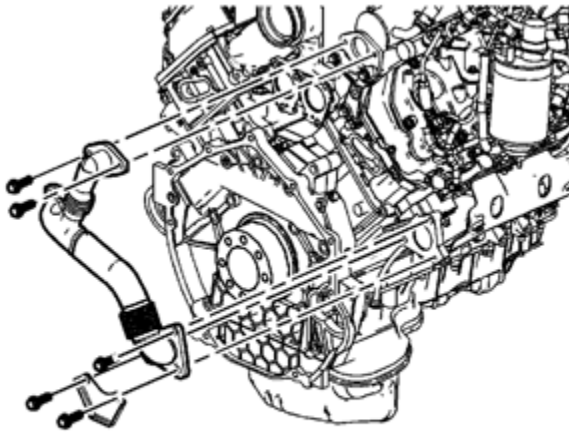
4. Remove the exhaust pipe and gaskets.

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Exhaust Pipe Removal - Right Side



1. Remove the exhaust pipe bolts in the proper sequence.

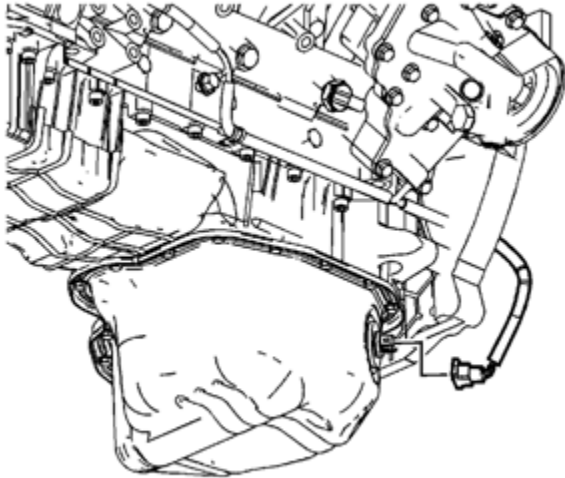


2. Remove the exhaust pipe, exhaust outlet bracket and gaskets.

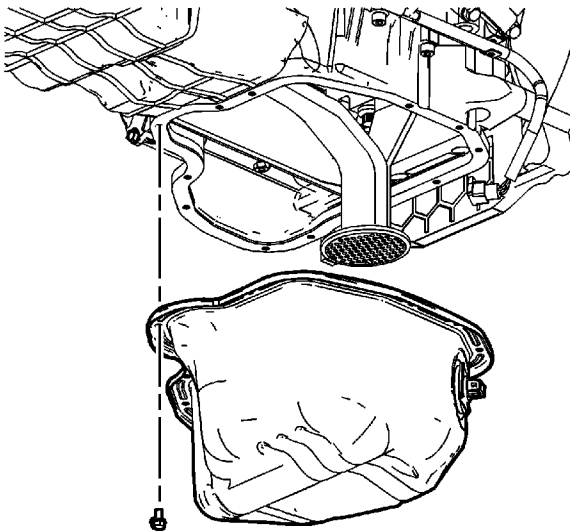
Lower Oil Pan Removal

Tools Required

[J 37228](#) Seal Cutter



1. Disconnect the oil level sensor.



2. Remove the lower oil pan bolts.

Important: Do not damage the sealing surfaces when separating the lower oil pan from the upper oil pan.

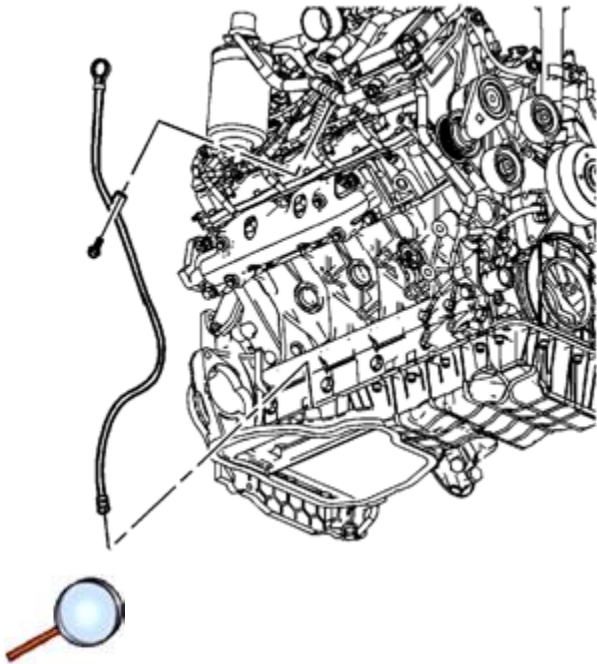
3. Separate the lower oil pan from the upper oil pan using [J 37228](#) .
4. Remove the lower oil pan.

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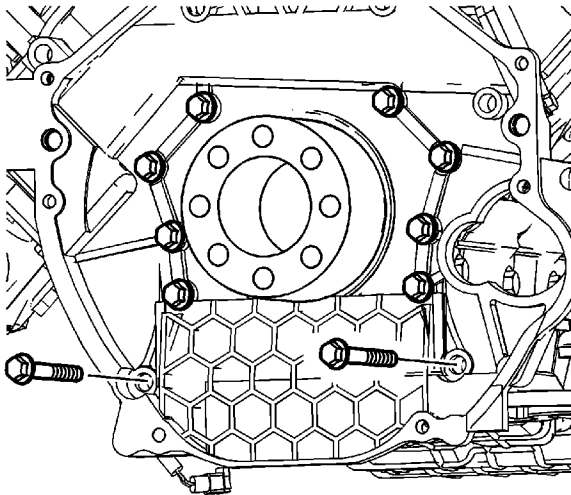
Upper Oil Pan Removal

Tools Required

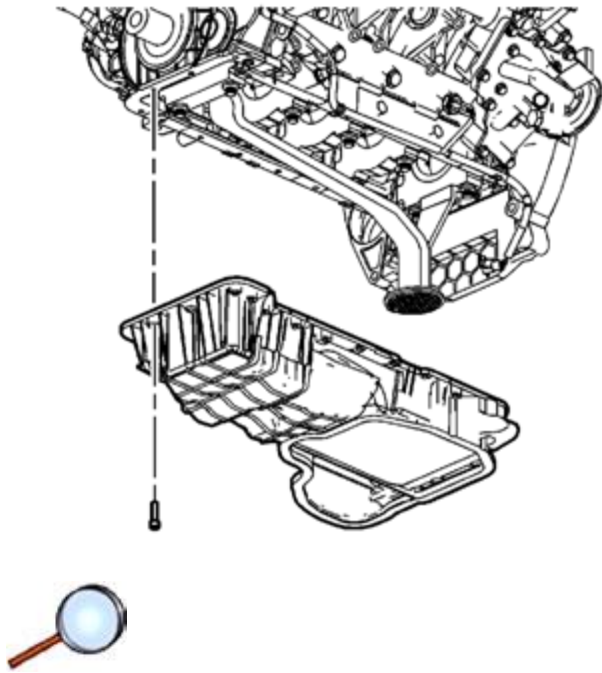
[J 37228](#) Seal Cutter



1. Remove the oil level indicator tube bracket bolt.
2. Remove the oil level indicator tube.



3. Remove the two oil pan to flywheel housing bolts.



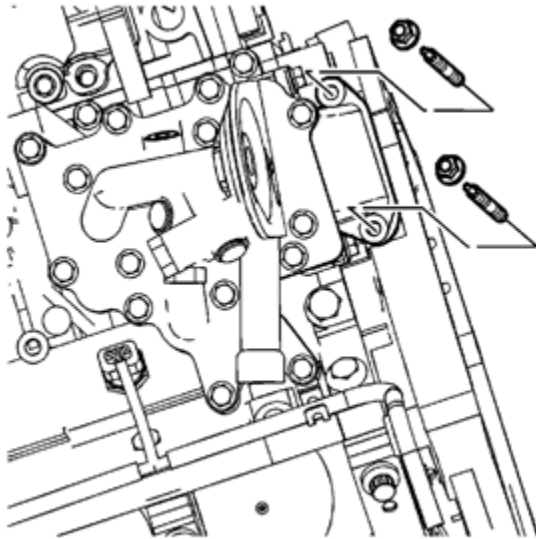
4. Remove the 24 upper oil pan bolts using a long bit 6 mm hex driver.
5. Separate the upper oil pan from the engine block using [J 37228](#).
6. Remove the upper oil pan.

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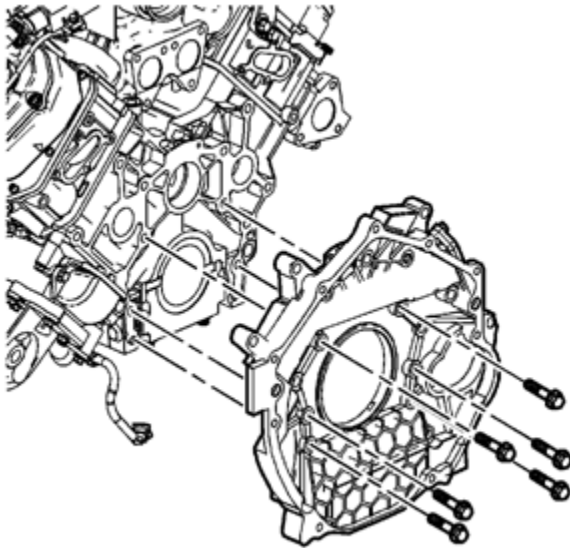
Engine Flywheel Housing Removal

Tools Required

[J 37228](#) Seal Cutter

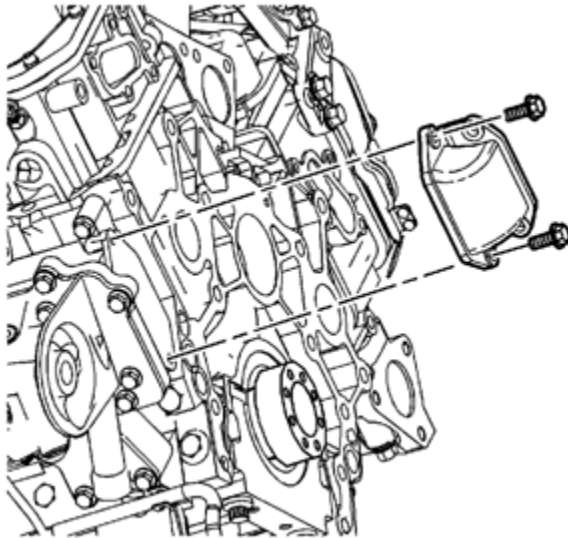


1. Remove the turbocharger oil return pipe nuts from the top of the flywheel housing.
2. Remove the turbocharger oil return pipe studs.



Important: The upper oil pan must be removed before removing the flywheel housing.

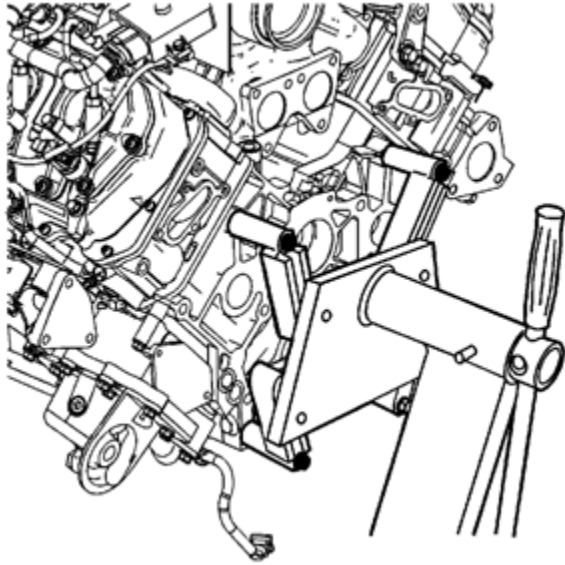
3. Remove the flywheel housing bolts.
4. Separate the flywheel housing from the cylinder block using [J 37228](#).
5. Remove the flywheel housing.



6. Remove the turbocharger oil return pipe gasket from the flywheel housing.
7. Remove the oil cooler adapter bolts.
8. Remove the oil cooler adapter with gaskets.

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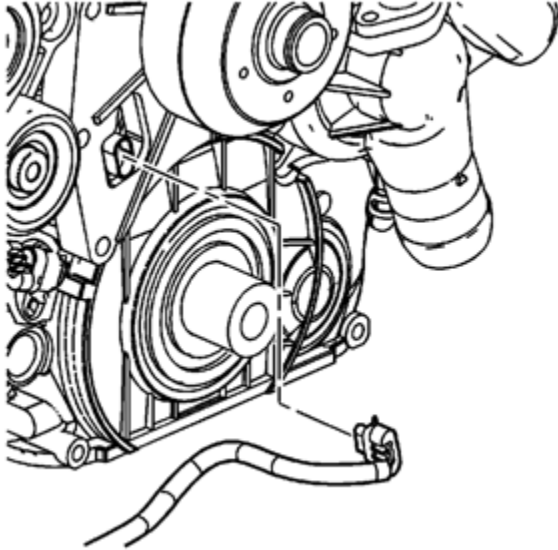
Engine Mounting to Stand



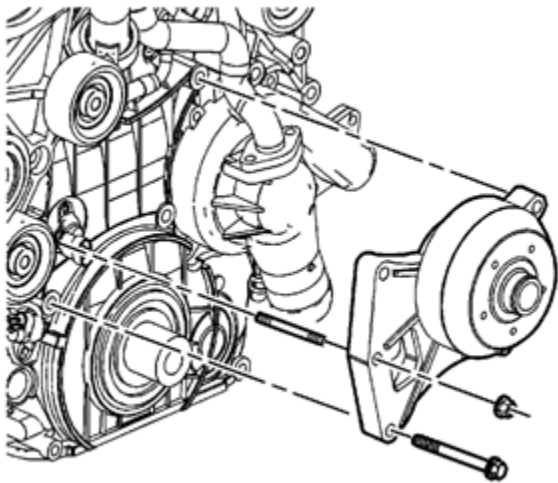
Warning: Do not mount the engine to a engine stand by the flywheel housing. The aluminum flywheel housing is not designed to support the weight of the engine when mounted to a typical rear-mount engine stand. Mounting the engine stand to the aluminum flywheel housing may result in engine damage and serious personal injury.

After the flywheel housing has been removed, mount the engine block to a suitable engine stand.

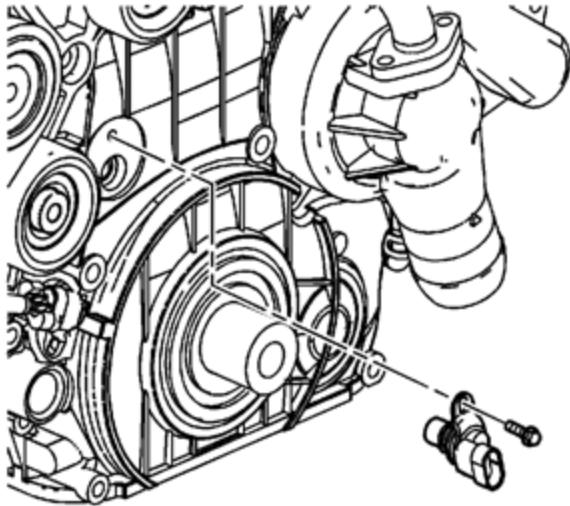
Cooling Fan Pulley Removal



1. Disconnect the camshaft position sensor connector.



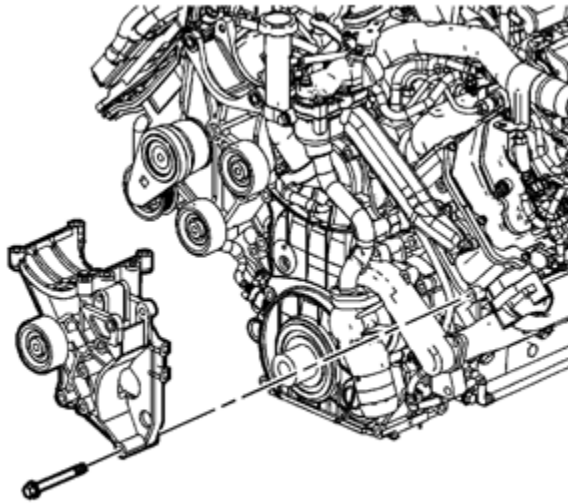
2. Remove the cooling fan pulley bolts and nuts.
3. Remove the cooling fan pulley.



4. Remove the camshaft position sensor retaining bolt.
5. Remove the camshaft position sensor.

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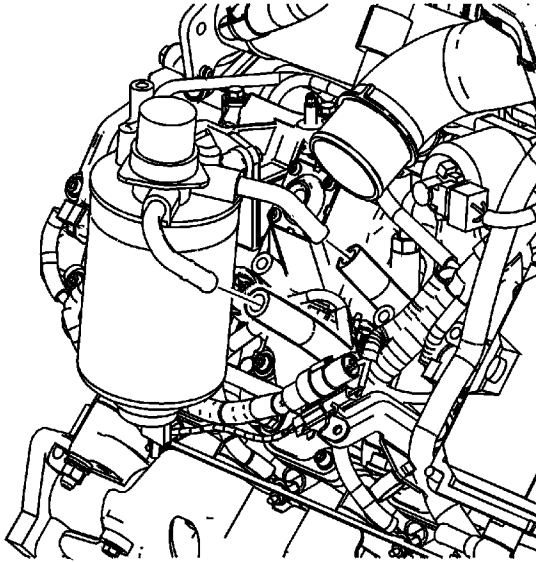
Power Steering Pump Mounting Bracket Removal



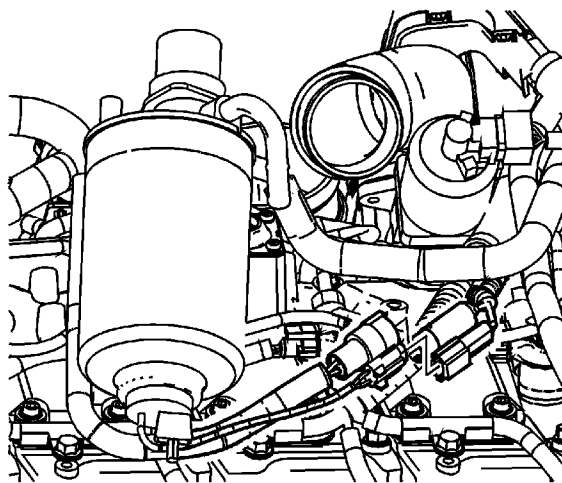
1. Remove the power steering pump mounting bracket bolts.
2. Remove the power steering pump mounting bracket.

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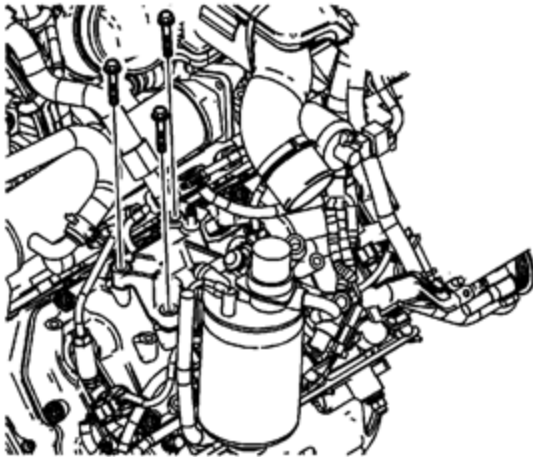
Fuel Filter Assembly Removal



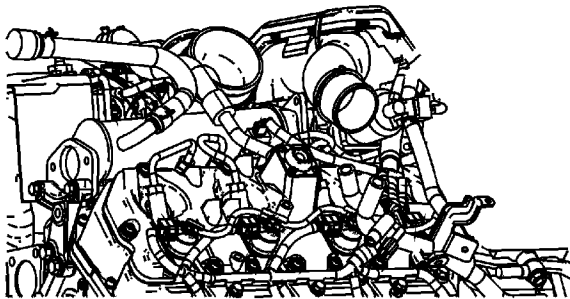
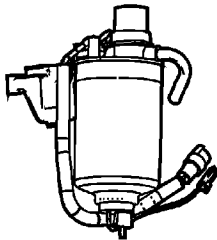
1. Remove the fuel hoses.



2. Disconnect the fuel filter assembly connectors.



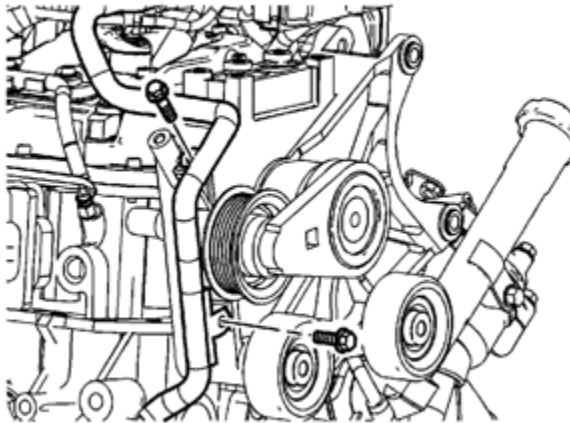
3. Remove the fuel filter bracket bolts.



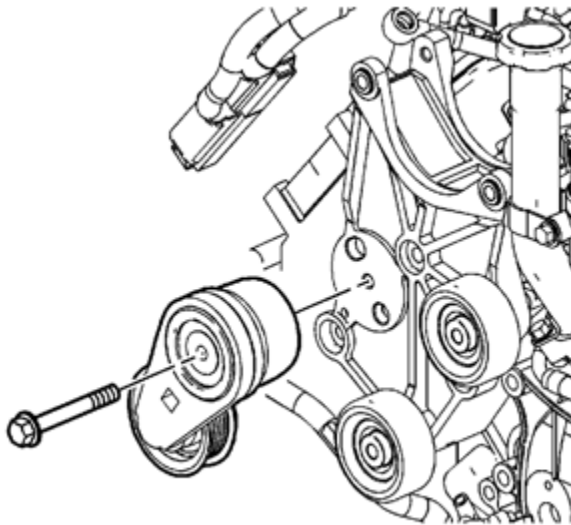
4. Remove the fuel filter assembly.

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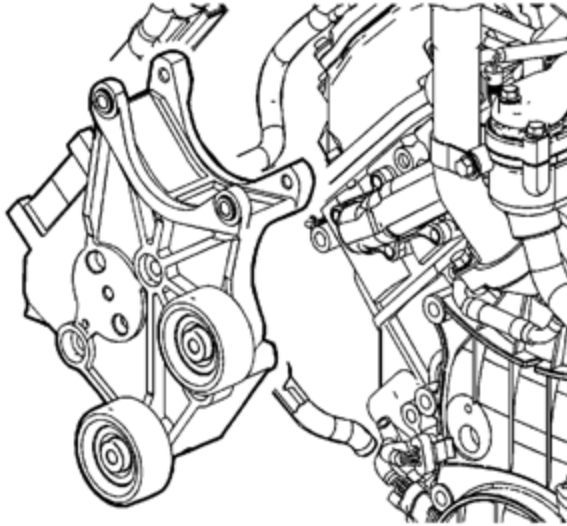
Generator and Drive Belt Tensioner Bracket Removal



1. Remove the electrical harness clip bolts.



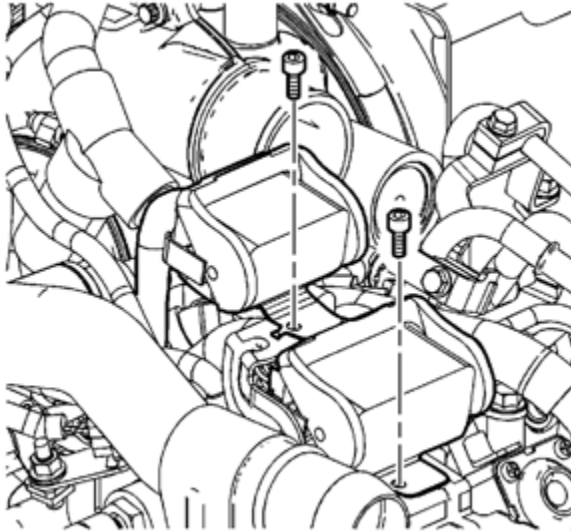
2. Remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.



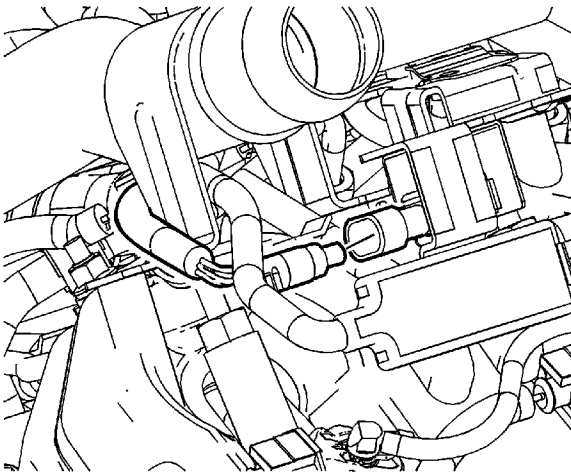
4. Remove the drive belt tensioner and generator mounting bracket bolts.
5. Remove the drive belt tensioner and generator mounting bracket.

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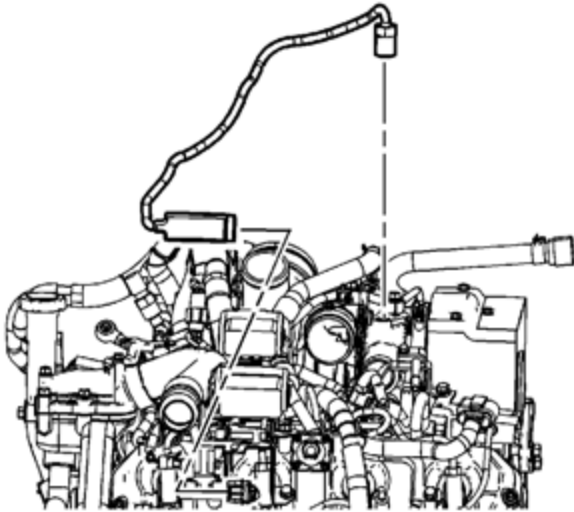
Engine Coolant Thermostat Housing Removal



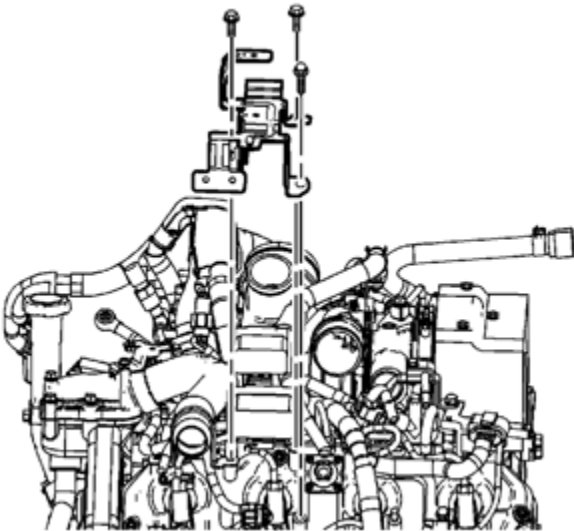
1. Remove the main engine electrical harness connector hold down bolts.



2. Remove the main engine electrical harness connectors.
3. Disconnect and remove the barometric sensor.

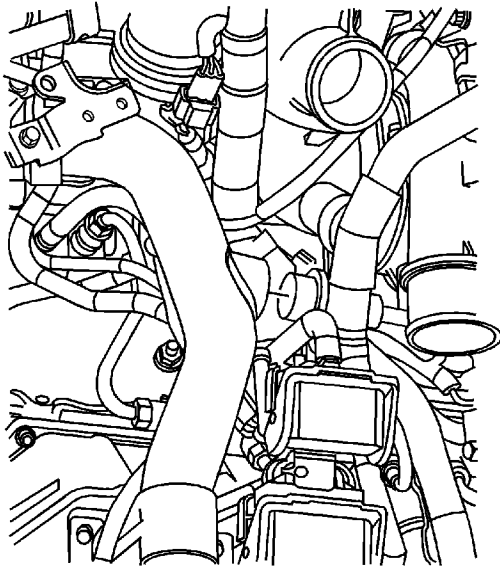


4. Disconnect and remove the turbocharger vane position sensor.

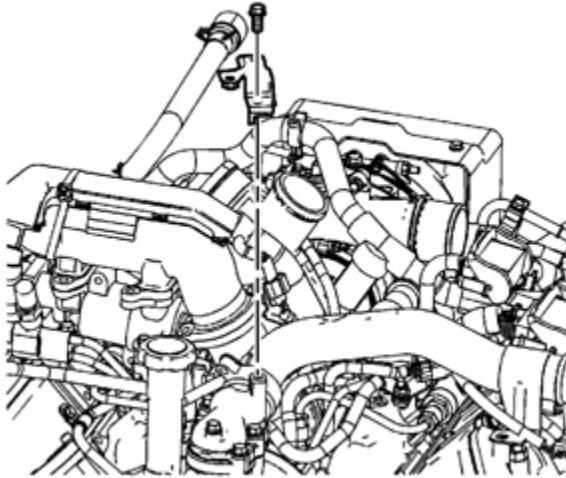


5. Remove the main electrical harness bracket bolts.
6. Remove the main electrical harness bracket.

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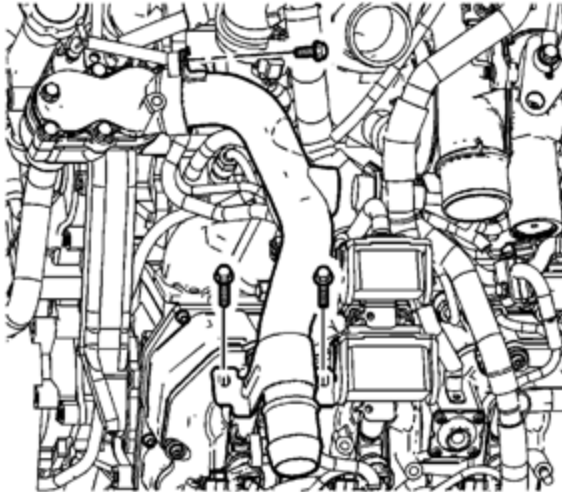


7. Disconnect the turbocharger coolant inlet hose.

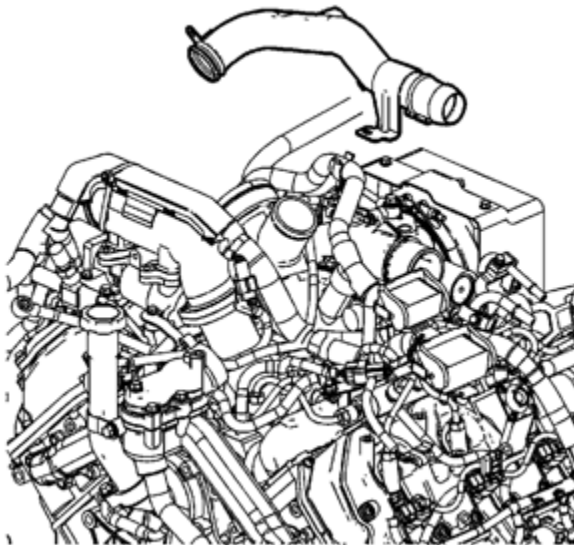


8. Remove the electrical harness bracket bolt.
9. Remove the electrical harness bracket.

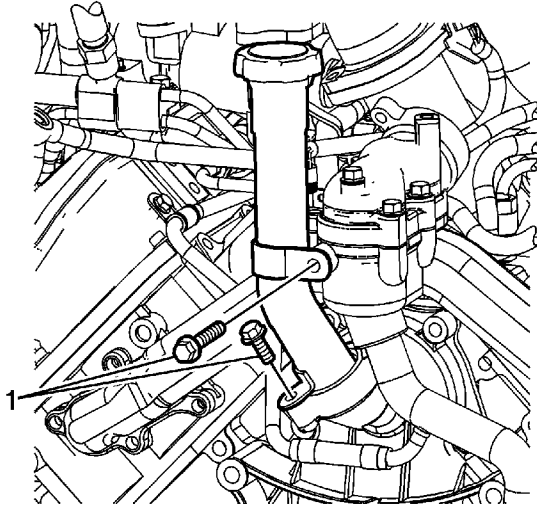
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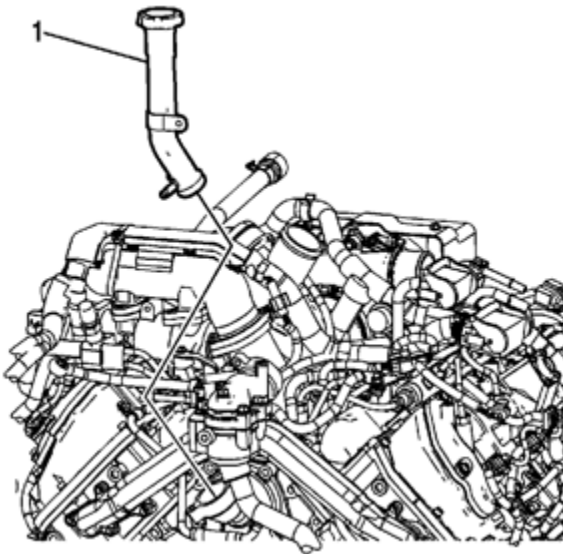
10. Remove the water outlet bolts.



11. Remove the water outlet.

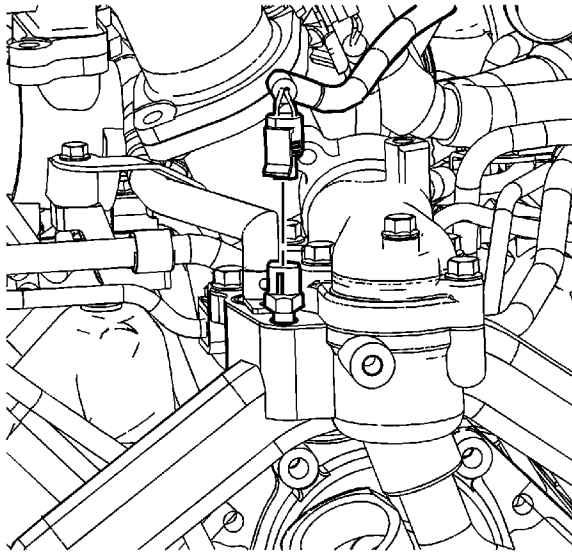


12. Remove the oil fill tube bolts.

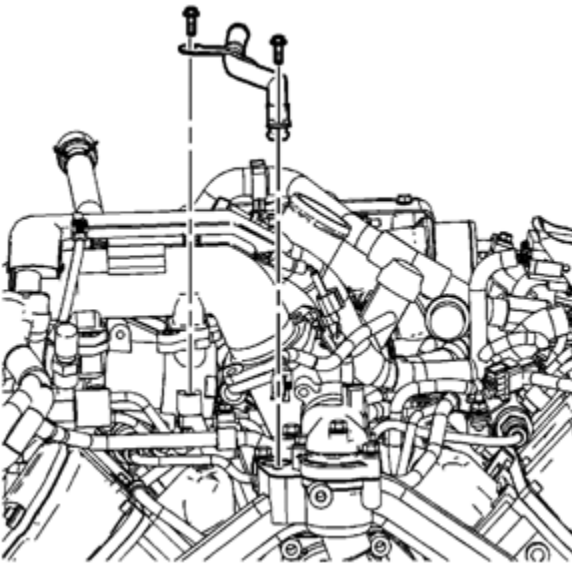


13. Remove the oil fill tube.

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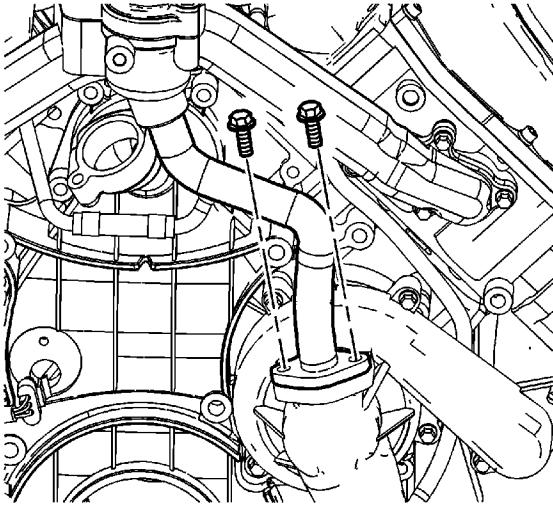


14. Disconnect the coolant temperature sensor.

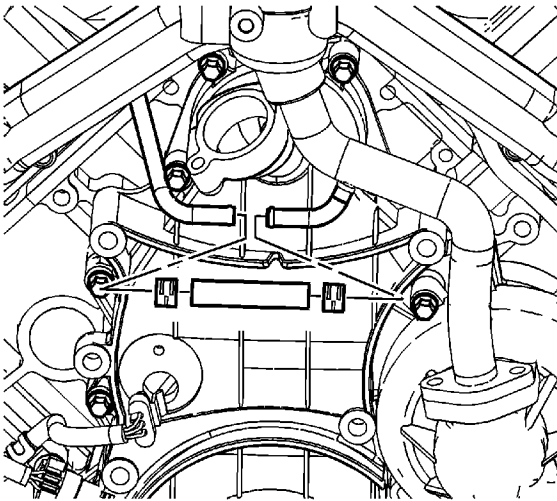


15. Remove the EGR coolant pipe bolts.
16. Remove the EGR coolant pipe.

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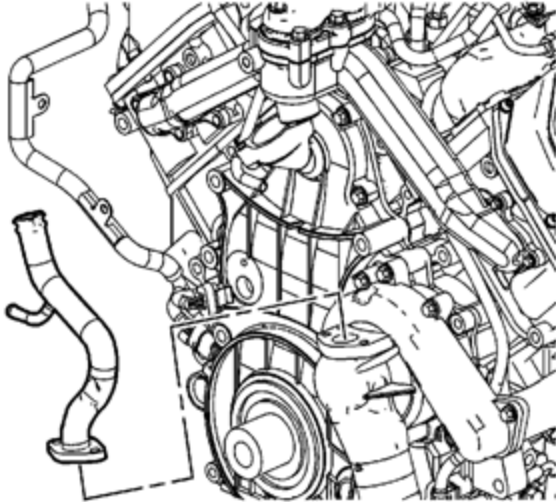


17. Remove the water pump inlet pipe bolts.

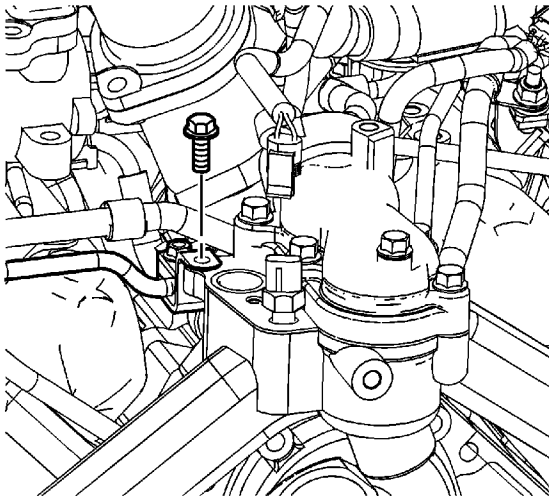


18. Remove the turbocharger coolant outlet hose and clamps.

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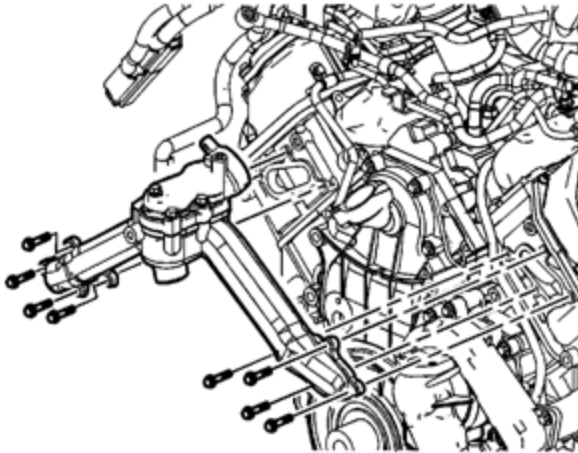


19. Remove the water pump inlet pipe.



20. Remove the fuel pipe bracket bolt.

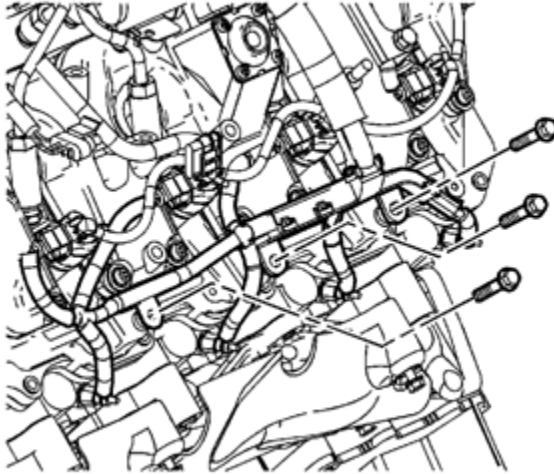
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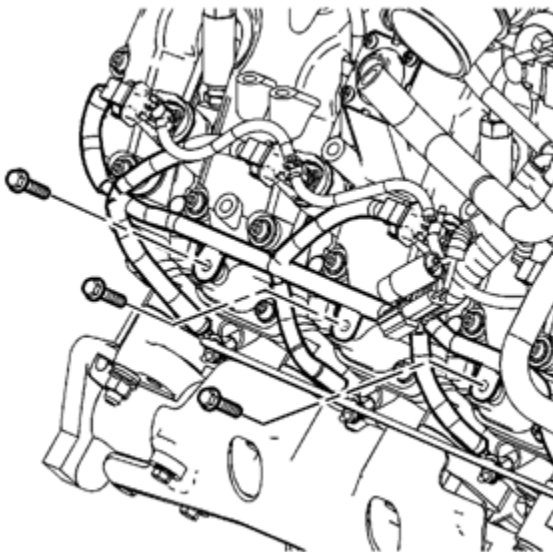
21. Remove the thermostat housing bolts.
22. Remove the thermostat housing.

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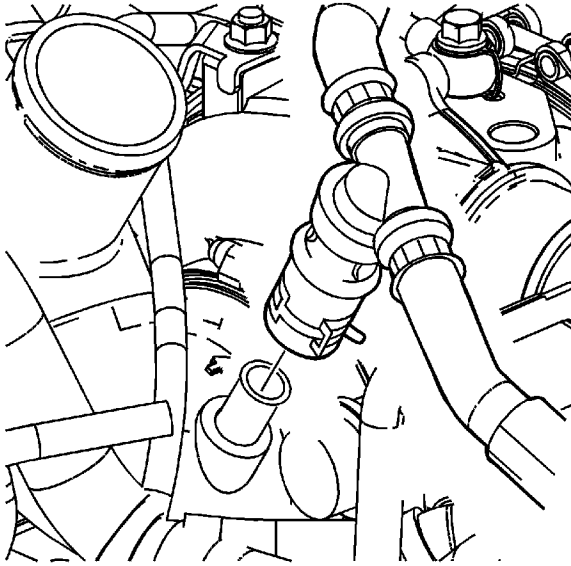
Engine Wiring Harness Assembly Removal



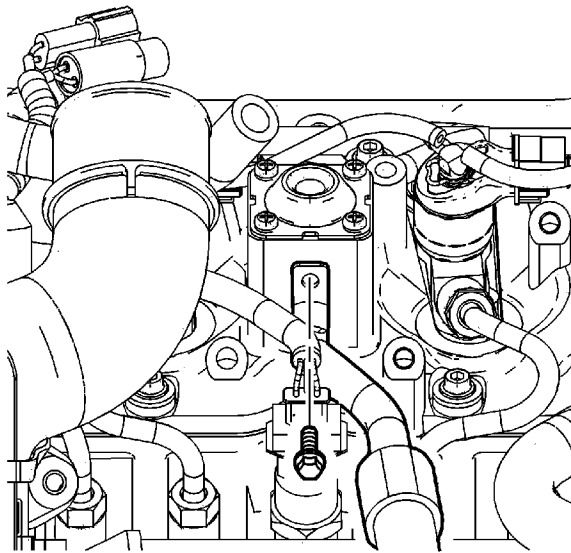
1. Remove the left glow plug harness bracket bolts.



2. Remove the right glow plug harness bracket bolts.

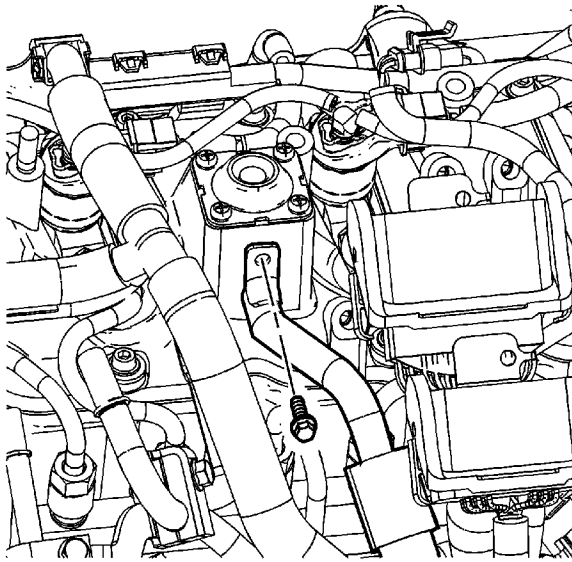


3. Disconnect the positive crankcase ventilation (PCV) hose clamp.

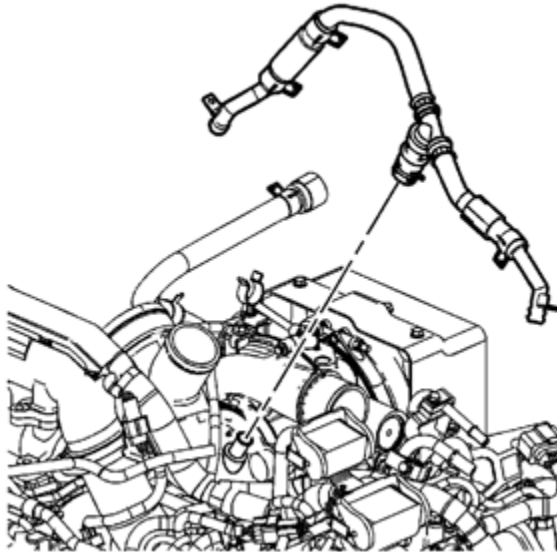


4. Remove the right PCV pipe bolt.

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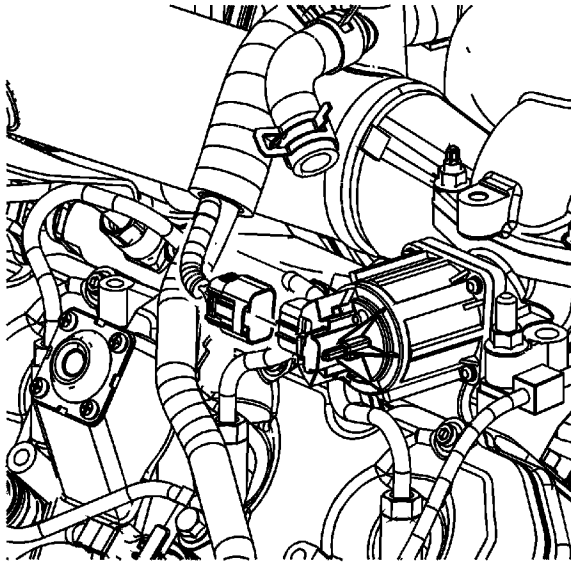


5. Remove the left PCV pipe bolt.

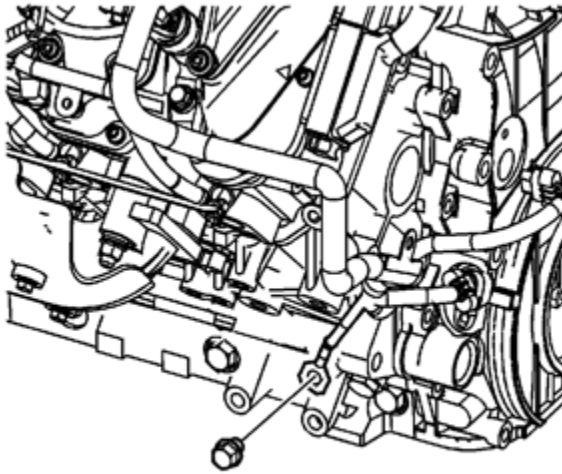


6. Remove the PCV pipe.

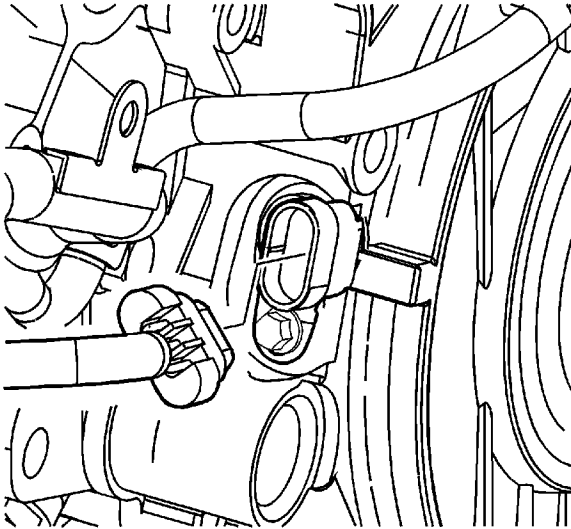
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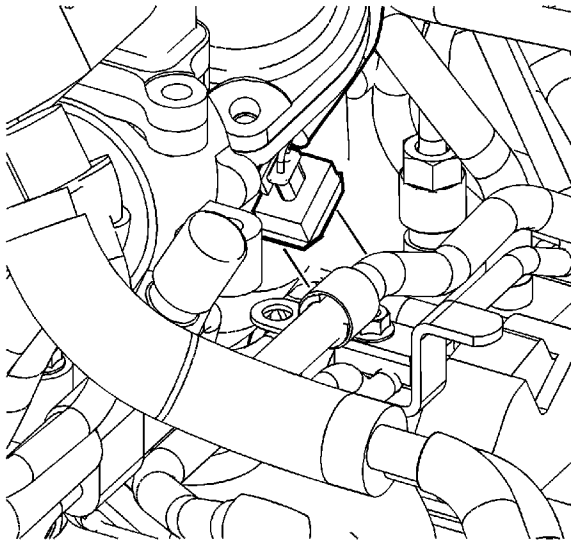
7. Disconnect the exhaust gas recirculation (EGR) valve electrical connector.



8. Remove the ground bolt.

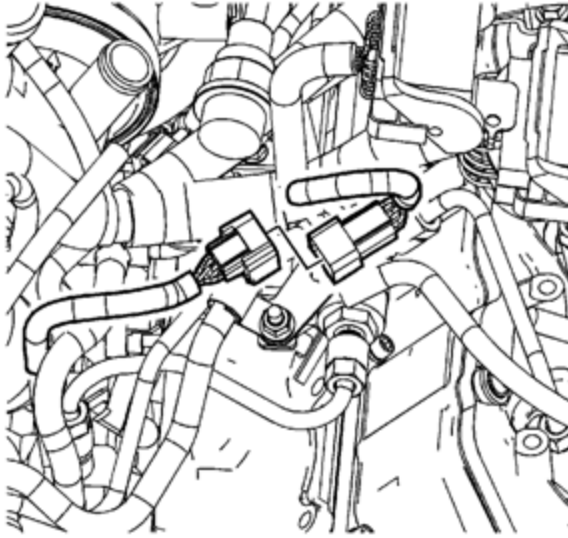


9. Disconnect the crankshaft position sensor electrical connector.

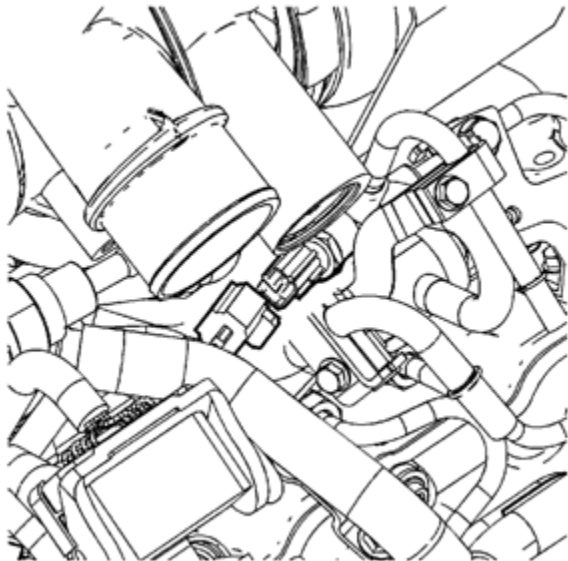


10. Disconnect the fuel pressure control valve electrical connector.

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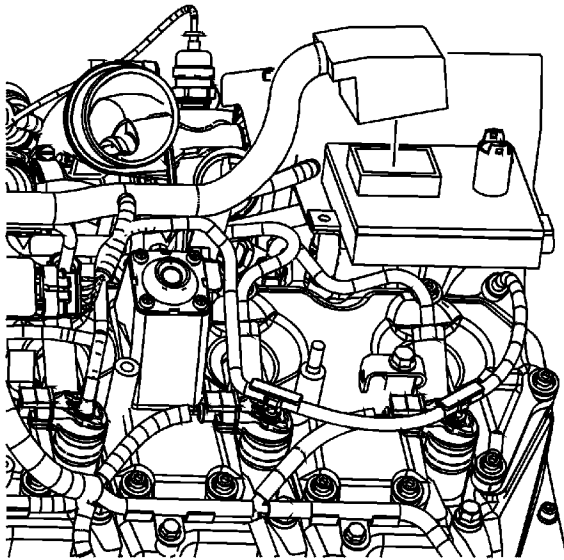


11. Disconnect the oil level sensor electrical harness connector.

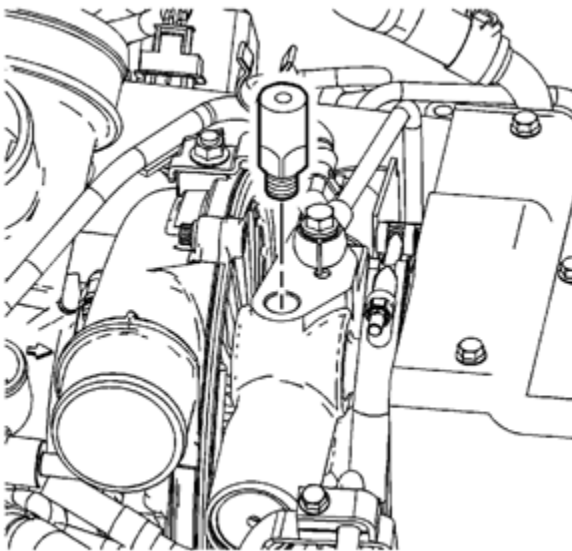


12. Disconnect the fuel temperature sensor connector.

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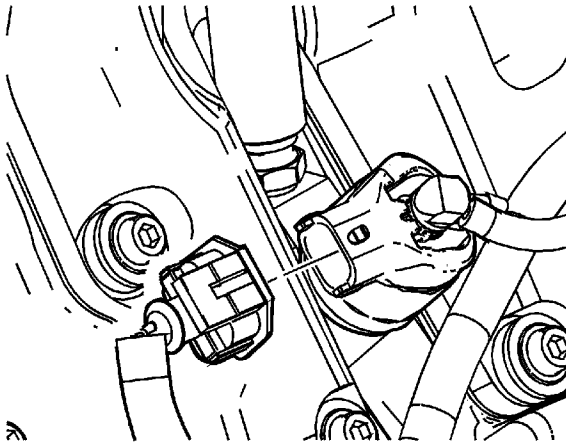


13. Disconnect the glow plug controller electrical connector.



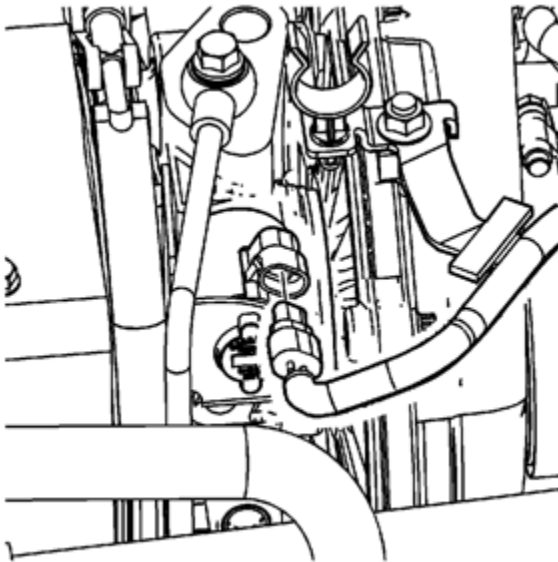
14. Disconnect and remove the turbocharger vane position sensor.

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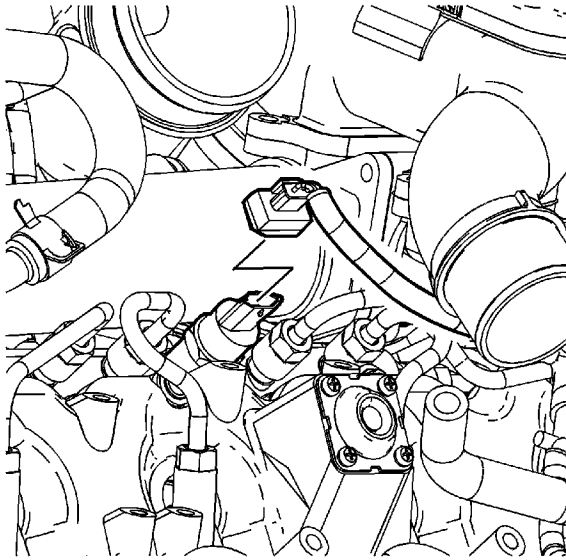


Caution: Label all the injector electrical connectors before the connectors are removed in order to prevent reconnecting to the wrong injector. Failure to properly connect the injectors in the correct sequence will cause severe engine damage.

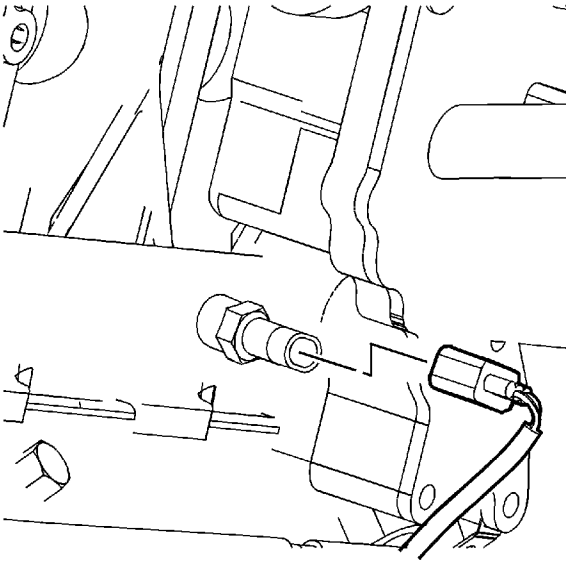
15. Disconnect the fuel injector electrical connections.



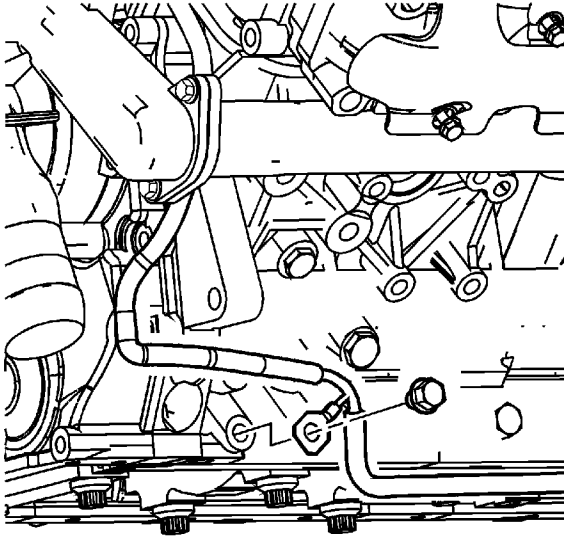
16. Disconnect the turbocharger vane control solenoid valve.



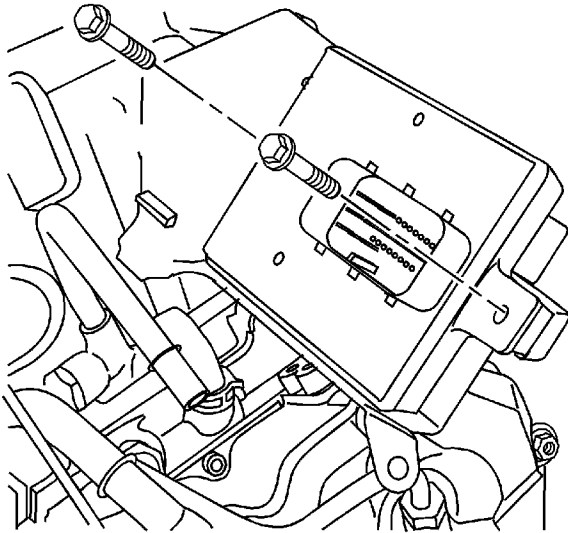
17. Disconnect the fuel rail pressure sensor.



18. Disconnect the oil pressure sensor electrical connector.

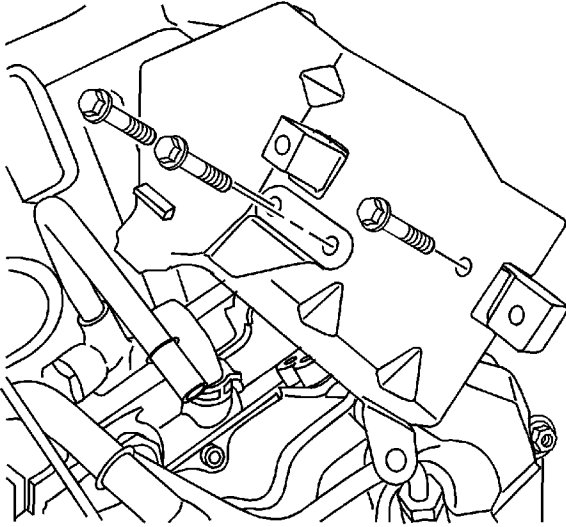


19. Remove the oil level sensor harness bolt.

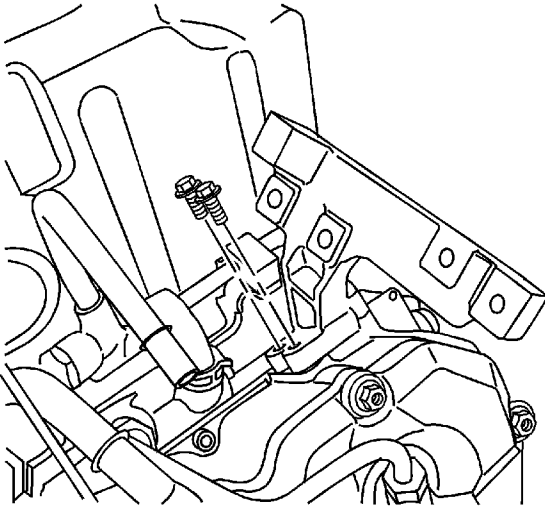


- 20. Remove the glow plug controller bolts.
- 21. Remove the glow plug controller.
- 22. Remove the glow plug controller shield bolts.
- 23. Remove the glow plug controller shield.

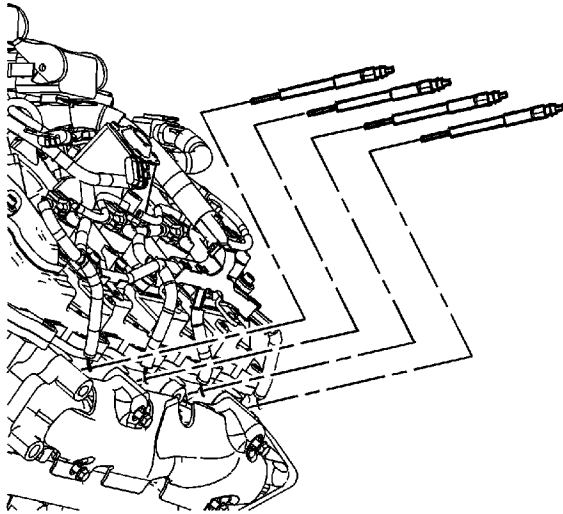
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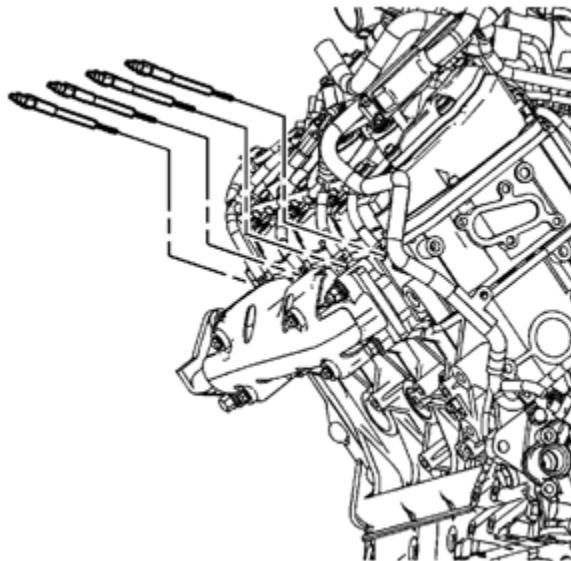
24. Remove the glow plug controller bracket bolts.



25. Remove the glow plug controller bracket.

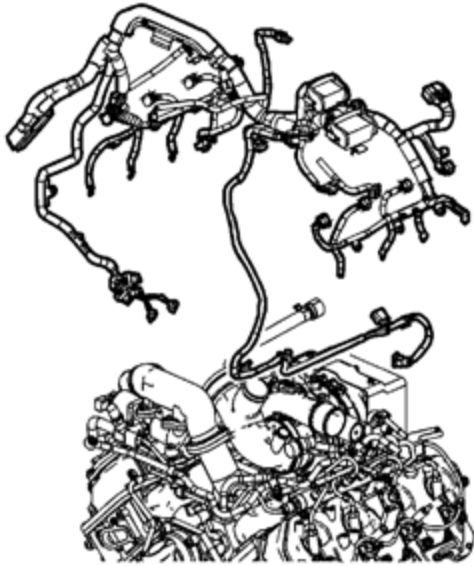


26. Remove the left glow plugs.

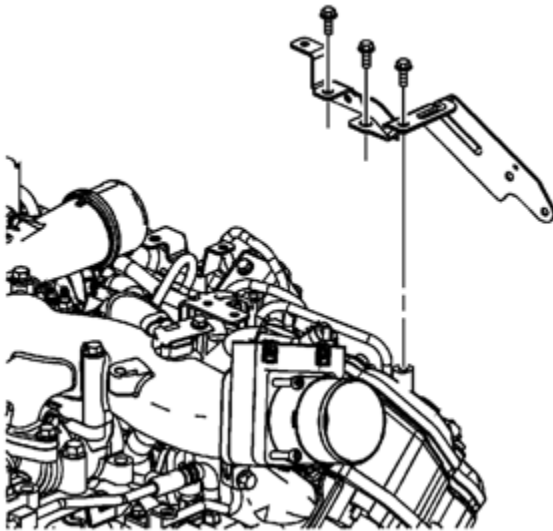


27. Remove the right glow plugs.

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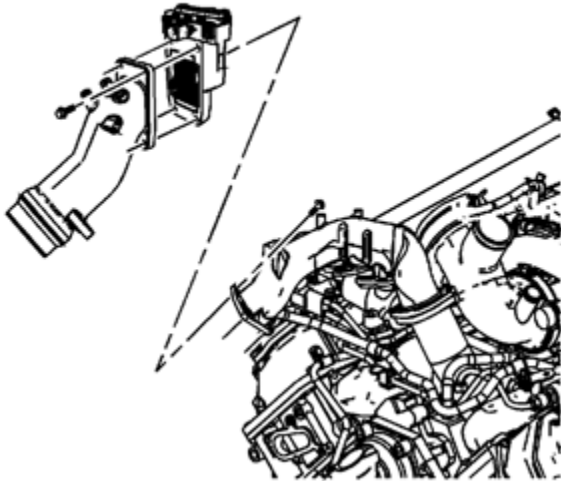


28. Remove the engine wiring harness.

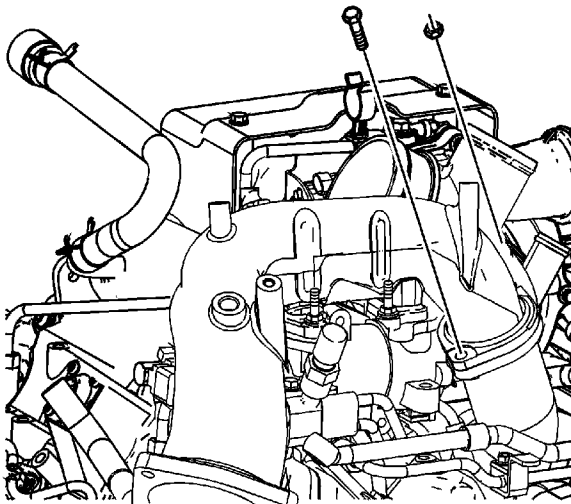


29. Remove the engine harness bracket bolts.
30. Remove the engine harness bracket.

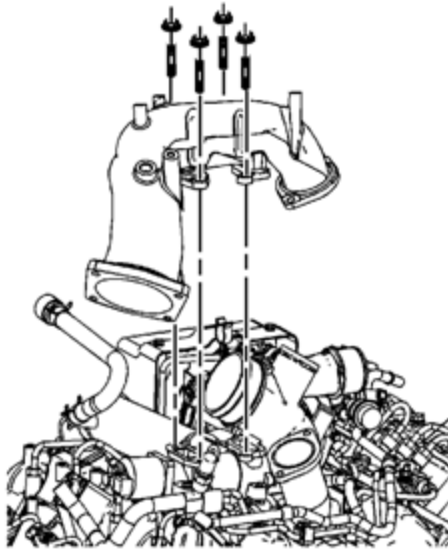
Exhaust Gas Recirculation Valve and Cooler Removal



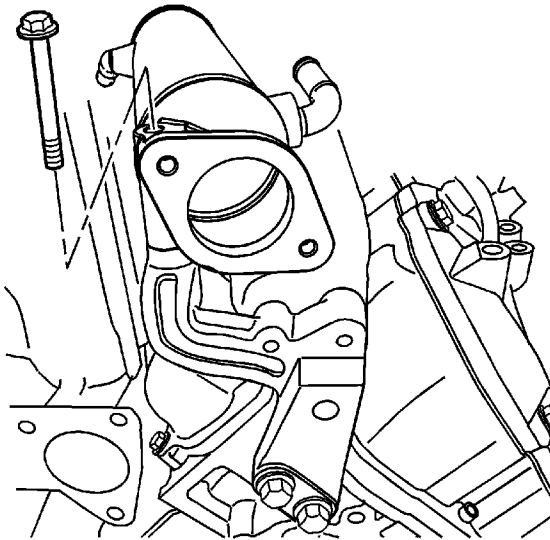
1. Remove the intake pipe to air inlet tube bolts.
2. Remove the intake pipe.
3. Remove the intake heater.



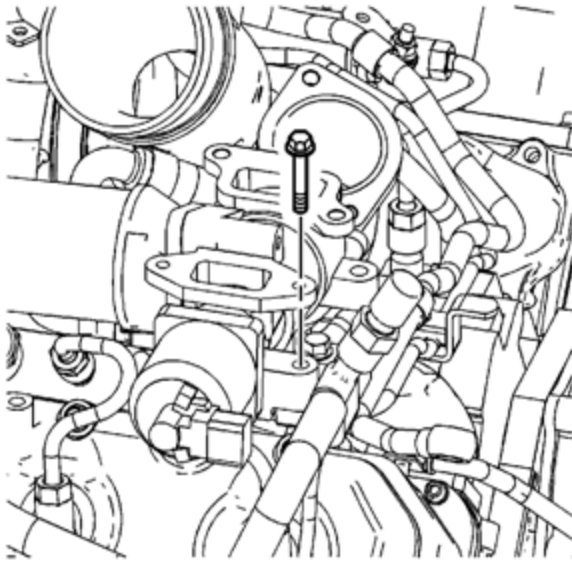
4. Remove the air inlet tube to intake manifold tube bolt and nut.



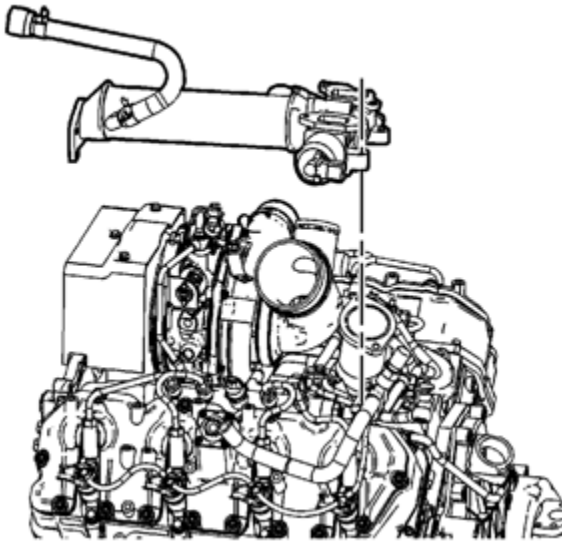
5. Remove the air inlet tube nuts.
6. Remove the air inlet tube.



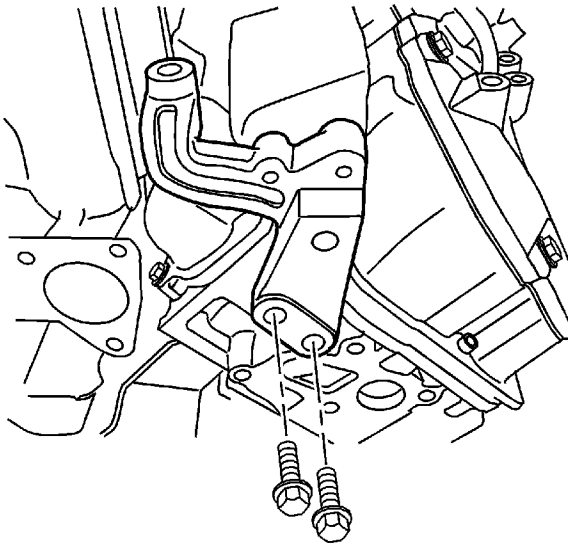
7. Remove the rear EGR cooler bolts.



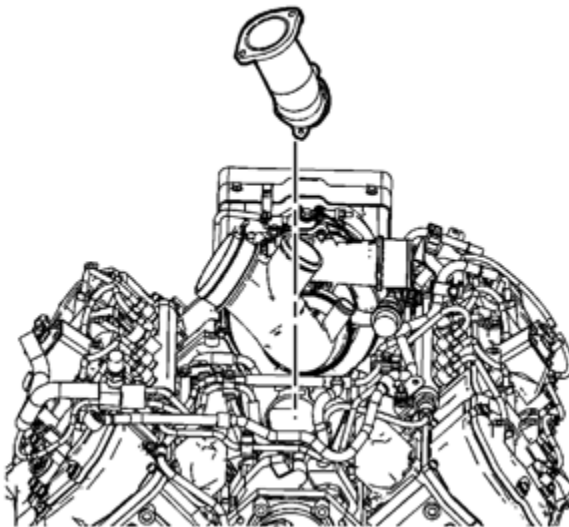
8. Remove the EGR mount bolt.



9. Remove the EGR and cooler.



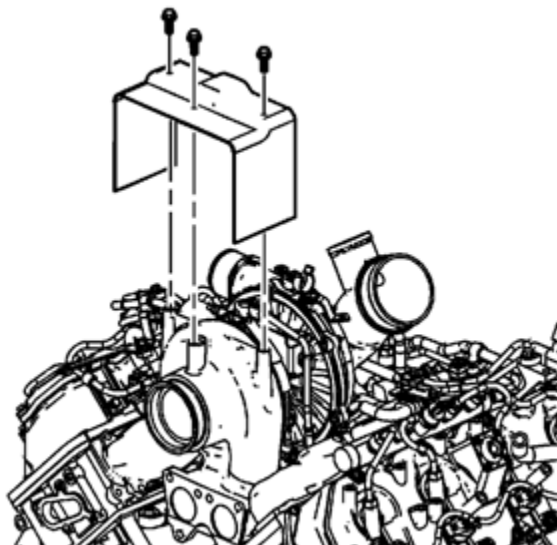
10. Remove the EGR cooler bracket bolts.
11. Remove the EGR cooler bracket.



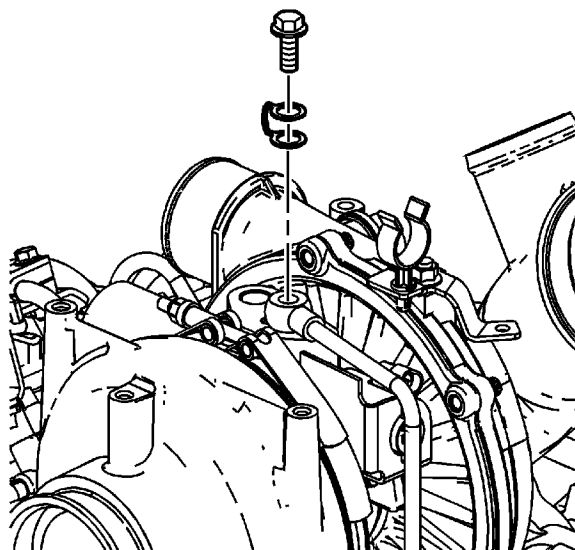
12. Remove the intake manifold tube.

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Turbocharger Removal



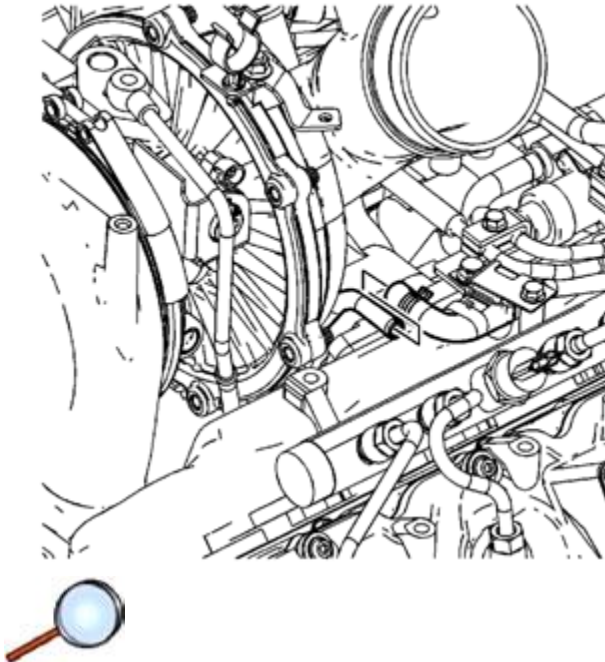
1. Remove the turbocharger upper heat shield bolts.
2. Remove the turbocharger upper heat shield.



Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of

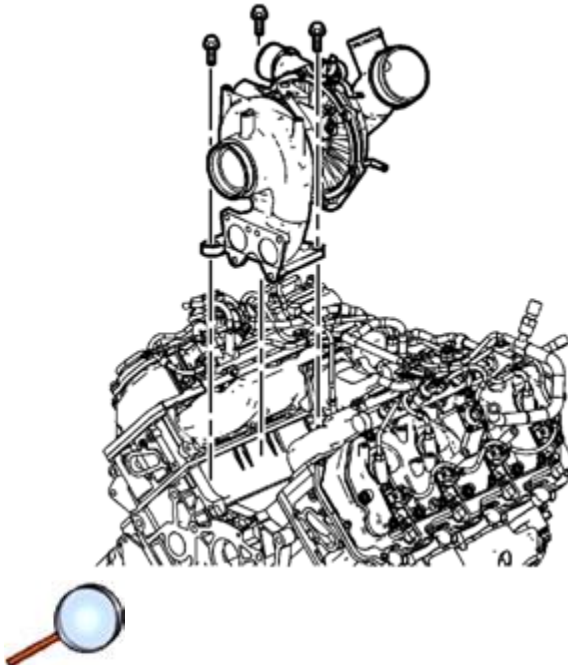
the turbocharger during removal or installation.

3. Remove the eye bolt and washers from the oil supply hose at the top of the turbocharger.

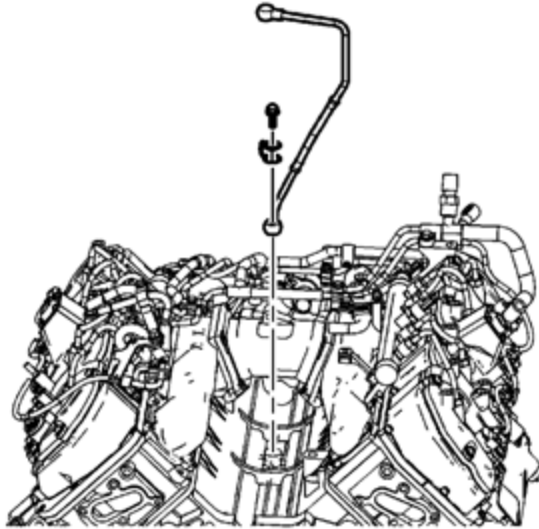


Note: Use care not to damage this hose during the procedure.

4. Loosen the hose clamp and remove the turbocharger cooling outlet hose.



5. Remove the turbocharger mounting bolts.
6. Remove the turbocharger assembly with the oil return pipe.

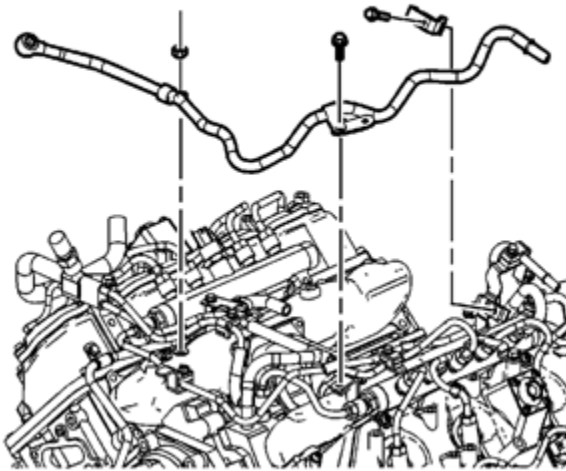


7. Remove the turbocharger lower heat shield from engine block.

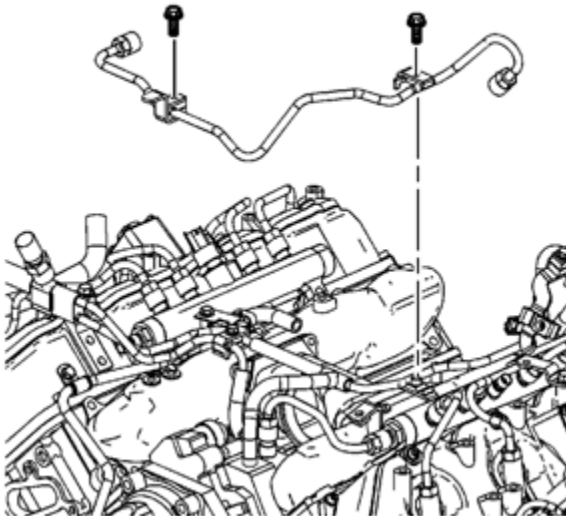
Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

8. Remove the turbocharger oil supply hose eye bolt and washers.
9. Remove the turbocharger oil supply hose.

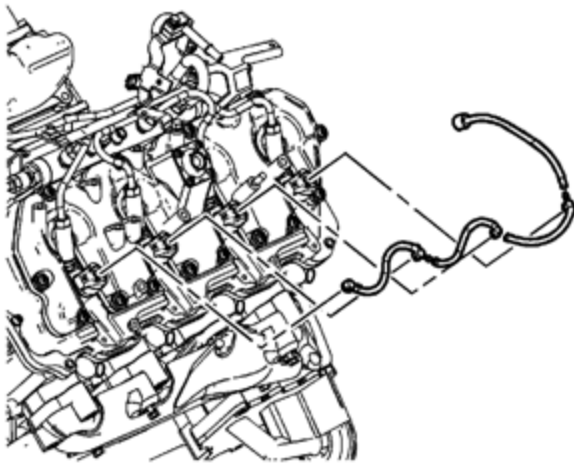
Fuel Pipes and Fuel Rail Removal



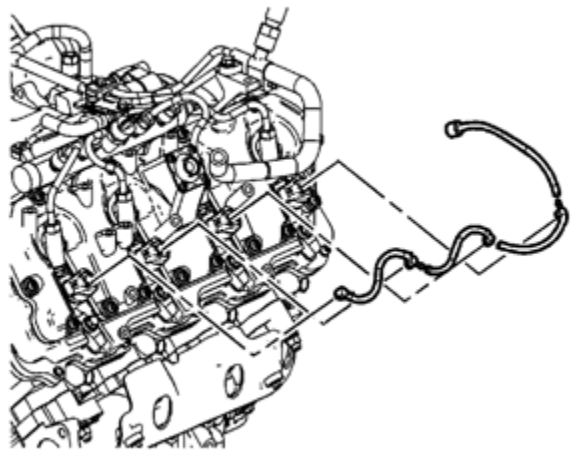
1. Remove the fuel feed pipe attaching nuts and bolts.
2. Remove the fuel feed pipe.



3. Disconnect the fuel rail balance pipe from fuel rails.
4. Remove the fuel rail balance pipe bolts.
5. Remove the fuel rail balance pipe.

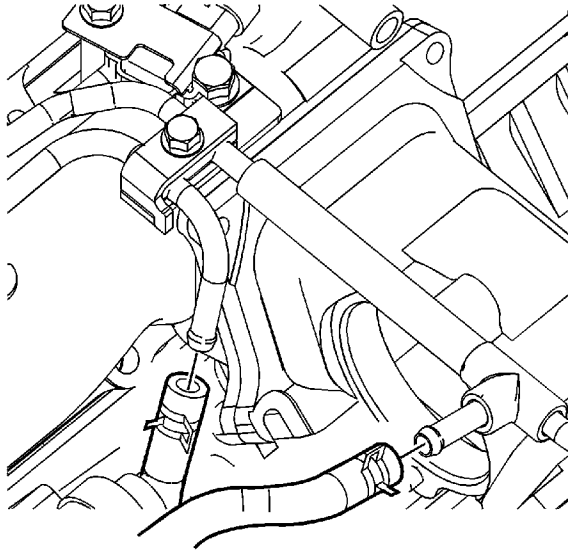


6. Remove the left fuel return hose.

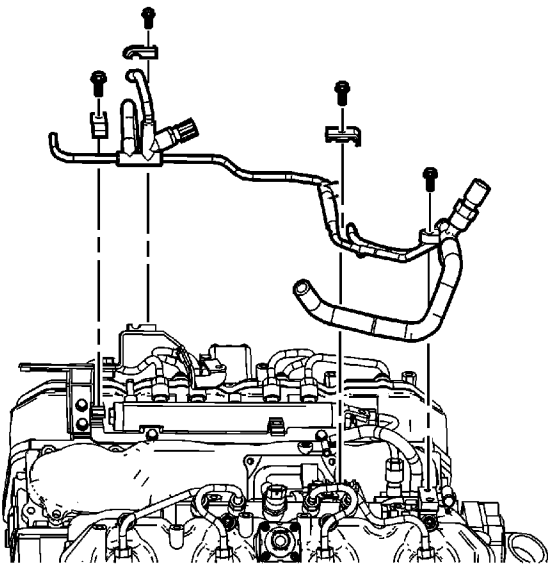


7. Remove the right fuel return hose.

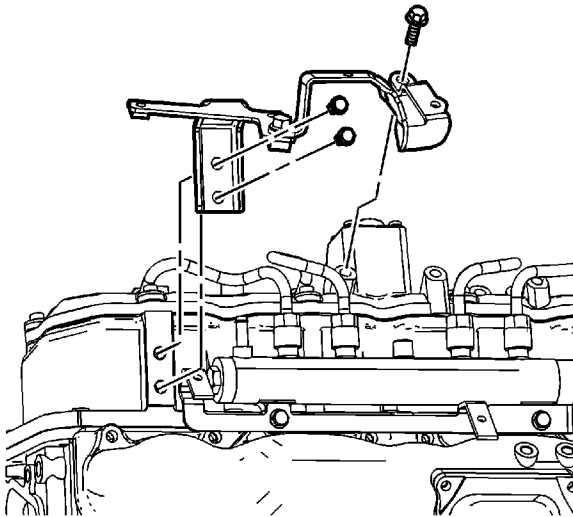
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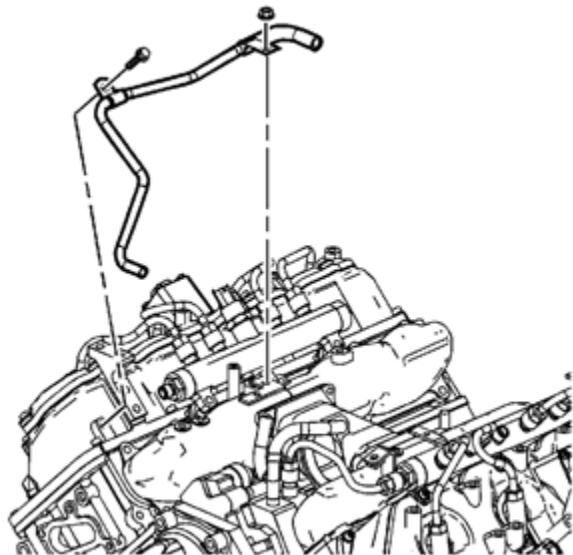
8. Disconnect the fuel hoses from the fuel injector pump.



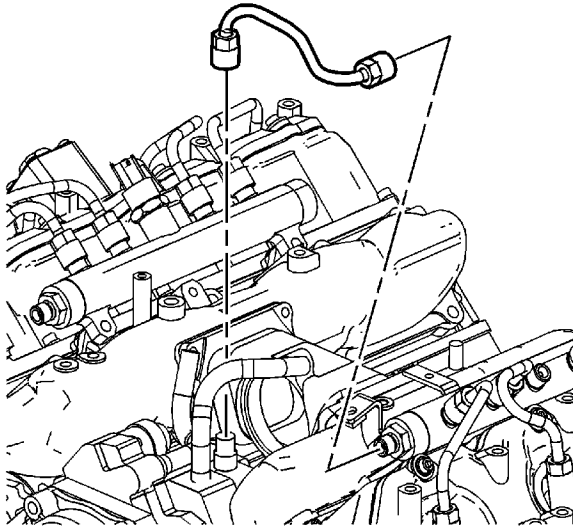
9. Remove the distribution block and fuel line assembly bolts.
10. Remove the distribution block and fuel line assembly.



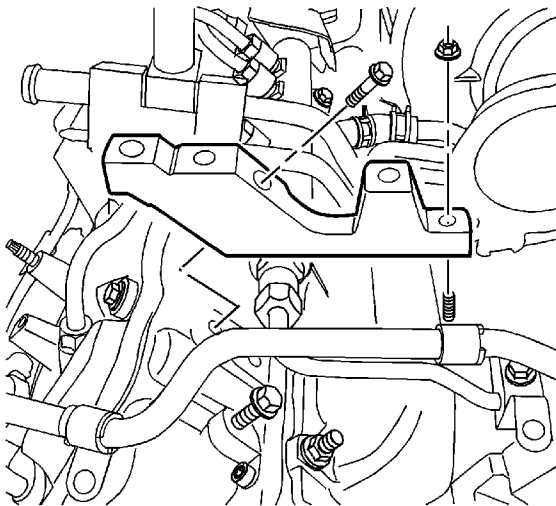
11. Remove the fuel pipe assembly bracket bolts.
12. Remove the fuel pipe assembly bracket.



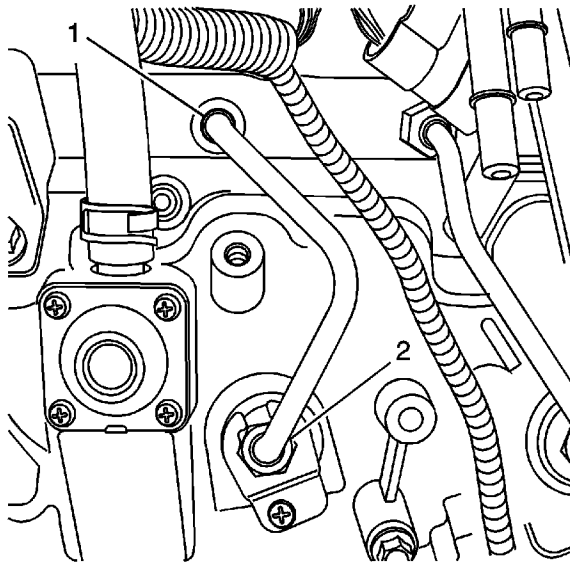
13. Remove the coolant pipe bolt and nut.
14. Remove the coolant pipe.



15. Remove the left fuel rail to pump pipe.



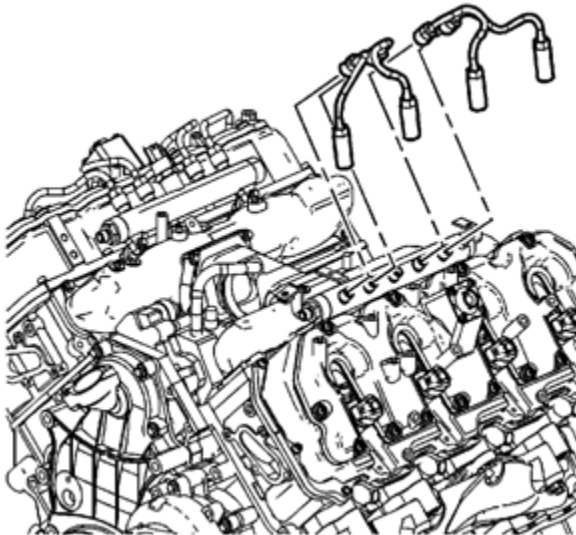
16. Remove the EGR mounting bracket bolt and nut.
17. Remove the EGR mounting bracket.



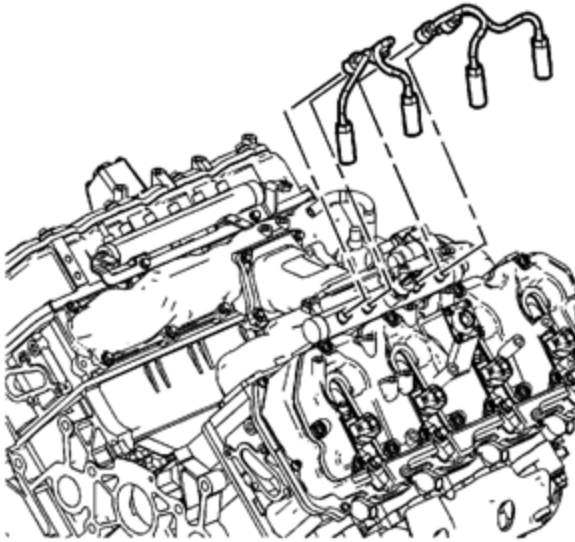
18. Using compressed air to blow away any debris between the fuel injector line and the fittings (1, 2). Wipe clean the fittings (1) of debris.

Caution: DO NOT use compressed air to clean debris from the fuel injector inlet after the fuel line is removed. Using compressed air can allow debris to enter the fuel injector inlet and damage the fuel injector.

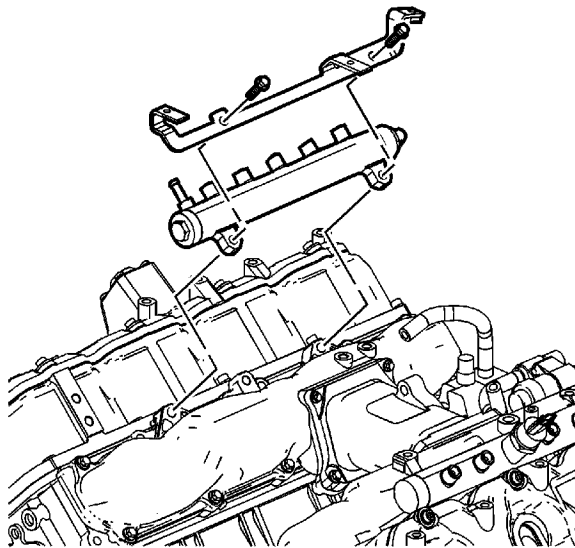
19. Spray lithium grease, GM P/N 12346293 or equivalent, between the fuel injector line and fitting (1, 2) to contain any debris during removal.



20. Remove the left fuel injector pipes.



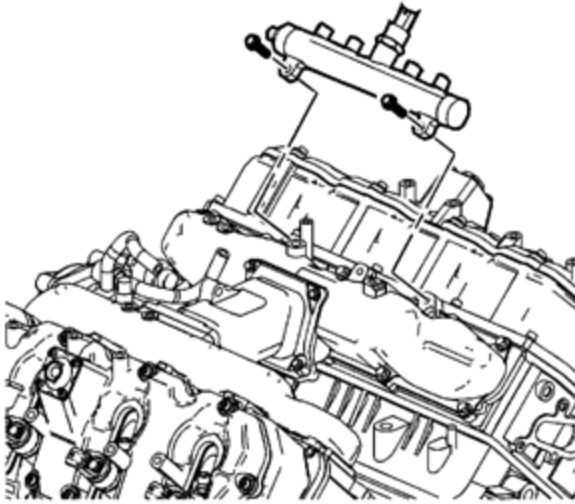
21. Remove the right fuel injector pipes.



22. Remove the left fuel rail and bracket bolts.

23. Remove the left fuel rail and bracket.

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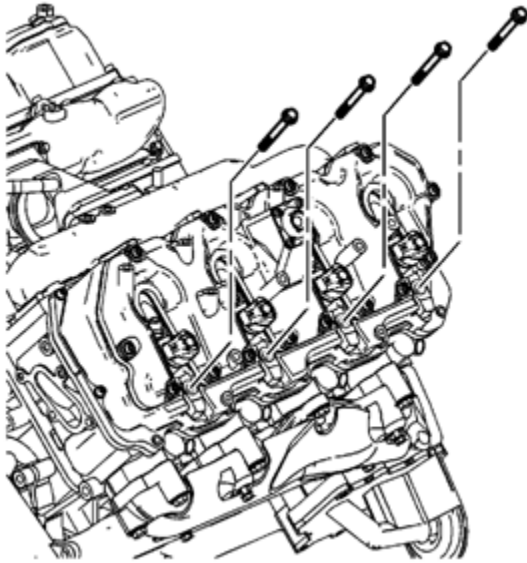
24. Remove the right fuel rail bolts.
25. Remove the right fuel rail.

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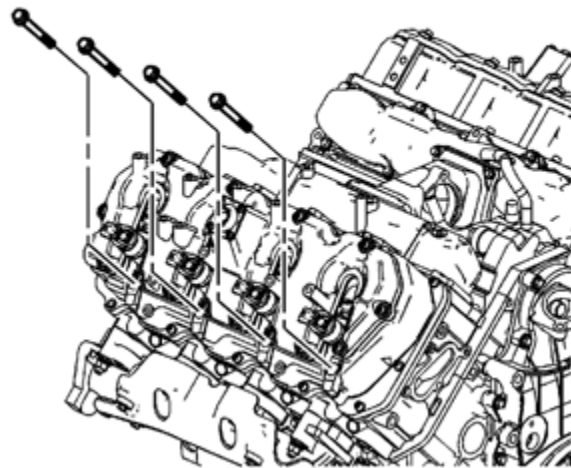
Fuel Injector Removal

Tools Required

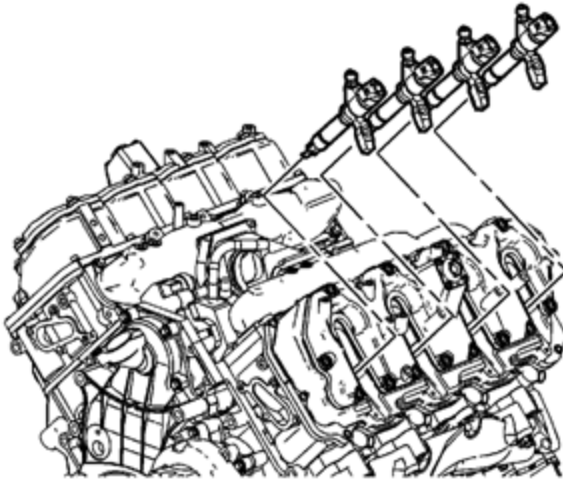
[J-46594](#) Fuel Injector Remover



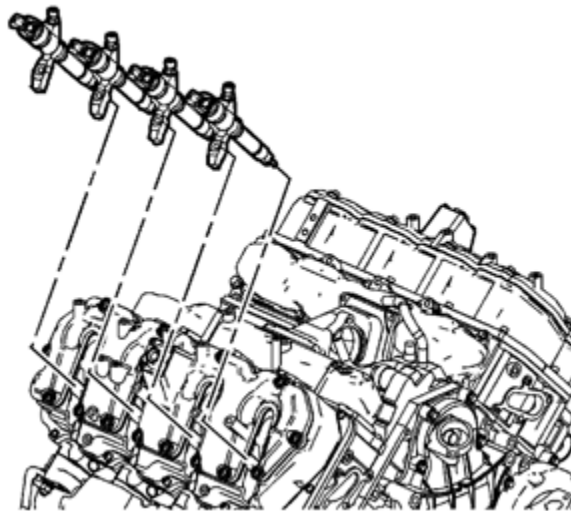
1. Remove the left fuel injector bracket bolts.



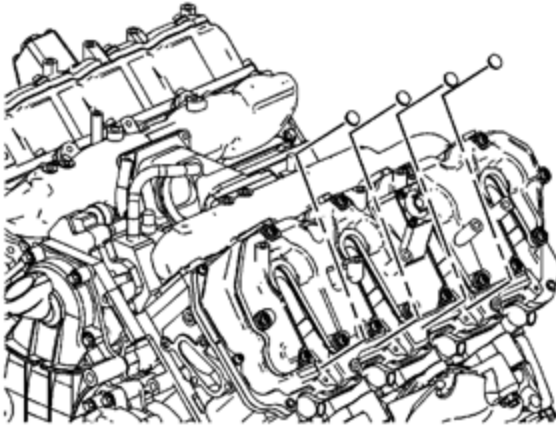
2. Remove the right fuel injector bracket bolts.



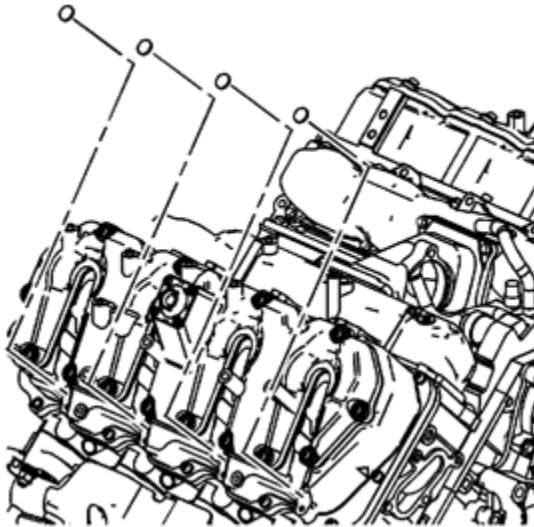
3. Install the [J-46594](#) into the fuel injector brackets.
4. Pull back on [J-46594](#) in one steady motion, until the fuel injector breaks free from its seat.
5. Remove the [J-46594](#).
6. Remove the left fuel injectors with brackets.



7. Remove the right fuel injectors with brackets.



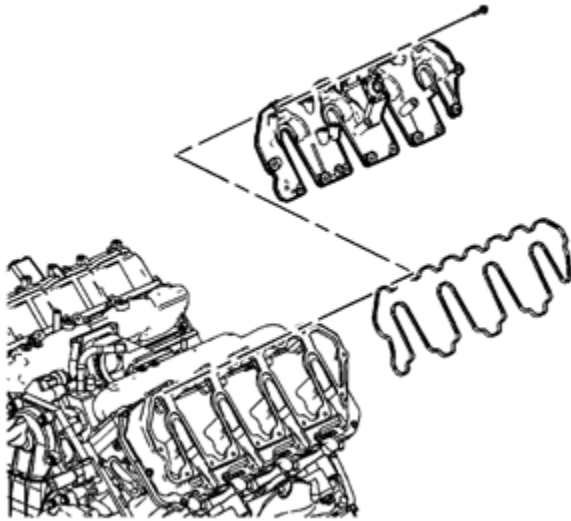
8. Remove the left injector bracket pins.



9. Remove the right injector bracket pins.
10. Remove the copper washer from the injector bore and discard.
11. Remove the O-ring from the injector and discard.

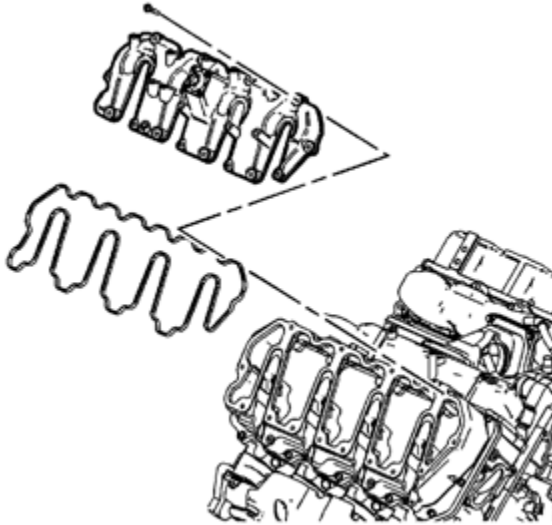
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Valve Rocker Arm Cover Removal - Upper Left Side



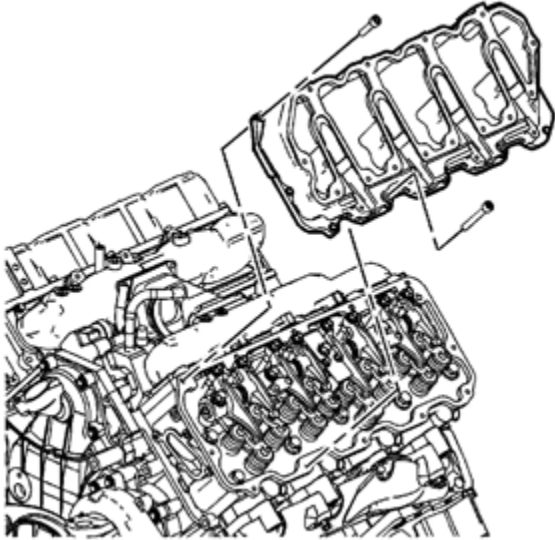
1. Remove the left upper valve rocker arm cover bolts.
2. Remove the left upper valve rocker arm cover.
3. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

Valve Rocker Arm Cover Removal - Upper Right Side



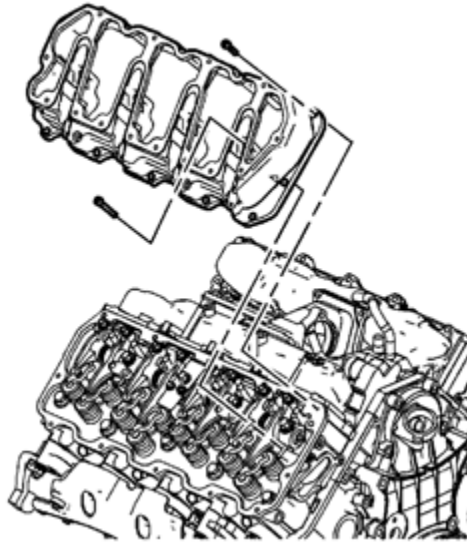
1. Remove the right upper valve rocker arm cover bolts.
2. Remove the right upper valve rocker arm cover.
3. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

Valve Rocker Arm Cover Removal - Lower Left Side



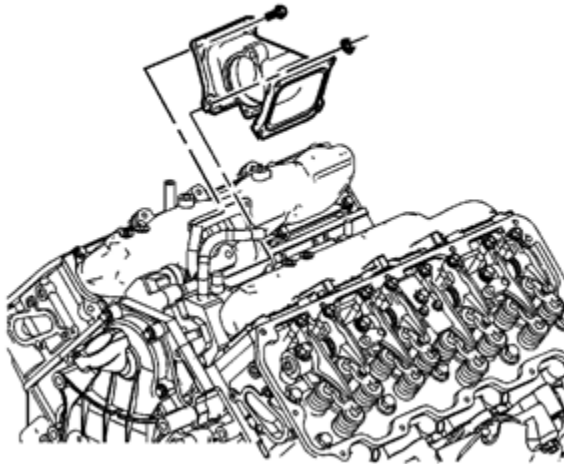
1. Remove the left lower valve rocker arm cover bolts.
2. Remove the left lower valve rocker arm cover.
3. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

Valve Rocker Arm Cover Removal - Lower Right Side



1. Remove the right lower valve rocker arm cover bolts.
2. Remove the lower valve rocker arm cover.
3. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

Intake Manifold Crossover Removal



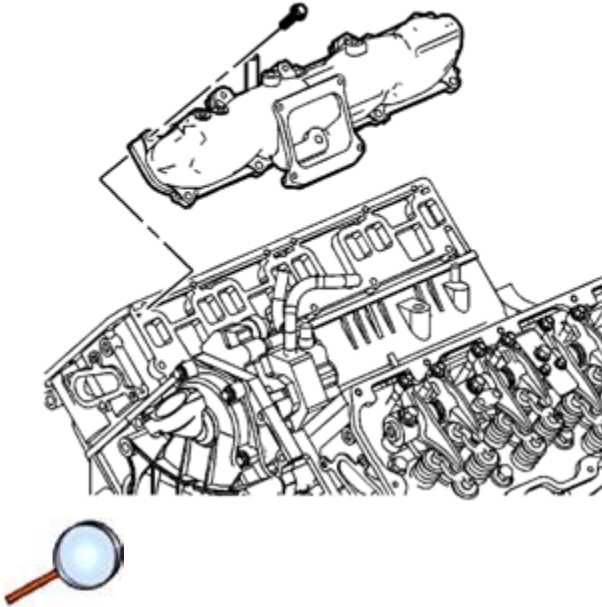
1. Remove the intake manifold crossover bolts and nuts.
2. Remove the intake manifold crossover.

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Intake Manifold Removal - Right Side

Tools Required

[J 37228](#) Seal Cutter

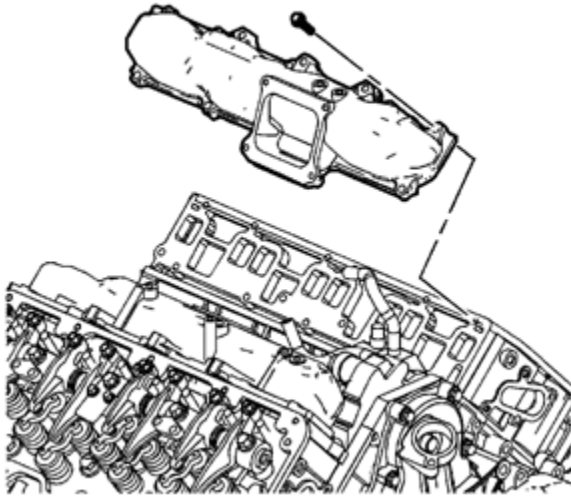


1. Remove the right intake manifold bolts. Do not forget to remove the bolt inside the intake manifold tube.
2. Separate the intake manifold from the cylinder head using [J 37228](#).
3. Remove the right intake manifold.

Intake Manifold Removal - Left Side

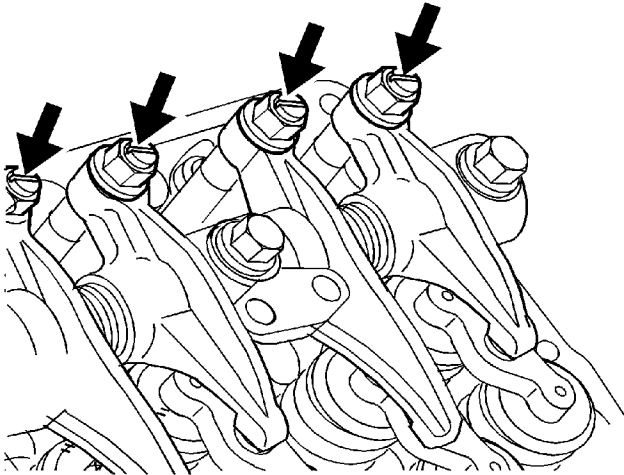
Tools Required

[J 37228](#) Seal Cutter

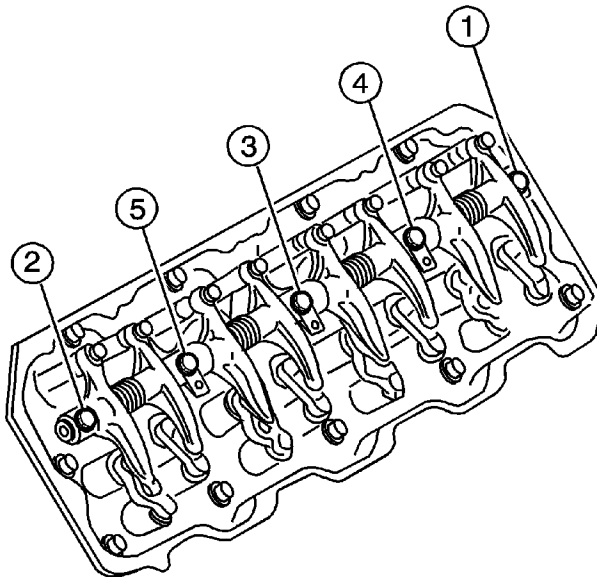


1. Remove the left intake manifold bolts. Do not forget to remove the bolt inside the intake manifold tube.
2. Separate the intake manifold from the cylinder head using [J 37228](#) .
3. Remove the left intake manifold.

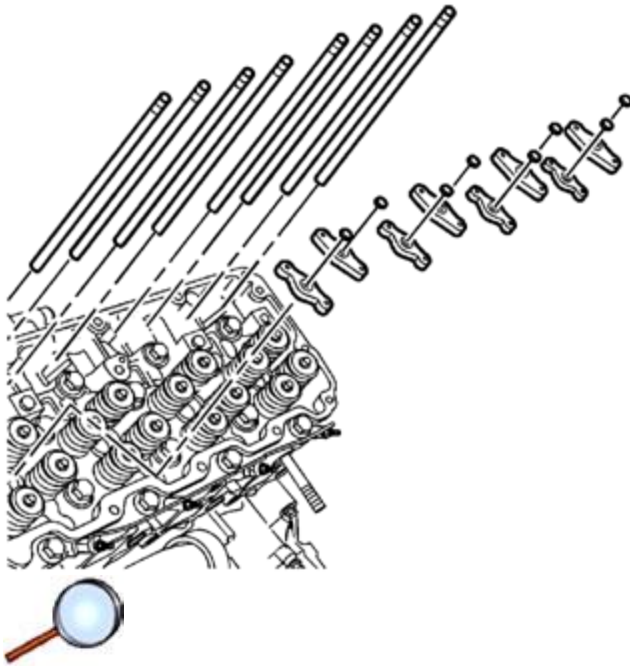
Valve Rocker Arm, Shaft, and Push Rod Removal



1. Loosen the valve clearance lock nuts on each rocker arm.
2. Loosen the valve clearance adjusting screw on each rocker arm to relieve tension on the valve train.



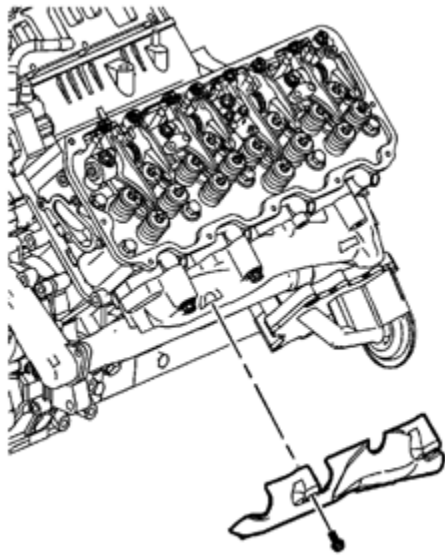
3. Remove the rocker arm shaft assembly bolts in the proper sequence.
4. Remove the rocker arm shaft assembly from the cylinder head.



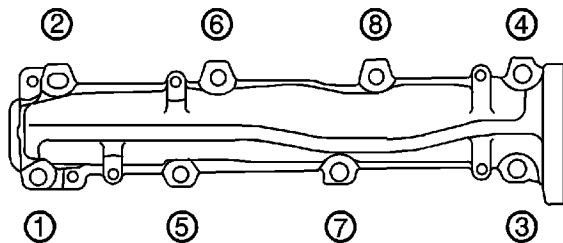
5. Remove the valve bridge pins.
6. Remove the valve bridges.
7. Remove the pushrods.

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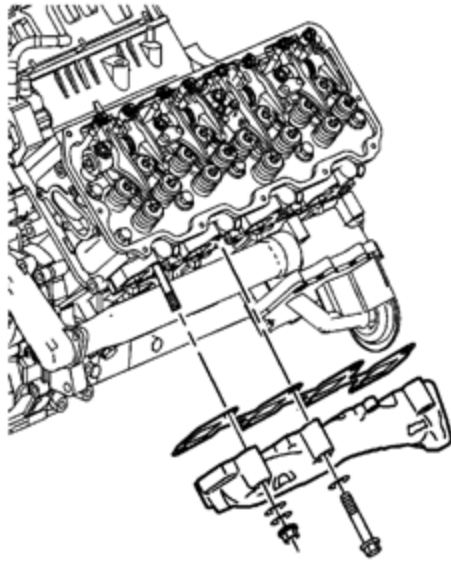
Exhaust Manifold Removal - Left Side



1. Remove the exhaust manifold heat shield bolts.
2. Remove the exhaust manifold heat shield.



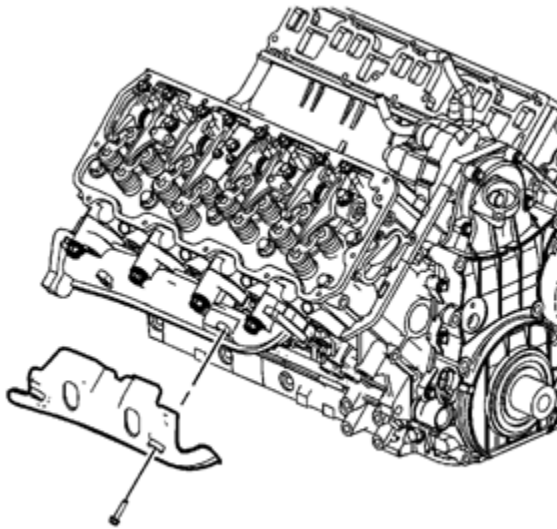
3. Remove the left exhaust manifold bolts and nuts in the proper sequence.



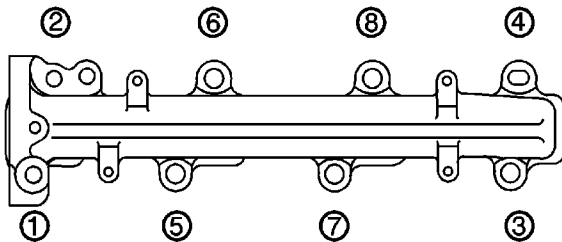
4. Remove the left exhaust manifold and gasket.

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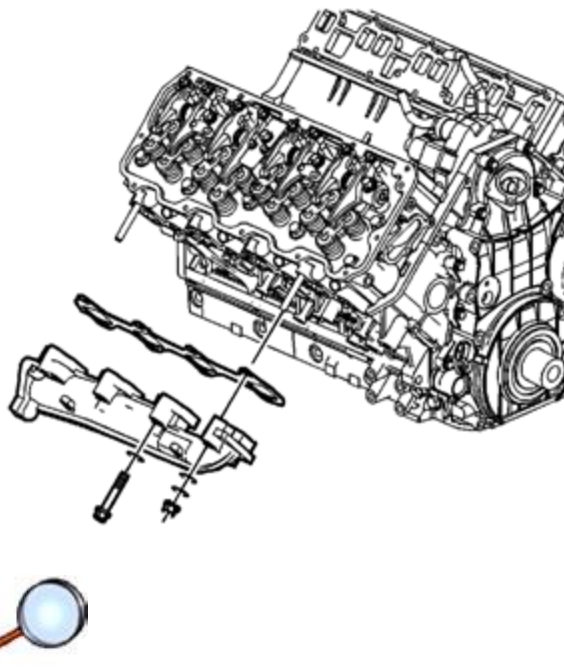
Exhaust Manifold Removal - Right Side



1. Remove the exhaust manifold heat shield bolts.
2. Remove the exhaust manifold heat shield.



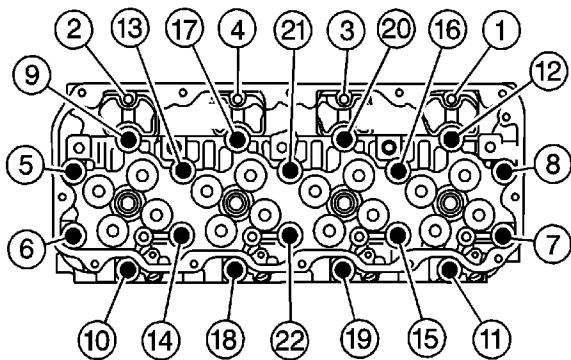
3. Remove the right exhaust manifold bolts and nuts in the proper sequence.



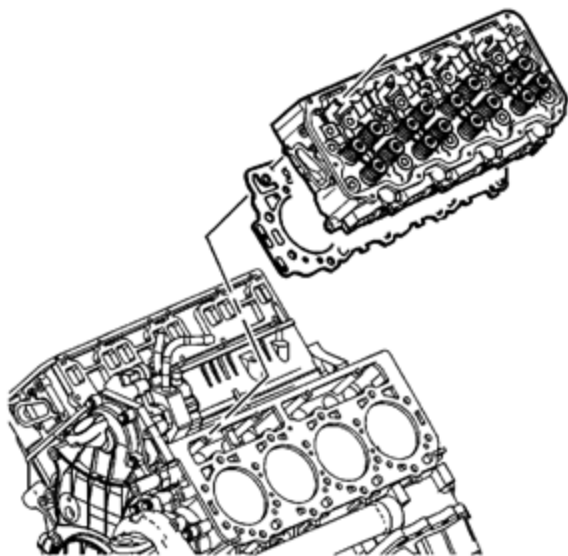
4. Remove the right exhaust manifold and gasket.

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Cylinder Head Removal - Left Side

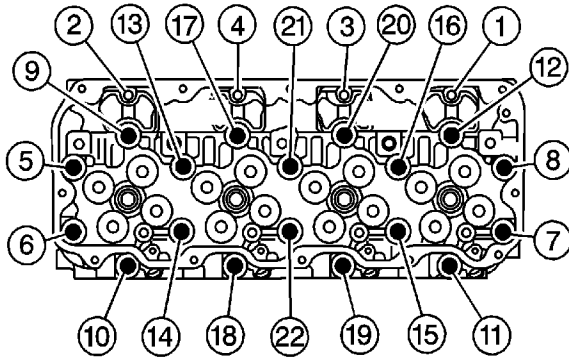


1. Remove the cylinder head bolts in the proper sequence.
2. Discard the large M12 bolts.

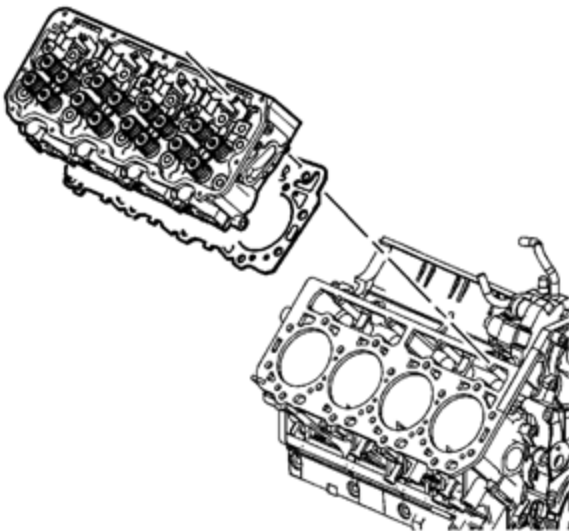


3. Remove the left cylinder head assembly.
4. Remove the left cylinder head gasket.

Cylinder Head Removal - Right Side

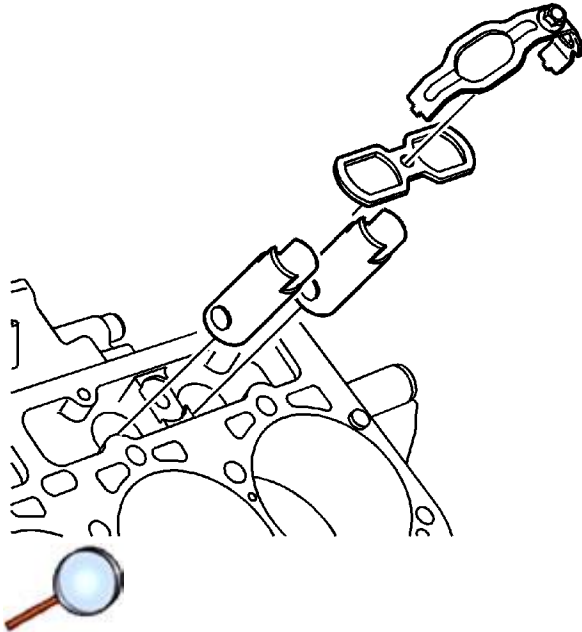


1. Remove the cylinder head bolts in the proper sequence.
2. Discard the large M12 bolts.



3. Remove the right cylinder head assembly.
4. Remove the right cylinder head gasket.

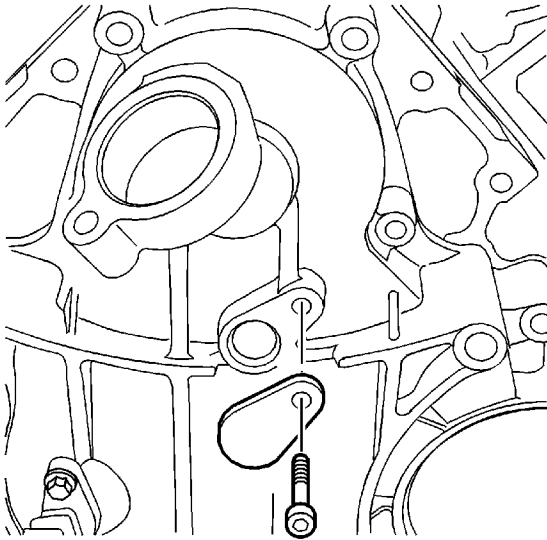
Valve Lifter Removal



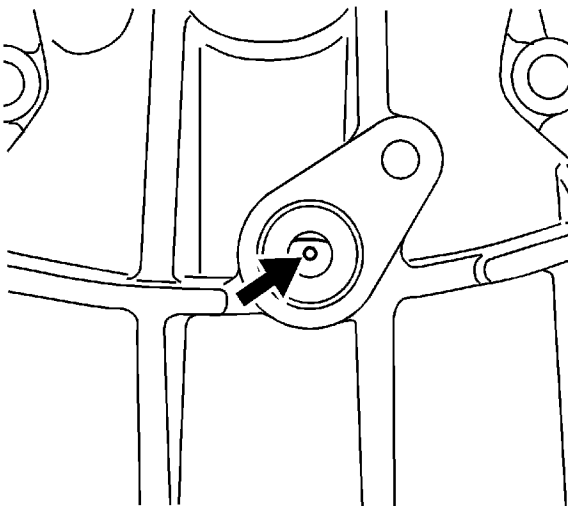
1. Loosen the valve lifter guide hold down bracket bolts.
2. Remove the valve lifter guide hold down brackets.
3. Remove the valve lifter guides.
4. Remove the valve lifters.

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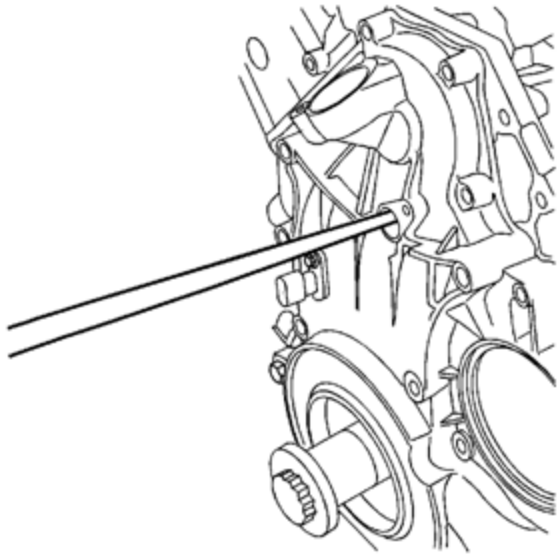
Fuel Injection Pump Removal



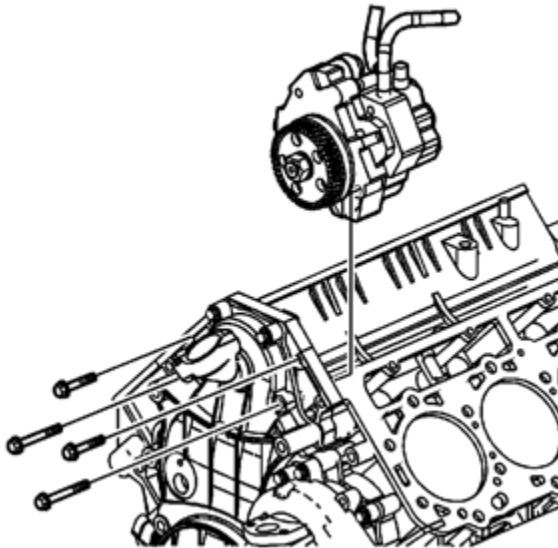
1. Remove the camshaft gear access hole cover bolt.
2. Remove the camshaft gear access hole cover.



3. Rotate the crankshaft until the camshaft gear tension relief hole is in line with the front cover access hole.

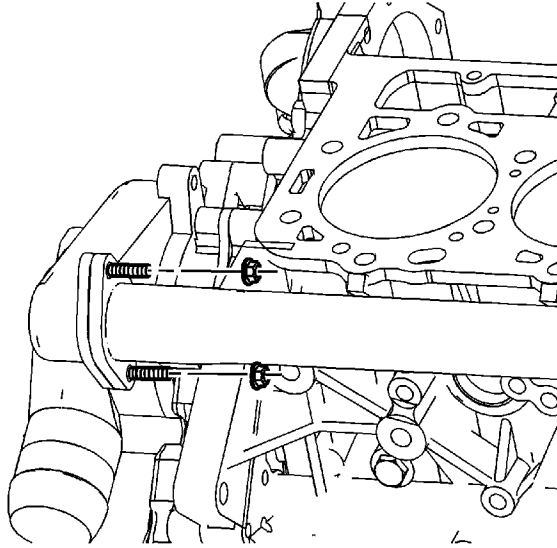


4. Use a suitable tool to unload the spring tension from the two piece cam gear. Apply pressure towards the right side of the engine while removing the injection pump.

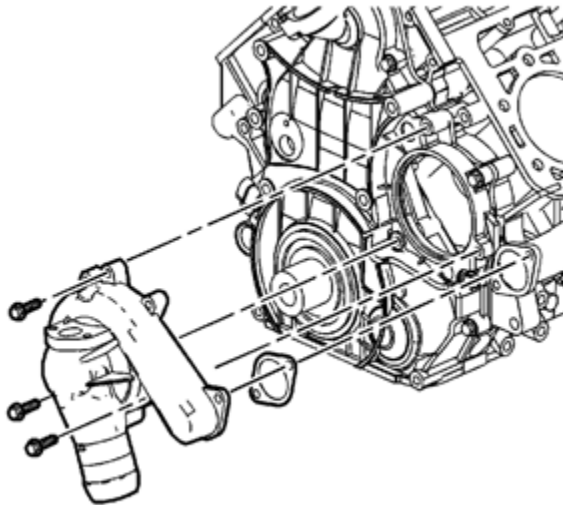


5. Remove the four fuel injection pump bolts.
6. Remove the fuel injection pump.

Water Pump Removal

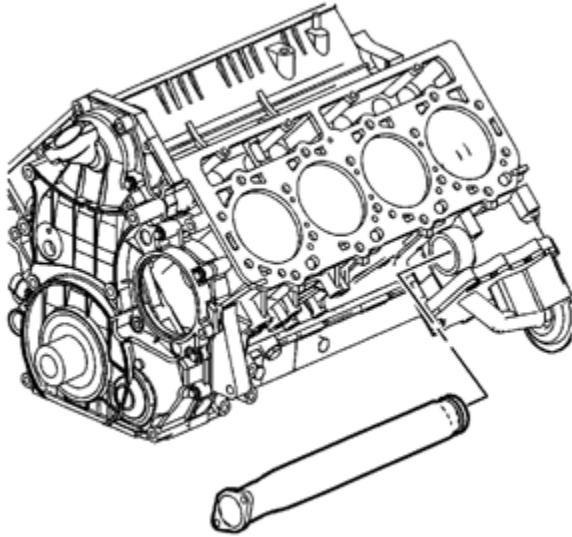


1. Remove the engine coolant pipe to water pump nuts.

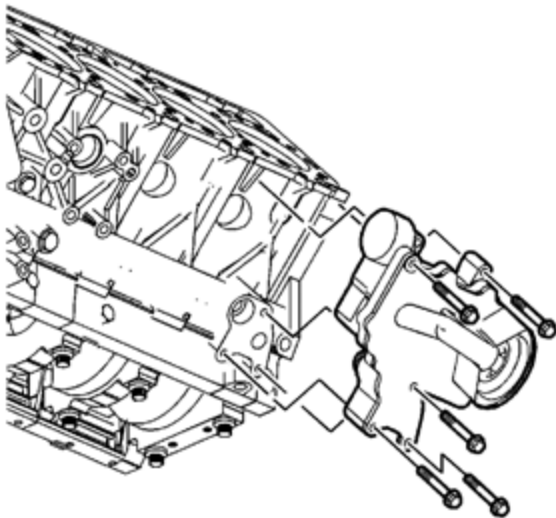


2. Remove the water pump bolts.
3. Remove the water pump assembly.
4. Remove the water pump seal and discard.
5. Remove the engine coolant pipe gasket and discard.

Oil Filter Adapter and Oil Cooler Assembly Removal



1. Remove the engine coolant pipe.
2. Remove the engine coolant pipe O-ring and discard.

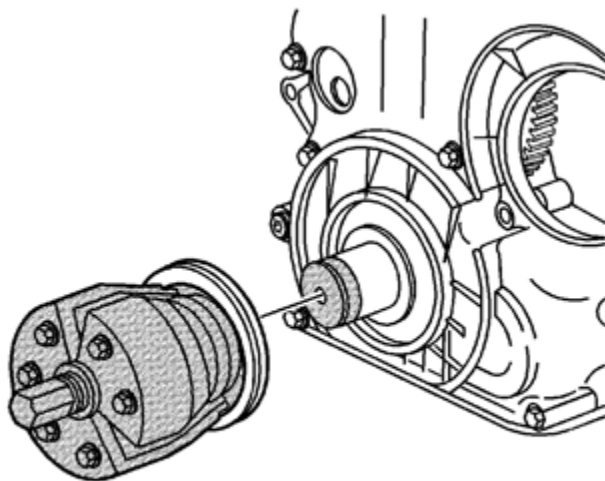


3. Remove the five oil filter adapter and oil cooler assembly bolts.
4. Remove the oil filter adapter and oil cooler assembly.

Crankshaft Front Oil Seal Removal

Tools Required

[J 44644](#) Crankshaft Front Oil Seal Remover

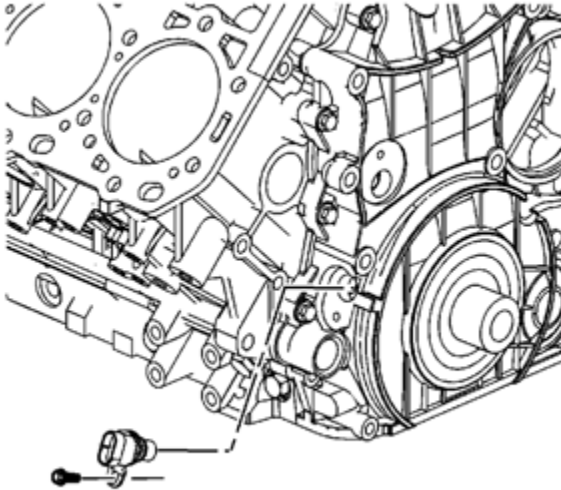


1. Install the button of [J 44644](#) into the crankshaft.
2. Press the jaws of [J 44644](#) into the felt portion of the seal far enough to engage the inner lip of the seal.
3. While holding the jaws of [J 44644](#) tightly to the seal's inner sleeve, tighten the jaw bolts.
4. Remove the crankshaft rear oil seal using the [J 44644](#) .

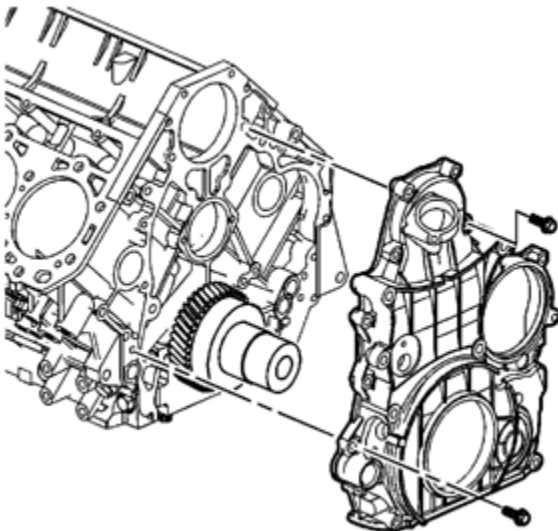
Engine Front Cover Removal

Tools Required

[J 37228](#) Seal Cutter



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

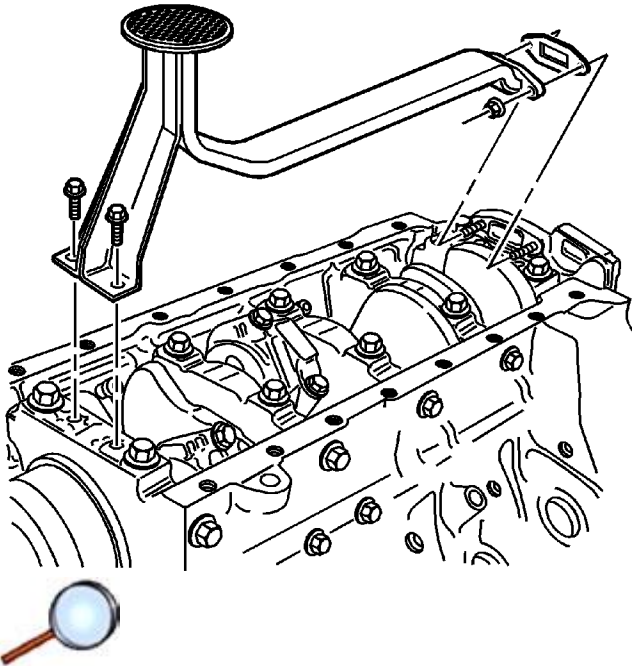


3. Remove the engine front cover bolts.

4. Separate the engine front cover from the cylinder block using [J 37228](#) .
5. Remove the engine front cover.

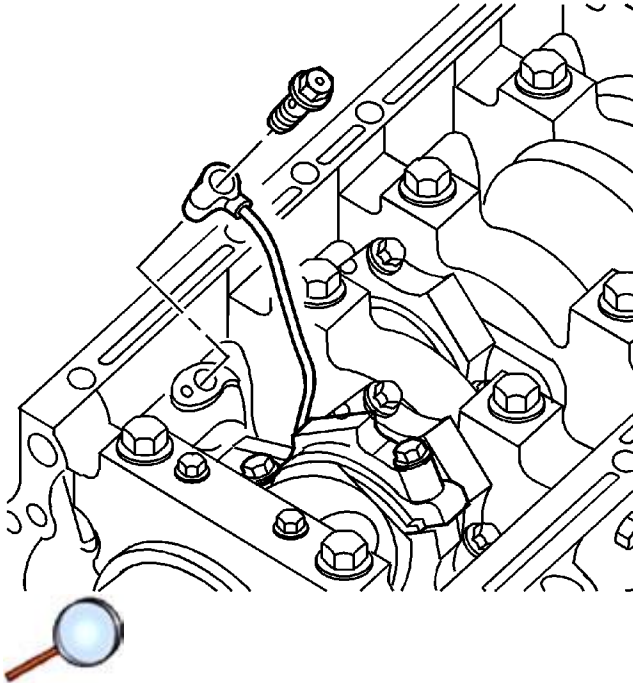
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Oil Pump Suction Pipe and Screen Assembly Removal



1. Remove the oil pump pipe and screen assembly bolts and nuts.
2. Remove the oil pump pipe and screen assembly.
3. Remove the oil pump pipe and screen assembly gasket and discard.

Piston Oil Cooling Nozzle Removal



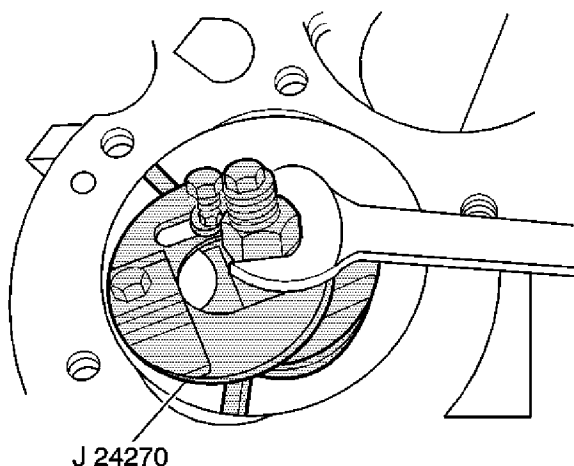
1. Rotate crankshaft as necessary to obtain access to piston oil cooling nozzles.
2. Remove the piston oil cooling nozzle eye bolt.
3. Remove the piston oil cooling nozzle.

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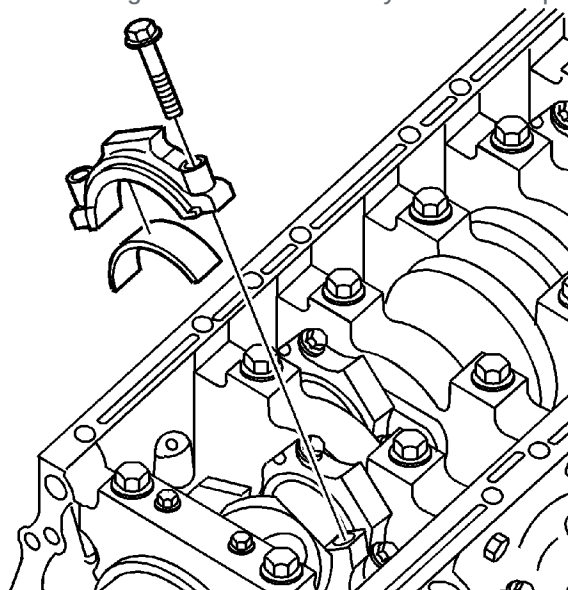
Piston, Connecting Rod, and Bearing Removal

Tools Required

[J 24270](#) Ridge Reamer

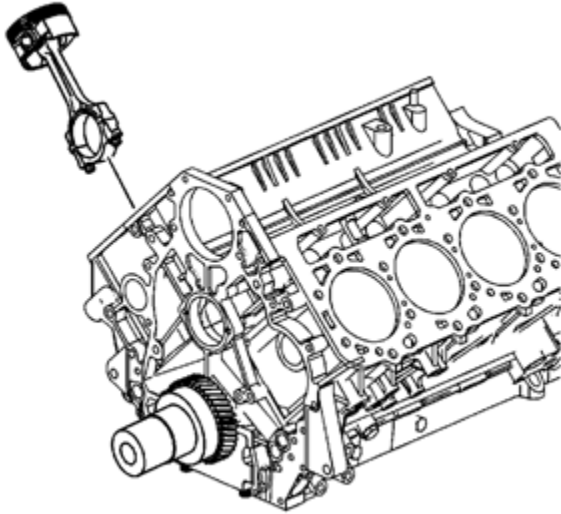


1. Rotate the crankshaft to place the piston at the bottom of the piston stroke.
2. Place a cloth on top of the piston.
3. Use the [J 24270](#) to remove the ridge at the top of the cylinder bore.
4. Remove cloth.
5. Remove cutting debris from the cylinder and piston.





6. Remove the connecting rod cap bolts. Set the bolts aside for use in plastic gauging if needed. New bolts will be used for final assembly.
7. Remove the connecting rod cap.
8. Remove the bearing insert from connecting rod.



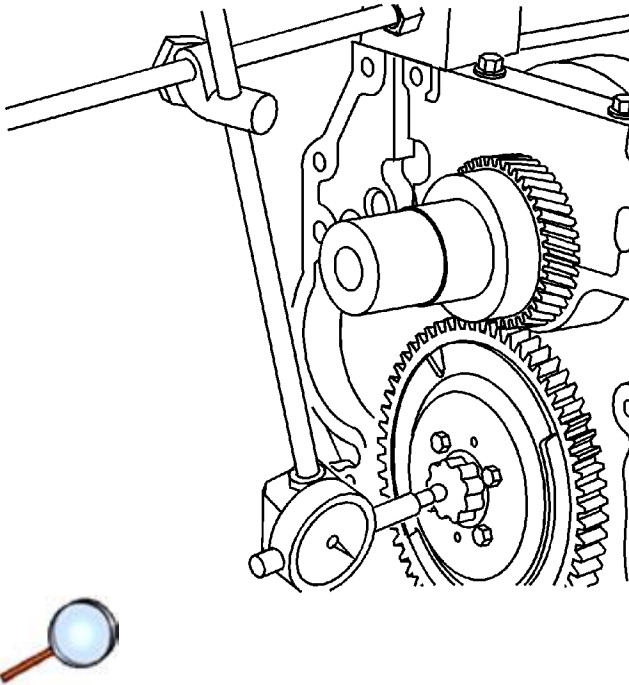
9. Push piston assembly out of cylinder.
10. Reassemble the connecting rod bearing, cap, and bolts upon removal.

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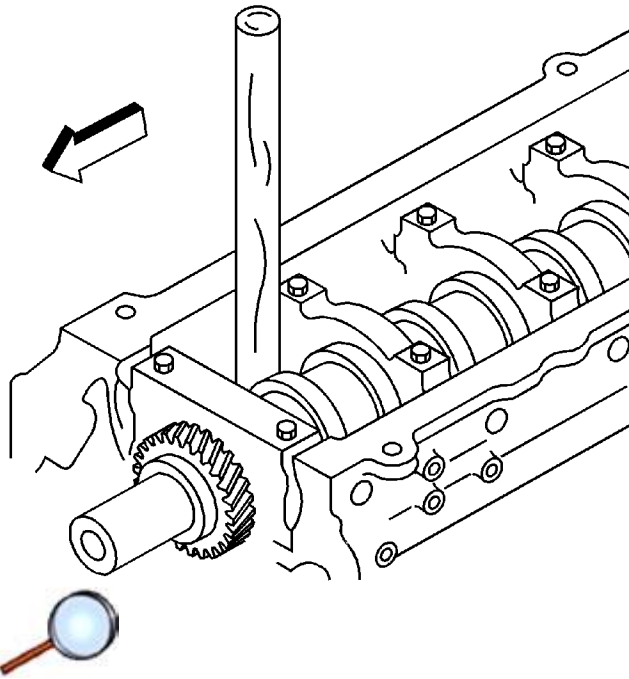
Camshaft Removal

Tools Required

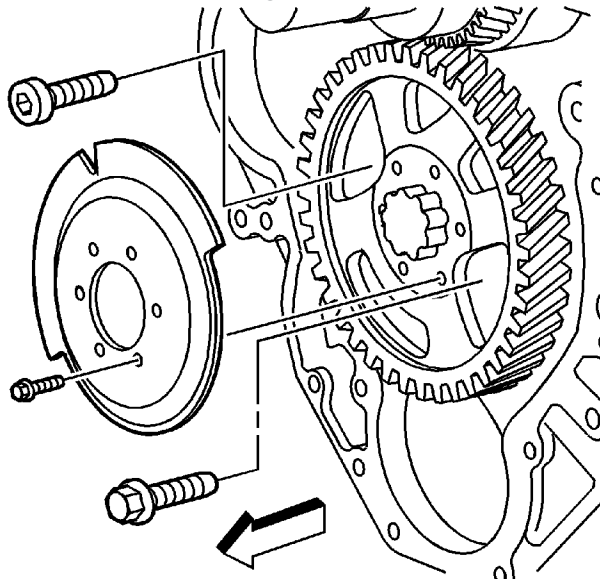
[J 7872](#) Dial Indicator Set



1. Measure the camshaft end play using [J 7872](#) .
 - The production value is 0.050-0.114 mm (0.002-0.0045 in) and service limit is 0.20 mm (0.008 in).
 - Replace the camshaft or the camshaft thrust plate if the measured value exceeds the service limit.



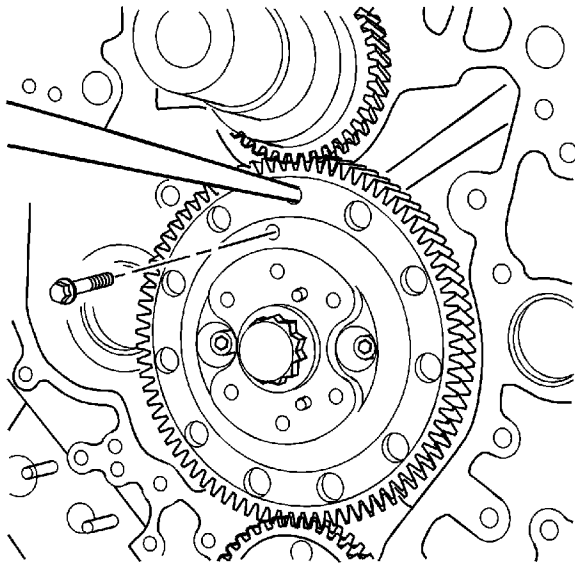
2. Block the crankshaft from turning with a wooden handle.
3. Loosen the camshaft gear bolt and leave the bolt finger tight.



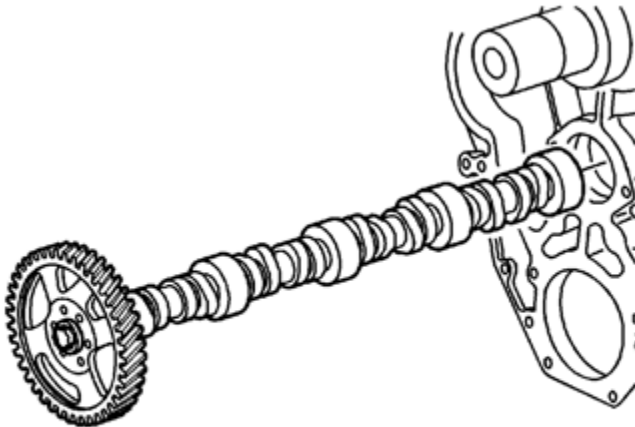
4. Remove the camshaft exciter ring bolts.

Important: The two piece cam gear must be bolted together to prevent the spring tension from unloading upon removal.

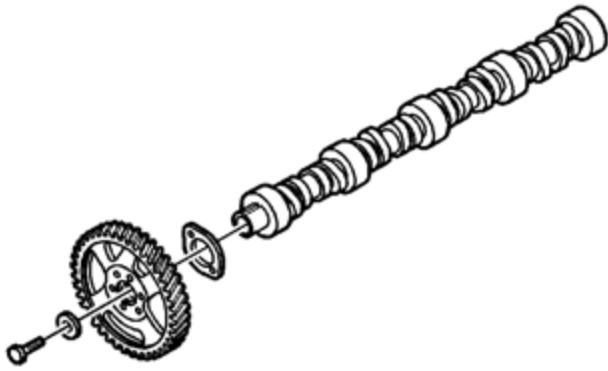
5. Remove the camshaft exciter ring.



6. Align the threaded hole with a suitable tool and install an exciter ring bolt to secure the spring tension.
7. Remove the camshaft thrust plate bolts through the holes in the camshaft gear.



8. Remove the camshaft with the camshaft gear attached.



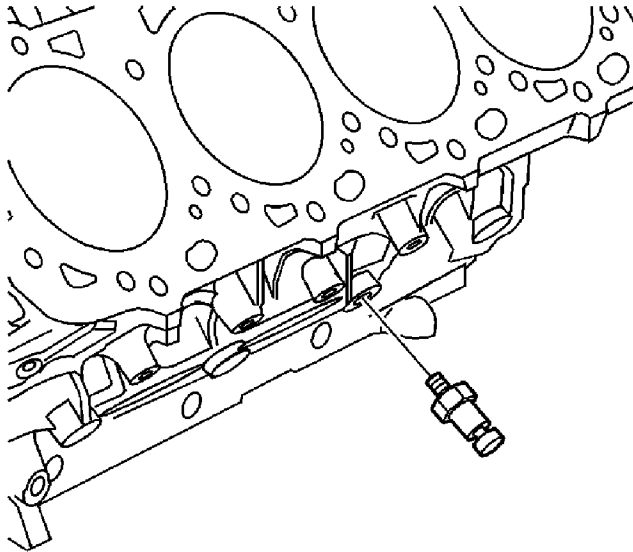
9. Remove the camshaft gear bolt and washer.
10. Remove the camshaft gear.
11. Remove the camshaft thrust plate.

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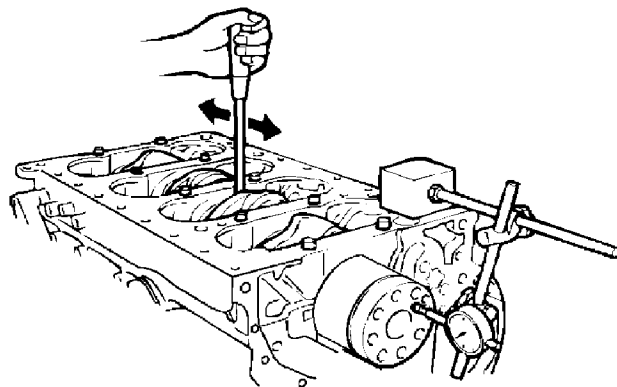
Crankshaft and Bearing Removal

Tools Required

[J 7872](#) Dial Indicator Set

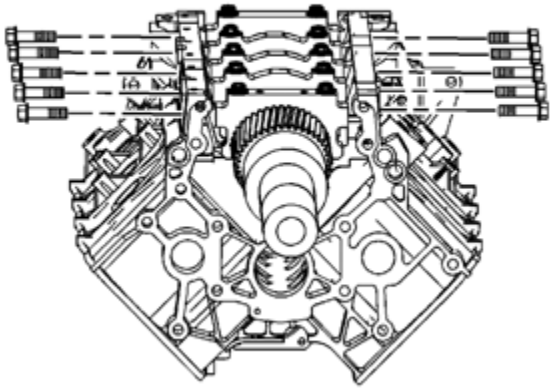


1. Remove the oil pressure sensor.

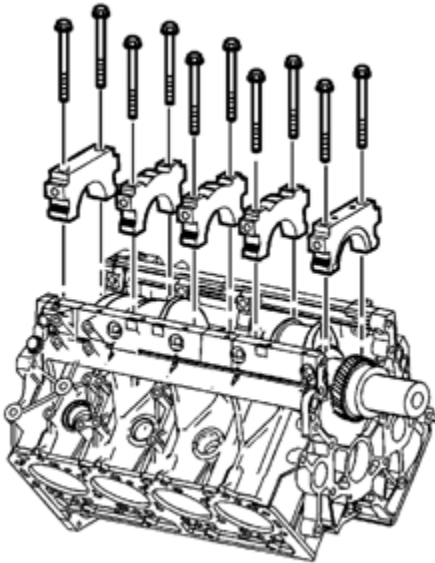


2. Measure crankshaft end play using [J 7872](#) . The production value is 0.04-0.205 mm (0.0016-0.0081 in) and the service limit is 0.54 mm (0.0213 in). Replace the thrust bearings upon

reassembly if the measured value exceeds the service limit.



3. Remove the crankshaft bearing cap side bolts.

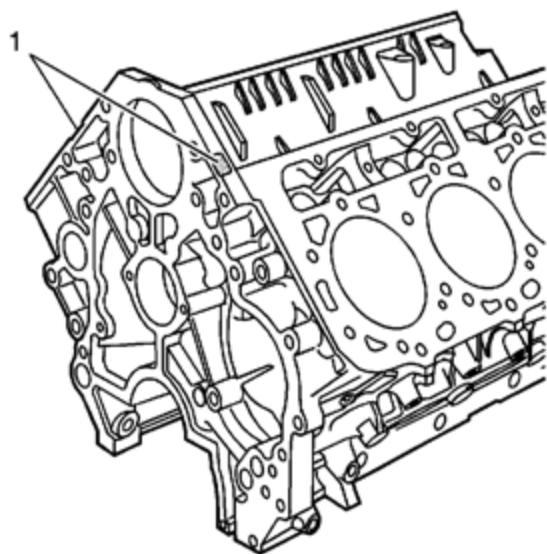


4. Remove the crankshaft bearing cap bolts.
5. Remove the crankshaft bearing caps.
6. Set the bolts aside for use in plastic gauging if needed.
7. Remove the crankshaft assembly.
8. Remove the crankshaft bearings from the engine block and the bearing caps.
9. Mark crankshaft bearings and caps so they may be installed in their original position.

Engine Block Cleaning and Inspection

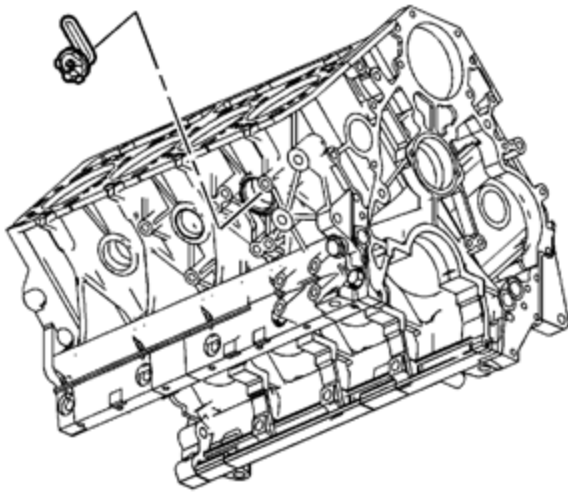
Note: All remanufactured cylinder blocks are steel stamped on both sides of the fuel pressure pump boss. The stamp indicates whether the cylinder is standard or over-bored, and if the deck is standard or has been milled.

Stamped ID	Cylinders Bore Size (in.)	Top Deck (STD or Milled)
SS	STD	STD
01S	0.010	STD
02S	0.020	STD
03S	0.030	STD
SM	STD	Milled
01M	0.010	Milled
02M	0.020	Milled
03M	0.030	Milled

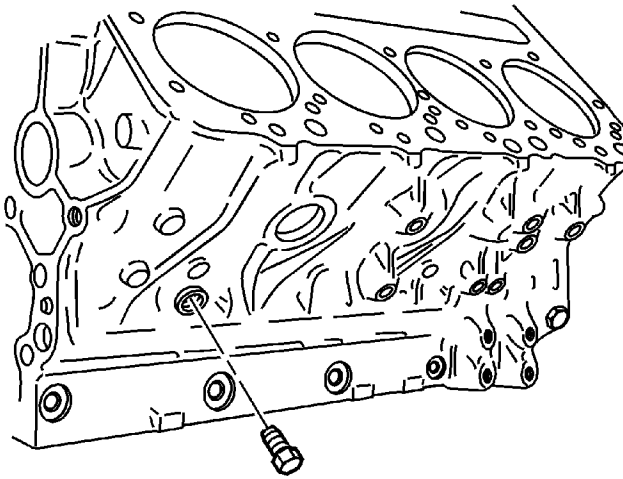


1. Inspect the block for stampings (1) indicating cylinder overbore or a milled deck.

Note: If the block has no stampings, the block has a standard bore and deck.

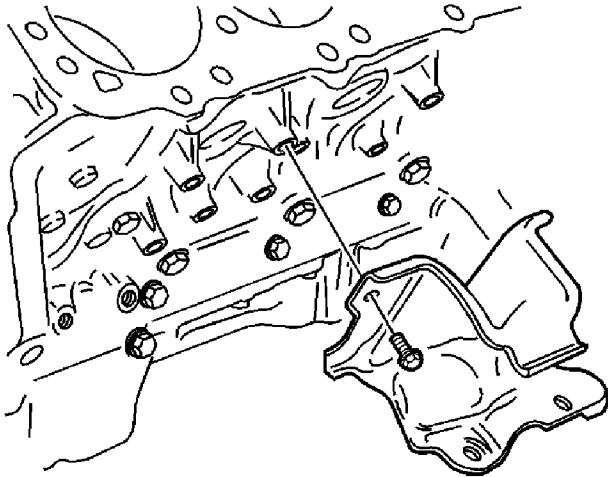


2. Remove the engine block heater.
3. Remove the O-ring from the block heater and discard.

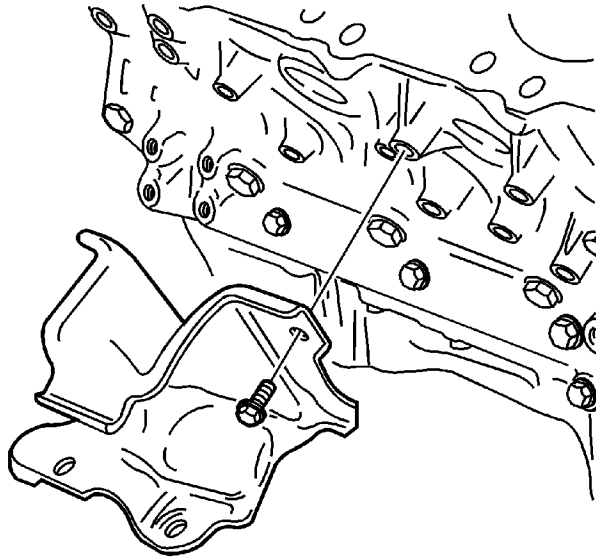


4. Remove the oil gallery plugs.

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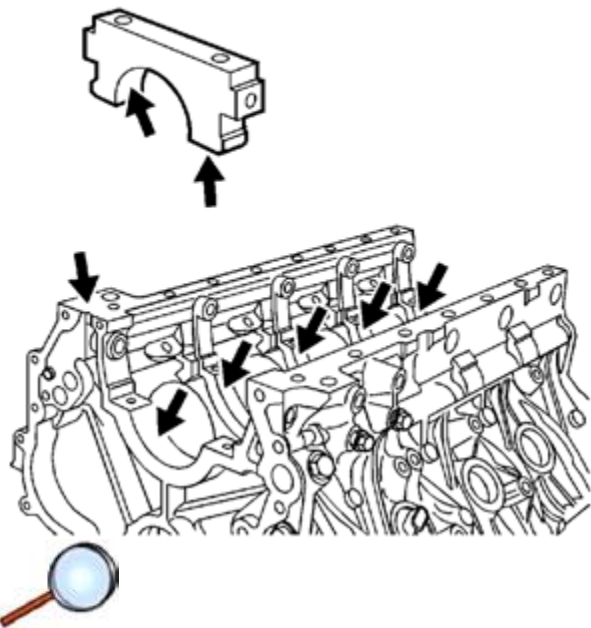


5. Remove the left engine mount bolts.
6. Remove the left engine mount.

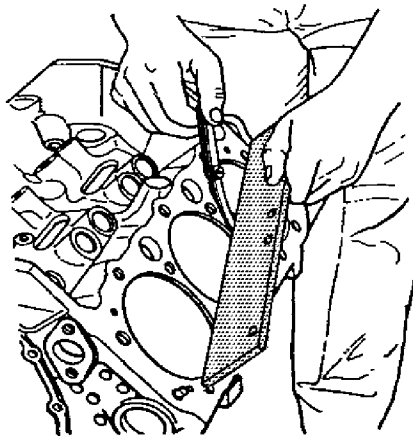


7. Remove the right engine mount bolts.
8. Remove the right engine mount.
9. Clean the sealing material from the gasket mating surfaces of the block.
10. Clean the block in cleaning solvent.
11. Flush the engine block with clean water or steam.
12. Clean the oil passages.
13. Clean the cylinder bores.
14. Inspect the block for cracks. Use the Magnaflux Spot check dye method, or the equivalent.
 - Inspect the cylinder walls.
 - Inspect the coolant jackets.
 - Inspect the crankshaft bearing webs.

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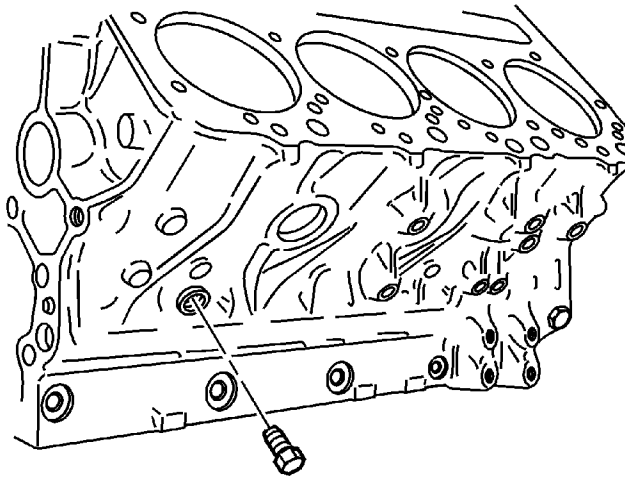


15. Inspect the crankshaft bearing bores and caps. The crankshaft bearing bore inside diameters should be round and uniform at all of the bearing supports.
16. Inspect the area where the crankshaft bearing inserts contact the crankshaft bearing bore. This area must be free of burrs and scratches.
17. Inspect the engine mount bosses.
18. Inspect the cylinder head gasket mating surfaces for pitting.

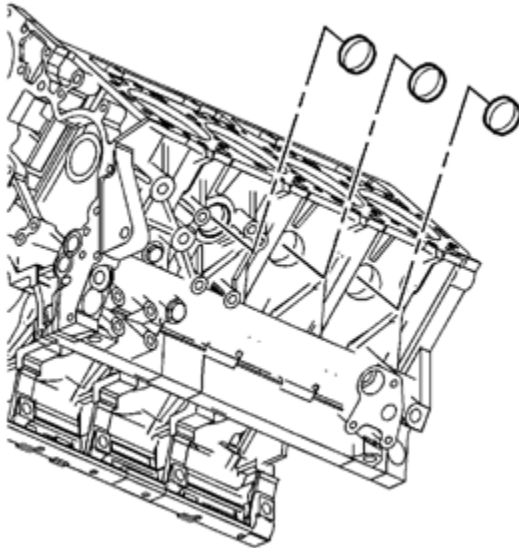


19. Inspect the engine block to cylinder head gasket surface area for warping. Use a straight edge and feeler gauge. Replace the block if it is warped more than 0.15 mm (0.006 in) longitudinally or more than 0.08 mm (0.003 in) transversely.
20. Apply sealer to the oil gallery plugs.

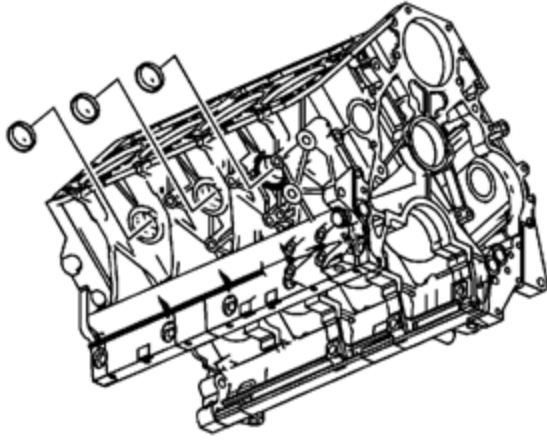
Caution: Refer to [Fastener Caution](#) in the Preface section.



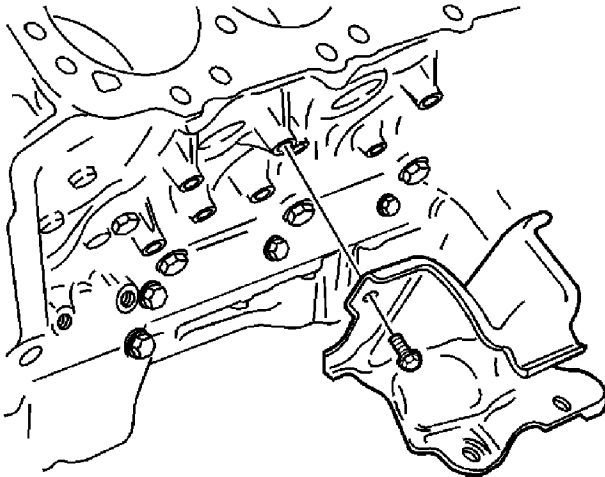
21. Install the oil gallery plugs and tighten to **53 N·m (39 lb ft)**.



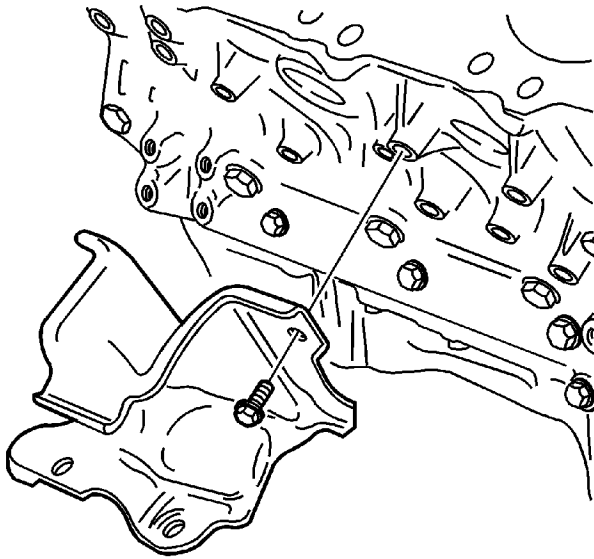
22. Install the left engine block coolant plugs and tighten to **18 N·m (13 lb ft)**.



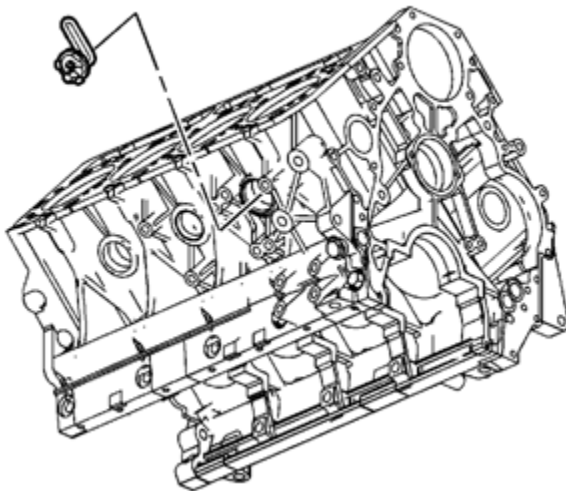
23. Install the right engine block coolant plugs and tighten to **18 N·m (13 lb ft)**.



24. Install the left engine mount and engine mount bolts. Tighten the engine mount bolts to **58 N·m (43 lb ft)**.



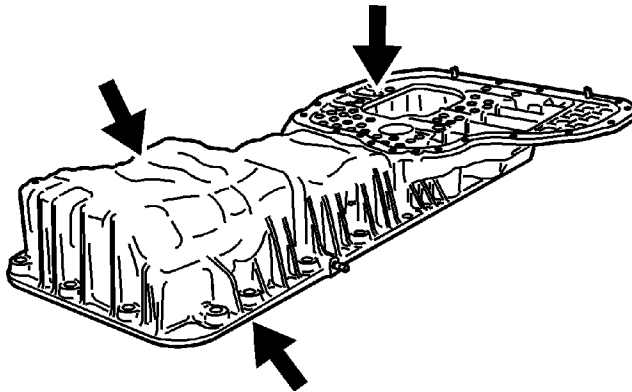
25. Install the right engine mount and engine mount bolts. Tighten the right engine mount bolts to **58 N·m (43 lb ft)**.



26. Install a new O-ring to the block heater.
27. Lubricate the O-ring with engine coolant.
28. Install the engine block heater.

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Upper Oil Pan Cleaning and Inspection



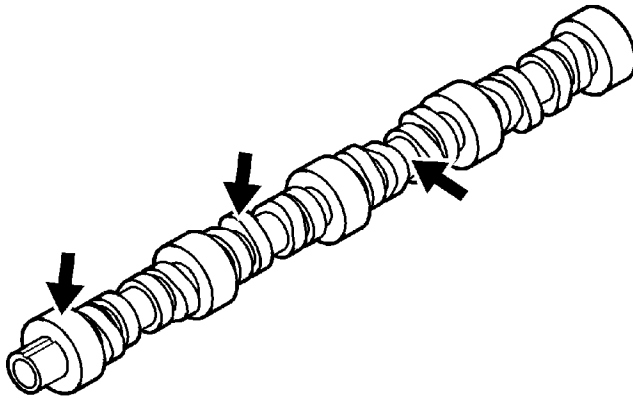
1. Clean the upper oil pan.
2. Carefully clean the sealer from the threaded holes.
3. Inspect the upper oil pan for cracks.
4. Inspect the upper oil pan sealing surfaces for damage.
5. Replace the upper oil pan if any damage is found.

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Camshaft and Bearings Cleaning and Inspection

Tools Required

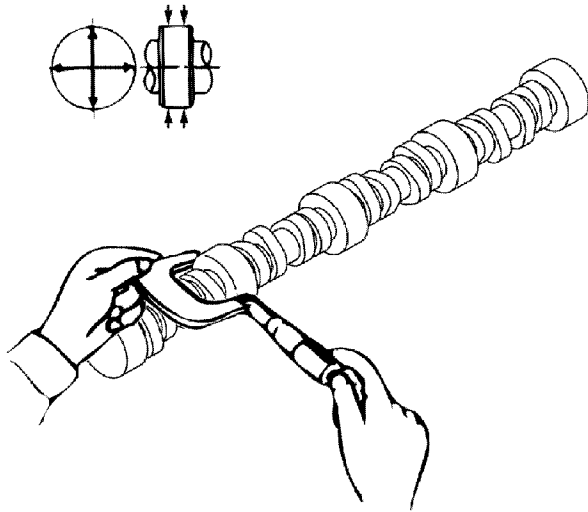
[J 7872](#) Dial Indicator Set



1. Clean the camshaft.

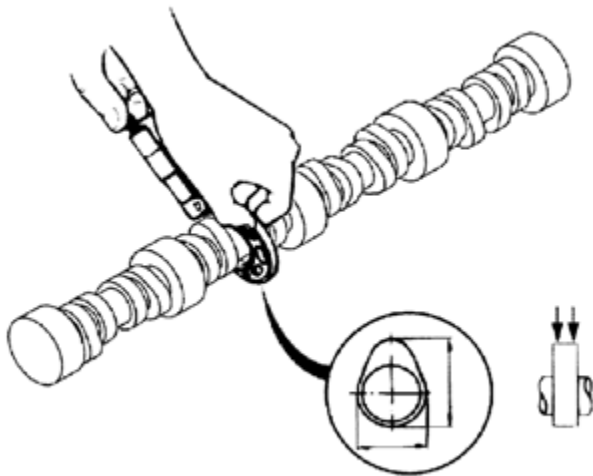
Important: The camshaft bearings are not serviceable. If the camshaft bearings are damaged, the engine must be replaced.

2. Visually inspect the camshaft bearings in the engine block for the following conditions:
 - Scoring
 - Nicks
 - Damage caused by lack of lubrication
 - Misaligned oil feed holes

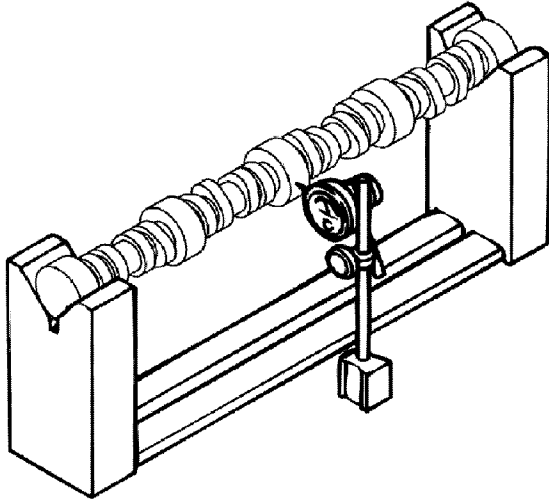


3. Measure the camshaft journal diameter.

- The production value is 60.932-60.962 mm (2.3990-2.4001 in) and service limit is 60.920 mm (2.3984 in).
- Replace the camshaft if the measured value is less than service limit.



4. Measure the camshaft lobe lift. The production value for intake is 7.273 mm (0.2863 in).
5. The production value for exhaust is 5.907 mm (0.2326 in).
6. Replace the camshaft if the measured value is less than the service limit.



7. Measure the camshaft runout.
 - Mount the camshaft on the V-blocks.
 - Use [J 7872](#) to measure the camshaft runout.
 - The runout service limit is 0.05 mm (0.0020 in).
8. Replace the camshaft if the run-out is over the service limit.

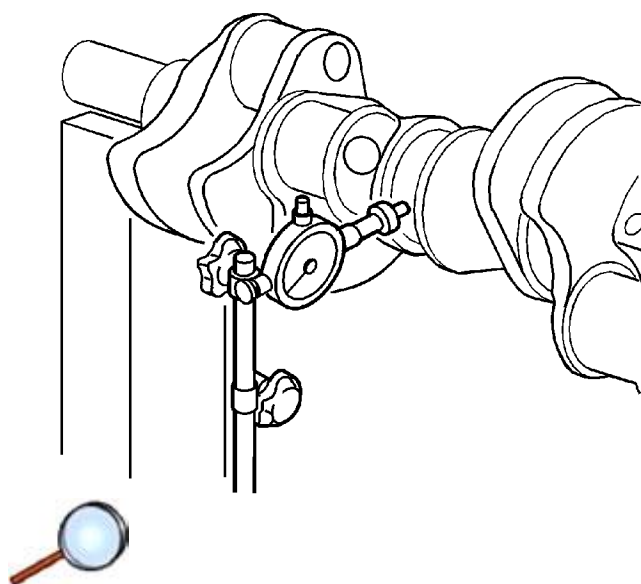
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Crankshaft and Bearing Cleaning and Inspection

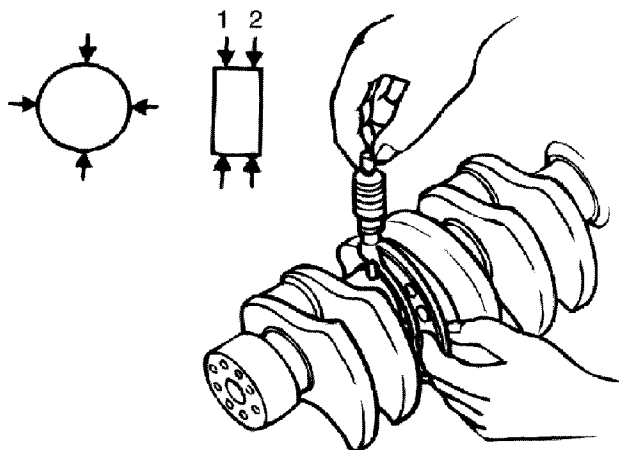
Special Tools

- J 7872 Dial Indicator Set
- J 45059 Angle Meter

For equivalent regional tools, refer to [Special Tools](#).



1. Clean the crankshaft and bearings.
2. Inspect the crankshaft for the following conditions.
 - Excessive wear or damage on the surface of the crankshaft journals.
 - Excessive wear or damage to the crankshaft gear.
 - Excessive wear or damage on the oil seal fitting surface.
 - Inspect the oil ports for obstructions.
 - Replace the crankshaft if there is excessive wear or damage to the journals, oil seal fitting surface or to the crankshaft gear.
3. Measure the crankshaft run out.
 - 3.1. Mount the crankshaft in wooden V-blocks.
 - 3.2. Set J 7872 set on the center of the crankshaft journal.
 - 3.3. Turn the crankshaft in the normal direction of rotation.
 - 3.4. Record readings. The production value is 0.05 mm (0.0020 in) and the service limit is 0.44 mm (0.0173 in).



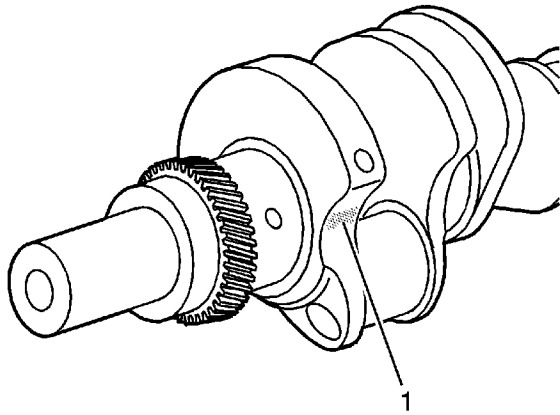
4. Measure the crankshaft journal diameter across four points.
 - The crankshaft journal outside diameter is 79.905-79.925 mm (3.1459-3.1466 in) and the service limit is 79.89 mm (3.1453 in).
 - Replace the crankshaft if the measured value is less than the service limit.
5. Measure the crankpin outside diameter across four points.
 - The crankpin outside diameter is 62.902-62.922 mm (2.4765-2.4772 in) and the service limit is 62.88 mm (2.4756 in).
 - Replace the crankshaft if the measured value is less than the service limit.

Crankshaft Bearing Selection

There are two methods for selecting the proper size crankshaft bearings. The first one is to select the bearing grade (color code) based on the cylinder block grade and the crankshaft journal grade from the Crankshaft Bearing Grade chart. The second is the plastic gauge method.

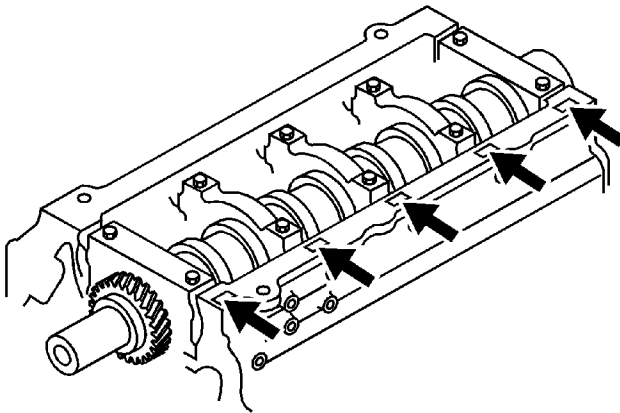
Crankshaft Bearing Selection Grade Chart Method

Stamp ID	Main Journal	Conn. Rod Journal
No Stamp	STD	STD
M20 R20	0.020 in	0.020 in

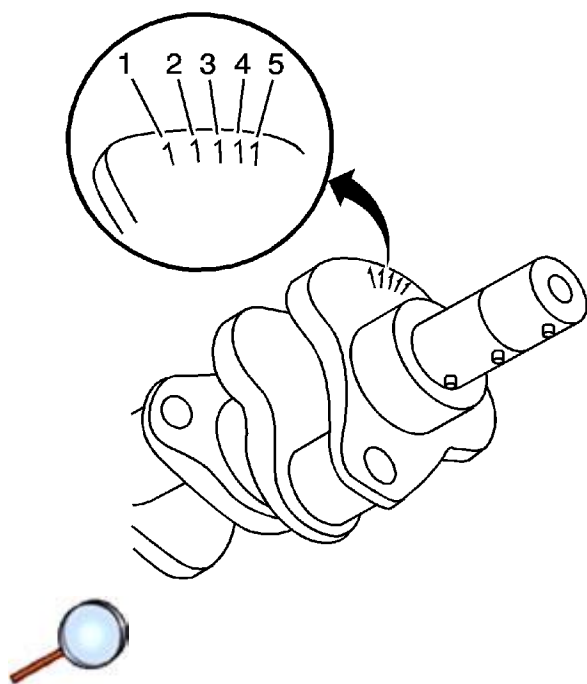


Note: All crankshafts that have been machined have a steel stamping (1) on the 1st counterweight.

1. Inspect the crankshaft for stamping (1) indicating undersized main and/or rod journals.



2. The cylinder block grade is indicated on the right lower portion of the cylinder block.



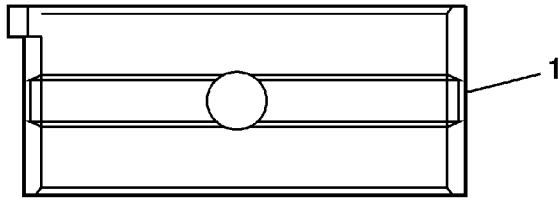
3. The crankshaft journal grade is indicated on the number 1 crankshaft counterweight.
4. Match the cylinder block grade and the crankshaft journal grade, refer to [Crankshaft Bearing Selection Specifications](#).
5. From the Crankshaft Bearing Grade chart, determine which bearing grade (color code) is required.
6. Verify the crankshaft bearing clearance using the plastic gage method.

Crankshaft Bearing Selection Plastic Gage Method

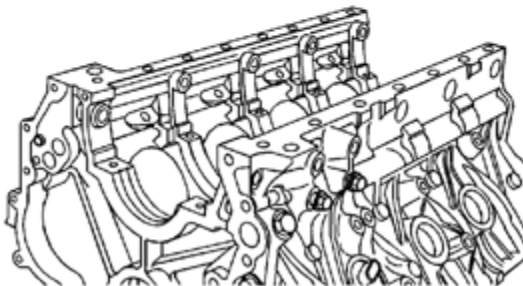
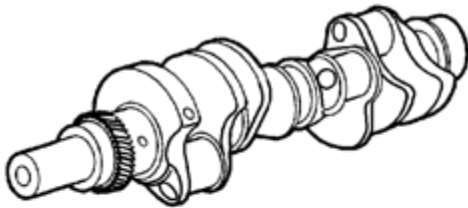
Special Tools

J 45059 Angle Meter

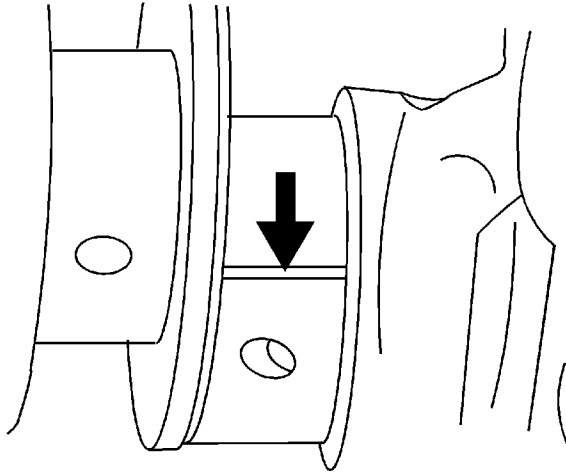
For equivalent regional tools, refer to [Special Tools](#).



1. Clean the cylinder block bearing fitting surfaces.
2. Clean the crankshaft and upper bearings (1) and lower bearings (2).
3. Install the bearings into the cylinder block and the bearing caps.

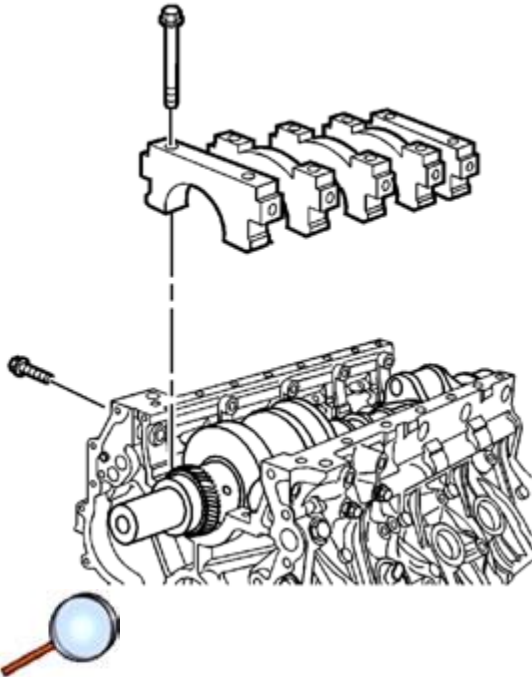


4. Install the crankshaft into the cylinder block.
5. Rotate the crankshaft approximately 30 degrees to seat the bearings.



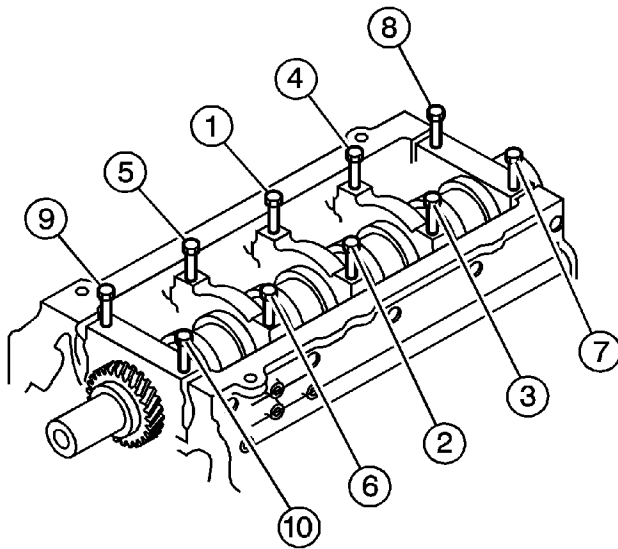
Note: Do not allow the crankshaft to rotate at any time during bearing cap installation and tightening or the plastic gauge measurement will be inaccurate.

6. Place the plastic gage over the crankshaft journal across the full width of the bearing.

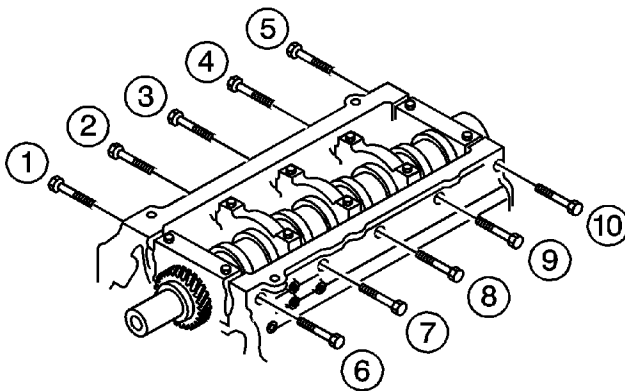


7. Install the crankshaft bearing caps.

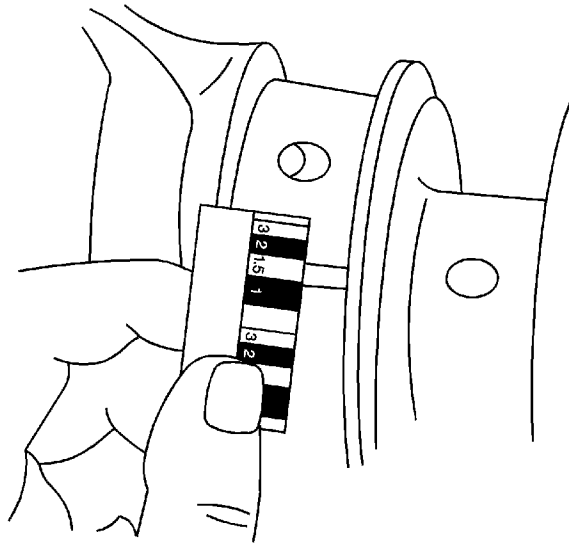
Caution: Refer to [Fastener Caution](#) in the Preface section.



8. Install the crankshaft bearing cap bolts.
9. Tighten the crankshaft bearing cap bolts in the proper sequence.
 - 9.1. 1st step **98 N·m (72 lb ft)**.
 - 9.2. 2nd step **132 N·m (97 lb ft)**.
 - 9.3. 3rd step **30 degrees** using J 45059 meter .

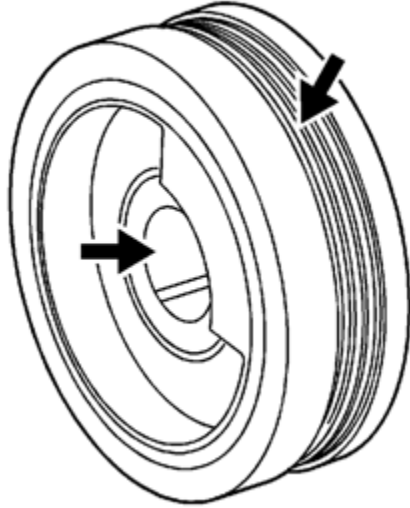


10. Install the crankshaft bearing cap side bolts. Tighten the crankshaft bearing cap side bolts in the proper sequence to **70 N·m (52 lb ft)**.
11. Remove the crankshaft bearing cap bolts.
12. Remove the crankshaft bearing caps.



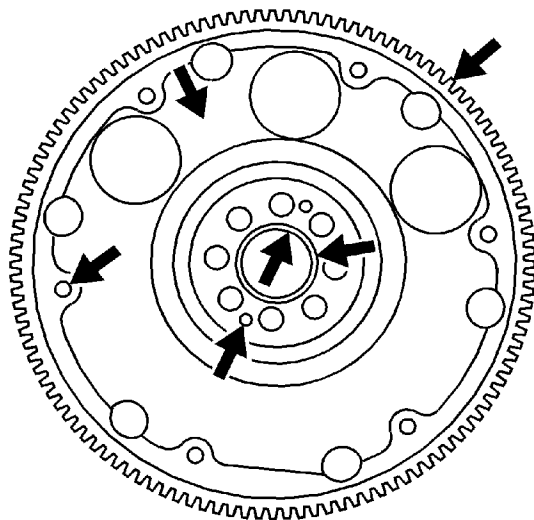
13. Compare the width of the plastic gauge with the scale printed on the plastic gauge container.
14. Select the crankshaft bearing grade that provides the proper oil clearances. The production specification for crankshaft bearing clearance is 0.039-0.070 mm (0.0015-0.0028 in) and the service limit is 0.014 mm (0.0055 in).

Crankshaft Balancer Cleaning and Inspection



1. Clean the crankshaft balancer.
2. Inspect the crankshaft balancer for damage to belt drive surface and to crankshaft balancer hub.
3. Inspect the balancer hub groove for damage or wear.
4. Replace the crankshaft balancer if any concerns exist.

Engine Flywheel Cleaning and Inspection



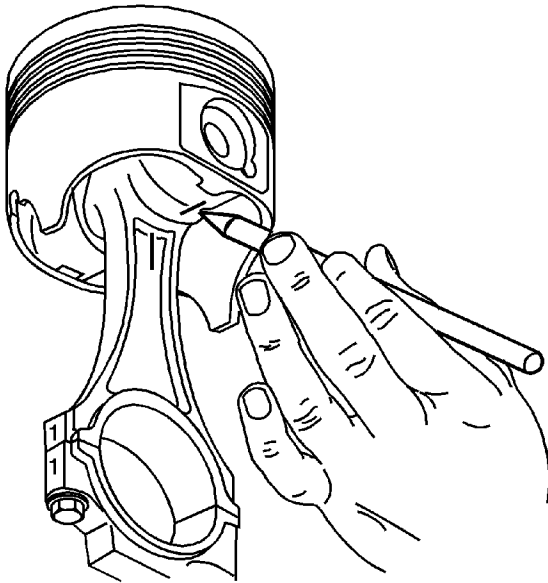
Important: In order to maintain the proper component balance, contact surface taper, and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the flywheel assembly.
2. Inspect the flywheel assembly for cracks or excessive wear on the teeth.
3. Replace the flywheel assembly if any concerns exist.

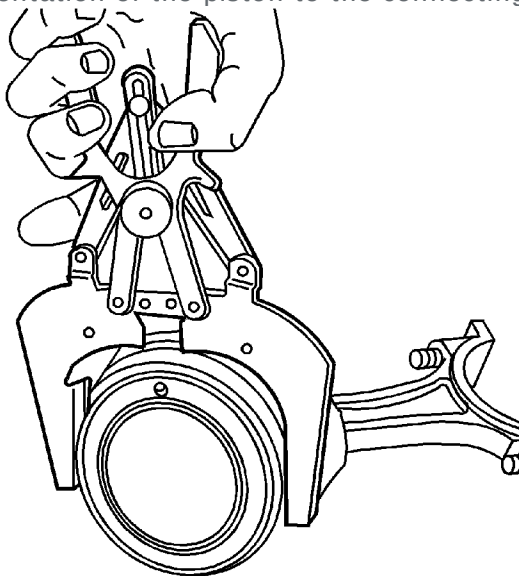
Piston and Connecting Rod Disassemble

Tools Required

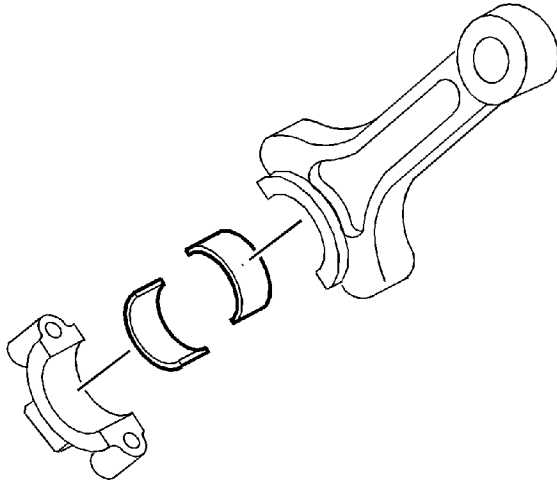
[J 43654](#) Piston Pin Retainer Remover/Installer



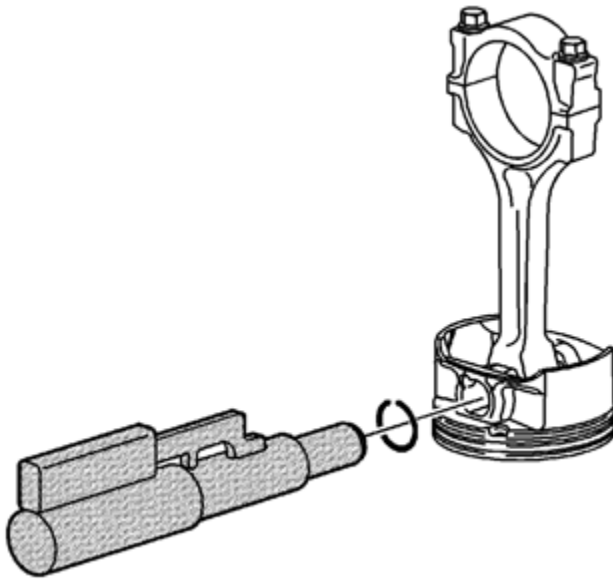
1. Mark orientation of the piston to the connecting rod.



2. Remove the piston rings using a piston ring expander.

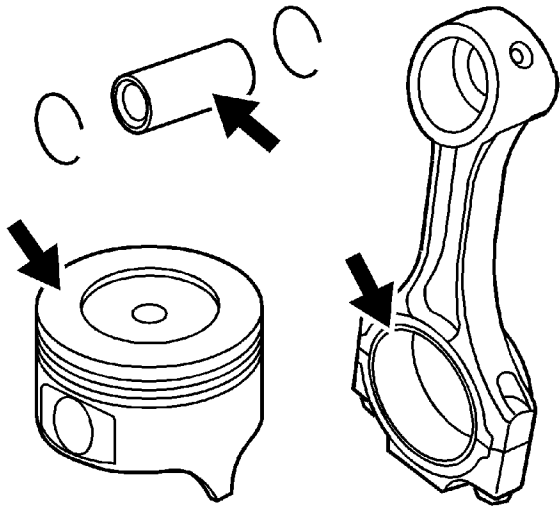


3. Remove the connecting rod bearing inserts.



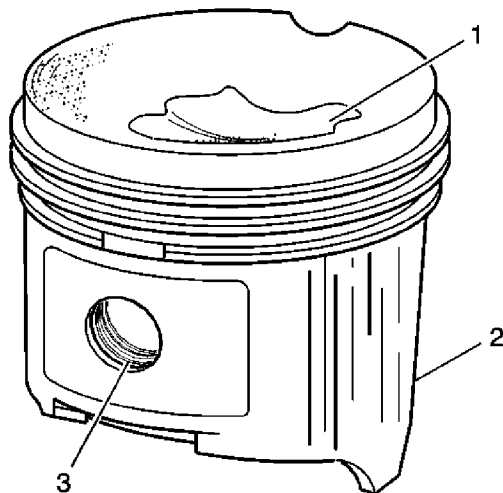
4. Use [J 43654](#) to remove the piston pin retainers.
5. Remove the piston pin. The pin is a full-floating style and should slide from the piston.
6. Remove the piston from the connecting rod.

Piston, Connecting Rod, and Bearing Cleaning and Inspection



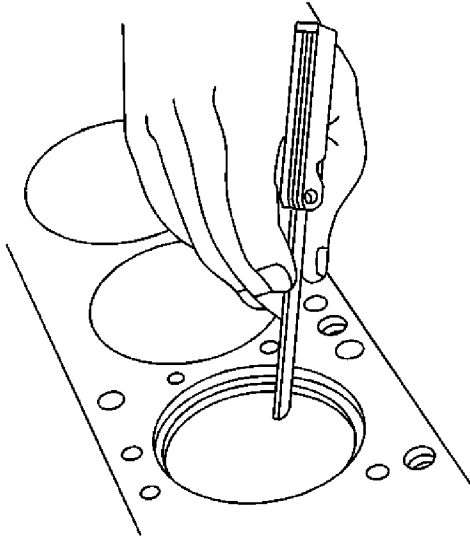
1. Clean the deposits from the following components:

- Connecting rod and bearings
- Piston
- Piston pin



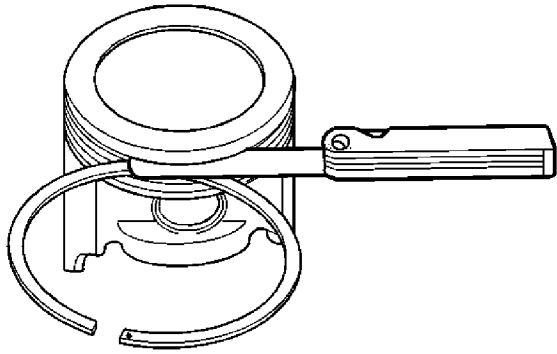
2. Inspect the piston for the following conditions:

- Scoring on the piston skirt (2)
- Scoring in the piston pin area (3)
- Cracks (1)
- Broken ring groove lands

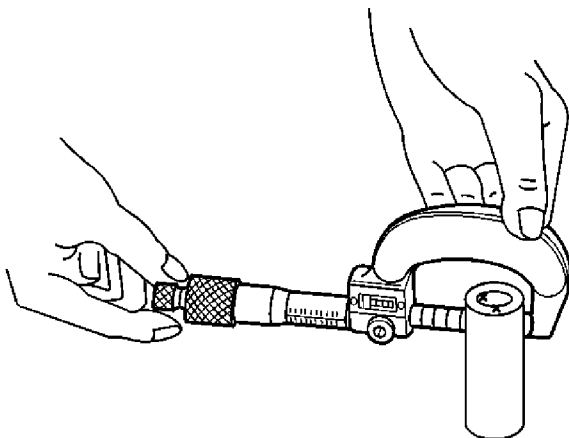


3. Measure the piston ring end gap.

- Use a piston to square the piston ring near the top of the cylinder.
- Use a feeler gauge to measure the piston ring gap.
- The 1st compression ring production gap is 0.30-0.45 mm (0.0118-0.0177 in) and the service limit is 1.37 mm (0.0539 in).
- The 2nd compression ring production gap is 0.50-0.65 mm (0.0197-0.0256 in) and the service limit is 1.35 mm (0.0531 in).
- The oil ring production gap is 0.15-0.35 mm (0.0059-0.0138 in) and the service limit is 1.20 mm (0.0472 in).
- Replace the piston ring if the measured value exceeds the service limit.

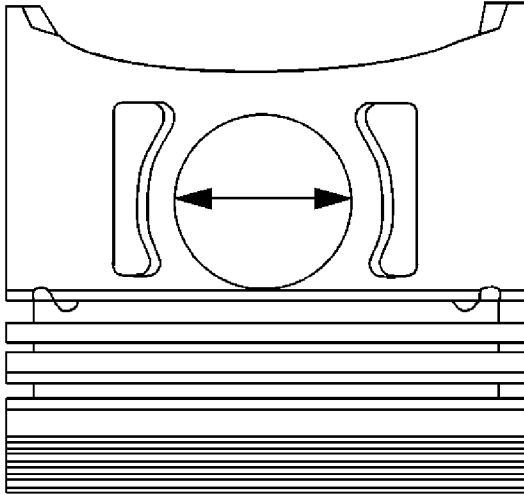


4. Measure the piston ring to piston ring groove clearance.
- Use a feeler gauge to measure the clearance between the piston ring and the piston ring groove at several points around the piston.
 - The 1st compression ring production clearance is 0.08-0.17 mm (0.0030-0.0007 in) and the service limit is 0.26 mm (0.0102 in).
 - The 2nd compression ring production clearance is 0.01-0.03 mm (0.0004-0.0012 in) and the service limit is 0.10 mm (0.0039 in).
 - The oil ring production clearance is 0.01-0.03 mm (0.0004-0.0012 in) and the service limit is 0.12 mm (0.0047 in).
 - Replace the piston ring if the measured value exceeds the service limit.



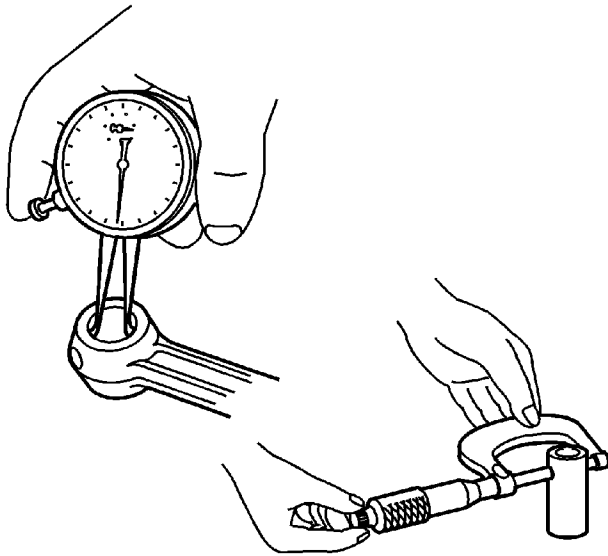
5. Measure the piston pin outside diameter.

- Measure the piston pin outside diameter at several points.
- The production value is 34.495-34.50 mm (1.3581-1.3563 in) and the service limit is 34.450 mm (1.3563 in).
- Replace the piston pin if the measured value is less than the service limit.



6. Measure the piston pin to piston pin bore clearance.

- Measure the piston pin bore.
- Subtract the piston pin measurement that was taken previously from the piston pin bore measurement. The difference between these two measurements will be the piston pin to piston pin bore clearance.
- The production clearance is 0.004-0.017 mm (0.0002-0.0007 in) and the service limit is 0.017 mm (0.0007 in).
- If the piston pin to piston pin bore clearance is beyond specifications then replace the piston.

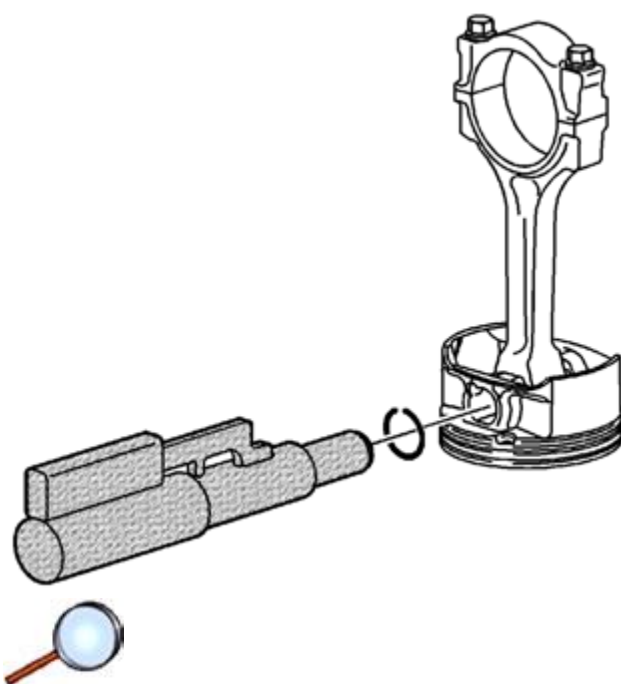


7. Measure the piston pin to connecting rod small end clearance.
 - Measure the inside diameter of the connecting rod small end.
 - Subtract the piston pin measurement that was taken previously from the connecting rod small end measurement. The difference between these two measurements will be the piston pin to connecting rod clearance.
 - The production clearance is 0.012-0.027 mm (0.0005-0.0011 in) and the service limit is 0.08 mm (0.0031 in).
 - Replace the connecting rod if the piston pin to connecting rod small end clearance is beyond specifications. The connecting rod small end bushing is not serviceable.

Piston and Connecting Rod Assemble

Tools Required

[J 43654](#) Piston Pin Retainer Remover/Installer

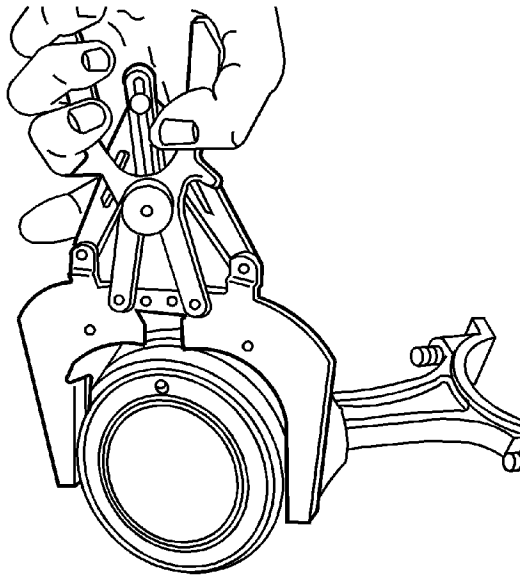


1. Apply engine oil to the connecting rod small end bushing and to the piston pin bore of the piston.
2. Install the piston pin into the piston and connecting rod.

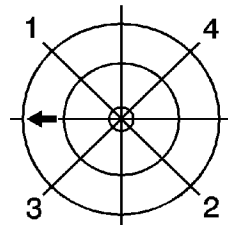
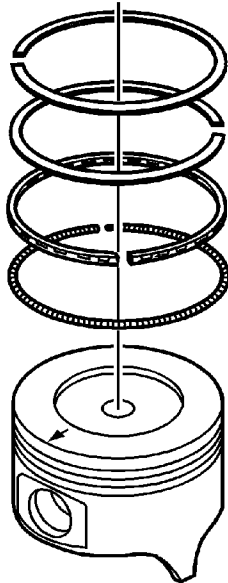
Important:

- For the right bank piston and connecting rod assemblies, reassemble so the grade mark on the connecting rod faces the right side of the engine and the piston front mark faces the front of the engine.
- For the left bank piston and connecting rod assemblies, reassemble so the grade mark on the connecting rod faces the left side of the engine and the piston front mark faces the front of the engine.

3. Install the piston pin retaining rings.



4. Apply engine oil to the piston ring grooves.
5. Install the piston rings using a piston ring expander.



Important: The 2N mark on the 2nd compression ring must face upwards. The piston has a groove between the 1st and the 2nd compression rings to allow for expansion of blowby gases. No ring is to be installed in this groove.

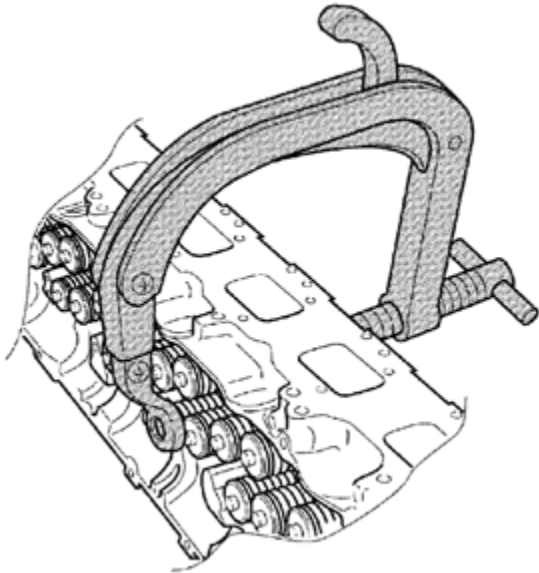
6. Orientate the piston ring end gaps as illustrated.

Cylinder Head Disassemble

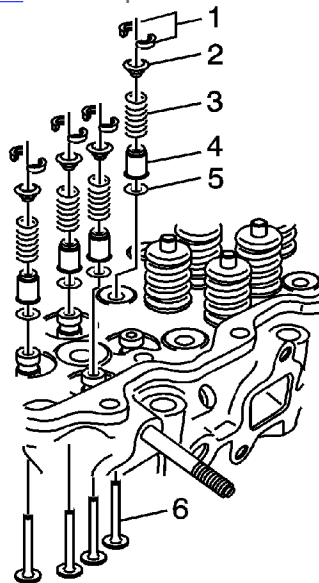
Tools Required

[J 8062](#) Valve Spring Compressor

[J 38820](#) Valve Stem Oil Seal Remover



1. Use the [J 8062](#) to compress the valve spring.



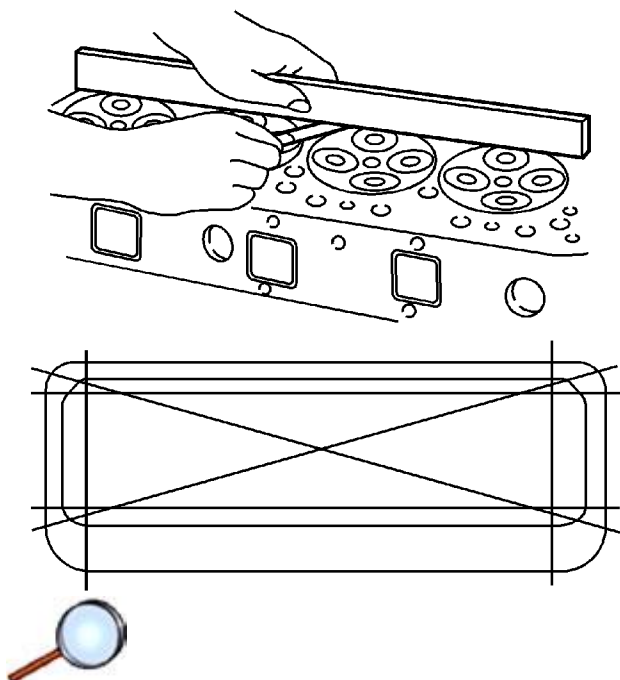
2. Remove the valve keys (1).
3. Remove the [J 8062](#) from the cylinder head.
4. Remove the valve spring upper seat (2).
5. Remove the valve spring (3).
6. Remove the valve (6).
7. Remove the valve stem seal (4) using [J 38820](#) .
8. Remove the valve spring lower seat (5).

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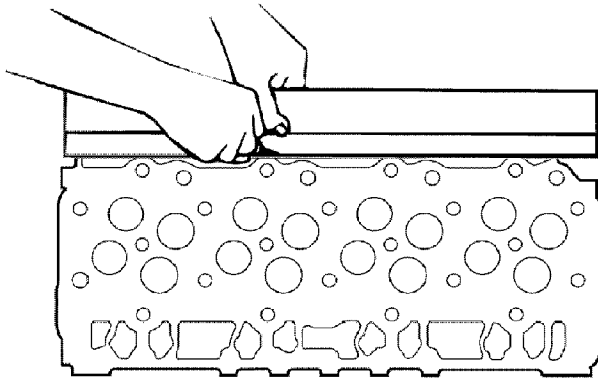
Cylinder Head Cleaning and Inspection

Tools Required

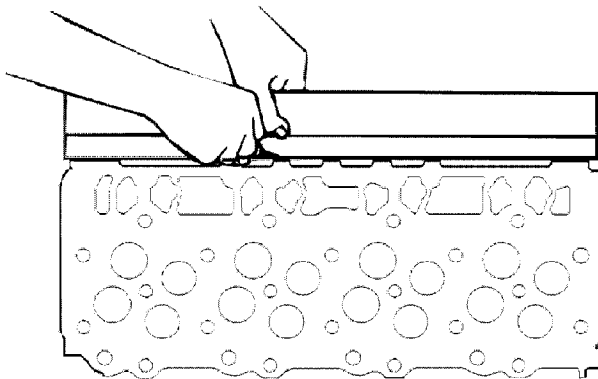
- [J 9666](#) Valve Spring Tester
- [EN-47909](#) Injector Bore and Sleeve Cleaning Kit



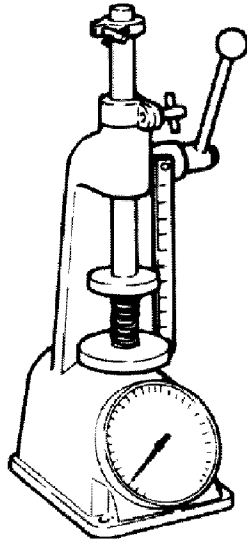
1. Clean the cylinder head of all foreign material. Do not use a motorized wire brush on any gasket sealing surface.
2. Clean the threaded holes.
3. Clean the injector bores using [EN-47909](#).
4. Inspect the cylinder head for the following:
 - Damage to the gasket surfaces
 - Damage to the threaded bolt holes
 - Cracks in the exhaust ports
 - External cracks in the water chamber
 - Cracks between the valve seats
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged or leaking core plugs
5. Measure the cylinder head for warpage with a straight edge and a feeler gauge. A cylinder head block deck with warpage in excess of 0.075 mm (0.0030 in) within a 516.5 mm (20.33 in) area must be replaced.



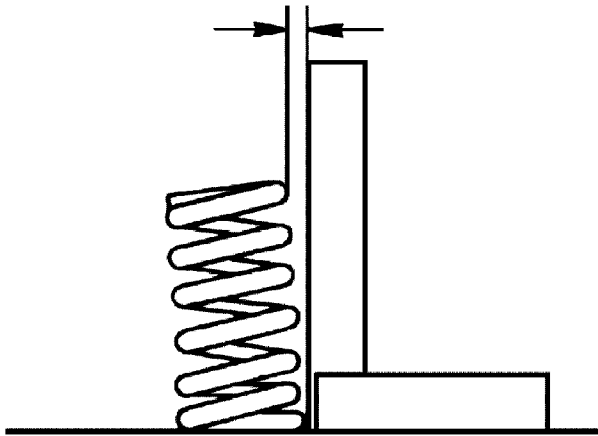
6. Measure the cylinder head exhaust manifold deck for warpage. A cylinder head exhaust manifold deck with warpage in excess of 0.1 mm (0.0039 in) within a 453 mm (17.83 in) area must be replaced.



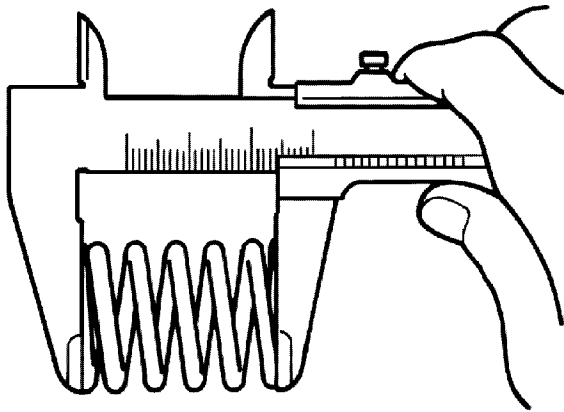
7. Measure the cylinder head intake manifold deck for warpage. A cylinder head intake manifold deck with warpage in excess of 0.3 mm (0.011 in) within a 493 mm (19.41 in) area must be replaced.



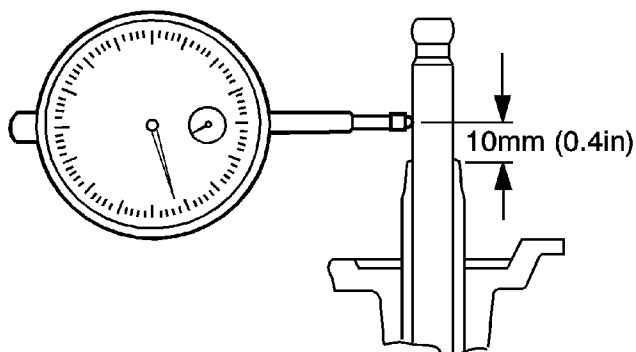
8. Measure the valve spring tension using [J 9666](#) . Replace the valve spring if the valve spring tension is less than 275 N (61.8 lb) at 41 mm (1.6142 in)



9. Measure the valve spring for squareness. Replace the valve spring if squareness is beyond 2.0 mm (0.0787 in).

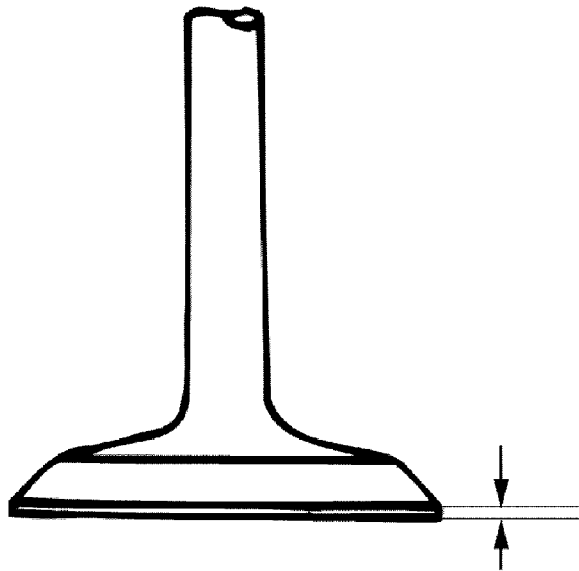


10. Measure the valve spring free length. The production free length is 56.6 mm (2.2283 in).
11. Measure the valve stem to guide clearance.
 - 11.1. Set a dial indicator to the valve stem measuring point.
 - 11.2. Move the valve stem from side to side while reading the total movement on the dial indicator. If the measured valve exceeds 0.20 mm (0.0079 in), replace the cylinder head.

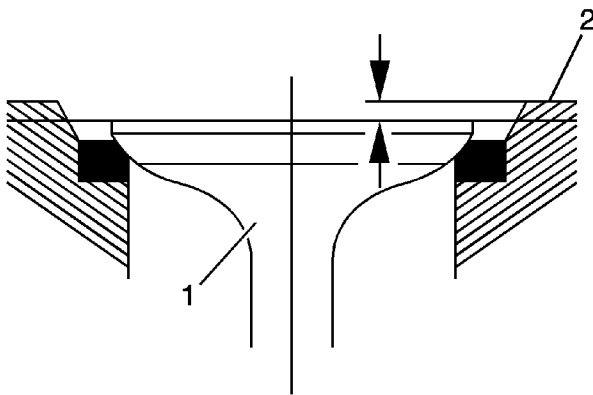


12. If the valve stem to guide clearance is over 0.25 mm (0.098 in) for the exhaust valve guides or 0.20 mm (0.0079 in) for the intake valve guides, the cylinder head must be replaced.
13. Inspect the valves for the following:
 - Bent valve stem
 - Scored valve stem

- Worn valve key grooves
- Pitted surfaces

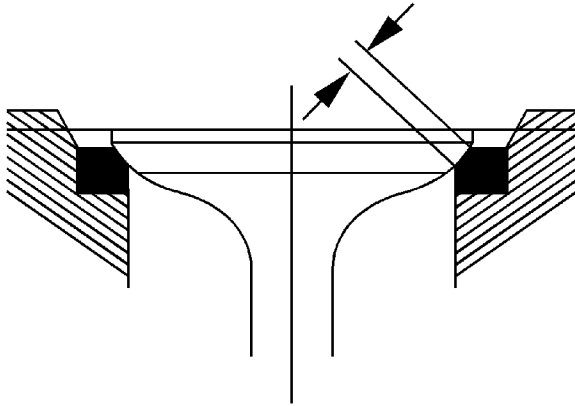


14. Measure the valve margin. The intake valve production margin is 1.2 mm (0.0472 in) and the service limit is 0.88 mm (0.0346 in). The exhaust valve production margin is 1.0 mm (0.0394 in) and the service limit is 0.73 mm (0.0287 in). Replace the valve if the valve margin is below the service limit.



15. Measure the valve depression.
- 15.1. Insert a new valve into the cylinder head (1).
 - 15.2. Use a depth gage or a straight edge to measure the valve depression from the cylinder head gasket surface (2). The intake valve depression is 0.6 mm (0.0236 in) and the service limit is 2.5 mm (0.0984 in). The exhaust valve depression is 0.9 mm

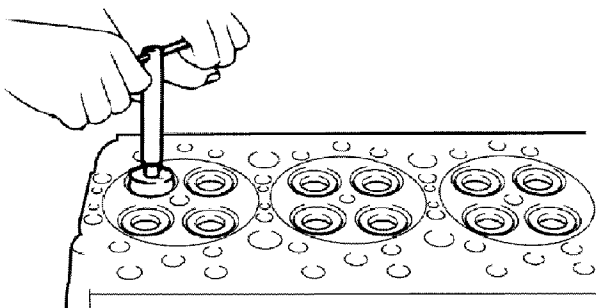
(0.0354 in) and the service limit is 2.0 mm (0.0787 in). Recondition the valve seat if the valve depression is above specifications.



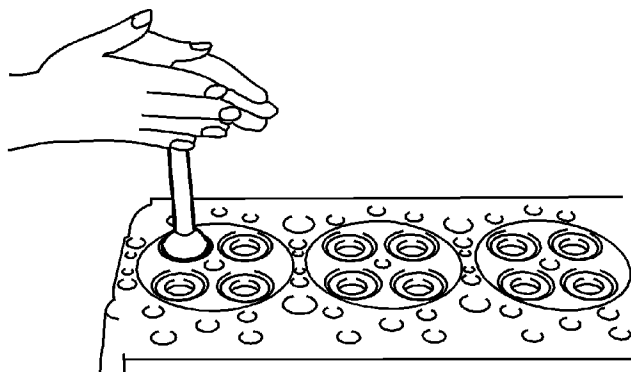
16. Measure the valve contact width.

- Inspect the valve contact area for roughness or unevenness.
- The intake valve contact width is 2.1 mm (0.0827 in) and the service limit is 2.5 mm (0.0984 in).
- The exhaust valve contact width is 2.1 mm (0.0827 in) and the service limit is 2.5 mm (0.0984 in).
- Recondition the valve seats to bring the contact width into specifications.

Valve and Seat Grinding



1. Remove the carbon from the valve guide and valve seat surface.
2. Resurface the valve face to 45 degrees. If valve margin falls below specifications after resurfacing then discard valve.
3. Use a suitable tool to bring the valve contact width to the standard value. The valve seat angle is 45 degrees.

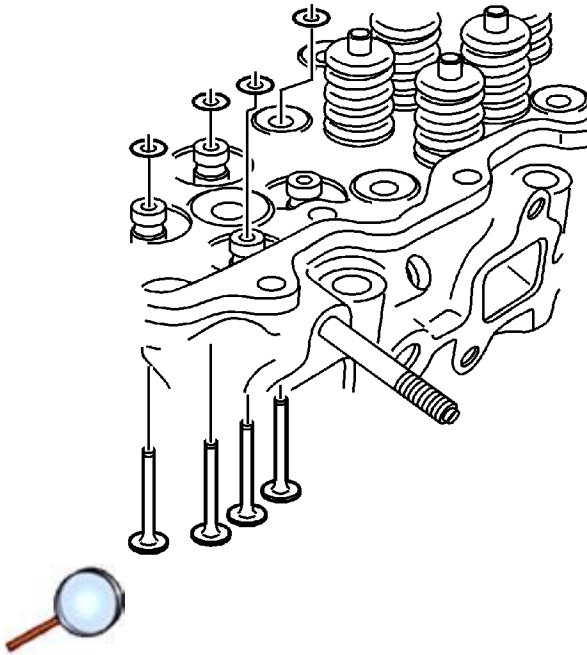


4. Apply valve lapping compound to the valve seat surface.
5. Insert the valve into the cylinder head.
6. Turn the valve back and forth in its seat to lap the valve face to the valve seat.

Cylinder Head Assemble

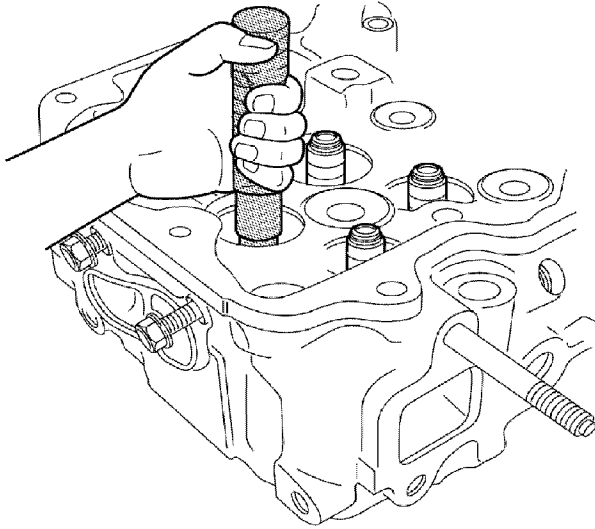
Tools Required

- [J 44640](#) Valve Stem Seal Installer
- [J 8062](#) Valve Spring Compressor

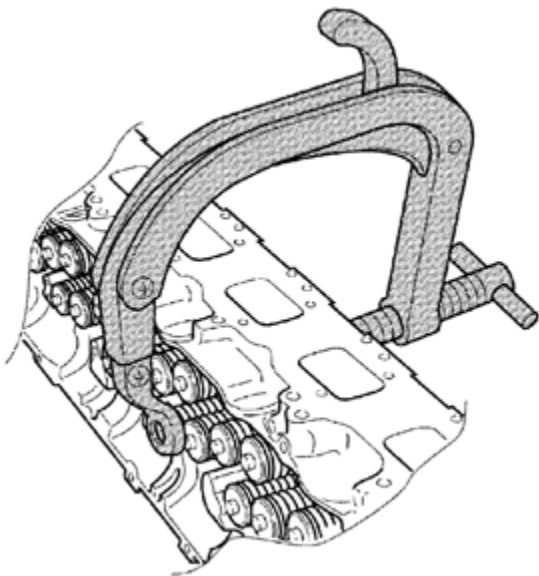


Important: Lubricate the valve stem with clean engine oil before installing.

1. Install the valves into the cylinder head.
2. Install the valve spring lower seat.

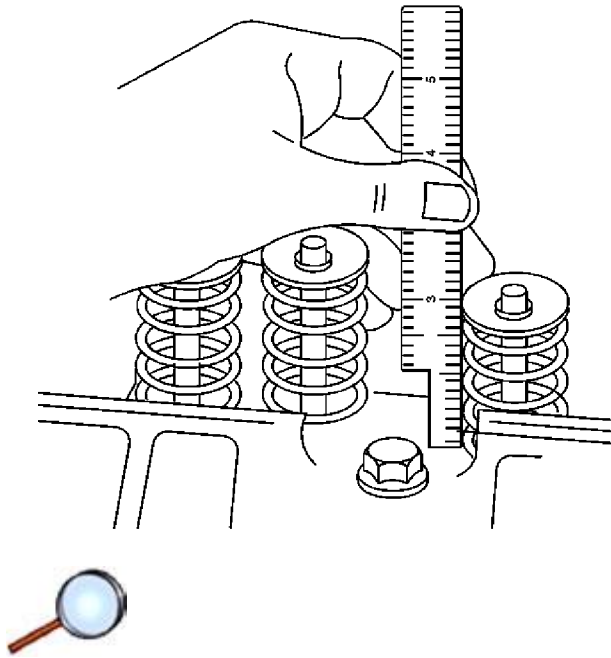


3. Install the valve stem seal using [J 44640](#) .
4. Install the valve spring with the painted end towards the cylinder head.
5. Install the valve spring upper seat.



6. Use the [J 8062](#) to compress the valve spring.
7. Install the valve keys.
8. Remove the [J 8062](#) from the cylinder head.

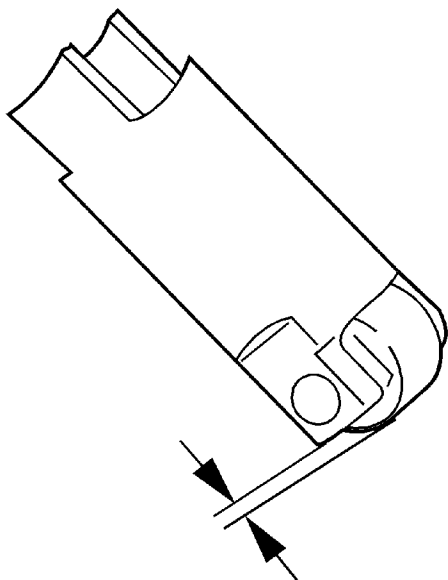
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9. Measure the valve installed height using a ruler. Measure from the base of the valve spring to the top of the valve. Refer to [Engine Mechanical Specifications](#).
10. Install the remaining valves, springs, and other components.

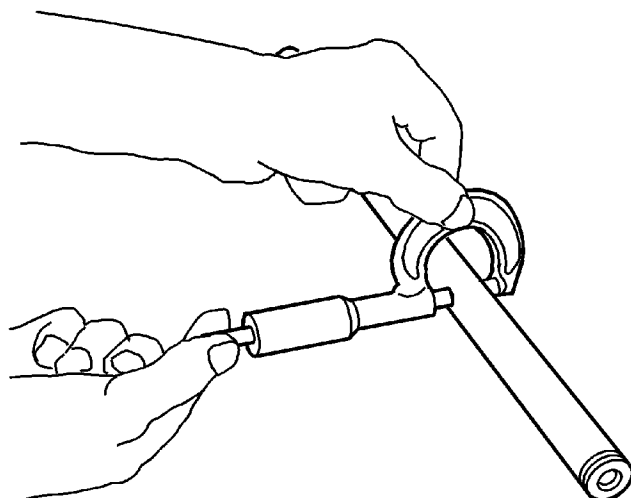
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Valve Lifters Cleaning and Inspection

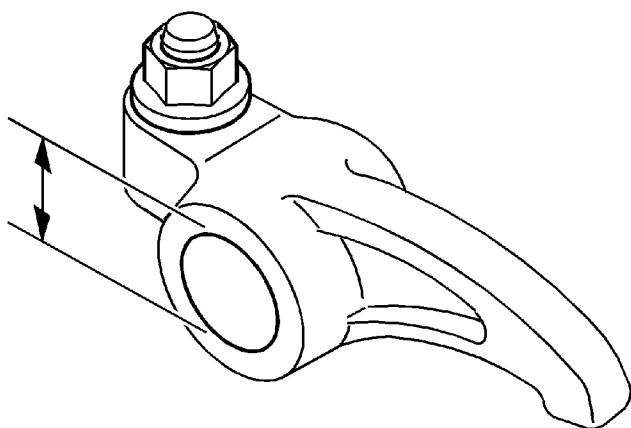


1. Push the roller towards the roller lifter body and measure the distance between the bottom of the roller and the roller lifter body. The production value is 0.989-1.0 mm (0.0389-0.0394 in) and the service limit is 0.9 mm (0.0354 in).
2. Replace the valve lifter if the measurement exceeds the service limit.
3. Inspect the valve lifters for the following:
 - The valve lifter body for scuffing and wear
 - The valve lifter roller assembly for wear
 - The valve lifter roller for smooth rotation

Valve Rocker Arm and Shaft Cleaning and Inspection

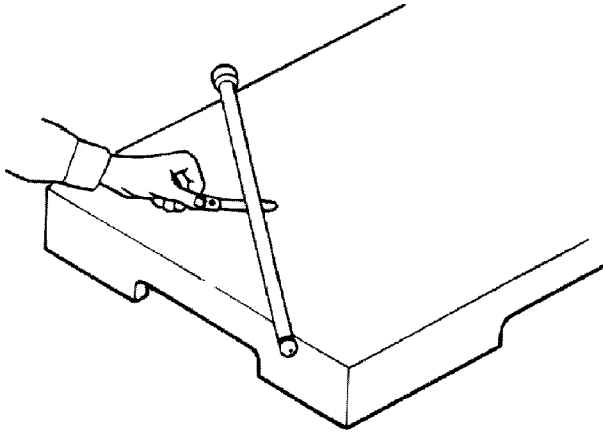


1. Measure the rocker arm shaft outside diameter where the rocker arm is located. The production value is 21.979-22.0 mm (0.8653-0.8661 in) and the service limit is 21.85 mm (0.8602 in).
2. Replace the rocker arm shaft if the measured value is less than the service limit.



3. Measure the rocker arm inside diameter. The production value is 22.01-22.035 mm (0.8665-0.8675 in).
4. Calculate the rocker arm shaft to rocker arm clearance.

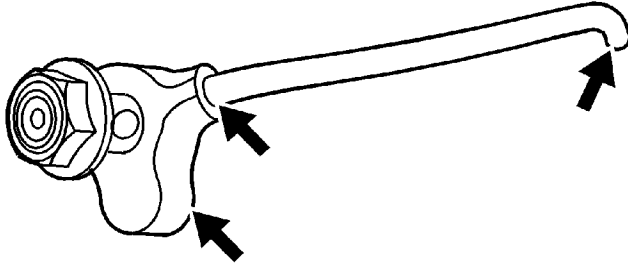
- 4.1. Subtract the rocker arm shaft outside diameter from the rocker arm inside diameter.
- 4.2. Replace the rocker arm if the rocker arm shaft to rocker arm clearance is over 0.2 mm (0.0079 in).
5. Inspect the valve lash adjusting screw and lock nut for damage. Replace the valve lash adjusting screw if any damage is found.



6. Measure the pushrods for warpage.
7. Replace the pushrod if the warpage exceeds 0.8 mm (0.031 in).

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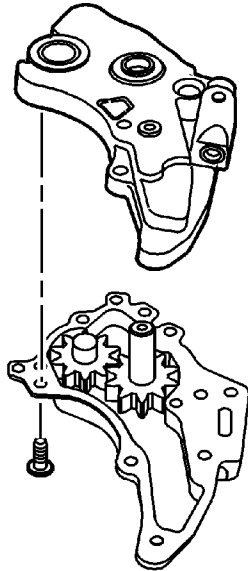
Piston Oil Cooling Nozzle Cleaning and Inspection



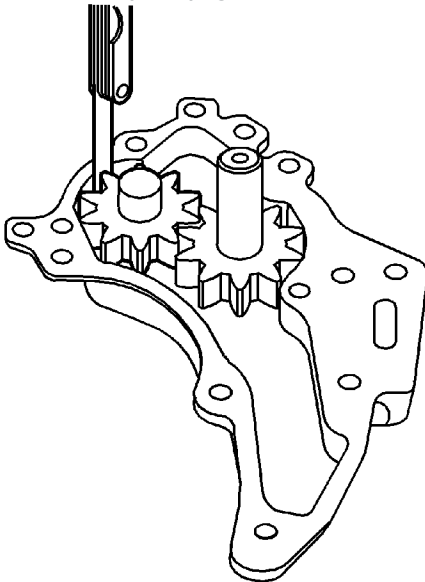
1. Inspect the piston oil cooling nozzle for damage.
2. Replace the piston oil cooling nozzle if any damage is found.

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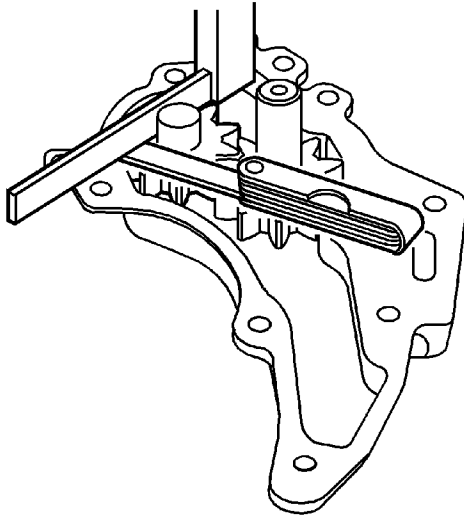
Oil Pump Cleaning and Inspection



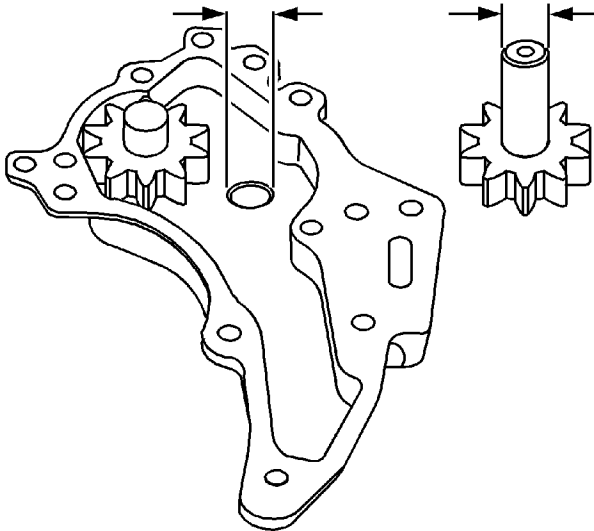
1. Remove the oil pump gear cover bolts.
2. Remove the oil pump gear cover.



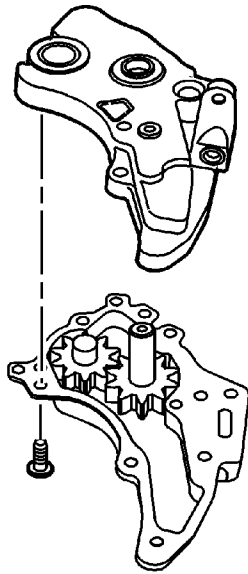
3. Use a feeler gauge to measure the clearance between the gear teeth and the oil pump housing. The production clearance is 0.125-0.221 mm (0.0049-0.0087 in) and the service limit is 0.221 mm (0.0087 in).
4. Replace the oil pump assembly if the clearance exceeds the service limit.



5. Use a feeler gauge and a straightedge to measure the clearance between the side of the gear and the cover. The production clearance is 0.064-0.109 mm (0.0025-0.0043 in) and the service limit is 0.109 mm (0.0043 in).
6. Replace the oil pump assembly if the clearance exceeds the service limit.



7. Calculate the driven gear shaft to bushing clearance.
 - 7.1. Measure the driven gear shaft outside diameter. The production specification is 19.947-19.960 mm (0.7853-0.7858 in) and the service limit is 19.86 mm (0.7819 in).
 - 7.2. Measure the driven gear bushing inside diameter. The production value is 20 mm (0.7874 in).
 - 7.3. Calculate the driven gear shaft to bushing clearance. The service limit is 0.14 mm (0.0055 in)
8. Replace the oil pump assembly if the clearance exceeds the service limit.



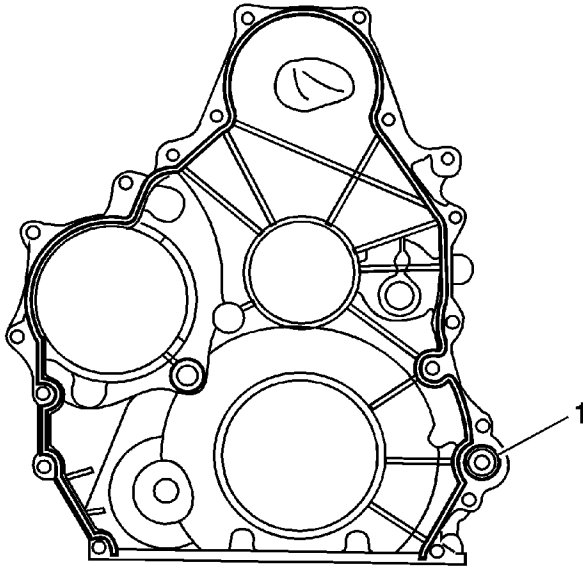
9. Install the oil pump gear cover to the oil pump assembly.

Caution: Refer to [Fastener Caution](#) in the Preface section.

10. Install the oil pump gear cover bolts and tighten to **21 N·m (15 lb ft)**.

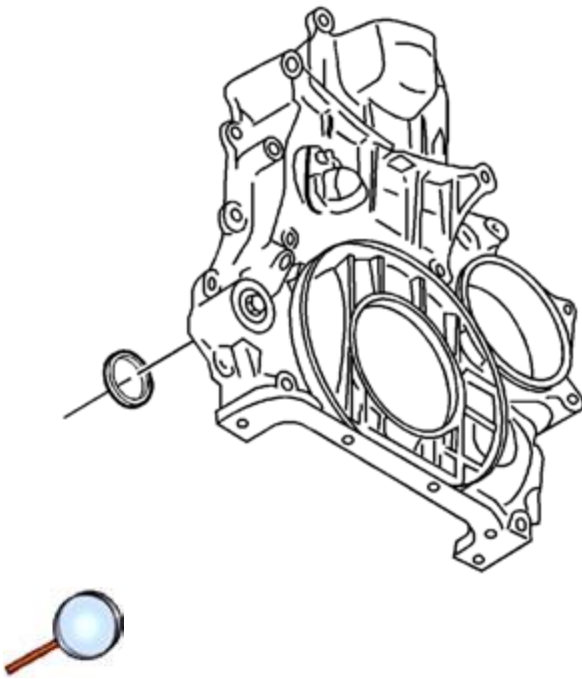
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Engine Front Cover Cleaning and Inspection



1. Remove the O-ring (1) from the engine front cover.
2. Remove the oil pressure relief valve from the engine front cover.
3. Clean the engine front cover.
4. Clean the engine front cover mating surfaces.
5. Inspect the engine front cover mating surfaces for damage.
6. Inspect the engine front cover O-ring sealing surface for damage.
7. Inspect the crankshaft front oil seal bore for damage.
8. Replace the engine front cover if any damage is found.

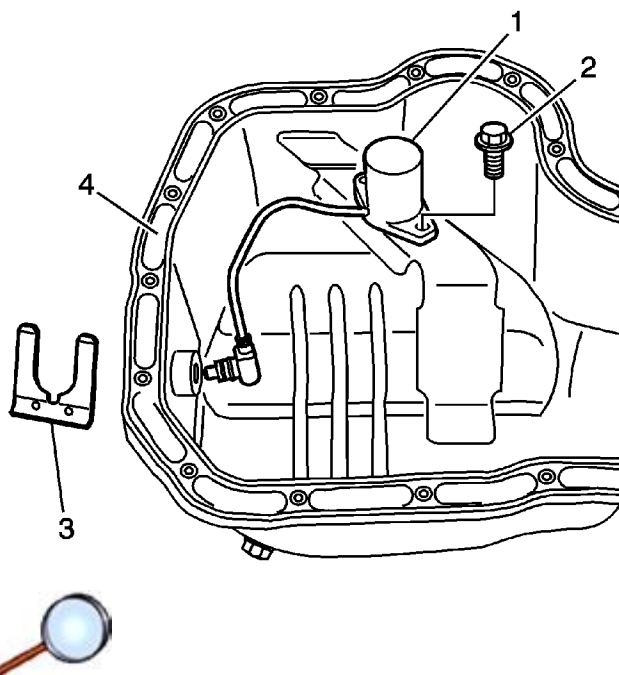
Caution: Refer to [Fastener Caution](#) in the Preface section.



9. Install the oil pressure relief valve with a new O-ring and tighten to **39 N·m (29 lb ft)**.

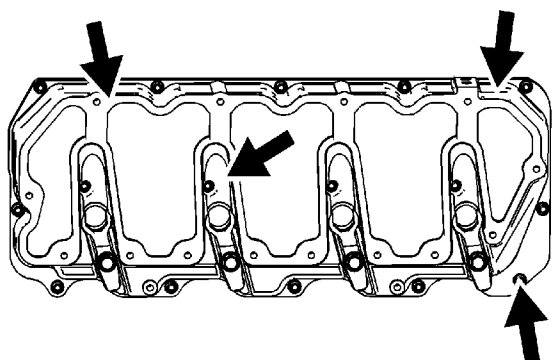
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Lower Oil Pan Cleaning and Inspection



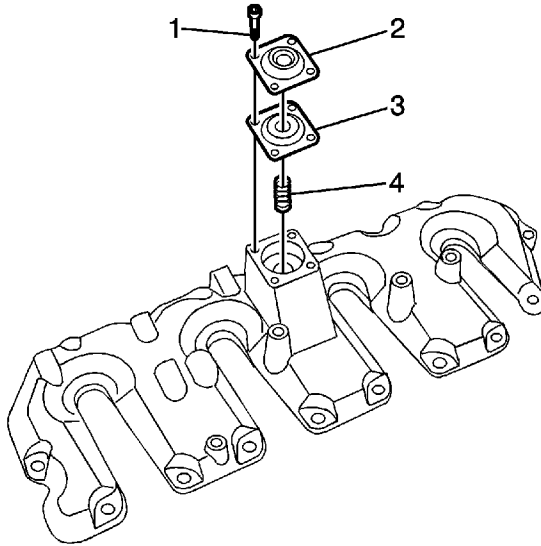
1. Remove the oil level sensor (1) and retaining clip (3).
2. Clean the lower oil pan (4). Remove any sludge or other deposits.
3. Clean the lower oil pan mating surface.
4. Inspect the lower oil pan (4) for dents or distortion.
5. Inspect the lower oil pan mating surface for damage.
6. Replace the lower oil pan (4) if any damage is found.
7. Install the oil level sensor (1) and retaining clip (3).

Valve Rocker Arm Cover Cleaning and Inspection - Lower

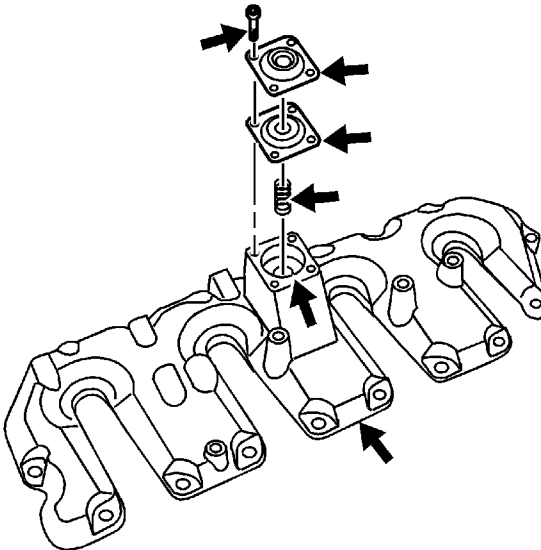


1. Remove the grommets.
2. Clean the lower valve rocker arm cover. Remove any sludge or other deposits.
3. Clean the lower valve rocker arm cover mating surfaces.
4. Inspect the lower valve rocker arm cover for cracks or other damage.
5. Inspect the lower valve rocker arm cover mating surfaces for damage.
6. Replace the lower valve rocker arm cover if any damage is found.
7. Inspect the grommets for damage.
8. Replace the grommets if any damage is found.
9. Install the grommets.

Valve Rocker Arm Cover Cleaning and Inspection - Upper

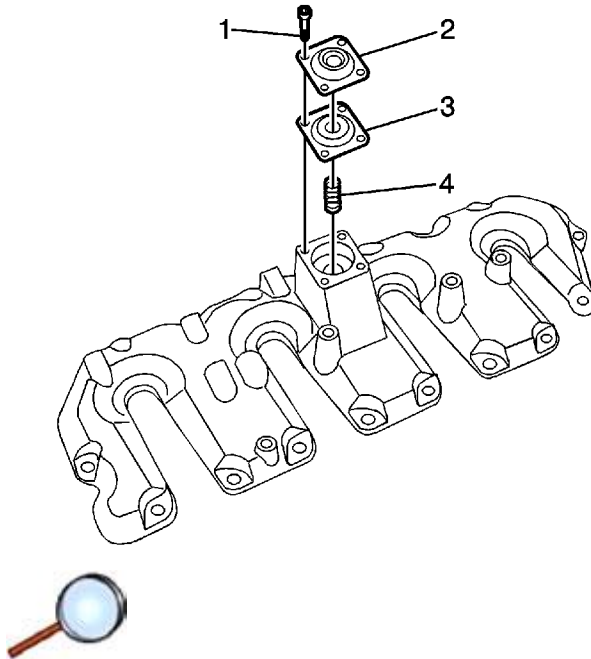


1. Remove the PCV cover screws (1).
2. Remove the PCV cover (2), diaphragm (3), and spring (4).



3. Clean the upper valve rocker arm cover. Remove any sludge or other deposits.
4. Clean the upper valve rocker arm cover mating surface.
5. Inspect the upper valve rocker arm cover for cracks or other damage.
6. Inspect the upper val age.

7. Replace the upper valve rocker arm cover if any damage is found.

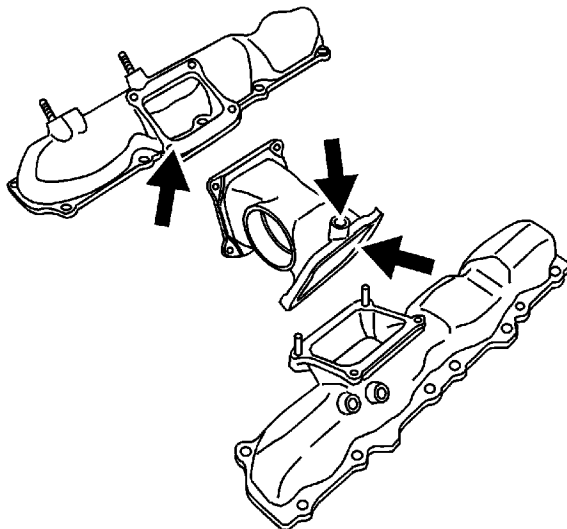


8. Inspect the PCV cover (2), diaphragm (3), and spring (4) for damage.
9. Install the PCV spring.
10. Install the PCV diaphragm.
11. Install the PCV cover.

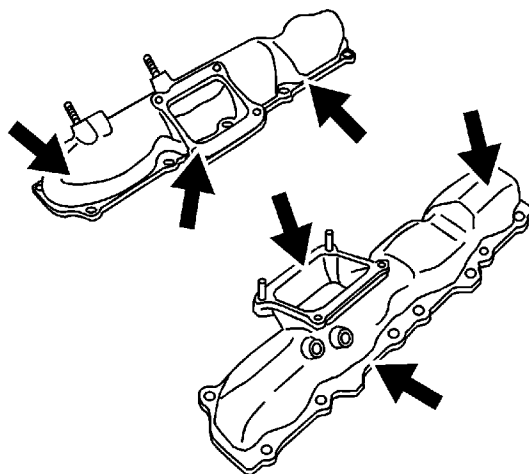
Caution: Refer to [Fastener Caution](#) in the Preface section.

12. Install the PCV cover screws (1) and tighten to **4 N·m (35 lb in)**.

Intake Manifold Cleaning and Inspection

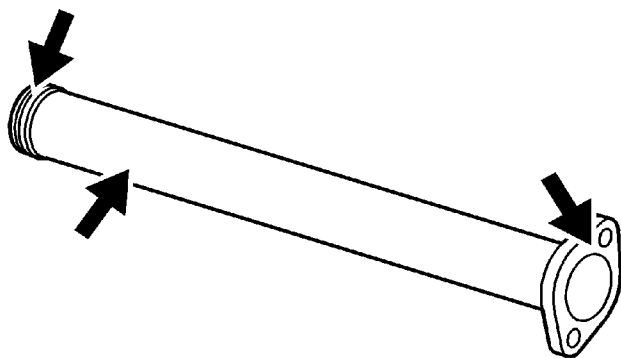


1. Clean the intake manifold crossover.
2. Clean the intake manifold mating surfaces.

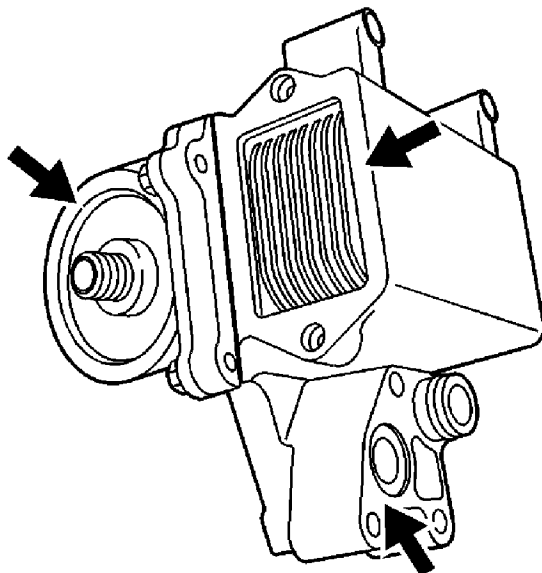


3. Clean the intake manifolds.
4. Clean the intake manifold mating surfaces.
5. Inspect the intake manifolds for cracks.
6. Inspect the intake manifold mating surfaces for damage.
7. Replace the intake manifolds if any damage is found.

Oil Filter Adapter and Oil Cooler Assembly Cleaning and Inspection

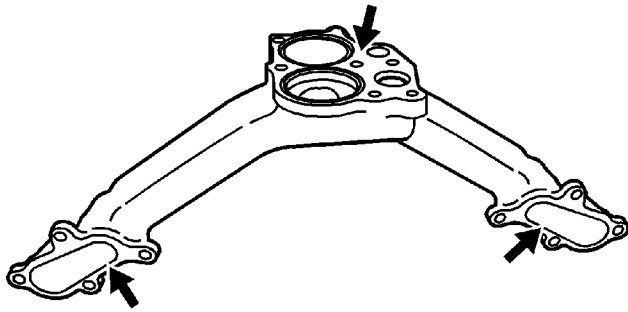


1. Clean the coolant tube.
2. Inspect the coolant tube for cracks.
3. Inspect the coolant tube mating surfaces for damage.



4. Clean the oil filter adapter.
5. Inspect the oil filter adapter mating surfaces for damage.
6. Replace the O-rings.

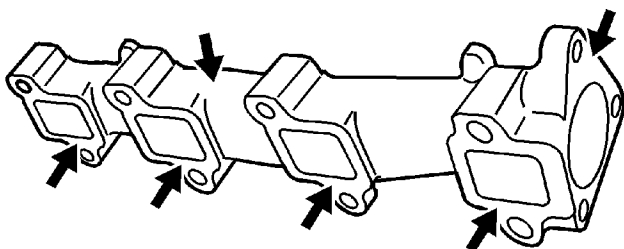
Engine Coolant Thermostat Housing Cleaning and Inspection



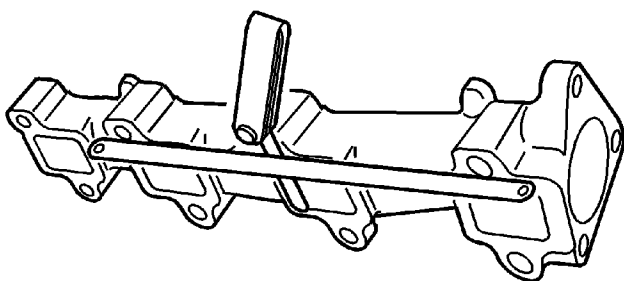
1. Clean the thermostat housing.
2. Clean the thermostat housing mating surfaces.
3. Inspect the thermostat housing for cracks.
4. Inspect the thermostat housing mating surfaces for damage.
5. Replace the thermostat housing if any damage is found.

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Exhaust Manifold Cleaning and Inspection



1. Clean the exhaust manifold.
2. Clean the exhaust manifold mating surfaces.
3. Inspect the exhaust manifold for cracks.
4. Inspect the exhaust manifold mating surfaces for damage.
5. Replace the exhaust manifold if any damage is found.



6. Measure the exhaust manifold flange for warpage with feeler gauge and a straightedge. Replace the exhaust manifold if the warpage is more than 0.3 mm (0.0118 in).
7. Install the exhaust manifold heat shield.

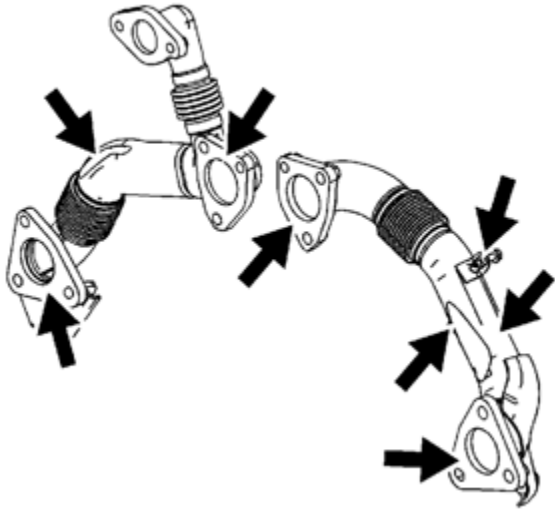
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Caution: Refer to [Fastener Caution](#) in the Preface section.

8. Install the exhaust manifold heat shield bolts and tighten to **8 N·m (71 lb in)**.

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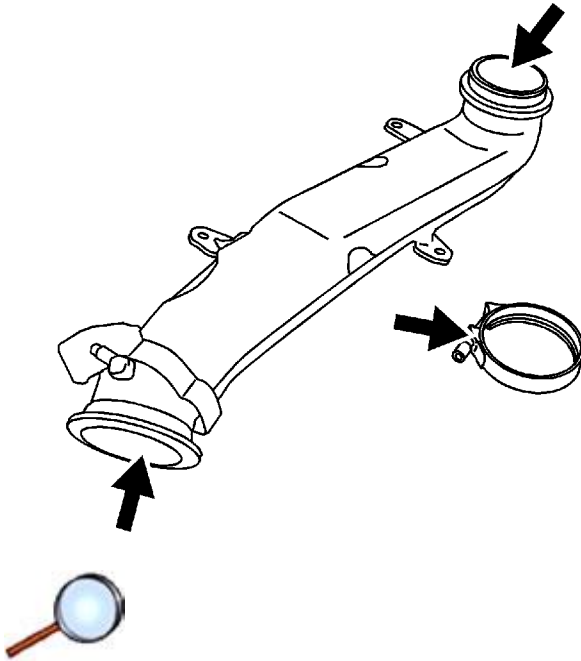
Exhaust Pipe Cleaning and Inspection



1. Clean the exhaust pipe.
2. Clean the exhaust pipe mating surfaces.
3. Inspect the exhaust pipe for dents or cracks.
4. Replace the exhaust pipe if any damage is found.

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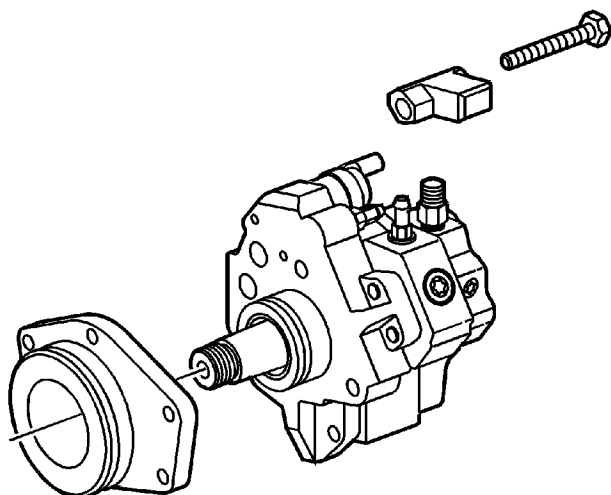
Exhaust Outlet Cleaning and Inspection



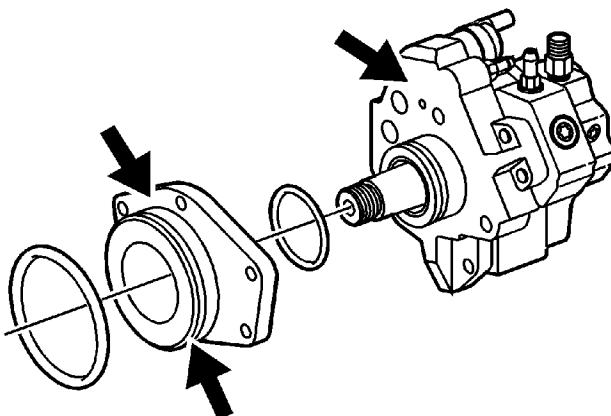
1. Clean the exhaust outlet.
2. Clean the exhaust outlet mating surfaces.
3. Inspect the exhaust outlet for dents or cracks.
4. Replace the exhaust outlet if any damage is found.

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Fuel Injection Pump Cleaning and Inspection



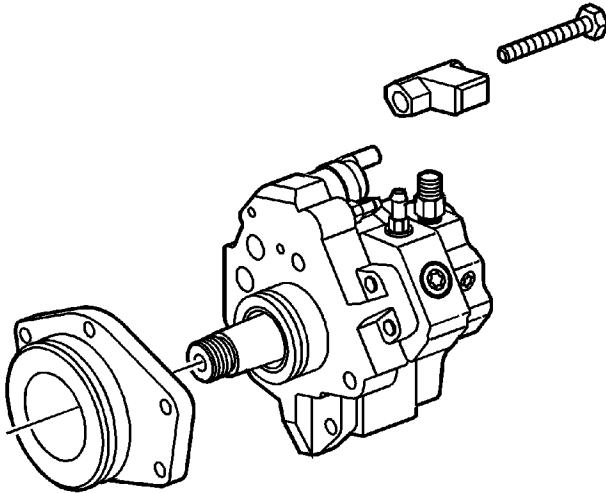
1. Remove the fuel injection pump adapter bolts.
2. Remove the fuel injection pump adapter.



3. Remove the O-ring from the fuel injection pump and discard.
4. Remove the O-ring from the fuel injection pump adapter and discard.
5. Clean the fuel injection pump adapter mating surfaces.
6. Clean the fuel injection pump mating surfaces.
7. Inspect the fuel injection pump and adapter for damage.
8. Replace component if any damage is found.

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9. Install a new O-ring onto fuel injection pump.
10. Install a new O-ring onto fuel injection pump adapter.
11. Lubricate the O-rings with engine oil.

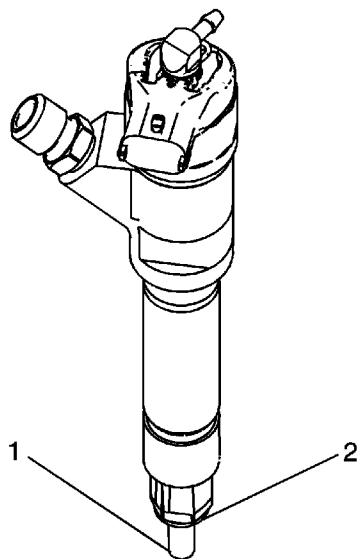


12. Install the fuel injection pump adapter to the fuel injection pump.

Caution: Refer to [Fastener Caution](#) in the Preface section.

13. Install the fuel injection pump adapter bolts and tighten to **21 N·m (15 lb ft)**.

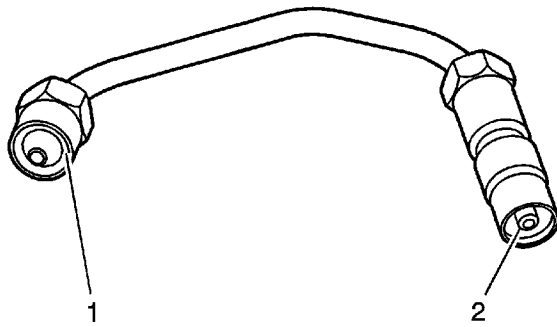
Fuel Injector Cleaning and Inspection



1. Use a soft bristle non-metallic brush and top engine cleaner, GM P/N 1052626 or equivalent, to remove any deposits from the nozzle tip (1) and the copper washer sealing area (2) before reinstallation.

Caution: The fuel injector must be cleaned with the proper cleaning equipment. DO NOT use abrasive cleaning methods, such as a metallic brush, to remove deposits. Cleaning an injector with improper tools will damage the fuel injector.

2. Inspect the fuel injector nozzle tip (1) for cracks, dents, or other damage.
3. Inspect the nozzle tip (1) for any signs of discoloration - dark yellow, tan, or blue due to excessive heat.
4. Replace the injector if any damage is found.



5. Clean the fuel injector high pressure line.
6. Inspect the fuel injector high pressure line for excessive corrosion or damage to the sealing surfaces (1, 2). Replace the line if any damage is found.

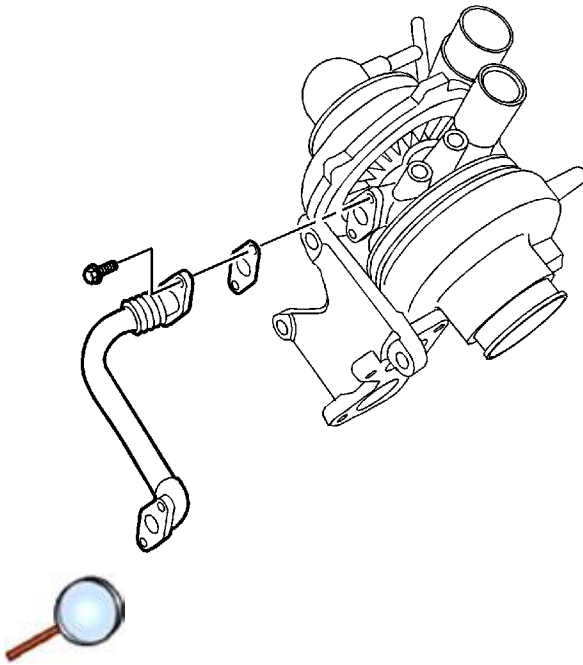
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Turbocharger Cleaning and Inspection

Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger.

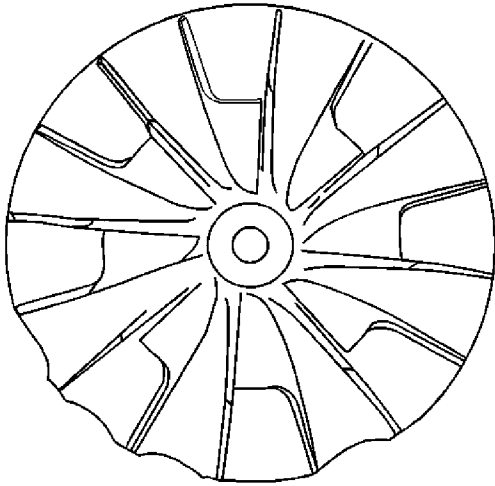
Use the following information to diagnose problems caused by the turbocharger.

The turbocharger is serviced as a complete unit.

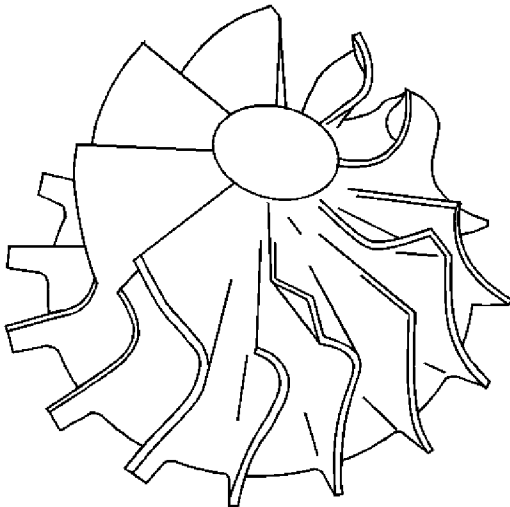


Important: Oil residue on the turbocharger compressor wheel is normal with a closed PCV system.

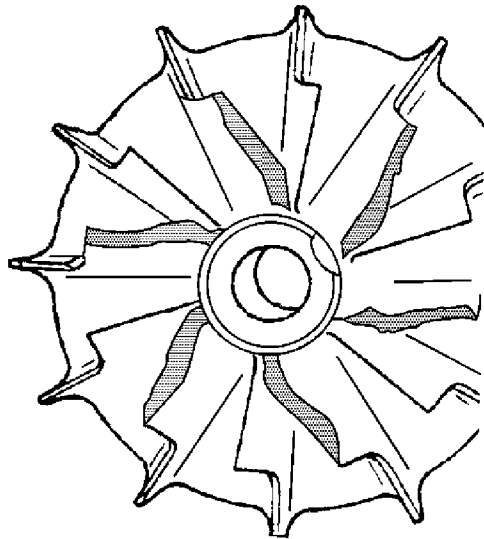
1. Remove the turbocharger oil return pipe bolts.
2. Remove the turbocharger oil return pipe and gasket.
3. Clean mating surfaces.



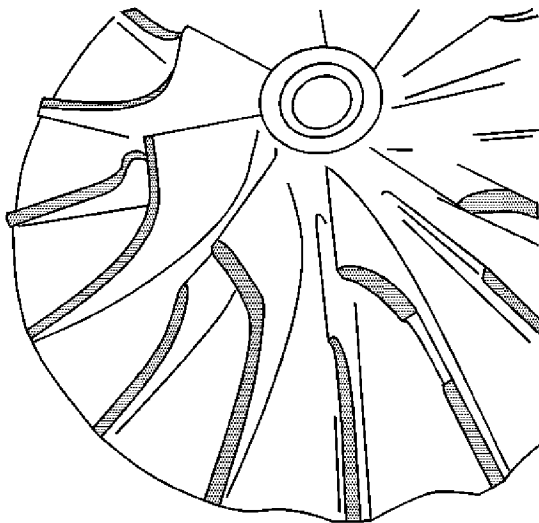
4. Inspect for damage to the compressor wheel, compared to a normal compressor wheel.



5. Inspect for damage to the compressor wheel, by a soft object.



6. Inspect for damage to the compressor wheel, by a hard object.

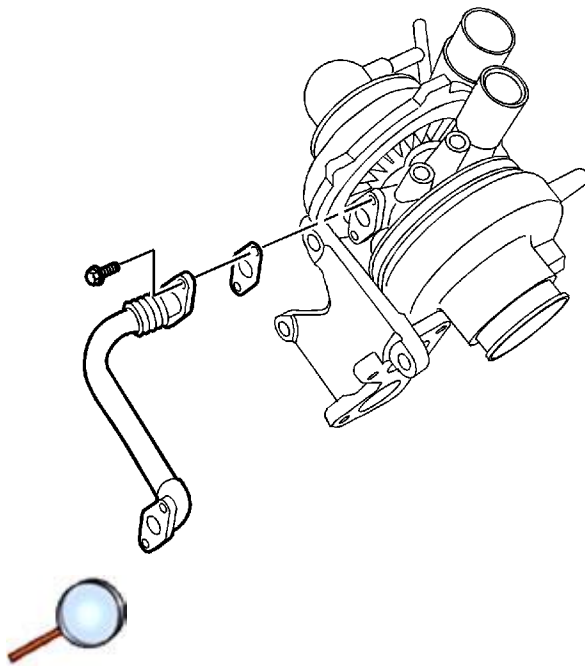


7. Inspect compressor blades for heavy rubbing.

Ensure that the following conditions do not exist on the compressor wheel blades:

- Cracks
- Bends
- Erosion of the blades
- Broken blades

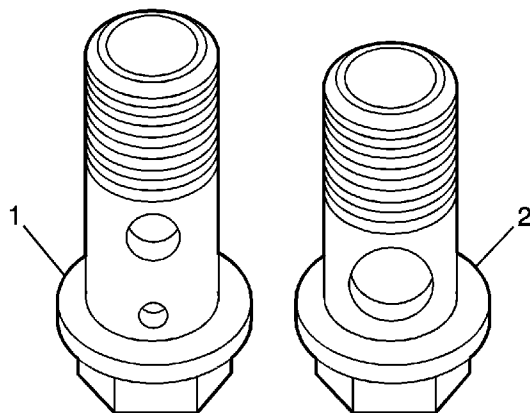
8. Check the housing for signs of rubbing.



9. Install the turbocharger oil return pipe and new gasket.
10. Install the turbocharger oil return pipe bolts.

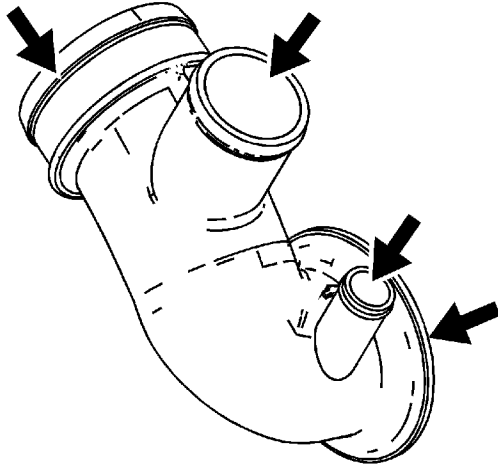
Tighten

Tighten the turbocharger oil return pipe bolts to 21 N·m (15 lb ft).



Important: If the cooling outlet hose eye bolts were removed, install the longer bolt (1) with two holes, in the top location. Install the shorter bolt (2) in the lower location.

11. Inspect the coolant outlet lines for damage.



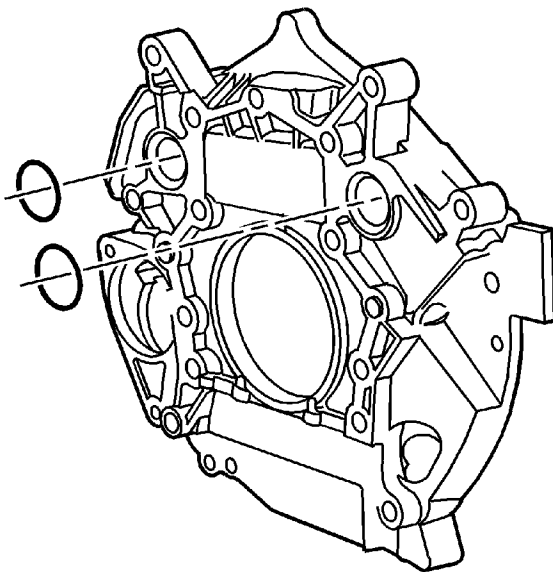
12. Clean the turbocharger inlet duct.
13. Clean the turbocharger inlet duct mating surfaces.
14. Inspect the turbocharger inlet duct for cracks.
15. Inspect the turbocharger inlet duct mating surfaces for damage.
16. Replace the turbocharger inlet duct if any damage is found.

Tighten

Tighten the inlet duct clamp to 5 N·m (44 lb in).

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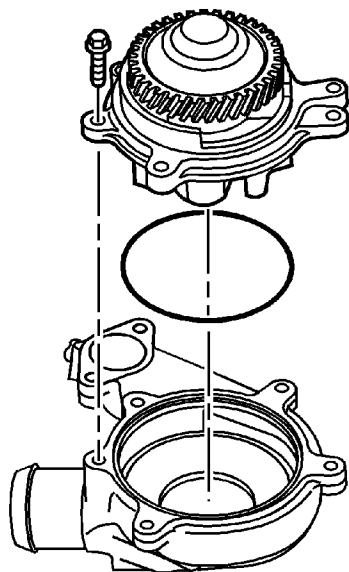
Engine Flywheel Housing Cleaning and Inspection



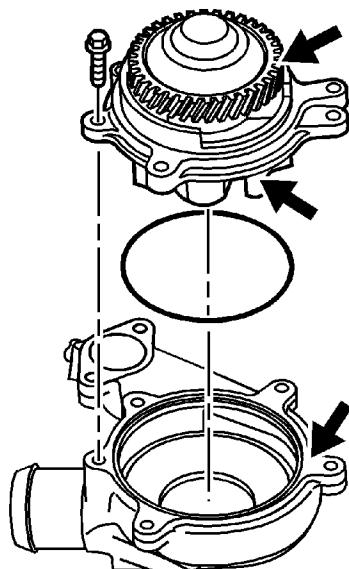
1. Remove the O-rings from the flywheel housing and discard.
2. Clean the flywheel housing.
3. Clean the flywheel housing mating surfaces.
4. Clean the flywheel housing O-ring sealing area.
5. Inspect the flywheel housing for cracks.
6. Inspect the flywheel housing mating surfaces for damage.
7. Inspect the crankshaft rear oil seal bore for damage.
8. Replace the flywheel housing if any damage is found.

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Water Pump Cleaning and Inspection



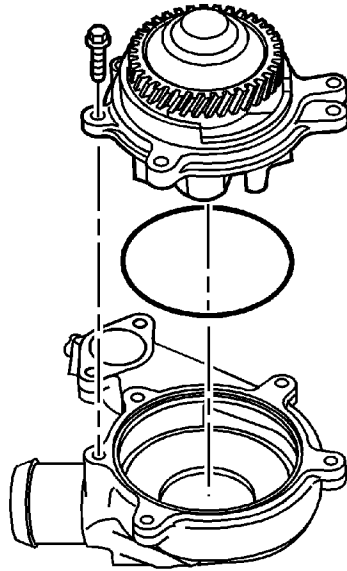
1. Remove the O-ring from the water pump and discard.
2. Remove the water pump to water pump housing bolts.
3. Remove the water pump from the water pump housing.
4. Remove the O-ring from the water pump housing and discard.



5. Clean the water pump assembly.
6. Clean the water pump mating surfaces.
7. Inspect the water pump gear for damage.
8. Inspect the water pump mating surfaces for damage.

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9. Inspect the water pump shaft for looseness.
10. Inspect the water pump assembly for damage.
11. Replace the water pump if any damage is found.



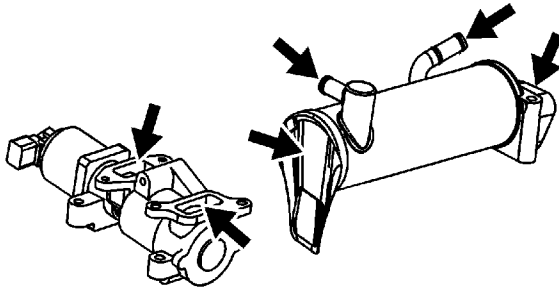
12. Install a new O-ring to the water pump housing.
13. Lubricate the O-ring with engine coolant.
14. Install the water pump to the water pump housing.

Caution: Refer to [Fastener Caution](#) in the Preface section.

15. Install the water pump to water pump housing bolts. Tighten the water pump to water pump housing bolts to **21 N·m (15 lb ft)**.
16. Install a new O-ring to the water pump.

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Exhaust Gas Recirculation Valve Cooler Cleaning and Inspection

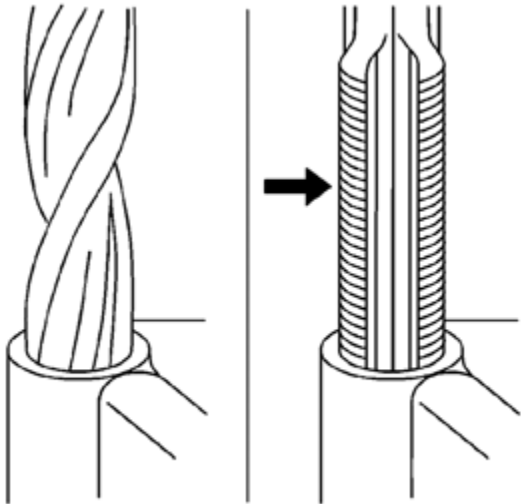


1. Remove the exhaust gas recirculation (EGR) cooling hoses.
2. Clean and inspect the EGR gasket surfaces.
3. Clean and inspect the EGR and cooler.
4. Replace the EGR or cooler if damaged.

Thread Repair

General purpose thread repair kits are available commercially.

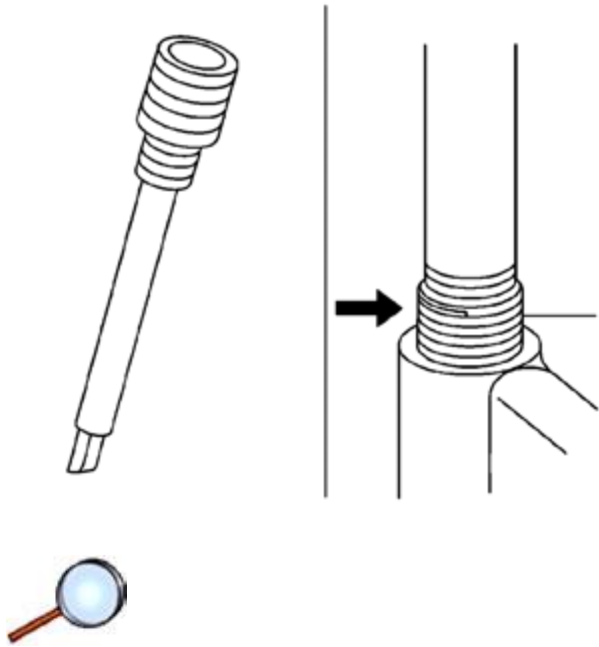
Warning: Refer to [Safety Glasses Warning](#) in the Preface section.



Note: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use.

Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread.
2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
3. Drill out the damaged thread.
4. Remove the chips.
5. Apply clean engine oil to the top thread.
6. Use the tap in order to cut new thread.
7. Clean the thread.

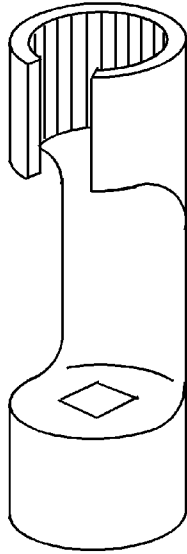


8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

Note: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

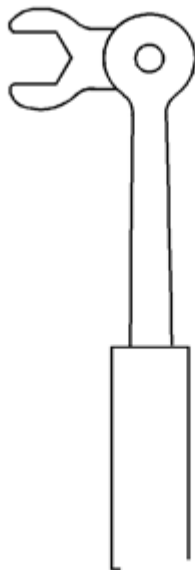
Fuel Line Torquing



The torque of a fuel line fitting is critical to prevent fuel leaks in a high pressure direct injection fuel system. The preferred method is through the use of a flare nut socket. With the use of a flare nut socket, the torque wrench can be set to the listed torque specification. Refer to [Fastener Tightening Specifications](#).

If a crows foot is used to torque the fuel lines, then special attention to the position of the crows foot in relation to the torque wrench is required.

•





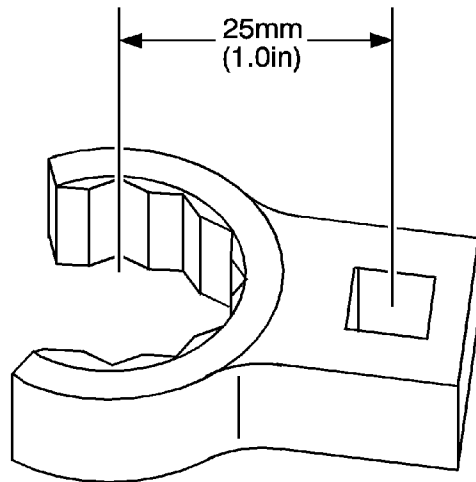
┆ If the crows foot is kept perpendicular (90 degrees) to the torque wrench during the entire tightening procedure, then the torque wrench can be set to the listed torque specification. Refer to [Fastener Tightening Specifications](#).

•

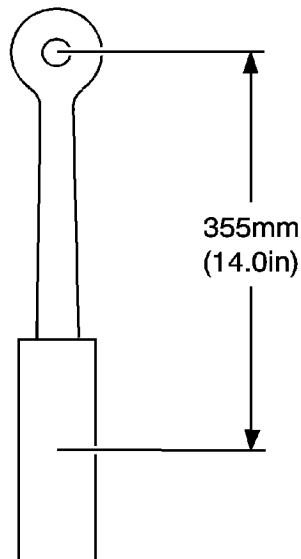


- ┆ If the crows foot is positioned straight with the torque wrench, then the torque setting needs to be corrected to compensate for the increased leverage.
- ┆ If the crows foot is held at any position other than 90 degrees or inline to the wrench, more complex corrections of the torque setting are required, and therefore, positioning the crows foot in this manner is not recommended.

If it is necessary to position a crows foot in line with the torque wrench, the procedure for adjusting the torque specification is as follows:



1. Measure the distance between the center of the crow's foot wrench end to the center of the square drive hole.



2. Measure the length of the torque wrench from the center of the square drive to the center of the handle.
3. Divide the measurement of the crow's foot length by the torque wrench length. This figure is the percentage of additional torque, over the torque wrench setting, that will be applied to the fitting.
4. Subtract the results of step 3 from the number 1. This figure is the percentage of the listed torque specification that the torque wrench should be set to.
5. Multiply the results of step 4 by the listed torque setting. Refer to [Fastener Tightening Specifications](#). This figure is the proper setting the torque wrench should be set at when using a crow's foot in line with the torque wrench.

Example

1. Crows foot measurement = 25 mm (1.0 in)
2. Torque wrench measurement = 355 mm (14.0 in)
3. $25 \text{ mm} / 355 \text{ mm} (1.0 \text{ in} / 14.0 \text{ in}) = 0.07$, or 7 %
4. $1 - 0.07 = 0.93$, or 93 %
5. $0.93 \times 41 \text{ N}\cdot\text{m} (30 \text{ lb ft}) = 38 \text{ N}\cdot\text{m} (28 \text{ lb ft})$

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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.

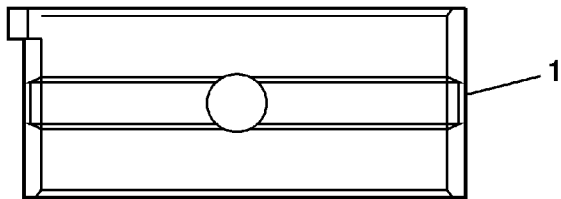
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Crankshaft and Bearing Installation

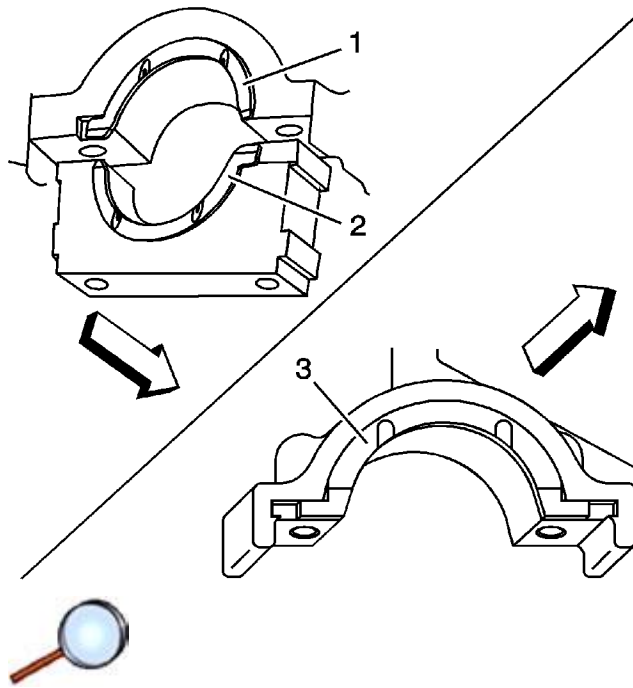
Special Tools

J 45059 Angle Meter

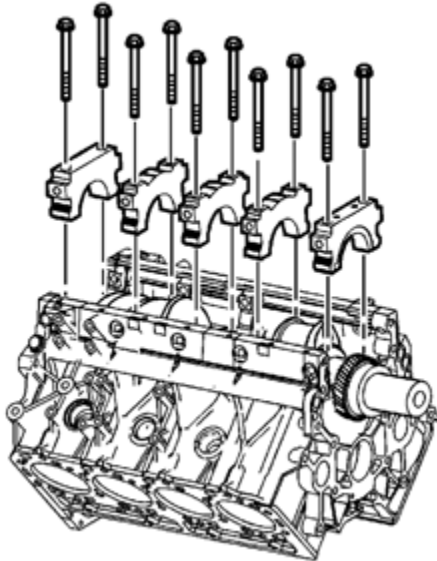
For equivalent regional tools, refer to [Special Tools](#)



1. Install the upper crankshaft bearings into the cylinder block. The bearing halves to be inserted into the crankshaft main bearing saddle have a wide groove and oil hole in the center of the bearing (1).
2. Install the lower crankshaft bearings into the crankshaft bearing caps. The bearing halves to be inserted into the crankshaft main bearing caps do NOT have an oil hole or groove in the bearing (2).

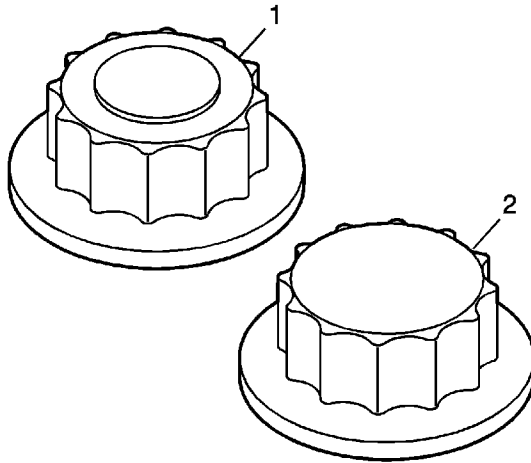


3. Install the upper thrust bearings to the cylinder block. There are two thrust bearings (1 and 3) in the cylinder block and one lower thrust bearing in the No. 5 crankshaft bearing cap (2).
4. Lubricate the crankshaft bearing surfaces with engine oil.
5. Install the crankshaft into the cylinder block.
6. Install the No. 5 crankshaft bearing cap with the lower thrust bearing (2).



7. Install the remaining four crankshaft bearing caps.

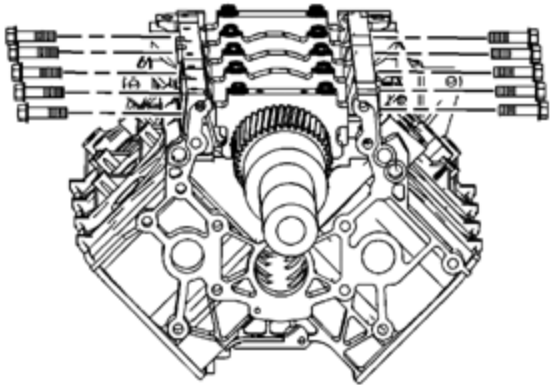
Caution: Refer to [Fastener Caution](#) in the Preface section.



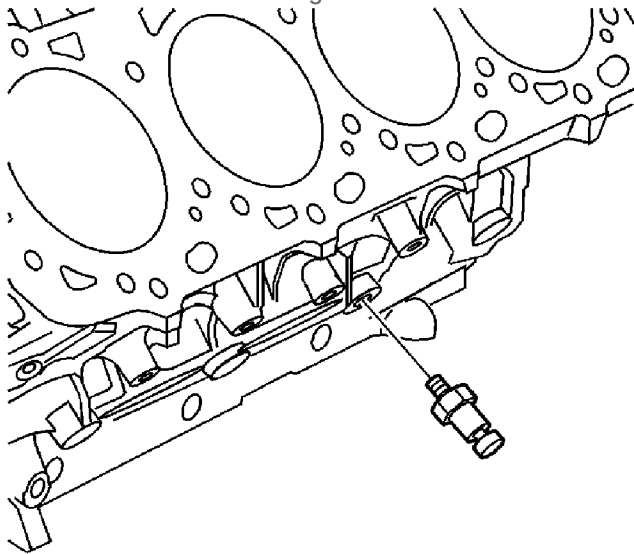
Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

Note: There are two different length crankshaft bearing cap bolts in production depending on the counter bore of the threaded hole/block. Using the wrong bolt may lead to improper thread engagement, bottoming out or improper clamp load. Look at the bolt head surface to determine which bolt was used in production. The bolt head will have either a raised circle (1) or it will be unmarked (2). Replace the bolt with the same type.

8. Install the NEW crankshaft bearing cap bolts.
9. Tighten the crankshaft bearing cap bolts in the proper sequence.
 - 9.1. 1st step **98 N·m (72 lb ft)**.
 - 9.2. 2nd step **132 N·m (97 lb ft)**.
 - 9.3. 3rd step 30 degrees using J 45059 meter .



10. Clean the crankshaft bearing side cap bolt threads, sealing flange and mounting holes with GM P/N 12377981 (Canadian P/N 10953463) or equivalent. Dry the bolts and mounting holes with compressed air.
11. Apply GM P/N 12346004 (Canadian P/N 10953480) to the threads and sealing flange of the bolts.
12. Install the ten bolts. Tighten the crankshaft bearing cap side bolts to **70 N·m (52 lb ft)**.



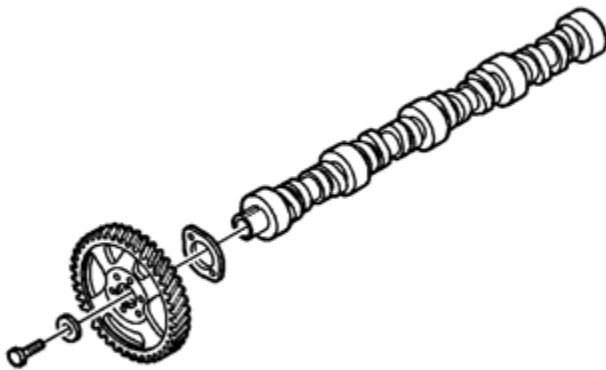
13. Install the oil pressure sensor and tighten to **41 N·m (30 lb ft)**.

Camshaft Installation

Special Tools

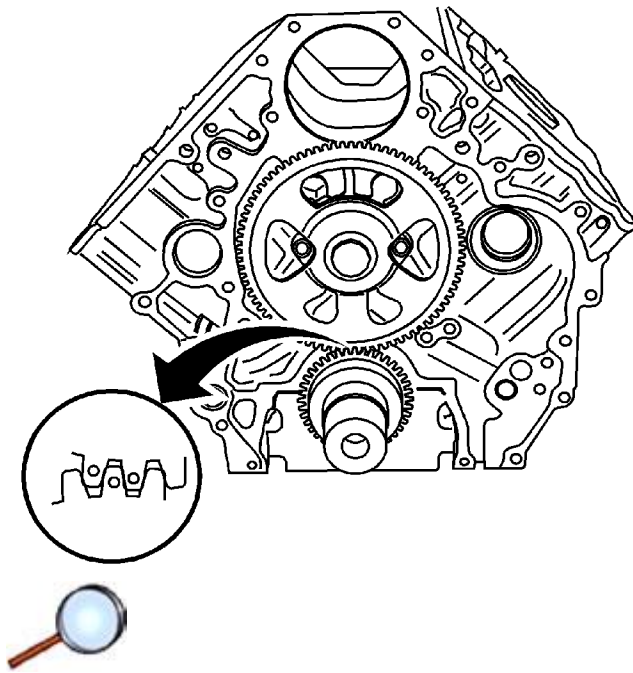
J 7872 Dial Indicator Set

For equivalent regional tools, refer to [Special Tools](#).



1. Install the camshaft thrust plate to the camshaft.
2. Install the camshaft driven gear.
3. Install a new camshaft driven gear bolt.

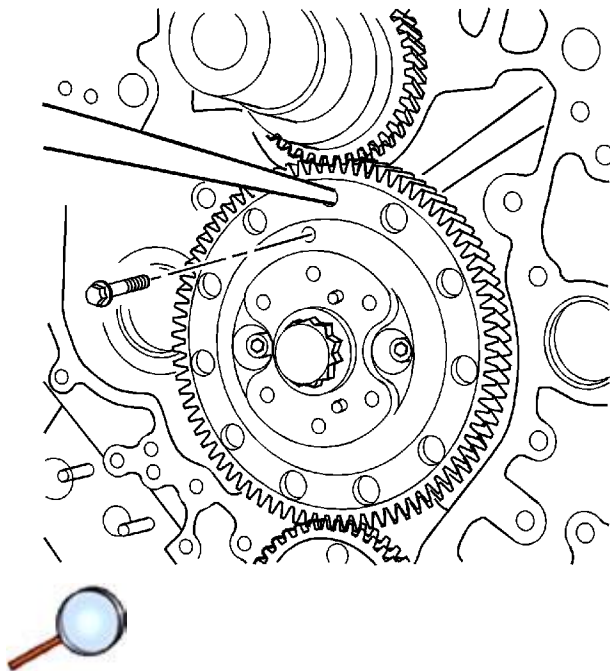
Leave the bolt finger tight.



4. Install the camshaft and gear assembly into the cylinder block, aligning the camshaft gear to the crankshaft gear as shown.

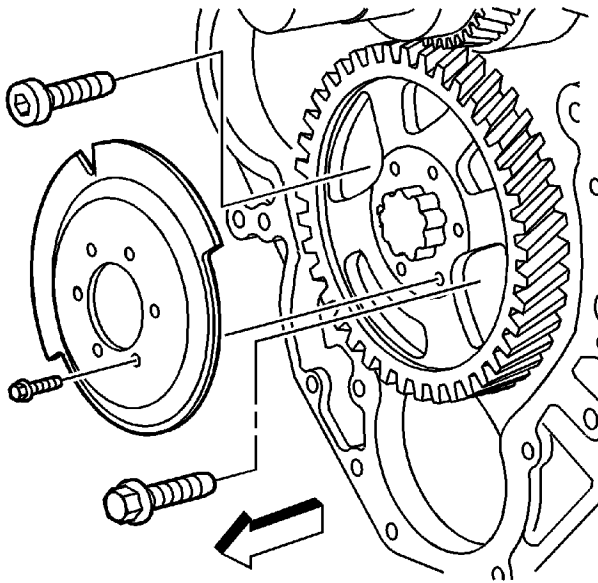
Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Install the camshaft thrust plate bolts and tighten to **22 N·m (16 lb ft)**.

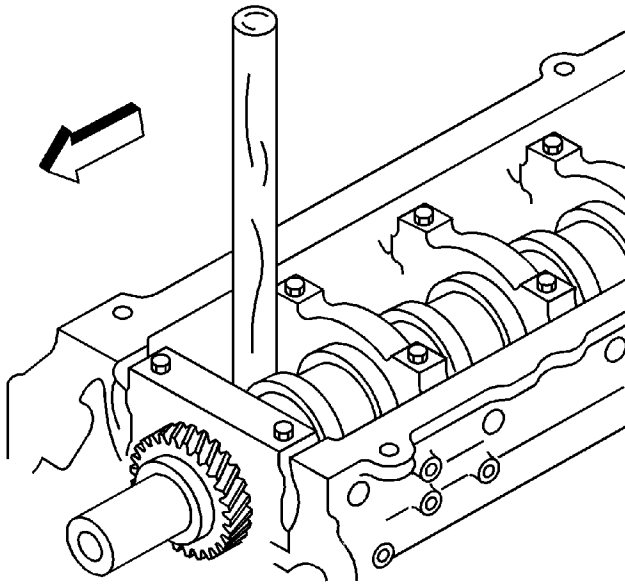


Note: Use a suitable tool to relieve the spring tension while removing the locking bolt.

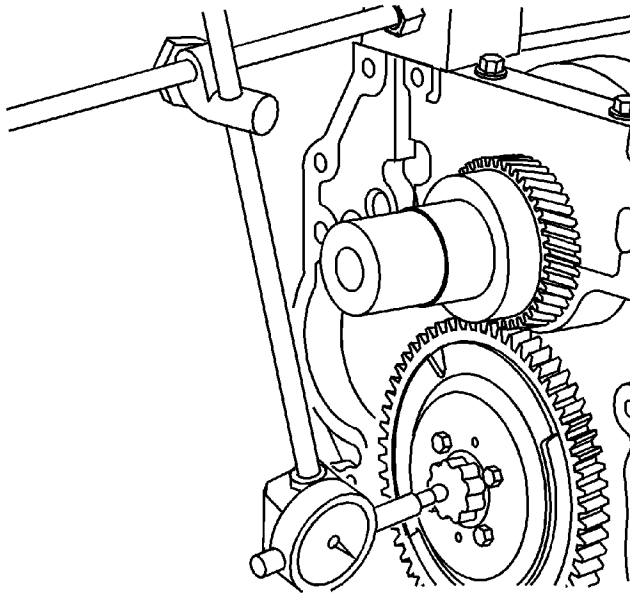
6. Remove the exciter ring bolt that was installed to hold the spring tension of the two piece cam gear.



7. Install the camshaft position sensor exciter ring to the camshaft gear.
8. Install the camshaft position sensor exciter ring bolts and tighten to **9 N·m (80 lb in)**.



9. Block the crankshaft from turning using a wooden handle.
10. Install the new camshaft gear bolt and tighten to **234 N·m (173 lb ft)**.



11. Measure the camshaft end play with J 7872 Dial Indicator Set .

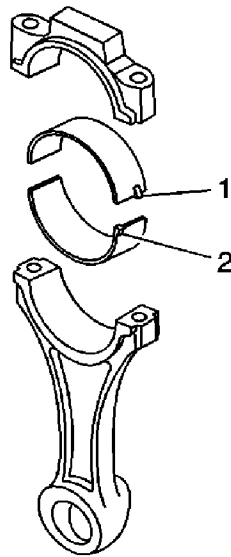
- The production value is 0.050-0.114 mm (0.0020-0.0045 in) and service limit is 0.2 mm (0.0079 in).
- Replace the camshaft gear or the camshaft thrust plate if measured value exceeds the service limit.

Piston, Connecting Rod, and Bearing Installation

Special Tools

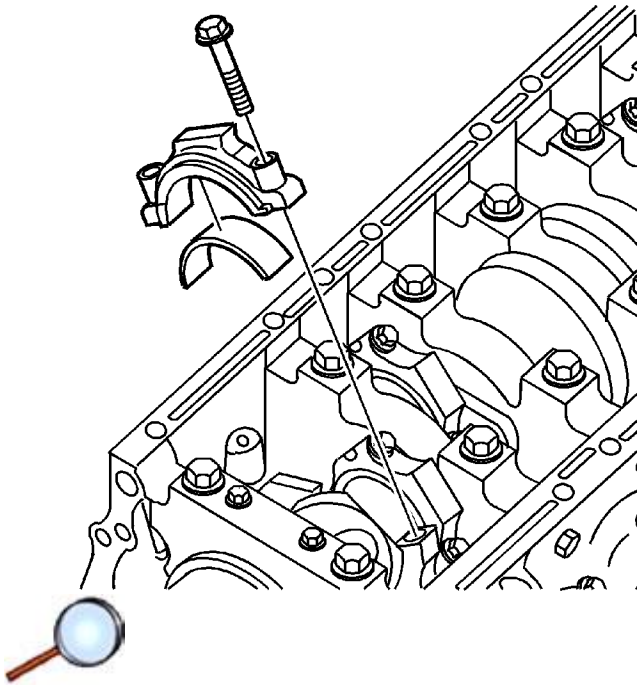
- J 8037 Piston Ring Compressor
- J 45059 Angle Meter

For equivalent regional tools, refer to [Special Tools](#).

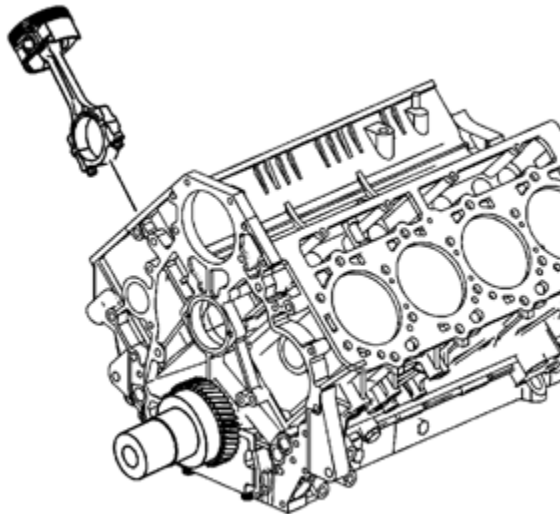


Note: The connecting rod bearing with the notch all the way out against the edge of the bearing (2) is the connecting rod bearing. The connecting rod bearing with the notch "in board" (1) is the connecting rod cap bearing.

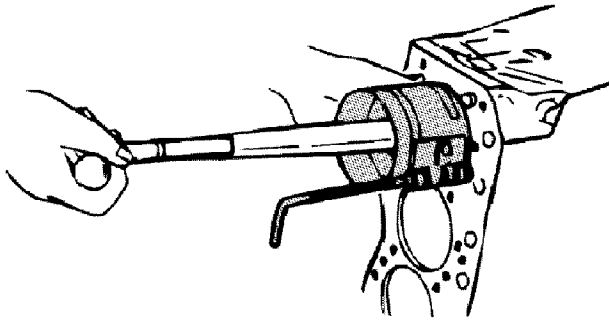
1. Select the connecting rod bearing according to the [Connecting Rod Bearings Selection Specifications](#) chart.
2. Position the crankshaft so the connecting rod journal is opposite the piston and connecting rod assembly being installed.



3. Install the connecting rod bearing inserts.
4. Lubricate the cylinder wall and piston rings with engine oil.
5. Install the J 8037 compressor to the piston to compress the piston rings.

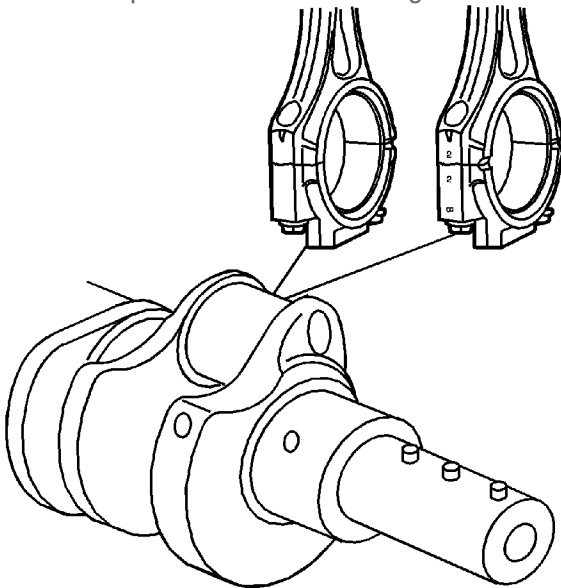


6. Orientate the piston front mark and the piston inside mark to the engine block.



Caution: The chamfered side of the connecting rod large journal ends must face away from each other on a common crankshaft journal. Placement of the chamfered side of the connecting rod large journal ends in any other direction or combination will cause damage to the crankshaft, connecting rod and connecting rod bearing.

7. Push the piston and connecting rod assembly into the engine.



8. Install the gauging plastic onto the connecting rod journal. Install the gauging plastic the full width of the journal.
9. Install the connecting rod cap with its stamped cylinder number aligned with the stamped cylinder number on the connecting rod.

Caution: Refer to [Fastener Caution](#) in the Preface section.

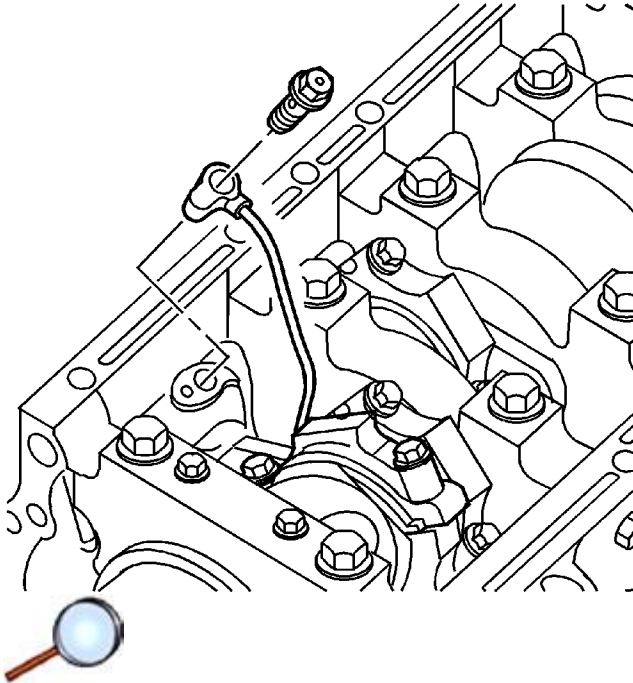
10. Install the original connecting rod cap bolts for the plastic gauging. NEW bolts will be used for final assembly.
11. Tighten the bolts in three steps.
 - 11.1. 1st step **64 N·m (47 lb ft)**
 - 11.2. 2nd step **30 degrees** using J 45059 meter
 - 11.3. 3rd step **30 degrees** using J 45059 meter
12. Remove the connecting rod cap bolts.
13. Compare the width of the gauging plastic with the scale printed on the gauging plastic container. The connecting rod bearing clearance should be 0.10 mm (0.0039 in).
14. Discard the original connecting rod bolts once the plastic gauging is completed. NEW connecting rod bolts will be used for final assembly.
15. Carefully clean the gauging plastic from the bearing surface and the crankpin.
16. Lubricate the connecting rod bearing inserts with engine oil.
17. Install the connecting rod caps with the stamped cylinder number aligned with the stamped cylinder number on the connecting rods.

Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

18. Install NEW connecting rod cap bolts.
19. Tighten the connecting rod cap bolts in three steps.
 - 19.1. 1st step **64 N·m (47 lb ft)**
 - 19.2. 2nd step **30 degrees** using J 45059 meter
 - 19.3. 3rd step **30 degrees** using J 45059 meter

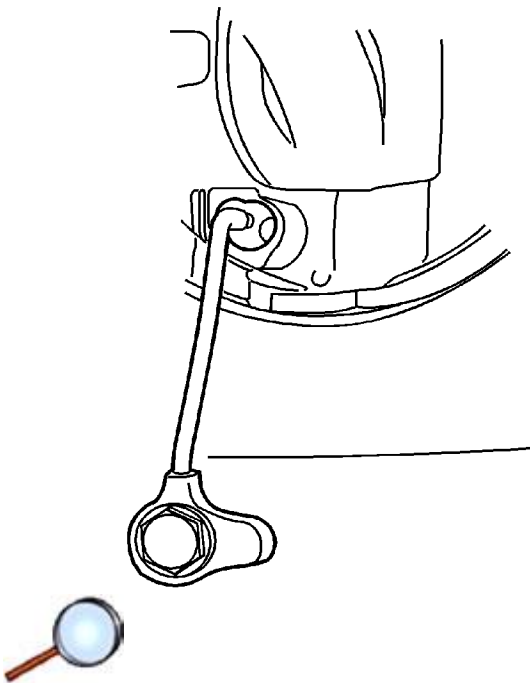
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Piston Oil Cooling Nozzle Installation



1. Install the piston oil cooling nozzle.

Caution: Refer to [Fastener Caution](#) in the Preface section.



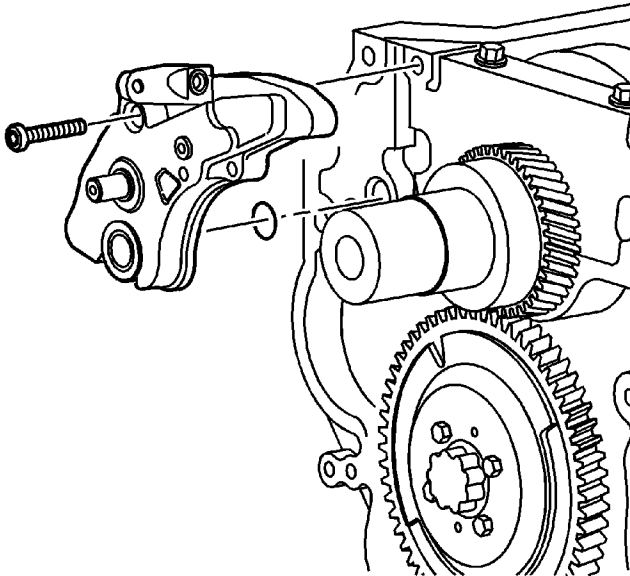
Caution: The piston oil cooling nozzle must be aligned to direct oil towards the oil inlet hole

on the bottom of the piston. Improper alignment of the piston oil cooling nozzle will allow insufficient oil lubrication to the piston and cause severe engine damage.

2. Install the piston oil cooling nozzle bolt and tighten to **21 N·m (15 lb ft)**.

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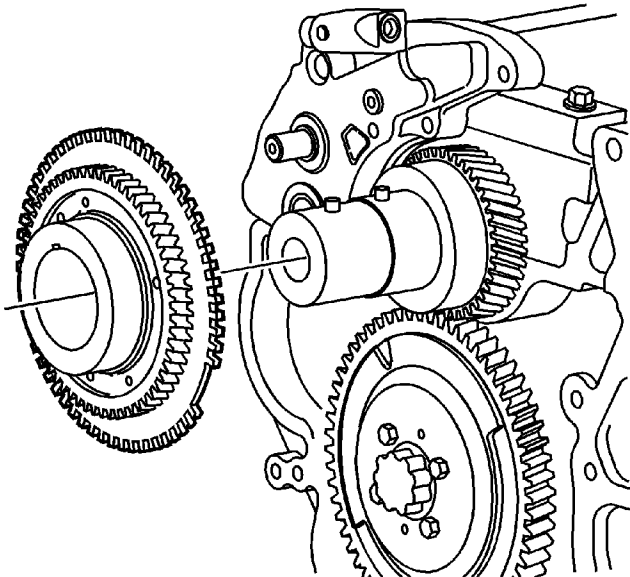
Oil Pump Installation



1. Install a new O-ring to the engine block.
2. Lubricate the O-ring with engine oil.
3. Install the oil pump.

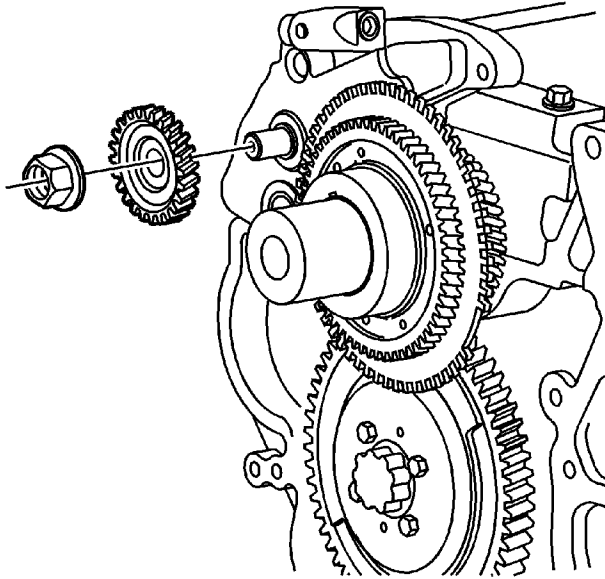
Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the oil pump bolts and tighten to **21 N·m (15 lb ft)**.

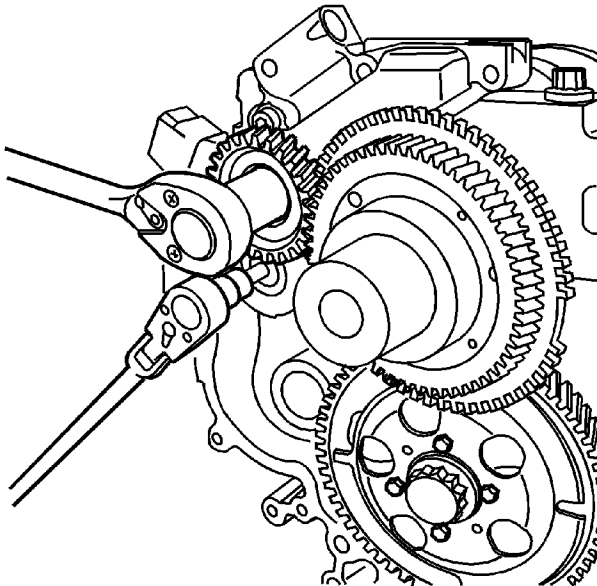


Note: Do not damage the crankshaft sensor reluctor teeth.

5. Install the oil pump drive gear and crank sensor reluctor assembly.



6. Install the oil pump driven gear.

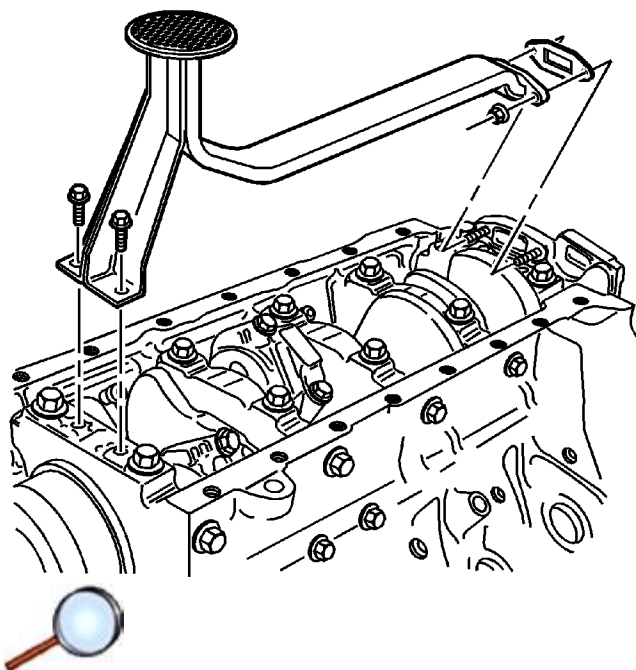


Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

Note: Look for an "L" on the end of the oil pump shaft. If there is an "L" present, the nut and shaft have left hand threads. Service the nut accordingly.

7. While holding the secondary oil pump shaft with a hex driver, install the oil pump driven gear nut. Tighten the oil pump driven gear nut to **100 N·m (74 lb ft)**.

Oil Pump Suction Pipe and Screen Assembly Installation

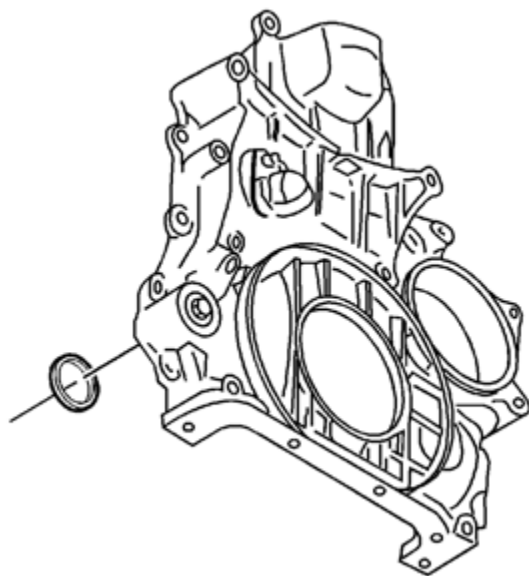


1. Install the oil pump pipe and screen gasket.
2. Install the oil pump pipe and screen.

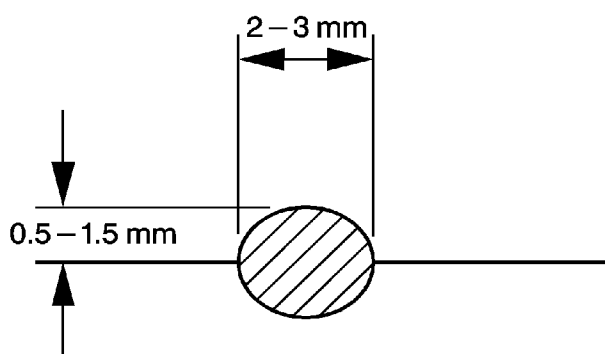
Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the oil pump pipe and screen assembly bolts and nuts.
 - 3.1. Tighten the oil pump pipe and screen assembly bolts to **25 N·m (18 lb ft)**.
 - 3.2. Tighten the oil pump pipe and screen assembly nuts to **25 N·m (18 lb ft)**.

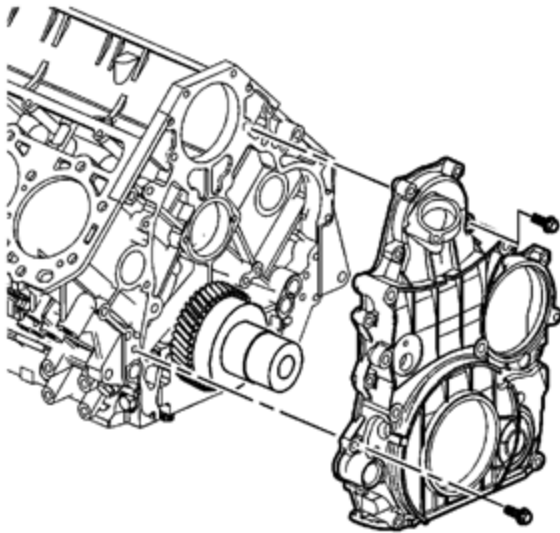
Engine Front Cover Installation



1. Install the relief valve O-ring to the engine front cover.
2. Lubricate the O-ring with engine oil.



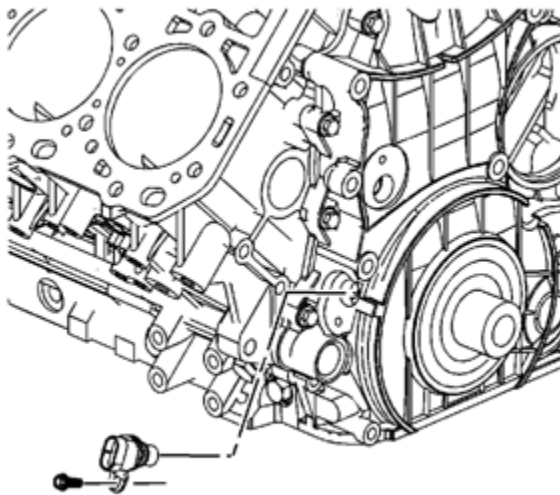
3. Apply a 2-3 mm wide and 0.5-1.5 mm high bead of GM P/N 12378521 (Canadian P/N 88901148) sealant to the mating surfaces of the engine front cover.



4. Install the engine front cover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Install the engine front cover bolts and tighten to **25 N·m (18 lb ft)**.

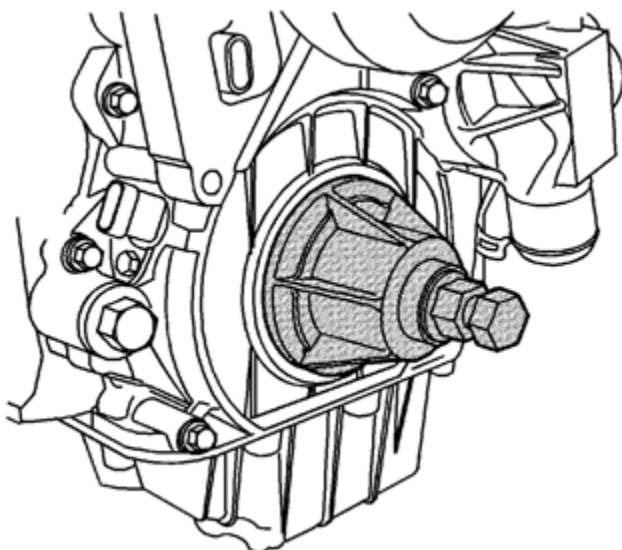


6. Install a new O-ring to the crankshaft position sensor spacer.
7. Lubricate the O-ring with engine oil.
8. Install the crankshaft position sensor spacer.
9. Install the crankshaft position sensor spacer bolts and tighten to **10 N·m (89 lb in)**.
10. Install a new O-ring to the crankshaft position sensor.
11. Lubricate the O-ring with engine oil.
12. Install the crankshaft position sensor.
13. Install the crankshaft position sensor bolt and tighten to **10 N·m (89 lb in)**.

Crankshaft Front Oil Seal Installation

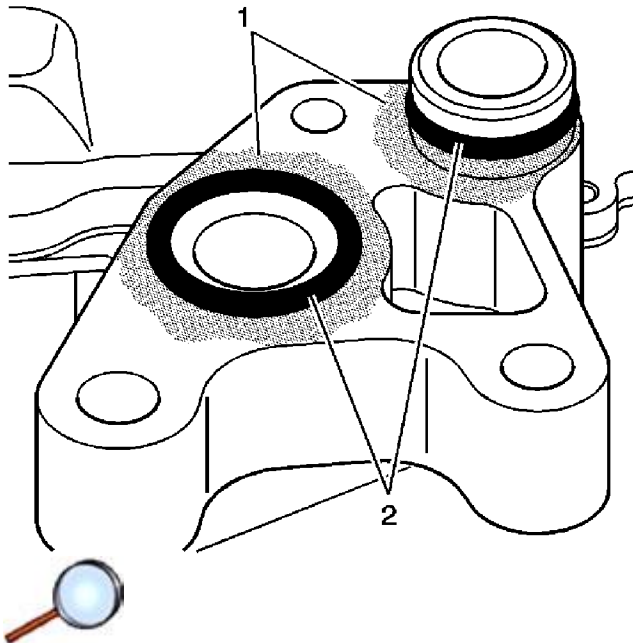
Tools Required

[J 44645](#) Crankshaft Front Oil Seal Installer

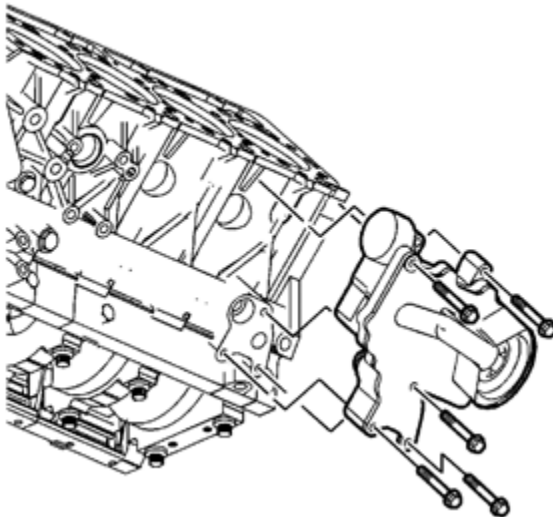


1. Lubricate the crankshaft sealing surface with engine oil.
2. Place the crankshaft front oil seal onto the crankshaft.
3. Install the [J 44645](#) to the crankshaft.
4. Press the crankshaft front oil seal onto the crankshaft with the [J 44645](#) until the tool bottoms out.
5. Remove the [J 44645](#) .

Oil Filter Adapter and Oil Cooler Assembly Installation



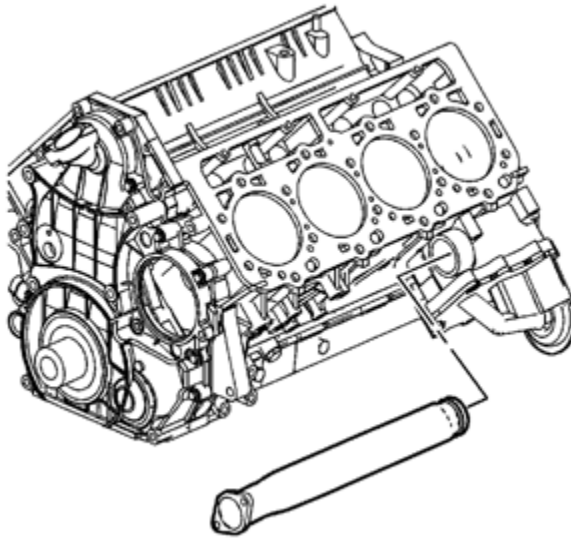
1. Install new O-rings (2) to the oil filter adapter and oil cooler assembly. Lubricate the O-rings with engine oil.
2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) to the O-ring sealing area (1).



3. Install the oil filter adapter and oil cooler assembly.

Caution: Refer to [Fastener Caution](#) in the Preface section.

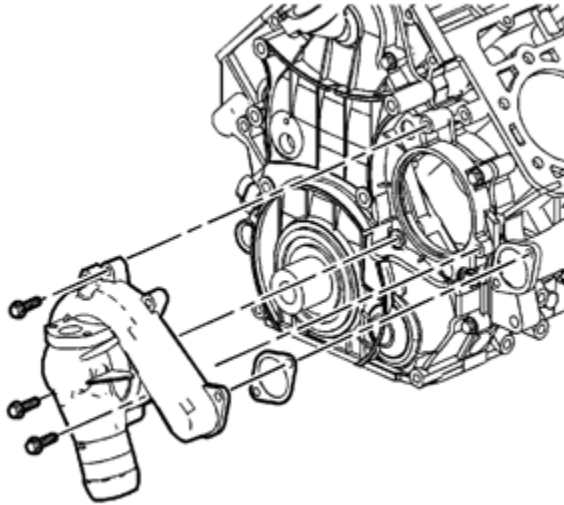
4. Install the five oil filter adapter and oil cooler assembly bolts (1) and tighten to **25 N·m (18 lb ft)**.



5. Install a new O-ring onto the engine coolant pipe.
6. Lubricate the O-ring with engine coolant. Do not use oil or grease.
7. Install the engine coolant pipe to the oil filter adapter and oil cooler assembly.

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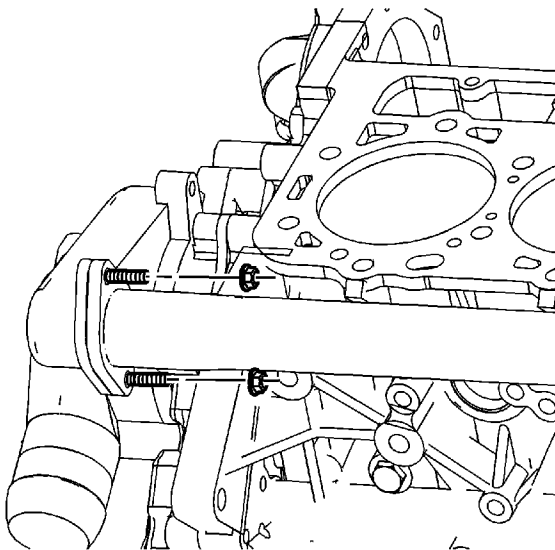
Water Pump Installation



1. Lubricate the water pump O-ring with engine oil.
2. Install the engine coolant pipe gasket.
3. Install the water pump seal.
4. Install the water pump. Be sure the water pump studs align with the coolant tube.

Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Install the water pump bolts and tighten to **25 N·m (18 lb ft)**.

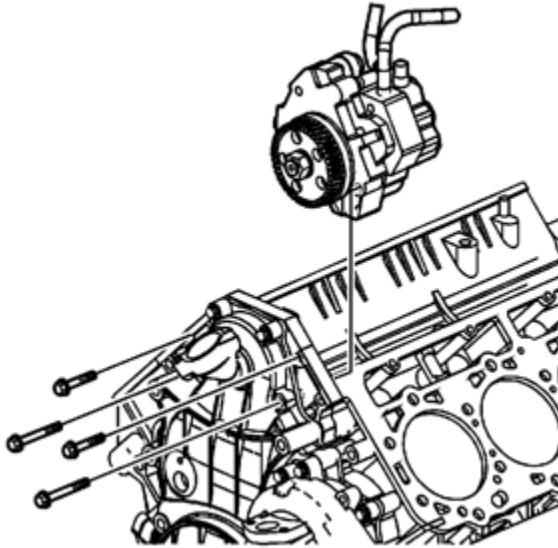




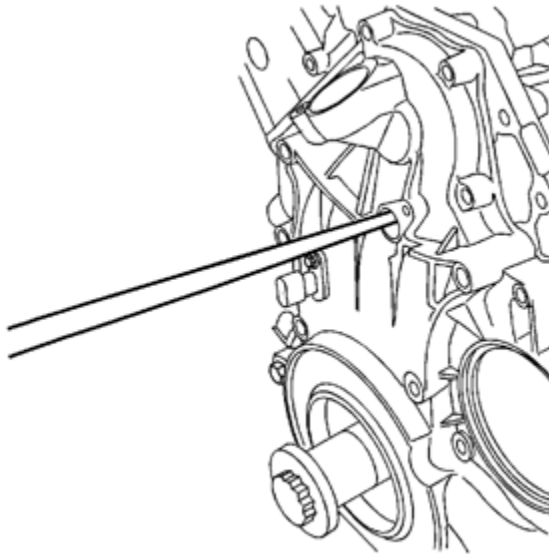
6. Install the water pump to coolant tube nuts Tighten the water pump to coolant tube nuts to **25 N·m (18 lb ft)**.

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Fuel Injection Pump Installation



1. Lubricate the O-ring on the fuel injection pump adapter with engine oil.



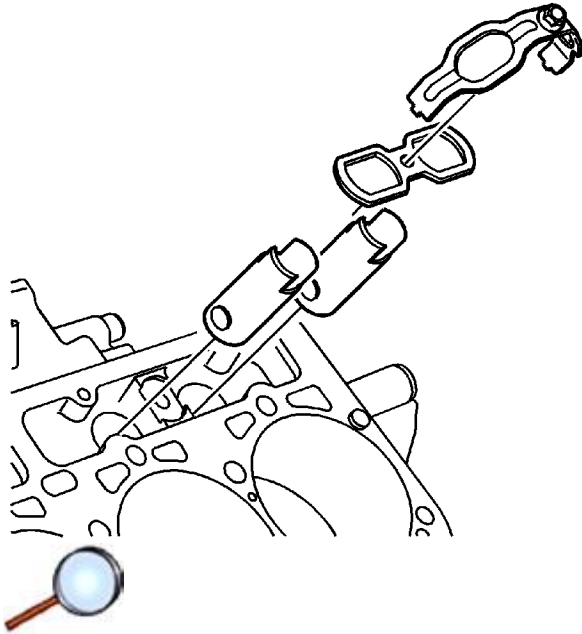
2. Use a suitable tool to unload the spring tension from the two piece cam gear. Apply pressure towards the right side of the engine while installing the fuel injection pump.
3. Install the fuel injection pump and adapter assembly.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the fuel injection pump bolts and tighten to **25 N·m (18 lb ft)**.

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Valve Lifter Installation



1. Install the valve lifter.
2. Install the valve lifter guides.
3. Install the valve lifter guide hold down bracket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

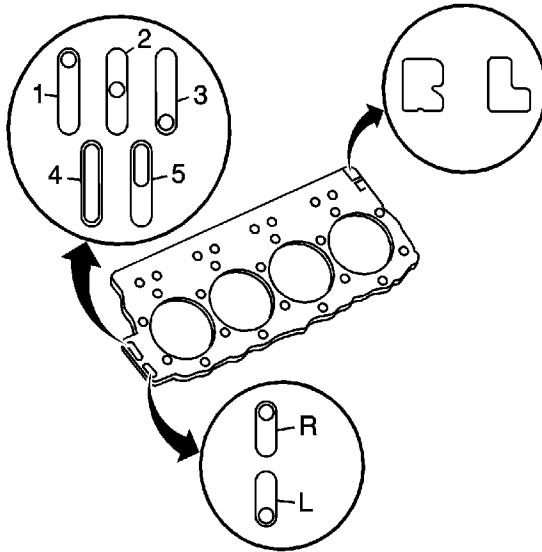
4. Install the valve lifter guide hold down bracket bolt **11 N·m (97 lb in)**.

Cylinder Head Gasket Selection

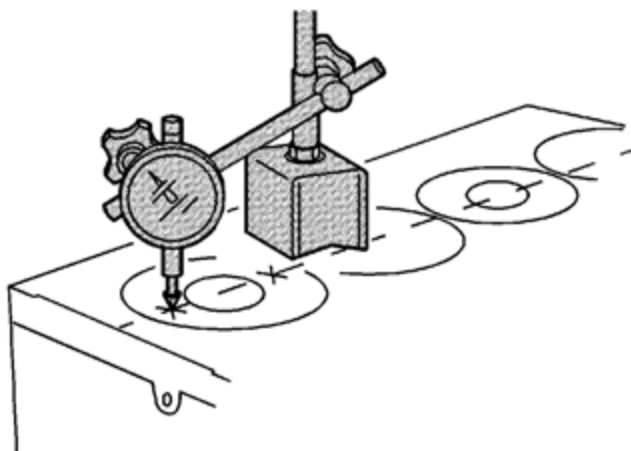
Tools Required

[J 7872](#) Dial Indicator Set

1. If a reciprocating component (crankshaft, connecting rod, piston, or bearings) has not been replaced, install the same grade head gasket that was removed.



2. The markings on the gasket are as follows:
 - Grade A (1)
 - Grade B (2)
 - Grade C (3)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) (4)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) and deck milled 0.008 in (0.203 mm) (5)
3. The cylinder head gasket thickness is determined by the piston head projection from the cylinder block deck surface. There are cylinder head gaskets available in three different thicknesses. Follow the procedure below and refer to [Cylinder Head Gasket Selection Specifications](#) to determine what gasket to use for each bank of cylinders.
4. Be sure the piston and cylinder deck are free of carbon, gasket material, or other objects that may give you an erroneous measurement.



5. Use [J 7872](#) to measure the piston projection across two different points on each piston.
 - 5.1. Zero the dial indicator to the cylinder deck surface.
 - 5.2. Place the dial indicator pointer on the piston top. Be sure the pointer is directly above the piston pin centerline to prevent inaccurate readings from piston rocking.
 - 5.3. Rotate the engine to roll the piston through Top Dead Center while noting the maximum reading on the dial indicator.
 - 5.4. Repeat procedure at the second measuring point on the piston.
6. Calculate the average value of piston projection for each cylinder.
7. Obtain the maximum piston projection value for that bank of cylinders.
8. Determine the gasket grade by the maximum piston projection value using the chart.
9. If the difference between the highest measured piston head projection and the lowest measured piston projection, within one bank of cylinders, exceeds 0.1 mm (0.0039 in), then the following items need to be checked.
 - Connecting rod to piston pin clearance
 - Piston to piston pin clearance

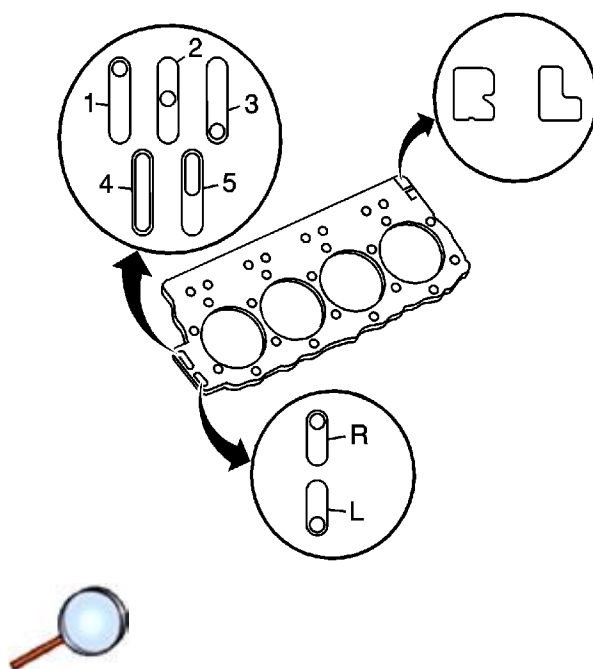
If any of the above clearances are beyond specifications, then refer to the appropriate section for repair. If all of the above clearances are within the service limits but the piston projection variation is over 0.1 mm (0.0039 in), then replace the connecting rod and piston assembly.

Cylinder Head Installation - Left Side

Special Tools

J 45059 Angle Meter

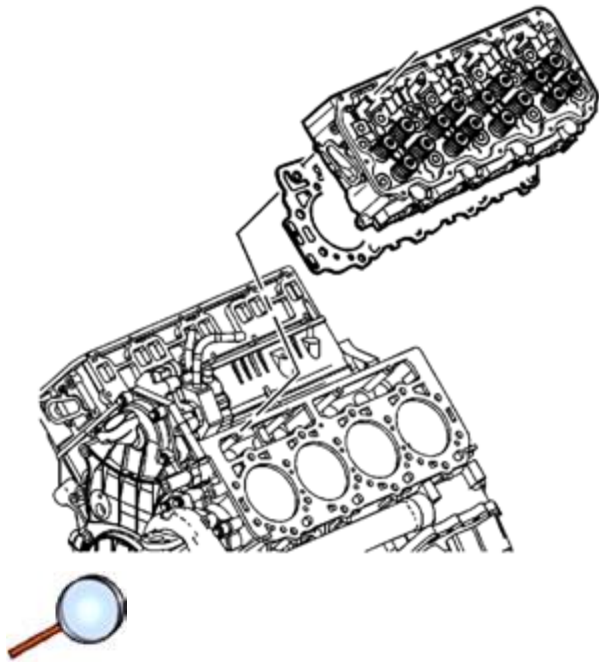
For equivalent regional tools, refer to [Special Tools](#).



Caution: The left and right cylinder head gaskets are not interchangeable. Improper placement of the cylinder head gasket will block coolant and oil passages. Blocked coolant and oil passages will cause severe engine damage.

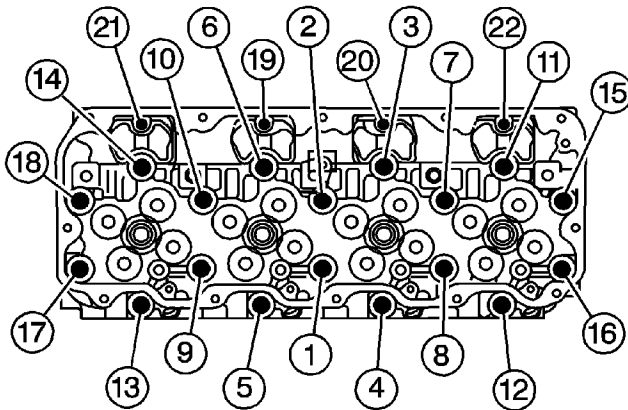
Note: The stamped letter, R or L, must face up. R is the right bank, L is the left bank.

1. The markings on the gasket are as follows:
 - Grade A (1)
 - Grade B (2)
 - Grade C (3)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) (4)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) and deck milled 0.008 in (0.203 mm) (5)
2. Install the left cylinder head gasket of the correct grade. The left and right cylinder head gaskets are not interchangeable. Refer to [Cylinder Head Gasket Selection](#).



3. Install the left cylinder head.

Caution: Refer to [Fastener Caution](#) in the Preface section.



Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

4. Install the NEW M12 cylinder head bolts.

Tighten the M12 cylinder head bolts in three steps:

- 4.1. 1st step **50 N·m (37 lb ft)**
- 4.2. 2nd step **80 N·m (59 lb ft)**
- 4.3. 3rd step tighten **60 degrees** using *J 45059* meter
- 4.4. 4th step tighten **60 degrees** using *J 45059* meter
5. Reuse the M8 bolts. Install the M8 bolts and tighten the M8 cylinder head bolts to **25 N·m (18 lb ft)**.

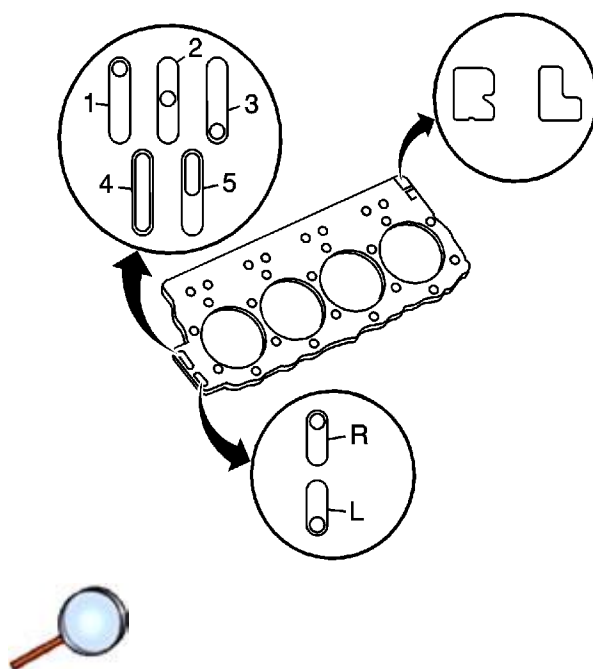
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Cylinder Head Installation - Right Side

Special Tools

J 45059 Angle Meter

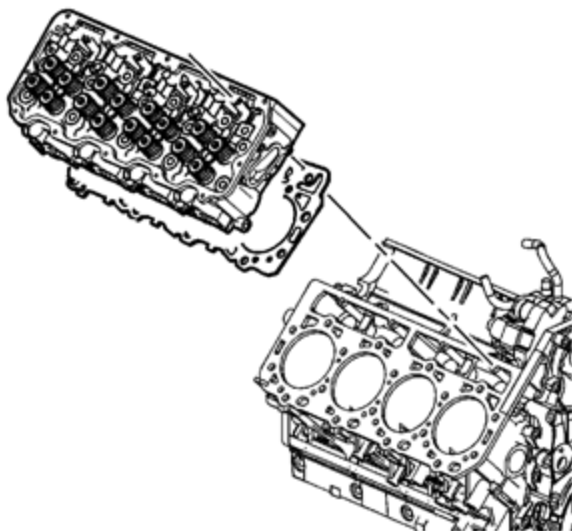
For equivalent regional tools, refer to [Special Tools](#).



Caution: The left and right cylinder head gaskets are not interchangeable. Improper placement of the cylinder head gasket will block coolant and oil passages. Blocked coolant and oil passages will cause severe engine damage.

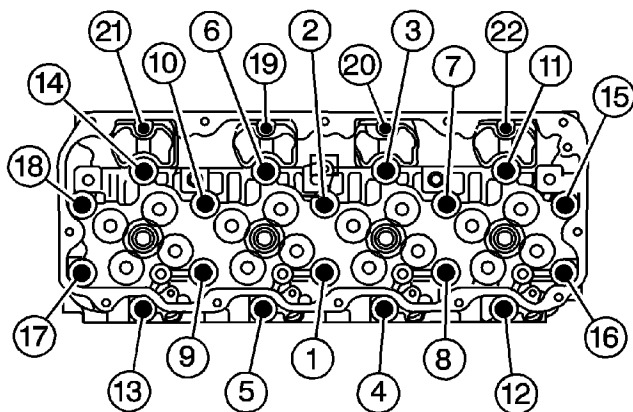
Note: The stamped letter, R or L, must face up. R is the right bank, L is the left bank.

1. The markings on the gasket are as follows:
 - Grade A (1)
 - Grade B (2)
 - Grade C (3)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) (4)
 - Block over-bored 0.010-0.030 in (0.254-0.762 mm) and deck milled 0.008 in (0.203 mm) (5)
2. Install the right cylinder head gasket of the correct grade. The left and right cylinder head gaskets are not interchangeable. Refer to [Cylinder Head Gasket Selection](#).



3. Install the right cylinder head.

Caution: Refer to [Fastener Caution](#) in the Preface section.



Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

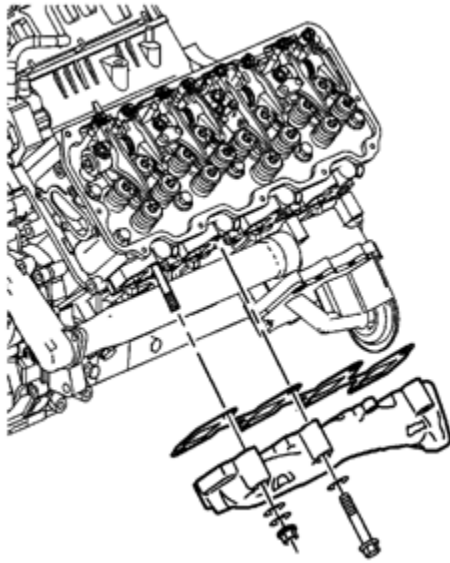
4. Install the NEW M12 cylinder head bolts. Reuse the M8 bolts.

Tighten the M12 cylinder head bolts in three steps:

- 4.1. 1st step **50 N·m (37 lb ft)**
- 4.2. 2nd step **80 N·m (59 lb ft)**
- 4.3. 3rd step tighten **60 degrees** using *J 45059* meter
- 4.4. 4th step tighten **60 degrees** using *J 45059* meter
5. Install the M8 bolts. Tighten the M8 cylinder head bolts to **25 N·m (18 lb ft)**.

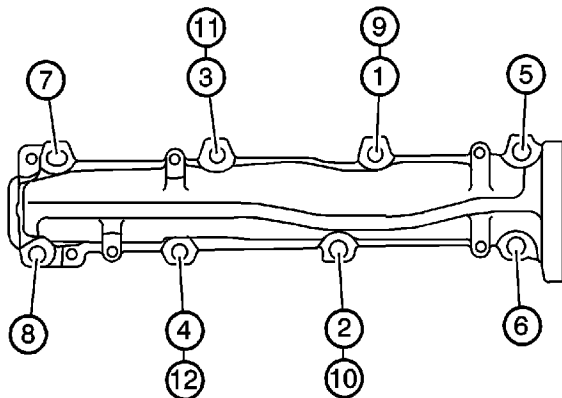
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Exhaust Manifold Installation - Left Side



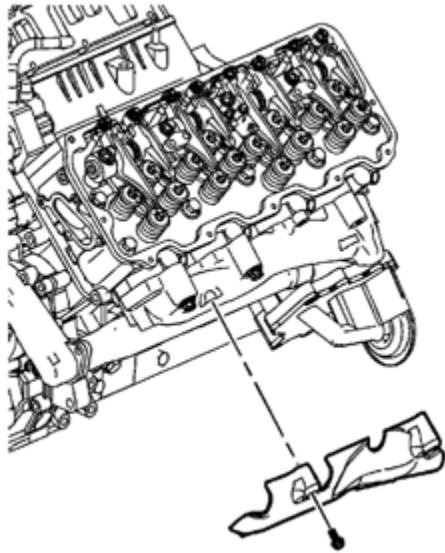
1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

Caution: Refer to [Fastener Caution](#) in the Preface section.



3. Install the exhaust manifold bolts and nuts.

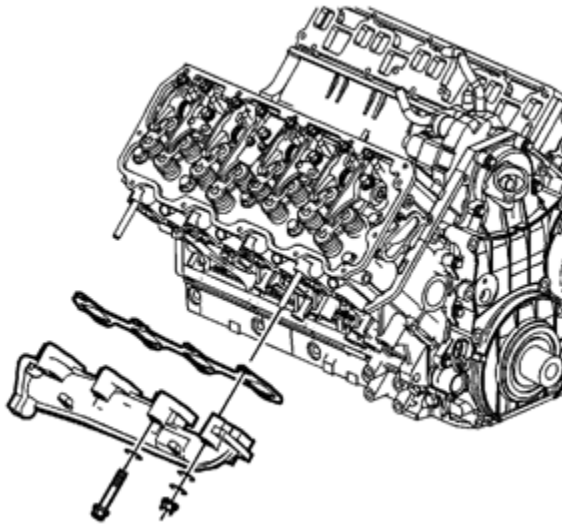
- 3.1. Tighten the exhaust manifold bolts and nuts to **57 N·m (42 lb ft)** in the proper sequence.
- 3.2. Tighten the center exhaust manifold bolts and nuts an additional pass to **57 N·m (42 lb ft)** in sequence.



4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts and tighten to **10 N·m (89 lb in)**.

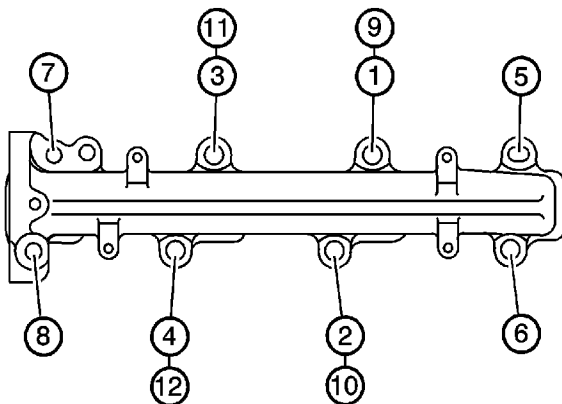
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Exhaust Manifold Installation - Right Side



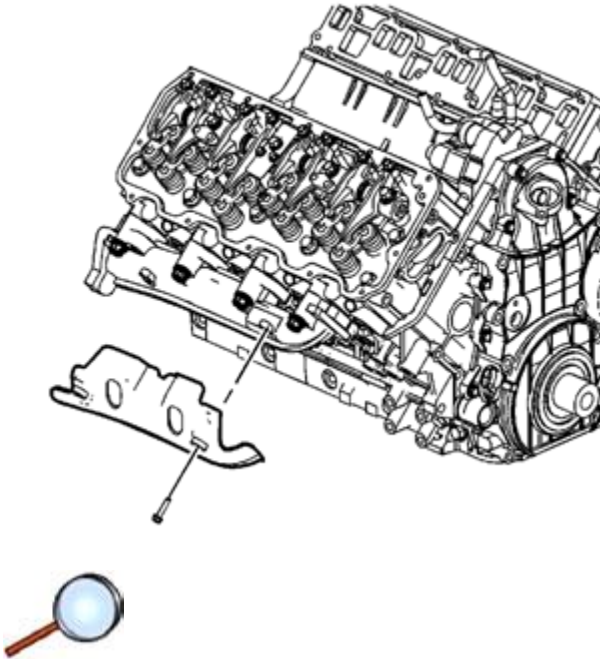
1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

Caution: Refer to [Fastener Caution](#) in the Preface section.



3. Install the exhaust manifold bolts and nuts.

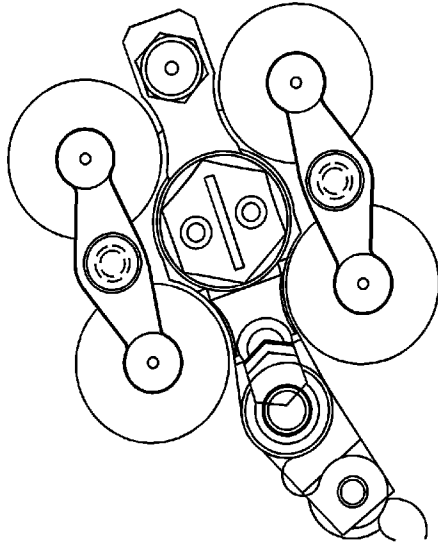
- 3.1. Tighten the exhaust manifold bolts and nuts to **57 N·m (42 lb ft)** in the proper sequence.
- 3.2. Tighten the center exhaust manifold bolts and nuts an additional pass to **57 N·m (42 lb ft)** in sequence.



4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts and tighten to **10 N·m (89 lb in)**.

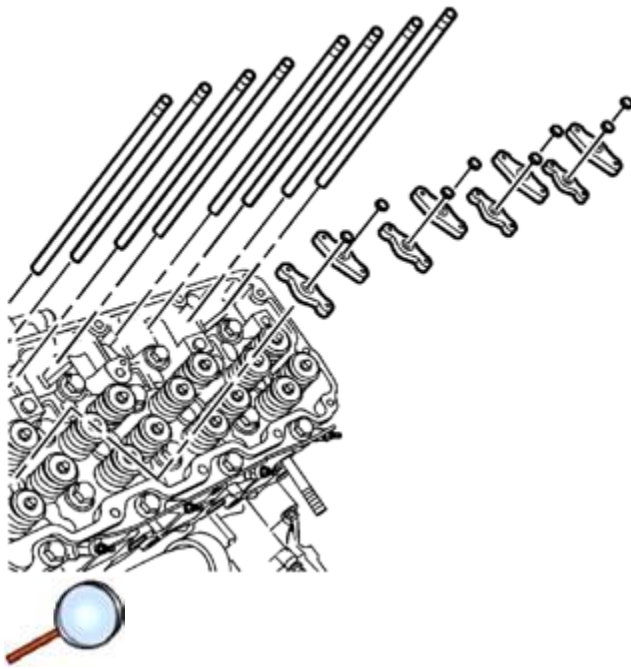
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Valve Rocker Arm, Shaft, and Push Rod Installation

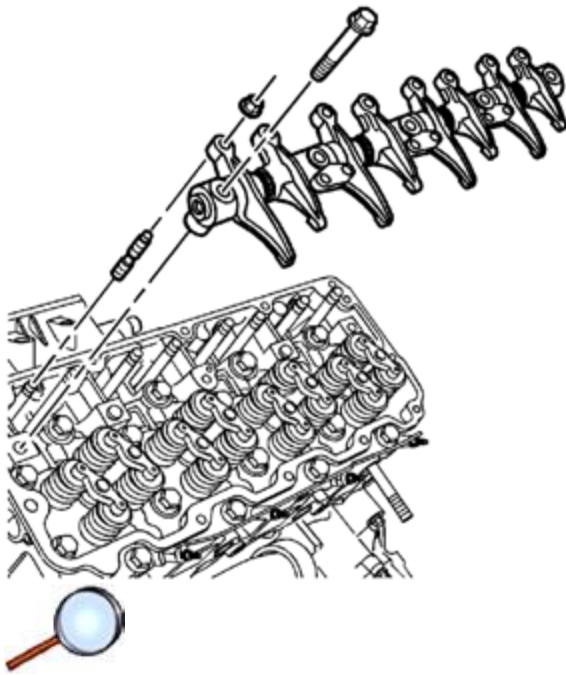


Note: Install the valve bridge with the expansion side of bridge away from the injector.

1. Install the valve bridge.



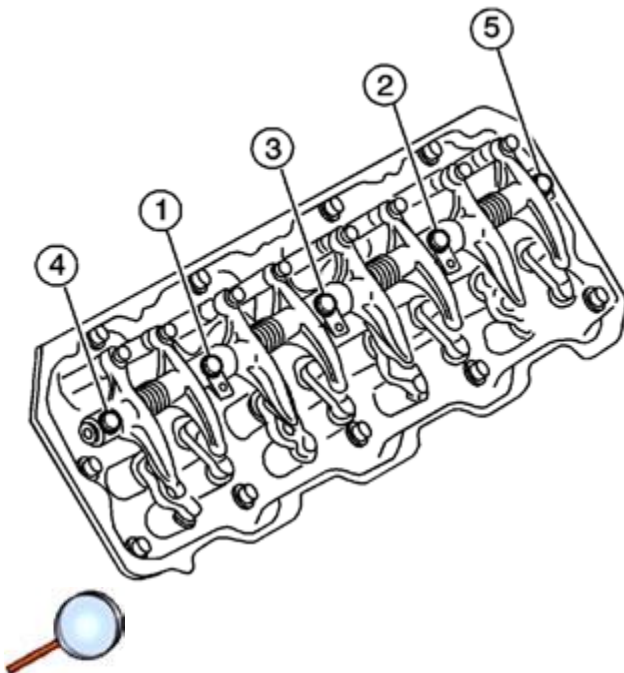
2. Install the valve bridge pins.
3. Install the pushrods.



Caution: The pushrods must be correctly seated in the valve lifter and valve rocker arms before the rocker arm shaft assembly is torqued into place. Improper seating of the pushrods can cause damage to the pushrods or the valve rocker arm shaft assembly components.

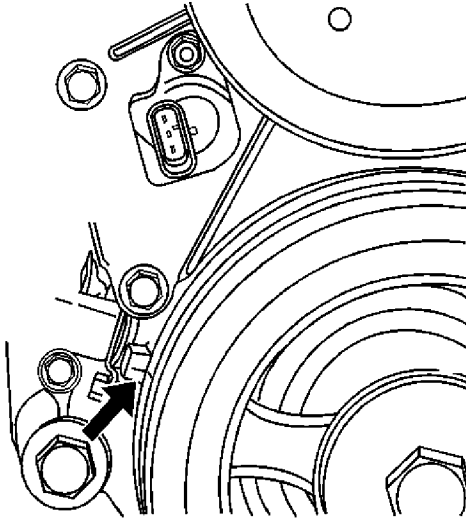
4. Install the rocker arm shaft assembly.

Caution: Refer to [Fastener Caution](#) in the Preface section.

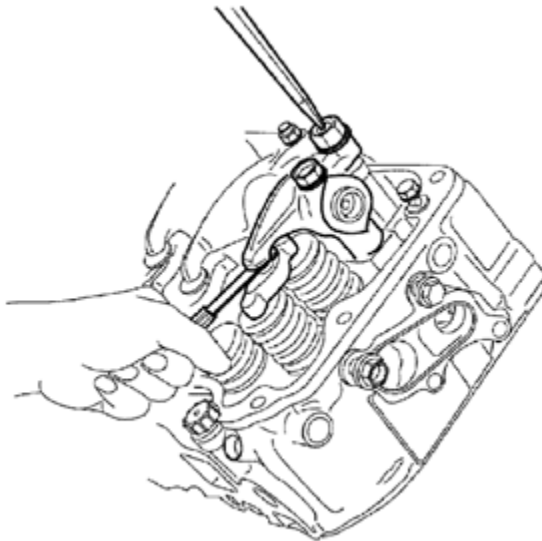


5. Install the rocker arm shaft assembly bolts. Tighten the rocker arm shaft assembly bolts in the proper sequence. Tighten the rocker arm shaft bolts to **41 N·m (30 lb ft)**.

Valve Clearance Adjustment

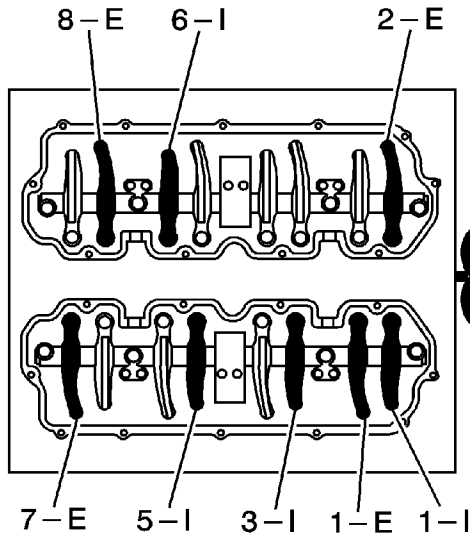


1. Rotate the crankshaft to bring the number 1 cylinder at the top dead center of the compression stroke. The number 1 cylinder is the front cylinder on the right bank. The mark on the crankshaft balancer should be aligned with the mark on the engine.

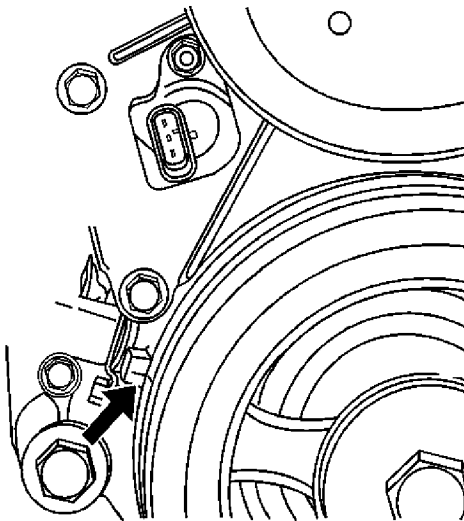


2. Loosen the valve adjusting screws.
3. Insert a feeler gauge between the tip of the rocker arm and the valve bridge.

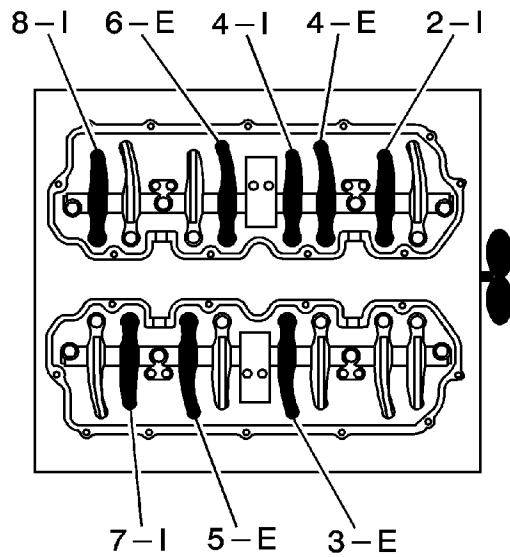
Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Adjust the valve lash to 0.3 mm (0.012 in). Refer to [Valve Clearance Adjustment Specifications](#) to determine which valves that can be adjusted when the engine is at Top Dead Center. Tighten the valve lash lock nut to **22 N·m (16 lb ft)**.

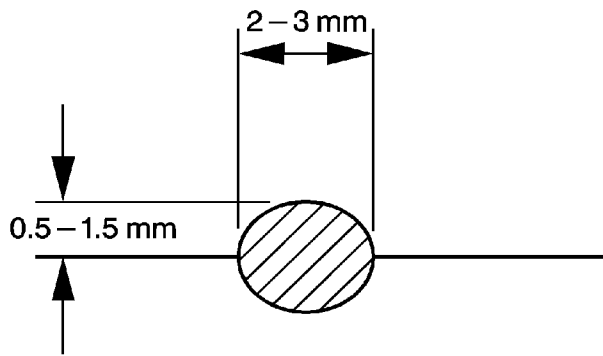


5. Rotate the crankshaft one revolution to bring the number 1 cylinder at Top Dead Center of the exhaust stroke.

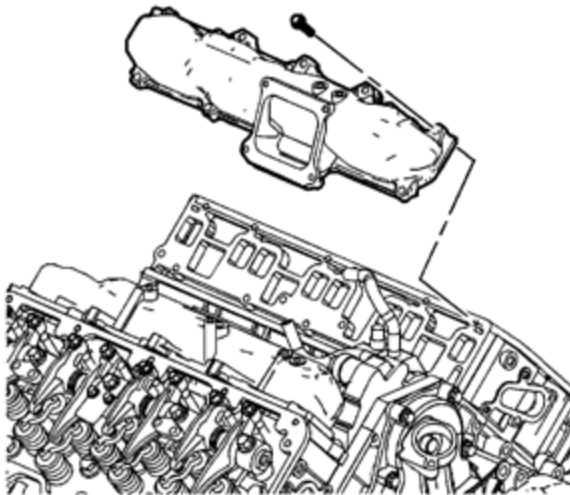


6. Adjust the valve lash to 0.3 mm (0.012 in). Refer to [Valve Clearance Adjustment Specifications](#) to determine which valves that can be adjusted when the engine is at Top Dead Center. Tighten the valve lash lock nut to **22 N·m (16 lb ft)**.

Intake Manifold Installation - Left Side

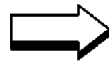
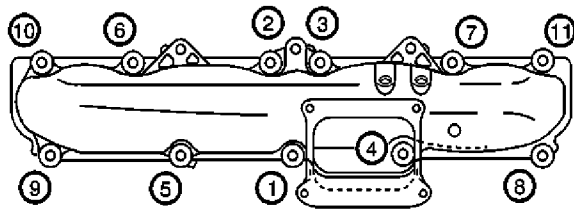


1. Apply a 2-3 mm wide by 0.5-1.5 mm high bead of GM P/N 12378521 (Canadian P/N 88901148) sealant on the intake manifold mating surface.



2. Install the intake manifold.

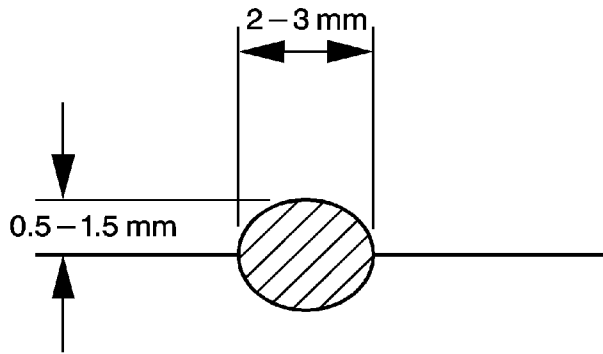
Caution: Refer to [Fastener Caution](#) in the Preface section.



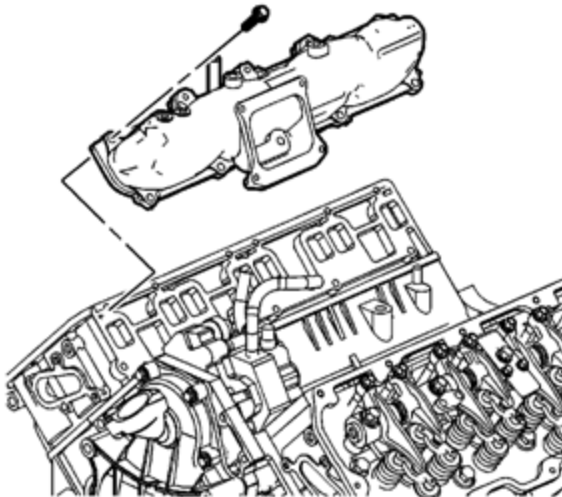
3. Install the intake manifold bolts and nuts and tighten to **25 N·m (18 lb ft)**.

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Intake Manifold Installation - Right Side

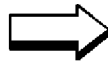
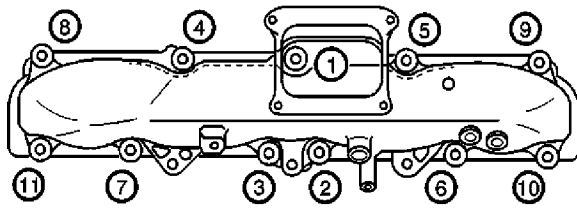


1. Apply a 2-3 mm wide by 0.5-1.5 mm high bead of GM P/N 12378521 (Canadian P/N 88901148) sealant on the intake manifold mating surface.



2. Install the intake manifold.

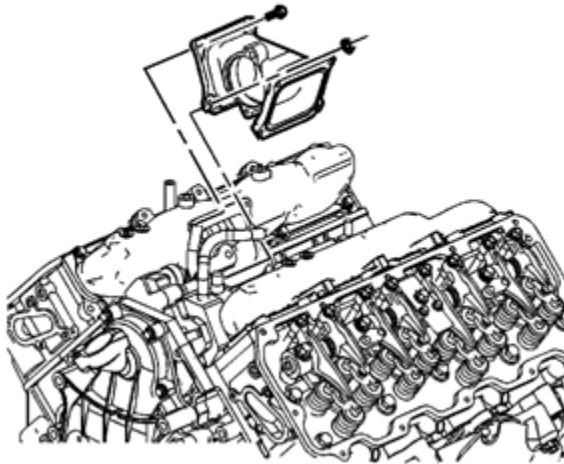
Caution: Refer to [Fastener Caution](#) in the Preface section.



3. Install the intake manifold bolts and nuts and tighten to **25 N·m (18 lb ft)**.

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Intake Manifold Crossover Installation

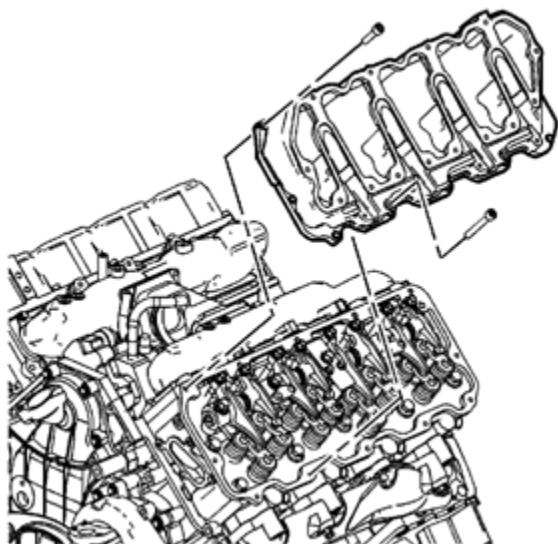


1. Install the intake manifold crossover gaskets.
2. Install the intake manifold crossover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the intake manifold crossover nuts and bolts in sequence. Tighten the intake manifold crossover nuts and bolts to **10 N·m (89 lb in)**.

Valve Rocker Arm Cover Installation - Lower Left Side

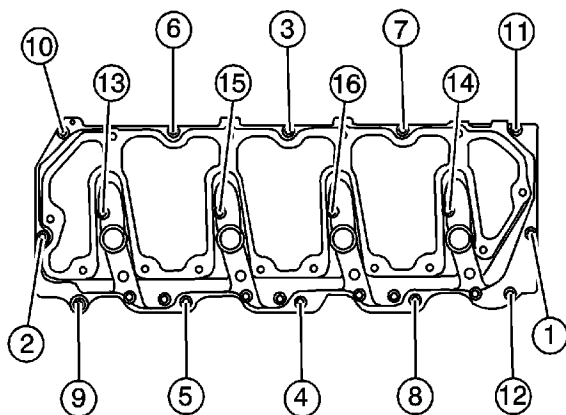


1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

Note: The gasket may be reused if it is not torn, cracked, stretched, or swollen.

2. Install the lower valve rocker arm cover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

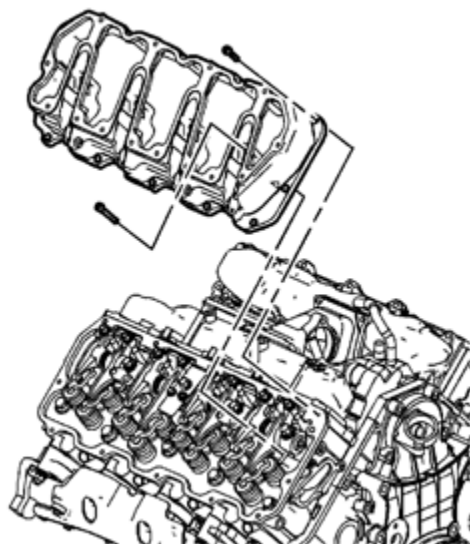




3. Install the lower valve rocker arm cover bolts.
 - 3.1. Tighten the lower valve rocker arm cover bolts in the proper sequence to **10 N·m (89 lb in)**.
 - 3.2. Retighten the lower valve rocker arm cover bolts in the proper sequence to the same torque, **10 N·m (89 lb in)**.

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Valve Rocker Arm Cover Installation - Lower Right Side

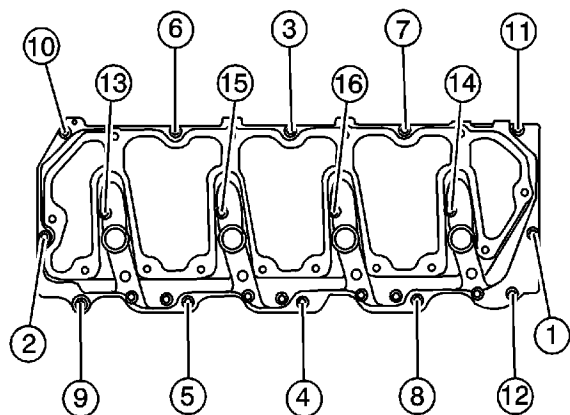


1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

Note: The gasket may be reused if it is not torn, cracked, stretched, or swollen.

2. Install the lower valve rocker arm cover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

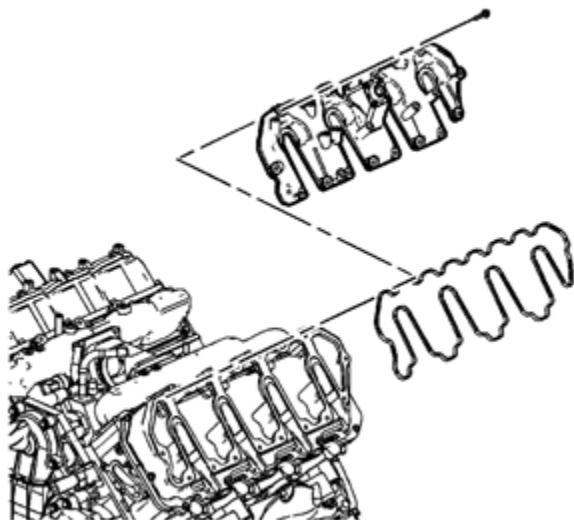




3. Install the lower valve rocker arm cover bolts.
 - 3.1. Tighten the lower valve rocker arm cover bolts in the proper sequence to **10 N·m (89 lb in)**.
 - 3.2. Retighten the lower valve rocker arm cover bolts in the proper sequence to the same torque, **10 N·m (89 lb in)**.

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Valve Rocker Arm Cover Installation - Upper Left Side

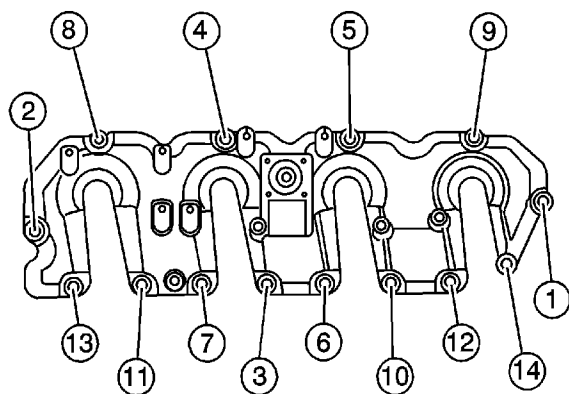


1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

Note: The gasket may be reused if it is not torn, cracked, stretched, or swollen.

2. Install the upper valve rocker arm cover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

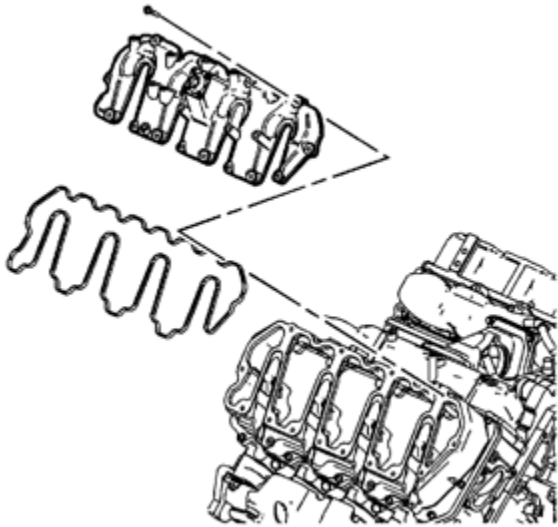




3. Install the upper valve rocker arm cover bolts. Tighten the upper valve rocker arm cover bolts to **8 N·m (71 lb in)**.

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Valve Rocker Arm Cover Installation - Upper Right Side

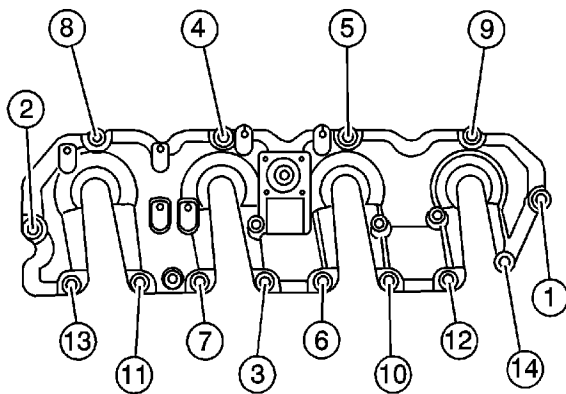


1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

Note: The gasket may be reused if it is not torn, cracked, stretched, or swollen.

2. Install the upper valve rocker arm cover.

Caution: Refer to [Fastener Caution](#) in the Preface section.

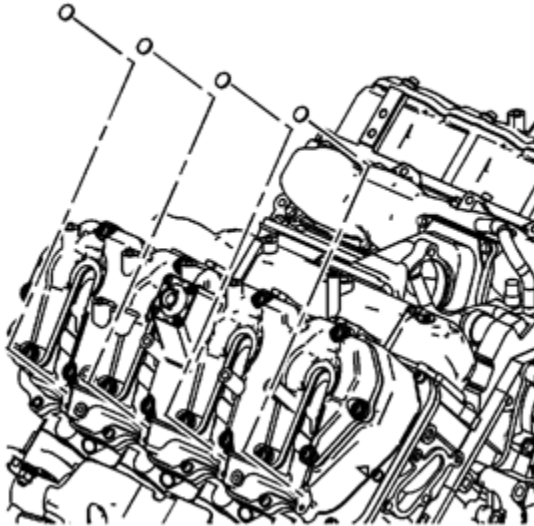




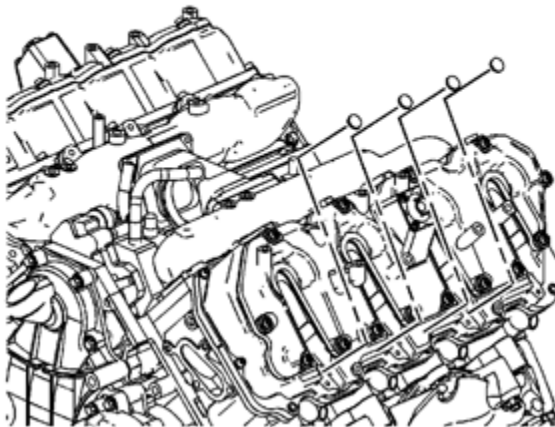
3. Install the upper valve rocker arm cover bolts. Tighten the upper valve rocker arm cover bolts in the proper sequence to **8 N·m (71 lb in)**.

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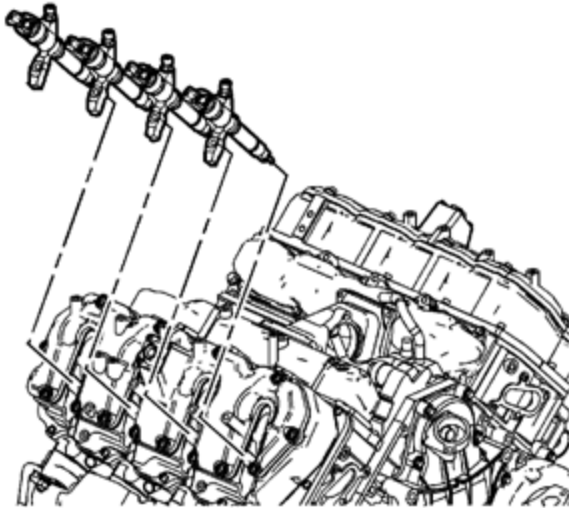
Fuel Injector Installation



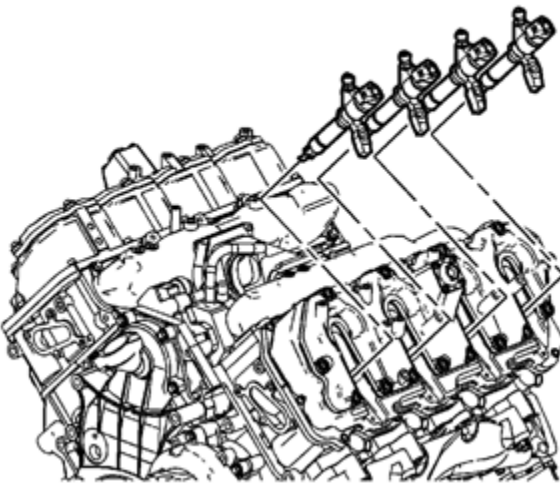
1. Install a new O-ring onto the fuel injector.
2. Lubricate the O-ring with engine oil.
3. Install a new copper washer into the fuel injector bore in the cylinder head.
4. Install the fuel injector right bracket pin.



5. Install the fuel injector left bracket pin.

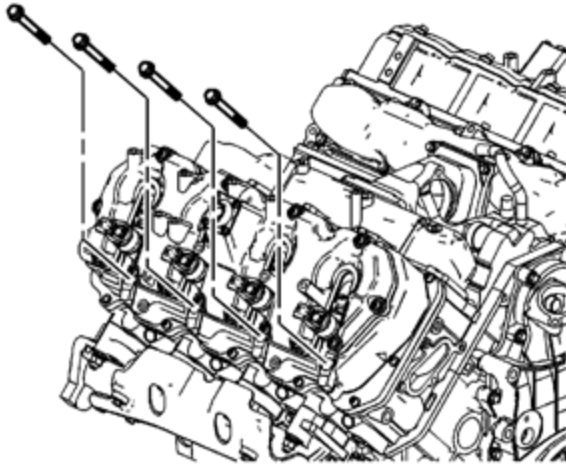


6. Install the right fuel injector with fuel injector bracket.

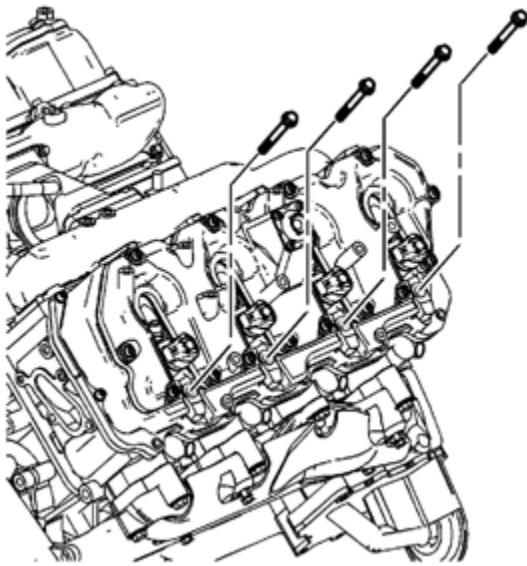


7. Install the left fuel injector with fuel injector bracket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

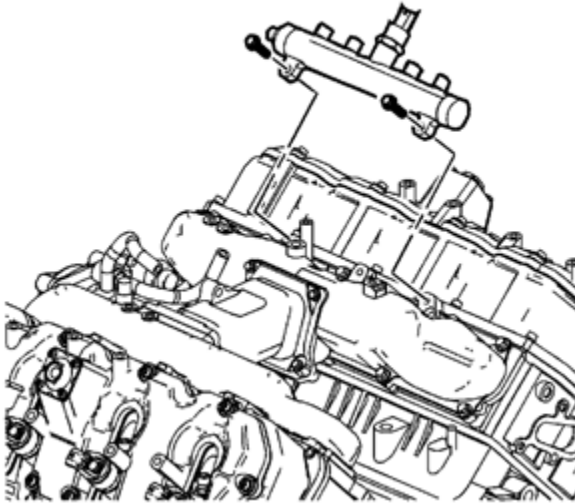


8. Install the right fuel injector bracket bolts and tighten to **30 N·m (22 lb ft)**.



9. Install the left fuel injector bracket bolts and tighten to **30 N·m (22 lb ft)**.

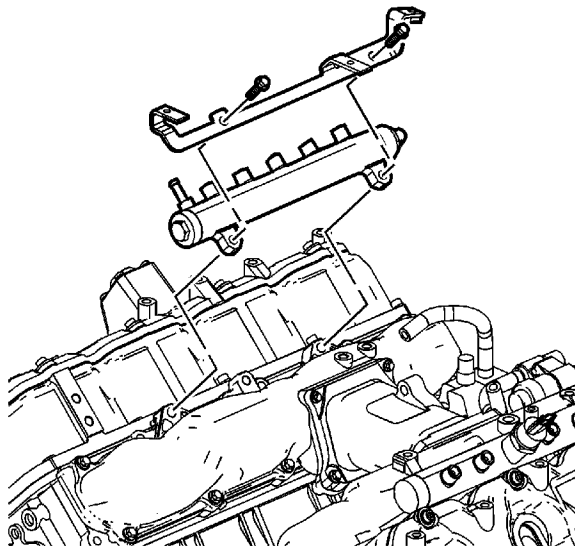
Fuel Pipes and Fuel Rail Installation



1. Install the right fuel rail.

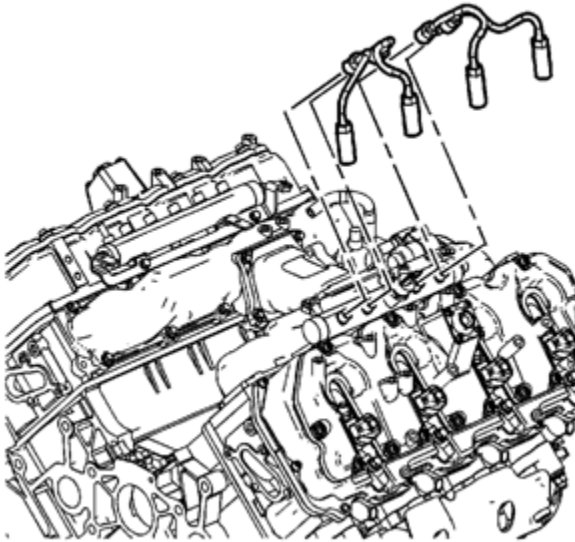
Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the right fuel rail mounting bolts and tighten to **25 N·m (18 lb ft)**.



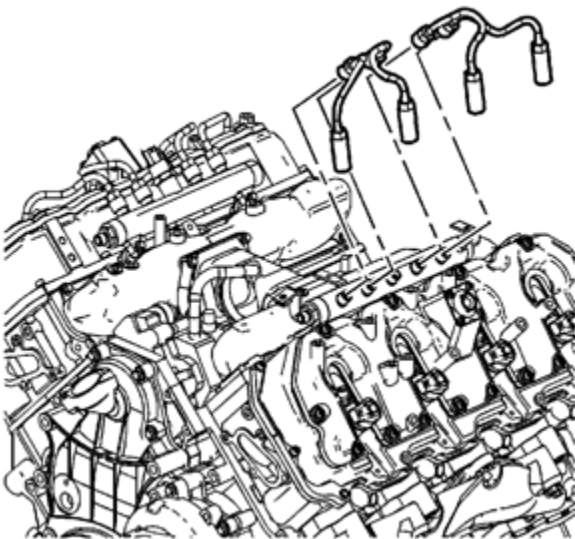
3. Install the left fuel rail.

4. Install the left fuel rail mounting bolts and tighten to **25 N·m (18 lb ft)**.



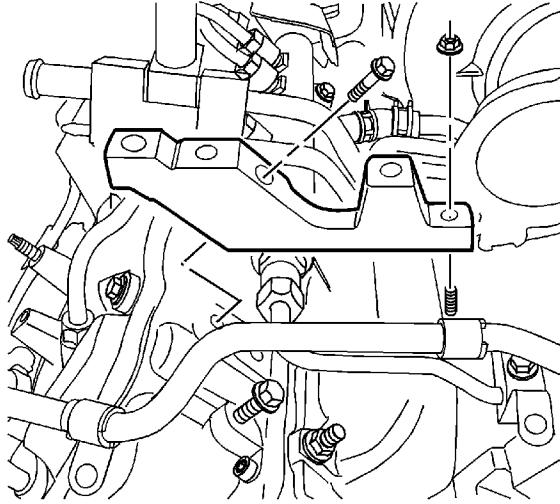
Warning: Improper torque methods of the fuel lines will result in fuel leaks and possible damage to the engine. Failure to follow proper fuel line fitting torque methods could result in serious personal injury.

5. Install the injection pipes to the right bank and tighten to **41 N·m (30 lb ft)**.

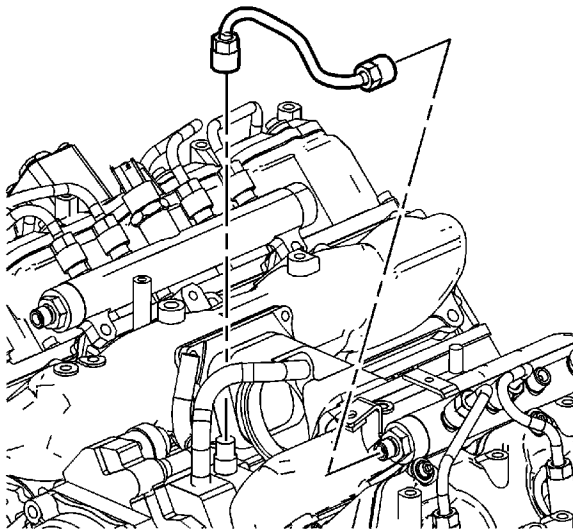


Warning: Improper torque methods of the fuel lines will result in fuel leaks and possible damage to the engine. Failure to follow proper fuel line fitting torque methods could result in serious personal injury.

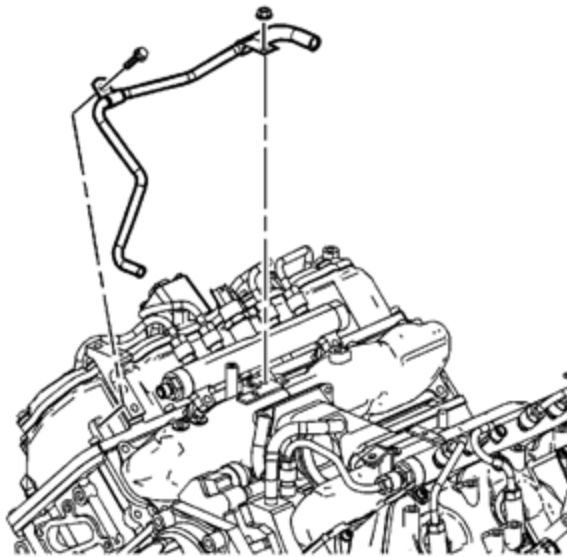
6. Install the injection pipes to the left bank and tighten to **41 N·m (30 lb ft)**.



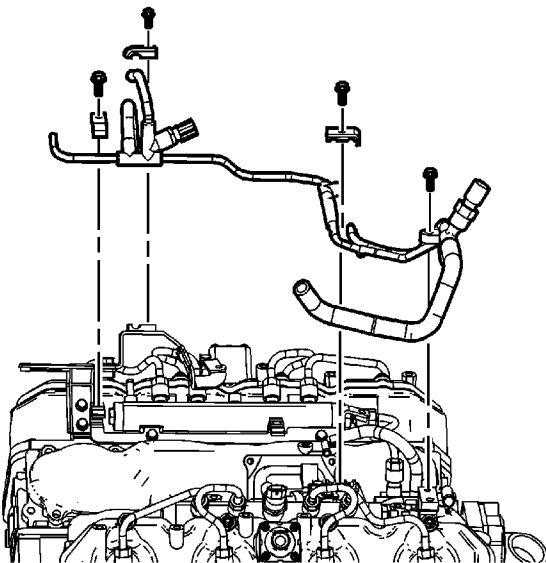
7. Install the exhaust gas recirculation (EGR) mounting brackets.
8. Install the EGR mounting bracket bolts and tighten to **20 N·m (15 lb ft)**.



9. Install the left fuel rail to pump pipe and tighten to **41 N·m (30 lb ft)**.

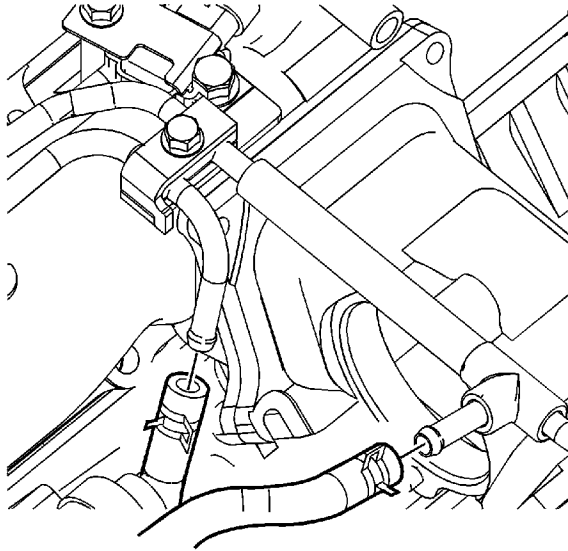


10. Install the coolant pipe.
11. Install the coolant pipe bolt and nut and tighten to **25 N·m (18 lb ft)**.

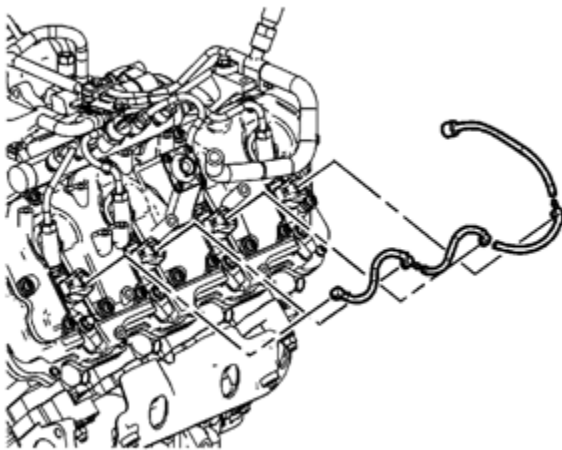


12. Install the distribution block and fuel line assembly.
13. Install the distribution block and fuel line assembly bolts. Tighten the fuel line assembly bolts to **25 N·m (18 lb ft)**.

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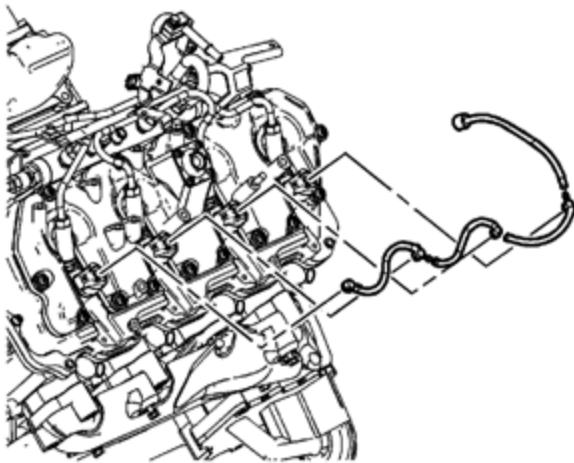


14. Connect the fuel hoses to the fuel injector pump.

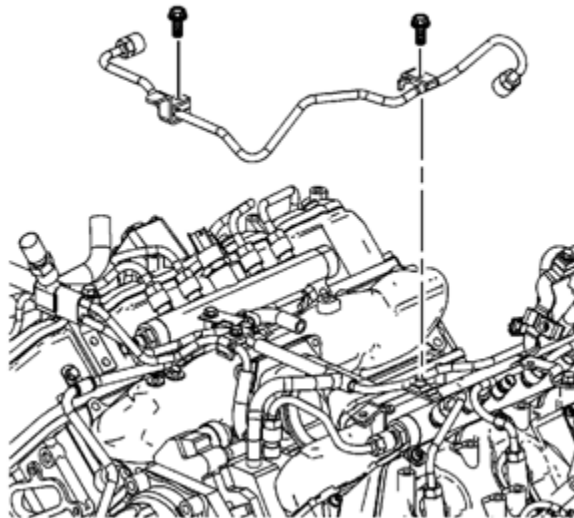


15. Install the right fuel return hose.

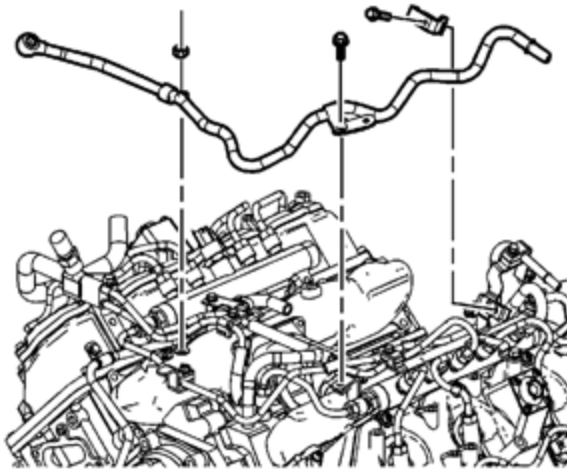
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16. Install the left fuel return hose.



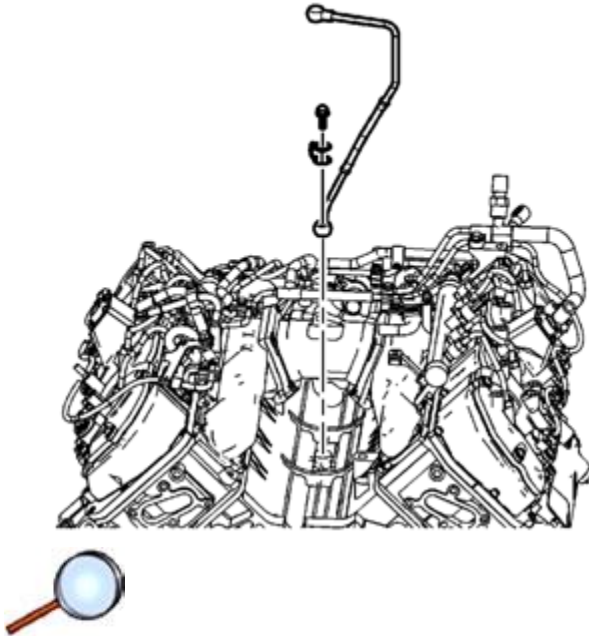
17. Install the fuel rail balance pipe.
18. Install the fuel rail balance pipe bolts and tighten to **21 N·m (15 lb ft)**.
19. Connect the fuel rail balance pipe to the fuel rails. Tighten the fuel rail balance pipe nuts to **41 N·m (30 lb ft)**.



20. Install the fuel feed pipe.
21. Install the fuel feed pipe attaching nuts and bolts. Tighten the fuel feed pipe bolts and nut to **25 N·m (18 lb ft)**.

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Turbocharger Installation



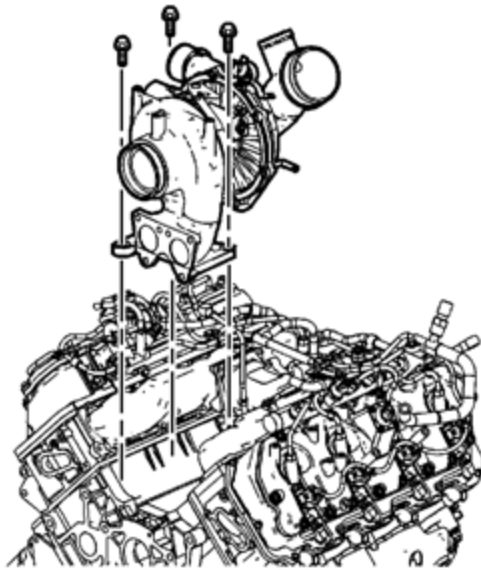
Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

1. Install the turbocharger oil supply line to the engine block.

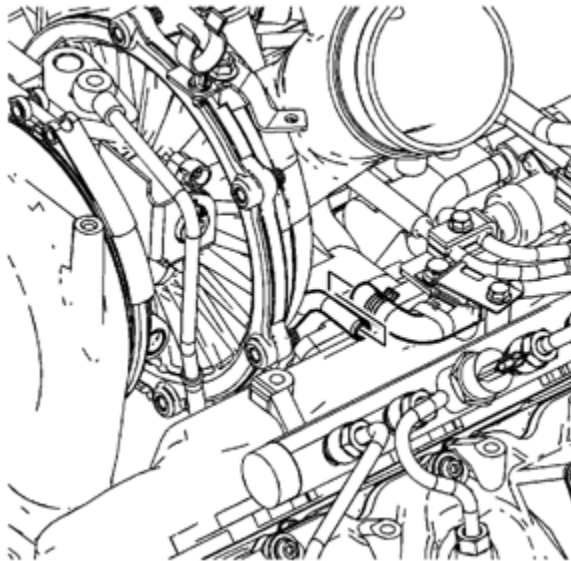
Caution: Refer to [Fastener Caution](#) in the Preface section.

Note: Lubricate the washers with diesel fuel before installing.

2. Install the turbocharger oil supply line eye bolt and washers. Tighten the turbocharger oil supply line eye bolt to **26 N·m (19 lb ft)**.
3. Install the turbocharger lower heat shield to the engine block.

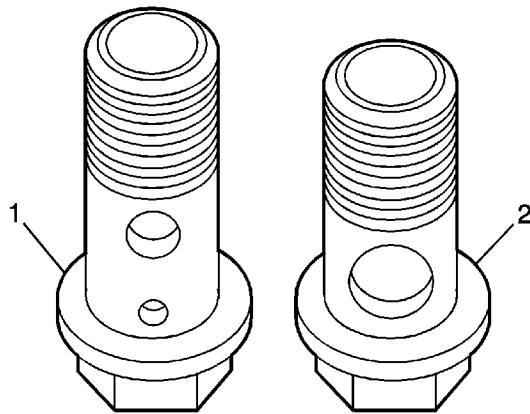


4. Install the turbocharger assembly with the oil return pipe.
5. Install the turbocharger mounting bolts and tighten to **108 N·m (80 lb ft)**.



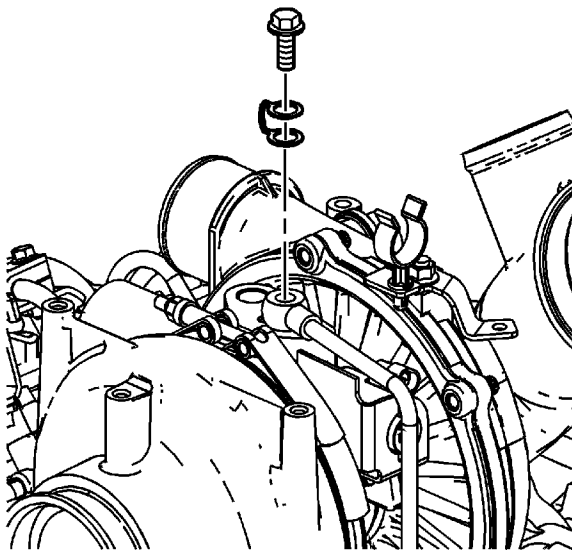
Note: Use care not to damage this hose during the procedure.

6. Install the turbocharger cooling outlet hose and tighten hose clamp.



Note: If the cooling outlet hose eye bolts were removed, install the longer bolt (1) with two holes, in the top location. Install the shorter bolt (2) in the lower location.

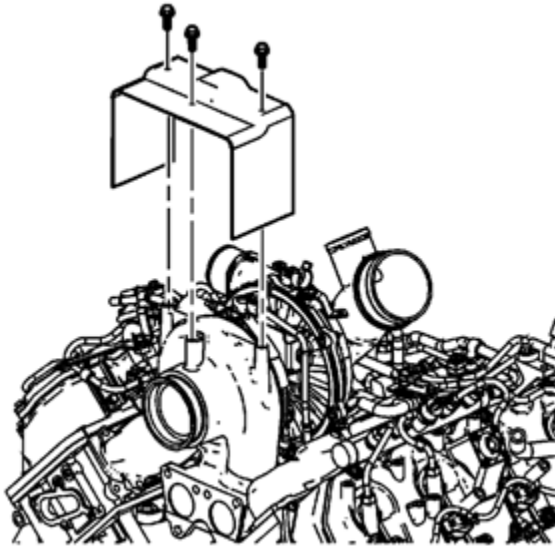
7. Install the cooling outlet hose eye bolts.



Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

8. Install the oil supply line eye bolt and washers to the turbocharger.

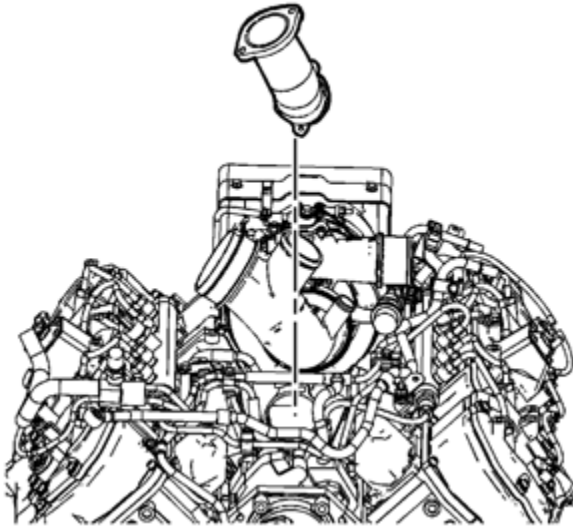
Lubricate the washers with diesel fuel before installing. Tighten the oil supply hose eye bolt to **26 N·m (19 lb ft)**.



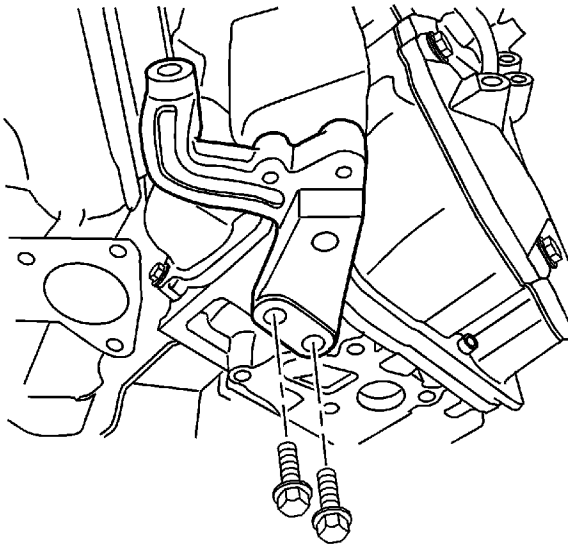
9. Install the turbocharger heat shield.
10. Install the turbocharger upper heat shield bolts and tighten to **10 N·m (89 lb in)**.

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Exhaust Gas Recirculation Valve and Cooler Installation



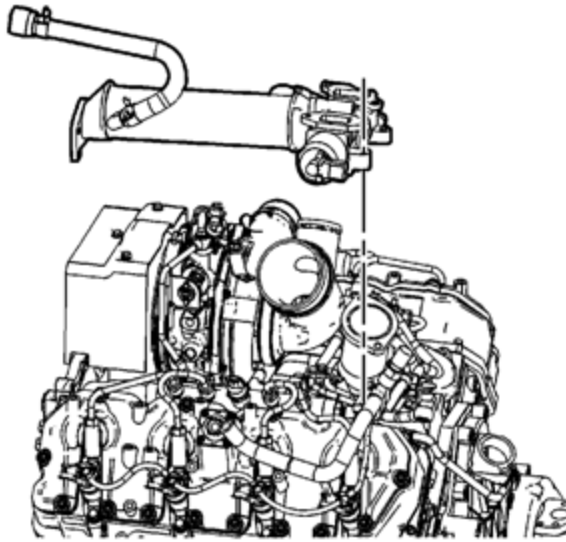
1. Install the intake manifold tube.



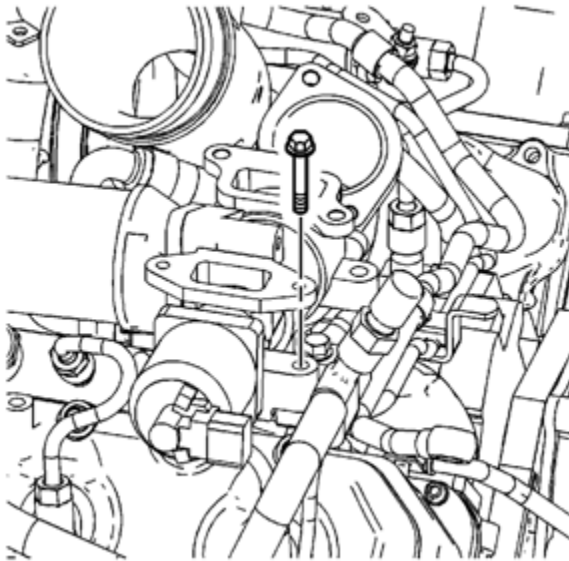
2. Install the exhaust gas recirculation (EGR) cooler bracket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the EGR cooler bracket bolts and tighten to **25 N·m (18 lb ft)**.

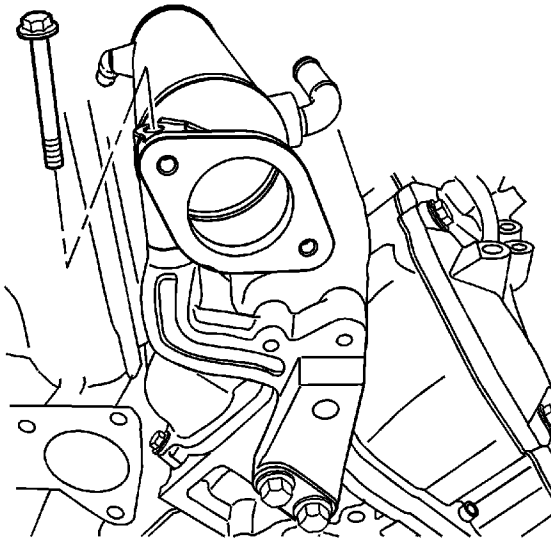


4. Install the EGR and cooler.

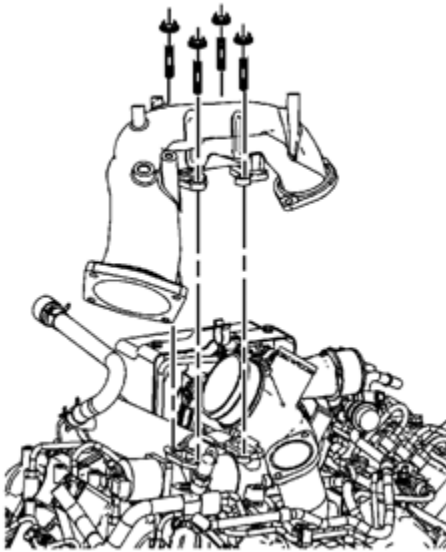


5. Install the EGR mount bolt and tighten to **50 N·m (37 lb ft)**.

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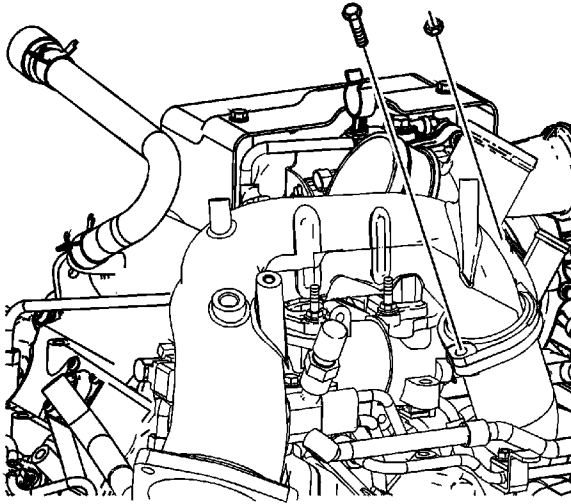


6. Install the top EGR cooler bolts and tighten to **25 N·m (18 lb ft)**.



7. Install the air inlet tube.
8. Install the air inlet tube nuts and tighten to **25 N·m (18 lb ft)**.

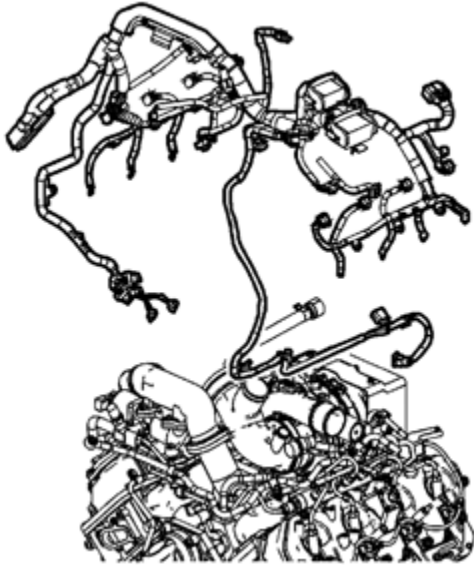
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9. Install the air inlet tube to intake manifold tube bolt and nut. Tighten the air inlet tube to intake manifold tube bolt and nut to **25 N·m (18 lb ft)**.

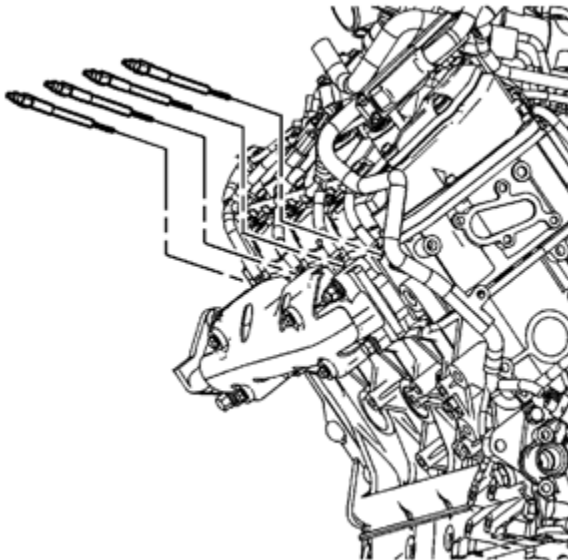
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Engine Wiring Harness Assembly Installation

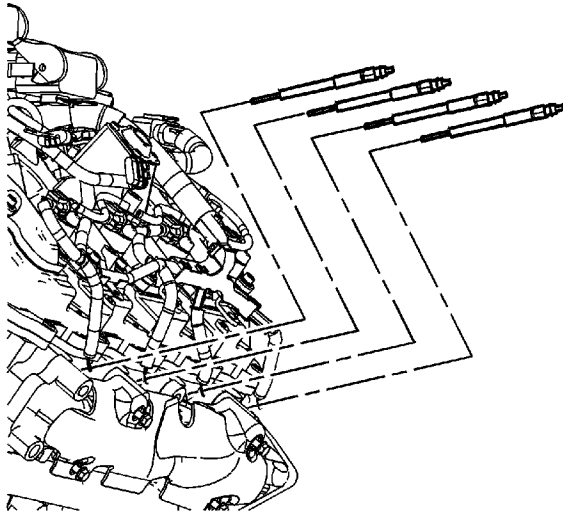


1. Install the engine wiring harness assembly.

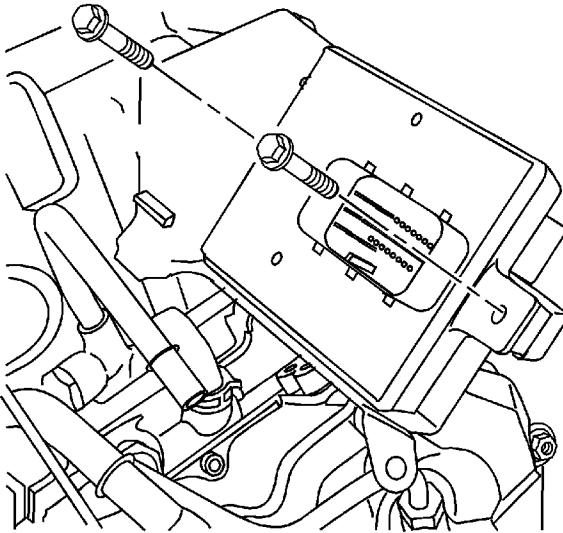
Caution: Refer to [Fastener Caution](#) in the Preface section.



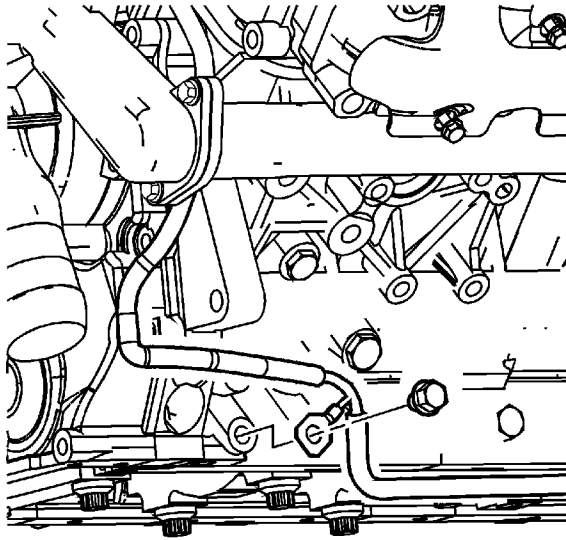
2. Install the right glow plugs and tighten to **18 N·m (13 lb ft)**.



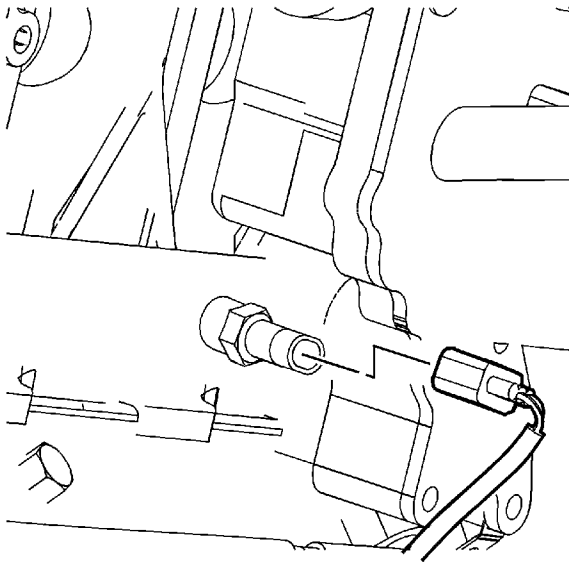
3. Install the left glow plugs tighten to **18 N·m (13 lb ft)**.



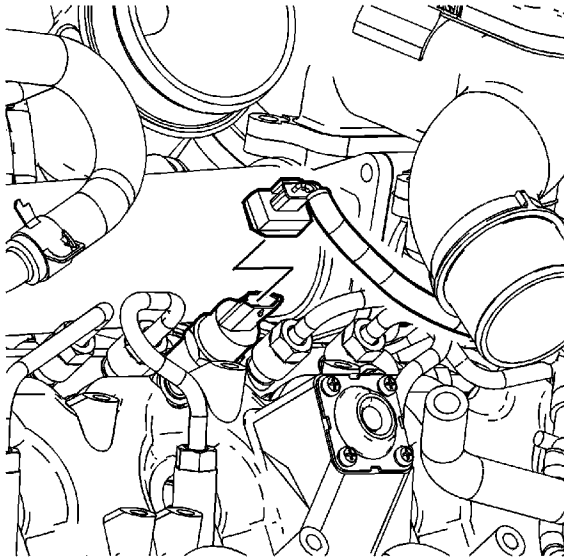
4. Install the glow plug nuts and tighten to **2 N·m (18 lb in)**.
5. Install the glow plug controller.
6. Install the glow plug controller bolts and tighten to **10 N·m (89 lb in)**.



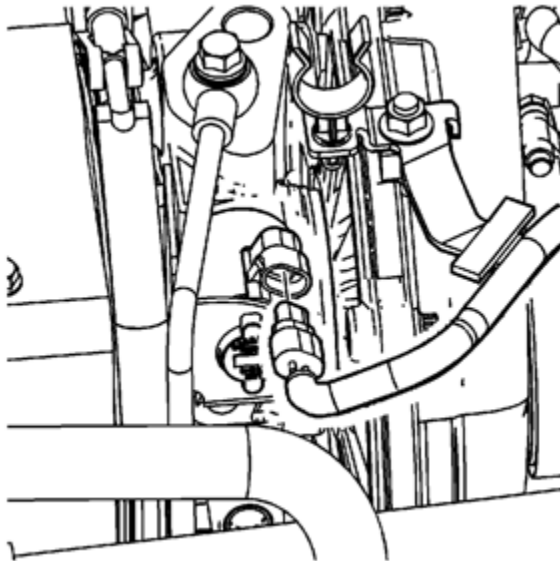
7. Install the oil level sensor harness bolt and tighten to **40 N·m (29 lb ft)**.



8. Connect the oil pressure sensor electrical connector.

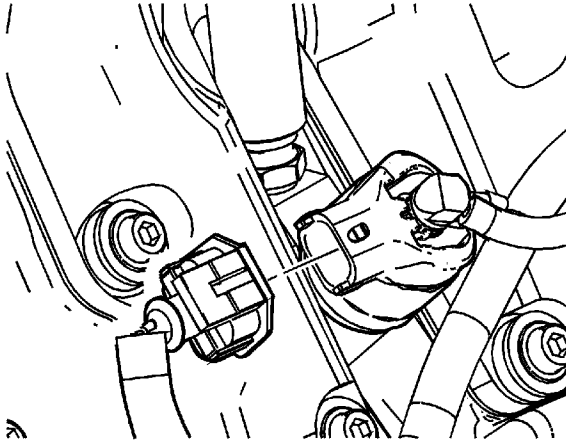


9. Connect the fuel rail pressure sensor.

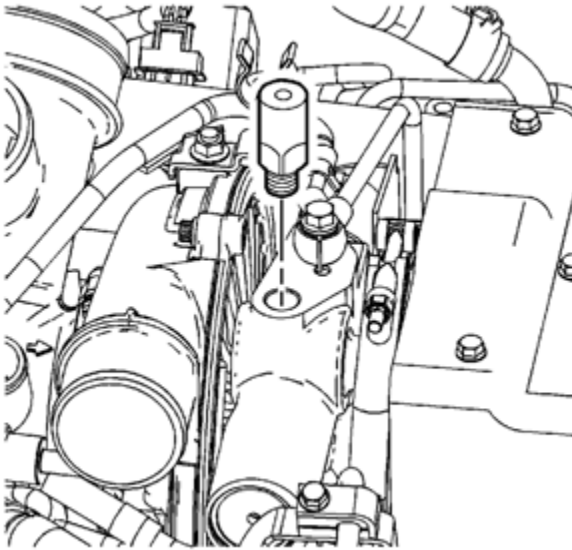


Caution: Label all the injector electrical connectors before the connectors are removed in order to prevent reconnecting to the wrong injector. Failure to properly connect the injectors in the correct sequence will cause severe engine damage.

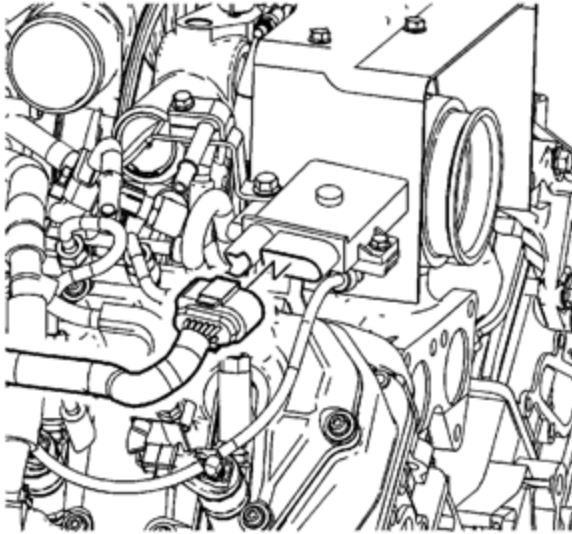
10. Connect the turbocharger vane control solenoid valve.



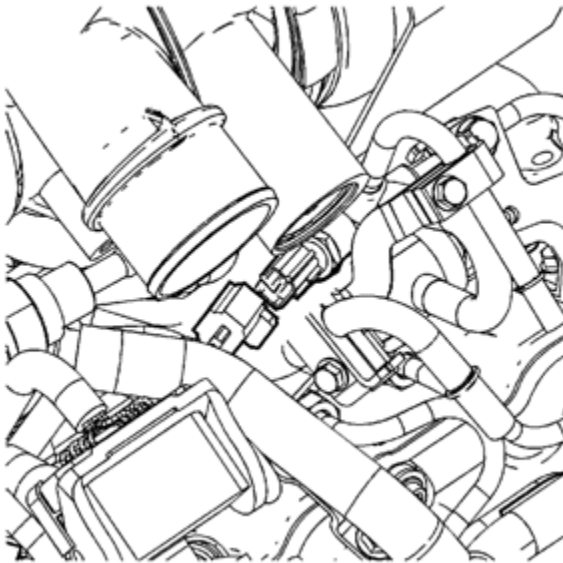
11. Connect the fuel injector electrical connections.



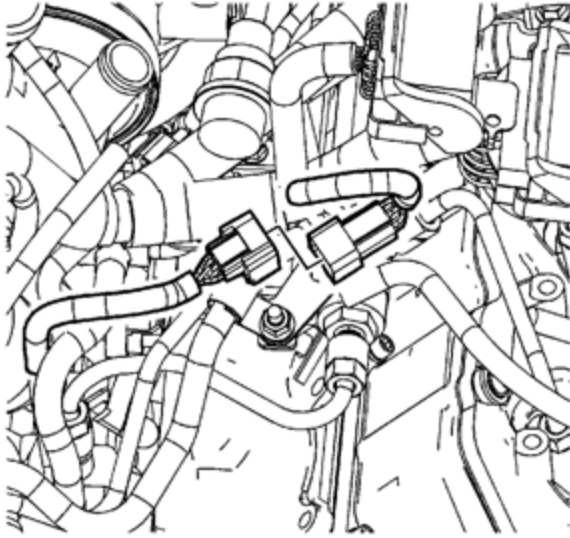
12. Connect and install the turbocharger vane position sensor. Tighten the turbocharger vane position sensor to **23 N·m (16 lb ft)**.



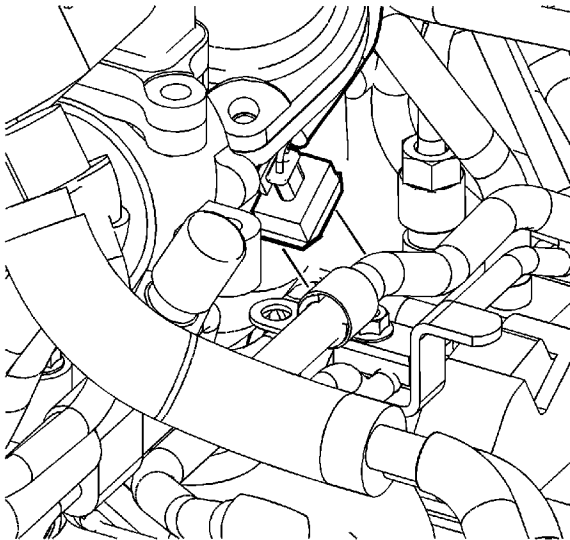
13. Connect the glow plug controller electrical connector.



14. Connect the fuel temperature sensor connector.

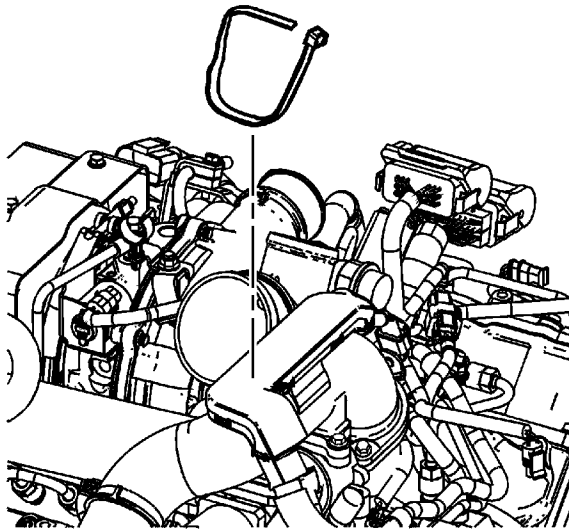


15. Connect the oil level sensor electrical harness connector.

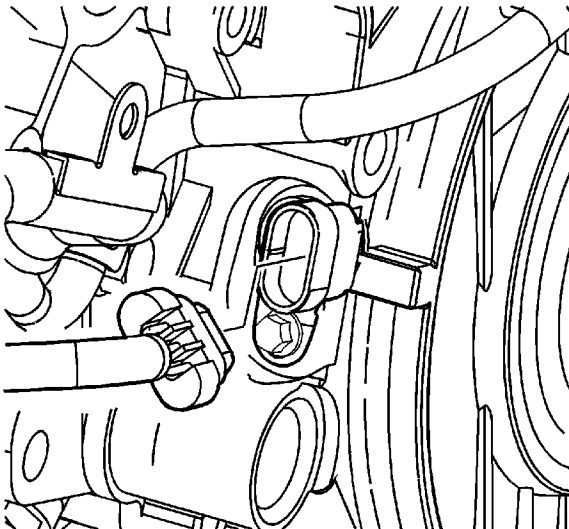


16. Connect the fuel pressure control valve electrical connector.

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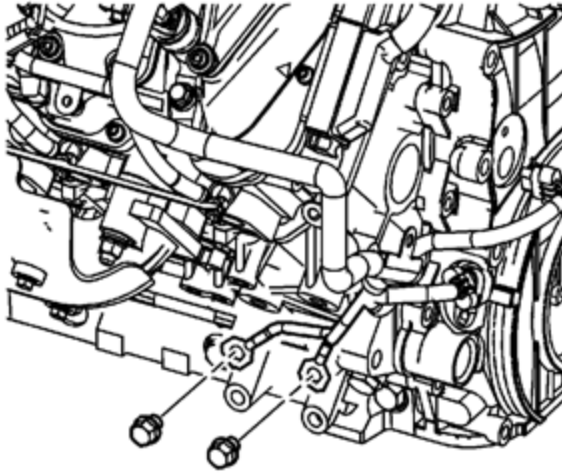


17. Install the tie strap to the electrical harness.

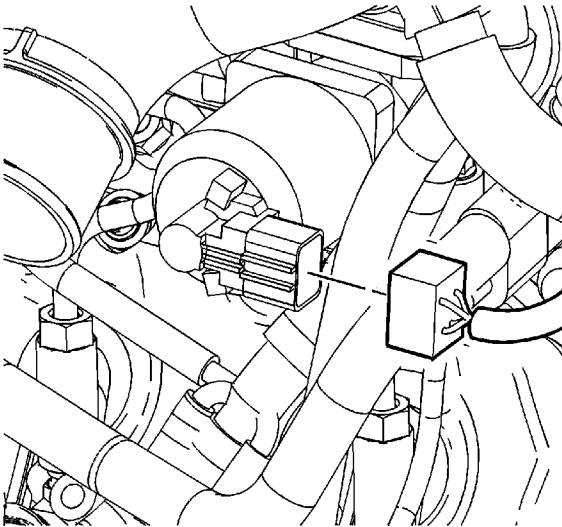


18. Connect the crankshaft position sensor electrical connector.

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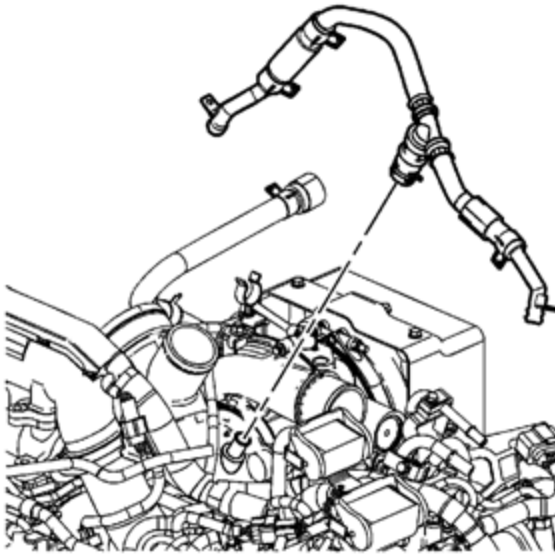


19. Install the two ground bolts and tighten to **41 N·m (30 lb ft)**.

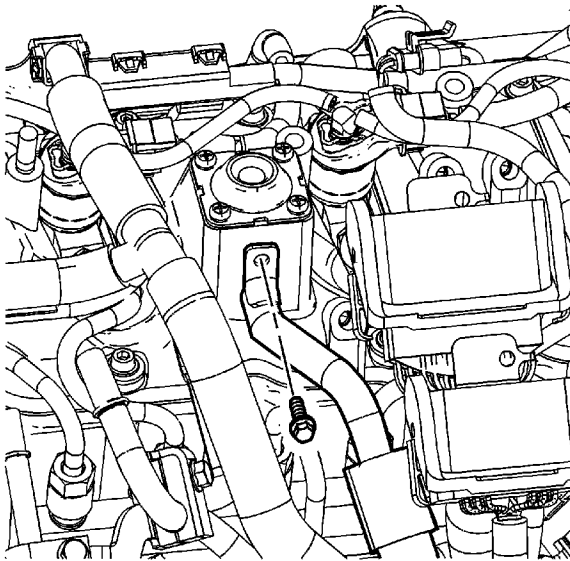


20. Connect the EGR valve electrical connector.

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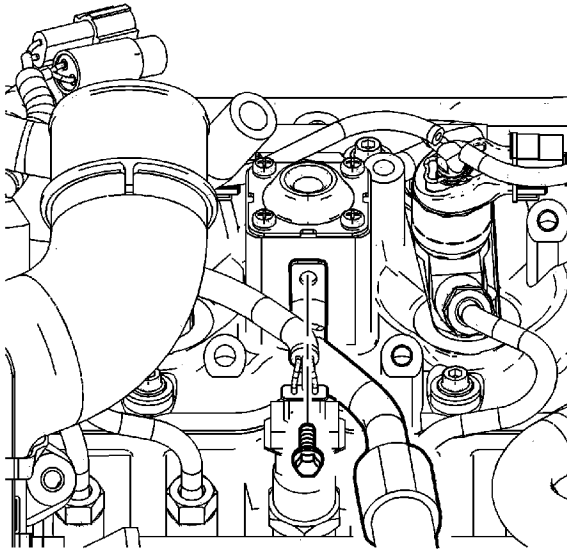


21. Install the positive crankcase ventilation (PCV) pipe.

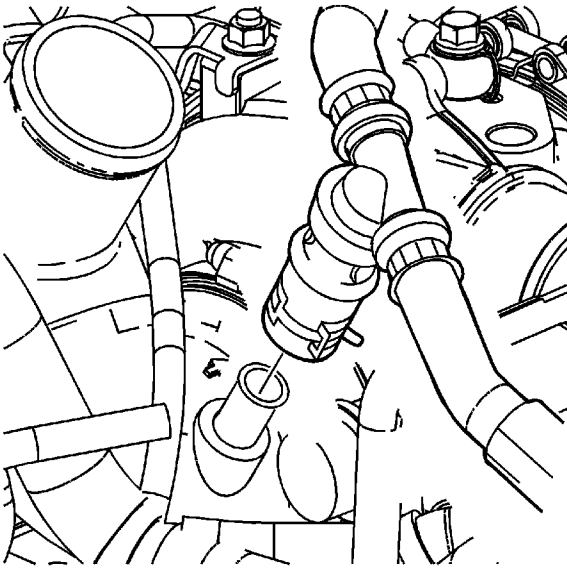


22. Install the left PCV pipe bolt and tighten to **25 N·m (18 lb ft)**.

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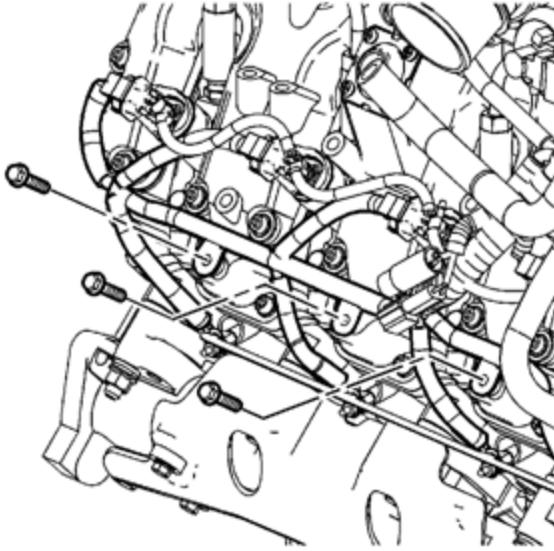


23. Install the right PCV pipe bolt and tighten to **25 N·m (18 lb ft)**.

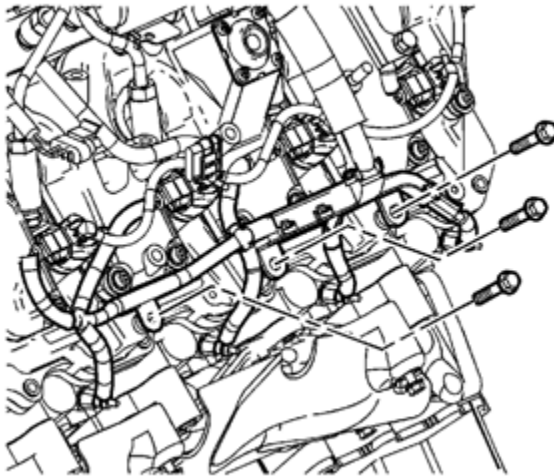


24. Connect the PCV hose clamp.

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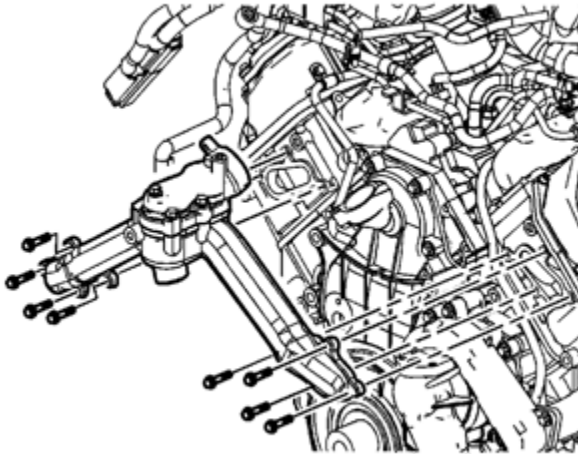


25. Install the right glow plug harness bracket bolts and tighten to **10 N·m (89 lb in)**.



26. Install the left glow plug harness bracket bolts and tighten to **10 N·m (89 lb in)**.

Engine Coolant Thermostat Housing Installation



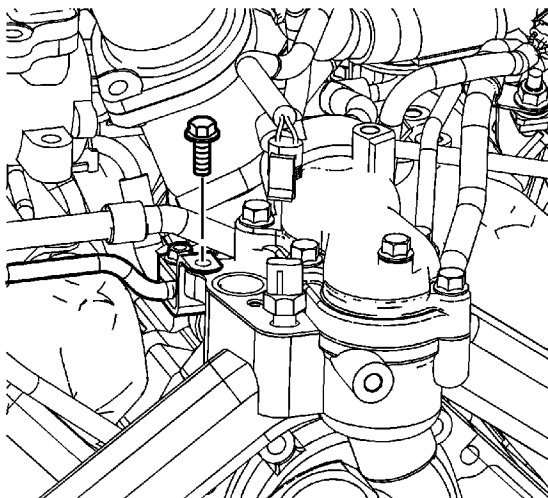
1. Install the thermostat housing.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the thermostat housing bolts and nuts.

Tighten

Tighten the thermostat housing bolts and nuts to 25 N·m (18 lb ft).

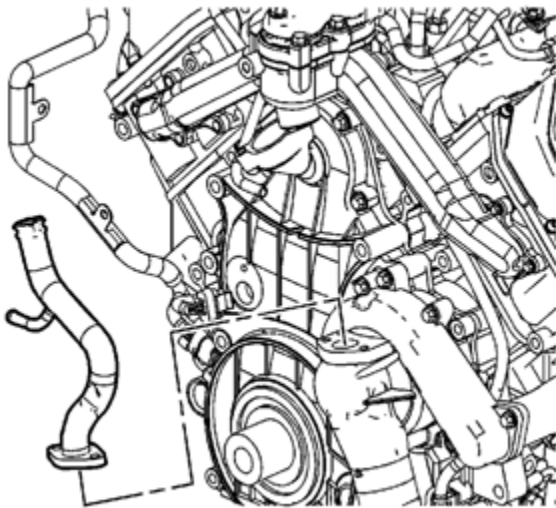




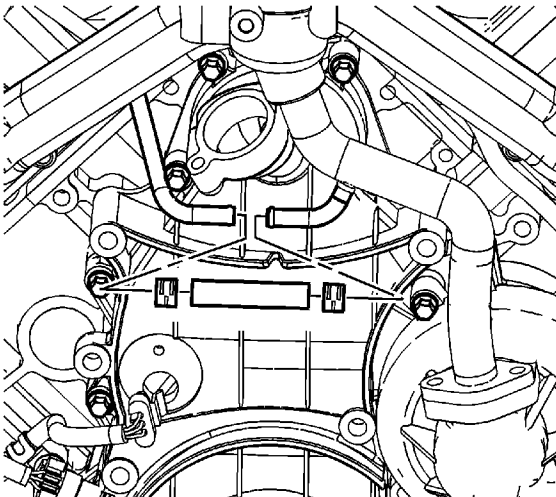
3. Install the fuel pipe bracket bolt.

Tighten

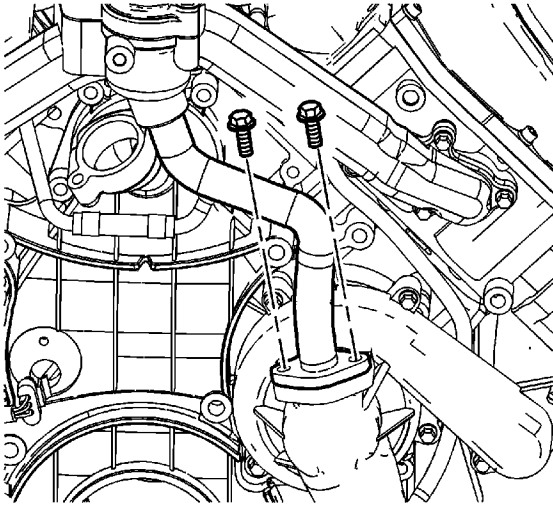
Tighten the fuel pipe bracket bolt to 25 N·m (18 lb ft).



4. Install the water pump inlet pipe.



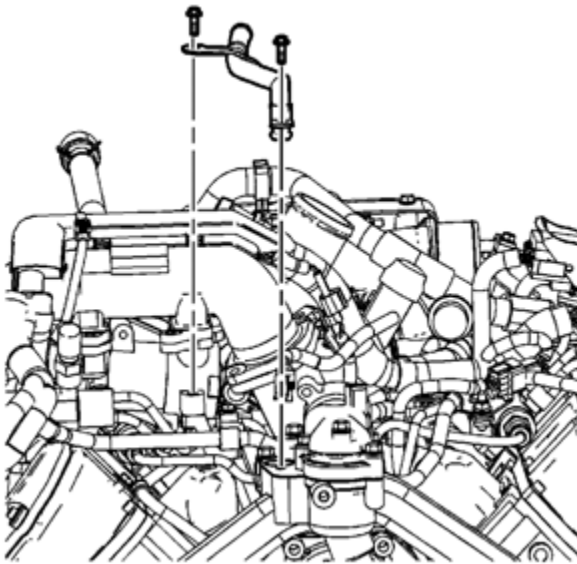
5. Install the turbocharger coolant outlet hose and clamps.



6. Install the water pump inlet pipe bolts.

Tighten

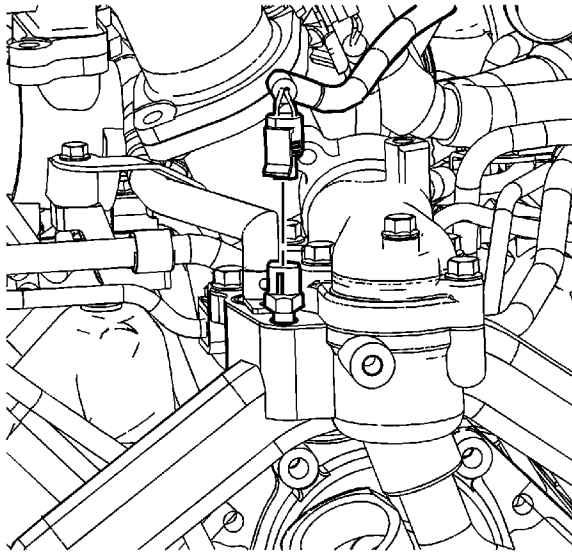
Tighten the water pump inlet pipe bolts to 25 N·m (18 lb ft).



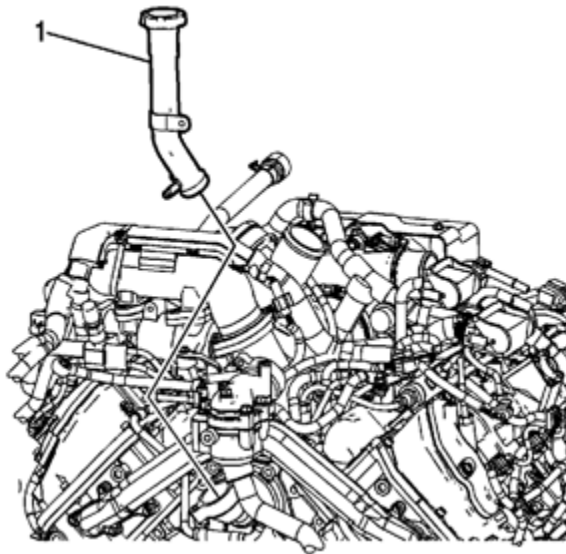
7. Install the EGR coolant pipe.
8. Install the EGR coolant pipe bolts.

Tighten

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

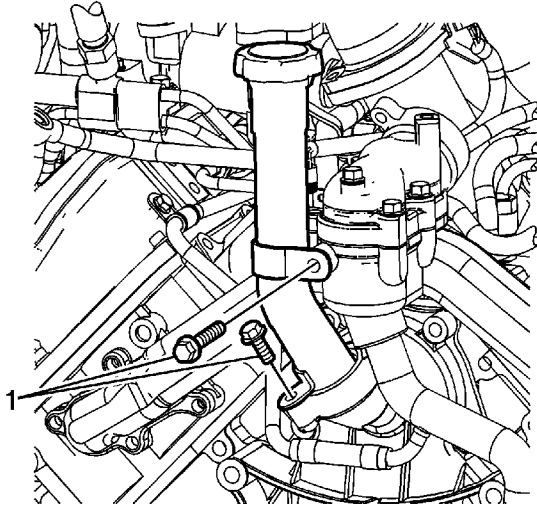


9. Connect the coolant temperature sensor.



10. Install the oil fill tube.

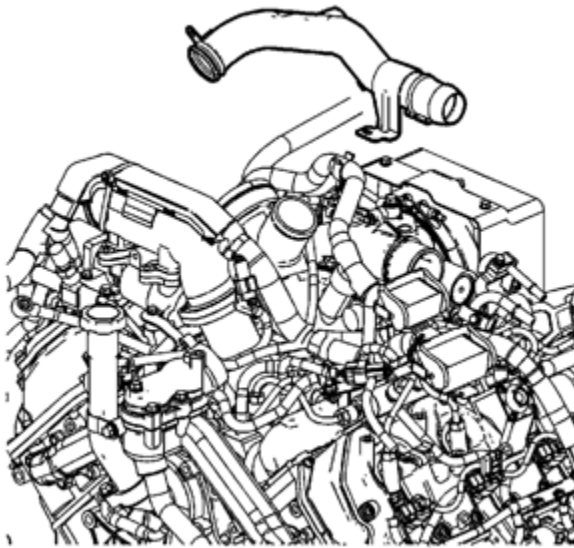
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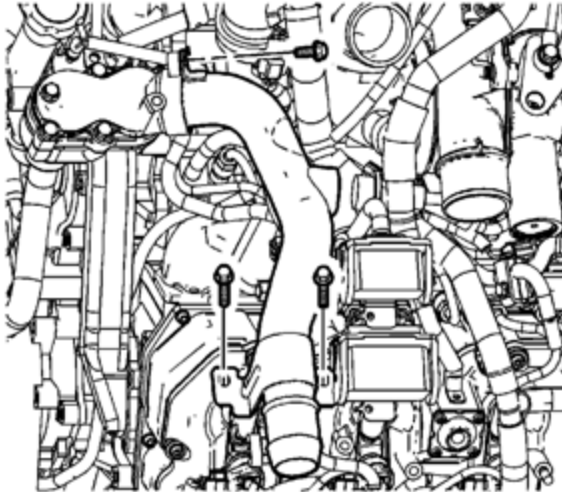
11. Install the oil fill tube bolts.

Tighten

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



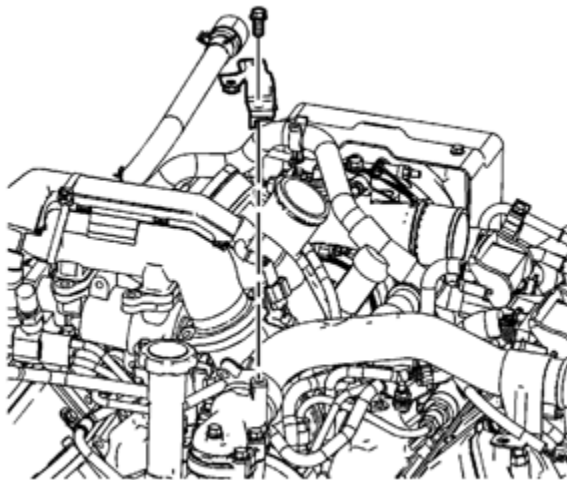
12. Install the water outlet.



13. Install the water outlet bolts.

Tighten

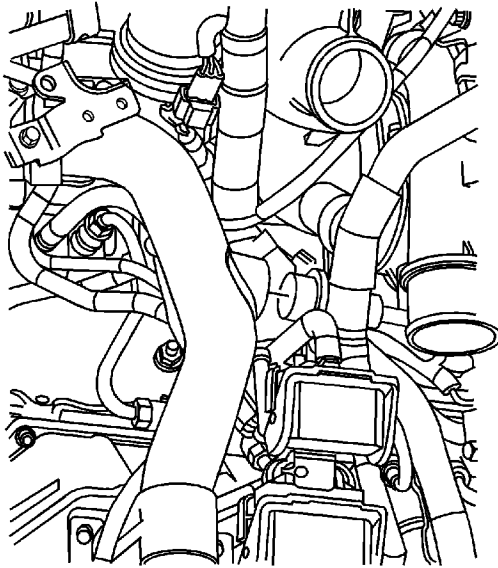
Tighten the water outlet bolts to 25 N·m (18 lb ft).



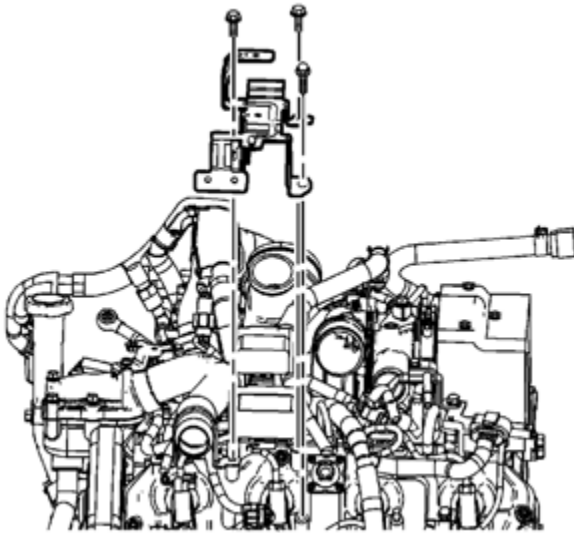
14. Install the electrical harness bracket.
15. Install the electrical harness bracket bolt.

Tighten

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



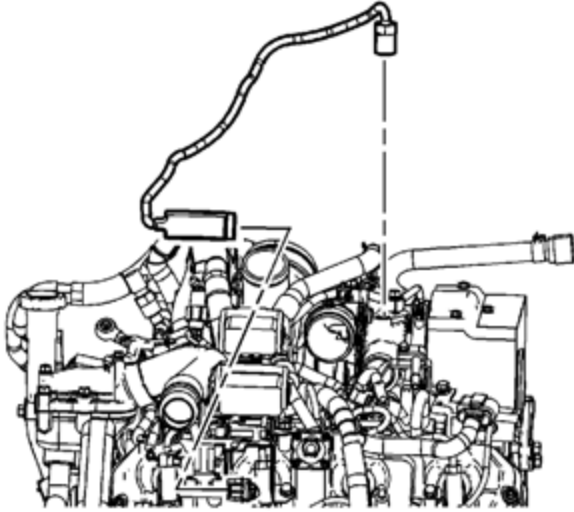
16. Connect the turbocharger coolant inlet hose.



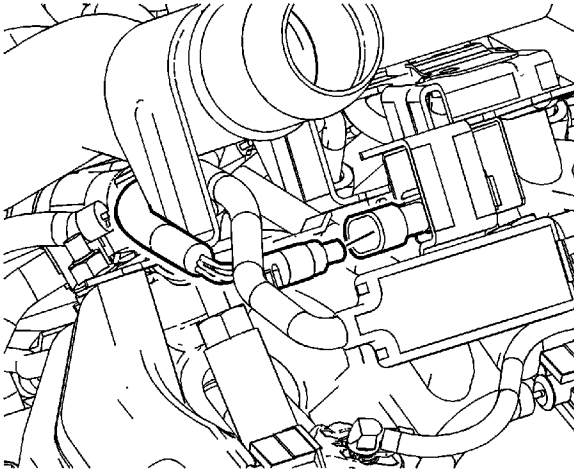
17. Install the main electrical harness bracket.
18. Install the main electrical harness bracket bolts.

Tighten

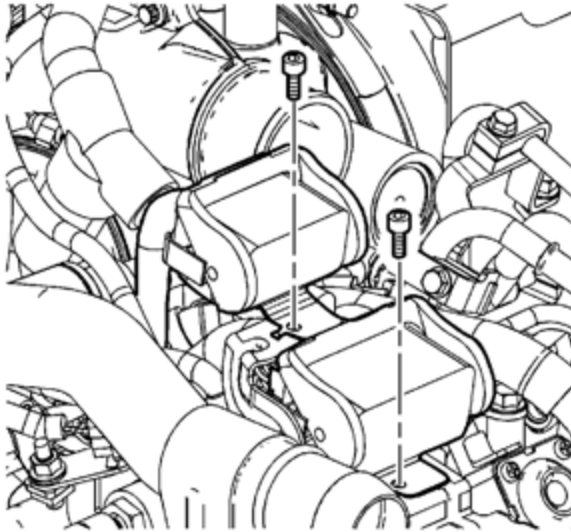
Tighten the main electrical harness bracket bolts to 10 N·m (89 lb in).



19. Connect and install the turbocharger vane position sensor.



20. Connect and install the barometric sensor.



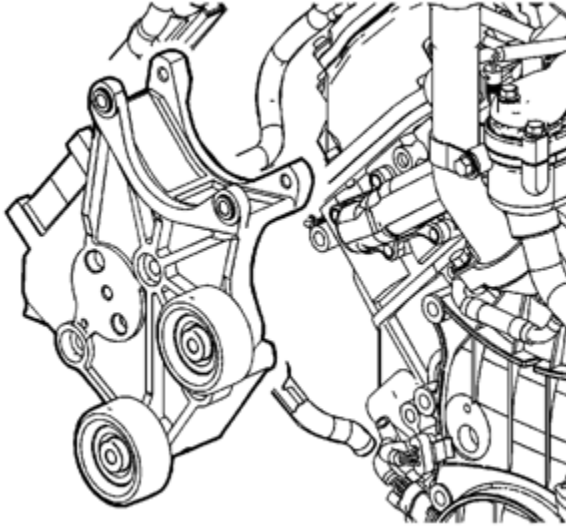
21. Install the main engine electrical harness connector hold down bolts.

Tighten

Tighten the main electrical harness connector hold down bolts to 10 N·m (89 lb in).

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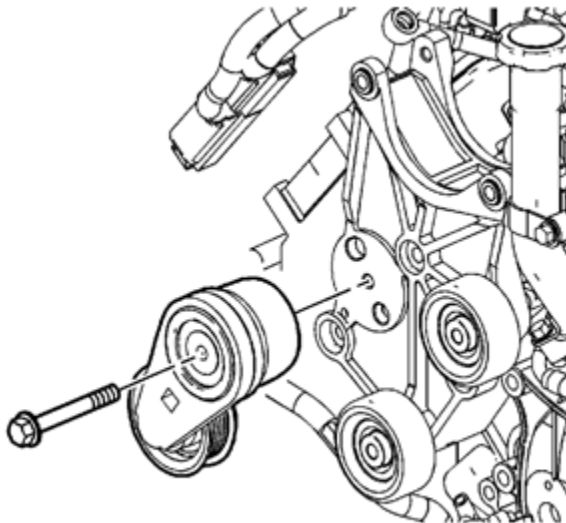
Generator and Drive Belt Tensioner Bracket Installation



1. Install the drive belt tensioner and generator mounting bracket.

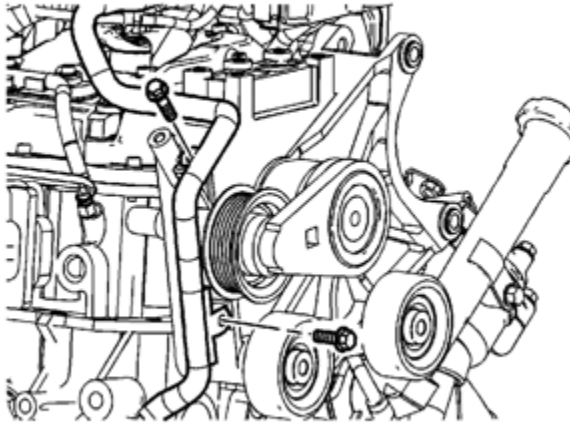
Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the drive belt tensioner and generator mounting bracket bolts. Tighten the drive belt tensioner and generator mounting bracket bolts to **50 N·m (37 lb ft)**.



3. Install the drive belt tensioner.

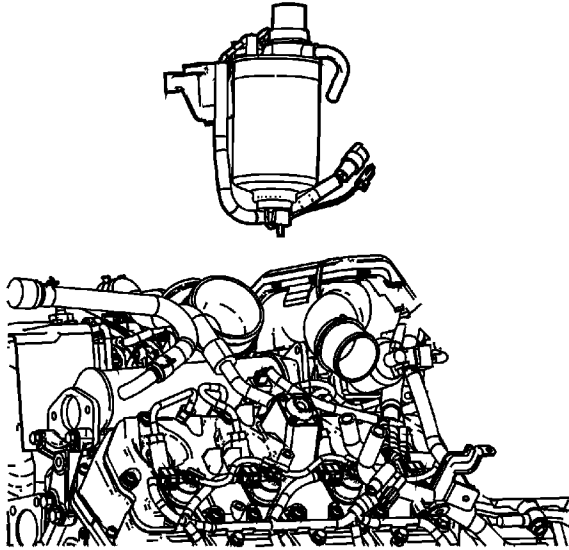
4. Install the drive belt tensioner bolt and tighten to **50 N·m (37 lb ft)**.



5. Install the electrical harness clip bolts and tighten to **10 N·m (89 lb in)**.

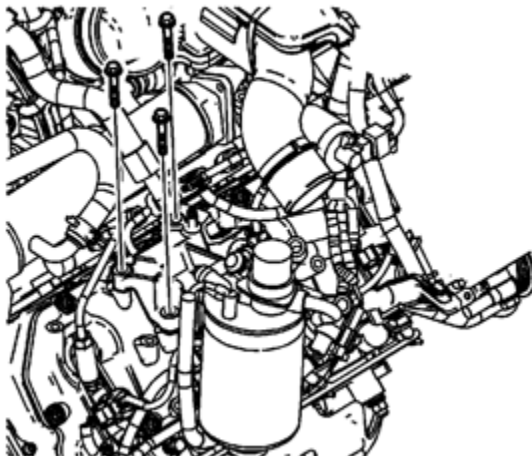
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Fuel Filter Assembly Installation



1. Install the fuel filter assembly.

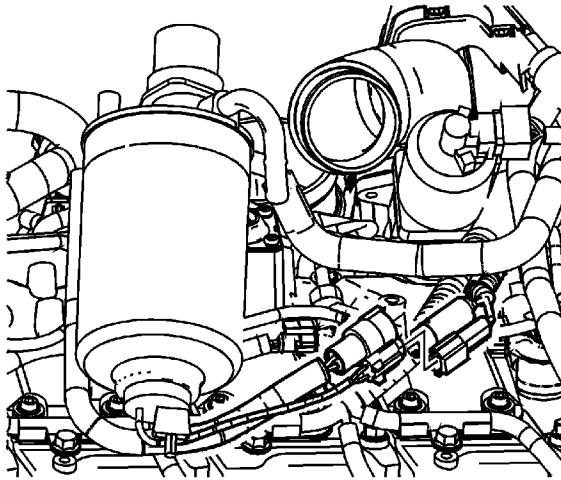
Caution: Refer to [Fastener Caution](#) in the Preface section.



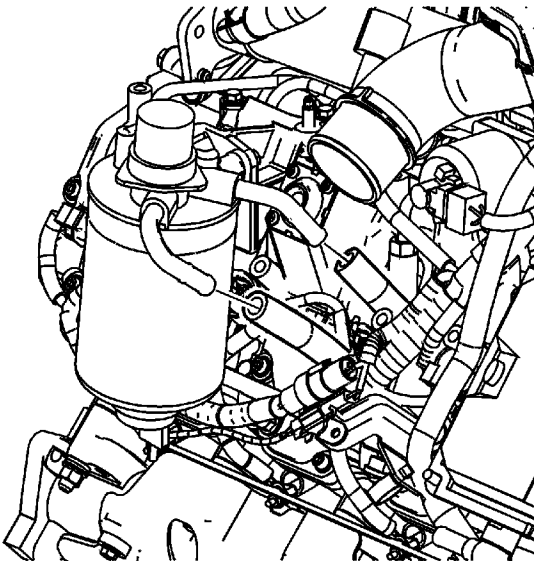
2. Install the fuel filter bracket bolts.

Tighten

Tighten the fuel filter bracket bolts to 21 N·m (15 lb ft).

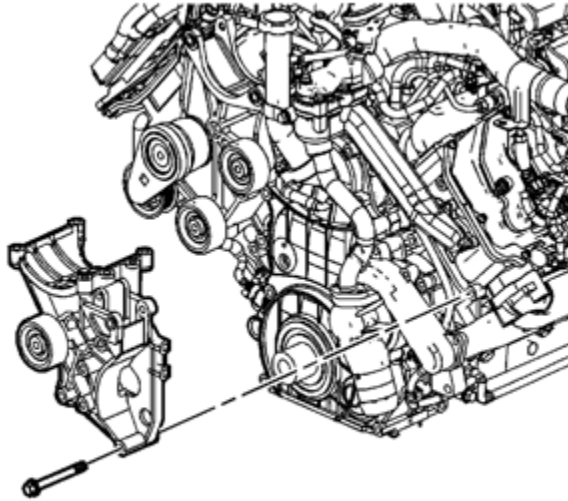


3. Connect the fuel filter assembly connectors.



4. Install the fuel hoses.

Power Steering Pump Mounting Bracket Installation

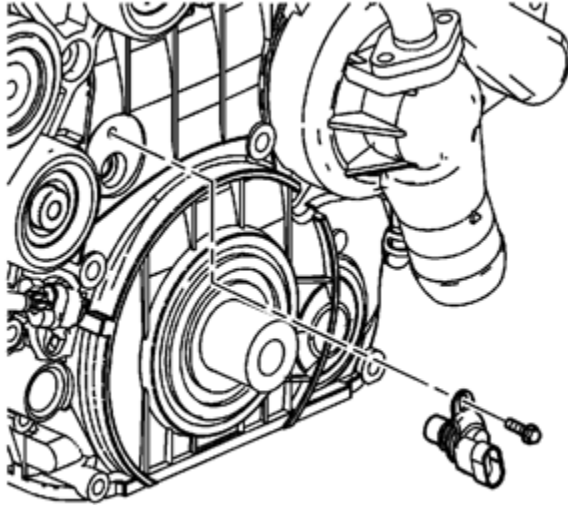


1. Install the power steering pump mounting bracket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the power steering pump mounting bracket bolts and tighten to **46 N·m (34 lb ft)**.

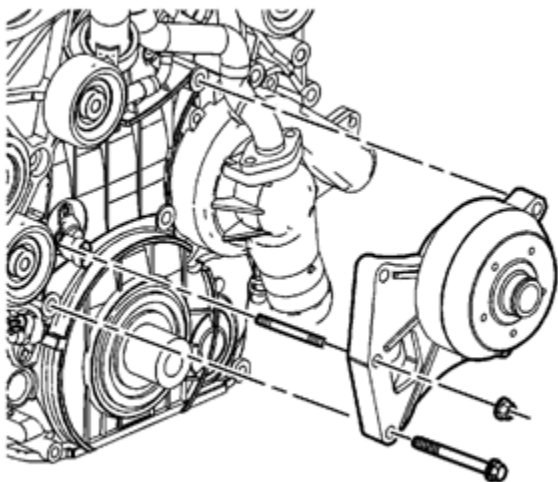
Cooling Fan Pulley Installation



1. Lubricate the camshaft position sensor O-ring with engine oil.
2. Install the camshaft position sensor.

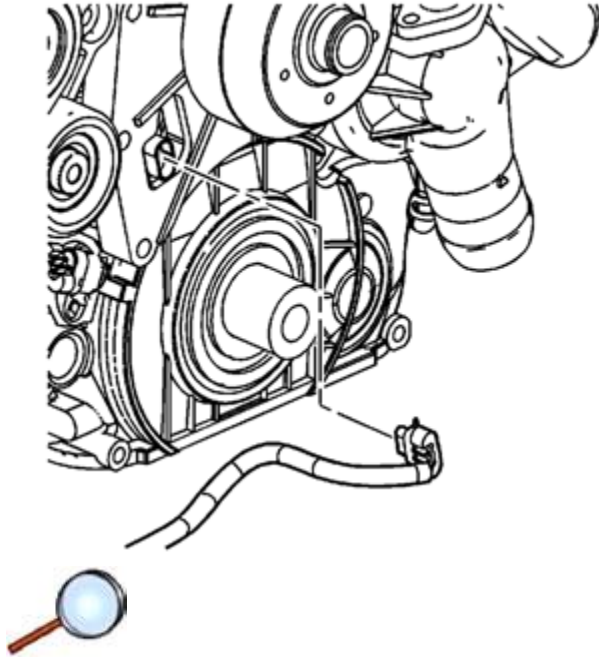
Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the camshaft position sensor retaining bolt and tighten to **10 N·m (89 lb in)**.



4. Install the cooling fan pulley.

5. Install the cooling fan pulley bolts and nuts and tighten to **41 N·m (30 lb ft)**.



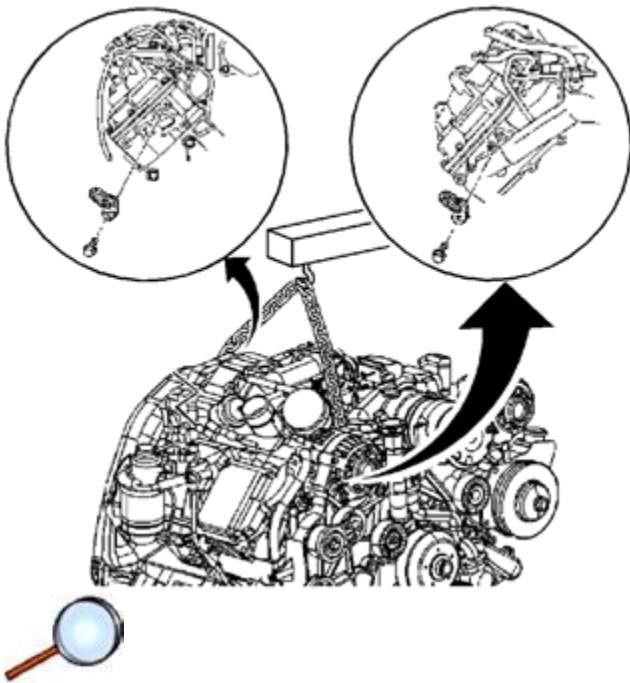
6. Connect the camshaft position sensor connector.

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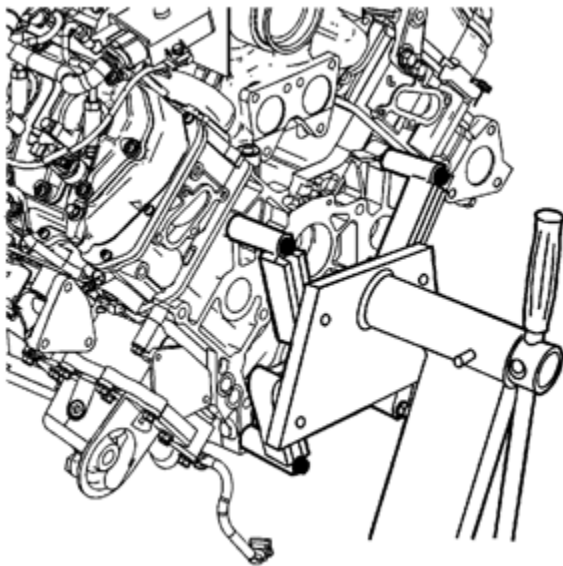
Engine Removal from Stand

Tools Required

[J 36857](#) Engine Lift Bracket



1. Bolt [J 36857](#) to the ends of the cylinder heads.

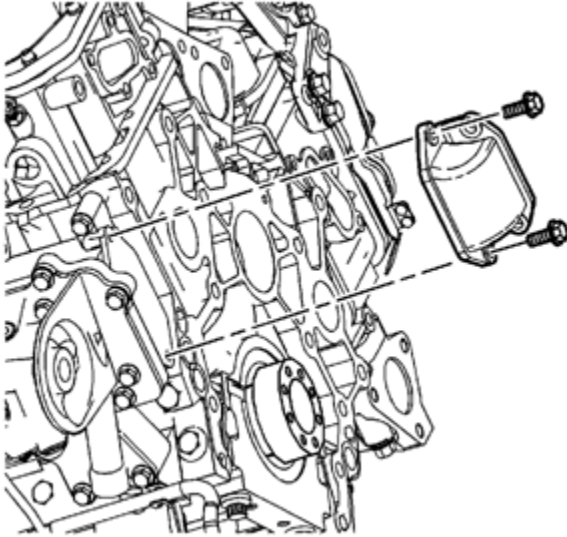


2. Lift the engine and the engine stand with a suitable hoist.
3. Remove the engine stand from the engine adapter.

4. Lower the engine to the floor. Support the engine with blocks.
5. Remove the engine adapter.

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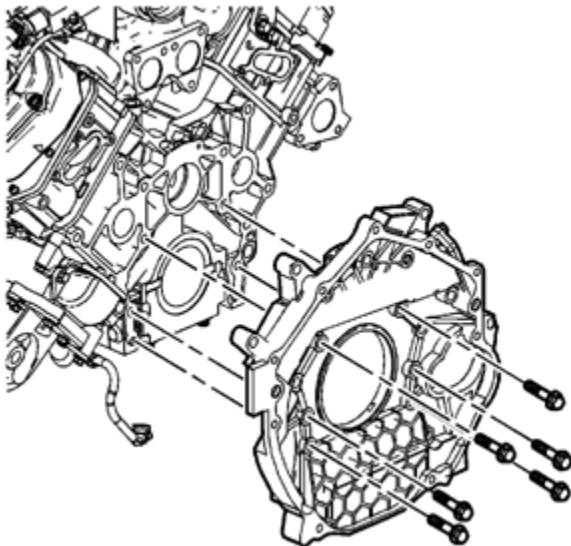
Engine Flywheel Housing Installation



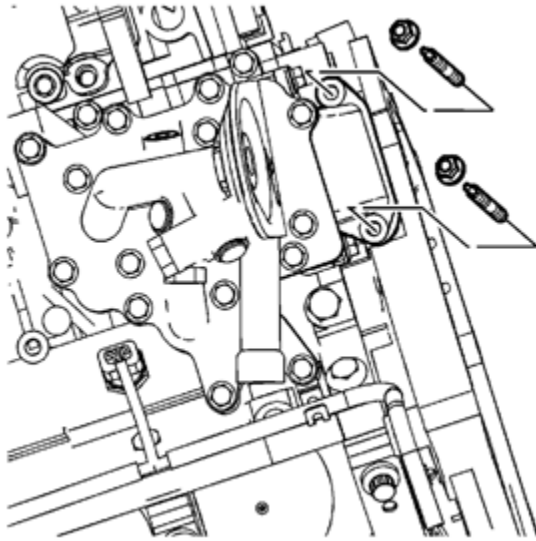
1. Install the oil cooler adapter with gaskets to the oil cooler.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the oil cooler adapter to oil cooler bolts and tighten to **21 N·m (15 lb ft)**.
3. Apply a 2-3 mm wide by 0.5-1.5 mm high bead of GM P/N 12378521 (Canadian P/N 88901148) sealant to the engine block mating surface.

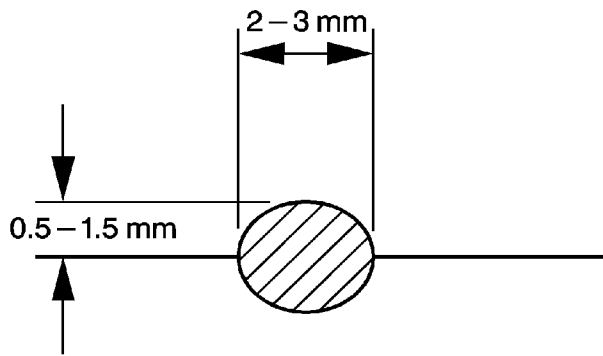


4. Install the flywheel housing to the cylinder block.
5. Install the flywheel housing bolts and tighten to **80 N·m (60 lb ft)**.

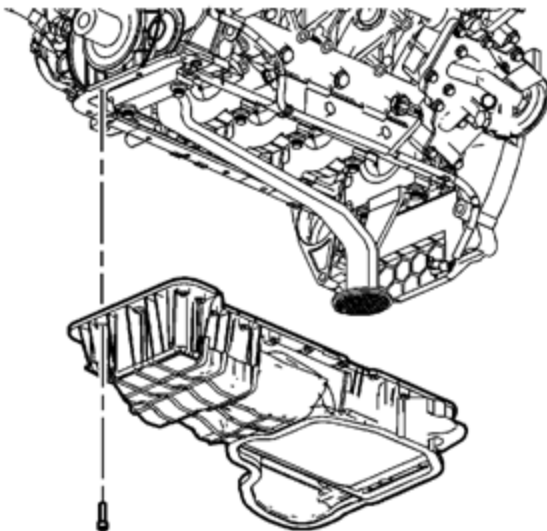


6. Install a new gasket to the turbocharger oil return pipe.
7. Install the turbocharger oil return pipe to flywheel housing studs. Tighten the turbocharger oil return pipe to flywheel housing studs to **10 N·m (89 lb in)**.
8. Install the turbocharger oil return pipe nuts and tighten to **25 N·m (18 lb ft)**.

Upper Oil Pan Installation

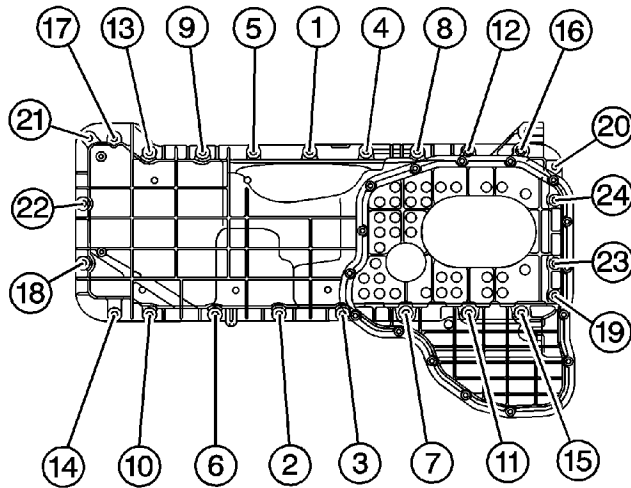


1. Apply a 2-3 mm wide by 0.5-1.5 mm bead of GM P/N 12378521 (Canadian P/N 88901148) sealant to the upper oil pan mating surfaces.

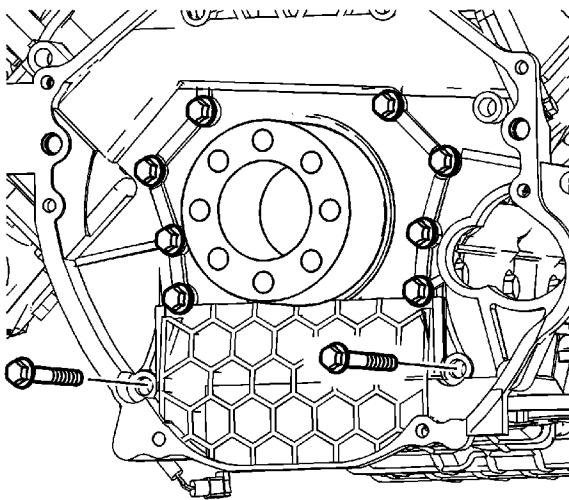


2. Install the upper oil pan to the engine block.

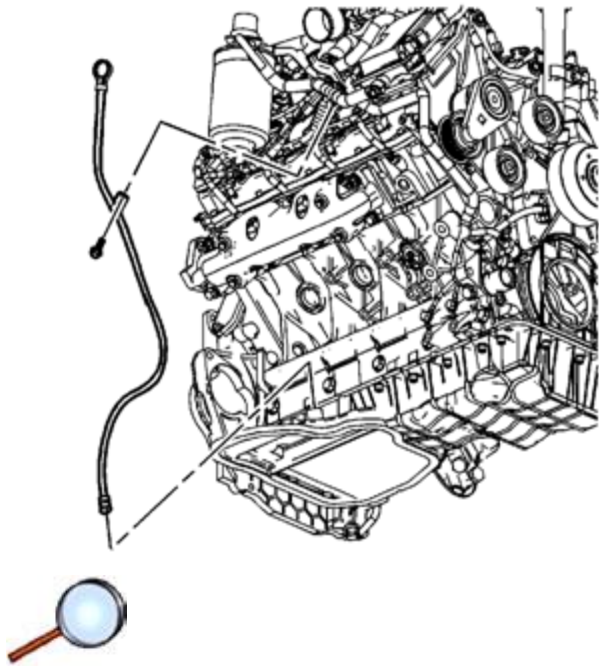
Caution: Refer to [Fastener Caution](#) in the Preface section.



3. Install the upper oil pan bolts. Tighten the upper oil pan bolts in sequence to **20 N·m (15 lb ft)**.



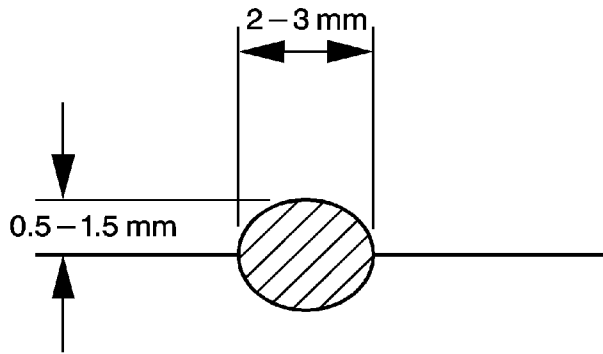
4. Install the two flywheel housing to upper oil pan bolts and tighten to **50 N·m (37 lb ft)**.



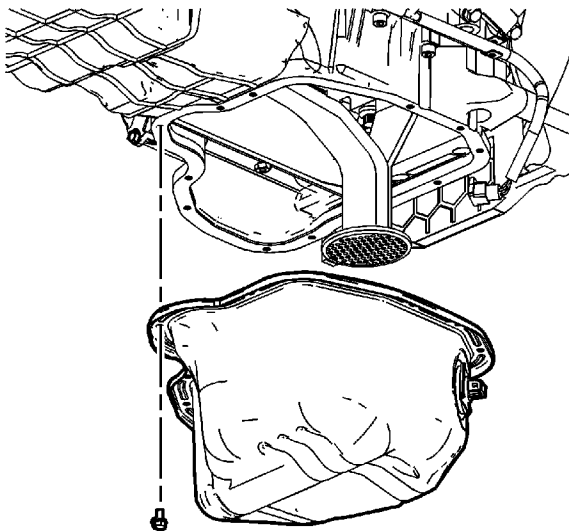
5. Install the oil level indicator tube.
6. Install the oil level indicator tube bracket bolt and tighten to **21 N·m (15 lb ft)**.

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Lower Oil Pan Installation

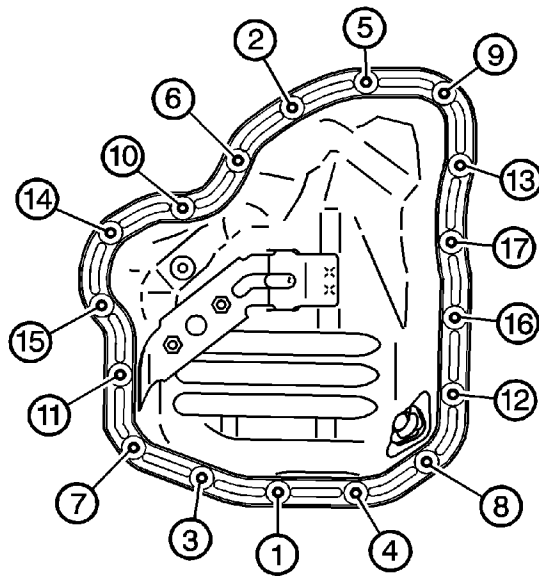


1. Apply a 2-3 mm wide by 0.5-1.5 mm high bead of GM P/N 12378521 (Canadian P/N 88901148) sealant to the lower oil pan mating surface.

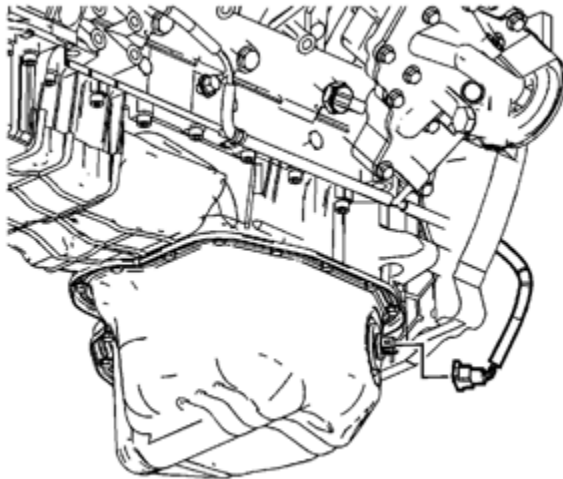


2. Install the lower oil pan.

Caution: Refer to [Fastener Caution](#) in the Preface section.



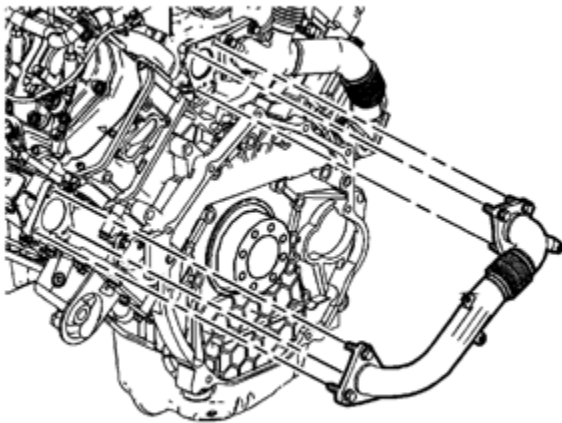
3. Install the lower oil pan bolts and nuts and tighten to **10 N·m (89 lb in)**.



4. Connect the oil level sensor.

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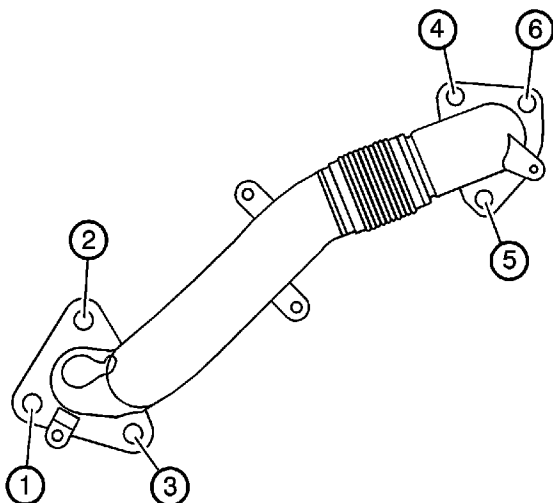
Exhaust Pipe Installation - Left Side



Note: Position the exhaust pipe gaskets with the tabs as shown. Failure to do so will cause improper alignment of the gaskets and result in exhaust leaks.

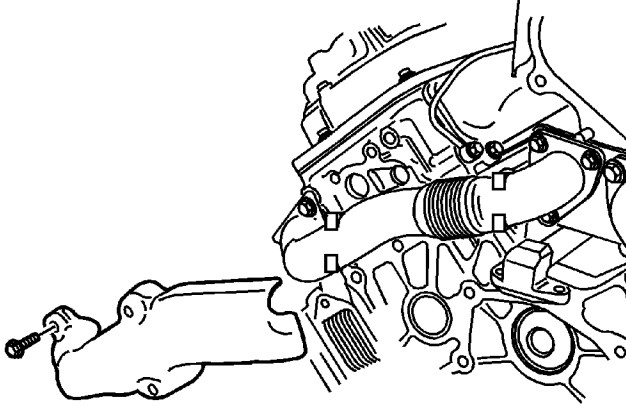
1. Install the exhaust pipe with gaskets.
2. Install the exhaust pipe to turbocharger bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.





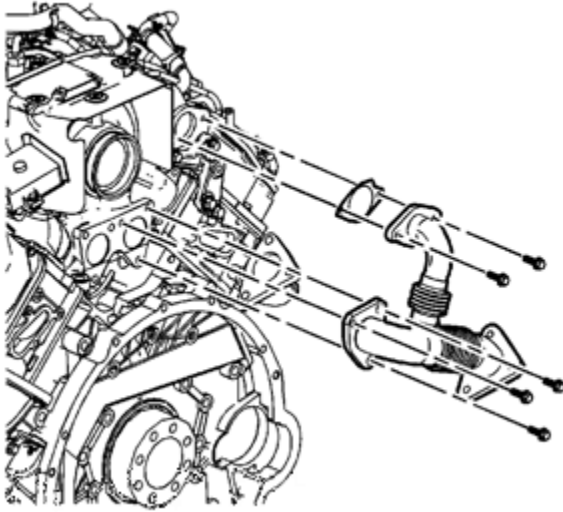
3. Install the exhaust pipe to exhaust manifold bolts. Tighten the exhaust pipe bolts to **53 N·m (39 lb ft)** in the proper sequence.



4. Install the exhaust pipe heat shield.
5. Install the exhaust pipe heat shield bolts and tighten to **10 N·m (89 lb in)**.

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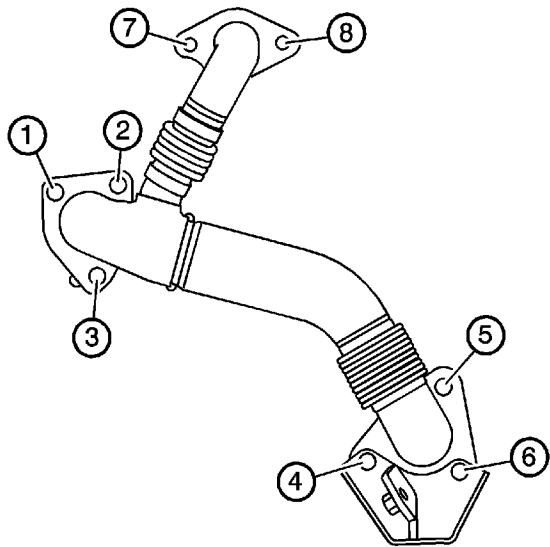
Exhaust Pipe Installation - Right Side



Note: Position the exhaust pipe gaskets with the tabs as shown. Failure to do so will cause improper alignment of the gaskets and result in exhaust leaks.

1. Install the exhaust pipe with gaskets.
2. Install the exhaust outlet bracket.
3. Install the exhaust pipe to turbocharger bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Install the exhaust pipe to exhaust manifold bolts in sequence.

Tighten

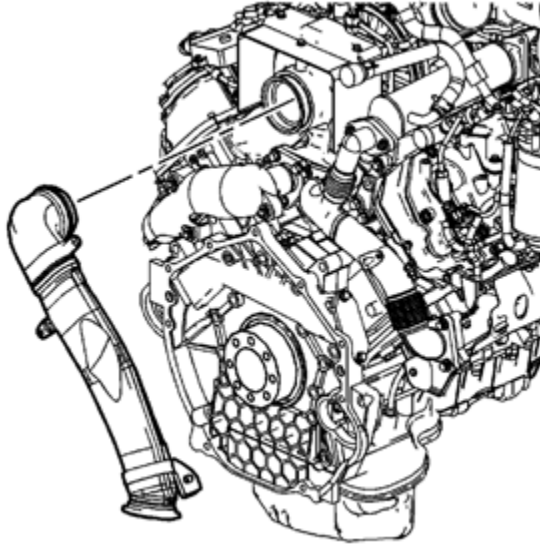
Tighten the exhaust pipe bolts to 53 N·m (39 lb ft) in sequence.

Tighten

Tighten the exhaust pipe to EGR cooler nuts to 26 N·m (19 lb ft).

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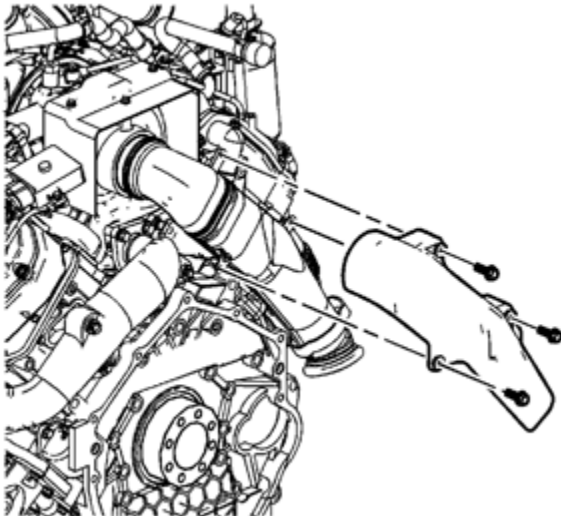
Exhaust Outlet Installation



1. Install the exhaust outlet.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the exhaust outlet clamp and tighten to **15 N·m (11 lb ft)**.



3. Install the exhaust outlet to right exhaust pipe bracket bolt and tighten to **34 N·m (25 lb ft)**.

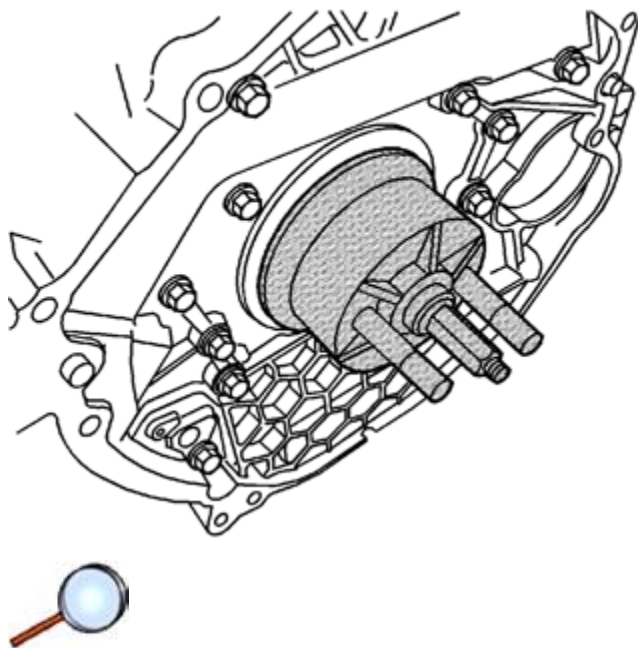
4. Install the exhaust outlet heat shield.
5. Install the exhaust outlet heat shield bolts and tighten to **10 N·m (89 lb in)**.

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Crankshaft Rear Oil Seal Installation

Tools Required

[J 44642](#) Crankshaft Rear Oil Seal Installer



1. Place the crankshaft rear oil seal onto the crankshaft.

Important: The [J 44642](#) must be fully secured to the crankshaft to ensure proper seal depth.

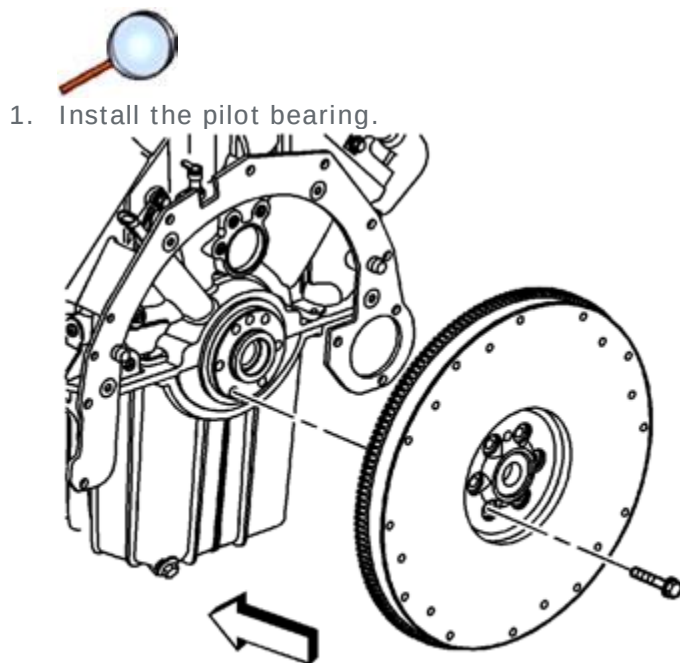
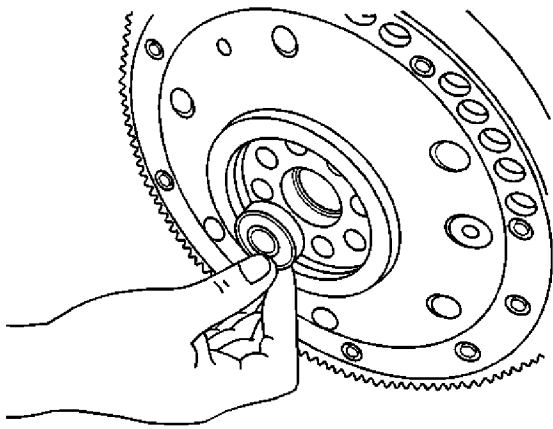
2. Install the [J 44642](#) to the crankshaft.
3. Press the crankshaft rear oil seal into position using the [J 44642](#) . The [J 44642](#) will bottom out when the seal reaches the proper depth.
4. Remove the [J 44642](#) .

Engine Flywheel Installation (Manual Transmission)

Special Tools

- J 44643 Flywheel Hold Tool
- J 45059 Angle Meter

For equivalent regional tools, refer to [Special Tools](#).





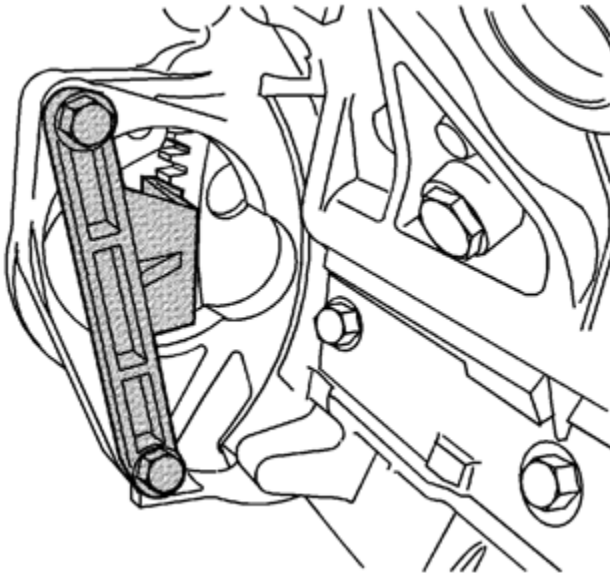
Warning: When removing, handling or installing this component wear protective gloves. The sharp edges on the component may be very sharp and may cause injury.

2. Install the flywheel.

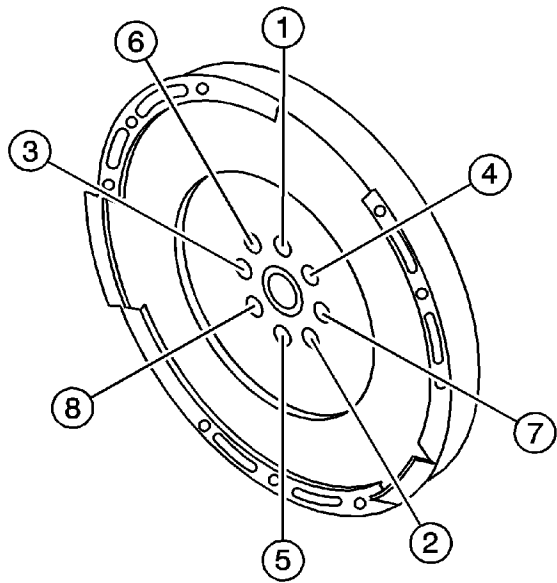
Caution: Refer to [Fastener Caution](#) in the Preface section.

Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

3. Loosely install NEW flywheel bolts.



4. Install J 44643 tool to hold the flywheel from rotating.



5. Use the following steps and the proper sequence to tighten the flywheel bolts:
 - 5.1. Tighten the flywheel bolts to **79 N·m (59 lb ft)**.
 - 5.2. Tighten the flywheel bolts to **60 degrees** using the *J 45059* meter .
 - 5.3. Tighten the flywheel bolts again to **60 degrees** using the *J 45059* meter .
6. Remove *J 44643* tool .

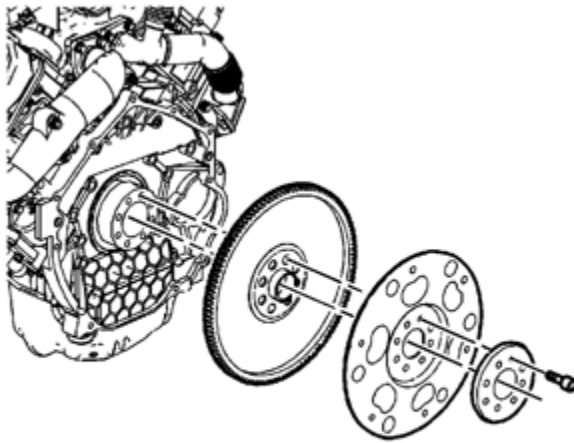
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Engine Flywheel Installation (Automatic Transmission)

Special Tools

- J 44643 Flywheel Hold Tool
- J 45059 Angle Meter

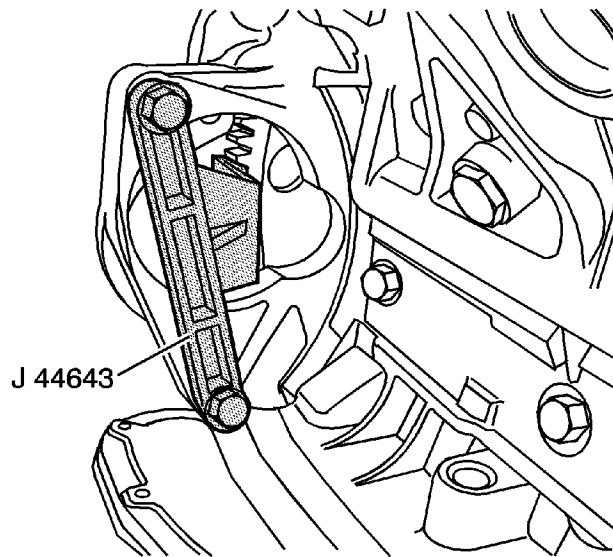
For equivalent regional tools, refer to [Special Tools](#).



1. Install the flywheel to the crankshaft.
2. Install the flywheel washer to the flywheel with the beveled side facing the engine.

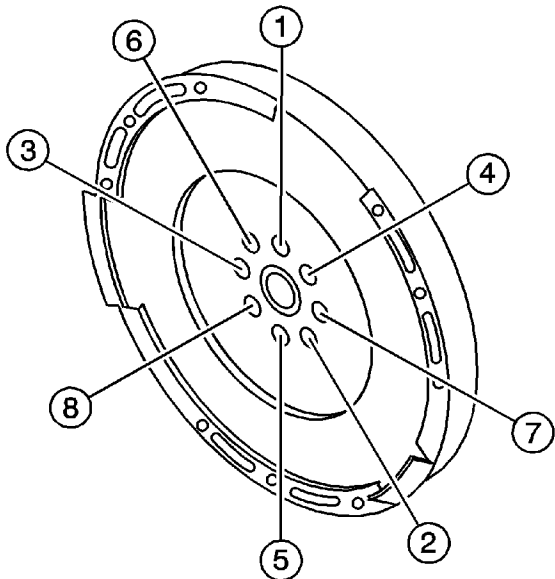
Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

3. Install NEW flywheel bolts.



4. Install the J 44643 tool to lock the flywheel.

Caution: Refer to [Fastener Caution](#) in the Preface section.

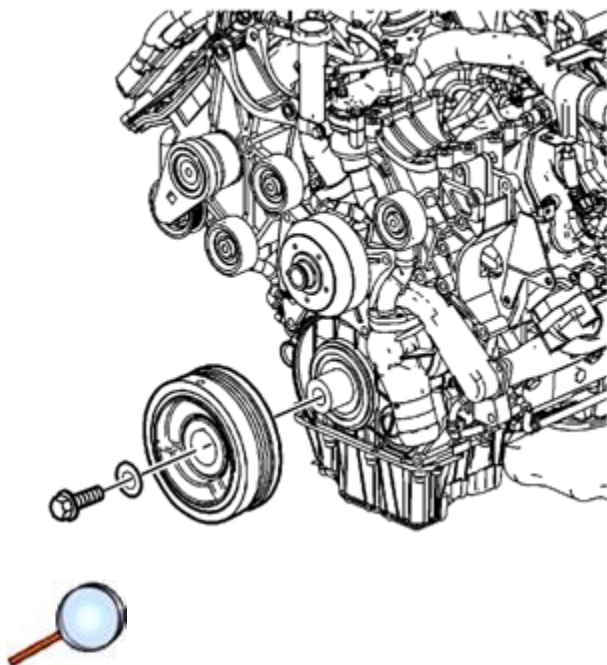


5. Tighten the flywheel bolts in the proper sequence.
 - 5.1. 1st step **79 N·m (59 lb ft)**.
 - 5.2. 2nd step **60 degrees** using J 45059 meter .
 - 5.3. 3rd step **60 degrees** using J 45059 meter .

Crankshaft Balancer Installation

Tools Required

[J 44643](#) Flywheel Hold Tool



1. Lightly lubricate the crankshaft balancer internal hub with engine oil.
2. Install the crankshaft balancer to the crankshaft.
3. Lightly lubricate the crankshaft balancer bolt with engine oil.

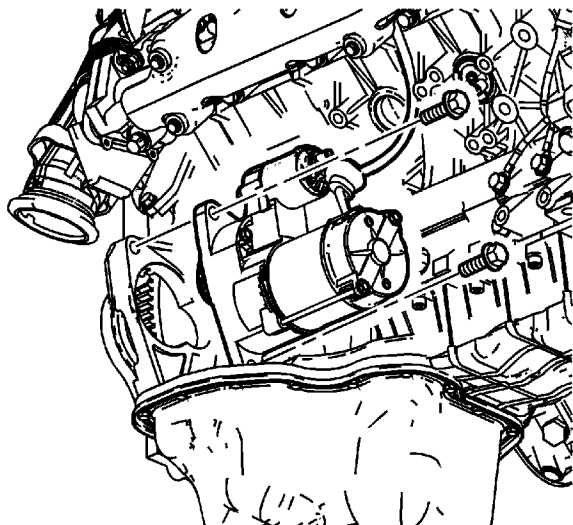
Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints, lubricants, 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.

4. Install the crankshaft balancer bolt and washer.

Tighten

1. Tighten the bolt to 100 N·m (74 lb ft) on the first pass.
2. Tighten the bolt an additional 105 degrees.
5. Remove the [J 44643](#).

Starter Installation



1. Install the starter motor to the flywheel housing.

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.

2. Install the starter motor bolts.

Tighten

Tighten the starter bolts to 78 N·m (58 lb ft).

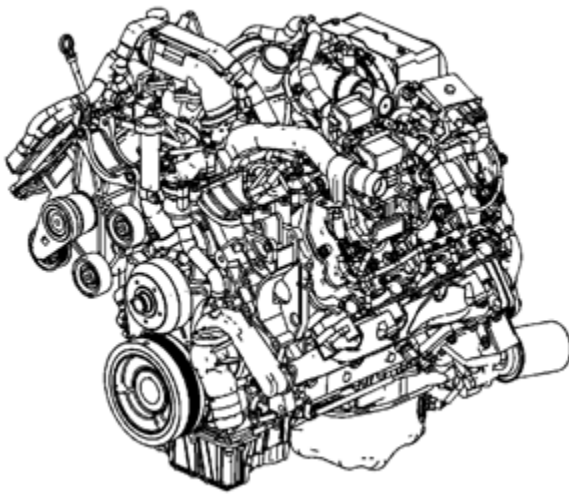
Engine Prelubing

Special Tools

J 45299 Engine Preluber

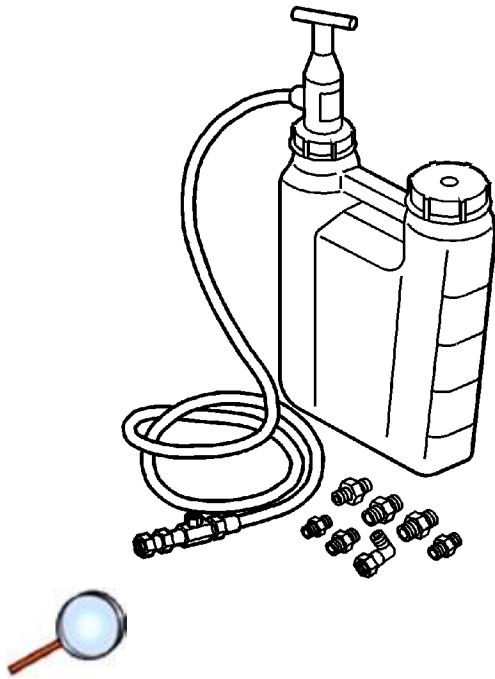
For equivalent regional tools, refer to [Special Tools](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.



Note: A constant/continuous flow of clean engine oil is required 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, and reinstall. Tighten the oil filter to **24 N·m (18 lb ft)**.
2. Remove the oil pressure sensor.
3. Install the M16 x 1.5 adapter P/N 509375.

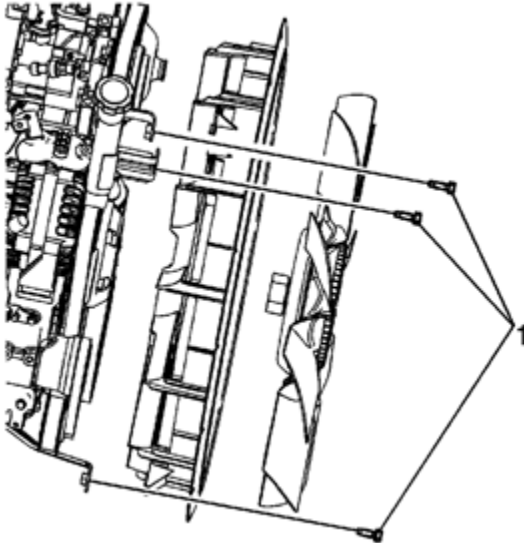


4. Install the flexible hose to the adapter and open the valve.
5. Pump the handle on J 45299 preluber to flow a minimum of 1-2 quarts of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
6. Close the valve and remove the flexible hose and adapter from the engine.
7. Install the oil pressure sensor and tighten to **41 N·m (30 lb ft)**.
8. Top off the engine oil to the proper level.

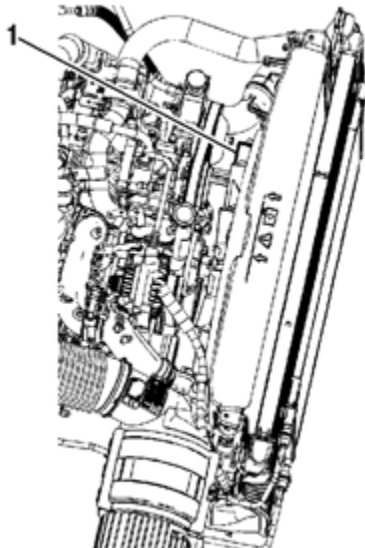
Drive Belt Replacement

Removal Procedure

1. Remove the upper fan shroud. Refer to [Engine Coolant Fan Upper Shroud Replacement](#).

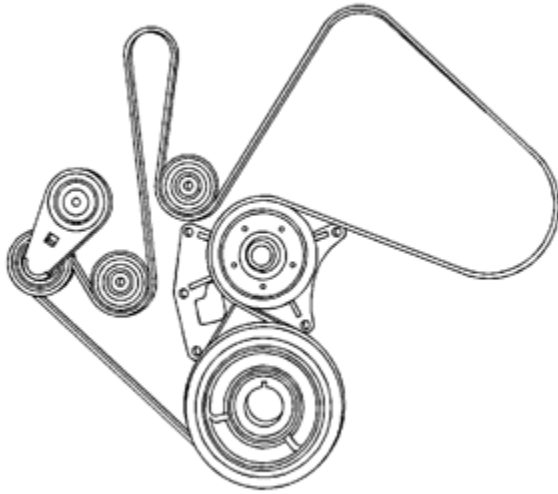


2. Remove the 3 engine cooling fan shroud bolts (1).

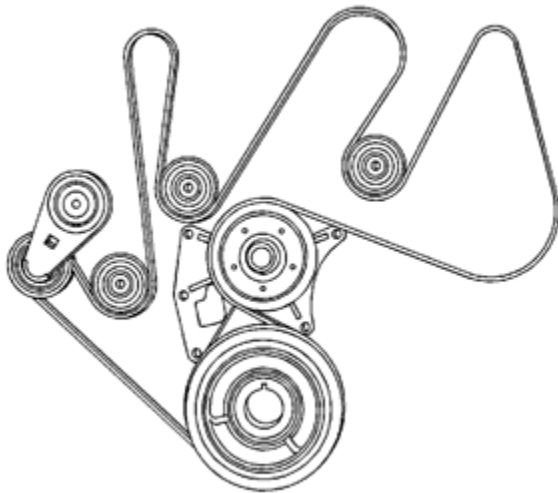


3. Position the engine cooling fan shroud (1) forward to the radiator.
4. Install a 1/2 inch breaker bar into the tensioner opening and rotate the tensioner counterclockwise.
5. Remove the belt from the tensioner.

6. Slowly release the tension on the tensioner arm.

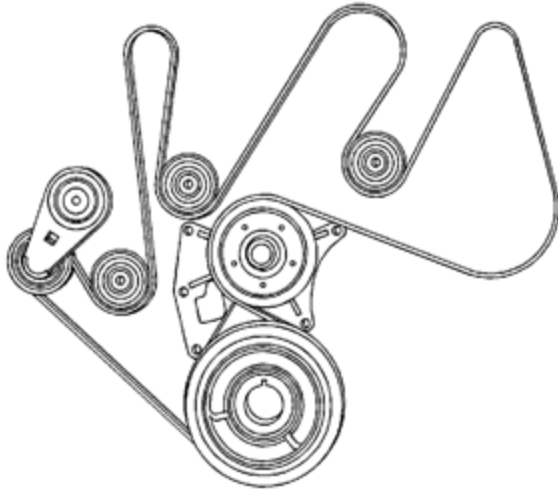


7. Remove the drive belt from the drive pulleys , if equipped with a single generator.

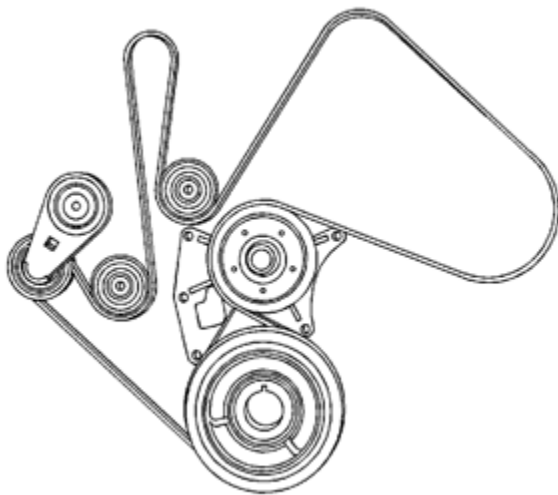


8. Remove the drive belt from the drive pulleys, if equipped with dual generators.
9. Inspect the drive belt for excessive cracking or any visible damage and replace if necessary.

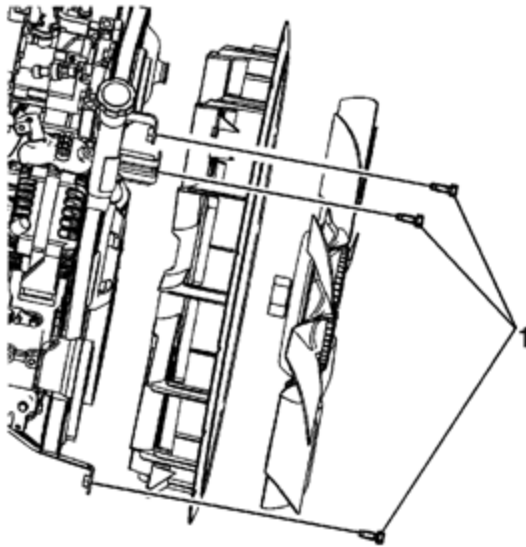
Installation Procedure



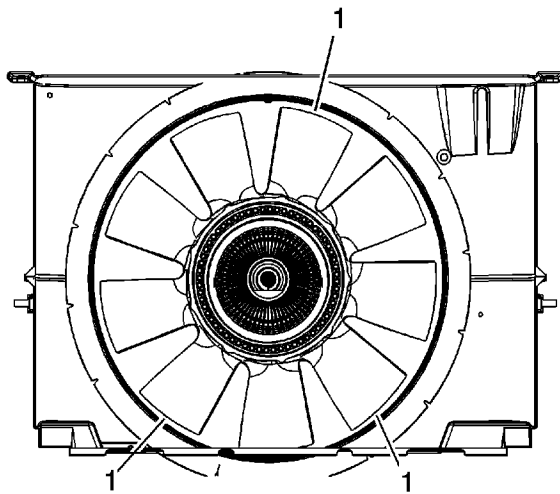
1. Install the drive belt, if equipped with dual generators.
2. Route the drive belt over and/or around all the drive pulleys except for the tensioner.



3. Install the drive belt, if equipped with a single generator.
4. Route the drive belt over and/or around all the drive pulleys except for the tensioner.
5. Install a 1/2 inch breaker bar into the tensioner opening and rotate the tensioner counterclockwise.
6. Install the belt over and/or around the tensioner.
7. Slowly release the tension on the tensioner arm.
8. Inspect the drive belt for proper installation on and/or around all pulleys.



9. Position the engine cooling fan shroud on the 3 mounting brackets (1).
10. Install the bolts. Loosely tighten the top mounting bolt at the oil filler neck.



11. Center the engine cooling fan shroud to the fan blade in 3 places (1).

Caution: Refer to [Fastener Caution](#) in the Preface section.

Note: Maintain a 6 mm (0.25 in) minimum clearance at all 3 places.

12. Fully tighten the 3 engine cooling fan shroud bolts (1).

Tighten

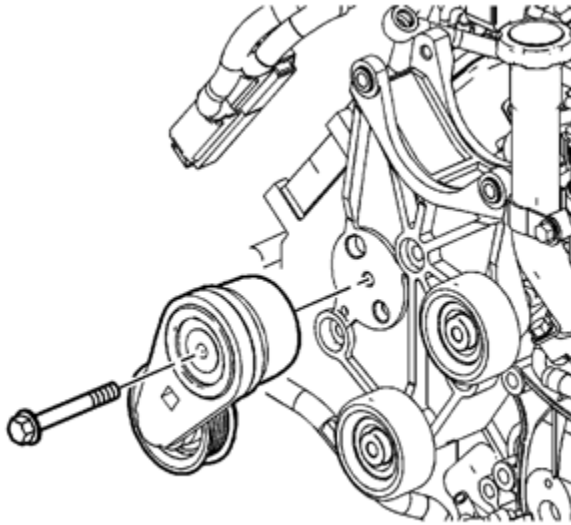
Tighten the bolts to 8 N·m (71 lb in).

13. Install the upper fan shroud. Refer to [Engine Coolant Fan Upper Shroud Replacement](#).

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Drive Belt Tensioner Replacement

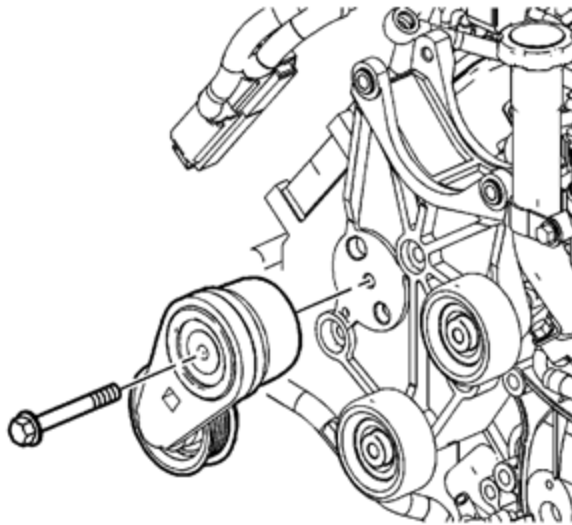
Removal Procedure



1. Remove the drive belt. Refer to [Drive Belt Replacement](#).
2. Remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.

Installation Procedure

Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Install the drive belt tensioner. Align the pin with the hole in the generator bracket.
2. Install the drive belt tensioner bolt.

Tighten

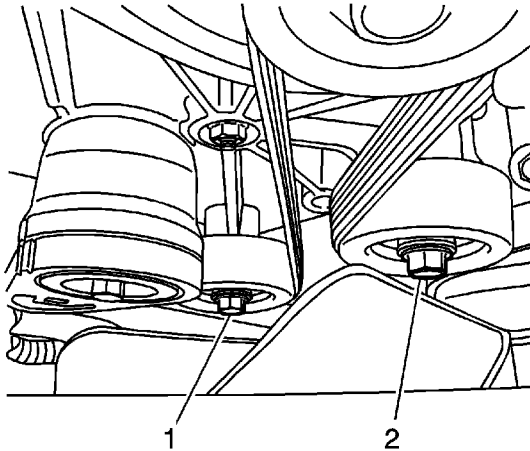
Tighten bolt to 50 N·m (37 lb ft).

3. Install the drive belt. Refer to [Drive Belt Replacement](#).

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Drive Belt Idler Pulley Replacement

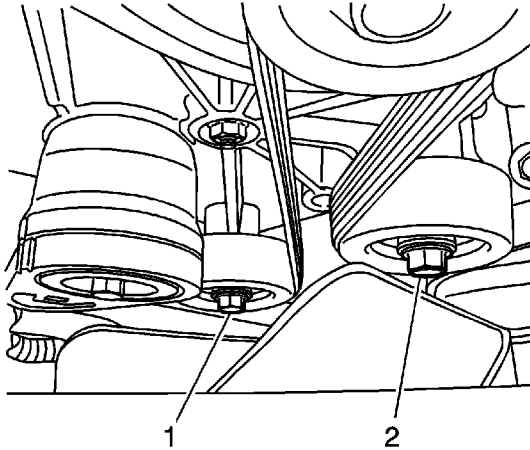
Removal Procedure



1. Remove the drive belt. Refer to [Drive Belt Replacement](#).
2. Remove the bolt (1) from the right side idler pulley.
3. Remove the idler pulley.
4. Remove the bolt (2) for the center idler pulley.
5. Remove the idler pulley.
6. If equipped with dual generators, remove the bolt from the left side idler pulley.
7. If equipped with dual generators, remove the idler pulley.

Installation Procedure

Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Install the right side idler pulley and bolt (1).

Tighten

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

2. Install the center idler pulley and bolt (2).

Tighten

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

3. If equipped with dual generators, install the left side idler pulley and bolt.

Tighten

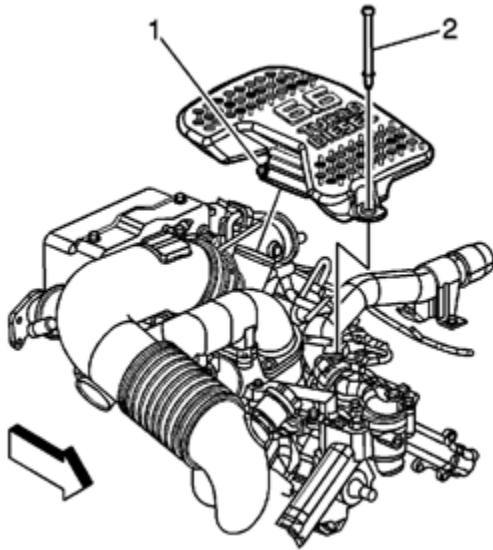
Tighten the bolt to 50 N·m (37 lb ft).

4. Install the drive belt. Refer to [Drive Belt Replacement](#).

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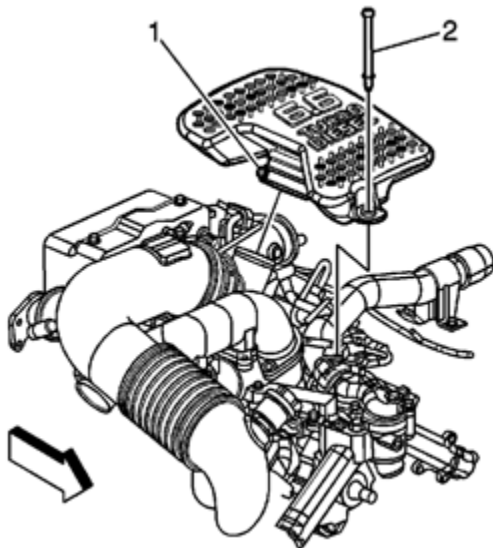
Intake Manifold Cover Replacement

Removal Procedure



1. Loosen the intake manifold cover clamp (1) at the resonator.
2. Loosen the intake manifold cover bolt (2).
3. Remove the intake manifold cover.

Installation Procedure





1. Install the intake manifold cover.
2. Tighten the intake manifold cover bolt (2) until snug.

Caution: Refer to [Fastener Caution](#) in the Preface section.

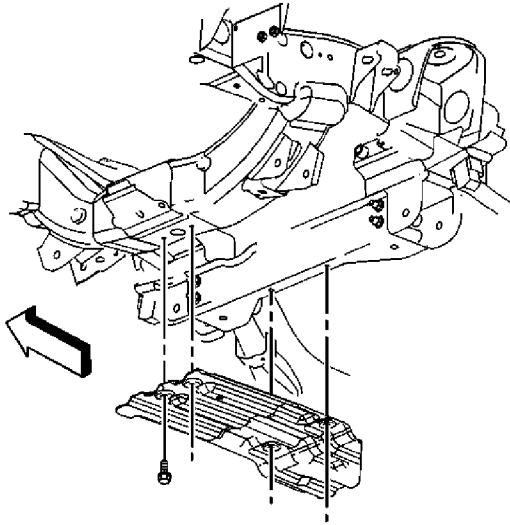
3. Tighten the intake manifold cover clamp (1) at the resonator.

Tighten

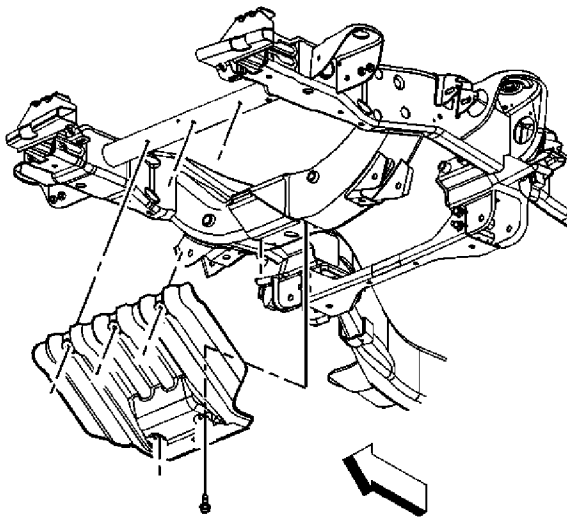
Tighten the clamp to 6 N·m (53 lb in).

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Engine Mount Inspection

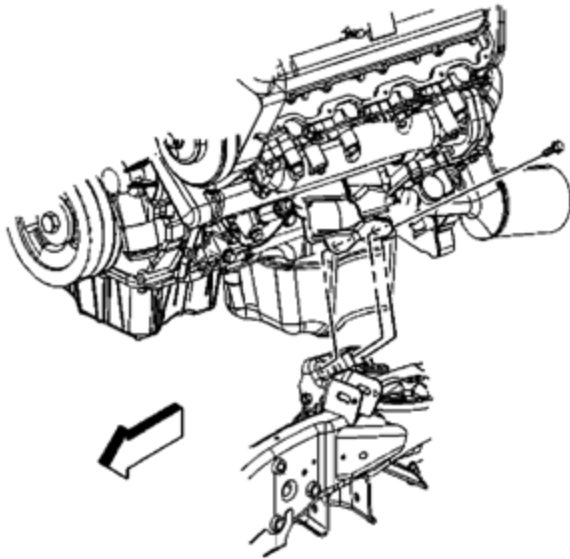


1. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
2. Remove the oil pan skid plate.



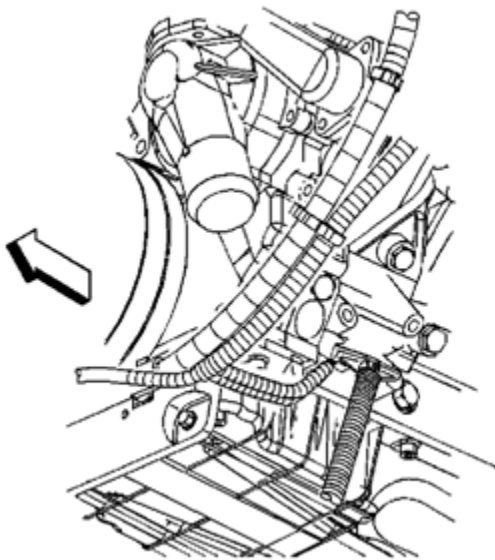
3. Remove the engine protection shield.

Caution: Refer to [Engine Mounting Caution](#) in the Preface section.



4. Inspect for loose or missing bolts at the following locations:
 - Engine mount bracket to engine
 - Engine mount frame bracket to frame
 - Engine mount to engine mount bracket
 - Engine mount to engine mount frame bracket
5. Replace missing or loose bolts. Refer to [Engine Mechanical Specifications](#).

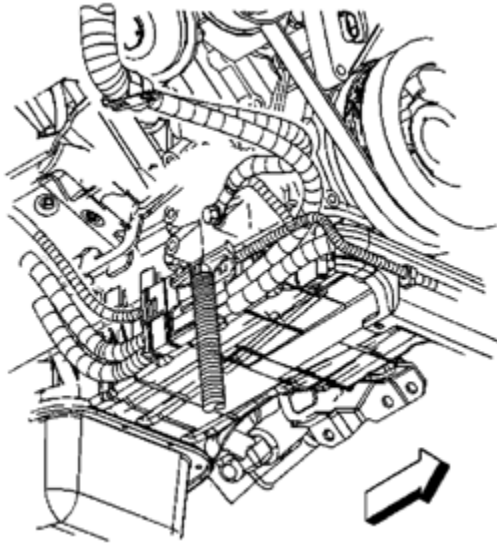
Caution: Refer to [Engine Lifting Caution](#) in the Preface section.



6. If the vehicle is 4-wheel drive (4WD), you will not be able to access the lifting points on the engine. In order to raise the engine, attach a chain to the front of the engine. Then follow the

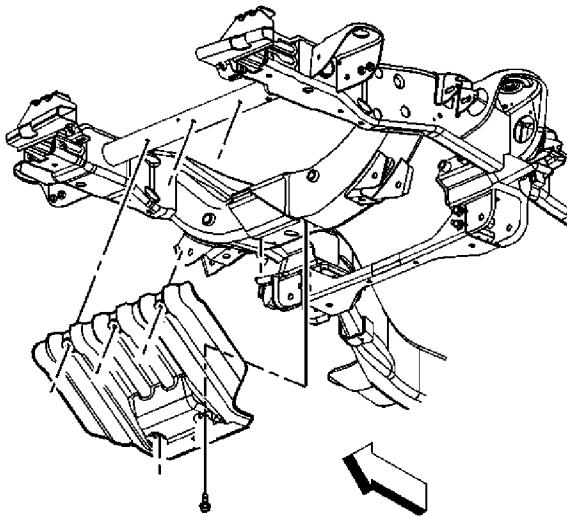
inspection steps.

7. If the vehicle is rear-wheel drive (RWD), in order to raise the engine to inspect the left engine mount, use a suitable jack on the ground wire bolt bosses on the left side of the engine



8. If equipped with an automatic transmission, remove the bolt retaining the transmission oil cooler line bracket.
9. Move the transmission oil cooler lines aside.
10. In order to raise the engine to inspect the right engine mount, use a suitable jack on the ground wire bolt bosses on the right side of the engine
11. Perform the following in order to inspect the engine mounts:
 - 11.1. Raise the engine to remove weight from the engine mount.
 - 11.2. Place a slight tension on the rubber cushion.
 - 11.3. Observe the engine mount for the following while raising the engine:
 - Heat check cracks covering the hard rubber surface
 - The rubber cushion is separated from the metal plate of the engine mount.
 - There is a split through the rubber cushion.
12. Replace the engine mount if any of the above conditions exist.

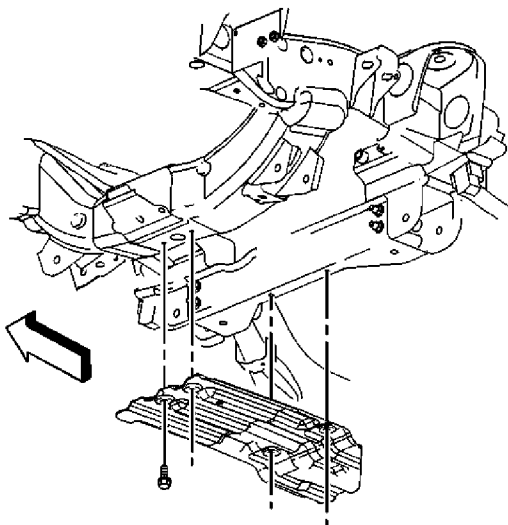
Caution: Refer to [Fastener Caution](#) in the Preface section.



13. Install the engine protection shield and bolts.

Tighten

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



14. Install the oil pan skid plate and bolts.

Tighten

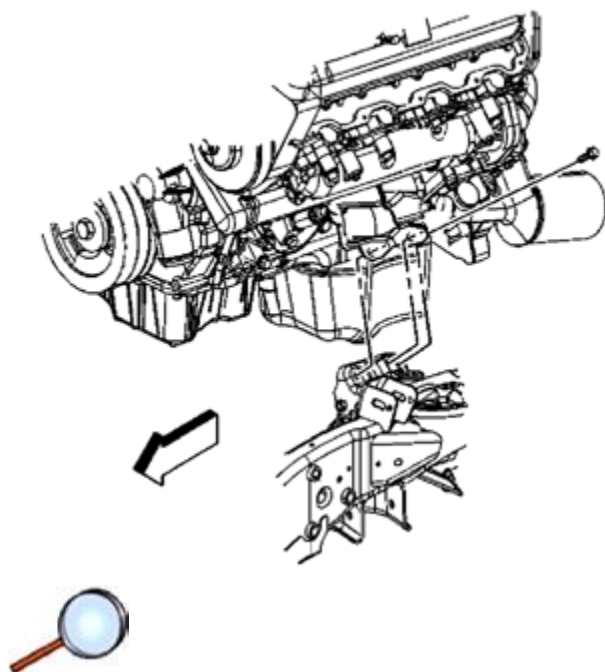
Tighten the oil pan skid plate bolts to 20 N·m (15 lb ft).

15. Lower the vehicle.

Engine Mount Replacement - Left Side

Removal Procedure

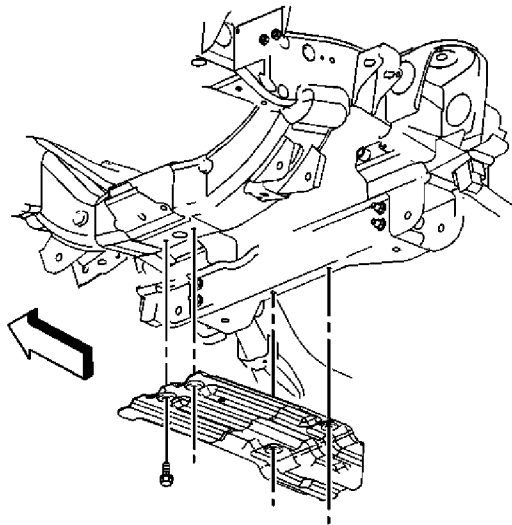
1. If RWD vehicle, raise the vehicle to a height to work through the front wheelhouse opening. Refer to [Lifting and Jacking the Vehicle](#).
2. If 4-wheel drive (4WD) vehicle, raise the vehicle in order to remove the front tires and wheels and support with jackstands.
3. Remove the wheelhouse inner panel. Refer to [Front Wheelhouse Liner Replacement - Left Side](#).



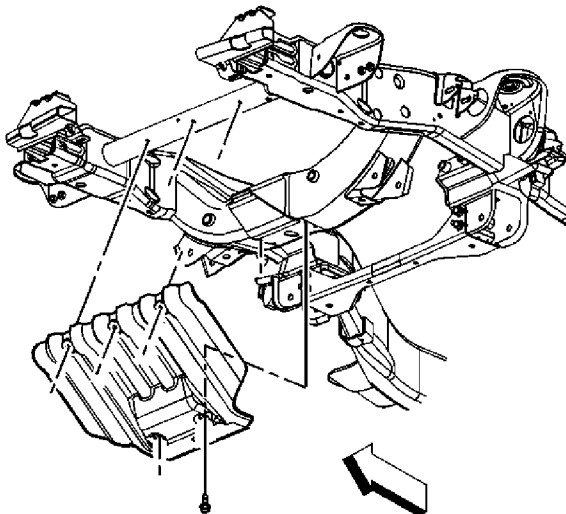
Caution: Broken engine mountings can cause misalignment of certain drive-train components. Misalignment of drive-train components causes eventual destruction of the drive-train components.

If one engine mount breaks, the rest of the engine mounts will have increased stress put on them. This could cause the rest of the engine mounts to break.

4. Working through the wheelhouse opening remove the 3 bolts retaining the engine mount to the engine mount frame bracket.

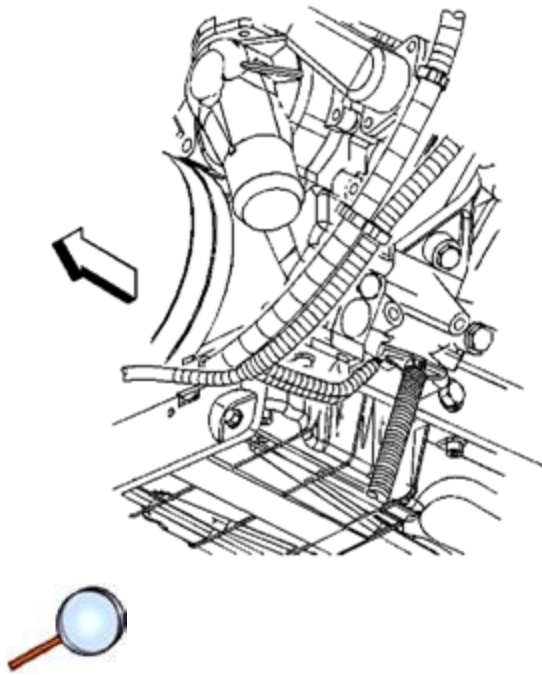


5. Remove the oil pan skid plate, if equipped.



6. Remove the engine protection shield from the vehicle, if equipped.

Caution: 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. Lifting the engine in an unapproved manner may cause component damage.



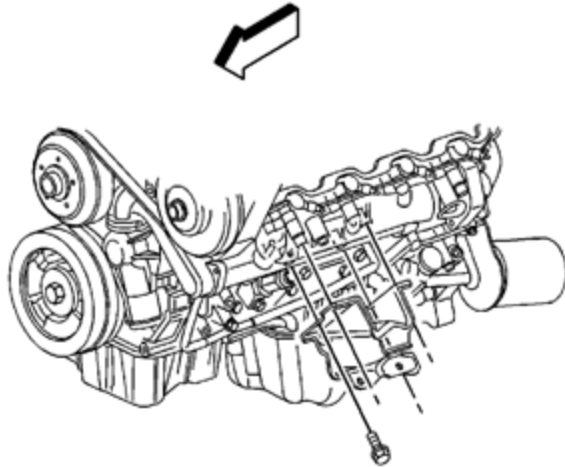
Note: When raising the engine only raise enough to separate the engine mount from the engine mount bracket. Raising any further will require removal of the fan shroud or the exhaust pipe.

7. If RWD vehicle, using a suitable jack on the ground wire bolt bosses, raise the engine.

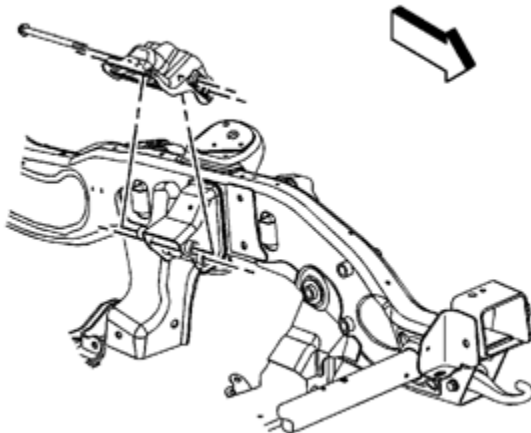
Only raise the engine enough to separate the engine mount to engine mount bracket.

8. If 4WD vehicle, attach a chain to the front of the engine. Use accessible mounting bolts for the generator mounting bracket and the power steering pump mounting bracket.
9. Raise the engine with a suitable lifting device to remove the engine mount.

Only raise the engine enough to separate the engine mount to engine mount bracket.

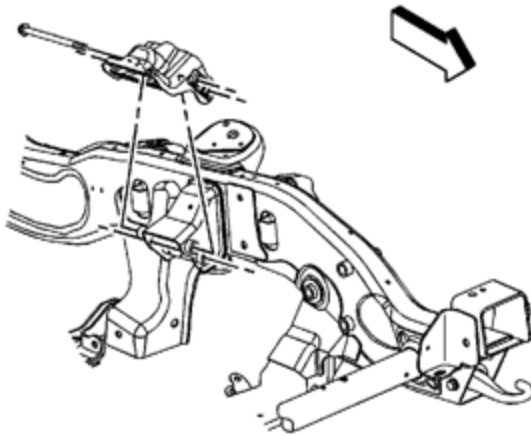


10. Remove the bolts holding the engine mount to the engine.

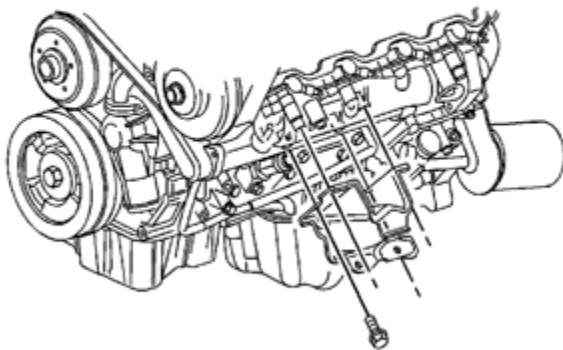


11. Remove the 2 through-bolts for the engine mount frame bracket.
12. Remove the engine mount frame bracket.
13. Remove the engine mount.

Installation Procedure



1. Position the engine mount frame bracket on the frame. Do not install the bolts.



2. Install the engine mount.
3. Perform the following procedure prior to installing the engine mount bracket bolts.
 - 3.1. Remove all traces of the original adhesive patch.
 - 3.2. Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
 - 3.3. Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the 2 through-bolts.

Tighten

Tighten the through-bolts to 75 N·m (55 lb ft).

5. Install the bolts holding the engine mount to the engine.

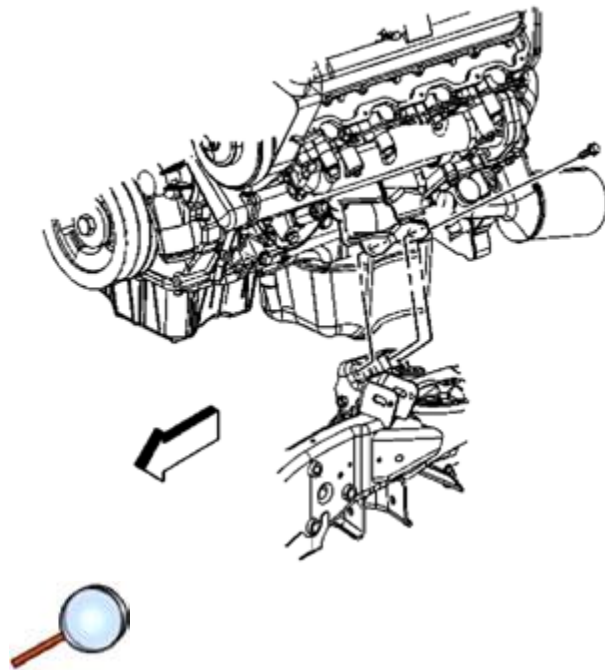
Tighten

Tighten the engine mount bolts to 58 N·m (43 lb ft).

6. Lower the engine.
7. If 4WD vehicle remove the chain from the front of the engine.
8. If 4WD vehicle, install the generator mounting bracket and the power steering mount bracket bolt.

Tighten

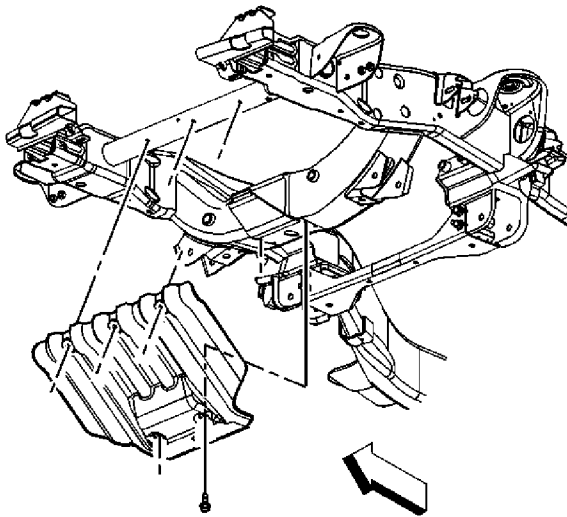
Tighten the mounting bracket bolts to 50 N·m (37 lb ft).



9. Install the 3 bolts holding the engine mount to the engine mount frame bracket.

Tighten

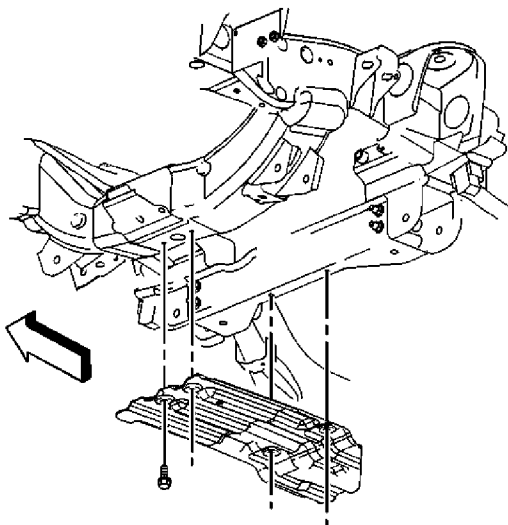
Tighten the engine mount to engine mount frame bracket bolts to 65 N·m (48 lb ft).



10. Install the engine protection shield and bolts.

Tighten

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



11. Install the oil pan skid plate.

Tighten

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

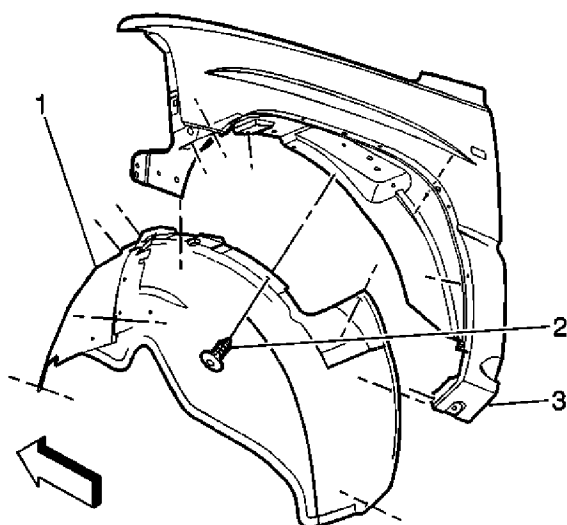
12. Remove the wheelhouse inner panel. Refer to [Front Wheelhouse Liner Replacement - Left Side](#).

13. Lower the vehicle.

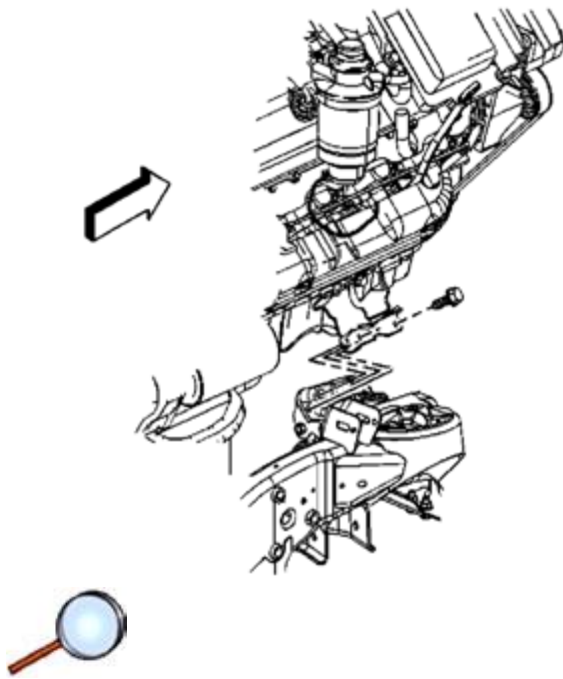
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Engine Mount Replacement - Right Side

Removal Procedure



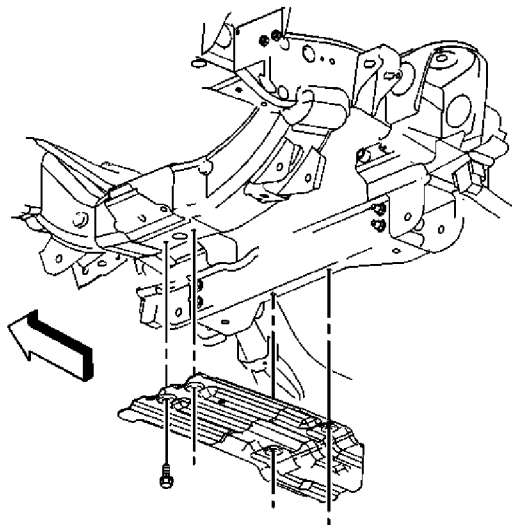
1. Remove the starter motor. Refer to [Starter Motor Replacement](#).
2. If RWD vehicle, raise the vehicle to a height to work through the front wheelhouse opening. Refer to [Lifting and Jacking the Vehicle](#).
3. If 4-wheel drive (4WD) vehicle, raise the vehicle in order to remove the front tires and wheels and support with jackstands.
4. Remove the right front tire and wheel, if necessary. Refer to [Tire and Wheel Removal and Installation](#).
5. Remove the pushpins holding the right front fender wheelhouse inner panel (1).
6. Remove the wheelhouse inner panel.



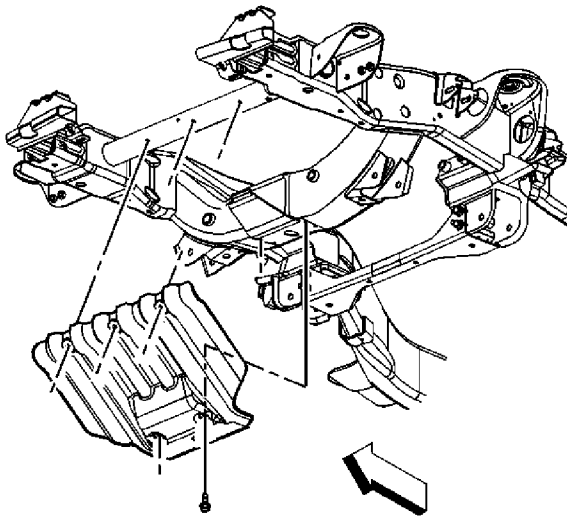
Caution: Broken engine mountings can cause misalignment of certain drive-train components. Misalignment of drive-train components causes eventual destruction of the drive-train components.

If one engine mount breaks, the rest of the engine mounts will have increased stress put on them. This could cause the rest of the engine mounts to break.

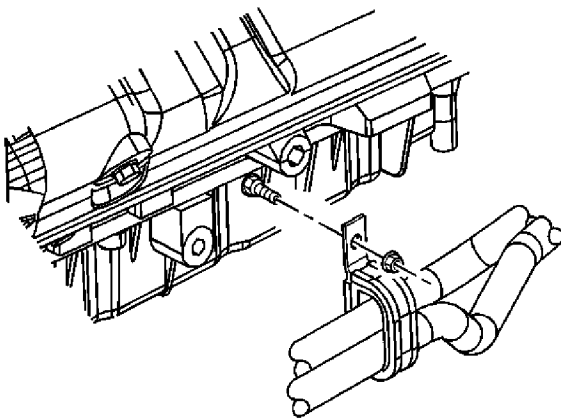
7. Working through the wheelhouse opening remove the 3 bolts retaining the engine mount to the engine mount frame bracket.



8. Remove the oil pan skid plate, if equipped.

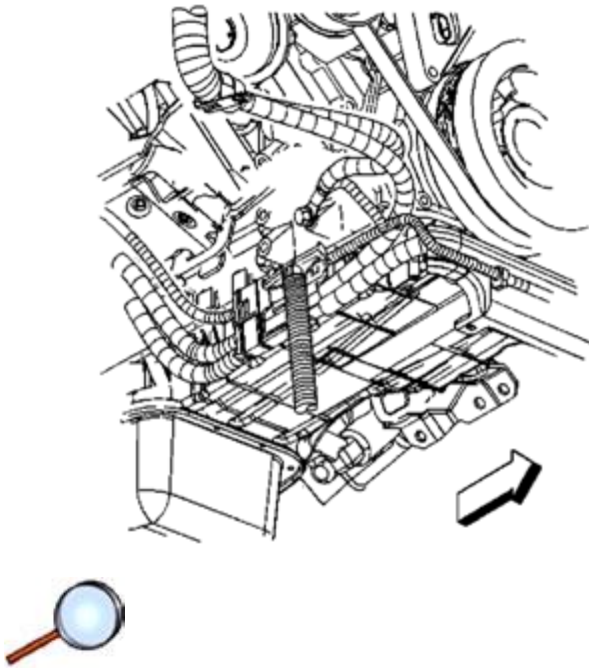


9. Remove the engine protection shield from the vehicle, if equipped.



10. If RWD vehicle and equipped with an automatic transmission, remove the bracket bolt for the transmission oil cooler lines to the engine.
11. Move the transmission oil cooler lines aside.

Caution: 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. Lifting the engine in an unapproved manner may cause component damage.



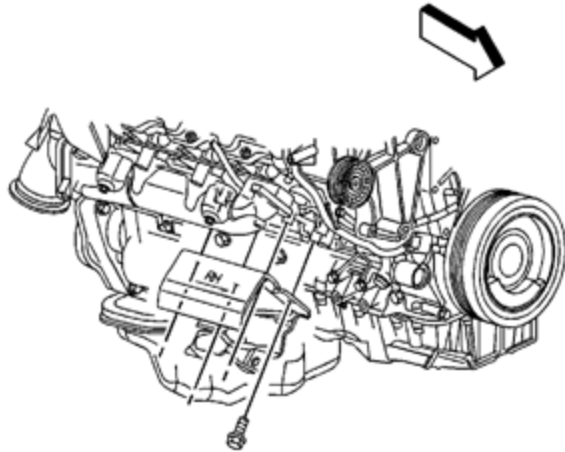
Note: When raising the engine only raise enough to separate the engine mount from the engine mount bracket. Raising any further the fan shroud or the exhaust pipe will require removal.

12. If RWD vehicle, using a suitable jack on the ground wire bolt bosses, raise the engine.

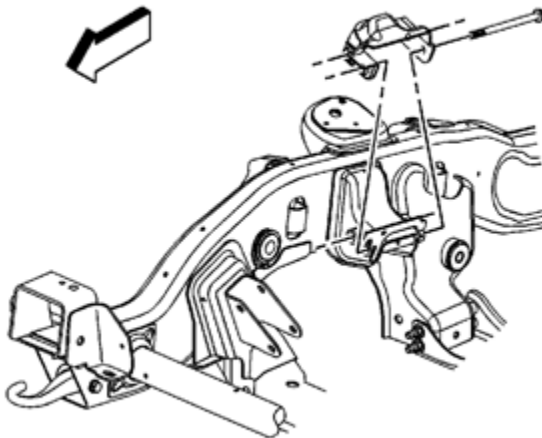
Only raise the engine enough to separate the engine mount to engine mount bracket.

13. If 4WD vehicle, attach a chain to the front of the engine. Use accessible mounting bolts for the generator mounting bracket and the power steering pump mounting bracket.
14. Raise the engine with a suitable lifting device to remove the engine mount.

Only raise the engine enough to separate the engine mount to engine mount bracket.

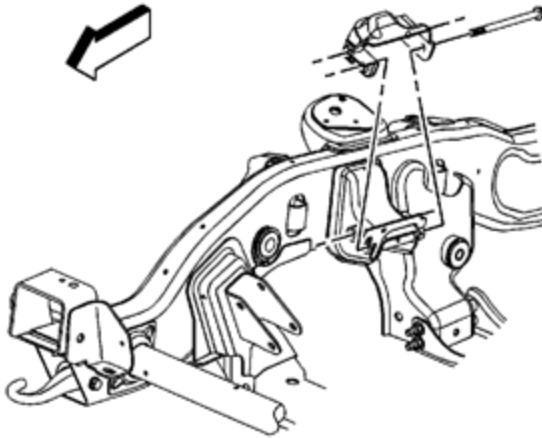


15. Remove the bolts holding the engine mount to the engine.



16. Remove the 2 through-bolts for the engine mount frame bracket.
17. Remove the engine mount frame bracket.
18. Remove the engine mount.

Installation Procedure



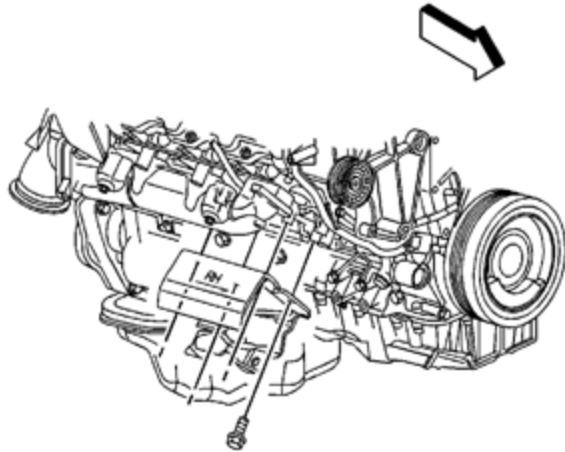
1. Position the engine mount frame bracket on the frame. Do not install the bolts.
2. Install the engine mount.
3. Perform the following procedure prior to installing the engine mount bracket bolts.
 - 3.1. Remove all traces of the original adhesive patch.
 - 3.2. Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
 - 3.3. Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the 2 through-bolts.

Tighten

Tighten the through-bolts to 75 N·m (55 lb ft).



5. Install the bolts holding the engine mount to the engine.

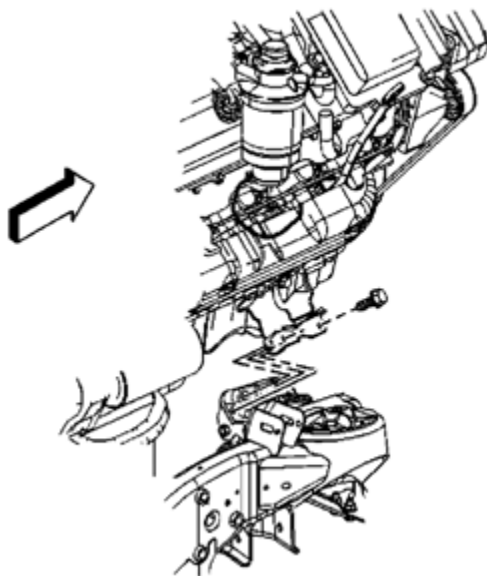
Tighten

Tighten the engine mount bolts to 58 N·m (43 lb ft).

6. Lower the engine.
7. If 4WD vehicle, remove the chain from the front of the engine.
8. If 4WD vehicle, install the generator mounting bracket and the power steering mount bracket bolt.

Tighten

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

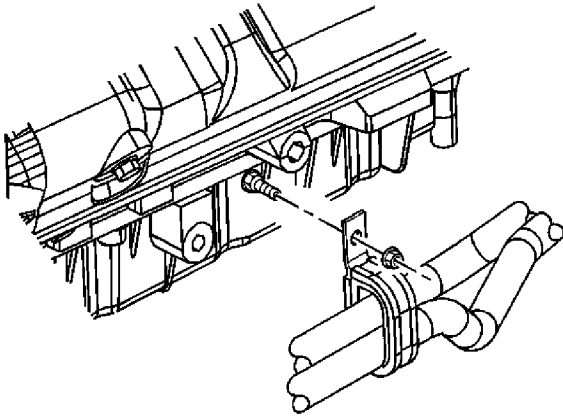




9. Install the 3 bolts holding the engine mount to the engine mount frame bracket.

Tighten

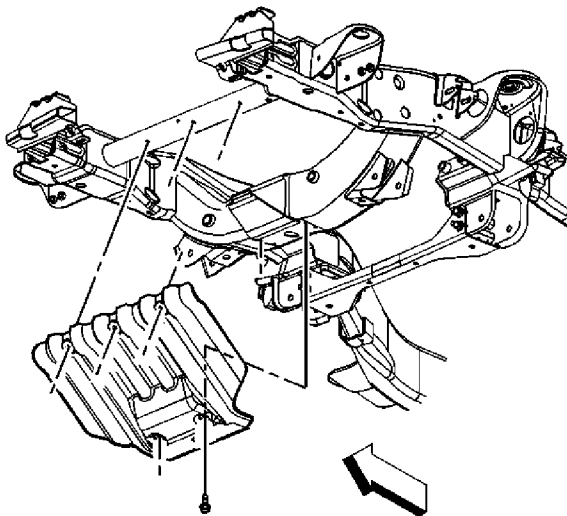
Tighten the engine mount to engine mount frame bracket bolts to 65 N·m (48 lb ft).



10. If RWD vehicle with an automatic transmission, install the bolt for the transmission oil cooler line bracket.

Tighten

Tighten the transmission oil cooler line bracket bolt to 9 N·m (80 lb in).

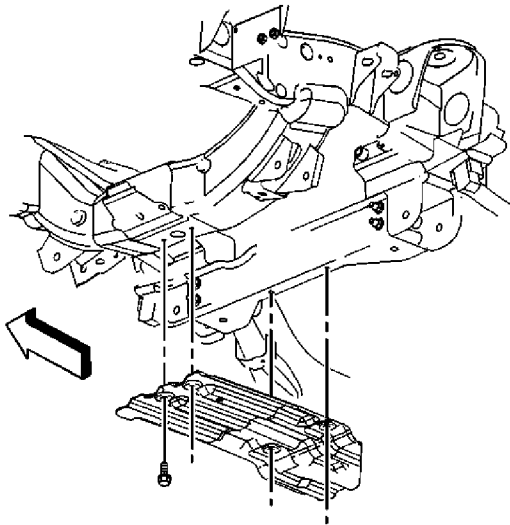




11. Install the engine protection shield and bolts.

Tighten

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



12. Install the oil pan skid plate.

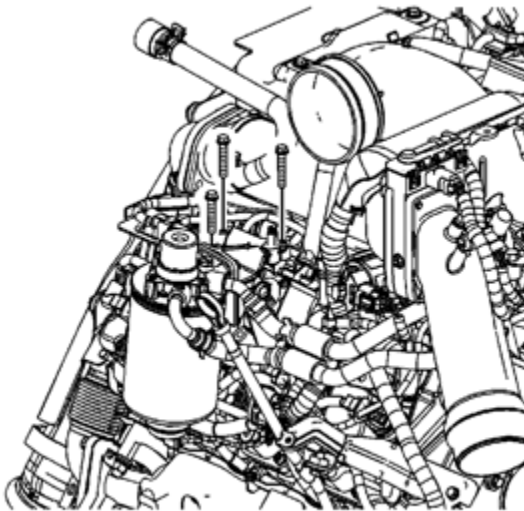
Tighten

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

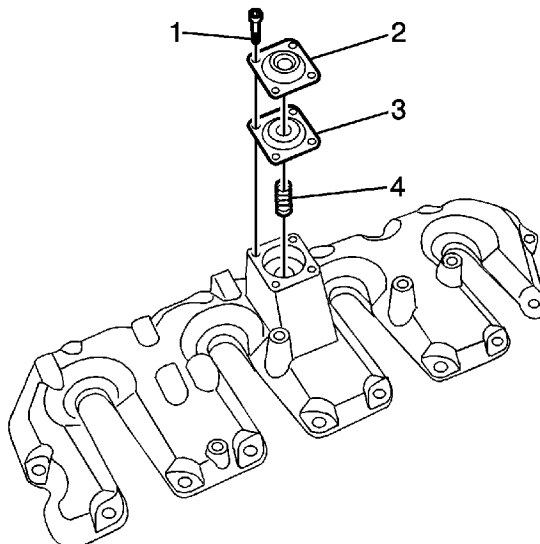
13. Install the right front tire and wheel. Refer to [Tire and Wheel Removal and Installation](#).
14. Install the front fender wheelhouse inner panel.
15. Install the starter motor. Refer to [Starter Motor Replacement](#).
16. Lower the vehicle.

Positive Crankcase Ventilation Valve Replacement (Passenger Side)

Removal Procedure



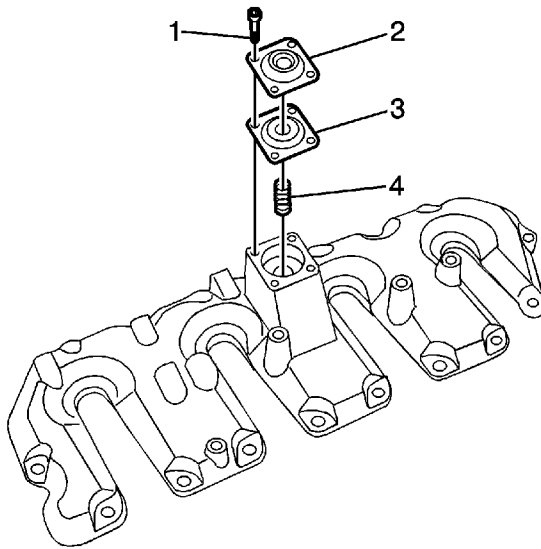
1. Remove the air cleaner outlet duct. Refer to [Air Cleaner Assembly Replacement](#).
2. Remove the fuel filter bracket bolts.
3. Position the fuel filter assembly out of the way.



4. Remove the positive crankcase ventilation (PCV) cover screws.
5. Remove the PCV cover, diaphragm, and spring.
6. Clean and inspect the cover, diaphragm and spring.
7. Discard the diaphragm if damage is found.

Installation Procedure

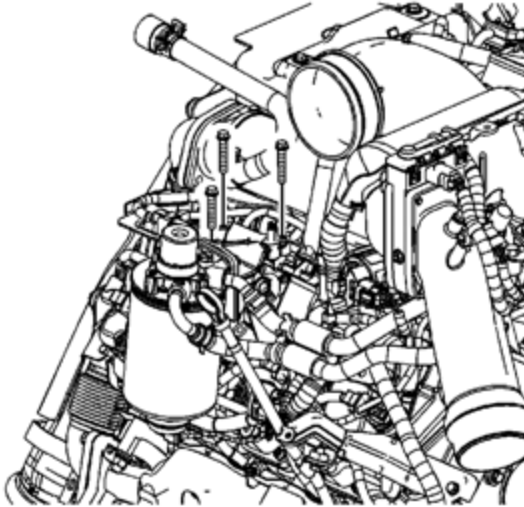
Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Install the spring, diaphragm and cover.
2. Install the PCV cover screws.

Tighten

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



3. Position the fuel filter assembly to the engine.
4. Install the fuel filter bracket bolts.

Tighten

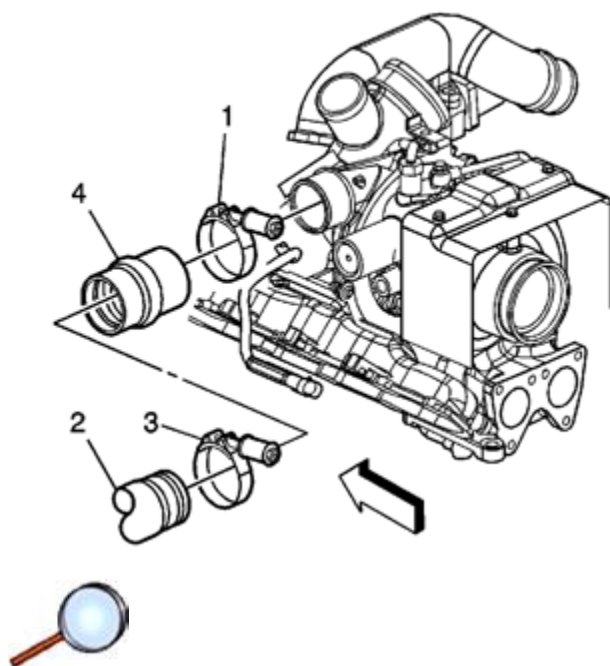
Tighten the bolts to 21 N·m (15 lb ft).

5. Install the air cleaner outlet duct. Refer to [Air Cleaner Assembly Replacement](#).

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Positive Crankcase Ventilation Valve Replacement (Driver Side)

Removal Procedure

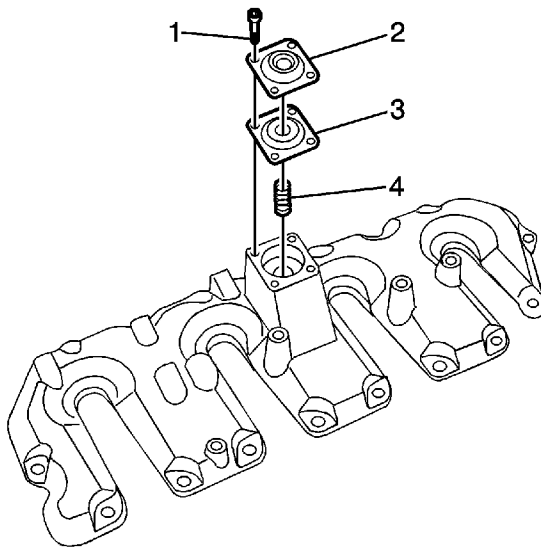


Note: After removing the charged air cooler duct, cover the turbocharger opening with tape in order to prevent entry of objects.

1. Loosen the charged air cooler inlet duct connector to turbocharger clamp (1).

Note: Do not use a screwdriver or other tool to pry the hose loose. The hose can be torn or damaged. Loosen the hose by twisting.

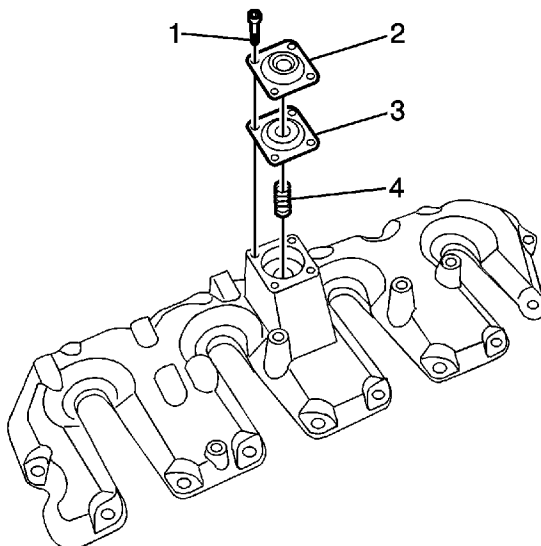
2. Remove the charged air cooler inlet duct connector (4) from the turbocharger.



3. Remove the positive crankcase ventilation (PCV) cover screws.
4. Remove the PCV cover, diaphragm, and spring.
5. Clean and inspect the cover, diaphragm, and spring.
6. Discard the diaphragm if damage is found.

Installation Procedure

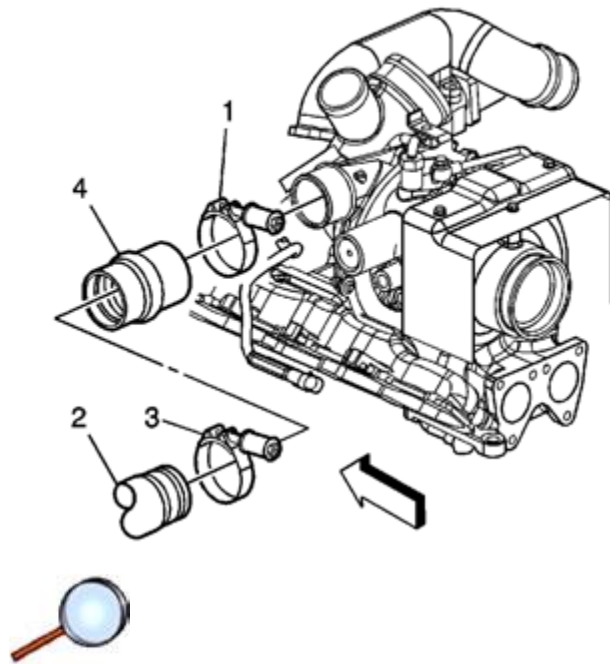
Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Install the spring, diaphragm, and cover.
2. Install the PCV cover screws.

Tighten

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



3. Remove the tape from the turbocharger openings.

Note: Lubricate the end of the duct prior to installation.

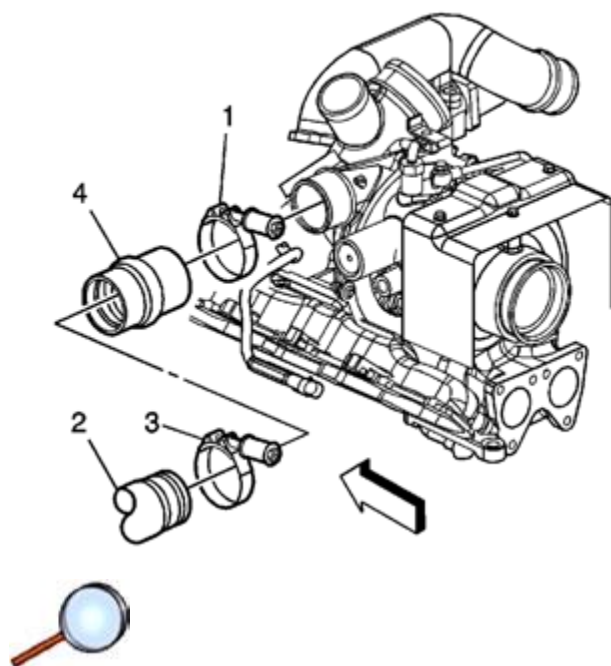
4. Install the charged air cooler inlet duct connector (4) to the turbocharger.
5. Tighten the charged air cooler inlet duct connector to turbocharger clamp (1).

Tighten

Tighten the clamp to 6 N·m (53 lb in).

Positive Crankcase Ventilation Hose / Pipe / Tube Replacement

Removal Procedure



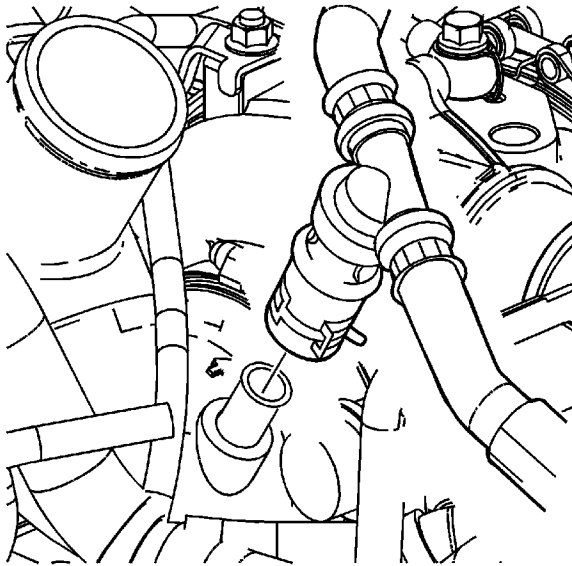
1. Remove the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).

Note: After removing the charged air cooler duct, cover the turbocharger opening with tape in order to prevent entry of objects.

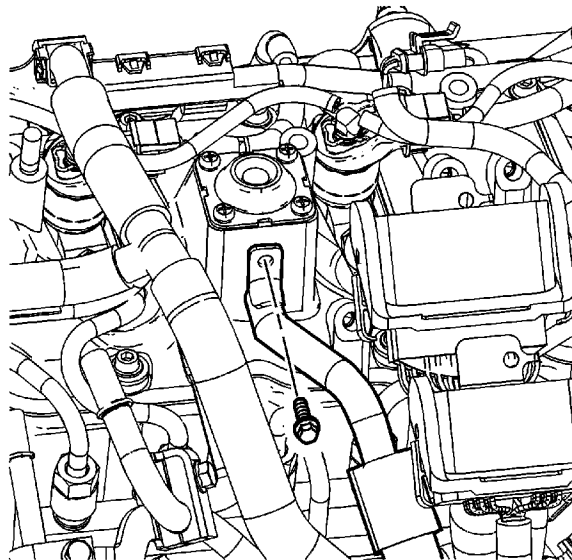
2. Loosen the charged air cooler inlet duct connector to turbocharger clamp (1).

Note: Do not use a screwdriver or other tool to pry the hose loose. The hose can be torn or damaged. Loosen the hose by twisting.

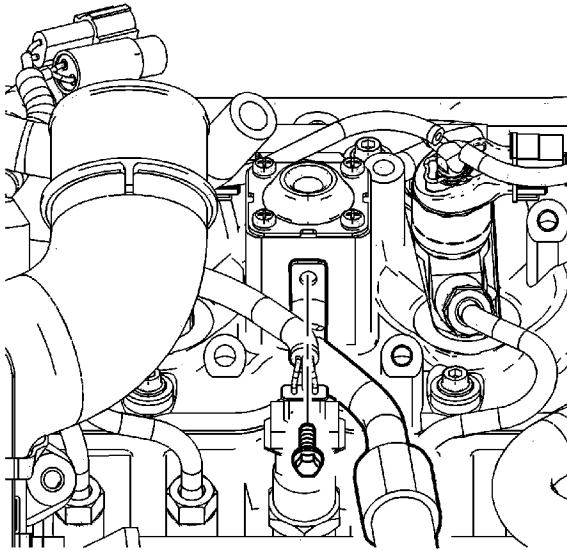
3. Remove the charged air cooler inlet duct connector (4) from the turbocharger.
4. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#).



5. Reposition the positive crankcase ventilation (PCV) hose clamp.
6. Remove the PCV hose from the air inlet pipe.
7. Remove the PCV hose from the clip on the top of the turbocharger.



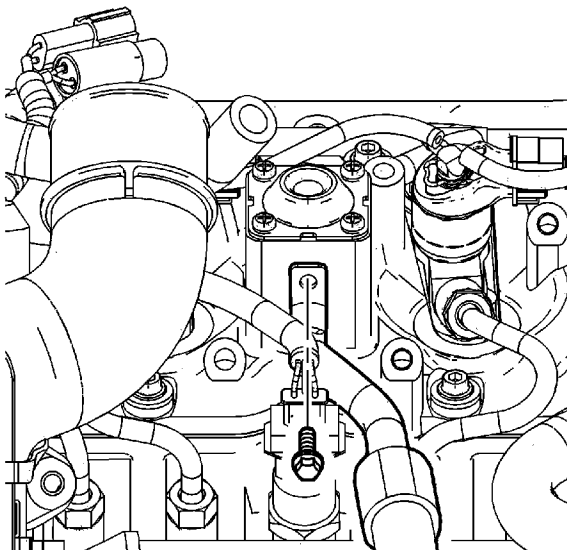
8. Remove the left PCV hose/pipe bolt.



9. Remove the right PCV hose/pipe bolt.
10. Remove the PCV hose/pipe.

Installation Procedure

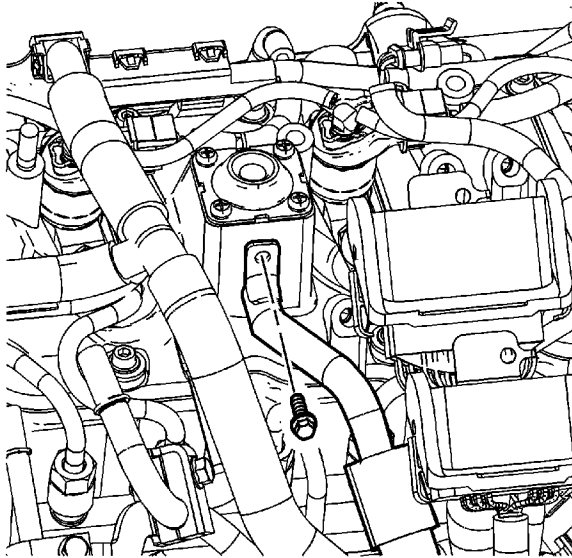
Caution: Refer to **Fastener Caution** in the Preface section.



1. Install the PCV hose/pipe.
2. Install the right PCV hose/pipe bolt.

Tighten

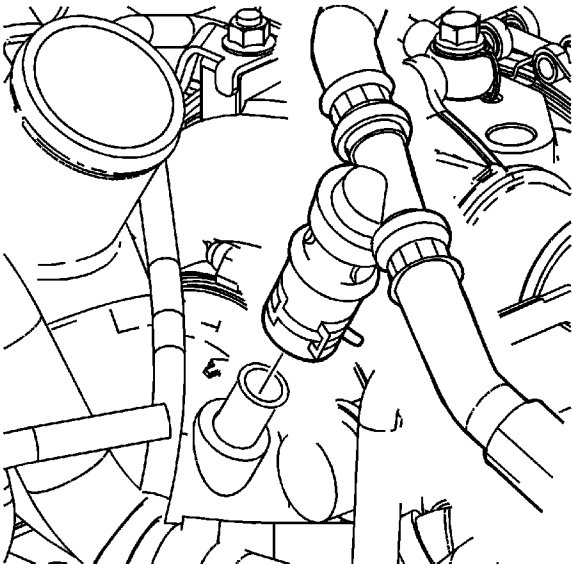
Tighten the bolt to 18 N·m (13 lb ft).



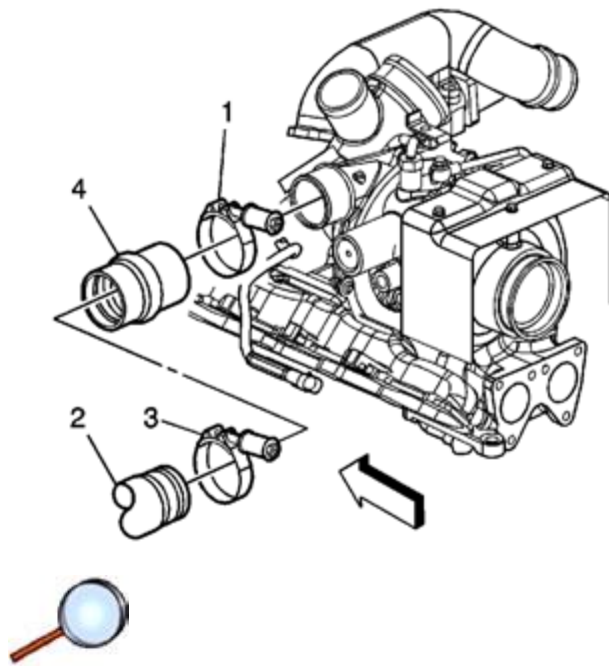
3. Install the left PCV hose/pipe bolt.

Tighten

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



4. Install the PCV hose to the air inlet pipe.
5. Position the PCV hose clamp.
6. Install the PCV hose to the clip on the top of the turbocharger.
7. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#).



8. Remove the tape from the turbocharger openings.

Note: Lubricate the end of the duct prior to installation.

9. Install the charged air cooler inlet duct connector (4) to the turbocharger.
10. Tighten the charged air cooler inlet duct connector to turbocharger clamp (1).

Tighten

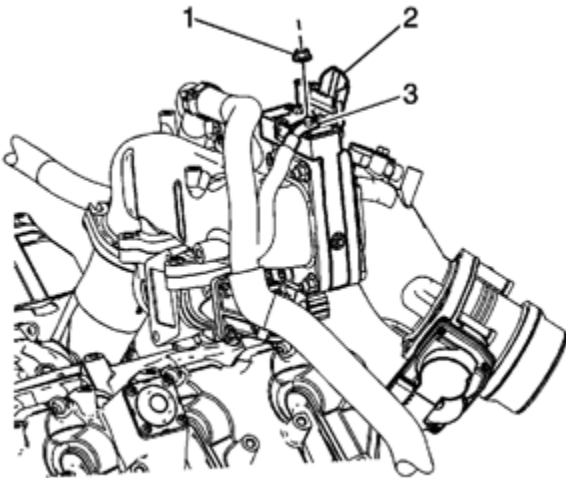
Tighten the clamp to 6 N·m (53 lb in).

11. Install the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).

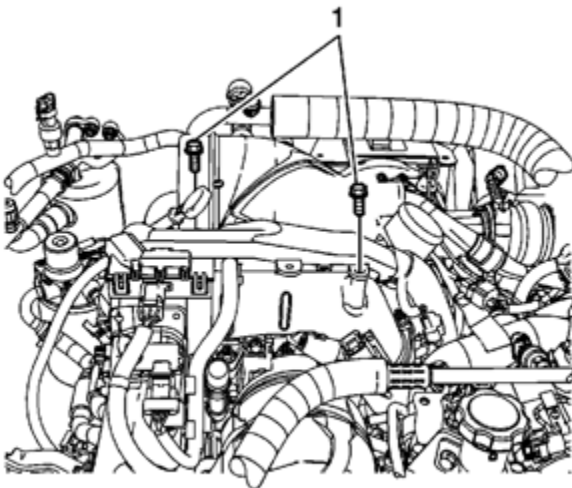
Intake Manifold Tube Replacement

Removal Procedure

1. Disconnect the negative battery cables. Refer to [Battery Negative Cable Disconnection and Connection](#).

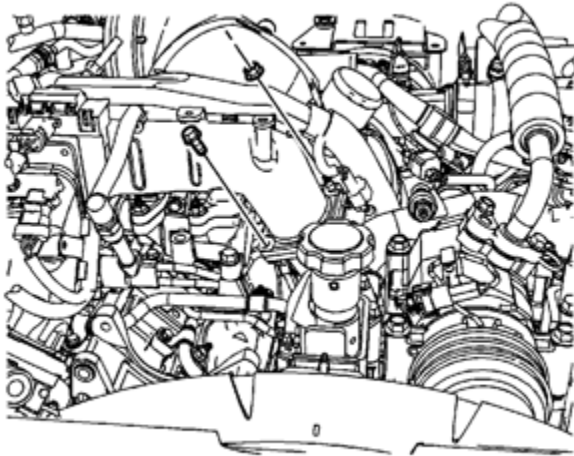


2. Open the intake air heater (IAH) harness lead cover (2).
3. Remove the engine wiring harness lead nut (1) from the IAH stud.
4. Remove the engine wiring harness lead (3) from the IAH stud.

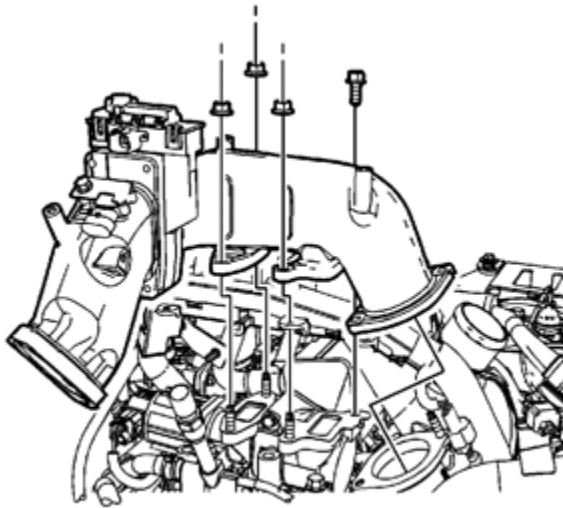


5. Remove the electrical harness bolts (1).

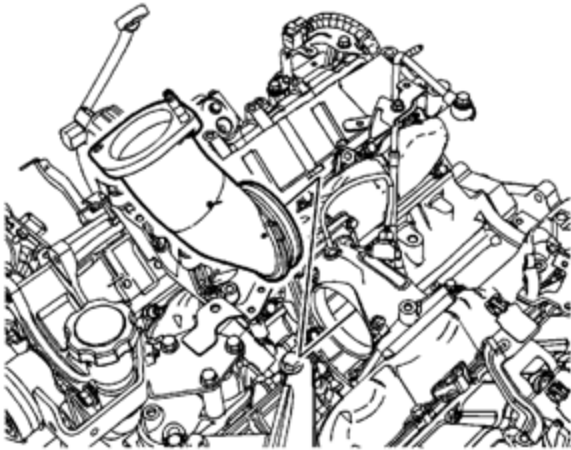
6. Reposition the harness clip from the intake manifold tube, as needed.



7. Remove the air inlet tube to intake manifold tube bolt and nut.

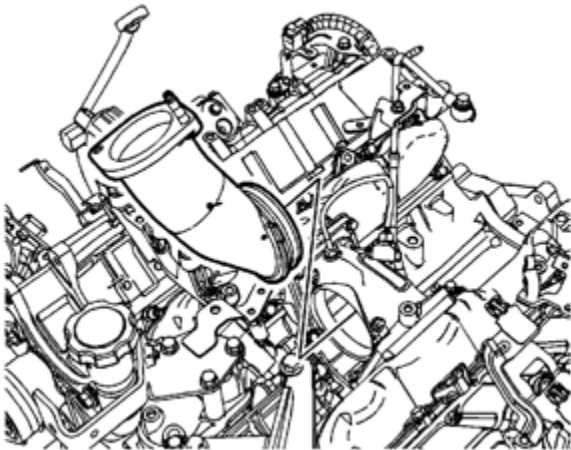


8. Disconnect the intake air heater electrical connector.
9. Disconnect the manifold absolute pressure (MAP) sensor electrical connector.
10. Remove the engine harness clip from the air inlet tube.
11. Remove the air inlet tube nuts and bolt.
12. Remove the air inlet tube.



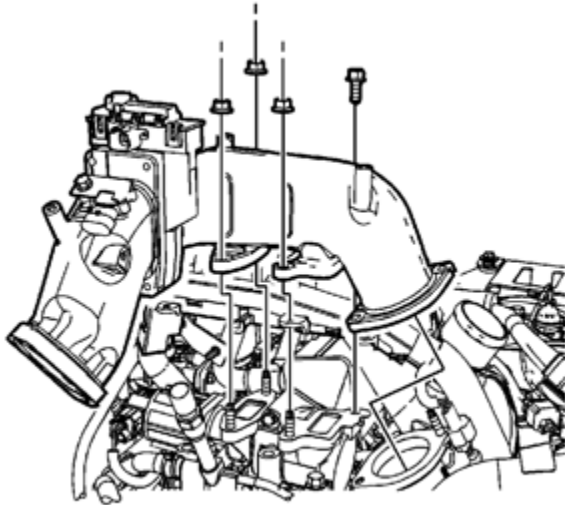
13. If necessary, remove the intake manifold tube.
14. If necessary, remove and discard the 2 O-ring seals from the tube.
15. Clean the gasket surfaces of the exhaust gas recirculation (EGR) cooler tube, intake manifold tube and inlet tube.

Installation Procedure



1. If necessary, install NEW O-ring seals onto the tube.
2. If necessary, install the intake manifold tube.

Caution: Refer to [Fastener Caution](#) in the Preface section.

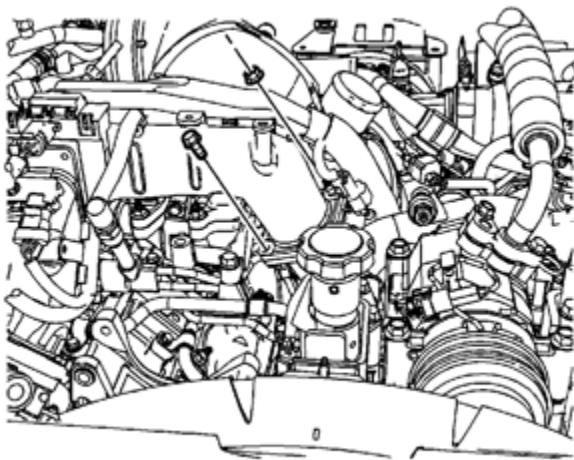


3. Install the air inlet tube and NEW gaskets.
4. Install the air inlet tube nuts and bolt.

Tighten

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

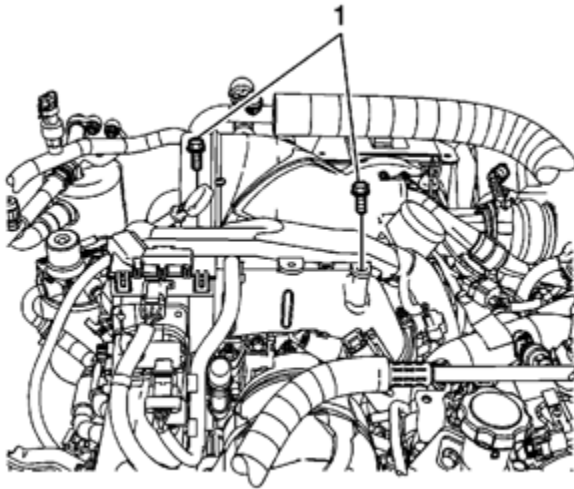
5. Connect the intake air heater electrical connector.
6. Connect the MAP sensor electrical connector.
7. Install the engine harness clip to the air inlet tube.



8. Install the air inlet tube to intake manifold tube bolt and nut.

Tighten

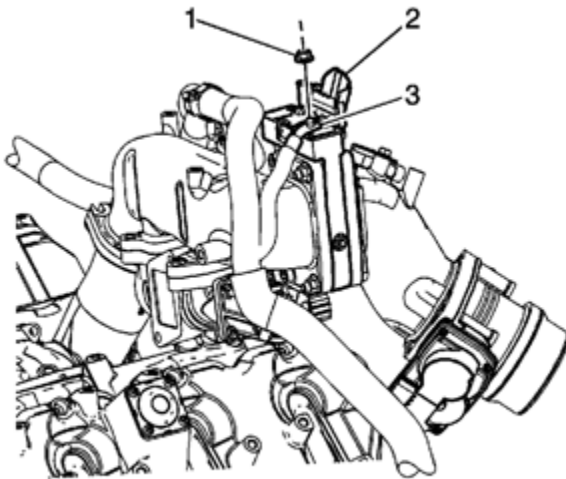
Tighten the bolt/nut to 10 N·m (89 lb in).



9. Install the electrical harness bolts (1).

Tighten

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



10. Install the engine wiring harness lead (3) to the IAH stud.
11. Install the engine wiring harness lead nut (1) to the IAH stud.

Tighten

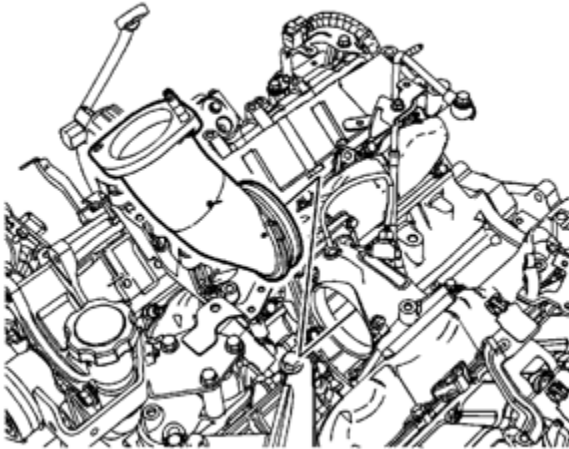
Tighten the nut to 10 N·m (89 lb in).

12. Close the IAH harness lead cover (2).
13. Connect the negative battery cables. Refer to [Battery Negative Cable Disconnection and Connection](#).

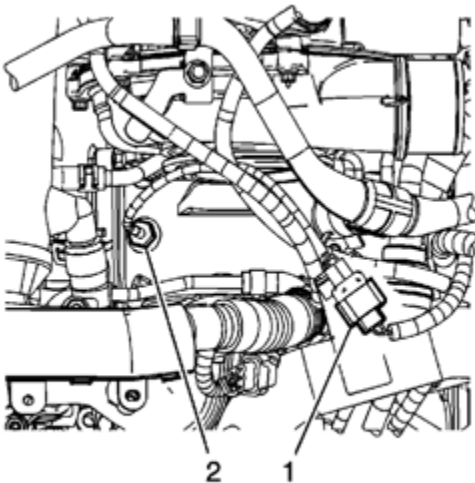
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Center Intake Manifold Replacement

Removal Procedure

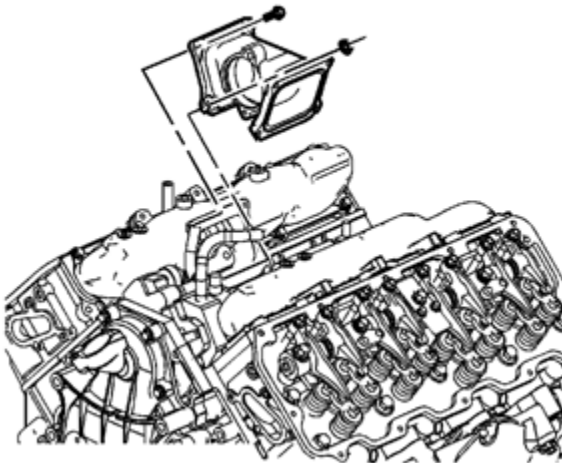


1. Remove the exhaust gas recirculation (EGR) valve cooler tube. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).
2. Remove the water outlet tube. Refer to [Water Outlet Tube Replacement](#).
3. Remove the intake manifold tube.
4. Remove and discard the 2 intake manifold tube gaskets.
5. Remove the turbocharger. Refer to [Turbocharger Replacement](#).



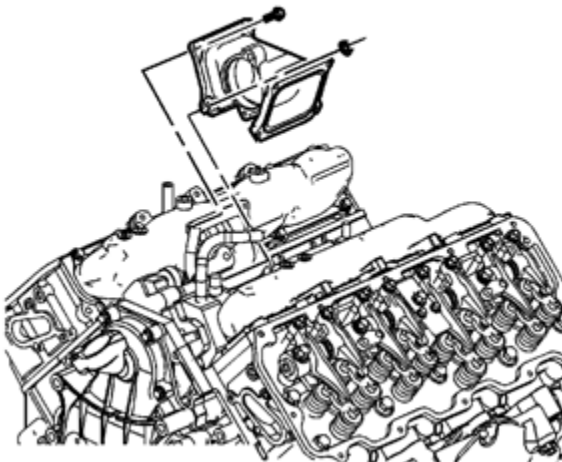


6. Disconnect the intake air temperature (IAT) sensor electrical connector (1).
7. Remove the IAT sensor (2).



8. Remove the center intake manifold bolts/nuts.
9. Pull-up the center intake manifold in order to remove.
10. Remove and discard the gaskets.
11. Clean the center intake manifold in cleaning solvent and air dry.

Installation Procedure



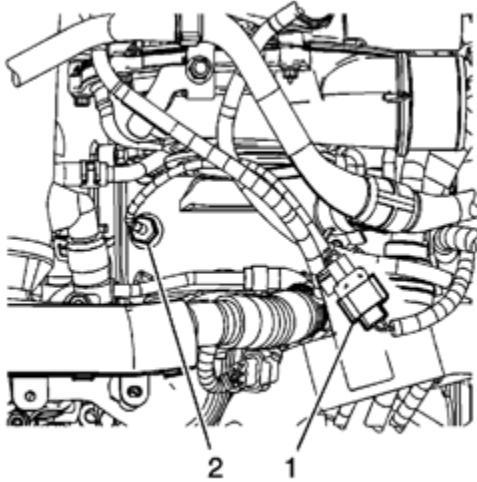
1. Install NEW center intake manifold gaskets.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the center intake manifold.
3. Install the center intake manifold bolts/nuts.

Tighten

Tighten the bolts/nuts to 10 N·m (89 lb in).

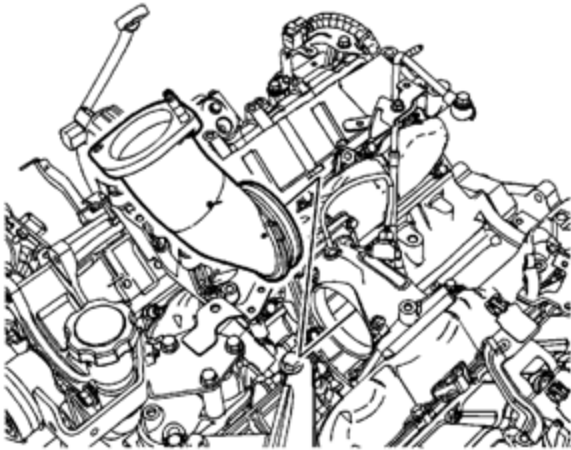


4. Install the IAT sensor (2).

Tighten

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

5. Connect the IAT sensor electrical connector (1).
6. Install the turbocharger. Refer to [Turbocharger Replacement](#).

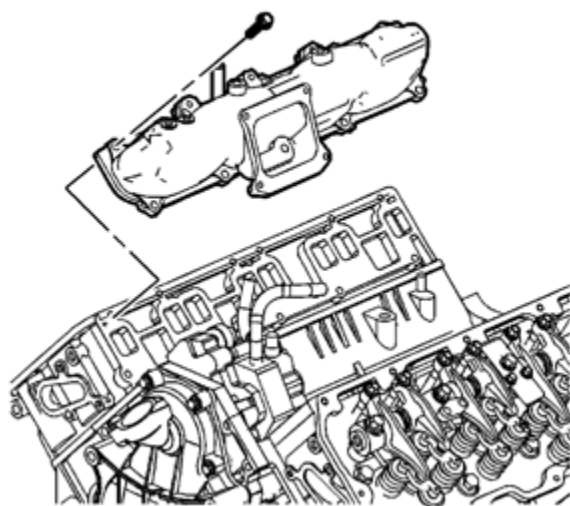


7. Install 2 NEW O-rings onto the intake manifold tube.
8. Lubricate the O-rings with clean engine oil to aid in the installation.
9. Install the intake manifold tube.
10. Install the water outlet tube. Refer to [Water Outlet Tube Replacement](#).
11. Install the EGR valve cooler tube. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).

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Intake Manifold Replacement - Left Side

Removal Procedure

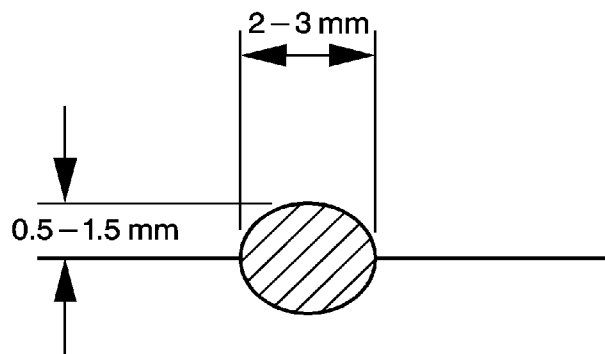


1. Remove the center intake manifold. Refer to [Center Intake Manifold Replacement](#).
2. Remove the glow plug module and bracket. Refer to [Glow Plug Control Module Replacement](#).
3. Remove the left fuel rail. Refer to [Fuel Injection Fuel Rail Assembly Replacement - Bank 1](#).
4. Remove the intake manifold bolts/nuts.

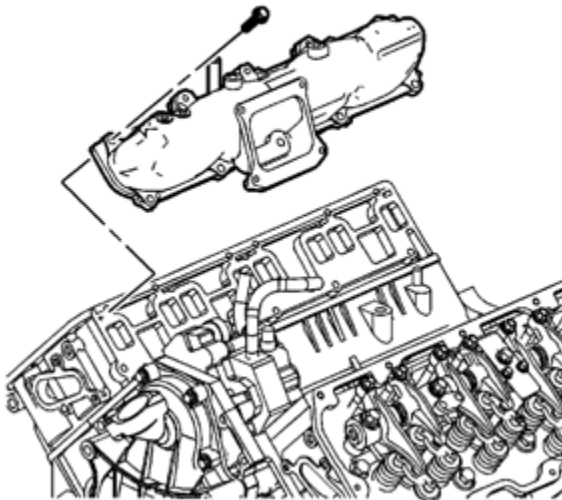
Note: The intake manifold uses sealer. Pry at the area by the fuel rail bolt holes in order to avoid damage to the sealing surfaces.

5. Remove the intake manifold.
6. To prevent entry of debris in the cylinder head tape the openings.
7. If required, clean and inspect the intake manifold. Refer to [Intake Manifold Cleaning and Inspection](#).

Installation Procedure

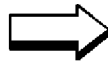
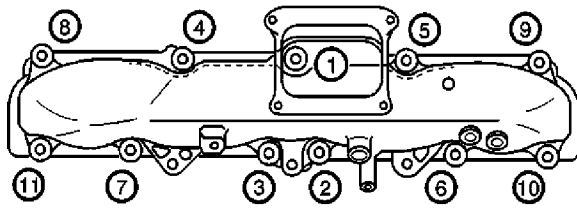


1. Apply a 2-3 mm (1/8 in) wide, by 0.5-1.5 mm (1/16 in) high bead of sealant to the intake manifold. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.



2. Install the intake manifold.
3. Install the intake manifold bolts/nuts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the intake manifold bolts/nuts in the sequence shown.

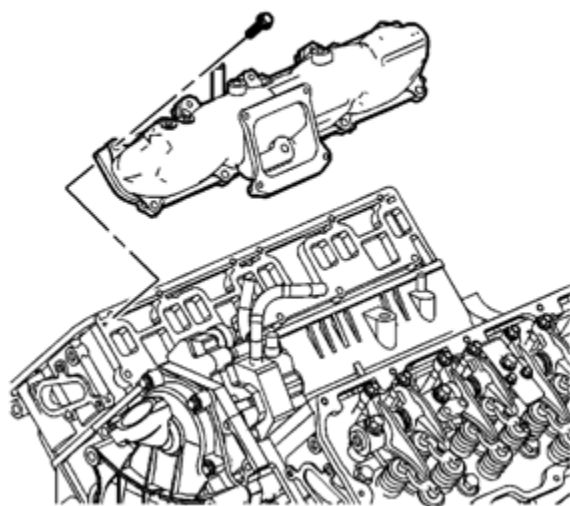
Tighten

Tighten the bolts/nuts to 21 N·m (15 lb ft).

5. Install the left fuel rail. Refer to [Fuel Injection Fuel Rail Assembly Replacement - Bank 1](#).
6. Install the glow plug module and bracket. Refer to [Glow Plug Control Module Replacement](#).
7. Install the center intake manifold. Refer to [Center Intake Manifold Replacement](#).

Intake Manifold Replacement - Right Side

Removal Procedure

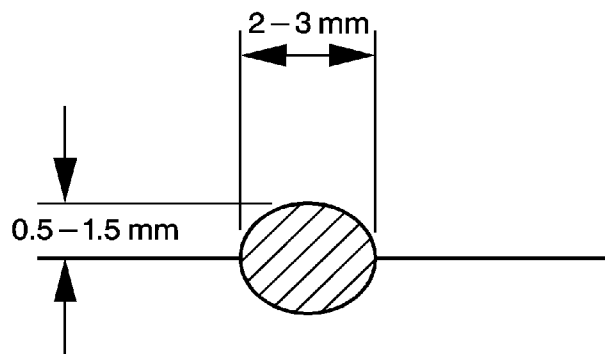


1. Remove the center intake manifold. Refer to [Center Intake Manifold Replacement](#).
2. Remove the right fuel rail. Refer to [Fuel Injection Fuel Feed Front Pipe Replacement - Right Side](#).
3. Remove the intake manifold bolts/nuts.
4. Remove the fuel return junction block. Refer to [Fuel Injection Fuel Feed Manifold Replacement](#).

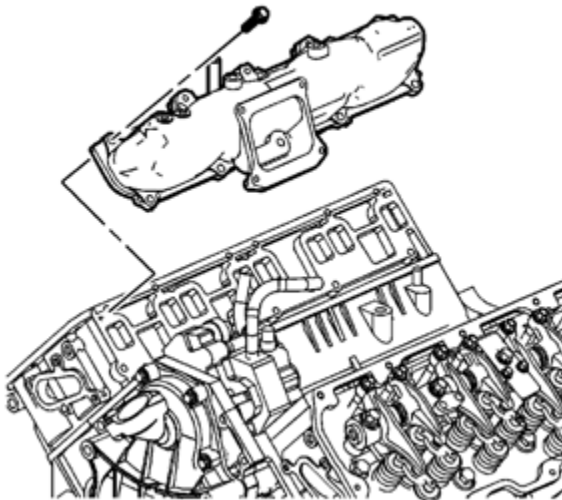
Note: The intake manifold uses sealer. Pry at the area by the fuel rail bolt holes in order to avoid damage to the sealing surfaces.

5. Remove the intake manifold.
6. To prevent entry of debris in the cylinder head tape the openings.
7. If required, clean and inspect the intake manifold. Refer to [Intake Manifold Cleaning and Inspection](#).

Installation Procedure

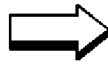
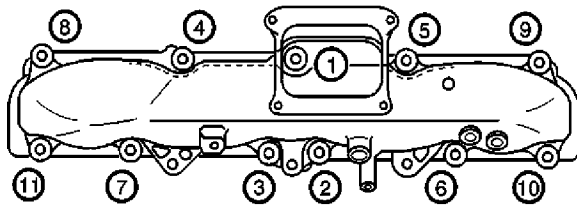


1. Apply a 2-3 mm (1/8 in) wide, by 0.5-1.5 mm (1/16 in) high bead of sealant to the intake manifold. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.



2. Install the intake manifold.
3. Install the intake manifold bolts/nuts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the intake manifold bolts/nuts in the sequence shown.

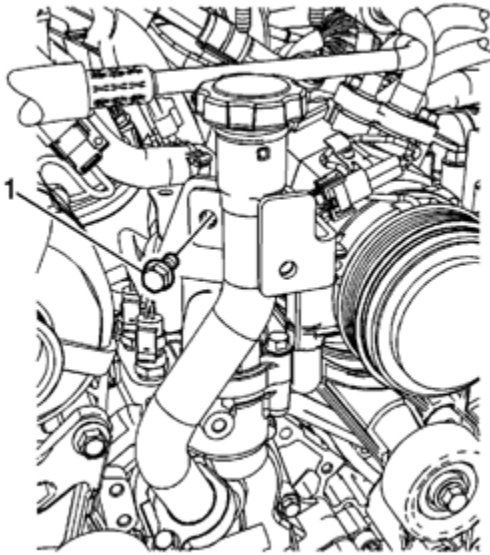
Tighten

Tighten the bolts/nuts to 21 N·m (15 lb ft).

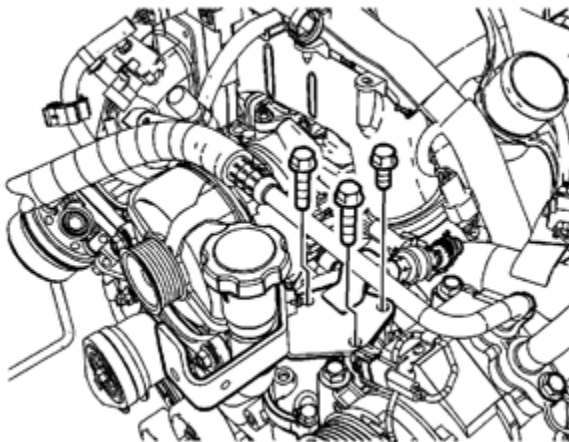
5. Install the fuel return junction block. Refer to [Fuel Injection Fuel Feed Manifold Replacement](#).
6. Install the right fuel rail. Refer to [Fuel Injection Fuel Feed Front Pipe Replacement - Right Side](#).
7. Install the center intake manifold. Refer to [Center Intake Manifold Replacement](#).

Oil Filler Tube Replacement

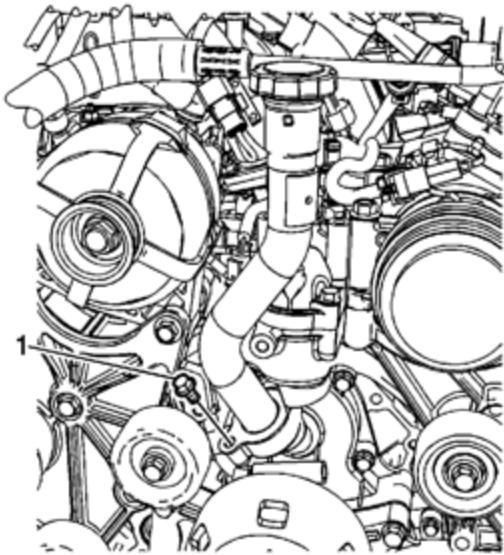
Removal Procedure



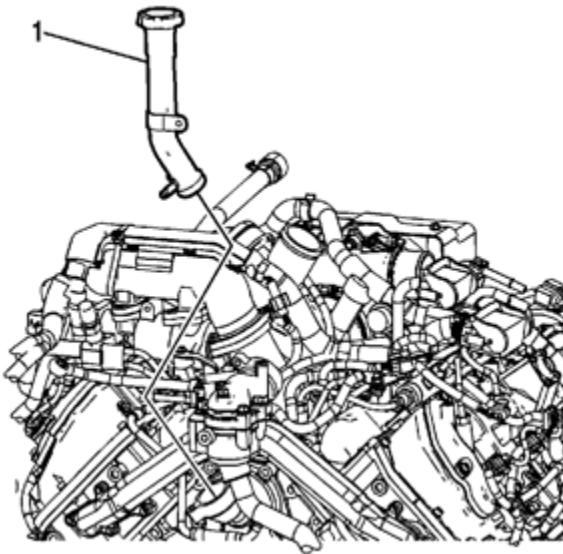
1. Remove the fan and clutch assembly. Refer to [Cooling Fan and Shroud Replacement](#).
2. Remove the drive belt. Refer to [Drive Belt Replacement](#).
3. Remove the upper oil fill tube bolt (1).



4. Remove the oil filler tube bracket bolts.
5. Remove the oil fill tube bracket.

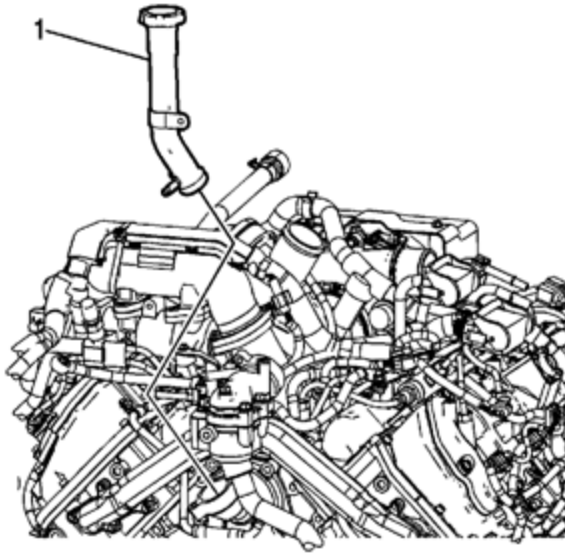


6. Remove the lower oil fill tube bolt (1).



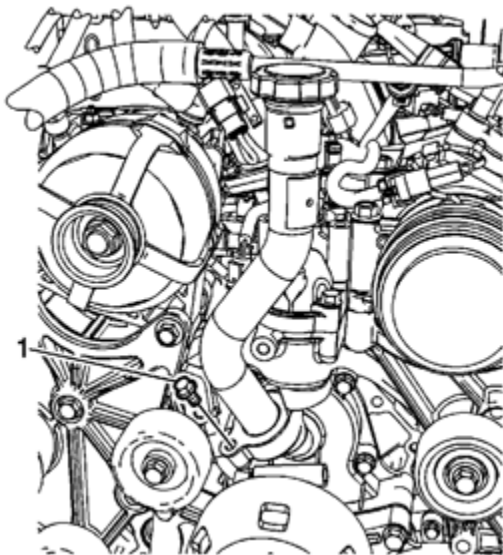
7. Remove the oil fill tube.
8. Remove and discard the oil fill tube O-ring seal.

Installation Procedure



1. Install a NEW O-ring seal onto the oil fill tube.
2. Install the oil fill tube.

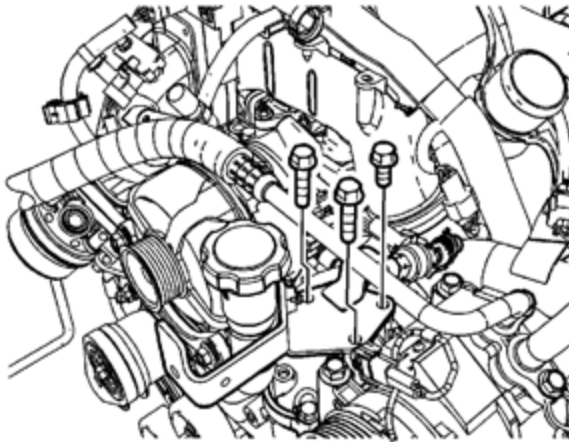
Caution: Refer to [Fastener Caution](#) in the Preface section.



3. Install the lower oil fill tube bolt (1).

Tighten

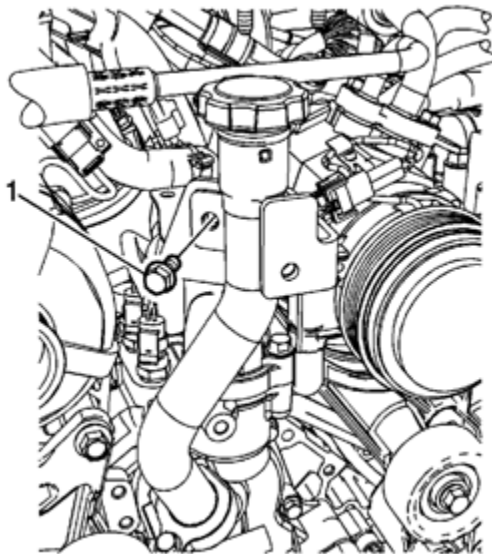
Tighten the bolts to 21 N·m (15 lb ft).



4. Install the oil fill tube bracket.
5. Install the oil filler tube bracket bolts.

Tighten

Tighten the bolts to 21 N·m (15 lb ft).



6. Install the upper oil fill tube bolt (1).

Tighten

Tighten the bolts to 21 N·m (15 lb ft).

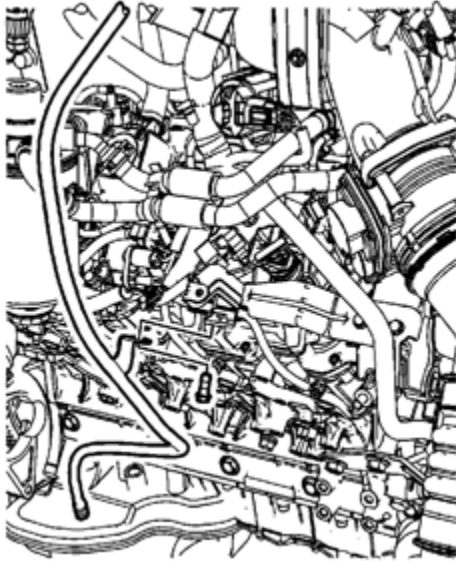
7. Install the drive belt. Refer to [Drive Belt Replacement](#).

8. Install the fan and clutch assembly. Refer to [Cooling Fan and Shroud Replacement](#).

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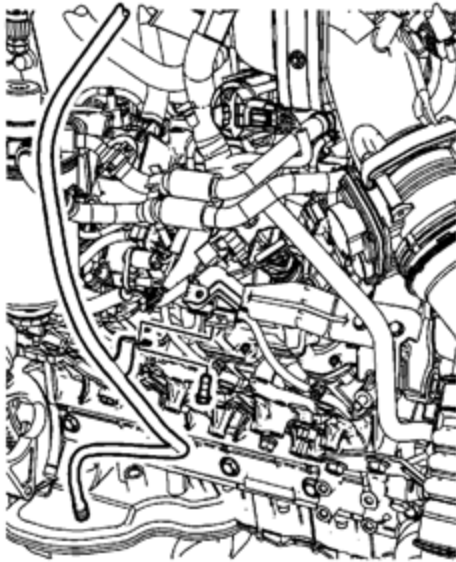
Oil Level Indicator Tube Replacement

Removal Procedure



1. Remove the oil level indicator.
2. Remove the exhaust manifold. Refer to [Exhaust Manifold Replacement - Right Side](#).
3. Remove the starter motor. Refer to [Starter Motor Replacement](#).
4. Remove the oil level indicator tube bolt at the indicator tube bracket.
5. Remove the oil level indicator tube and O-ring seals.
6. Remove and discard the O-ring seals.

Installation Procedure



1. Install NEW O-ring seals onto the oil level indicator tube.
2. Lightly lubricate the O-ring seals with engine oil.

Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the oil level indicator tube.
4. Install the oil level indicator tube bolt at the indicator tube bracket.

Tighten

Tighten the bolt to 21 N·m (15 lb ft).

5. Install the starter motor. Refer to [Starter Motor Replacement](#).
6. Install the exhaust manifold. Refer to [Exhaust Manifold Replacement - Right Side](#).
7. Install the oil level indicator.

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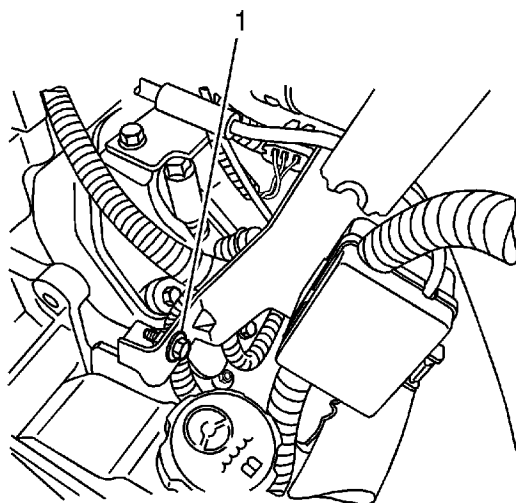
Valve Rocker Arm Cover Replacement - Upper Left Side

Removal Procedure

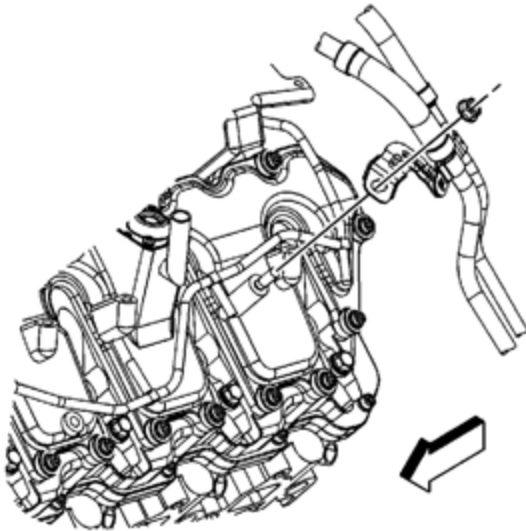
1. Remove the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).
2. Drain the cooling system. Refer to [Cooling System Draining and Filling](#).
3. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).

Note: After removing the charged air cooler duct, cover the turbocharger opening with tape in order to prevent entry of objects.

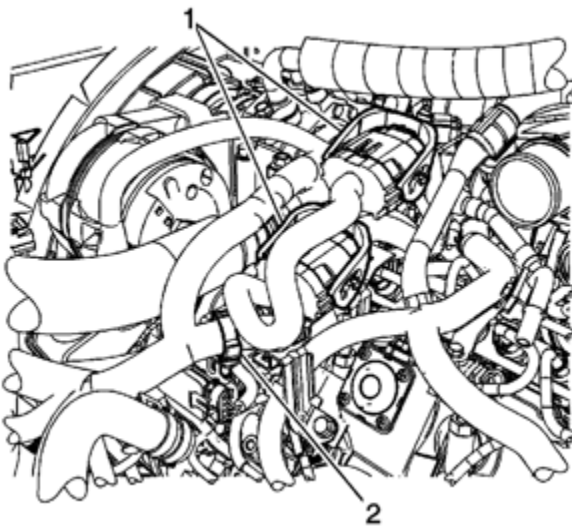
4. Remove the charged air cooler inlet duct. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).



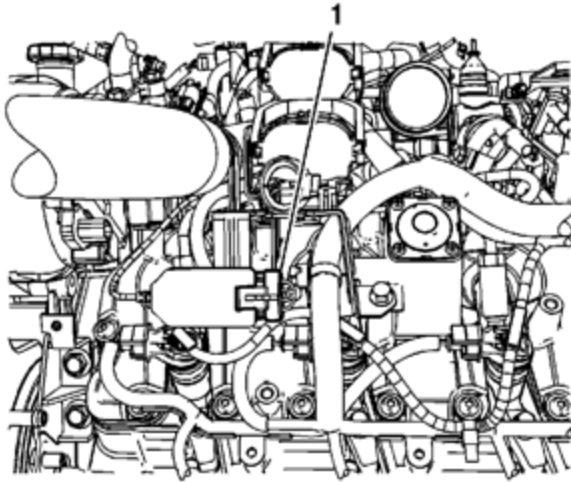
5. Remove the battery cable to generator nut.
6. If equipped, remove the battery cable to the auxiliary generator.
7. Remove the battery cable harness clip from the bracket.
8. Remove the battery cable junction block bolt (1) from the power steering pump.
9. Move and secure the battery cables out of the way.



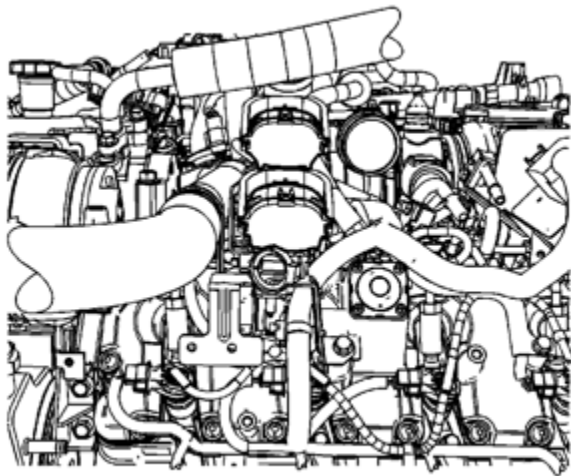
10. Disconnect the fuel lines. Refer to [Metal Collar Quick Connect Fitting Service](#).
11. Remove the fuel hose bracket nut.



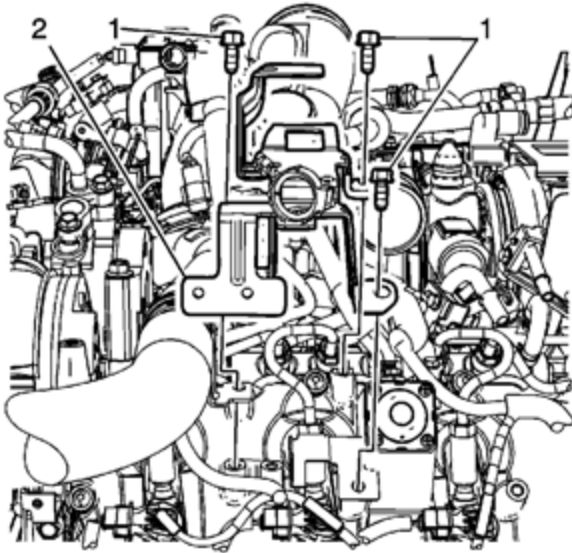
12. Disconnect the main engine electrical harness connectors. Lift up on the latches (1) in order to disconnect the connectors.
13. Open the harness clip (2).
14. Remove the main engine electrical harness connectors.



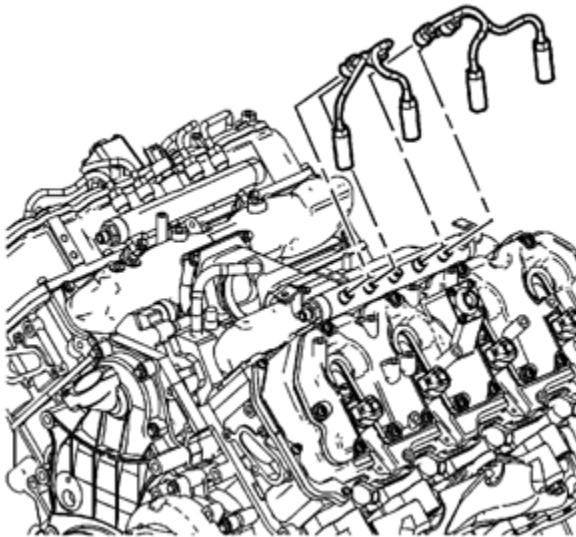
15. Disconnect the turbocharger vane position sensor electrical connector (1).



16. Unclip the main engine electrical harness connectors from the main electrical connector harness bracket.



17. Remove the main electrical connector harness bracket bolts (1).
18. Remove the main electrical connector harness bracket (2).
19. Remove the water outlet tube. Refer to [Water Outlet Tube Replacement](#).
20. Remove the auxiliary generator, if equipped. Refer to [Auxiliary Generator Replacement](#).
21. Remove the positive crankcase ventilation (PCV) hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).

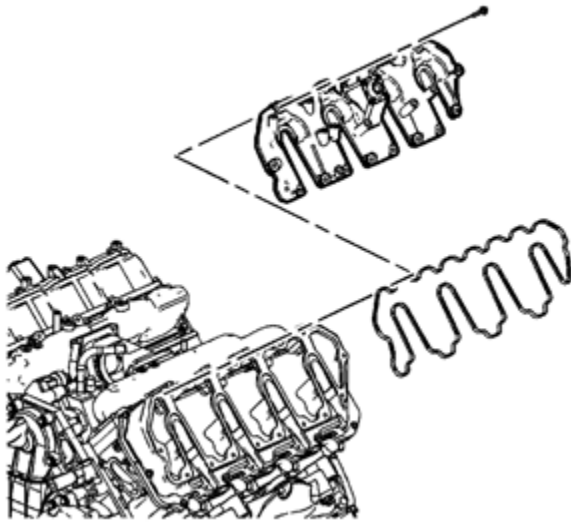


22. Prior to removing the fuel injector pipes, use compressed air to blow any debris from between the injector line and fittings. Wipe the fittings clean of debris.
23. Spray lithium grease between the fuel injector line and fittings to assist in containing any debris during removal. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.

Caution: DO NOT use compressed air to clean debris from the fuel injector inlet after the fuel line is removed. Using compressed air can allow debris to enter the fuel injector inlet and

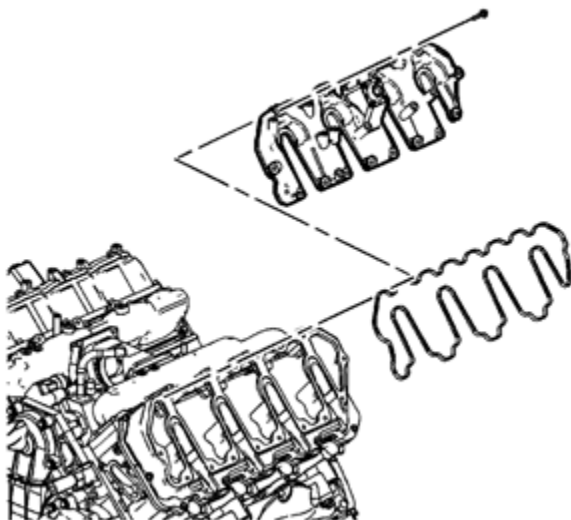
damage the fuel injector.

24. Remove the left fuel injector pipes.



25. Remove the upper valve rocker arm cover bolts.
26. Remove the upper valve rocker arm cover.
27. Remove the upper valve rocker arm cover gasket.
28. Inspect the upper valve rocker arm cover gasket for damage, replace if necessary. Otherwise reuse the old gasket.
29. If required, clean and inspect the upper valve rocker arm cover. Refer to [Valve Rocker Arm Cover Cleaning and Inspection - Upper](#).

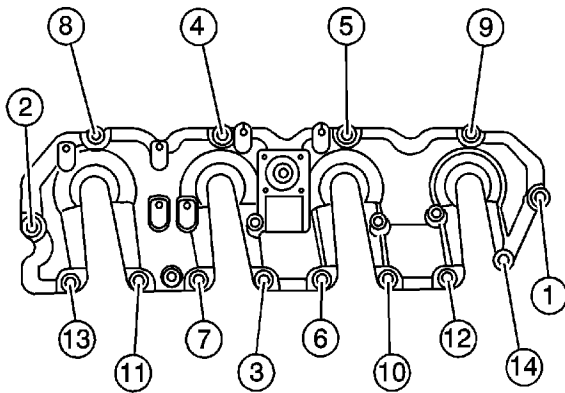
Installation Procedure





1. Install the valve rocker arm cover gasket.
2. Install the upper valve rocker arm cover.
3. Install the upper valve rocker arm cover bolts.

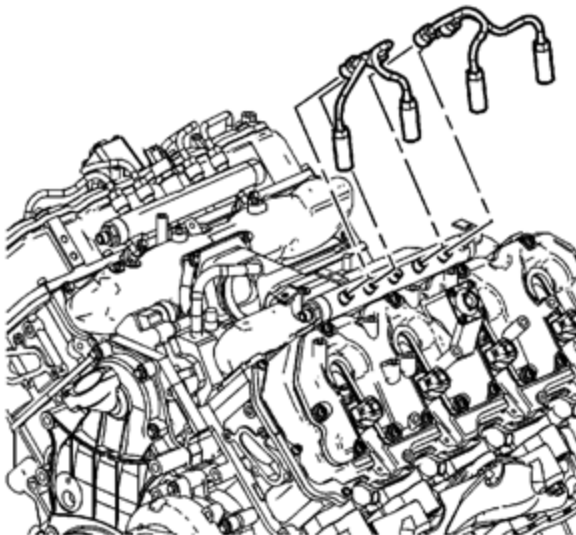
Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the upper valve rocker arm cover bolts in the sequence shown.

Tighten

Tighten the bolts to 8 N·m (71 lb in).





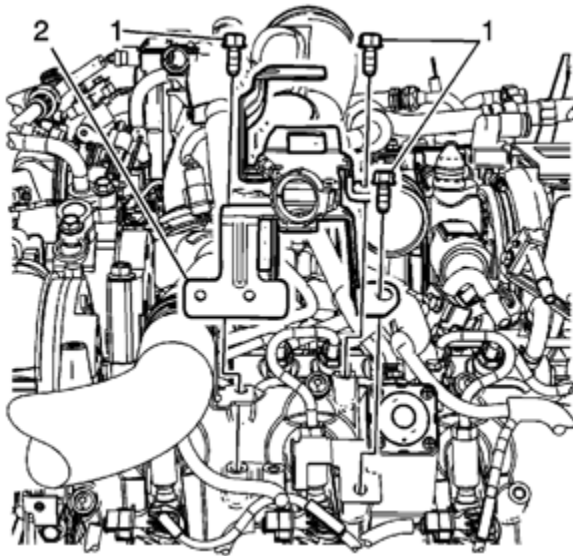
Caution: Ensure proper torquing of the fuel injector line. An under-torqued fuel injector line will not seal properly and an over-torqued fuel injector line may damage the fuel injector fitting. An improperly sealed or damaged fuel injector line or fuel injector fitting will cause a fuel leak.

5. Install the left fuel injector pipes.

Tighten

Tighten the pipes to 41 N·m (30 lb ft).

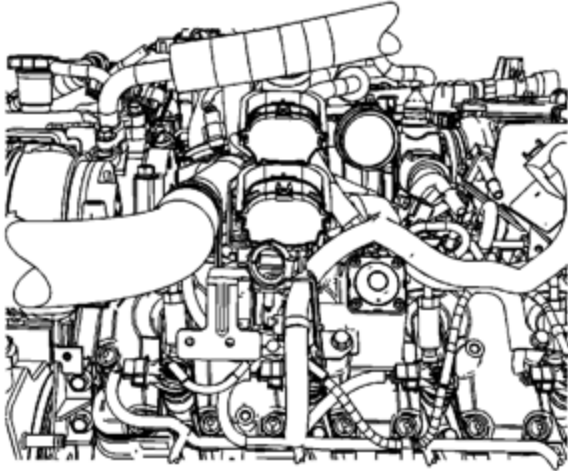
6. Install the water outlet tube. Refer to [Water Outlet Tube Replacement](#).
7. Install the auxiliary generator, if equipped. Refer to [Auxiliary Generator Replacement](#).
8. Install the PCV hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).



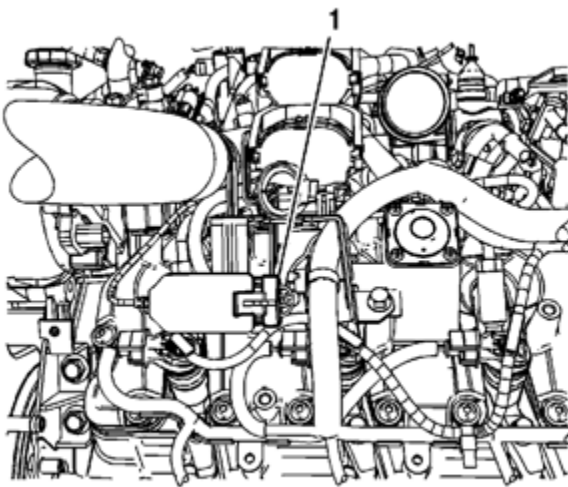
9. Install the main electrical connector harness bracket (2).
10. Install the main electrical connector harness bracket bolts (1).

Tighten

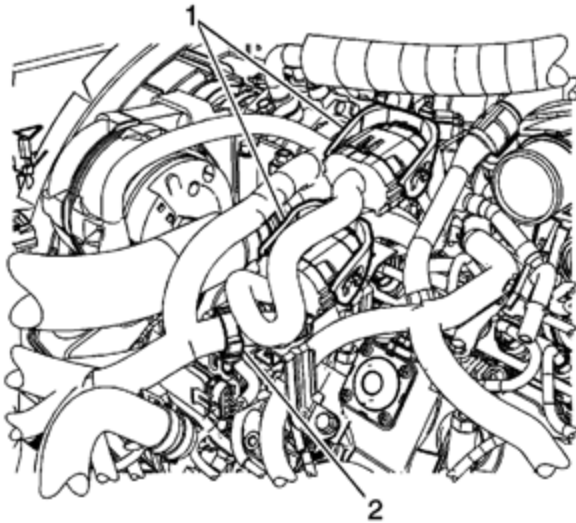
Tighten the bolts to 21 N·m (15 lb ft).



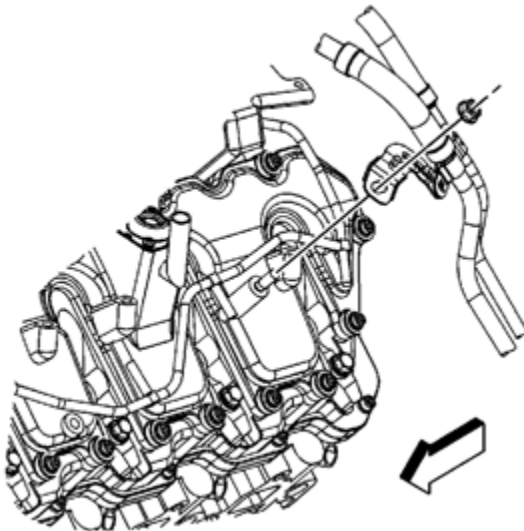
11. Clip the main engine electrical harness connectors to the main electrical connector harness bracket.



12. Connect the turbocharger vane position sensor electrical connector (1).



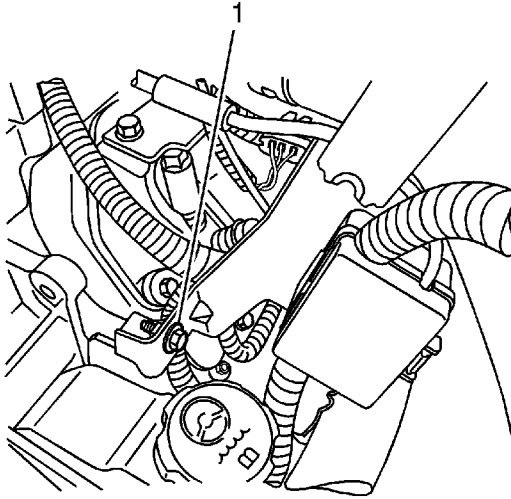
13. Connect the main engine electrical harness connectors.
14. Push down on the latches (1) in order to connect the connectors.
15. Close the harness clip (2).



16. Connect the fuel lines. Refer to [Metal Collar Quick Connect Fitting Service](#).
17. Install the fuel hose bracket nut.

Tighten

Tighten the nut to 21 N·m (15 lb ft).



18. Position the generator positive cable.
19. Install the generator positive cable in the clip on the engine front cover.
20. Install the generator positive cable and nut.

Tighten

Tighten the nut to 9 N·m (80 lb in).

21. Install the positive battery cable junction block bracket and bolt (1) to the power steering pump.

Tighten

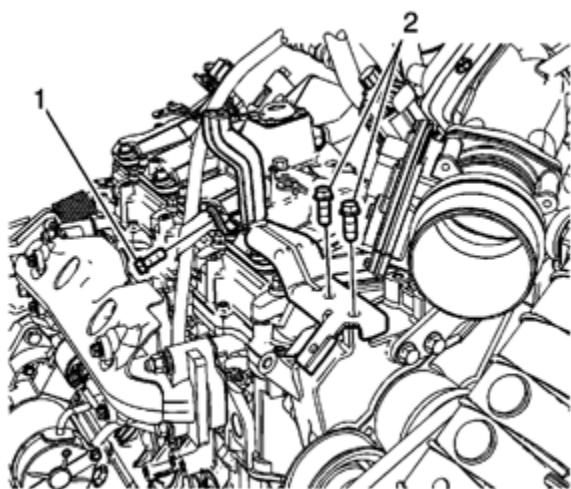
Tighten the bolt to 9 N·m (80 lb in).

22. Remove the tape from the turbocharger openings.
23. Install the charged air cooler inlet duct. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).
24. Fill the cooling system. Refer to [Cooling System Draining and Filling](#).
25. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).
26. Install the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).

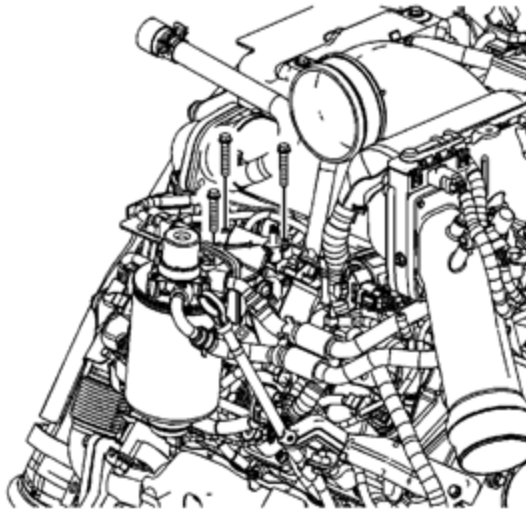
Valve Rocker Arm Cover Replacement - Upper Right Side

Removal Procedure

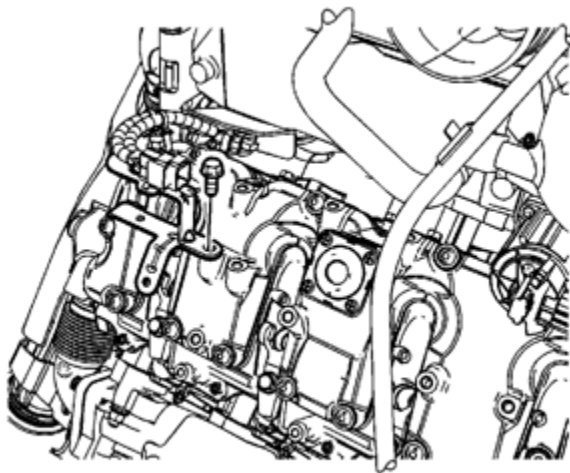
1. Remove the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).
2. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#).
3. Remove the charged air cooler outlet duct. Refer to [Charge Air Cooler Outlet Pipe Replacement](#).
4. Remove the exhaust gas recirculation (EGR) cooler tube. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).
5. Remove the heater outlet hose bolt from the bracket.
6. Position the heater outlet hose out of the way.



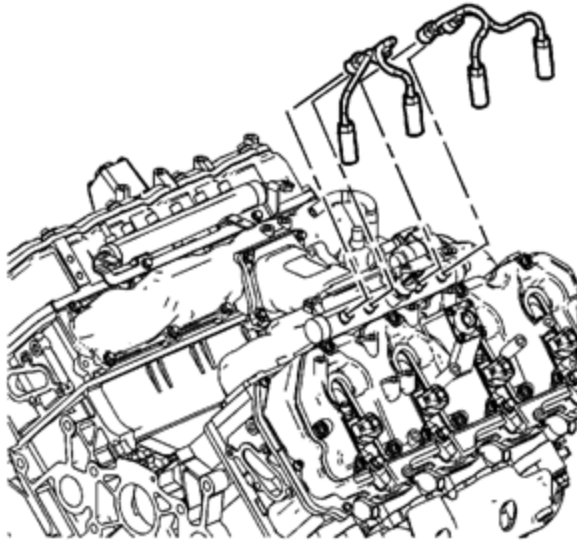
7. Remove the wiring harness retainer from the bracket.
8. Remove the oil level indicator tube bolt (1).
9. Remove the oil level indicator tube bracket bolts (2).
10. Remove the bracket.



11. Remove the fuel filter bracket bolts.
12. Reposition the fuel filter with bracket.
13. Remove the positive crankcase ventilation (PCV) hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).



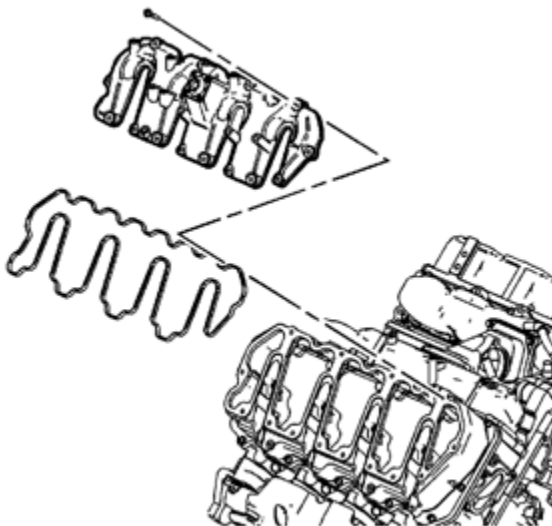
14. Remove the engine harness bracket bolt.
15. Position engine harness brackets aside.



16. Prior to removing the fuel injector pipes, use compressed air to blow any debris from between the injector line and fittings. Wipe the fittings clean of debris.
17. Spray lithium grease between the fuel injector line and fittings to assist in containing any debris during removal. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.

Caution: DO NOT use compressed air to clean debris from the fuel injector inlet after the fuel line is removed. Using compressed air can allow debris to enter the fuel injector inlet and damage the fuel injector.

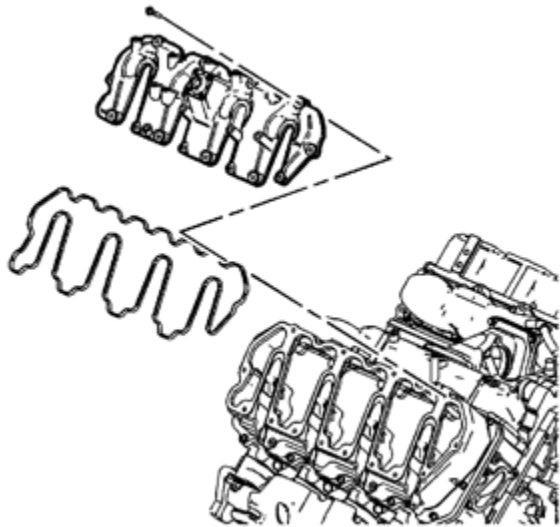
18. Remove the right fuel injector pipes.



19. Remove the upper valve rocker arm cover bolts.
20. Remove the upper valve rocker arm cover.

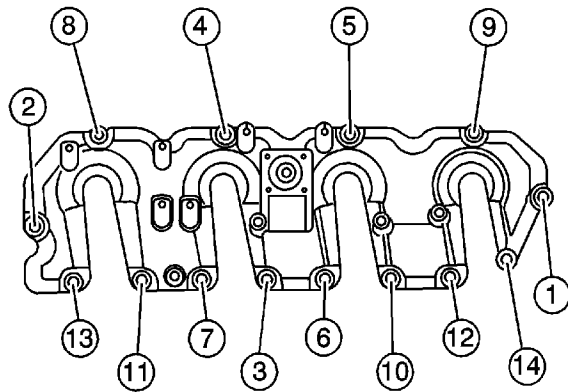
21. Remove the upper valve rocker arm cover gasket.
22. Inspect the upper valve rocker arm cover gasket for damage, replace if necessary. Otherwise reuse the old gasket.
23. If required, clean and inspect the upper valve rocker arm cover. Refer to [Valve Rocker Arm Cover Cleaning and Inspection - Upper](#).

Installation Procedure



1. Install the upper valve rocker arm cover gasket.
2. Install the upper valve rocker arm cover.
3. Install the upper valve rocker arm cover bolts.

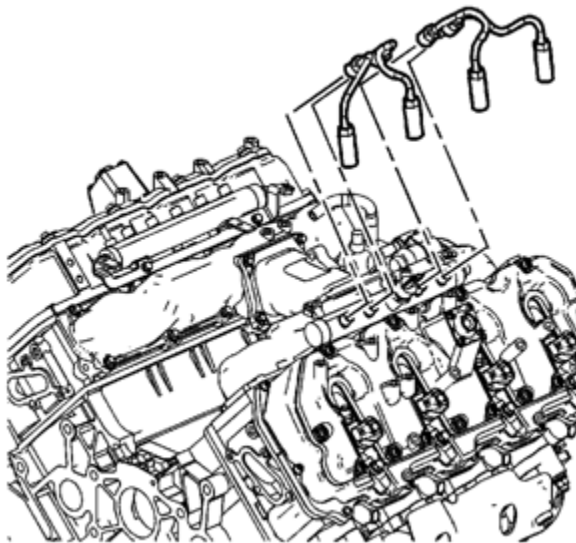
Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the upper valve rocker arm cover bolts in the sequence shown.

Tighten

Tighten the bolts to 8 N·m (71 lb in).

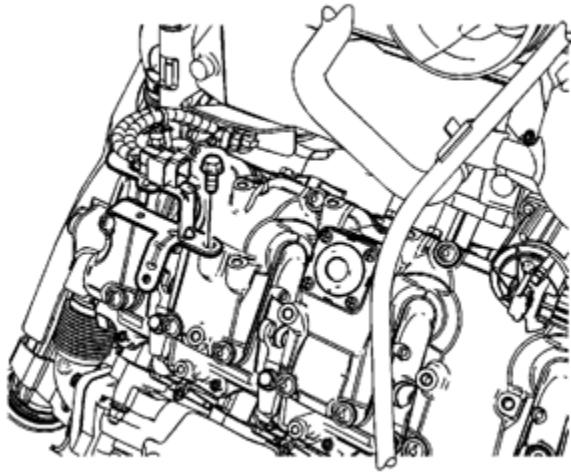


Caution: Ensure proper torquing of the fuel injector line. An under-torqued fuel injector line will not seal properly and an over-torqued fuel injector line may damage the fuel injector fitting. An improperly sealed or damaged fuel injector line or fuel injector fitting will cause a fuel leak.

5. Install the fuel injector pipes.

Tighten

Tighten the pipes to 41 N·m (30 lb ft).

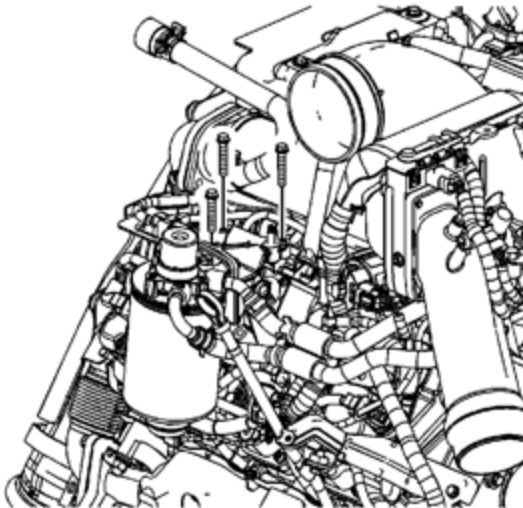


6. Position engine harness brackets.
7. Install the engine harness bracket bolt.

Tighten

Tighten the bolt to 21 N·m (15 lb ft).

8. Install the PCV hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).



9. Position the fuel filter with bracket to the rocker cover.

10. Install the fuel filter bracket bolts.

Tighten

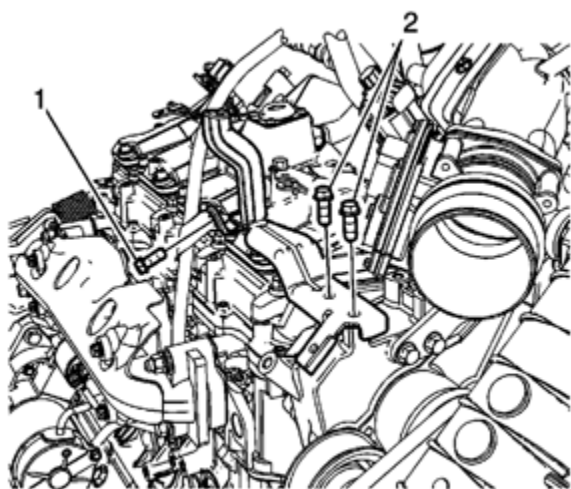
Tighten the bolts to 21 N·m (15 lb ft).

11. Position the heater outlet hose.
12. Install the heater hose bracket bolt to the bracket.

Tighten

Tighten the bolt to 21 N·m (15 lb ft).

13. Install the EGR cooler tube. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).



14. Install the bracket.
15. Install the oil level indicator tube bracket bolts (2).

Tighten

Tighten the bolts to 21 N·m (15 lb ft).

16. Install the oil level indicator tube bolt (1).

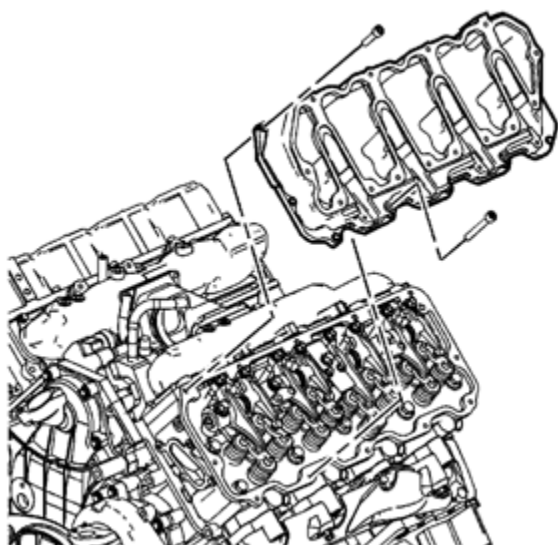
Tighten

Tighten the bolt to 21 N·m (15 lb ft).

17. Install the wiring harness retainer to the bracket.
18. Install the charged air cooler outlet duct. Refer to [Charge Air Cooler Outlet Pipe Replacement](#).
19. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#).
20. Install the intake manifold cover. Refer to [Intake Manifold Cover Replacement](#).

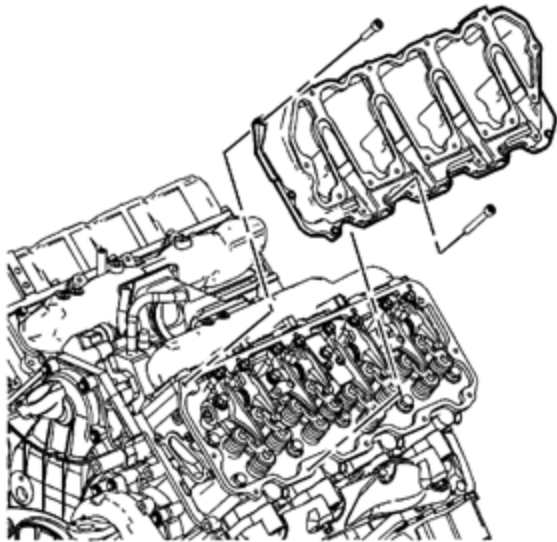
Valve Rocker Arm Cover Replacement - Lower Left Side

Removal Procedure



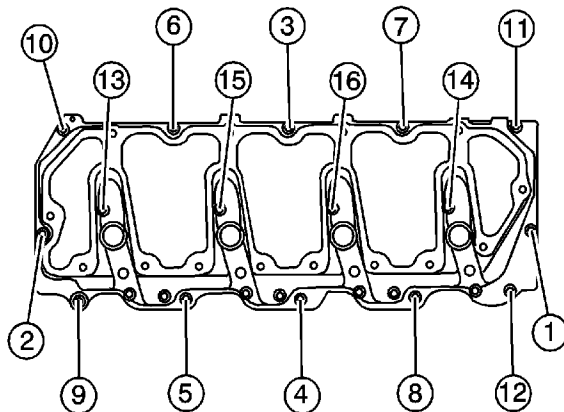
1. Remove the upper left valve rocker arm cover. Refer to [Valve Rocker Arm Cover Replacement - Upper Left Side](#).
2. Remove the fuel injectors. Refer to [Fuel Injector Replacement](#).
3. Remove the lower valve rocker arm cover bolts.
4. Remove the lower valve rocker arm cover.
5. Remove the gasket from the lower valve rocker arm cover.
6. Inspect the lower valve rocker arm cover gasket for damage, replace if necessary. Otherwise reuse the old gasket.
7. If required, clean and inspect the lower valve rocker arm cover. Refer to [Valve Rocker Arm Cover Cleaning and Inspection - Lower](#).

Installation Procedure



1. Install the lower valve rocker arm cover gasket.
2. Install the lower valve rocker arm cover.
3. Install the lower valve rocker arm cover bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the lower valve rocker arm cover bolts in the sequence shown.

Tighten

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

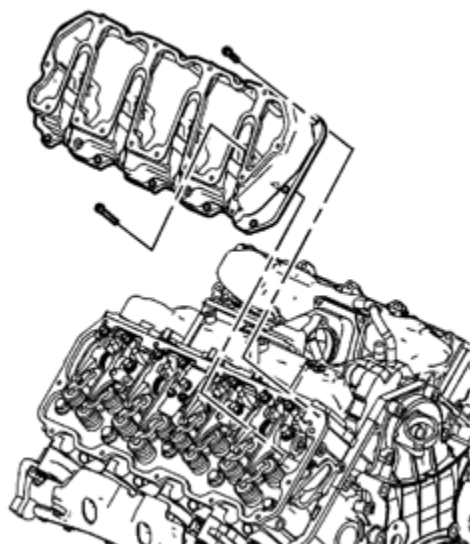
5. Install the fuel injectors. Refer to [Fuel Injector Replacement](#).

6. Install the upper left valve rocker arm cover. Refer to [Valve Rocker Arm Cover Replacement - Upper Left Side](#).

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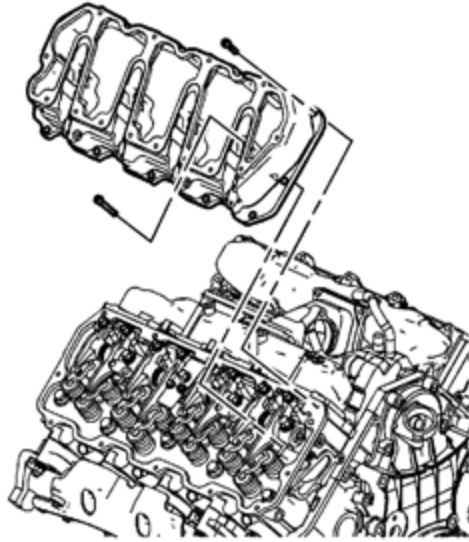
Valve Rocker Arm Cover Replacement - Lower Right Side

Removal Procedure



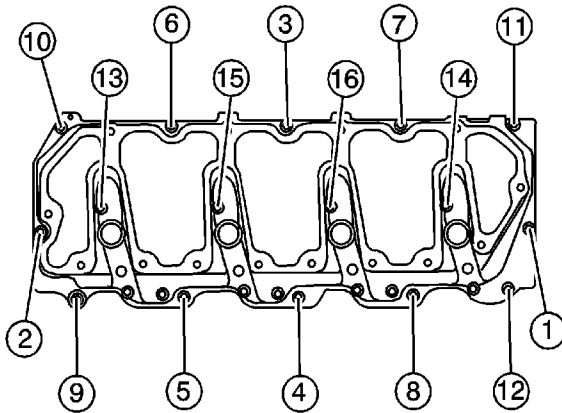
1. Remove the upper right valve rocker arm cover. Refer to [Valve Rocker Arm Cover Replacement - Upper Right Side](#).
2. Remove the fuel injectors. Refer to [Fuel Injector Replacement](#).
3. Remove the lower valve rocker arm cover bolts.
4. Remove the lower valve rocker arm cover.
5. Remove the gasket from the lower valve rocker arm cover.
6. Inspect the lower valve rocker arm cover gasket for damage, replace if necessary. Otherwise reuse the old gasket.
7. If required, clean and inspect the lower valve rocker arm cover. Refer to [Valve Rocker Arm Cover Cleaning and Inspection - Lower](#).

Installation Procedure



1. Install the lower valve rocker arm cover gasket.
2. Install the lower valve rocker arm cover.
3. Install the lower valve rocker arm cover bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Tighten the bolts in the sequence shown.

Tighten

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

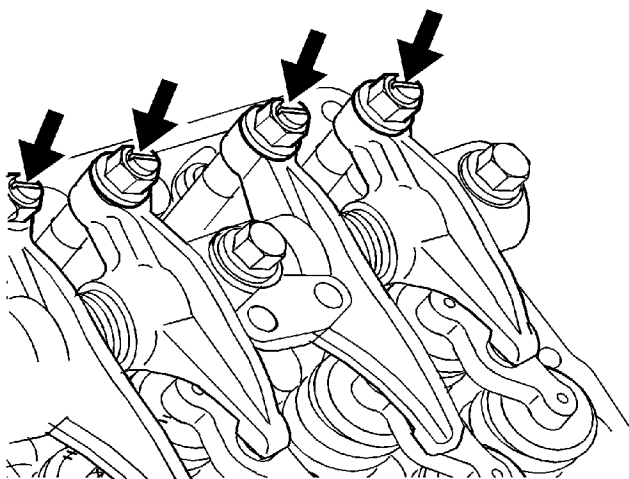
5. Install the fuel injectors. Refer to [Fuel Injector Replacement](#).

6. Install the right upper valve rocker arm cover. Refer to [Valve Rocker Arm Cover Replacement - Upper Right Side](#).

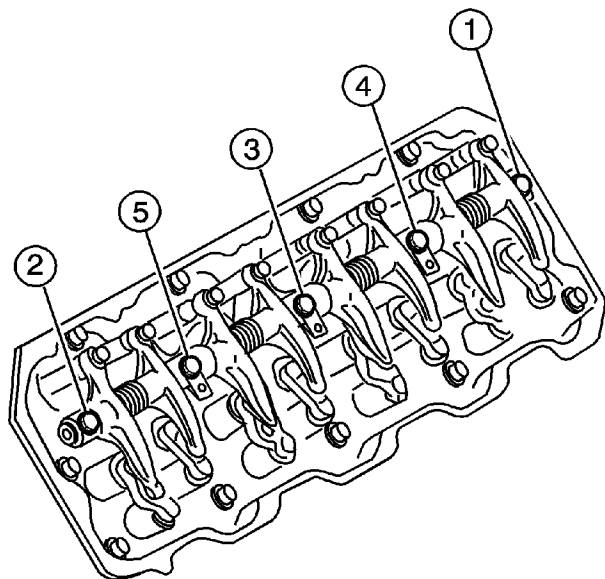
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Valve Rocker Arm, Shaft, and Push Rod Replacement

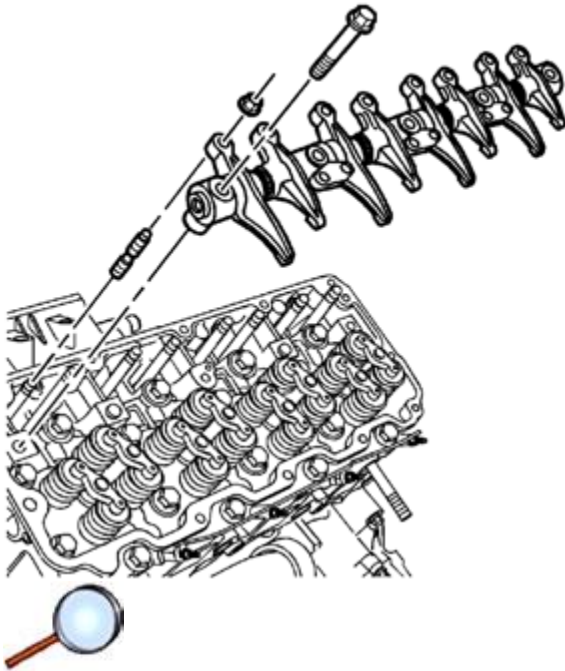
Removal Procedure



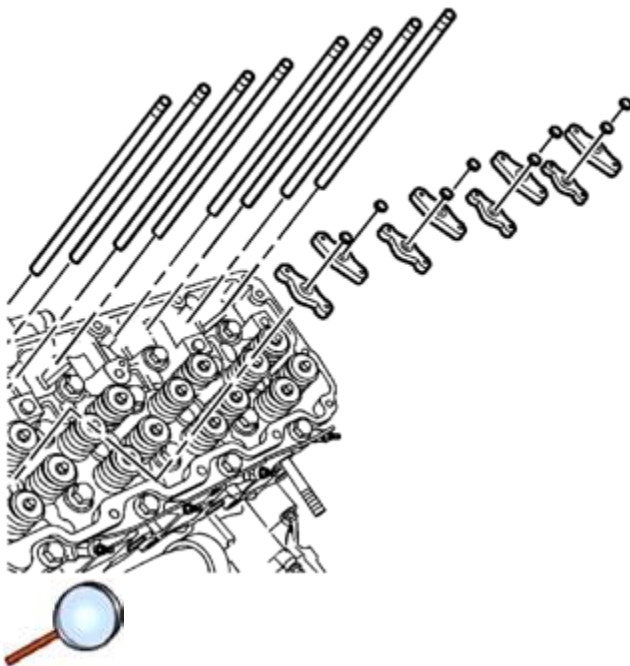
1. Remove the lower valve rocker arm covers. Refer to [Valve Rocker Arm Cover Replacement - Lower Left Side](#) or [Valve Rocker Arm Cover Replacement - Lower Right Side](#).
2. Loosen the valve clearance lock nuts on each rocker arm.
3. Loosen the valve clearance adjusting screw on each rocker arm in order to relieve tension on the valvetrain.



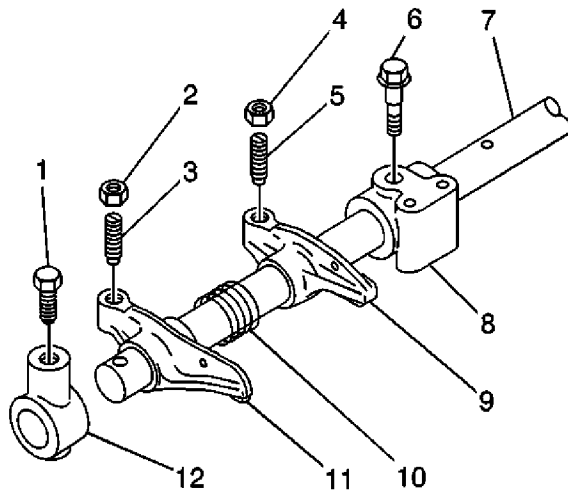
4. Remove the rocker arm shaft assembly bolts in the sequence shown. Leave the bolts in the rocker arm shaft brackets.



5. Remove the rocker arm shaft assembly from the cylinder head.

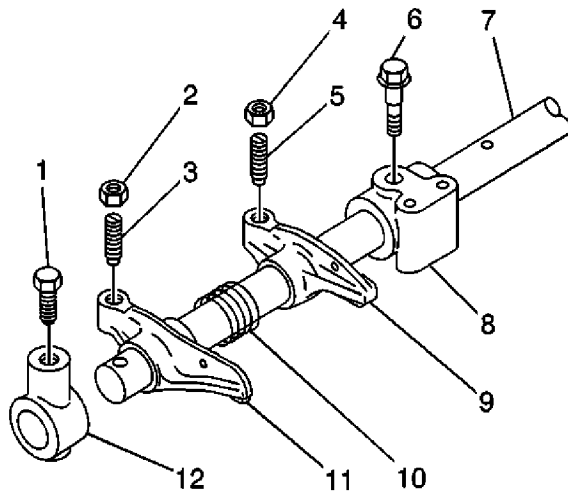


6. Remove the valve bridge pins.
7. Remove the valve bridges.
8. Remove the pushrods.



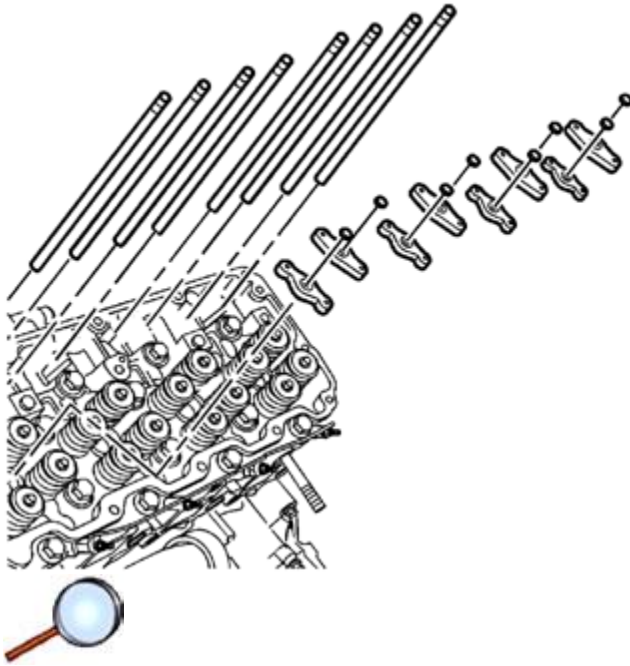
9. Remove the rocker arm shaft bracket bolts (1), if necessary.
10. Remove the bracket (12), rocker arm (11), and spring (10), if necessary.
11. Remove the remaining rocker arms, springs, and brackets, if necessary.
12. If required, clean and inspect the valve rocker arm and shaft. Refer to [Valve Rocker Arm and Shaft Cleaning and Inspection](#).

Installation Procedure



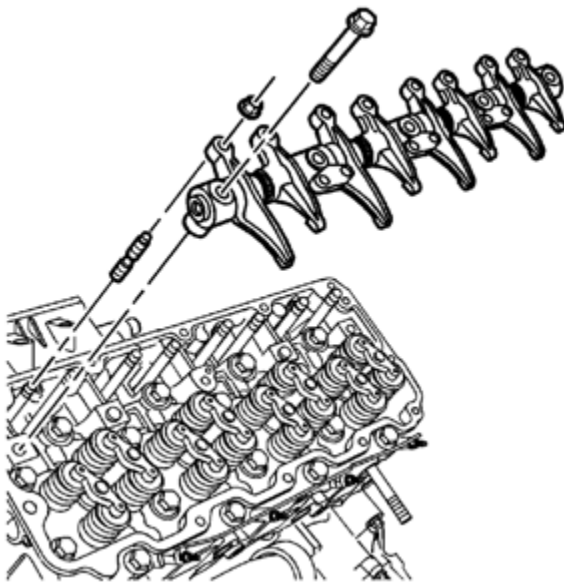
1. Lubricate the rocker arm shaft (7) and the inside of the rocker arms with clean engine oil, if necessary.
2. Install the rocker arm bracket (12) and bolt (1) on one end of the rocker arm shaft, if necessary.

3. Install the intake rocker arm (9), spring (10), exhaust rocker arm (11), and bracket (12) with bolt (1). Continue in the same sequence to the last bracket, if necessary.
4. Push the bracket (12) to compress the springs and then install the bolt (1), if necessary.



5. Lubricate the top of the valves, the valve bridge stem, the valve lifter bridge, and the valve spring caps with clean engine oil.
6. Install the valve bridge.
7. Install the valve bridge pins.
8. Lubricate the valve lifter end of the pushrod with clean engine oil.
9. Install the pushrods.

To ensure the pushrod is properly installed, gently pull up on the pushrod. Resistance should be felt from the pushrod trying to lift the valve lifter.

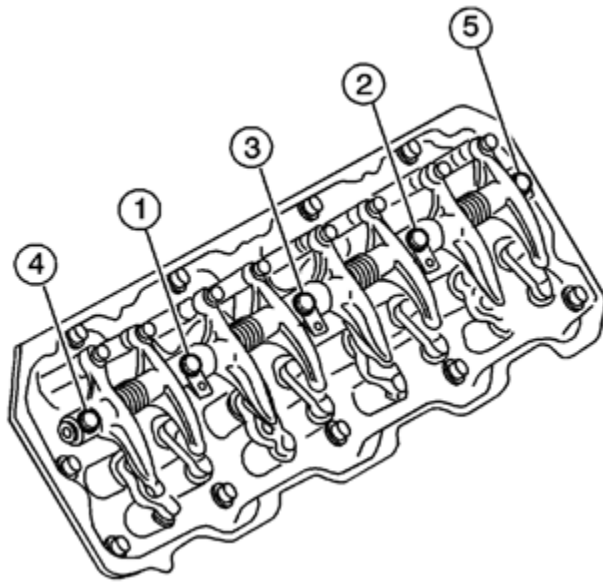




Caution: The pushrods must be correctly seated in the valve lifter and valve rocker arms before the rocker arm shaft assembly is torqued into place. Improper seating of the pushrods can cause damage to the pushrods or the valve rocker arm shaft assembly components.

10. Install the rocker arm shaft assembly.

Caution: Refer to [Fastener Caution](#) in the Preface section.



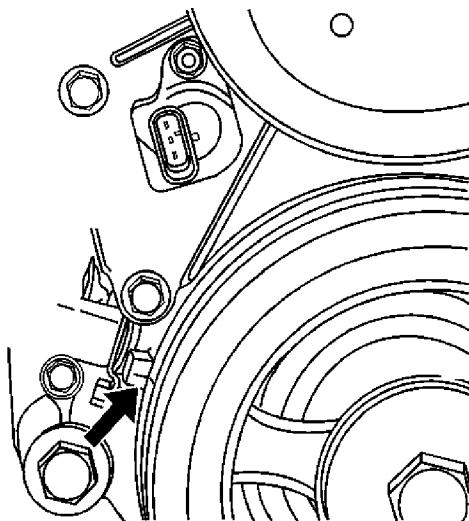
11. Tighten the rocker arm shaft bolts in the sequence shown.

Tighten

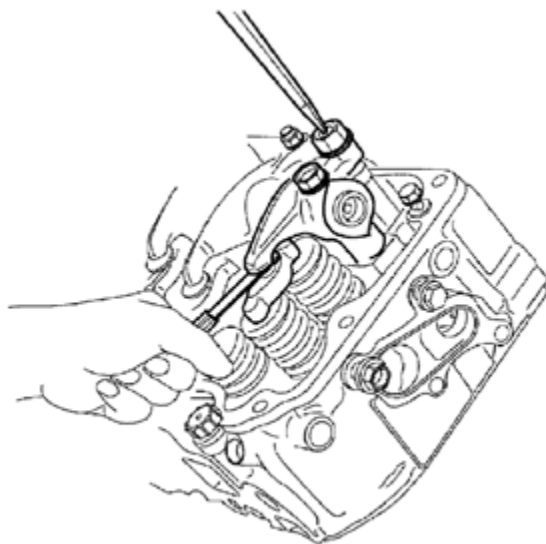
Tighten the bolts to 41 N·m (30 lb ft).

12. Adjust the valve clearance. Refer to [Valve Clearance Adjustment](#).
13. Install the lower valve rocker arm covers. Refer to [Valve Rocker Arm Cover Replacement - Lower Left Side](#) or [Valve Rocker Arm Cover Replacement - Lower Right Side](#).

Valve Clearance Adjustment

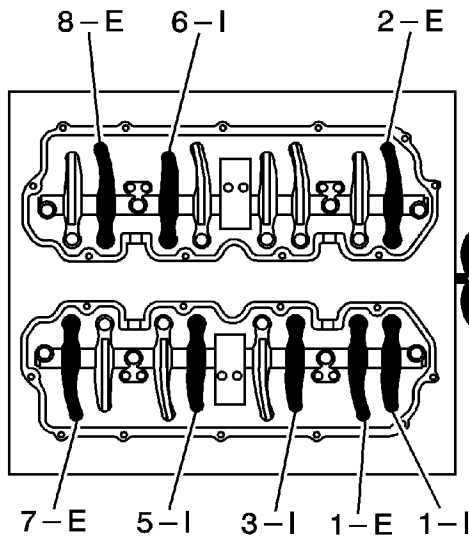


1. Remove the fan clutch. Refer to [Fan Clutch Replacement](#).
2. Remove the upper valve rocker arm covers. Refer to [Valve Rocker Arm Cover Replacement - Upper Left Side](#) and [Valve Rocker Arm Cover Replacement - Upper Right Side](#).
3. Rotate the crankshaft in order to bring the number 1 cylinder to top dead center (TDC) of the compression stroke. The number 1 cylinder is the front cylinder on the right bank. The mark on the crankshaft balancer should be aligned with the mark on the engine.



4. Loosen the valve adjusting screws.
5. Insert a feeler gage between the tip of the rocker arm and the valve bridge.

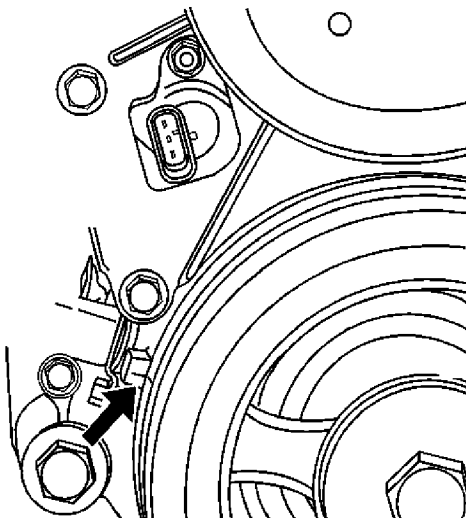
Caution: Refer to [Fastener Caution](#) in the Preface section.



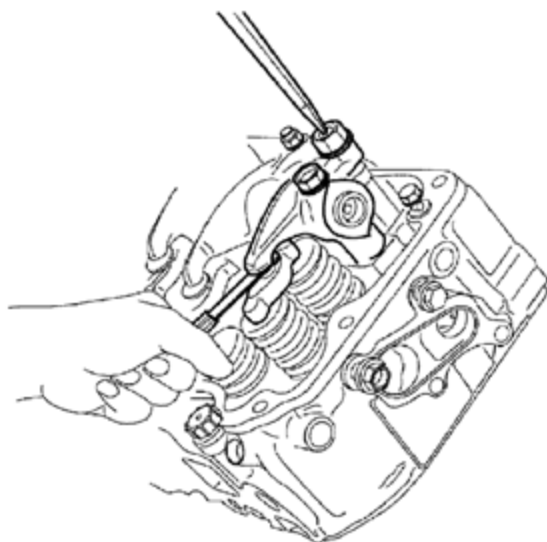
6. Adjust the valve lash to 0.3 mm (0.012 in). Refer to [Valve Clearance Adjustment Specifications](#) to determine which valves can be adjusted when the engine is at TDC.
7. Tighten the lock nut.

Tighten

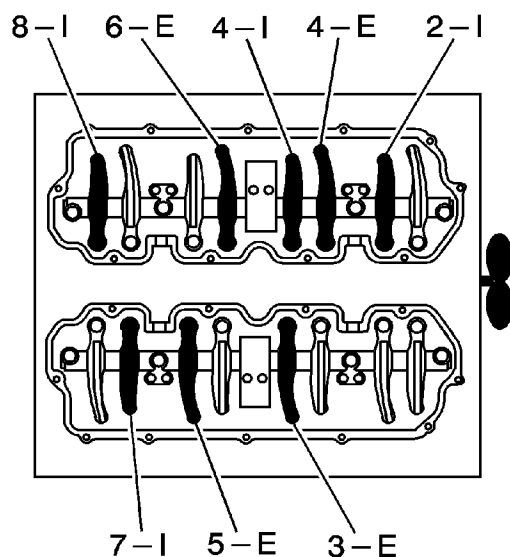
Tighten nut to 22 N·m (16 lb ft).



8. Rotate the crankshaft one revolution in order to bring the number 1 cylinder to TDC of the exhaust stroke.



9. Loosen the valve adjusting screws.
10. Insert a feeler gage between the tip of the rocker arm and the valve bridge.



11. Adjust the valve clearance to 0.3 mm (0.012 in). Refer to [Valve Clearance Adjustment Specifications](#) to determine which valves can be adjusted when the engine is at TDC.
12. Tighten the lock nut.

Tighten

Tighten nut to 22 N·m (16 lb ft).

13. Install the upper valve rocker arm covers. Refer to [Valve Rocker Arm Cover Replacement - Upper Left Side](#) and [Valve Rocker Arm Cover Replacement - Upper Right Side](#).
14. Install the fan clutch. Refer to [Fan Clutch Replacement](#).

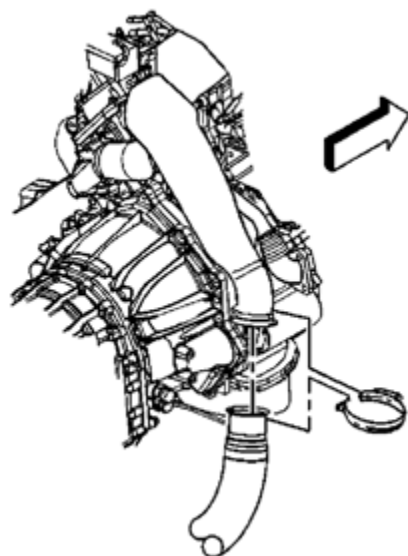
Turbocharger Replacement

Removal Procedure

Caution: If a turbocharger has failed, clean any turbocharger debris or excessive oil from the charge air cooler system before installing the new turbocharger. Failure to clean debris from the charge air cooler system will cause severe turbocharger and engine damage upon startup. Failure to clean excessive oil from the charge air cooler system may cause an engine runaway condition on startup, resulting in severe engine damage.

Note: If a turbocharger failure is thought to be caused due to lack of oil, the camshaft bearing should be checked. The number 4 camshaft bearing bore feeds the turbocharger oil supply (feed) pipe. If this camshaft bearing spins in the bore, the turbocharger will be starved for oil. This will cause a failure of the turbocharger. Failure to diagnosis this condition will result in repeat turbocharger failures.

1. Remove the transmission. Refer to [Transmission Replacement](#).
2. Remove the left and right wheelhouse liners. Refer to [Front Wheelhouse Liner Replacement - Right Side](#) and [Front Wheelhouse Liner Replacement - Left Side](#).

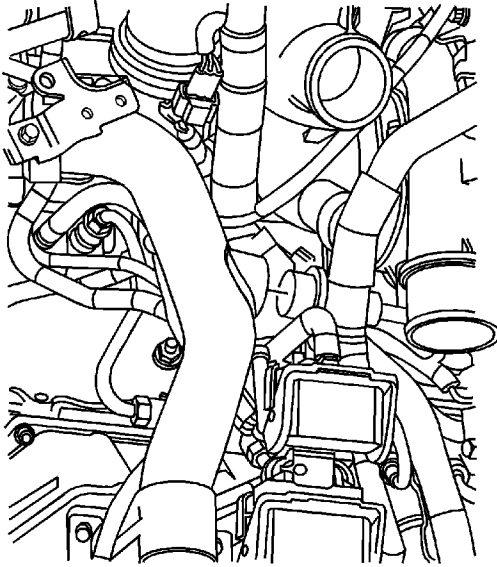


3. Loosen the exhaust pipe clamp. Slide the clamp onto the exhaust pipe.
4. Remove the left exhaust pipe. Refer to [Exhaust Pipe Replacement - Left Side](#).
5. Remove the turbocharger exhaust pipe. Refer to [Turbocharger Exhaust Pipe Replacement](#).
6. Remove the right exhaust pipe. Refer to [Exhaust Pipe Replacement - Right Side](#).
7. Remove the exhaust gas recirculation (EGR) valve cooler. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).
8. Remove the air conditioning (A/C) suction hose. Refer to [Suction Hose Replacement](#).
9. Reposition the suction hose aside.

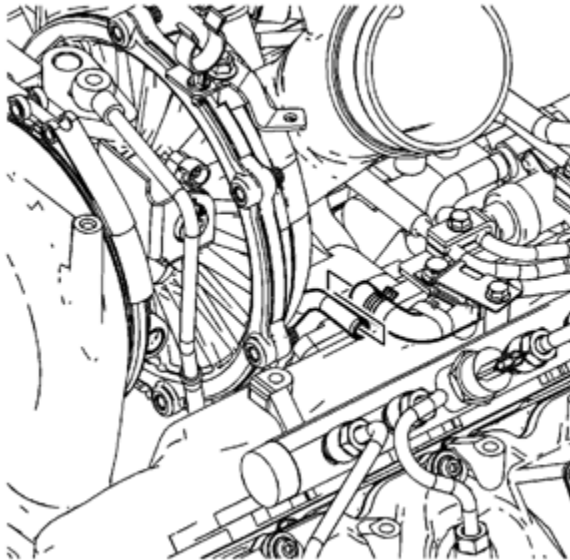
Note: After removing the charged air cooler duct, cover the turbocharger opening with tape

in order to prevent entry of objects.

10. Remove the charge air cooler inlet pipe. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).

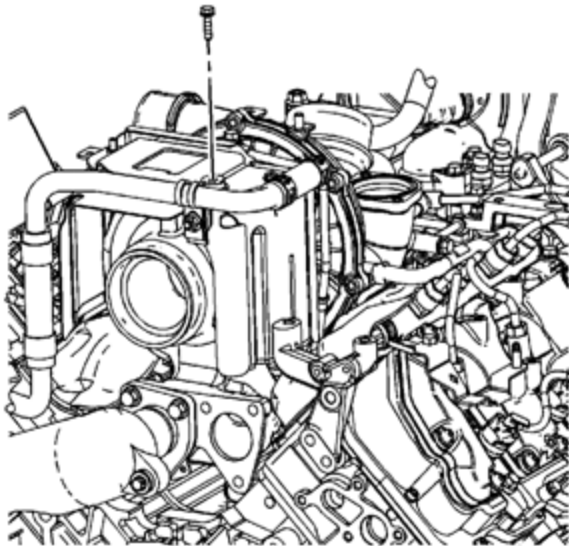


11. Remove the turbocharger inlet coolant hose from the turbocharger coolant bypass valve.

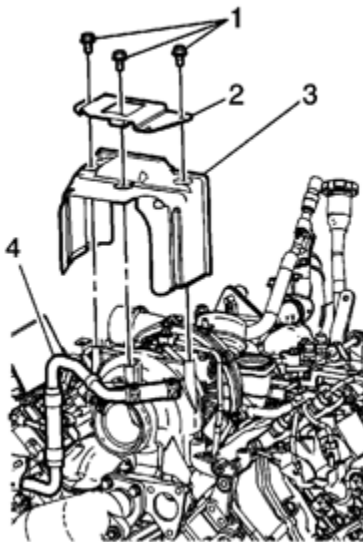


Note: Use care not to damage this hose during the procedure.

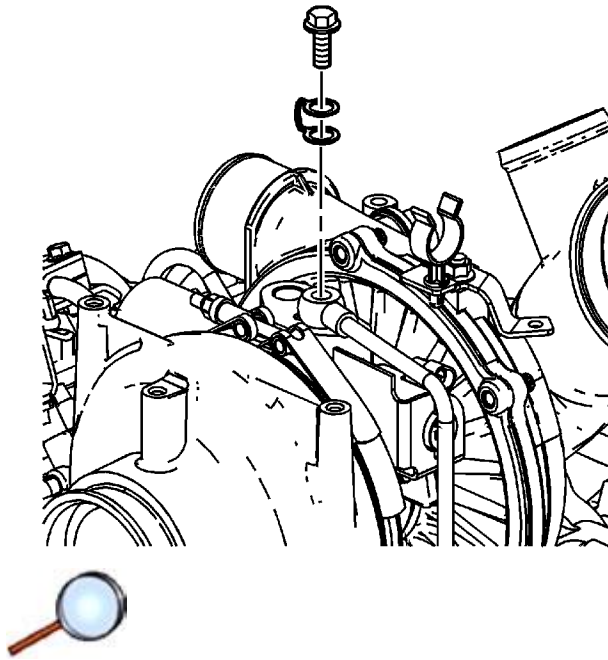
12. Reposition the hose clamp and remove the turbocharger outlet coolant hose from the turbocharger.
13. Remove the positive crankcase ventilation (PCV) hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).



14. Remove the glow plug module and both brackets. Refer to [Glow Plug Control Module Replacement](#).
15. Remove the EGR cooler pipe bolt.

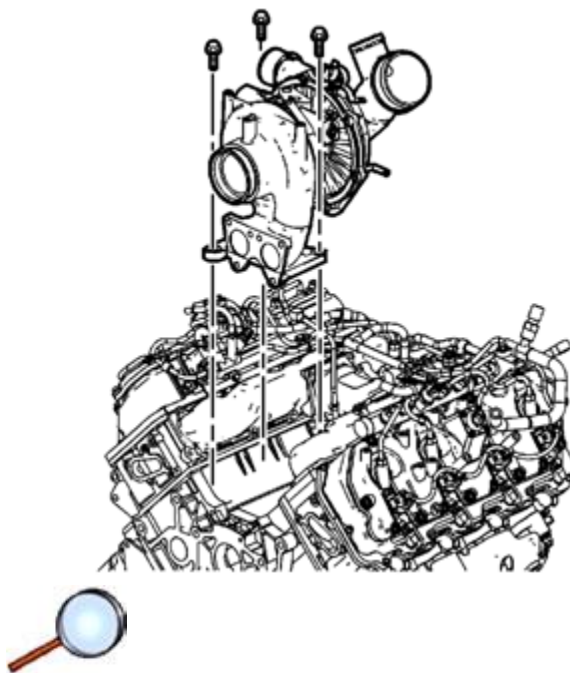


16. Reposition the EGR cooler pipe (4) out of the way.
17. Remove the EGR valve adapter pipe bracket bolts (1).
18. Remove the EGR valve adapter pipe bracket (2) and turbocharger heat shield (3).



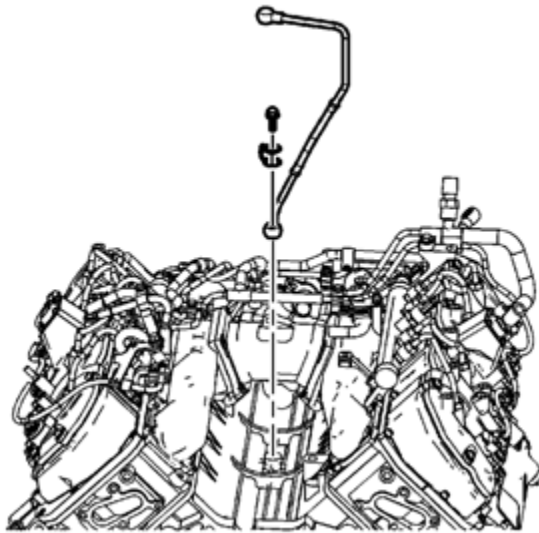
Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

19. Remove the turbocharger oil feed pipe banjo bolt and washer.
20. Reposition the oil feed pipe out of the way.
21. Remove the turbocharger oil return pipe nuts at the top of the flywheel housing.
22. Disconnect the turbocharger vane position sensor electrical connector.

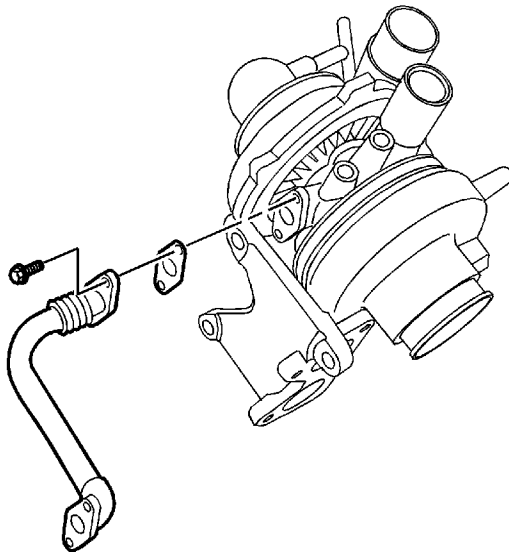


23. Remove the turbocharger bolts.
24. Remove the turbocharger (with the oil return pipe).

25. Remove and discard the turbocharger oil return pipe gasket at the flywheel housing.



26. Remove the turbocharger lower heat shield, if necessary.
27. Remove the oil feed pipe bolt, washer, and pipe, if necessary.
28. If the turbocharger has failed, perform the following steps to verify the condition of the number 4 camshaft bearing before installing a new turbocharger:
- 28.1. Visually inspect for correct alignment of the number 4 camshaft bearing oil hole through the turbocharger oil supply hole in the block.
 - 28.2. Turn the engine over by hand 1/2 turn and inspect for camshaft bearing movement, indicating a spun camshaft bearing.
 - 28.3. If the bearing is spun the engine **MUST** be replaced.



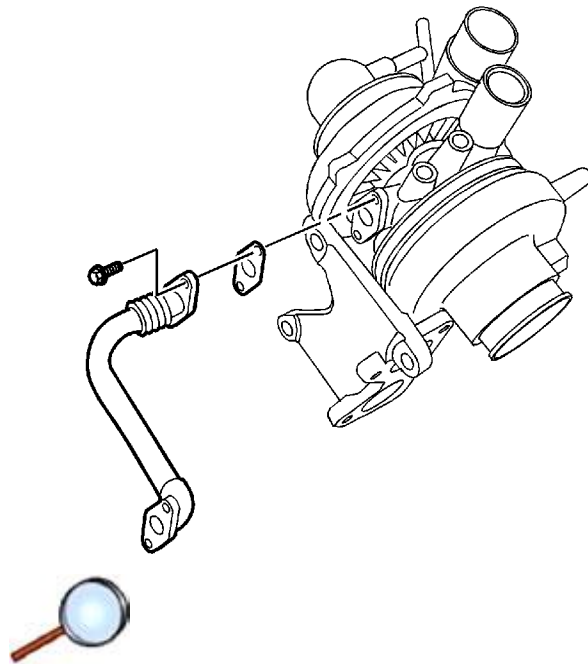
29. Remove the turbocharger outlet coolant pipe banjo bolt and washers.
30. If replacing the turbocharger, remove the oil return pipe bolts, pipe and gasket. Discard the

gasket.

31. Clean all turbocharger to engine gasket mating surfaces.
32. If required, clean and inspect the turbocharger. Refer to [Turbocharger Cleaning and Inspection](#)

Installation Procedure

Caution: Refer to [Fastener Caution](#) in the Preface section.



1. If the turbocharger was replaced, install the oil return pipe, bolts, and a NEW gasket.

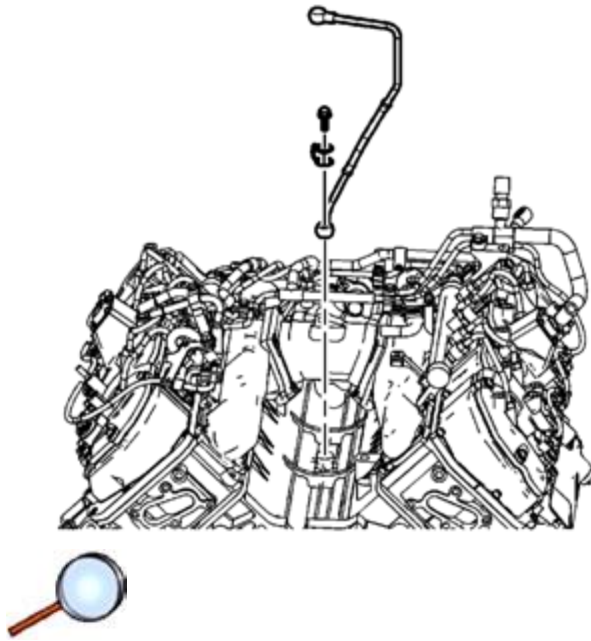
Tighten

Tighten the bolts to 21 N·m (15 lb ft).

2. Install the turbocharger outlet coolant pipe banjo bolt and washers.

Tighten

Tighten the bolt to 26 N·m (19 lb ft).



Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

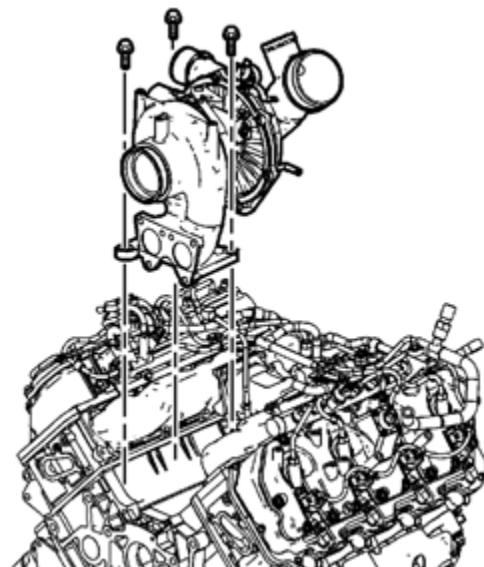
Note: Lubricate the washer with diesel fuel prior to installing.

3. Install the oil feed pipe, washer, and bolt, if necessary.

Tighten

Tighten the bolt to 34 N·m (25 lb ft).

4. Install the turbocharger lower heat shield, if necessary.





5. Install a NEW turbocharger oil return pipe gasket at the flywheel housing.
6. Install the turbocharger (with the oil return pipe).
7. Install the turbocharger bolts.

Tighten

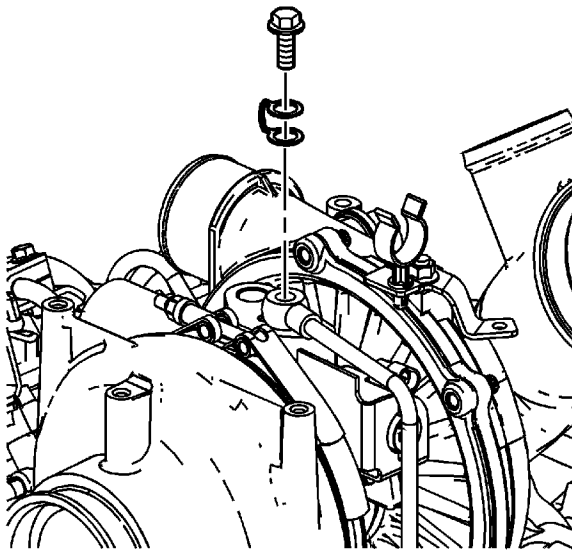
Tighten the bolts to 108 N·m (80 lb ft).

8. Install the turbocharger oil return pipe nuts at the top of the flywheel housing.

Tighten

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

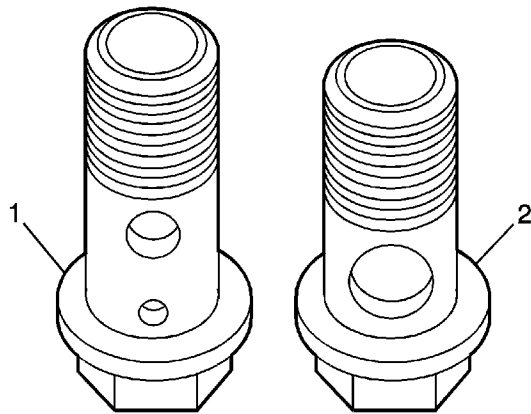
9. Connect the turbocharger vane position sensor electrical connector.



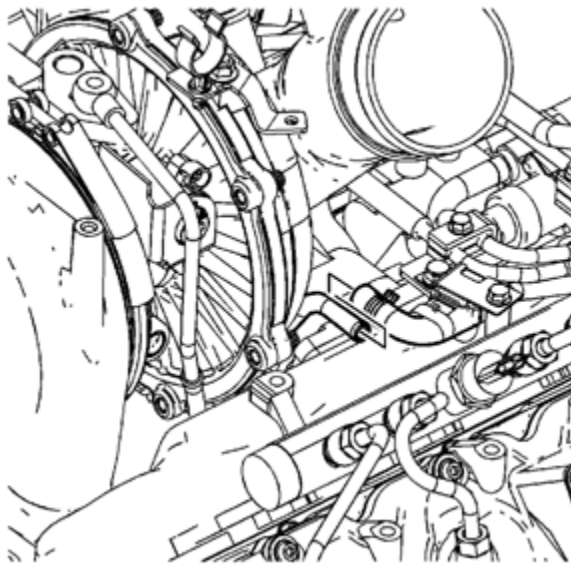
10. If installing a NEW turbocharger, add about 120-150 cc (4-5 oz) of clean engine oil in the turbocharger oil feed pipe opening while rotating the impeller.
11. Position the oil feed pipe to the turbocharger.
12. Install a NEW turbocharger oil feed pipe washer and the banjo bolt.

Tighten

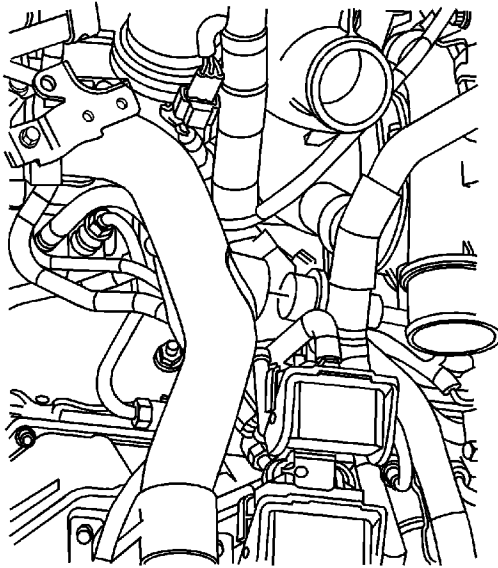
Tighten the bolt to 34 N·m (25 lb ft).



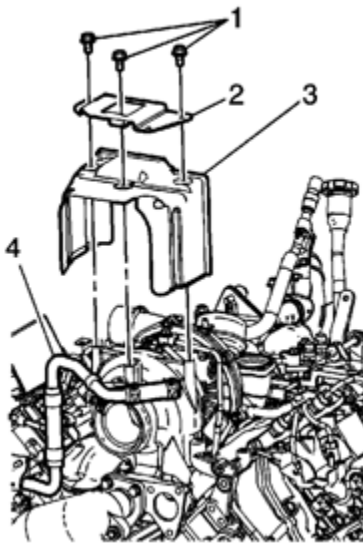
13. Install the PCV hose/pipe. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).
14. If the cooling outlet hose eye bolts were removed, install the longer bolt (1) with 2 holes, in the top location. Install the shorter bolt (2) in the lower location.



15. Install the turbocharger outlet coolant hose to the turbocharger and position the hose clamp.



16. Install the turbocharger inlet coolant hose to the turbocharger coolant bypass valve.

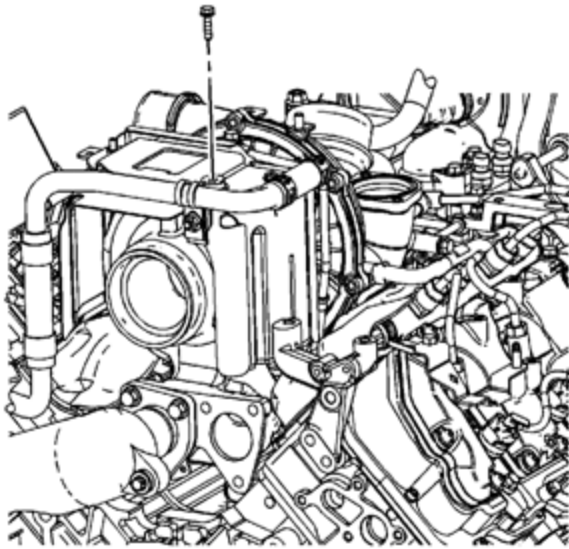


17. Install the turbocharger heat shield (3) and EGR valve adapter pipe bracket (2).
18. Install the EGR valve adapter pipe bracket bolts (1).

Tighten

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

19. Install the EGR cooler. Refer to [Exhaust Gas Recirculation Valve Cooler Replacement](#).
20. Install the glow plug module and both brackets. Refer to [Glow Plug Control Module Replacement](#).



21. Install the EGR cooler pipe bolt.

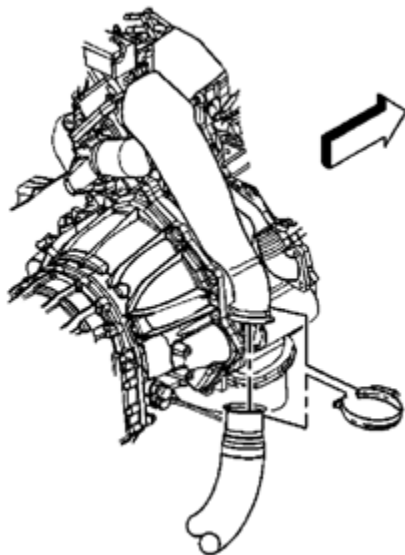
Tighten

Tighten the bolt to 9 N·m (80 lb in).

22. Remove the tape from the turbocharger openings.

Note: Lubricate the end of the duct prior to installation.

23. Install the charge air cooler inlet pipe. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).
24. Install the A/C suction hose. Refer to [Suction Hose Replacement](#).
25. Install the air intake pipe. Refer to [Air Intake Pipe Replacement](#).
26. Fill the cooling system. Refer to [Cooling System Draining and Filling](#).



27. Install the right exhaust pipe. Refer to [Exhaust Pipe Replacement - Right Side](#).
28. Install the turbocharger exhaust pipe. Refer to [Turbocharger Exhaust Pipe Replacement](#).
29. Install the left exhaust pipe. Refer to [Exhaust Pipe Replacement - Left Side](#).
30. Slide the clamp onto the exhaust pipe. Tighten the exhaust pipe clamp.

Tighten

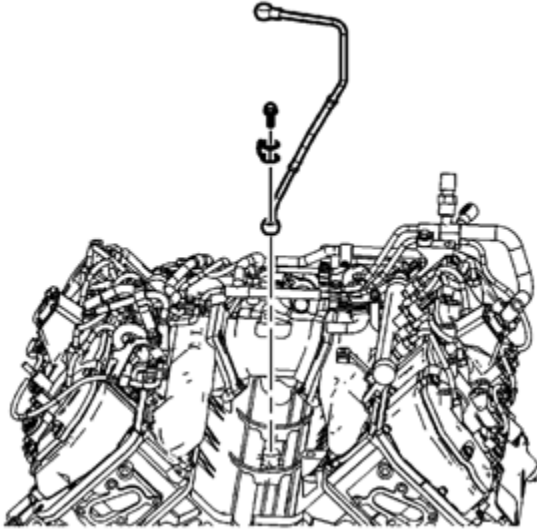
Tighten the clamp to 40 N·m (30 lb ft).

31. Install the left and right wheelhouse liners. Refer to [Front Wheelhouse Liner Replacement - Right Side](#) and [Front Wheelhouse Liner Replacement - Left Side](#).
32. Install the transmission. Refer to [Transmission Replacement](#).
33. If a NEW turbocharger was installed, perform the turbocharger learn procedure. Refer to [Turbocharger Learn](#).
34. Road test the vehicle for normal operation.
35. Inspect for coolant, oil, or exhaust leaks. Correct as necessary.

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Turbocharger Oil Feed Pipe Replacement

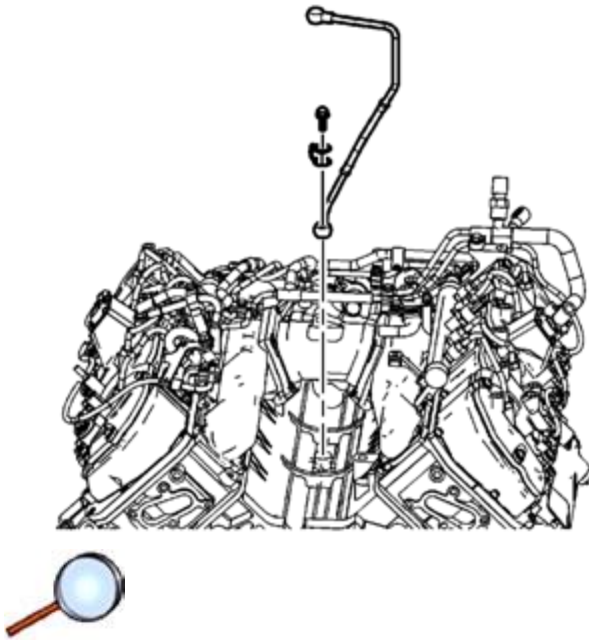
Removal Procedure



1. Remove the turbocharger. Refer to [Turbocharger Replacement](#).
2. Remove the turbocharger oil feed pipe bolt.
3. Remove the oil feed pipe and washer.

Installation Procedure

Caution: Refer to [Fastener Caution](#) in the Preface section.



Caution: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

Note: Lubricate the NEW washer with diesel fuel before installing.

1. Position the oil feed pipe and a NEW washer into place.
2. Install the oil feed pipe bolt.

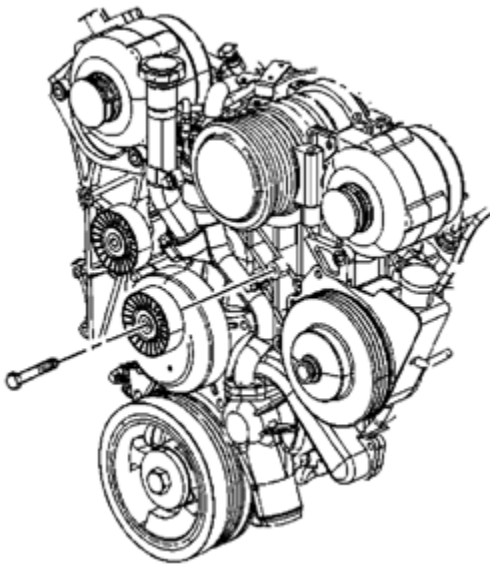
Tighten

Tighten the bolt to 34 N·m (25 lb ft).

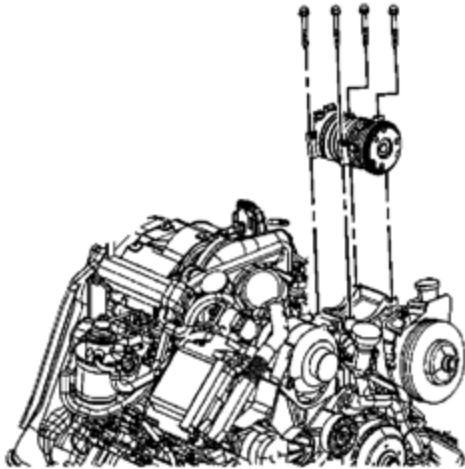
3. Install the turbocharger. Refer to [Turbocharger Replacement](#).

Air Conditioning (A/C) Compressor and Power Steering Pump Bracket Replacement

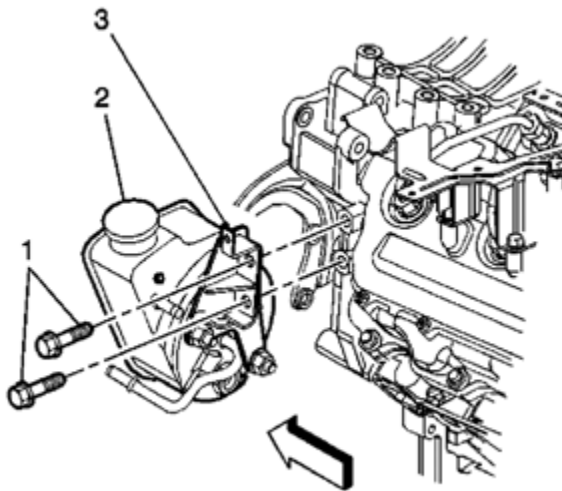
Removal Procedure



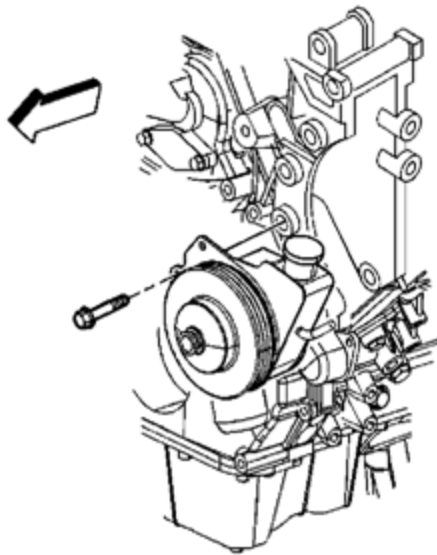
1. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).
2. Remove the cooling fan and shroud. Refer to [Cooling Fan and Shroud Replacement](#).
3. Remove the drive belt. Refer to [Drive Belt Replacement](#).
4. If equipped, remove the auxiliary generator. Refer to [Auxiliary Generator Replacement](#).
5. If equipped with dual generators, remove the bolt from the left side idler pulley (smooth pulley).
6. Remove the idler pulley.



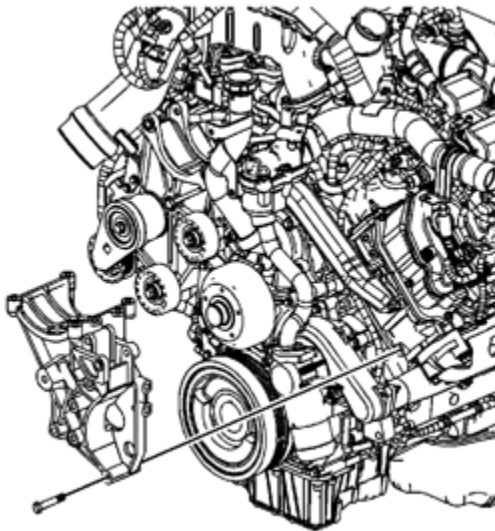
7. Disconnect the air conditioning (A/C) compressor clutch electrical connector.
8. Disconnect the A/C cut out switch electrical connector.
9. Remove the A/C compressor bolts.
10. Move the A/C compressor with the hoses attached to the right side of the engine compartment.



11. Remove the rear power steering pump bracket bolts (1).

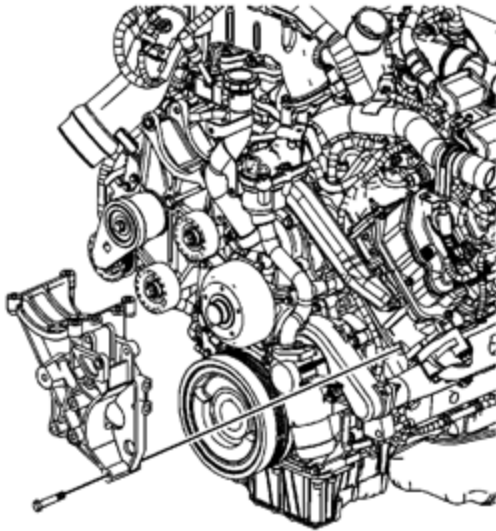


12. Remove the power steering pump front bracket bolts.
13. Move and secure the power steering pump out of the way. The hoses and battery cables can remain attach to pump.



14. Remove the A/C compressor and power steering pump bracket bolts and nuts.
15. Remove the A/C compressor and power steering pump bracket.

Installation Procedure



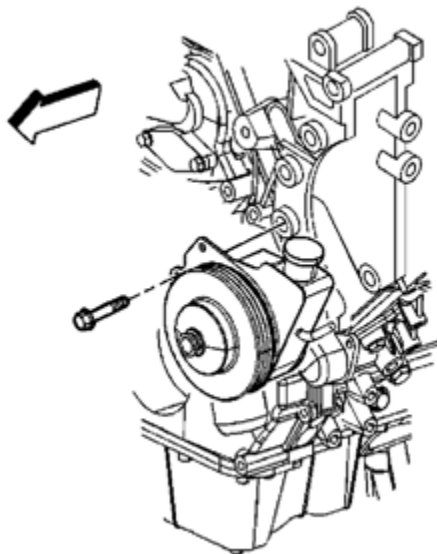
1. Position the A/C compressor and power steering pump bracket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

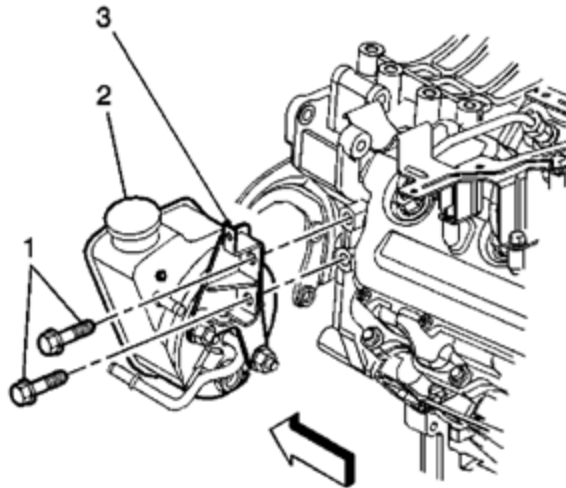
2. Install the A/C compressor and power steering pump bracket bolts and nuts.

Tighten

Tighten the bolts to 46 N·m (34 lb ft).



3. Install the power steering pump and loosely install the front bracket bolts.

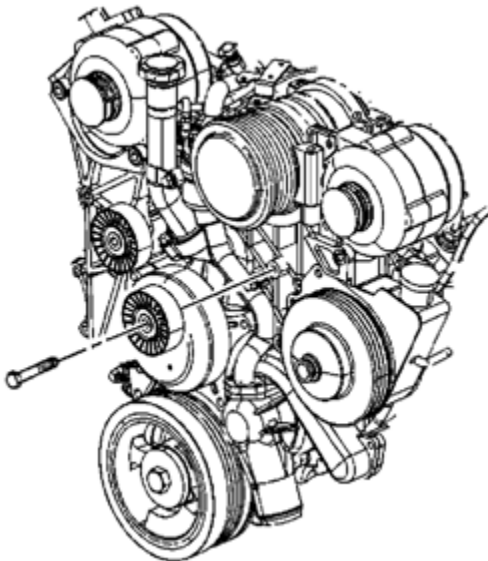


Note: Tighten the front bracket bolts before the rear bracket bolts to ensure pulley alignment.

4. Loosely install the rear power steering pump bracket bolts (1).

Tighten

1. Tighten the front bracket bolts to 50 N·m (37 lb ft).
2. Tighten the rear bracket bolts to 50 N·m (37 lb ft).

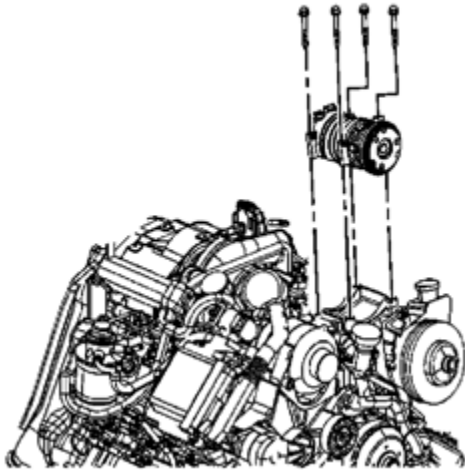


5. If equipped with dual generators, install the left side idler pulley and bolt.

Tighten

Tighten the bolt to 43 N·m (32 lb ft)

6. Install the auxiliary generator. Refer to [Auxiliary Generator Replacement](#).



7. Position the A/C compressor.
8. Install the A/C compressor bolts.

Tighten

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

9. Connect the A/C cut out switch electrical connector.
10. Connect the A/C clutch electrical connector.
11. Install the drive belt. Refer to [Drive Belt Replacement](#).
12. Install the cooling fan and shroud. Refer to [Cooling Fan and Shroud Replacement](#).
13. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).

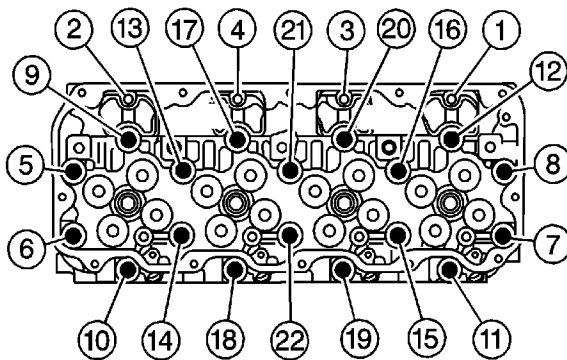
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Cylinder Head Replacement - Left Side

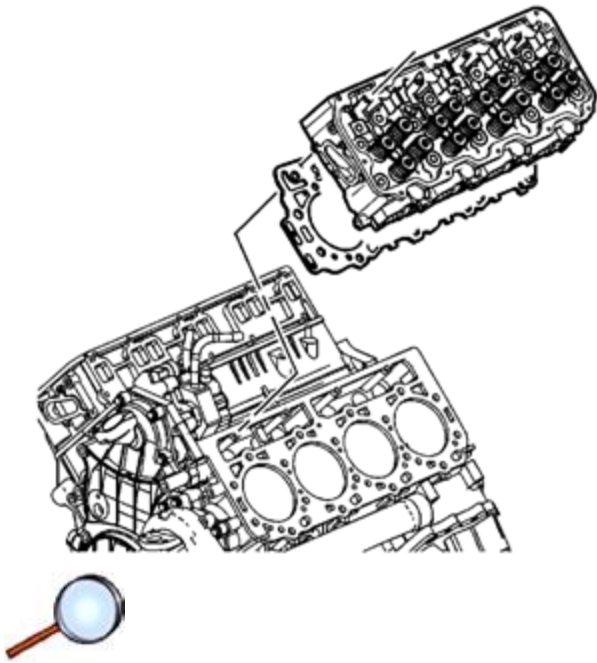
Special Tools

[J 45059](#) Angle Meter

Removal Procedure



1. Remove the engine assembly. Refer to [Engine Replacement](#).
2. Remove the thermostat housing crossover. Refer to [Thermostat Housing Crossover Replacement](#).
3. Remove the intake manifold. Refer to [Intake Manifold Replacement - Left Side](#).
4. Remove the exhaust manifold. Refer to [Exhaust Manifold Removal - Left Side](#).
5. Remove the valve rocker arm shaft, pushrods, and valve bridges. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
6. Remove the glow plugs. Refer to [Glow Plug Replacement - Bank 2](#).
7. Remove the cylinder head bolts in the sequence shown.
8. Discard the large M12 bolts.

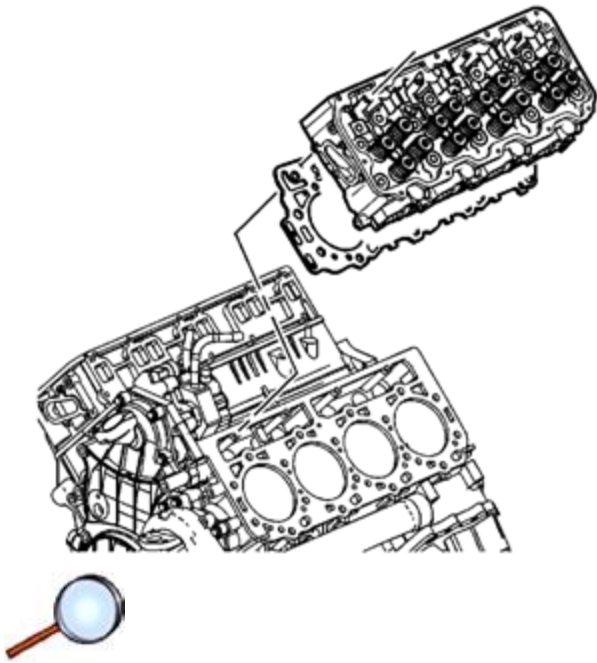


9. Remove the cylinder head.
10. Remove and discard the cylinder head gasket.
11. Clean the sealing surface of the engine block and the cylinder head.

Caution: 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.

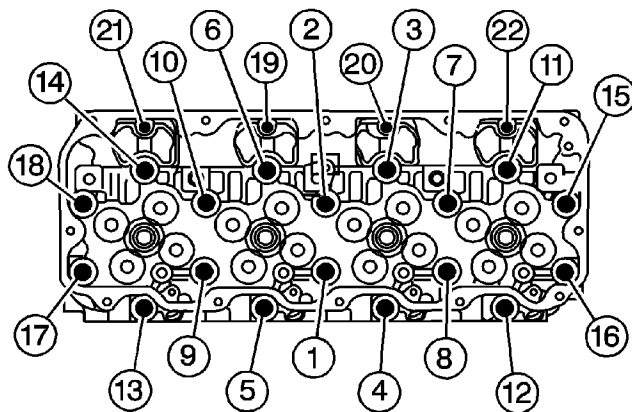
12. Clean the cylinder head bolt holes in the engine block.
13. For service to the cylinder head refer to the following:
 - [Cylinder Head Disassemble](#)
 - [Cylinder Head Cleaning and Inspection](#)
 - [Cylinder Head Assemble](#)

Installation Procedure



Caution: The left and right cylinder head gaskets are not interchangeable. Improper placement of the cylinder head gasket will block coolant and oil passages. Blocked coolant and oil passages will cause severe engine damage.

1. Install the cylinder head gasket of the correct grade. Refer to [Cylinder Head Gasket Selection Specifications](#).
2. Install the cylinder head.



Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

3. Install NEW M12 cylinder head bolts.
4. Reuse the M8 cylinder head bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Tighten the cylinder head bolts in the following steps using the sequence shown:

Tighten

1. Tighten the M12 bolts a first pass to 50 N·m (37 lb ft).
2. Tighten the M12 bolts a second pass to 80 N·m (59 lb ft)
3. Tighten the M12 bolts a third pass to 60 degrees, using [J 45059](#) .
4. Tighten the M12 bolts a final pass to 60 degrees, using [J 45059](#) .
5. Tighten the M8 bolts to 25 N·m (18 lb ft).
6. Install the glow plugs. Refer to [Glow Plug Replacement - Bank 2](#).
7. Install the valve rocker arm shaft, pushrods, and valve bridges. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
8. Install the exhaust manifold. Refer to [Exhaust Manifold Installation - Left Side](#).
9. Install the intake manifold. Refer to [Intake Manifold Replacement - Left Side](#).
10. Install the thermostat housing crossover. Refer to [Thermostat Housing Crossover Replacement](#).
11. Install the engine assembly. Refer to [Engine Replacement](#).
12. Road test the vehicle for normal operation.

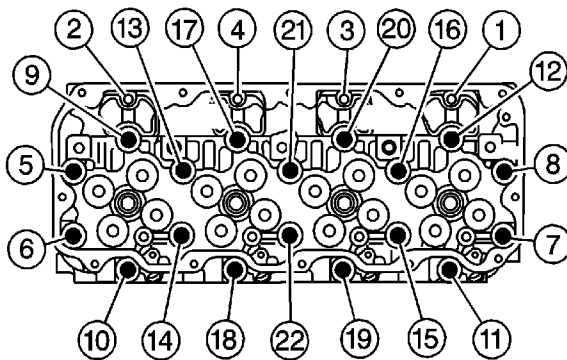
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Cylinder Head Replacement - Right Side

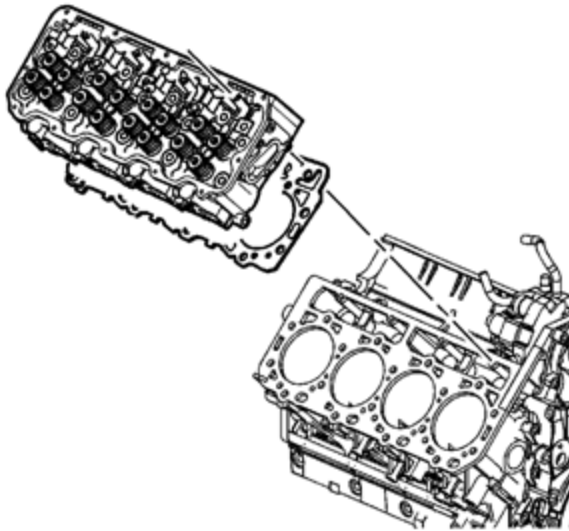
Special Tools

[J 45059](#) Angle Meter

Removal Procedure



1. Remove the engine assembly. Refer to [Engine Replacement](#).
2. Remove the thermostat housing crossover. Refer to [Thermostat Housing Crossover Replacement](#).
3. Remove the intake manifold. Refer to [Intake Manifold Replacement - Right Side](#).
4. Remove the exhaust manifold. Refer to [Exhaust Manifold Removal - Right Side](#).
5. Remove the valve rocker arm shaft, pushrods, and valve bridges. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
6. Remove the glow plugs. Refer to [Glow Plug Replacement - Bank 1](#).
7. Remove the cylinder head bolts in the sequence shown.
8. Discard the large M12 bolts.

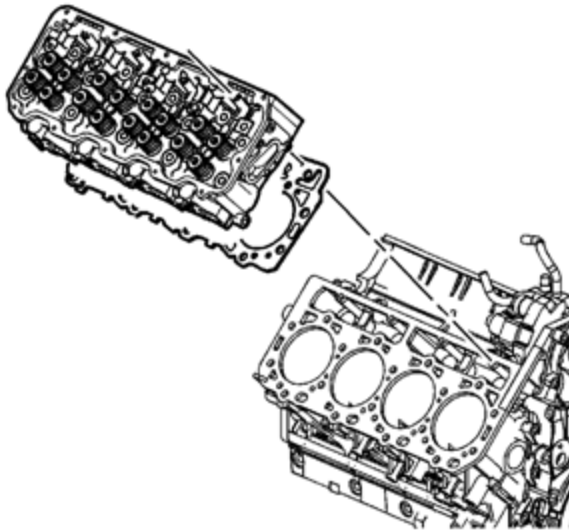


9. Remove the cylinder head.
10. Remove and discard the cylinder head gasket.
11. Clean the sealing surface of the engine block and the cylinder head.

Caution: 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.

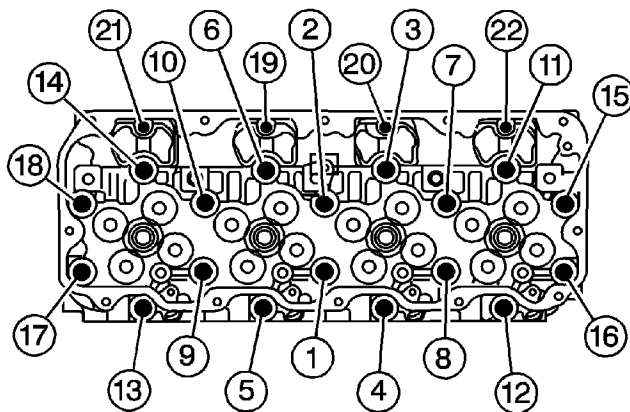
12. Clean the cylinder head bolt holes in the engine block.
13. For service to the cylinder head, refer to the following procedures:
 - [Cylinder Head Disassemble](#)
 - [Cylinder Head Cleaning and Inspection](#)
 - [Cylinder Head Assemble](#)

Installation Procedure



Caution: The left and right cylinder head gaskets are not interchangeable. Improper placement of the cylinder head gasket will block coolant and oil passages. Blocked coolant and oil passages will cause severe engine damage.

1. Install the cylinder head gasket of the correct grade. Refer to [Cylinder Head Gasket Selection Specifications](#).
2. Install the cylinder head.



Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

3. Install the NEW M12 cylinder head bolts.
4. Reuse the M8 cylinder head bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Tighten the cylinder head bolts in the following steps using the sequence shown:

Tighten

1. Tighten the M12 bolts a first pass to 50 N·m (37 lb ft).
2. Tighten the M12 bolts a second pass to 80 N·m (59 lb ft)
3. Tighten the M12 bolts a third pass to 60 degrees, using [J 45059](#) .
4. Tighten the M12 bolts a final pass to 60 degrees, using [J 45059](#) .
5. Tighten the M8 bolts to 25 N·m (18 lb ft).
6. Install the valve rocker arm shaft, pushrods, and valve bridges. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
7. Install the glow plugs. Refer to [Glow Plug Replacement - Bank 1](#).
8. Install the right exhaust manifold. Refer to [Exhaust Manifold Installation - Right Side](#).
9. Install the right intake manifold. Refer to [Intake Manifold Replacement - Right Side](#).
10. Install the thermostat housing crossover. Refer to [Thermostat Housing Crossover Replacement](#).
11. Road test the vehicle for normal operation.
12. Install the engine assembly. Refer to [Engine Replacement](#).

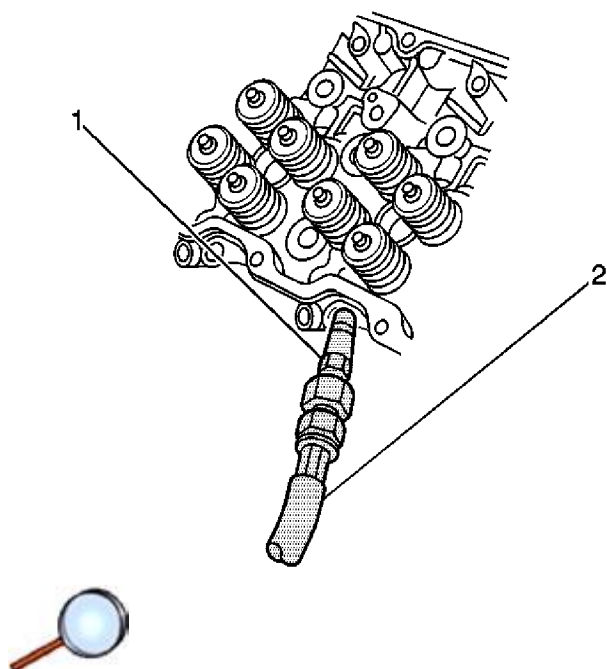
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Valve Stem Oil Seal and Valve Spring Replacement

Special Tools

- [J 26999](#) Compression Gage
- [J 26999-20](#) Compression Gage Adapter
- [J 44646](#) Valve Spring Compressor
- [J 44640](#) Valve Stem Seal Installer

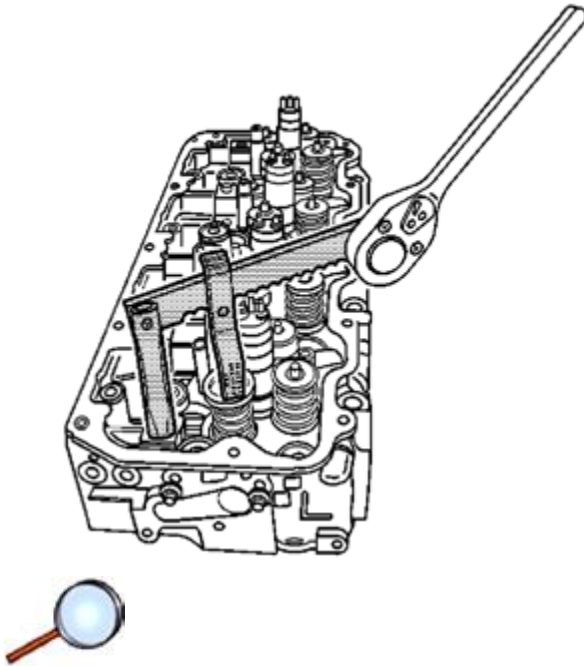
Removal Procedure



1. Remove the upper and lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#) and [Engine Coolant Fan Upper Shroud Replacement](#).
2. Remove the valve rocker arm shaft, valve bridges, and pushrods for the cylinder head being serviced. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
3. Remove the glow plug for the cylinder requiring service. Refer to [Glow Plug Replacement - Bank 1](#) or [Glow Plug Replacement - Bank 2](#).
4. In order to apply shop air to the cylinders use the following procedures to modify [J 26999-20](#) (1) and [J 26999](#) (2):
 - 4.1. Remove the valve core from [J 26999-20](#) to allow air to flow.
 - 4.2. Remove the quick connect fitting from [J 26999](#) .
 - 4.3. Adapt the quick connect fitting in order to use for shop air.
 - 4.4. Connect the quick connect fitting to [J 26999-20](#) .

Note: Rotate the cylinder to be serviced to the bottom of the stroke. This is to ensure that the engine does not rotate when the compressed air is applied to the cylinder being serviced.

5. Install [J 26999-20](#) into the glow plug hole for the cylinder being serviced.
6. Apply compressed air to hold the valves in place. If the compressed air is released, the valves can drop into the cylinder.

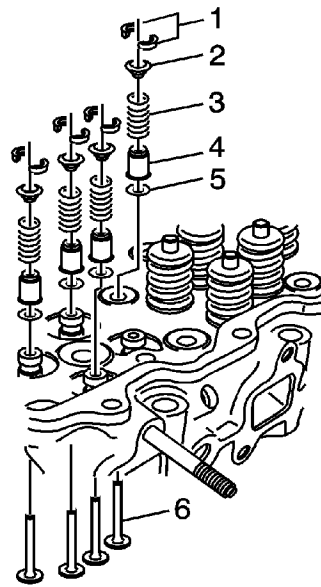


Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

7. Install [J 44646](#) to the rocker arm bosses on the cylinder head.

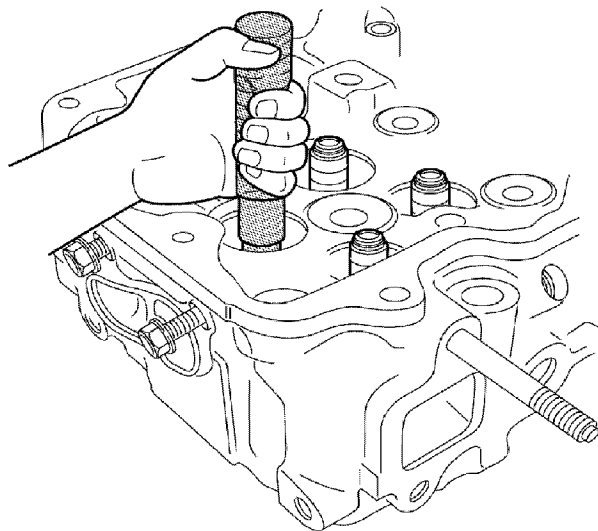
[J 44646](#) should be installed in the rocker arm boss next to the cylinder being serviced. The pivot pin can be removed from the stand to allow the stand to be installed. The lever has different locating holes for the pivot pin depending on available clearance. The lever is also notched for different locations of the compressor.

8. Using [J 44646](#) compress the valve spring.



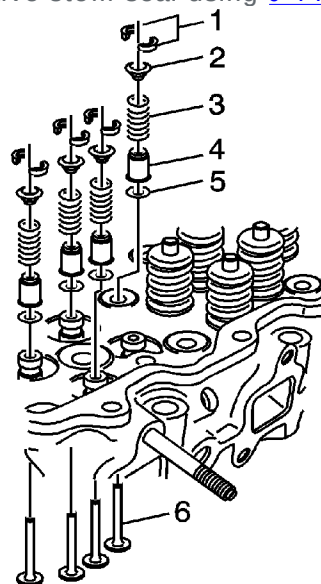
9. Remove the valve keys (1) from the valve stem.
10. Carefully release the valve spring tension.
11. Remove the valve spring upper seat (2) and the valve spring (3).
12. Remove the valve stem oil seal (4).
13. Remove the valve spring lower seat (5).
14. Continue removing the remaining valve stem seals for the cylinder using the above procedure.

Installation Procedure

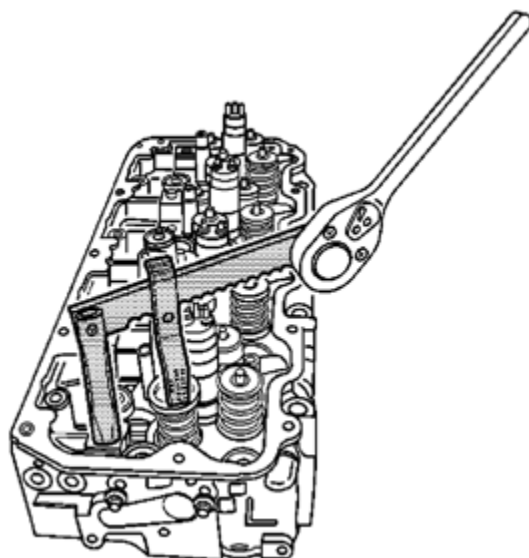


Caution: Air pressure should remain applied to the cylinder for installation.

1. Install the valve spring lower seat.
2. Install the valve stem seal using [J 44640](#).



3. Install the valve spring (3), the painted end of the valve spring goes toward the cylinder head.
4. Install the valve spring upper seat (2).



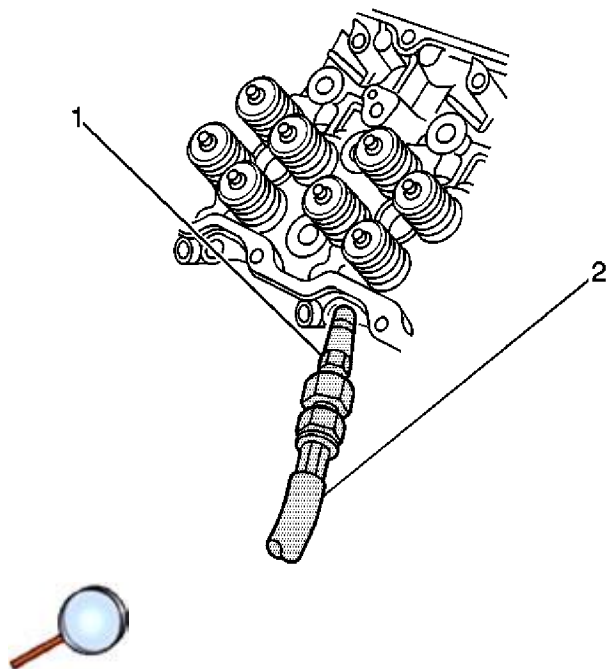
Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

5. Using [J 44646](#) compress the valve spring.

6. Install the valve keys to the valve stem.

Caution: The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

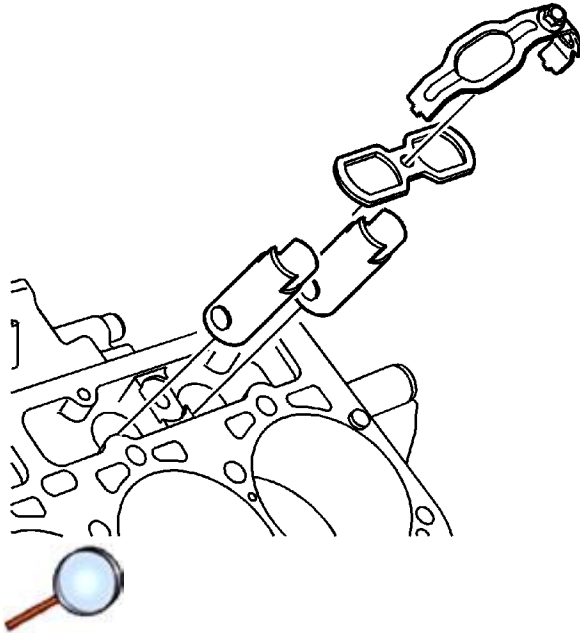
7. Carefully release the valve spring pressure. Make sure the valve keys stay in place.
8. Continue to install the 3 remaining valve stem seals for the cylinder.



9. Release the compressed air holding the valves in place.
10. Remove [J 26999-20](#) (1) from the glow plug hole.
11. Continue to replace the valve stem seals on the remaining cylinders using the above procedures.
12. Install the glow plug. Refer to [Glow Plug Replacement - Bank 1](#) or [Glow Plug Replacement - Bank 2](#).
13. Install the valve rocker arm shaft, the valve bridges, and the push rods. Refer to [Valve Rocker Arm, Shaft, and Push Rod Replacement](#).
14. Install the upper and lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#) and [Engine Coolant Fan Upper Shroud Replacement](#).

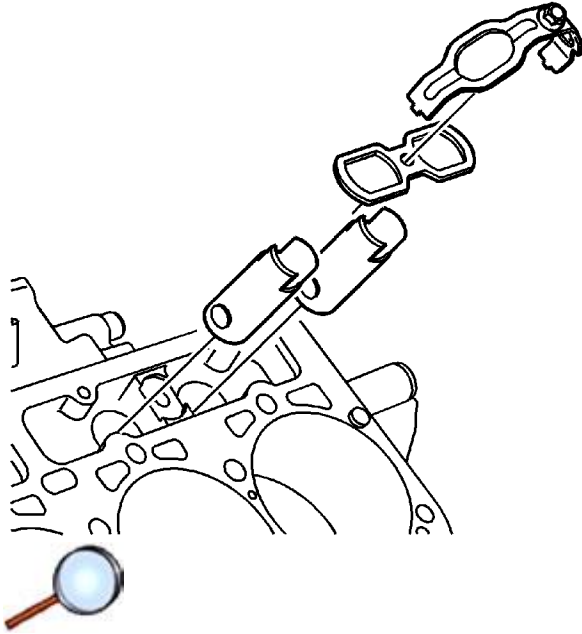
Valve Lifter Replacement

Removal Procedure



1. Remove the cylinder head. Refer to [Cylinder Head Replacement - Left Side](#) or [Cylinder Head Replacement - Right Side](#).
2. Loosen the valve lifter guide retainer bolts.
3. Remove the valve lifter guide retainers.
4. Remove the valve lifter guides.
5. Remove the valve lifters.
6. If required, clean and inspect the lifters. Refer to [Valve Lifters Cleaning and Inspection](#).

Installation Procedure



1. Apply clean engine oil to the roller and outside of the valve lifter.
2. Install the valve lifter.
3. Install the valve lifter guides.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the valve lifter guide retainer.
5. Install the valve lifter guide retainer bolt.

Tighten

Tighten the bolt to 11 N·m (97 lb in).

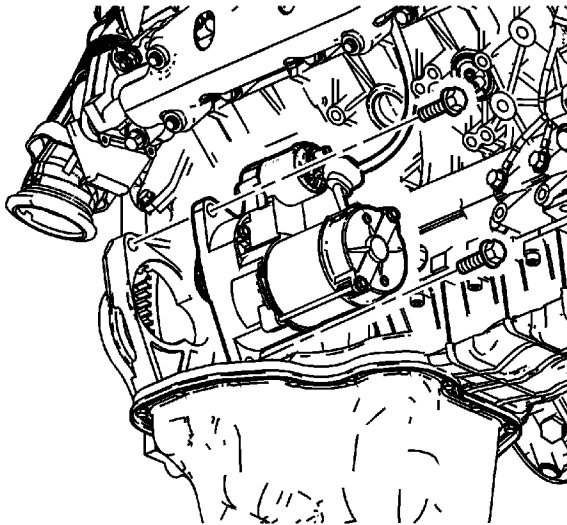
6. Install the cylinder head. Refer to [Cylinder Head Replacement - Left Side](#) or [Cylinder Head Replacement - Right Side](#).

Crankshaft Balancer Replacement

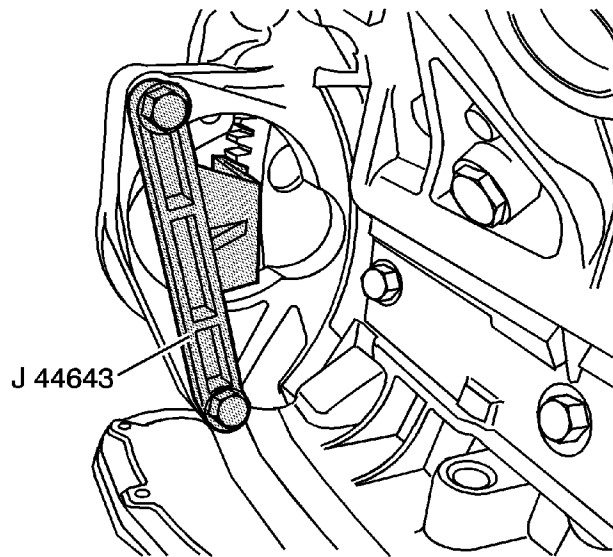
Special Tools

[J 44643](#) Flywheel Holding Tool

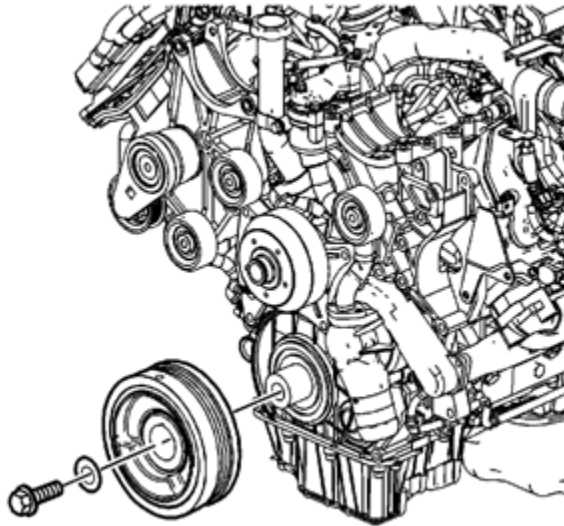
Removal Procedure



1. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).
2. Remove the right wheelhouse panel. Refer to [Front Wheelhouse Liner Replacement - Right Side](#).
3. Remove the starter motor bolts. Reposition the starter aside. The wiring to the starter does not require removal.

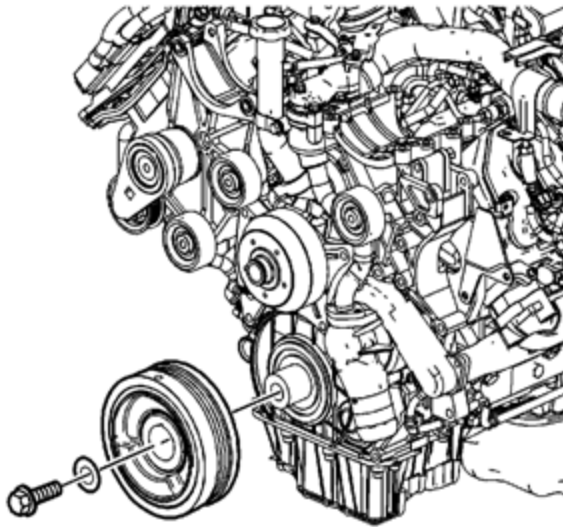


4. Install [J 44643](#) in order to hold the flywheel.
5. Remove the lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#).



6. Remove the crankshaft balancer bolt.
7. Remove the crankshaft balancer.
8. If required, clean and inspect the crankshaft balancer. Refer to [Crankshaft Balancer Cleaning and Inspection](#).

Installation Procedure



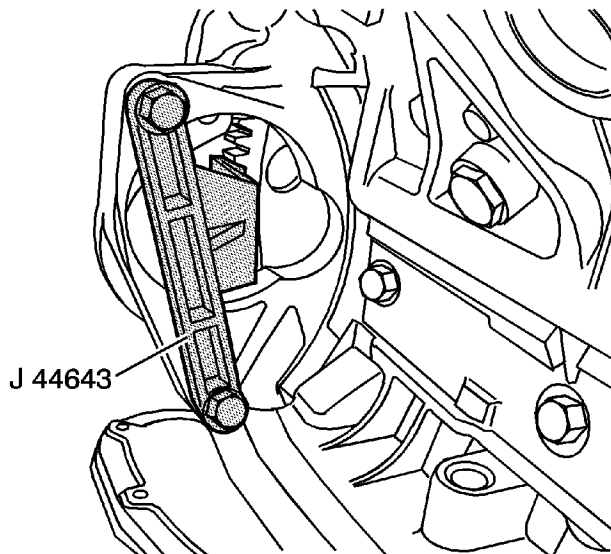
1. Lubricate the crankshaft balancer internal hub with clean engine oil.
2. Install the crankshaft balancer on the crankshaft.

Caution: Refer to [Fastener Caution](#) in the Preface section.

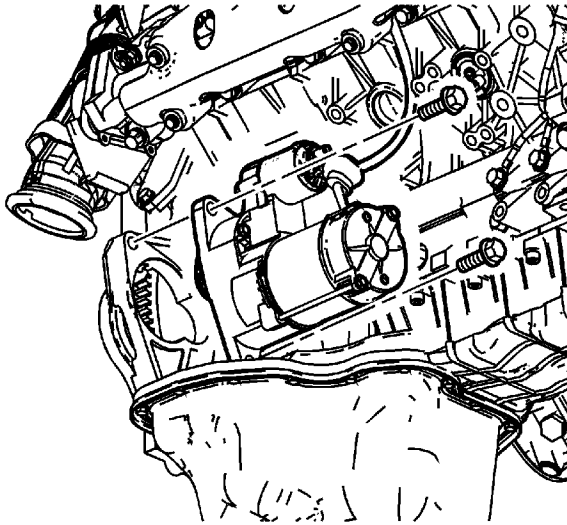
3. Lubricate the crankshaft balancer bolt with clean engine oil.
4. Install the crankshaft balancer bolt and washer.

Tighten

Tighten the bolt to 353 N·m (260 lb ft).



5. Remove [J 44643](#).



6. Position the starter motor.
7. Install the starter motor bolts.

Tighten

Tighten the bolts to 78 N·m (58 lb ft).

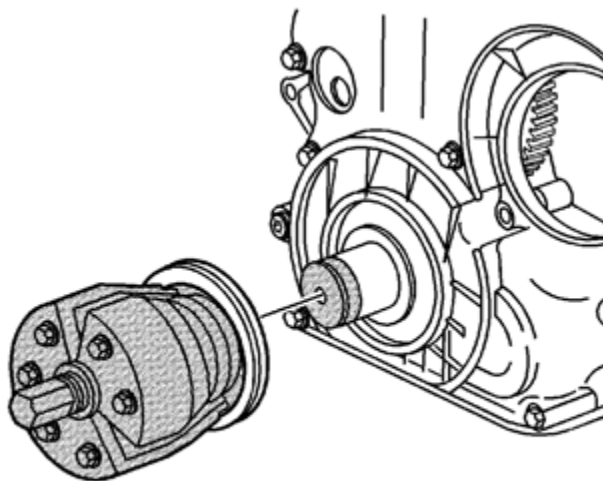
8. Install the right wheelhouse panel. Refer to [Front Wheelhouse Liner Replacement - Right Side](#).
9. Install the lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#).
10. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).

Crankshaft Front Oil Seal Replacement

Special Tools

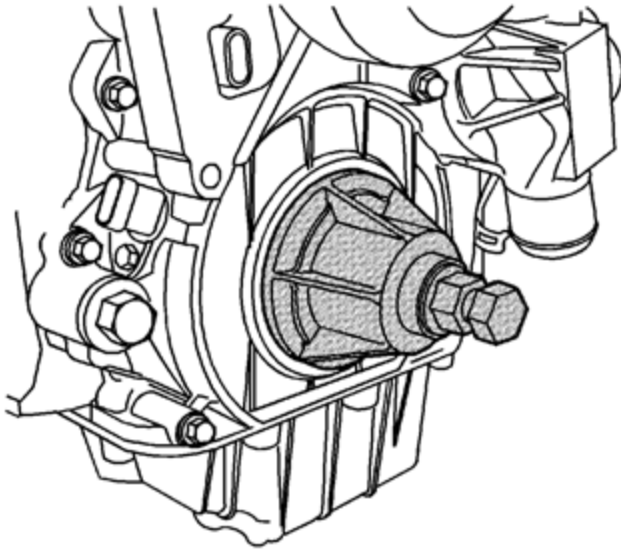
- [J 44644](#) Crankshaft Front Oil Seal Remover
- [J 44645](#) Crankshaft Front Oil Seal Installer

Removal Procedure



1. Remove the crankshaft balancer. Refer to [Crankshaft Balancer Replacement](#).
2. Install the button of [J 44644](#) into the crankshaft.
3. Press the jaws of [J 44644](#) into the felt portion of the seal far enough to engage the inner lip of the seal.
4. While holding the [J 44644](#) tightly to the seal inner sleeve, tighten the jaw bolts.
5. Using [J 44644](#) , remove the crankshaft front oil seal.

Installation Procedure



1. Clean the front crankshaft seal bore and the crankshaft.
2. Lubricate the crankshaft sealing surface with clean engine oil.
3. Place the crankshaft front oil seal onto the crankshaft.
4. Install [J 44645](#) to the crankshaft.
5. Press the crankshaft front oil seal onto the crankshaft using [J 44645](#) until the tool bottoms out.
6. Remove [J 44645](#).
7. Install the crankshaft balancer. Refer to [Crankshaft Balancer Replacement](#).

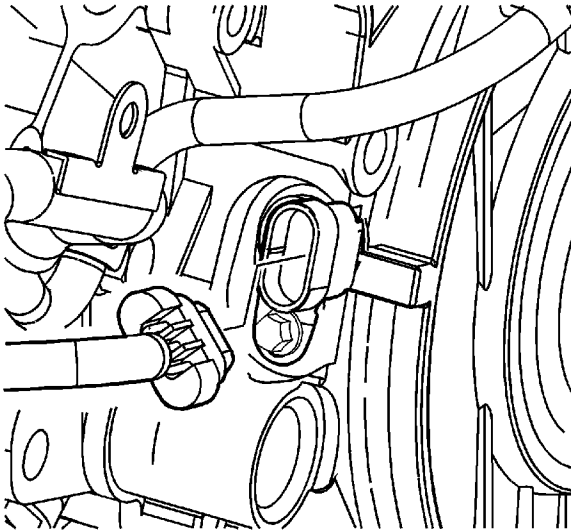
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Engine Front Cover Replacement

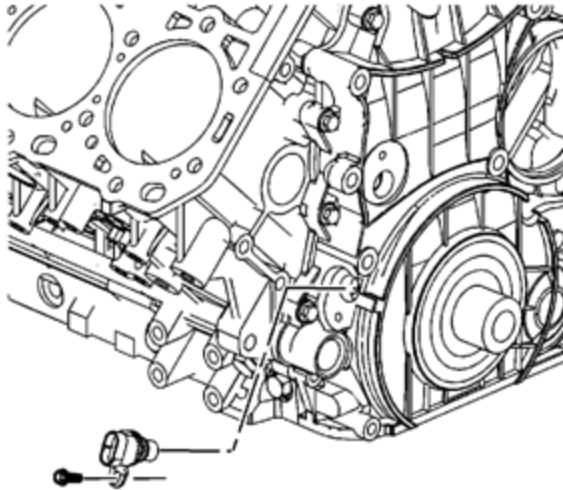
Special Tools

[J 37228](#) Seal Cutter

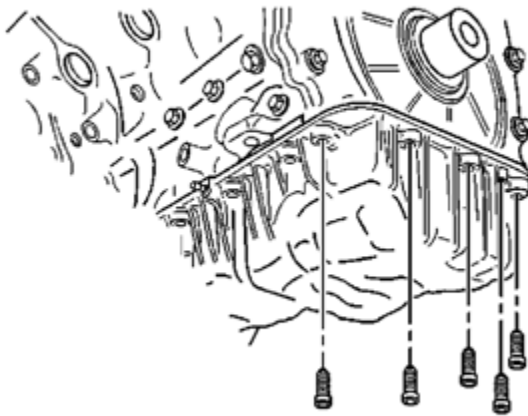
Removal Procedure



1. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).
2. Remove the water pump. Refer to [Water Pump Replacement](#).
3. Remove the crankshaft front oil seal. Refer to [Crankshaft Front Oil Seal Replacement](#).
4. Remove the right wheelhouse panel. Refer to [Front Wheelhouse Liner Replacement - Right Side](#).
5. Disconnect the crankshaft position (CKP) sensor electrical connector.

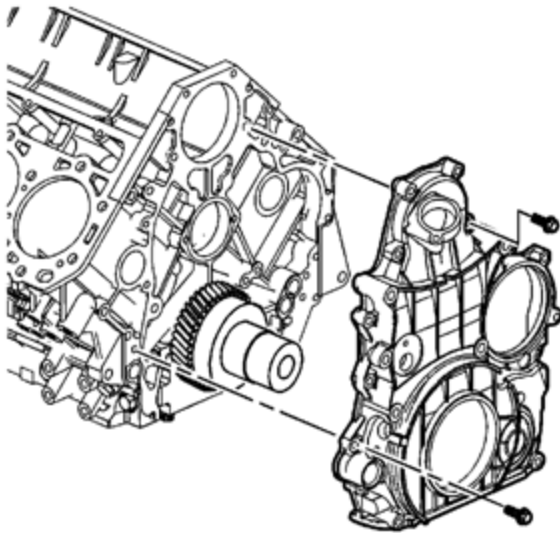


6. Remove the CKP sensor bolt and sensor.
7. Remove the CKP sensor spacer bolts and spacer.
8. Remove and discard the O-rings from the sensor and the spacer.



9. Remove the upper oil pan to engine front cover bolts.

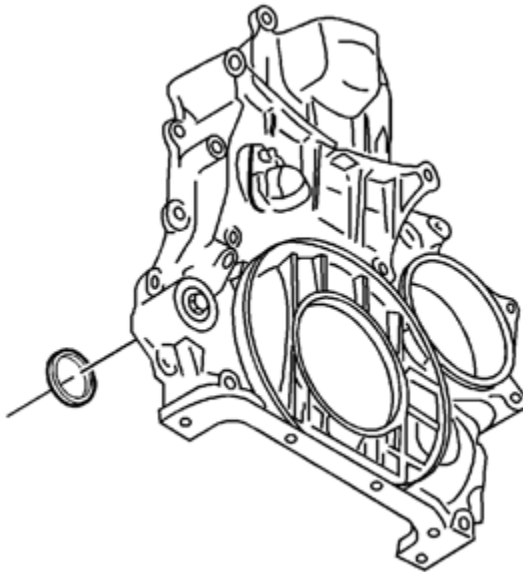
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10. Remove the engine front cover bolts.
11. Separate the engine front cover from the cylinder block and upper oil pan using [J 37228](#).

Note: Do not bend the turbocharger coolant pipe.

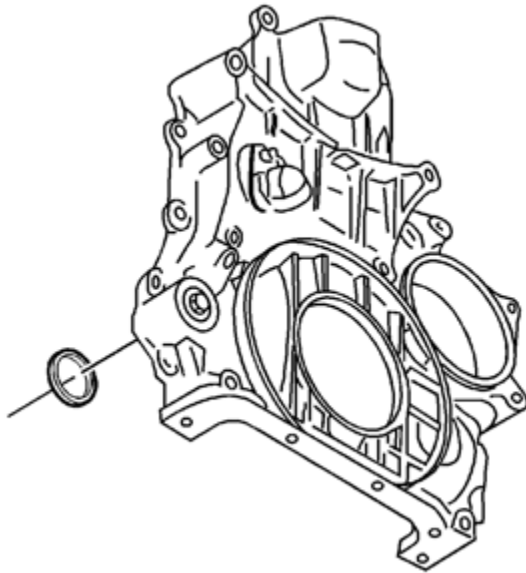
12. Remove the engine front cover.



13. If necessary, remove the pressure relief valve O-ring.
14. Clean and inspect the front cover. Refer to [Engine Front Cover Cleaning and Inspection](#).

Installation Procedure

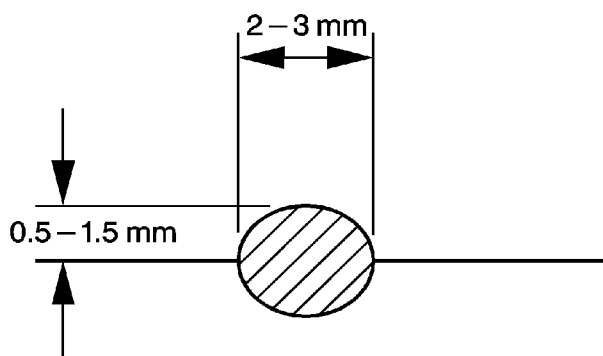
Caution: Refer to [Fastener Caution](#) in the Preface section.



1. If necessary, install a NEW pressure relief valve O-ring.
2. Lubricate the O-ring with engine oil.

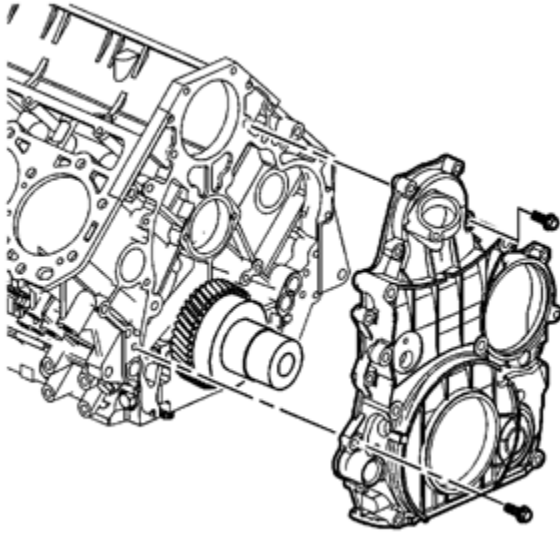
Tighten

Tighten the valve to 39 N·m (29 lb ft).



3. Apply a 2-3 mm (1/8 in) wide by 0.5-1.5 mm (1/16 in) high, bead of sealant to the engine front cover sealing surface to the engine block. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.
4. Apply a 2-3 mm (1/8 in) wide by 0.5-1.5 mm (1/16 in) high, bead of sealant to the engine front cover sealing surface to the upper oil pan. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.

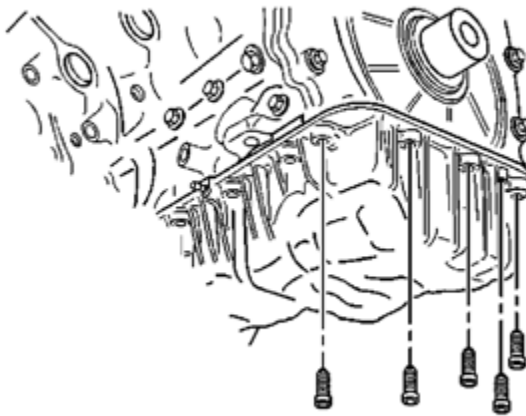
[Sealers](#) for the correct part number.



5. Install the engine front cover.
6. Install the engine front cover bolts.

Tighten

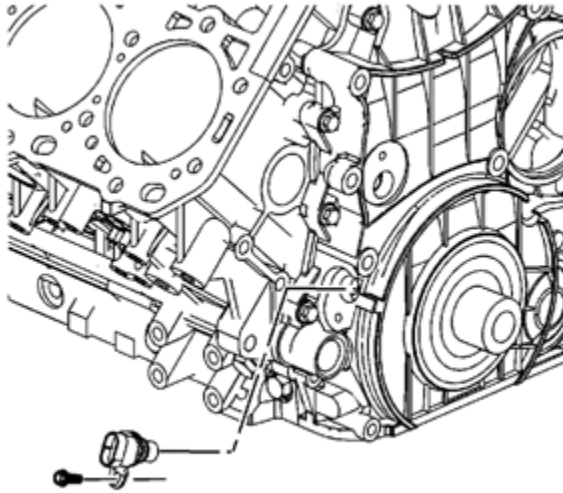
Tighten the bolts to 25 N·m (18 lb ft).



7. Install the upper oil pan to engine front cover bolts.

Tighten

Tighten the bolts to 21 N·m (15 lb ft).



8. Install a NEW O-ring to the CKP sensor spacer.
9. Lubricate the O-ring with clean engine oil.

Note: The crankshaft position sensor spacers are machined with different timing positions. However, if the crankshaft position sensor spacer requires replacement, replace with a grade "C" spacer.

10. Install the CKP sensor spacer and bolts.

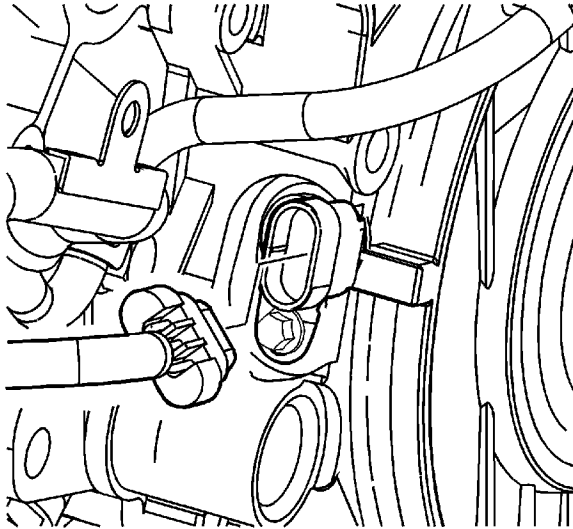
Tighten

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

11. Install a NEW O-ring to the CKP sensor.
12. Lubricate the O-ring with clean engine oil.
13. Install the CKP sensor and bolt.

Tighten

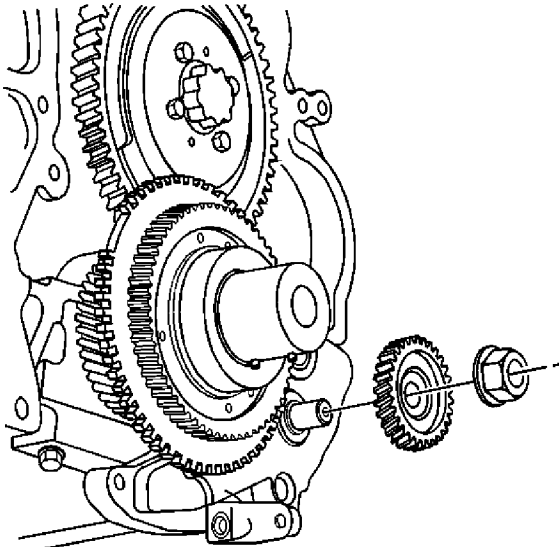
Tighten the bolt to 10 N·m (89 lb in).



14. Connect the CKP sensor electrical connector.
15. Install the right wheelhouse panel. Refer to [Front Wheelhouse Liner Replacement - Right Side](#).
16. Install the crankshaft front oil seal. Refer to [Crankshaft Front Oil Seal Replacement](#).
17. Install the water pump. Refer to [Water Pump Replacement](#).
18. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#).

Camshaft Position Sensor Exciter Ring Replacement

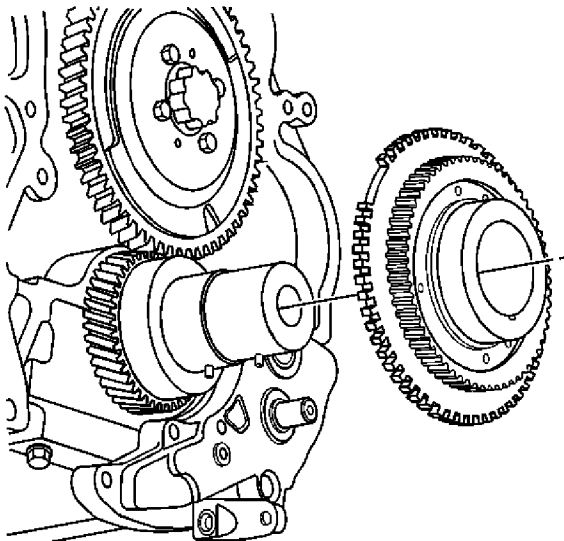
Removal Procedure



1. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).

Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

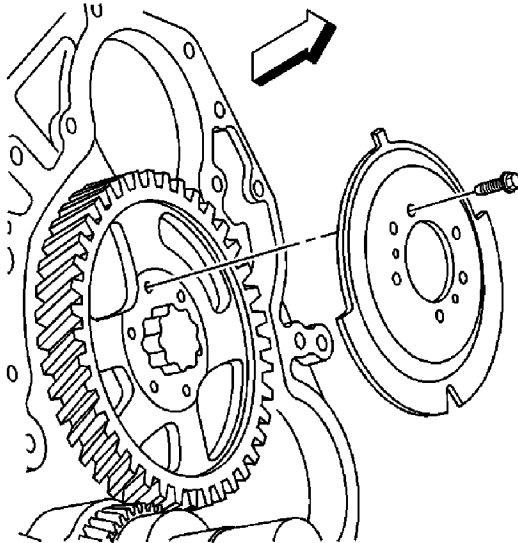
2. While holding the secondary oil pump shaft with a hex driver, remove the oil pump driven gear nut.
3. Remove the oil pump driven gear.





Note: DO NOT remove the reluctor from the oil pump drive gear. The reluctor is timed to the gear and once removed the correct timing will be lost.

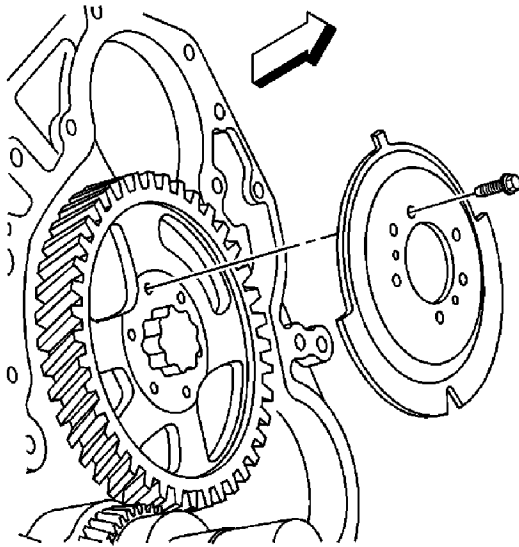
4. Remove the oil pump drive gear and crankshaft sensor reluctor.



5. Remove the camshaft reluctor screws.
6. Remove the camshaft reluctor.
7. Clean and inspect the camshaft reluctor for damage. Replace the reluctor if damage is found.

Installation Procedure

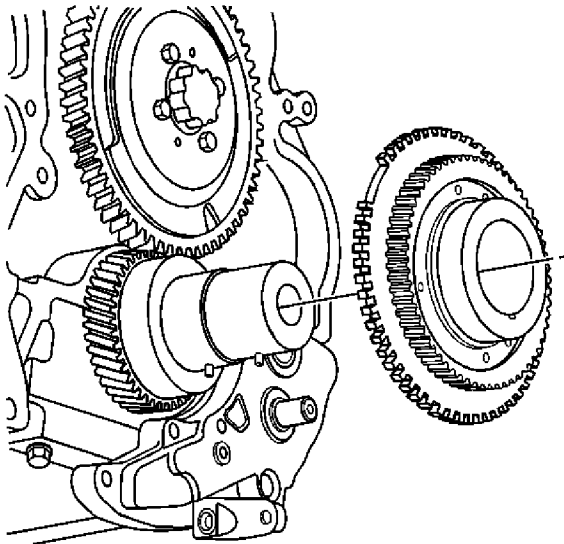
Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Position the camshaft reluctor to the camshaft gear.
2. Install the camshaft reluctor bolts.

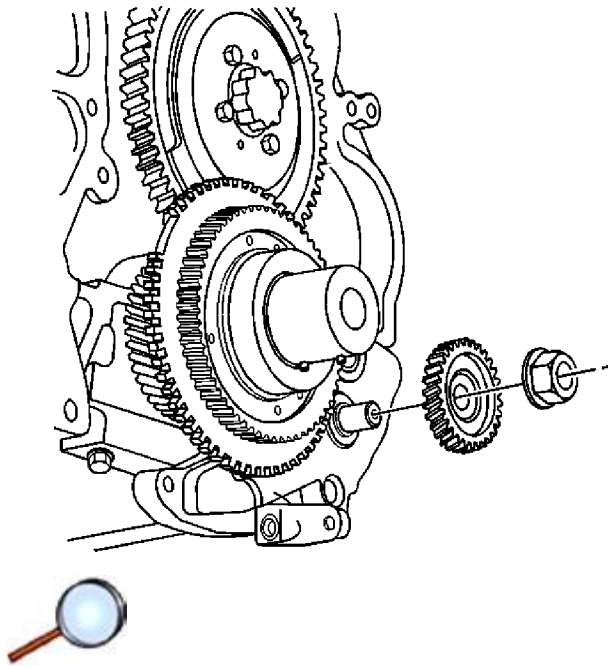
Tighten

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



Note: Do not damage the teeth on the reluctor.

3. Install the oil pump drive gear and reluctor to the crankshaft.



4. Install the oil pump driven gear.

Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

5. While holding the secondary oil pump shaft with a hex driver, install the oil pump driven gear nut.

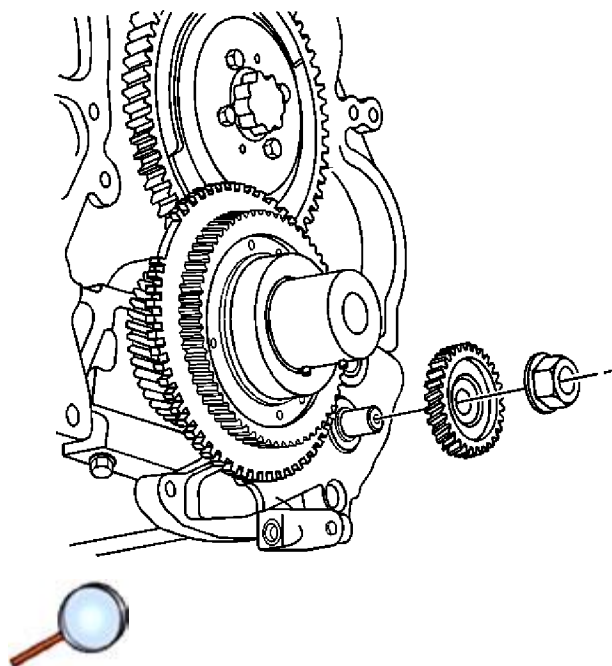
Tighten

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

6. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).

Crankshaft Reluctor and Oil Pump Drive Gear Replacement

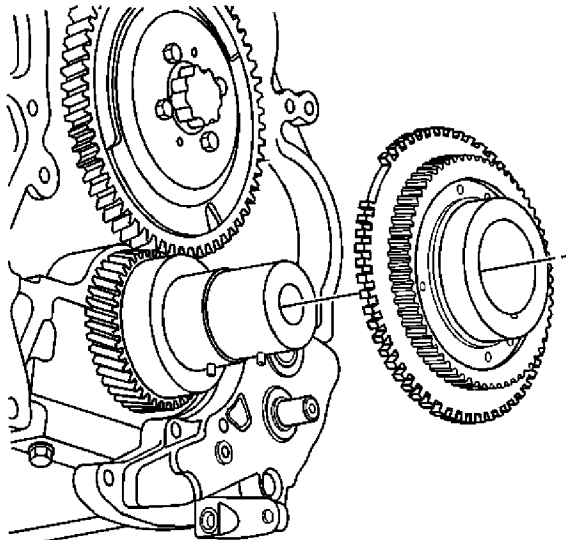
Removal Procedure



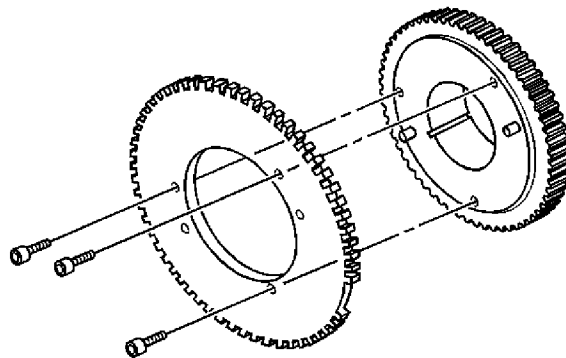
1. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
2. Remove the upper oil pan. Refer to [Upper Oil Pan Replacement](#).

Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

3. While holding the secondary oil pump shaft with a hex driver, remove the oil pump driven gear nut.
4. Remove the oil pump driven gear.



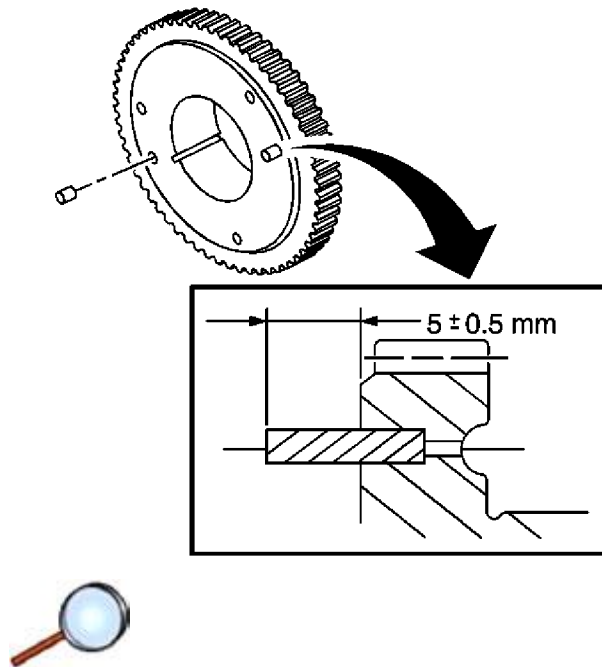
5. Remove the oil pump drive gear and crankshaft sensor reluctor. Do not damage the crankshaft reluctor teeth.



Note: Do not remove the reluctor from the oil pump drive gear unless replacing the reluctor or the oil pump drive gear. The reluctor is timed to the gear and once removed the correct timing will be lost.

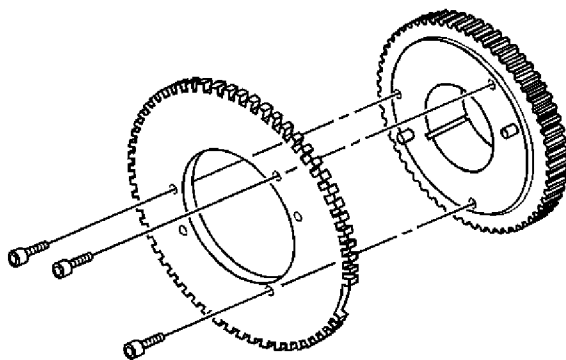
6. Remove the crankshaft reluctor to oil pump drive gear bolts.
7. Inspect the crankshaft reluctor for the damage, bent teeth, being bent or warped.
8. Inspect the oil pump drive gear for damaged or worn teeth.
9. Inspect the oil pump drive gear crankshaft pin for wear.
10. Inspect the groove of the crankshaft pin in the oil pump drive gear for wear.
11. Replace any parts that are damaged or worn.

Installation Procedure



Note: The crankshaft reluctor and the oil pump drive gear are timed at the factory. In order to re-establish proper timing, install knock pins in the oil pump drive gear if the crankshaft reluctor was removed from the oil pump drive gear. The knock pins are available through the parts department.

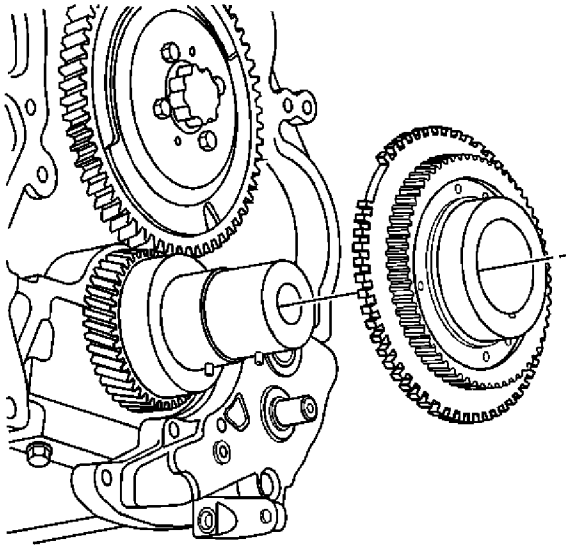
1. Install the knock pins in the oil pump drive gear to a height of 4.5-5.5 mm (0.177-0.217 in)



2. Install the crankshaft reluctor on the oil pump drive gear. Ensure the reluctor is aligned on the knock pins.

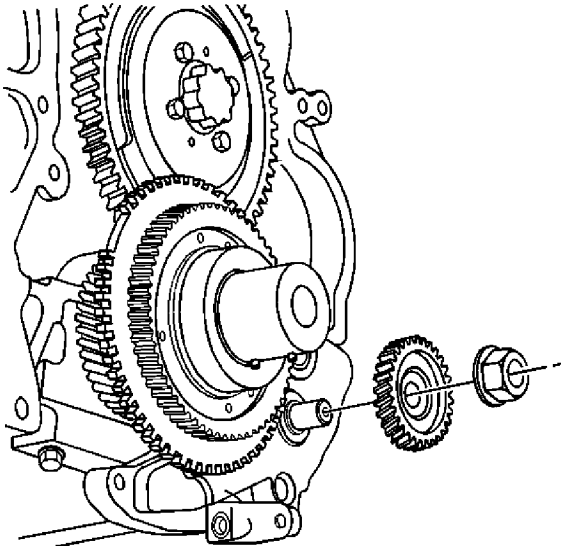
Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the crankshaft reluctor bolts and tighten to **8 N·m (71 lb in)**.



Note: Do not damage the teeth on the crankshaft reluctor.

4. Install the oil pump drive gear and reluctor to the crankshaft.



5. Install the oil pump driven gear.

Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

6. While holding the secondary oil pump shaft with a hex driver, install the oil pump driven gear

nut and tighten to **100 N·m (74 lb ft)**.

7. Install the upper oil pan. Refer to [Upper Oil Pan Replacement](#).
8. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).

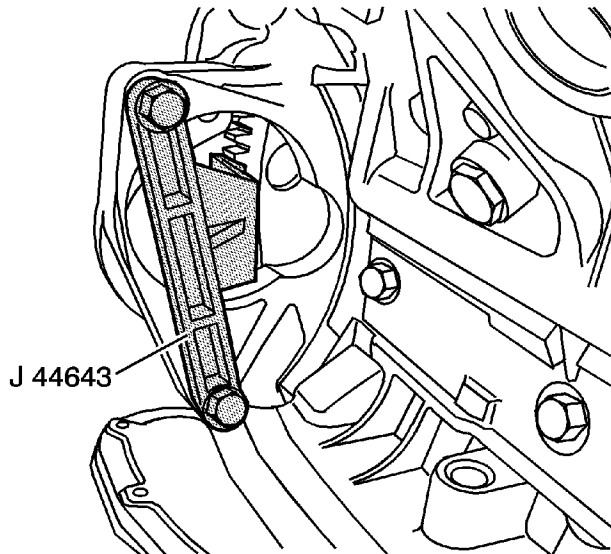
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Camshaft Replacement

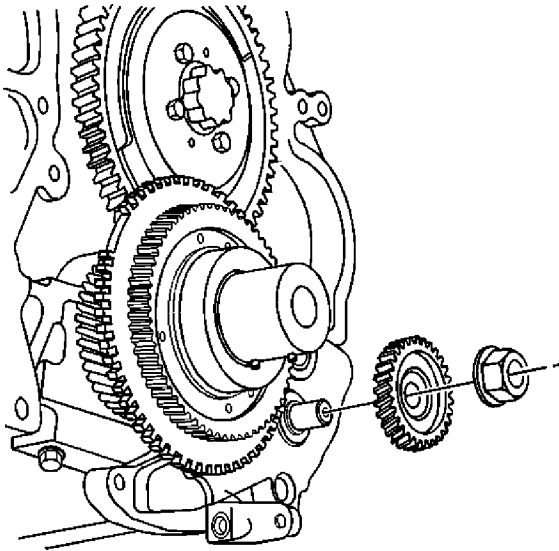
Special Tools

- [J 26900-12](#) Dial Indicator
- [J 26900-13](#) Magnetic Base
- [J 44643](#) Flywheel Holding Tool

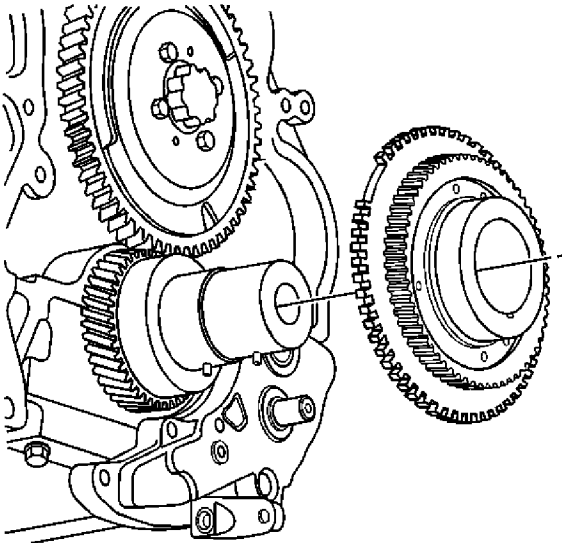
Removal Procedure



1. Remove the engine assembly. Refer to [Engine Replacement](#).
2. Remove the valve lifters. Refer to [Valve Lifter Replacement](#).
3. Install [J 44643](#) flush to the flywheel opening.
4. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).

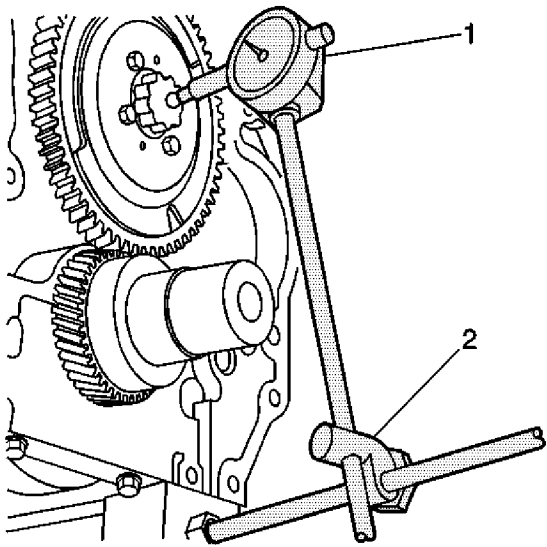


5. Remove the oil pump driven gear nut.
6. Remove the oil pump driven gear.

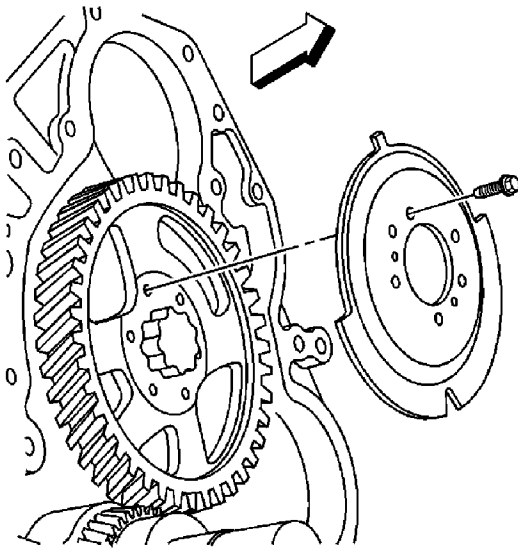


Note: The crankshaft reluctor and the oil pump drive gear are timed together at the factory. Do not remove the crankshaft reluctor from the oil pump drive gear.

7. Remove the oil pump drive gear and crankshaft reluctor.
 - Do not remove the crankshaft reluctor bolts.
 - Do not damage the reluctor teeth.



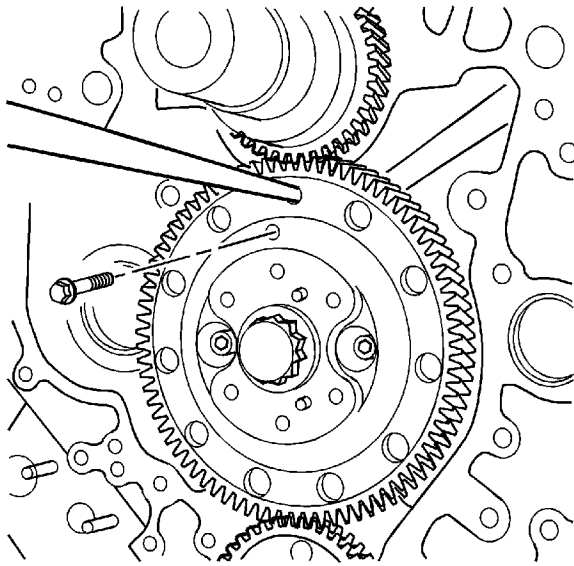
8. Using [J 26900-12](#) (1) and [J 26900-13](#) (2), measure the camshaft end play.
 - The production value is 0.050-0.114 mm (0.002-0.0045 in) and service limit is 0.20 mm (0.008 in).
 - Replace the camshaft gear or the camshaft thrust plate if measured value exceeds service limit.



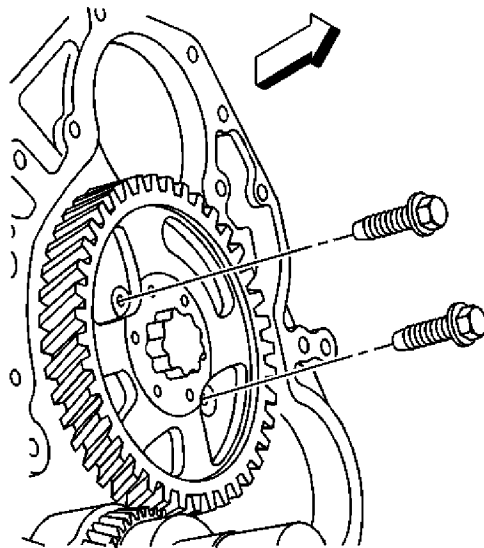
9. Remove the camshaft reluctor screws.
10. Remove the camshaft reluctor.

Note: The two piece cam gear must be bolted together to prevent the spring tension from unloading upon removal.

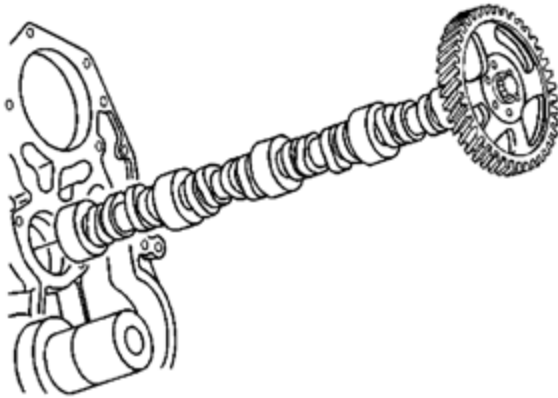
11. Remove the camshaft exciter ring.



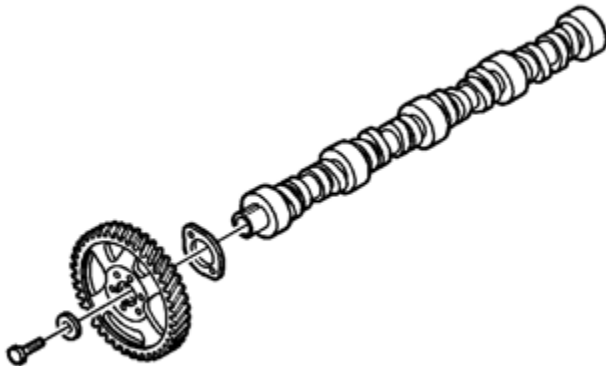
12. Align the threaded hole with a suitable tool and install an exciter ring bolt to secure the spring tension.
13. Remove the camshaft thrust plate bolts through the holes in the camshaft gear.



14. In order to loosen the camshaft gear bolt use [J 44643](#) in order to hold the engine from turning.
15. Loosen the camshaft gear bolt and leave the bolt finger tight.
16. Remove the camshaft thrust plate bolts through the holes in the camshaft gear.

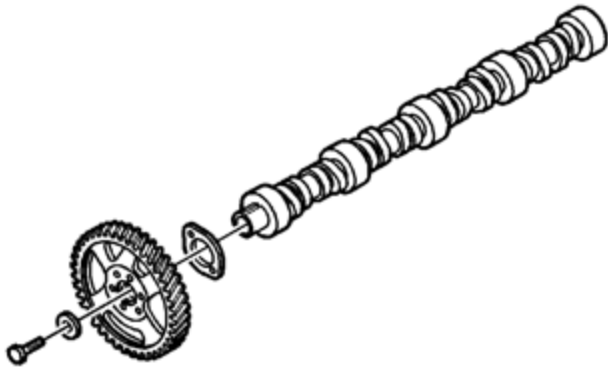


17. Remove the camshaft with the camshaft gear attached.



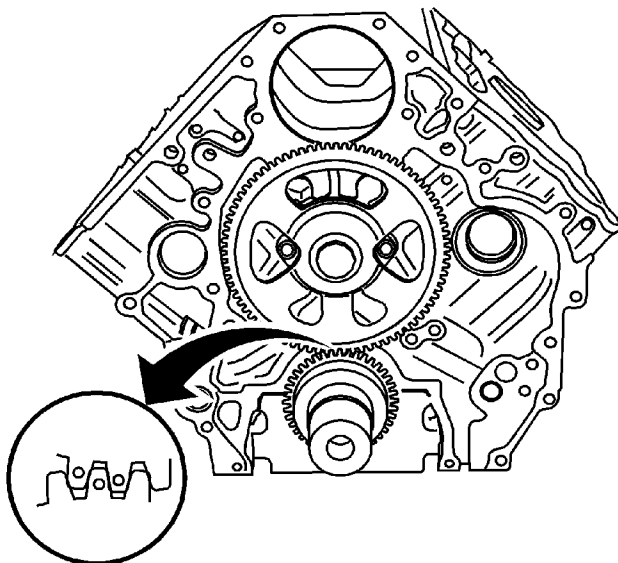
18. Remove the camshaft gear bolt and discard.
19. Remove the camshaft gear.
20. Remove the camshaft thrust plate.
21. Clean and inspect the camshaft and bearings. Refer to [Camshaft and Bearings Cleaning and Inspection](#).

Installation Procedure



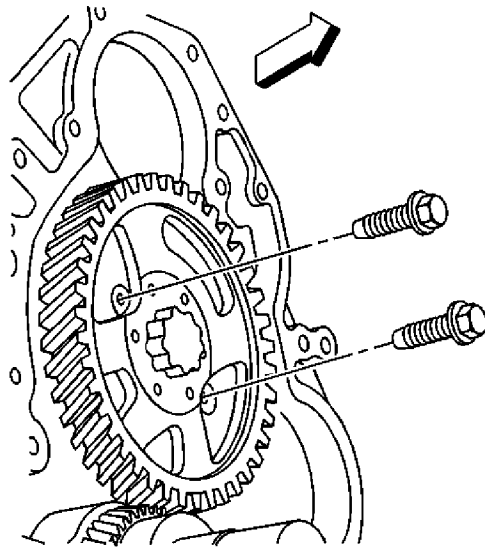
1. Install the camshaft thrust plate to the camshaft.
2. Install the camshaft driven gear.
3. Install a NEW camshaft driven gear bolt.

Leave the bolt finger tight.



4. Install the camshaft into the cylinder block, align the camshaft gear to the crankshaft gear as shown.

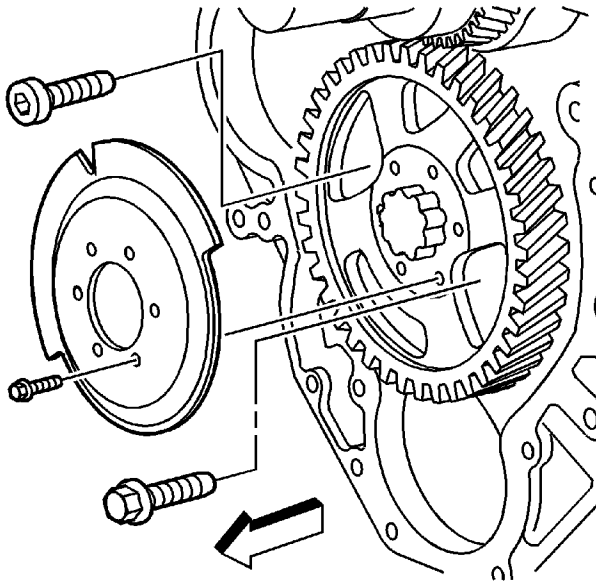
Caution: Refer to [Fastener Caution](#) in the Preface section.



5. Apply threadlock to the threads of the camshaft thrust plate bolts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.
6. Install the camshaft thrust plate bolts.

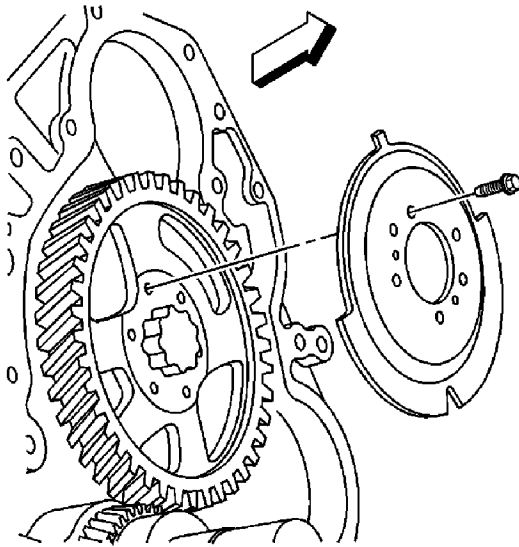
Tighten

Tighten the bolts to 22 N·m (16 lb ft).



Note: Use a suitable tool to relieve the spring tension while removing the locking bolt.

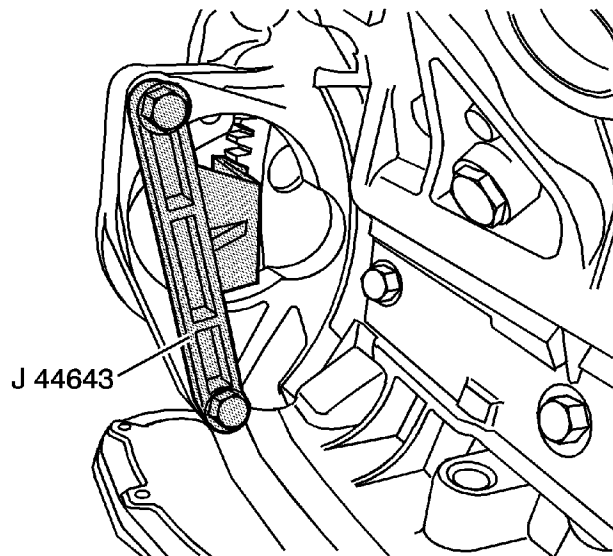
7. Remove the exciter ring bolt that was installed to hold the spring tension of the two piece cam gear.



8. Install the camshaft reluctor to the camshaft gear.
9. Install the camshaft reluctor bolts.

Tighten

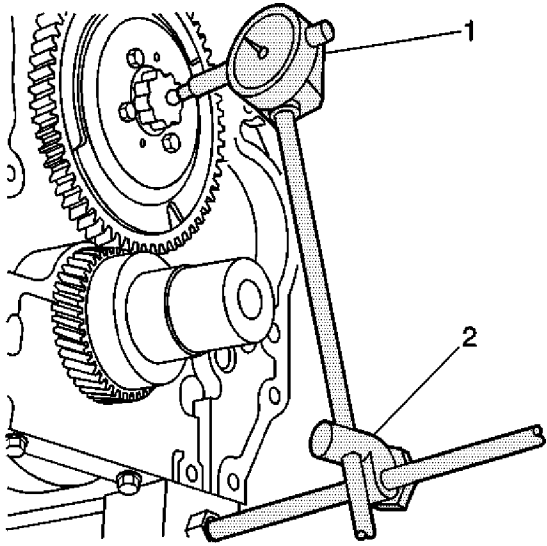
Tighten the bolts in a cross-bolt pattern to 9 N·m (80 lb in).



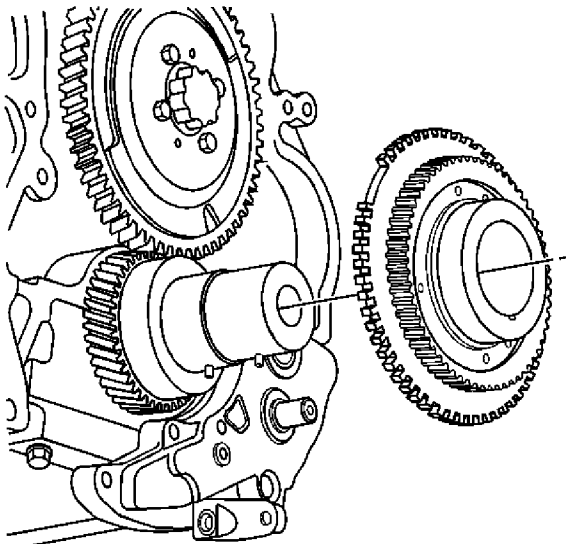
10. Reinstall [J 44643](#) in the starter opening, if removed.
11. Install a NEW camshaft gear bolt.

Tighten

Tighten the bolt to 234 N·m (173 lb ft).

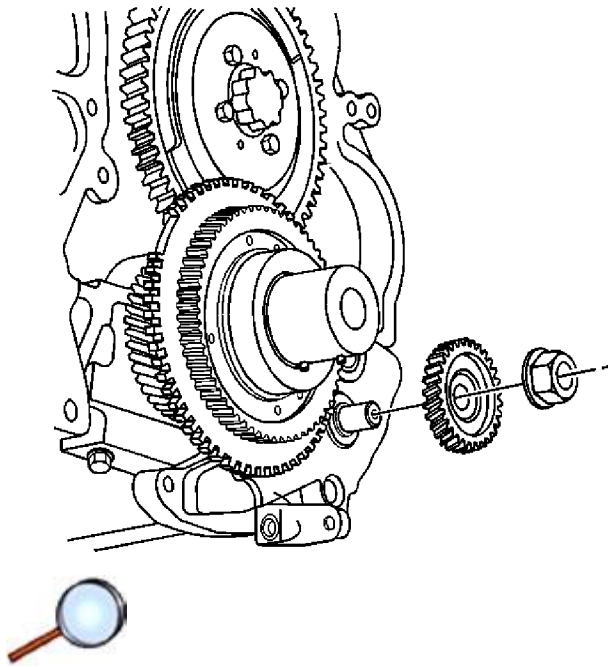


12. Using [J 26900-12](#) (1) and [J 26900-13](#) (2) measure the camshaft end play.
- The production value is 0.050-0.114 mm (0.002-0.0045 in) and service limit is 0.20 mm (0.008 in).
 - Replace the camshaft gear or the camshaft thrust plate if measured value exceeds the service limit.



Important: Do not damage the teeth on the crankshaft reluctor.

13. Install the oil pump drive gear and reluctor to the crankshaft.



14. Install the oil pump driven gear.
15. Install the oil pump driven gear nut.

Tighten

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

16. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).
17. Install the engine assembly. Refer to [Engine Replacement](#).
18. Install the valve lifters. Refer to [Valve Lifter Replacement](#).

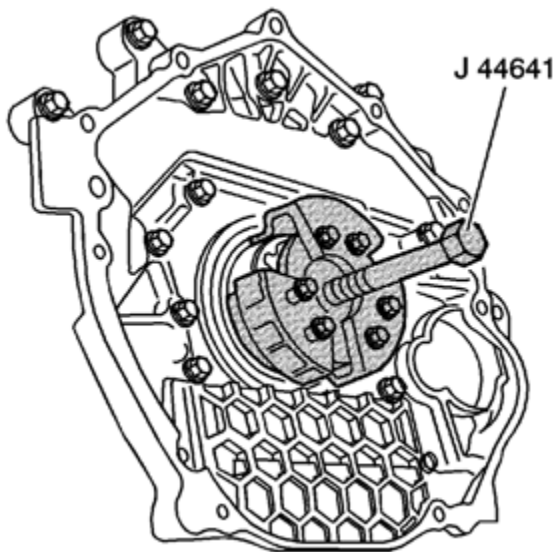
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Crankshaft Rear Oil Seal Replacement

Special Tools

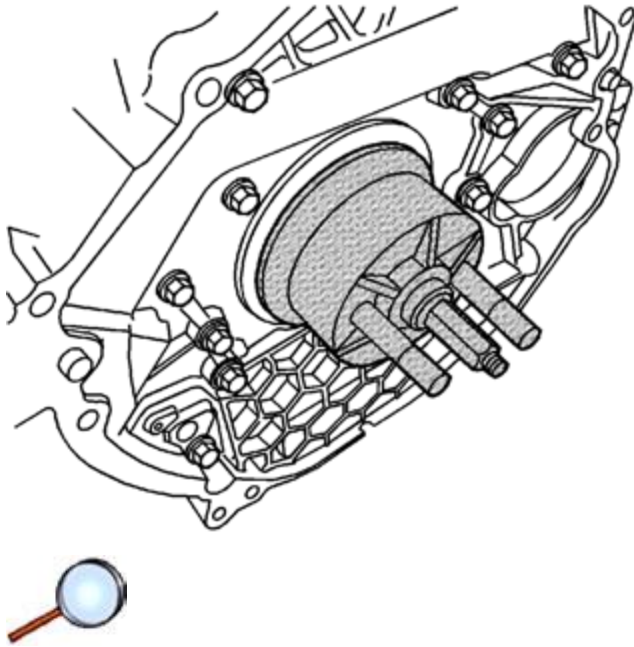
- [J 44641](#) Crankshaft Rear Oil Seal Remover
- [J 44642](#) Crankshaft Rear Oil Seal Installer

Removal Procedure



1. Remove the flywheel. Refer to [Engine Flywheel Replacement](#).
2. Clean the area around the crankshaft rear oil seal.
3. Install the button of [J 44641](#) into the crankshaft.
4. Press the jaws of [J 44641](#) into the felt portion of the seal far enough to engage the inner lip of the seal.
5. While holding the [J 44641](#) tightly to the seal inner sleeve, tighten the jaw bolts.
6. Remove the crankshaft rear oil seal using [J 44641](#).

Installation Procedure



1. Ensure that the crankshaft is free of oil and dirt.
2. Clean the seal bore in the flywheel housing.
3. Position the crankshaft rear oil seal onto the crankshaft.

Important: [J 44642](#) must be fully secured to the crankshaft to ensure proper seal depth.

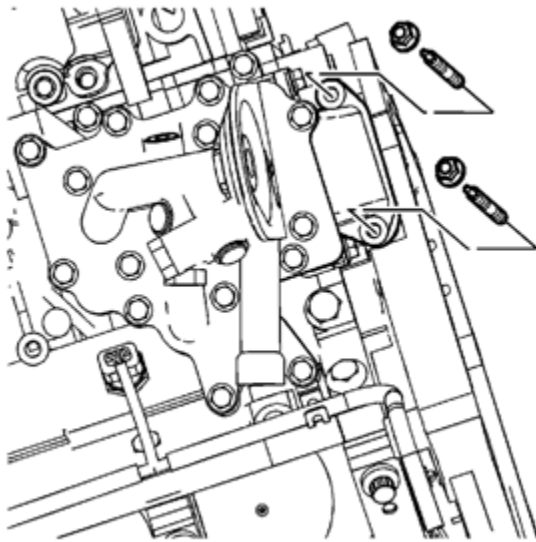
4. Install [J 44642](#) to the crankshaft.
5. Press the crankshaft rear oil seal into position using [J 44642](#) , the tool will bottom out when the seal reaches the proper depth.
6. Remove [J 44642](#) .
7. Install the flywheel. Refer to [Engine Flywheel Replacement](#).

Engine Flywheel Housing Replacement

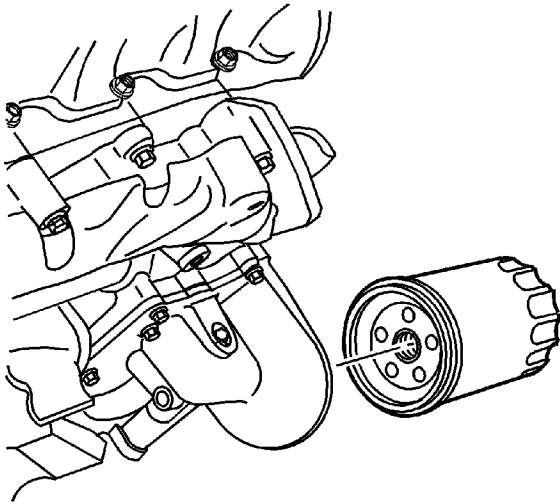
Special Tools

[J 37228](#) Seal Cutter

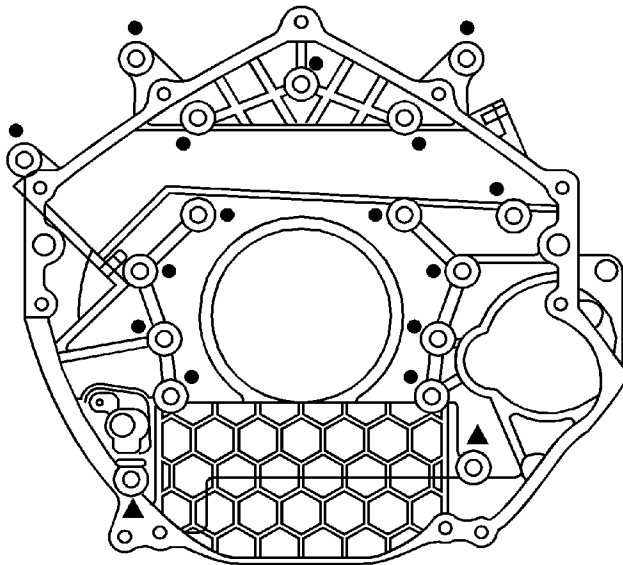
Removal Procedure



1. Drain the cooling system. Refer to [Cooling System Draining and Filling](#).
2. Remove the crankshaft rear oil seal. Refer to [Crankshaft Rear Oil Seal Replacement](#).
3. Remove the turbocharger oil return pipe nuts from the top of the flywheel housing.
4. Remove the oil cooler adapter studs and nuts from the flywheel housing.

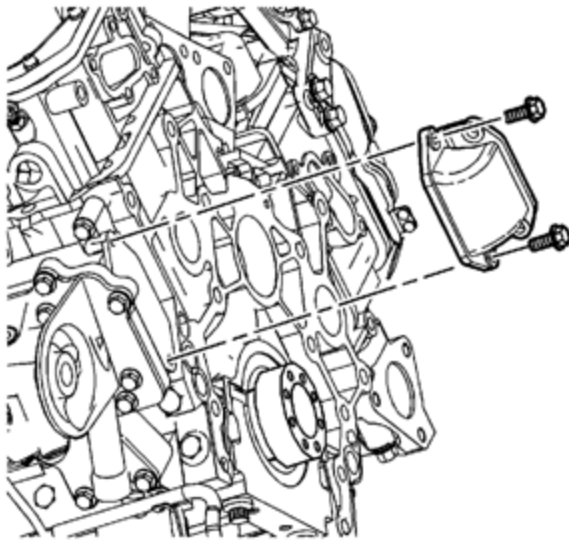


5. Remove the upper oil pan. Refer to [Upper Oil Pan Replacement](#).
6. Remove the oil filter.



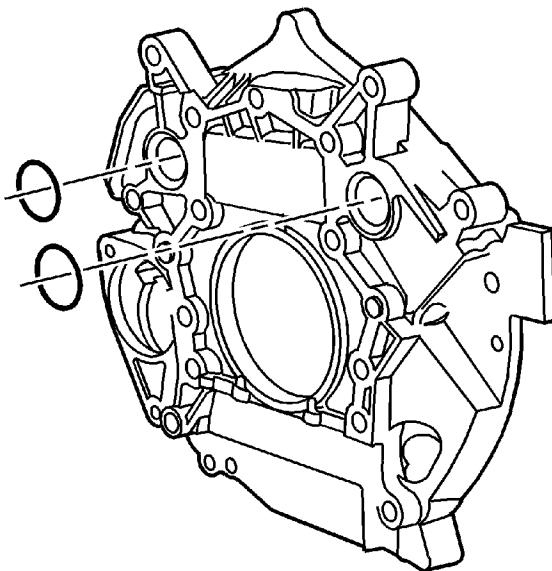
7. Remove the flywheel housing bolts, denoted by the black circles.
8. Separate the flywheel from the cylinder block using [J 37228](#).
9. Remove the flywheel housing.

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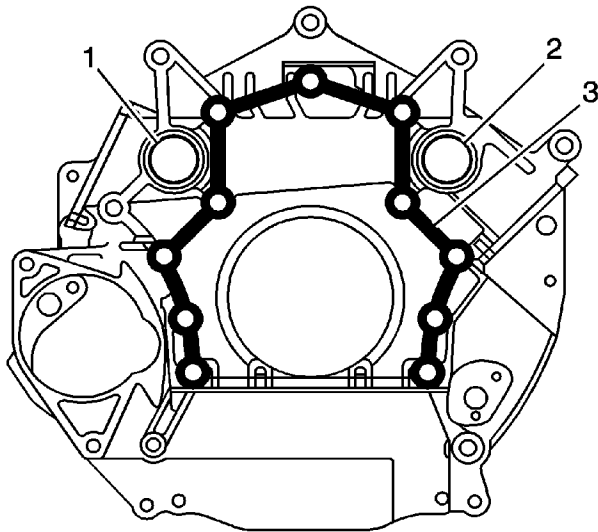


10. Remove the turbocharger oil return pipe gasket from the flywheel housing.
11. Remove the oil cooler adapter bolts.
12. Remove the oil cooler adapter and gaskets.
13. If required, clean and inspect the flywheel housing. Refer to [Engine Flywheel Housing Cleaning and Inspection](#).

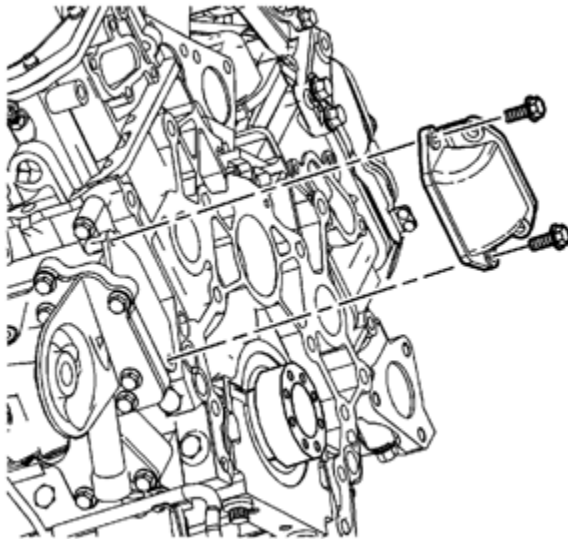
Installation Procedure



1. Install NEW O-ring seals to the flywheel housing, if necessary.



2. Apply a 2 mm (1/8 in) wide bead of sealant (3) to the flywheel housing sealing surfaces. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.



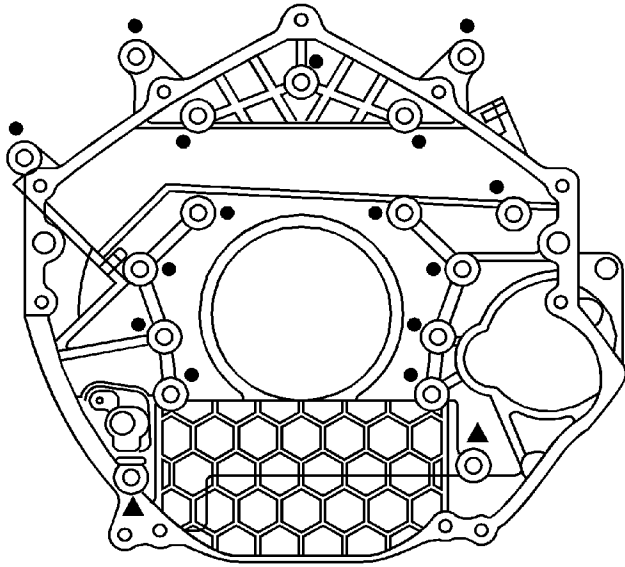
3. Install a NEW oil cooler adapter gasket.
4. Install a NEW oil cooler adapter to flywheel housing gasket.
5. Install the oil cooler adapter to the flywheel housing.

Caution: Refer to [Fastener Caution](#) in the Preface section.

6. Install the oil cooler adapter bolts.

Tighten

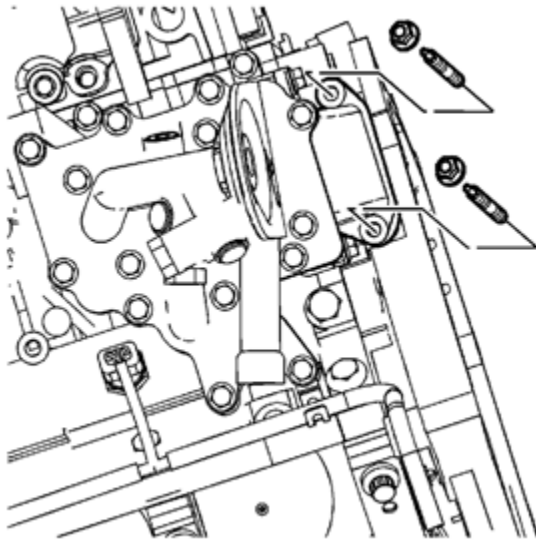
Tighten the bolts/nuts to 21 N·m (15 lb ft).



7. Install the flywheel housing bolts, denoted by the black circles.

Tighten

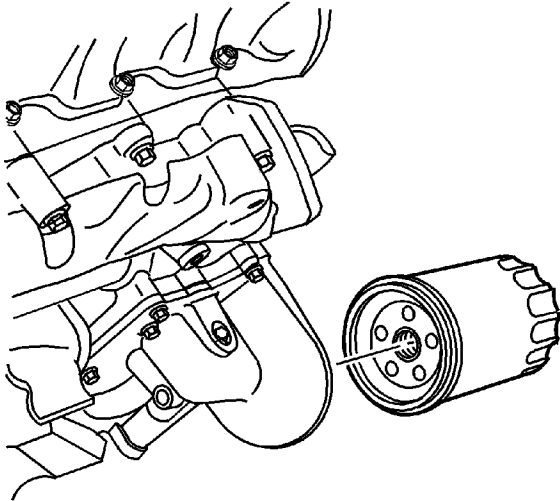
Tighten the bolts to 90 N·m (67 lb ft).



8. Install the oil cooler adapter studs and nuts to the flywheel housing.

Tighten

- Tighten the oil cooler adapter studs to 10 N·m (89 lb in).
- Tighten the oil cooler adapter nuts to 25 N·m (18 lb ft).



9. Install the oil filter.
10. Install the upper oil pan. Refer to [Upper Oil Pan Replacement](#).
11. Install a NEW gasket to the turbocharger oil return pipe.
12. Install the turbocharger oil return pipe to flywheel housing nuts.

Tighten

Tighten the nuts to 21 N·m (15 lb ft).

13. Install the crankshaft rear oil seal. Refer to [Crankshaft Rear Oil Seal Replacement](#).
14. Fill the cooling system. Refer to [Cooling System Draining and Filling](#).

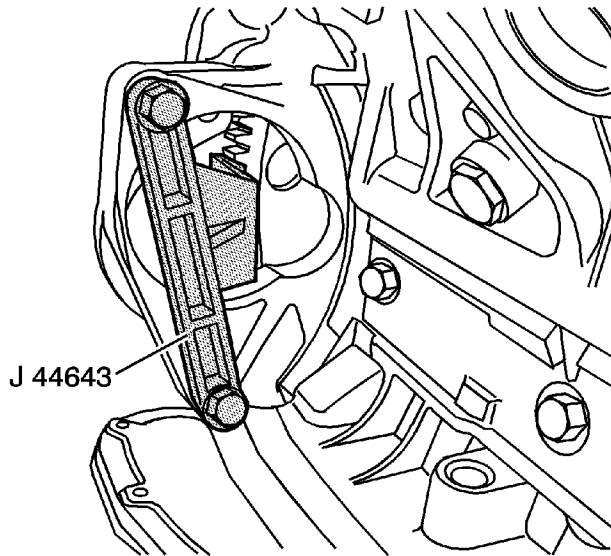
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Engine Flywheel Replacement

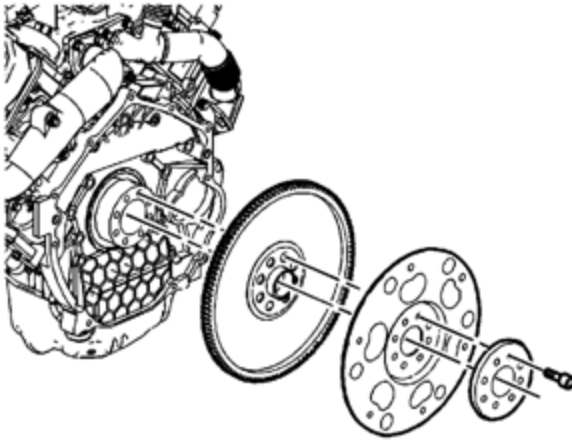
Special Tools

- [J 44643](#) Flywheel Holding Tool
- [J 45059](#) Angle Meter

Removal Procedure



1. Remove the transmission. Refer to [Transmission Replacement](#) for the 4L60-E /4L65-E/4L70-E transmission, [Transmission Replacement](#) for the 4L50/4L80/4L90 transmission, or [Transmission Replacement](#) for the Allison transmission.
2. Install [J 44643](#) in order to hold the flywheel.

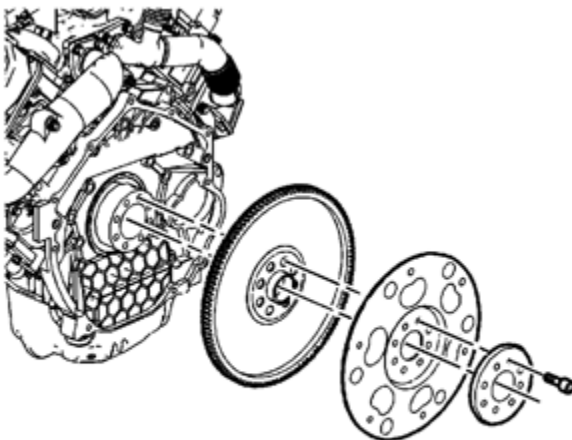


Warning: When removing, handling or installing this component wear protective gloves. The sharp edges on the component may be very sharp and may cause injury.

3. Remove and discard the flywheel bolts.
4. Remove the flywheel washer and flywheel.

Installation Procedure

Warning: When removing, handling or installing this component wear protective gloves. The sharp edges on the component may be very sharp and may cause injury.





Note: When installing the flywheel, ensure that the tapered side of the teeth are facing the starter.

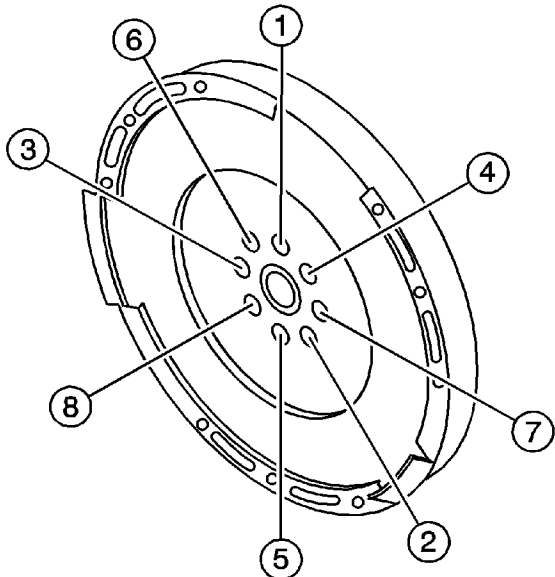
1. Install the flywheel.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the flywheel washer with the beveled side facing the engine.

Caution: This component uses bolts with a preapplied molybdenum disulfide coating for thread lubrication. Do not remove the coating or use any additional lubricant. Improperly lubricated threads will adversely affect the bolt torque and clamp load. Improper bolt torque and clamp load can lead to engine damage.

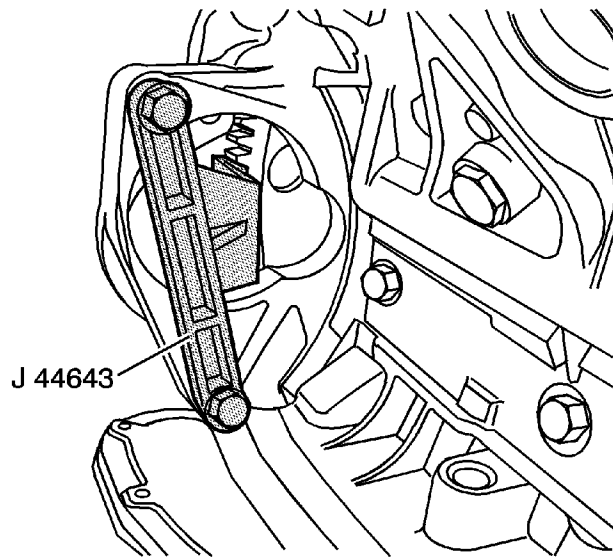
3. Install NEW flywheel bolts.



4. Tighten the flywheel bolts in the proper sequence.

Tighten

1. Tighten the bolts a first pass to 79 N·m (58 lb ft).
2. Tighten the bolts a second pass to 60 degrees using [J 45059](#).
3. Tighten the bolts a final pass an additional 60 degrees using [J 45059](#).



5. Remove [J 44643](#) from the flywheel.
6. Install the transmission. Refer to [Transmission Replacement](#) for the 4L60-E/4L65-E/4L70-E transmission, [Transmission Replacement](#) for the 4L50/4L80/4L90 transmission, or [Transmission Replacement](#) for the Allison transmission.

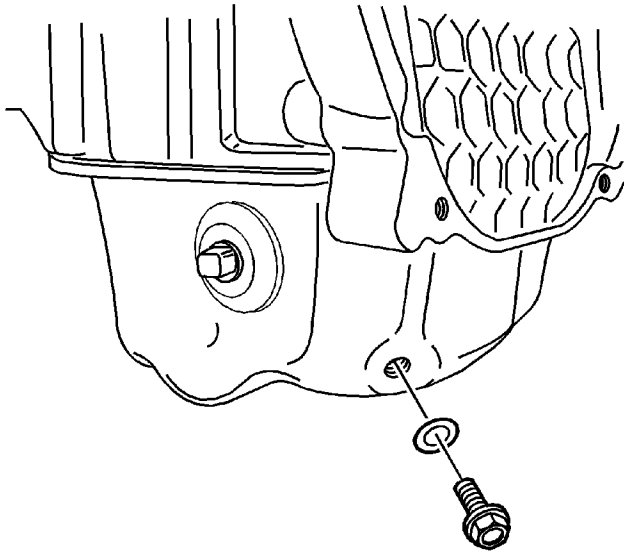
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Lower Oil Pan Replacement

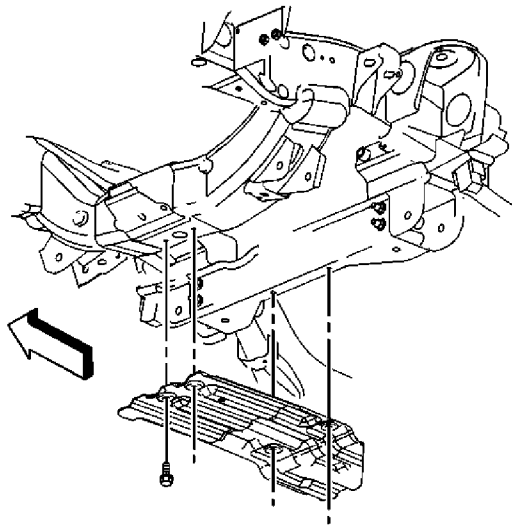
Soecial Tools

[J 37228](#) Seal Cutter

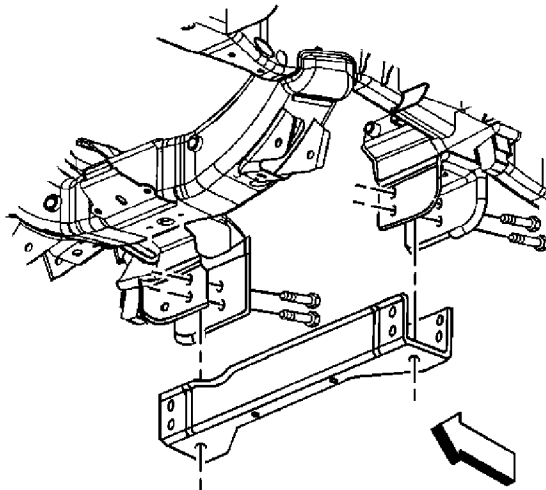
Removal Procedure



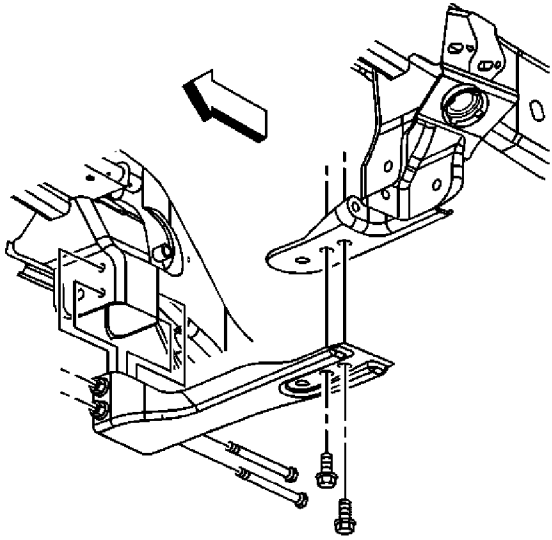
1. Raise and suitably support the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
2. Place a suitable container under the engine in order to drain the oil.
3. Remove the oil drain plug.
4. Drain the engine oil.



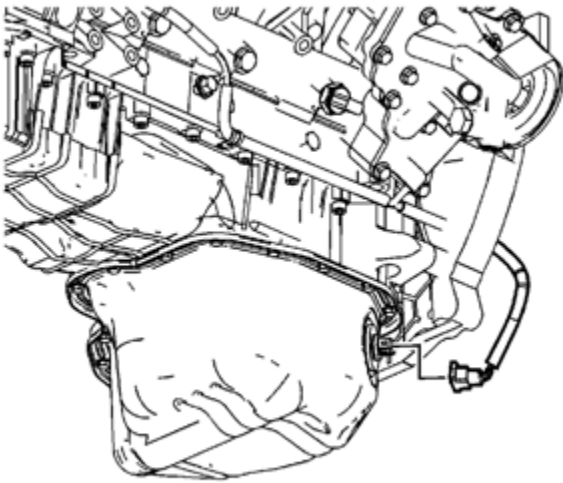
5. Remove the oil pan skid plate bolts and plate, if equipped.



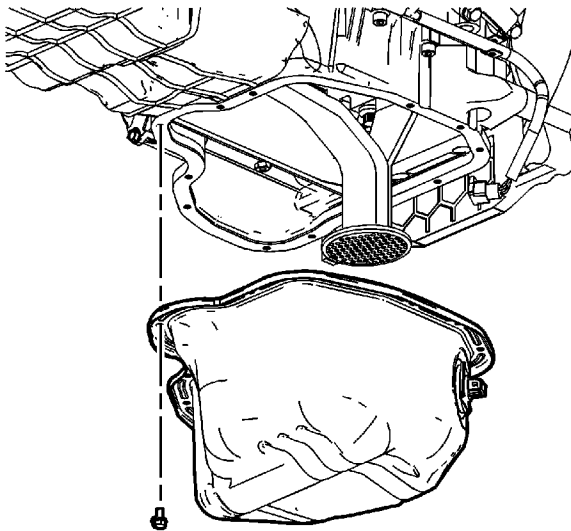
6. If equipped with a 2-wheel drive (2WD) vehicle, remove the crossmember bolts and crossmember.



7. If equipped with a 4-wheel drive (4WD) vehicle, remove the crossmember bolts and crossmember.



8. Disconnect the oil level sensor electrical connector.

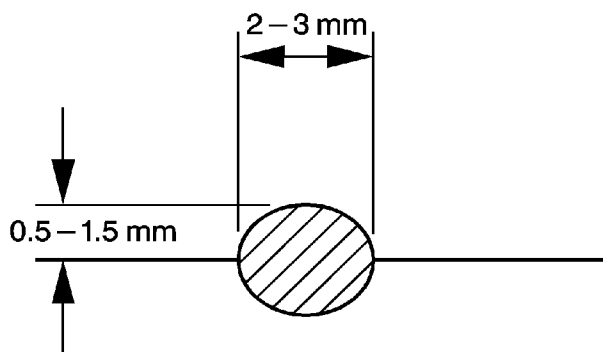


9. Remove the lower oil pan bolts/nuts.

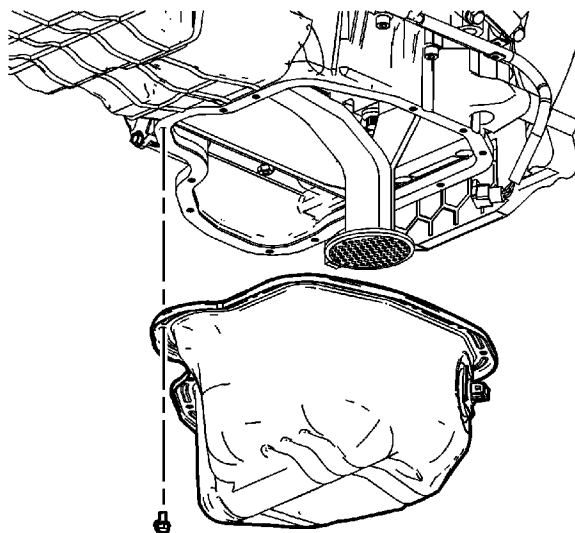
Note: DO NOT damage the sealing surfaces when separating the lower oil pan from the upper oil pan.

10. Separate the lower oil pan from the upper oil pan using [J 37228](#).
11. Remove the lower oil pan.
12. If necessary, clean and inspect the lower oil pan. Refer to [Lower Oil Pan Cleaning and Inspection](#).

Installation Procedure

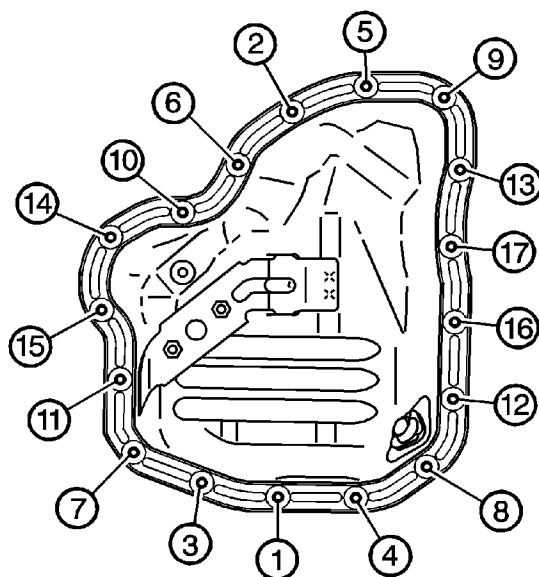


1. Apply a 2-3 mm (0.79-0.118 in) by 0.5-1.5 mm (0.02-0.06 in) wide bead of sealant to the lower oil pan mating surface. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.



2. Install the lower oil pan.
3. Install the lower oil pan bolts/nuts.

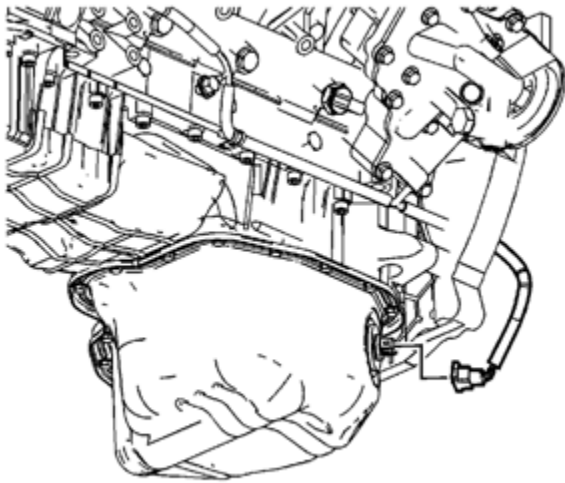
Caution: Refer to [Fastener Caution](#) in the Preface section.



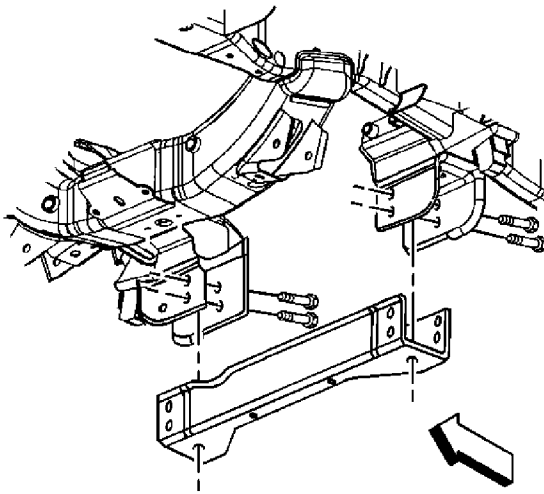
4. Tighten the oil pan bolts/nuts in the sequence shown.

Tighten

Tighten the bolts/nuts to 10 N·m (89 lb in).



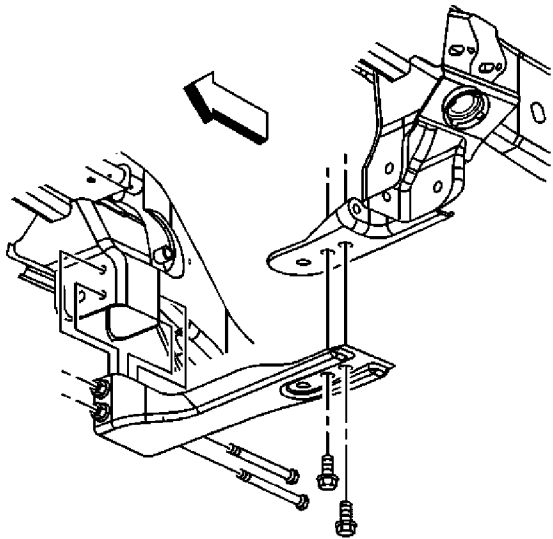
5. Connect the oil level sensor electrical connector.



6. If equipped with a 2WD, install the crossmember and bolts.

Tighten

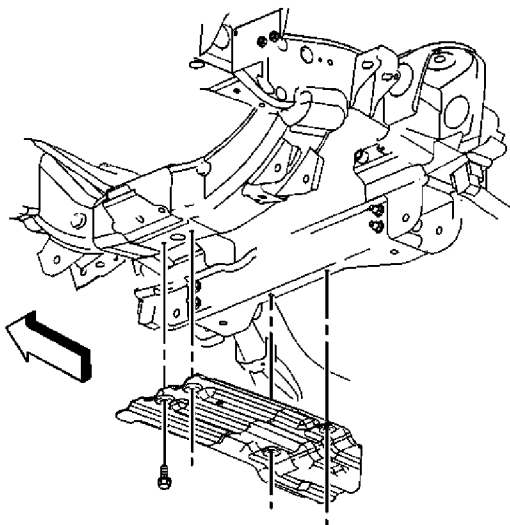
Tighten the bolts to 100 N·m (74 lb ft).



7. If equipped with a 4WD, install the crossmember and bolts.

Tighten

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



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

Tighten

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

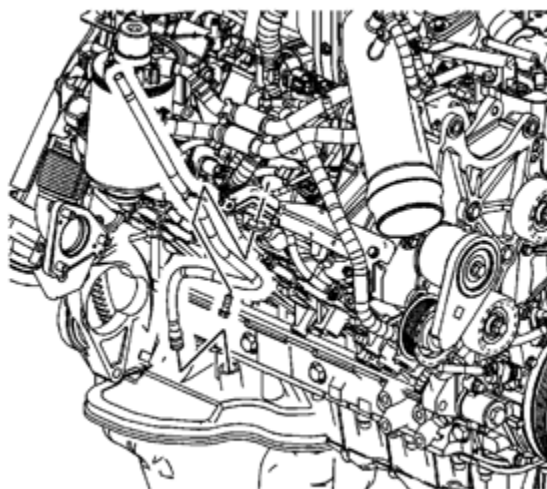
9. Install NEW engine oil and a oil filter. Refer to [Engine Oil and Oil Filter Replacement](#).
10. Lower the vehicle.

Upper Oil Pan Replacement

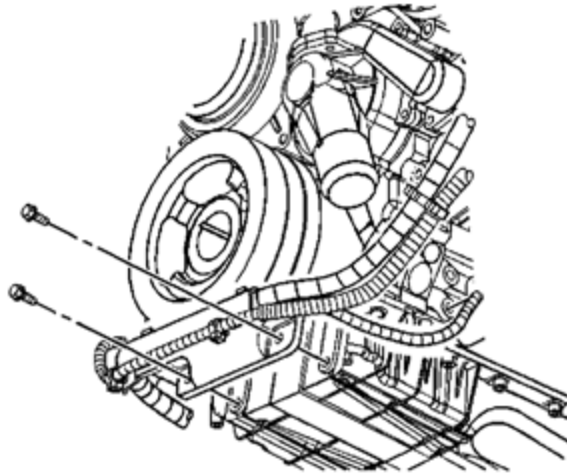
Special Tools

[J 37228](#) Seal Cutter

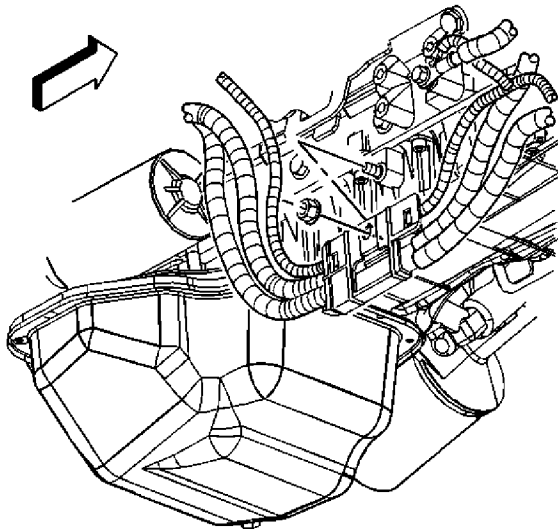
Removal Procedure



1. Remove the oil level indicator.
2. Remove the oil level indicator tube bolt from the indicator tube bracket.
3. If vehicle is a 4-wheel drive (4WD), remove the front differential carrier. Refer to [Differential Carrier Assembly Replacement](#).
4. If vehicle is a 2-wheel drive (2WD), disconnect the relay rod from the pitman arm and idler arm. Refer to [Relay Rod Replacement](#).
5. Remove the lower oil pan. Refer to [Lower Oil Pan Replacement](#).
6. Remove the engine flywheel. Refer to [Engine Flywheel Replacement](#).

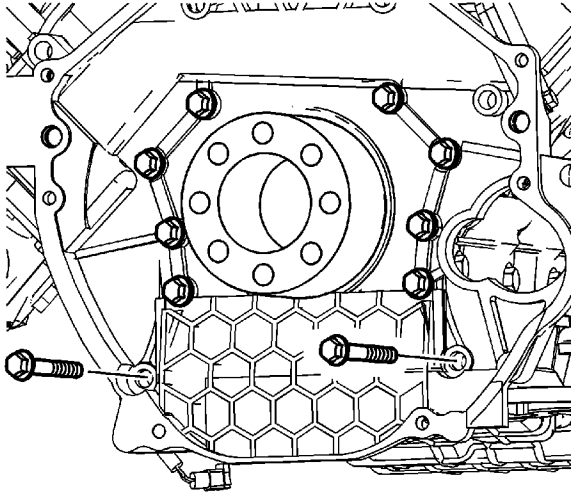


7. Remove the battery cable bracket bolts.

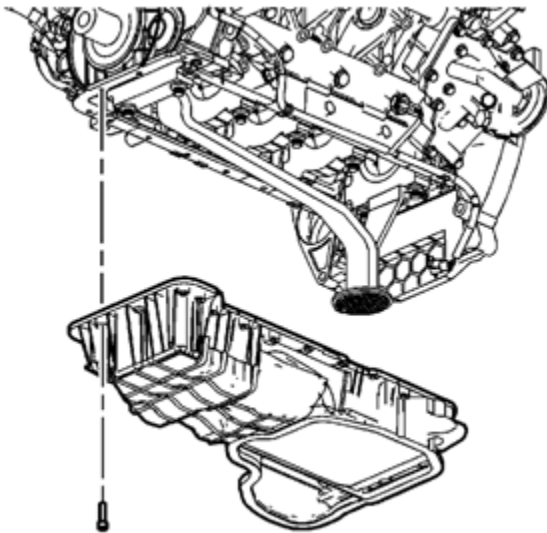


8. Remove the battery cable bracket nut.

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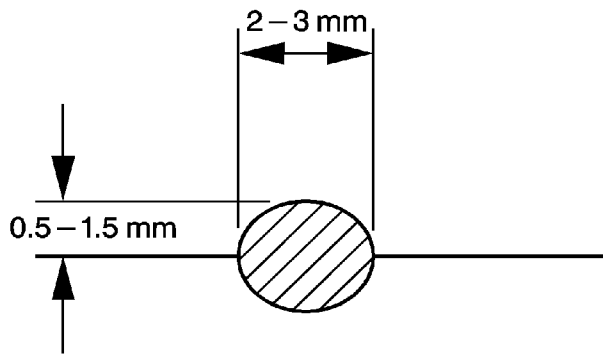


9. Remove the two flywheel housing to upper oil pan bolts.

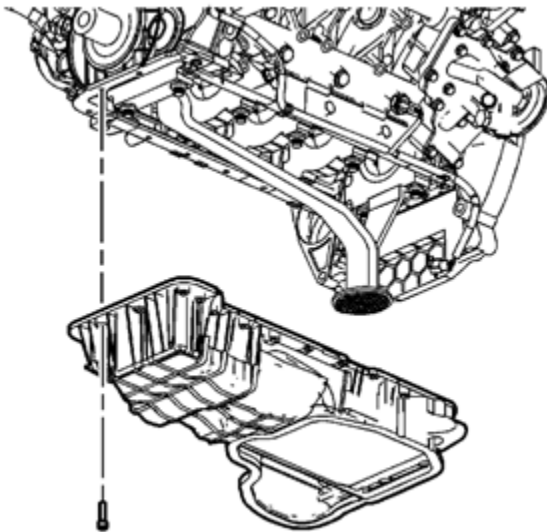


10. Remove the upper oil pan bolts and any brackets. Mark the bolt location of the bracket.
11. Separate the upper oil pan from the engine block using [J 37228](#) .
12. Remove the upper oil pan. The oil level indicator tube needs to be removed while lowering the upper oil pan.
13. If required, clean and inspect the upper oil pan. Refer to [Upper Oil Pan Cleaning and Inspection](#) .

Installation Procedure

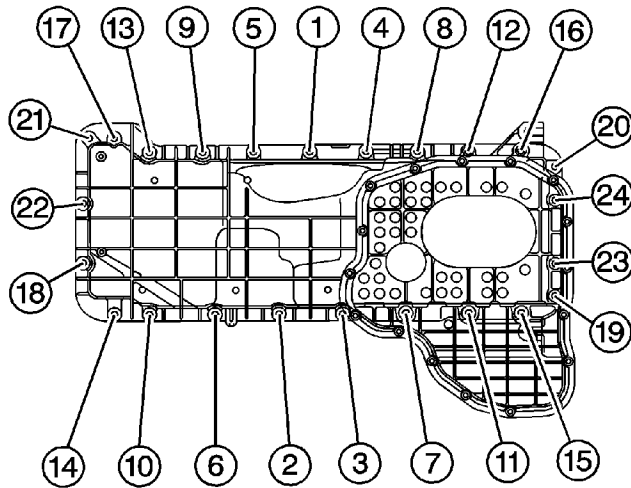


1. Apply a 2-3 mm (0.79-0.118 in) wide by 0.5-1.5 mm (0.02-0.06 in) bead of sealant to the upper oil pan mating surfaces. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.
2. Apply a 2-3 mm (0.79-0.118 in) wide by 0.5-1.5 mm (0.02-0.06 in) bead of sealant to the flywheel housing sealing surface. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.



3. Install the upper oil pan to the engine block. Ensure the oil level indicator tube is installed into the upper oil pan.

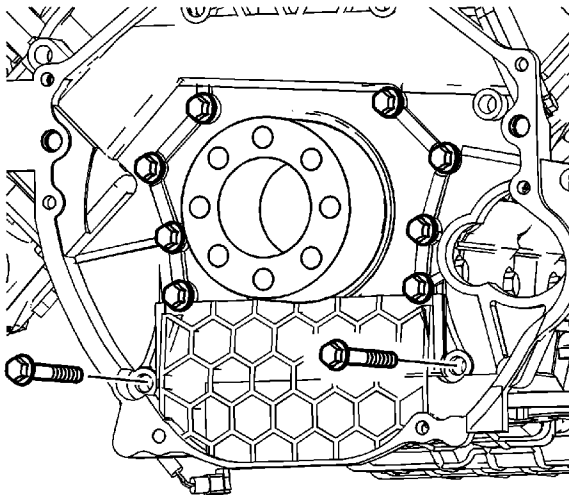
Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Install any brackets and the upper oil pan bolts in the sequence shown.

Tighten

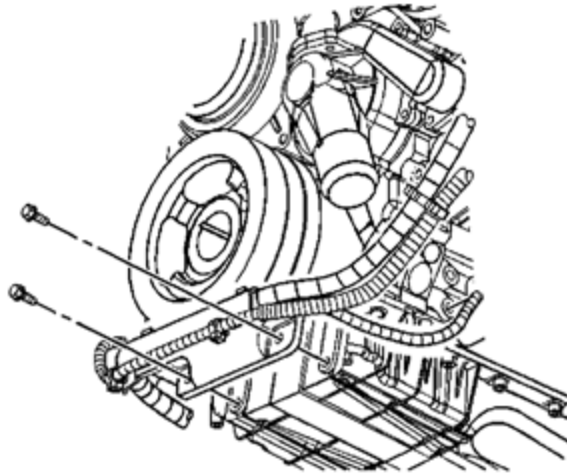
Tighten the bolts to 20 N·m (15 lb ft).



5. Install the two flywheel housing to upper oil pan bolts.

Tighten

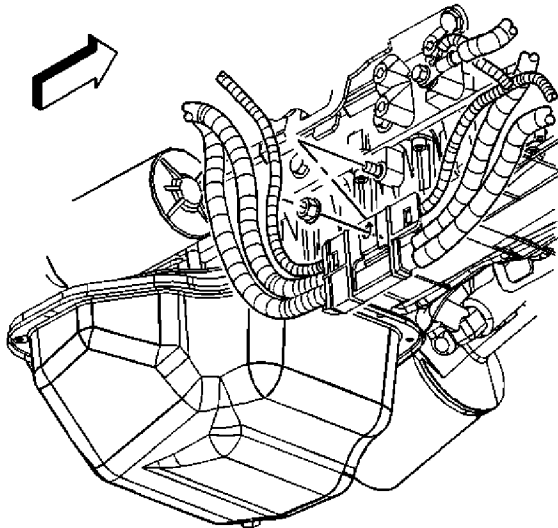
Tighten the bolts to 50 N·m (37 lb ft).



6. Install the battery cable bracket bolts.

Tighten

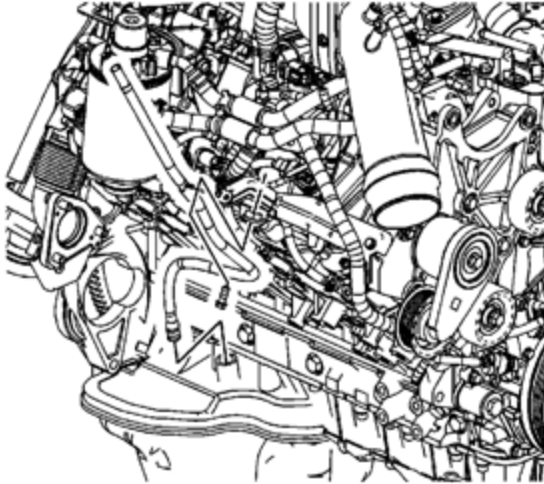
Tighten the bolts to 12 N·m (106 lb in).



7. Install the battery cable bracket nut.

Tighten

Tighten the nut to 8 N·m (71 lb in).



8. Install the engine flywheel. Refer to [Engine Flywheel Replacement](#).
9. Install the lower oil pan. Refer to [Lower Oil Pan Replacement](#).
10. If vehicle is a 4WD, install the front differential carrier. Refer to [Differential Carrier Assembly Replacement](#).
11. If vehicle is a 2WD, Connect the relay rod to the pitman arm and idler arm. Refer to [Relay Rod Replacement](#).
12. Lower the vehicle.
13. Install the oil level indicator tube bolt to the indicator tube bracket.

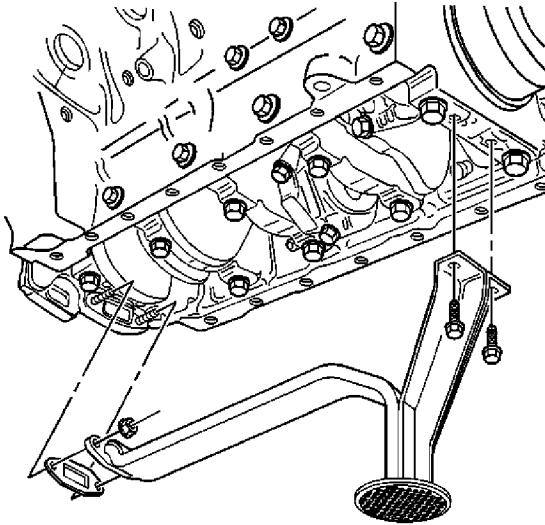
Tighten

Tighten the bolt to 21 N·m (15 lb ft).

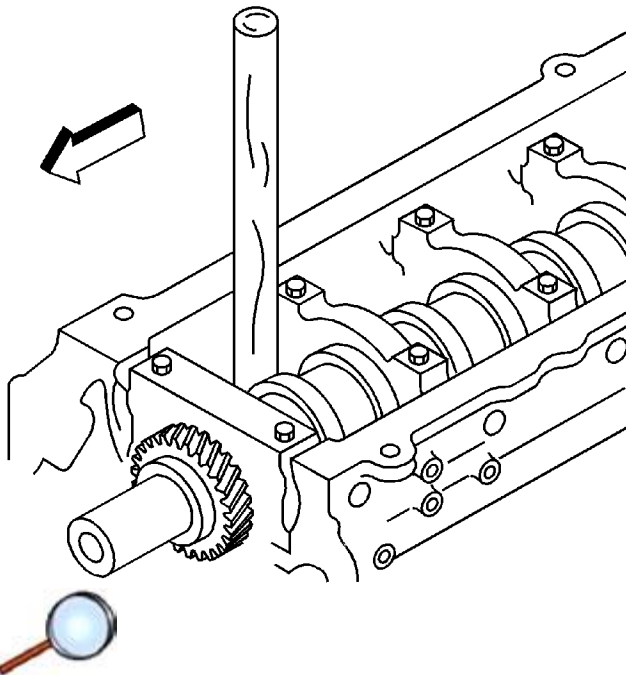
14. Install the oil level indicator.
15. Fill the engine with oil. Refer to [Engine Oil and Oil Filter Replacement](#).

Oil Pump Replacement

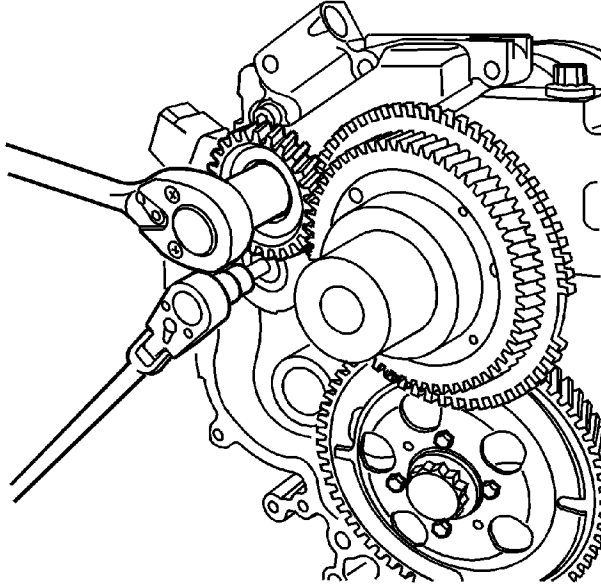
Removal Procedure



1. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
2. Remove the upper oil pan. Refer to [Upper Oil Pan Replacement](#).
3. Remove the oil pump screen bolts and nuts.
4. Remove the oil pump screen.
5. Remove and discard the oil pump screen gasket.

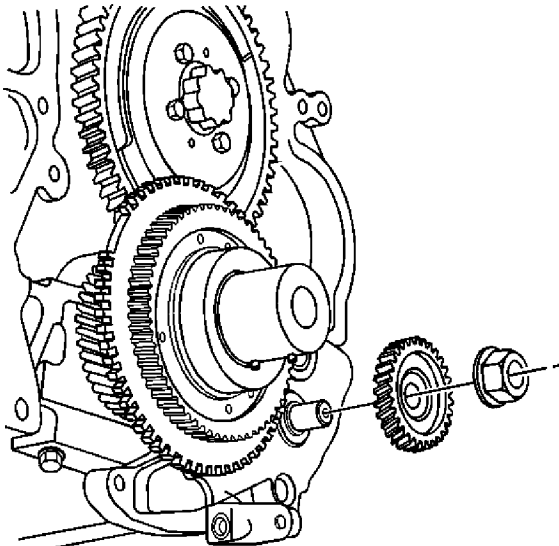


6. Block the crankshaft from turning with a wooden handle.

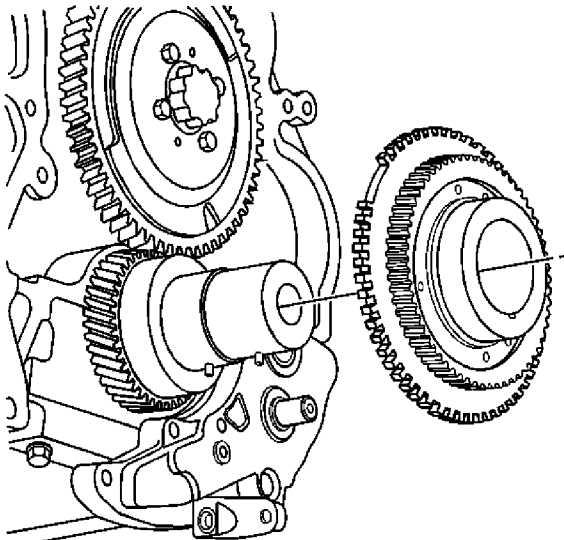


Note: Look for an "L" on the end of the oil pump shaft. If there is an "L" present, the nut and shaft have left hand threads. Service the nut accordingly.

7. While holding the secondary oil pump shaft with a hex driver, remove the oil pump driven gear nut.

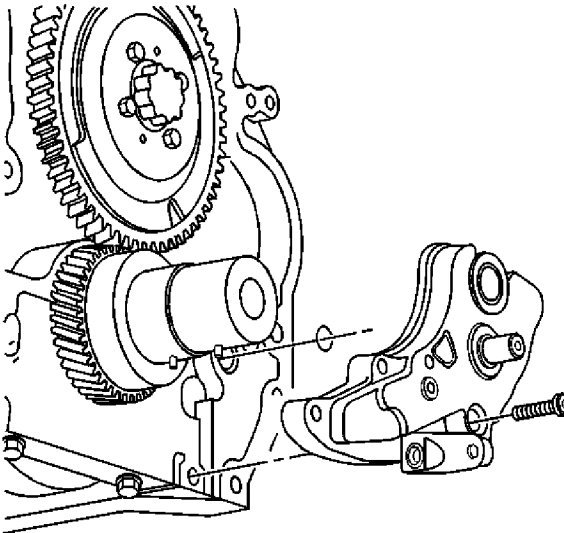


8. Remove the oil pump driven gear.



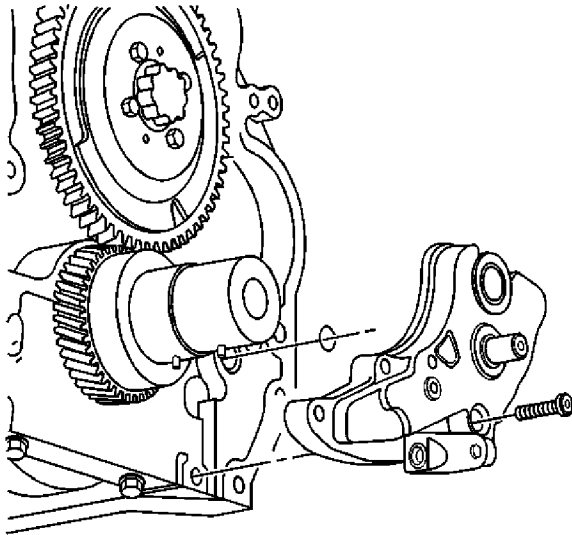
Note: Do not damage the crankshaft reluctor. Do not remove the crankshaft reluctor to oil pump drive bolts.

9. Remove the oil pump drive gear and crankshaft reluctor.
 - Use a brass drift.
 - Tap on the back as close to the center of the reluctor.



10. Remove the hex head and the allen head bolt in order to remove the oil pump.
11. Remove the oil pump.
12. Remove the O-ring seal for the oil pump.
13. If required, clean and inspect the oil pump. Refer to [Oil Pump Cleaning and Inspection](#).

Installation Procedure



1. Install a NEW oil pump O-ring seal.

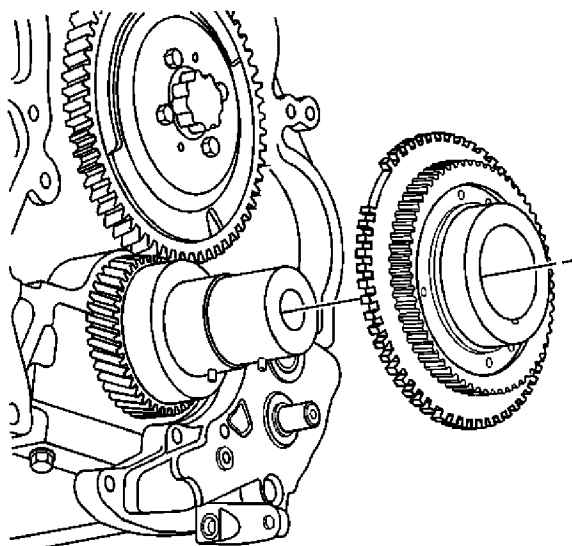
Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the oil pump.
3. Install the oil pump bolts.

Tighten

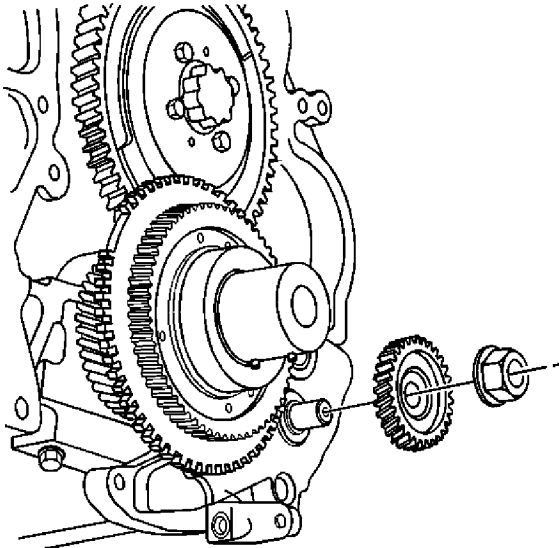
Tighten the bolts to 21 N·m (15 lb ft).

4. Inspect the oil pump drive gear for wear.
5. Replace the oil pump drive gear pin if worn.

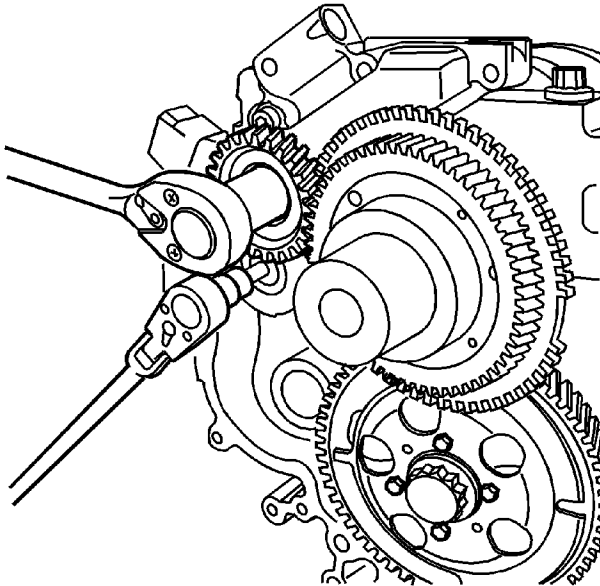




6. Install the oil pump drive gear and reluctor to the crankshaft.



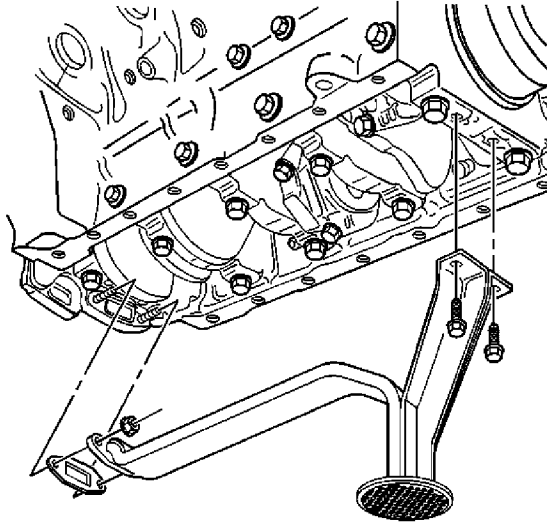
7. Install the oil pump driven gear.



8. While holding the secondary oil pump shaft with a hex driver, install the oil pump driven gear nut.

Tighten

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



9. Install a NEW oil pump screen gasket to the oil pump.
10. Install the oil pump screen.
11. Install the oil pump screen bolts and nuts.

Tighten

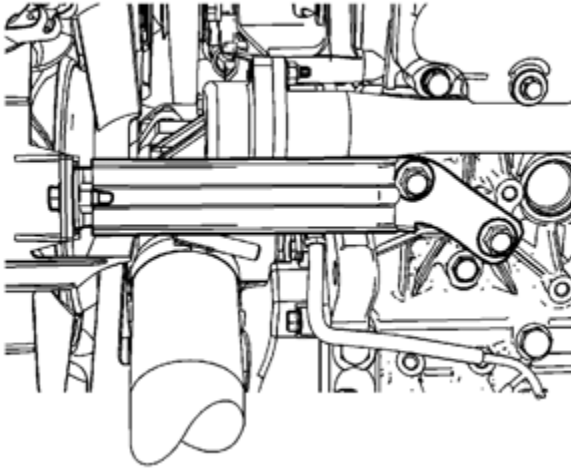
Tighten the bolts/nuts to 25 N·m (18 lb ft).

12. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).
13. Install the upper oil pan. Refer to [Upper Oil Pan Replacement](#).

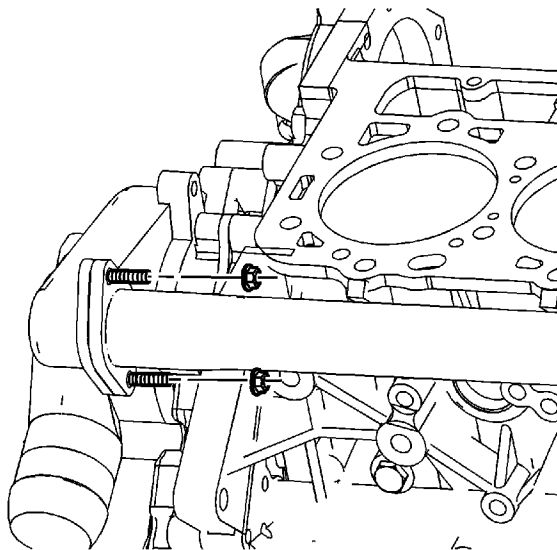
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Oil Filter Adapter and Oil Cooler Assembly Replacement

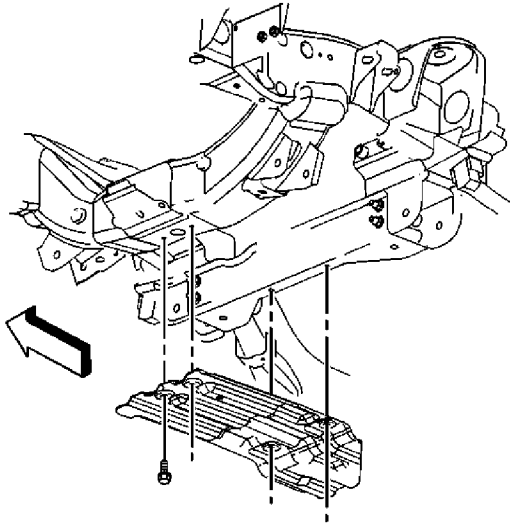
Removal Procedure



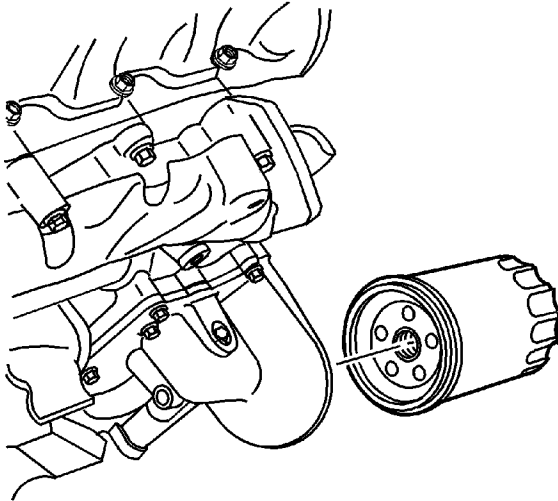
1. Drain the engine coolant and the engine block. Refer to [Cooling System Draining and Filling](#).
2. Remove the charge air inlet pipe. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).
3. Remove the cooling fan shroud bracket bolts (1).
4. Remove the cooling fan shroud bracket (2).



5. Loosen the water pump outlet pipe nuts at the coolant pipe.

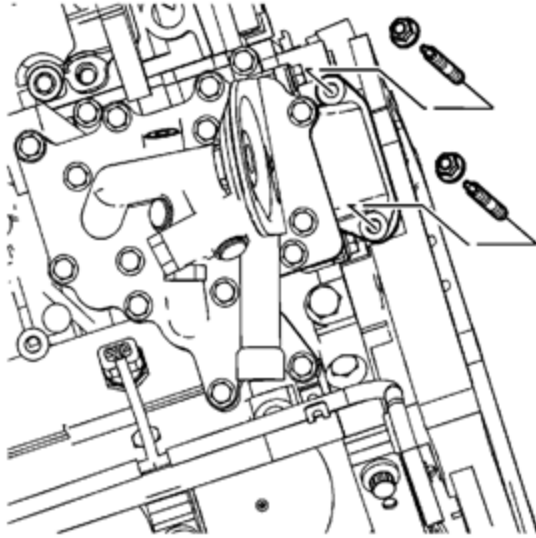


6. If equipped, remove the oil pan skid plate bolts and plate.

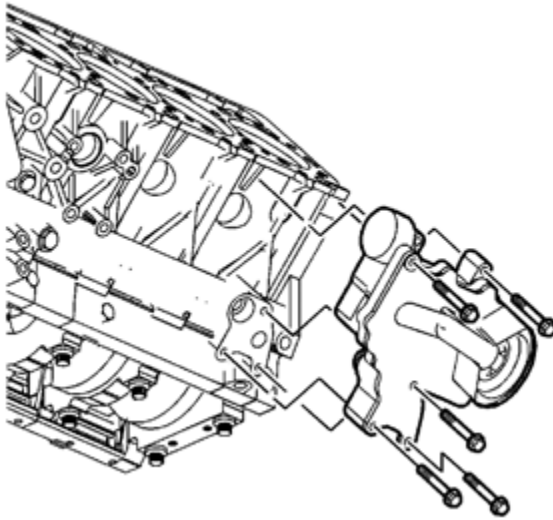


7. Remove the oil filter.

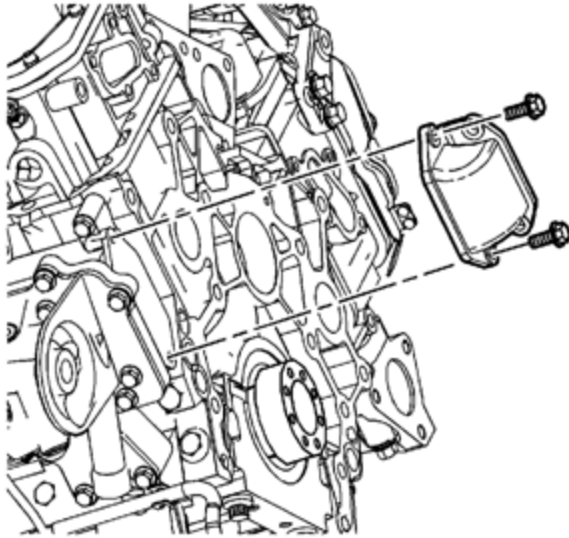
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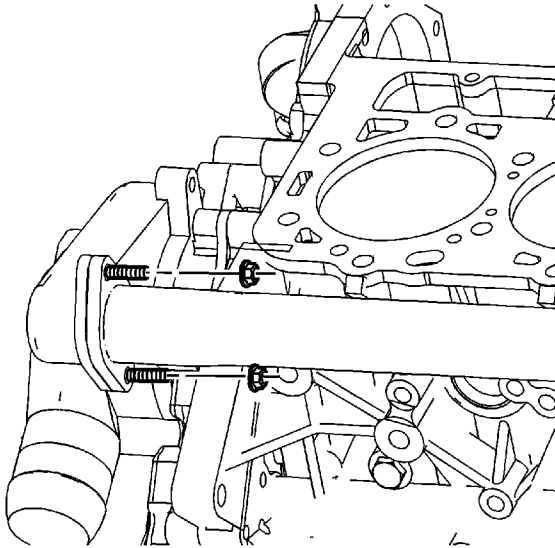
8. Remove the oil cooler adapter nuts and studs from the flywheel housing.



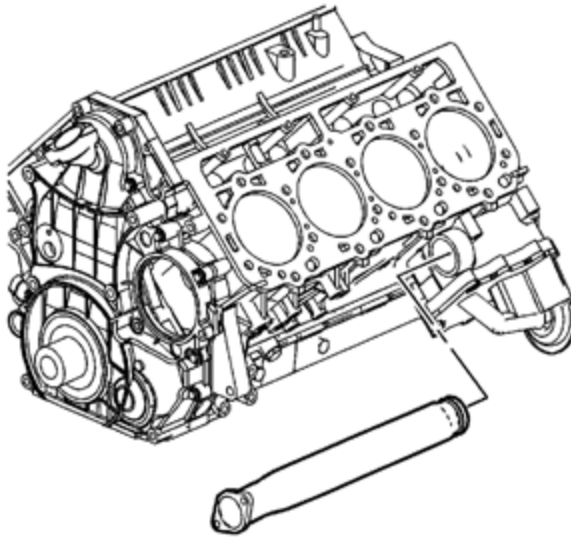
9. Remove the oil cooler assembly bolts.



10. Remove the oil cooler adapter bolts from the oil filter adapter/oil cooler.
11. Remove the oil cooler and adapter.

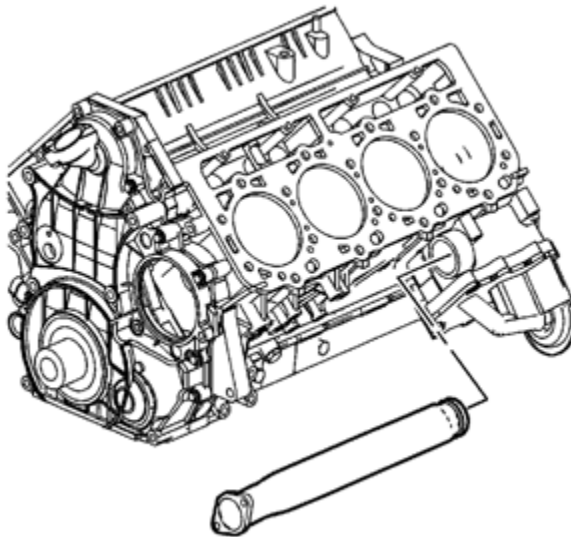


12. Remove the coolant pipe nuts.



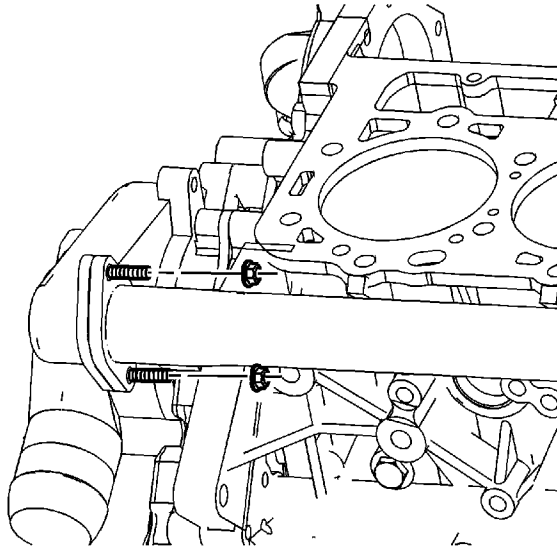
13. Remove the coolant pipe.
14. Remove and discard the oil filter adapter/oil cooler O-ring seals.
15. Remove and discard the coolant pipe O-ring and gasket.
16. If required, clean and inspect the oil filter adapter/oil cooler. Refer to [Oil Filter Adapter and Oil Cooler Assembly Cleaning and Inspection](#).

Installation Procedure



1. Install new coolant pipe O-ring and gasket.
2. Install new oil filter adapter/oil cooler O-ring seals.
3. Install the coolant pipe.

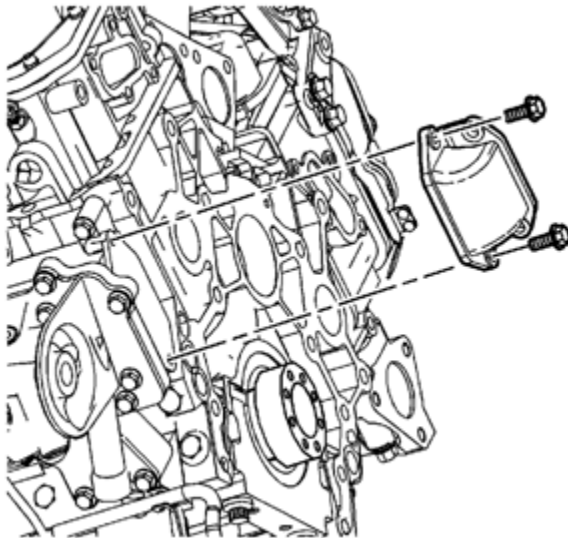
Caution: Refer to [Fastener Caution](#) in the Preface section.



4. Install the coolant pipe nuts.

Tighten

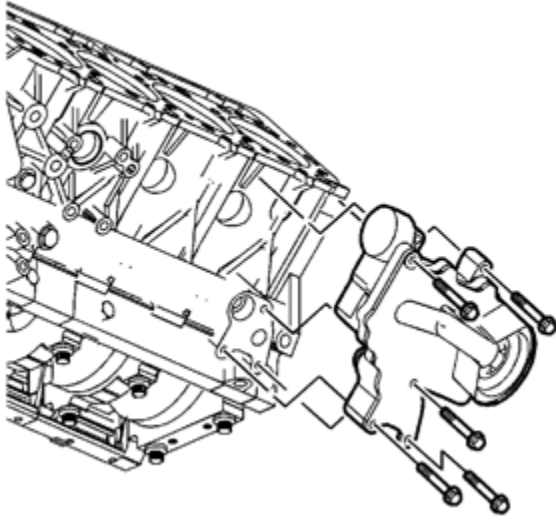
Tighten the coolant pipe nuts to 25 N·m (18 lb ft).



5. Install the oil cooler and adapter.
6. Install the oil cooler adapter bolts to the oil filter adapter/oil cooler.

Tighten

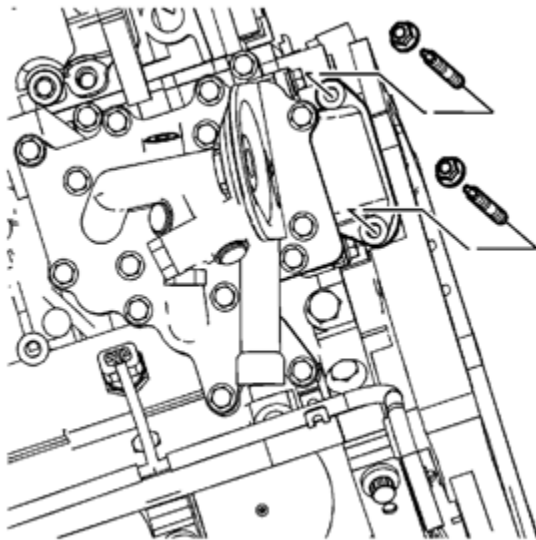
Tighten the oil cooler adapter bolts to 25 N·m (18 lb ft).



7. Install the oil cooler assembly bolts.

Tighten

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

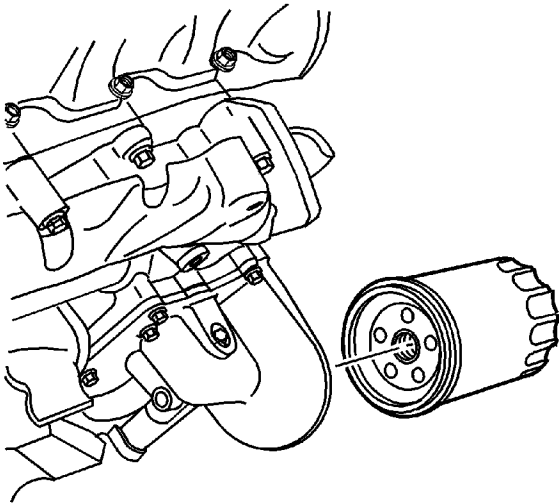


8. Install the oil cooler adapter nuts and studs to the flywheel housing.

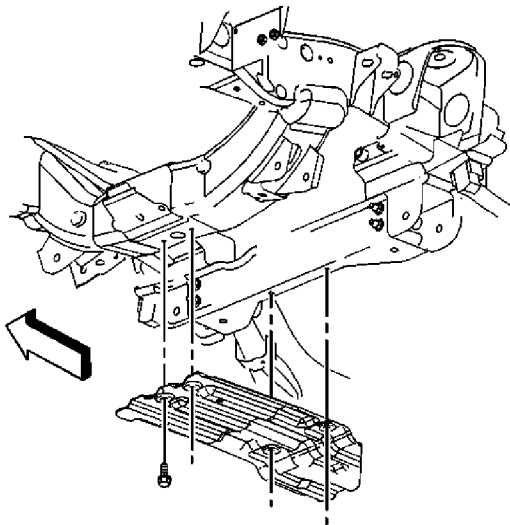
Tighten

- Tighten the oil cooler adapter nuts to 25 N·m (18 lb ft).

- Tighten the oil cooler adapter studs to 10 N·m (89 lb in).



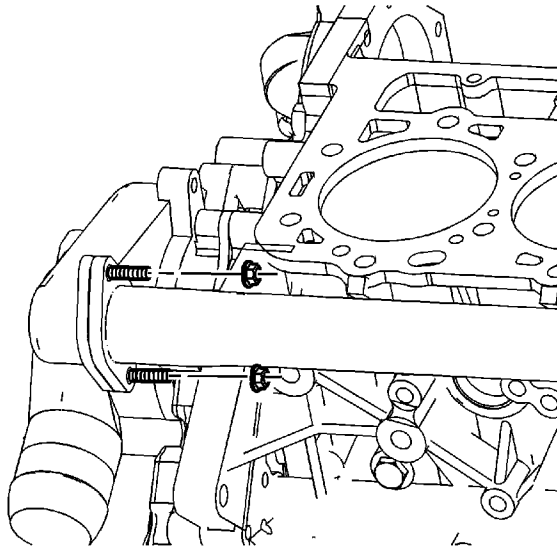
9. Install the oil filter.



10. If removed, install the oil pan skid plate bolts and plate.

Tighten

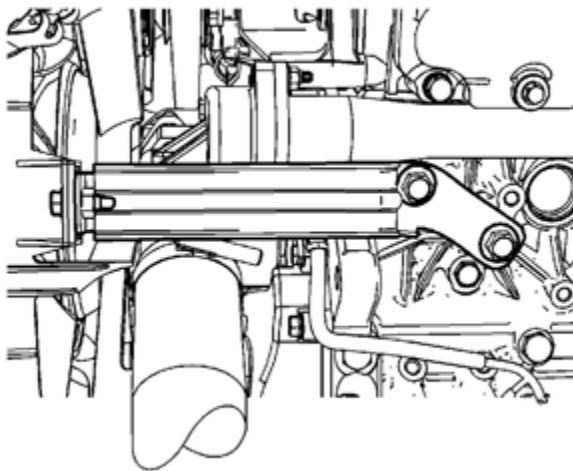
Tighten the bolts to 20 N·m (15 lb ft).



11. Install the water pump outlet pipe nuts at the coolant pipe.

Tighten

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



12. Position the cooling fan shroud bracket (2).
13. Install the cooling fan shroud bracket bolts (1).

Tighten

Tighten the fan shroud bolt to 8 N·m (71 lb in).

Tighten

Tighten the fan shroud bracket to engine block bolts to 58N·m (63 lb ft).

14. Install the charge air inlet pipe. Refer to [Charge Air Cooler Inlet Pipe Replacement](#).
15. Fill the cooling system. Refer to [Cooling System Draining and Filling](#).

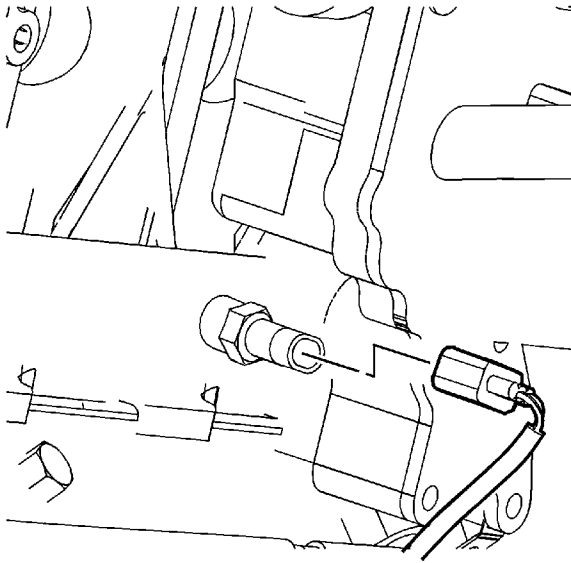
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Engine Oil Pressure Sensor and/or Switch Replacement

Special Tools

[DT-48827](#) Skip Shift Socket

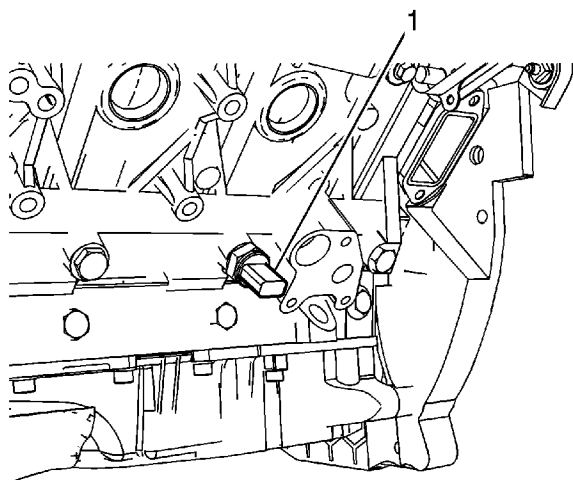
Removal Procedure



1. Remove the left wheelhouse inner panel. Refer to [Front Wheelhouse Liner Replacement - Left Side](#).

Note: Clean the area around the sensor. Do not allow debris to enter the engine.

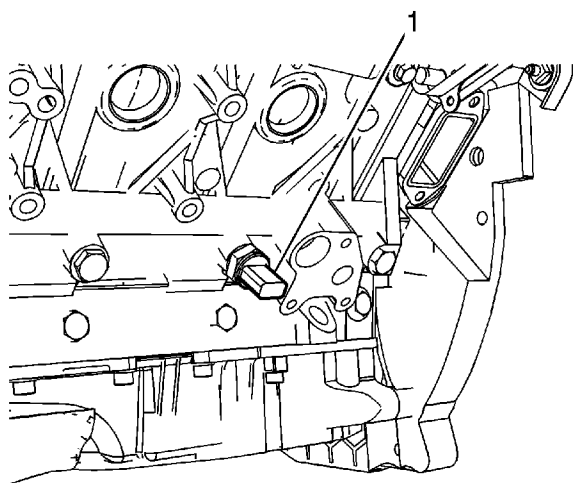
2. Disconnect the oil pressure sensor electrical connector.



3. Using [DT-48827](#) , remove the oil pressure sensor (1).

Installation Procedure

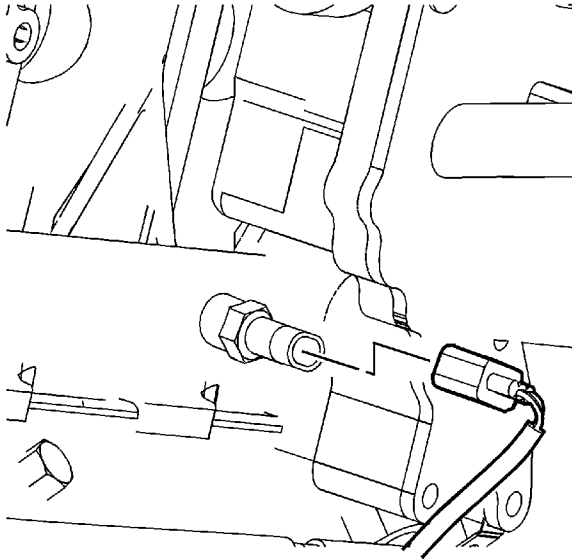
Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Apply sealant to the threads of the oil pressure sensor. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the correct part number.
2. Using [DT-48827](#) , install the oil pressure sensor (1).

Tighten

Tighten the sensor to 49 N·m (36 lb ft).

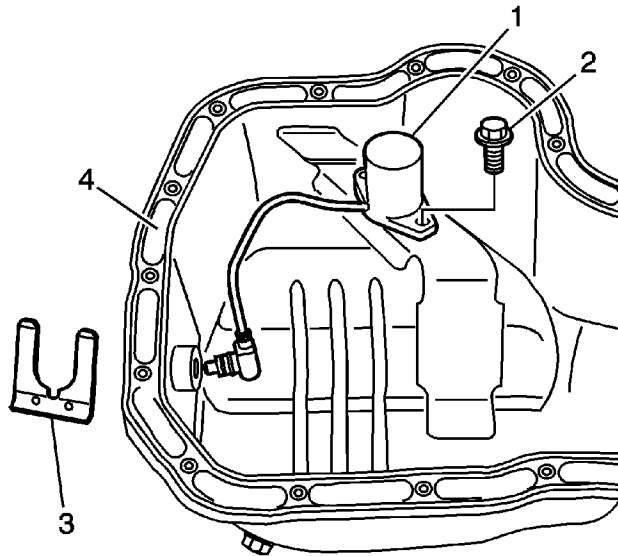


3. Connect the oil pressure sensor electrical connector.
4. Install the left wheelhouse inner panel. Refer to [Front Wheelhouse Liner Replacement - Left Side](#).
5. Check and add engine oil if necessary.

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Engine Oil Level Sensor and/or Switch Replacement

Removal Procedure

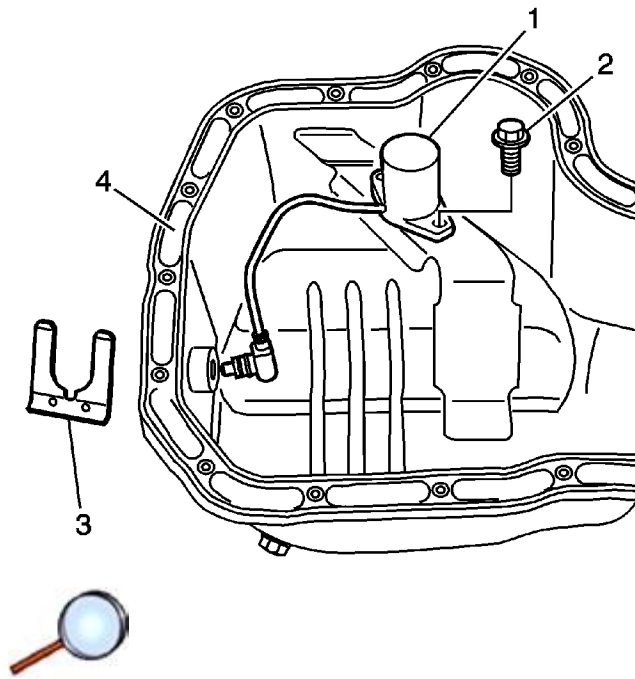


1. Remove the lower oil pan. Refer to [Lower Oil Pan Replacement](#).
2. Remove the oil level sensor clip (3).
3. Remove the oil level sensor bolt (2) and sensor (1).

Installation Procedure

Note: When routing the oil level sensor wire, ensure that the wire is routed along the side of the oil pan.

Caution: Refer to [Fastener Caution](#) in the Preface section.



1. Install the oil level sensor (1) and bolt (2) and tighten to **9 N·m (80 lb in)**.
2. Install the oil level sensor clip (3).
3. Install the lower oil pan. Refer to [Lower Oil Pan Replacement](#).

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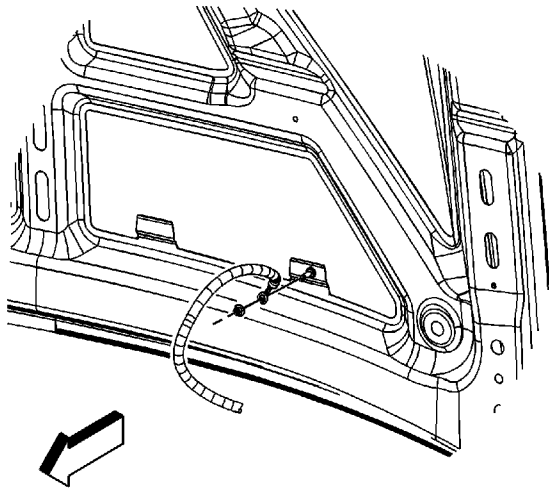
Engine Replacement

Special Tools

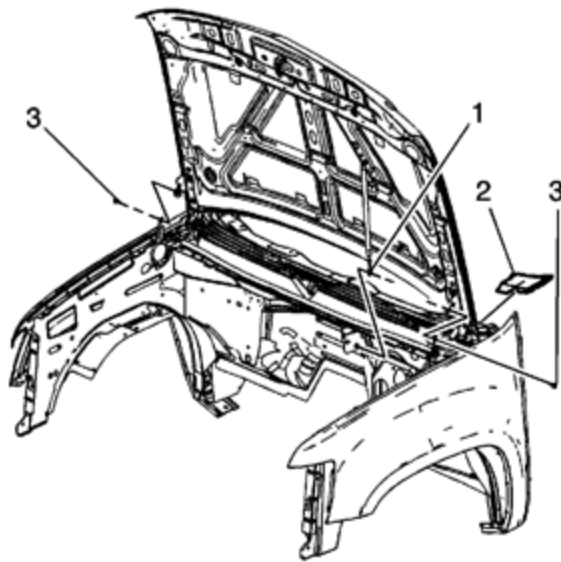
- [J 36857](#) Engine Lift Brackets
- [J 41769](#) Fuel Line Quick Disconnect Tool
- [J 44581](#) Fuel Line Disconnect Tool

Removal Procedure

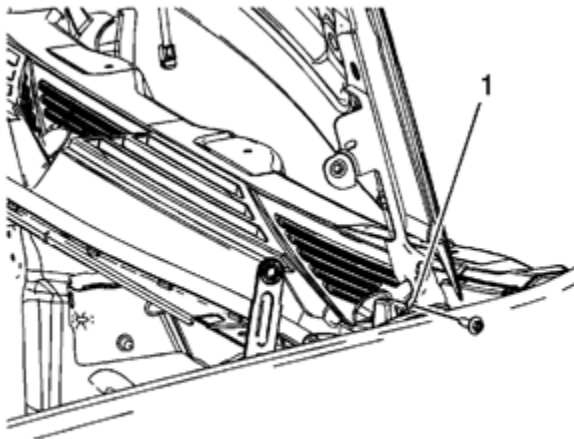
Note: In order to remove the engine the vehicle needs to be on a hoist. The front wheels and tires will also require removal. The vehicle will have to be supported by the frame when the tires are removed.



1. Open the hood.
2. Remove the ground strap from the stud.



3. Assemble 2 sets of the following: an M6 bolt, 2 each 19.05 mm (0.75 in) flat washers and an M6 nut.
4. Release the retainer securing the hood strut rod to the hood strut bracket stud.
5. Remove the air inlet grille end caps (1), lift the end cap up in order to disengage the retainers. (left side shown, right side similar).
6. Have an assistant support the hood.
7. Remove the hood hinge bolts (2) and set aside.



Note: There is a positive stop which limits the hood from being opened too far.

8. Raise the hood until the service position notch (1) in the upper hinge is reached.
9. Install the 2 sets of the M6 bolts to both the left and right side service notches and tighten finger tight.

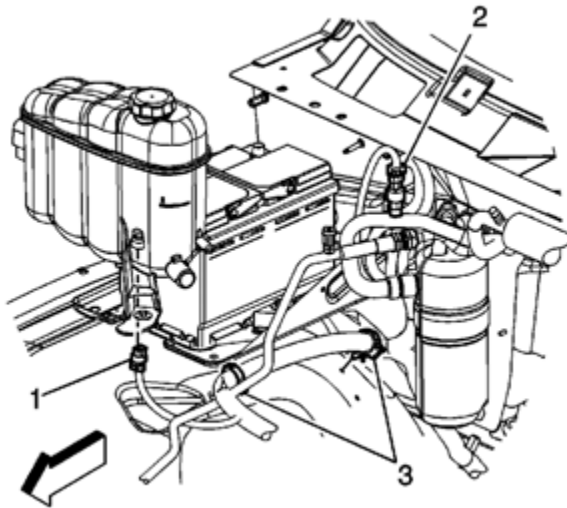
Caution: Refer to [Fastener Caution](#) in the Preface section.

10. Lower the hood until the bolts rest against the lower hinge, tighten the bolts to secure the hood.

Tighten

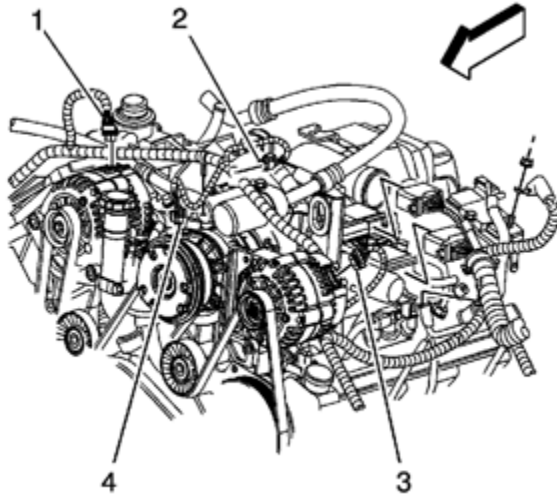
Tighten the bolts to 20 N·m (15 lb ft).

11. The hood is now set in the service position.
12. Recover the air conditioning (A/C) system. Refer to [Refrigerant Recovery and Recharging](#).
13. Disconnect the negative battery cables. Refer to [Battery Negative Cable Disconnection and Connection](#).
14. Drain the cooling system. Refer to [Cooling System Draining and Filling](#).

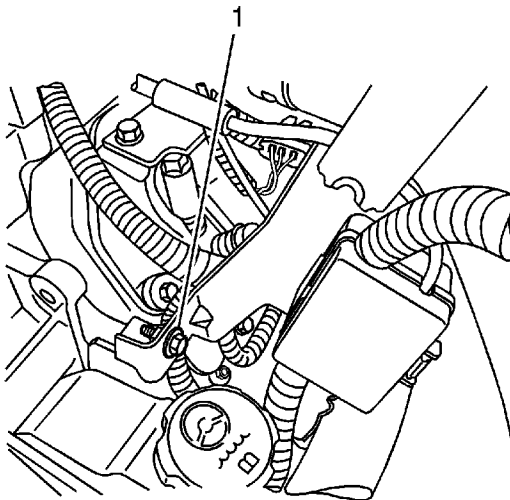


15. Disconnect the following engine wire harness connectors:
 - Surge tank switch (1)
 - A/C pressure cycling switch (2)
 - Remove the engine wire harness clips from the wheelhouse inner panel (3).
16. Remove the air cleaner. Refer to [Air Cleaner Assembly Replacement](#).
17. Remove the surge tank. Refer to [Radiator Surge Tank Replacement](#).
18. Raise and suitably support the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
19. Remove both front tires and wheels. Refer to [Tire and Wheel Removal and Installation](#).
20. Remove both fender wheelhouse inner panels. Refer to [Front Wheelhouse Liner Replacement - Right Side](#) and [Front Wheelhouse Liner Replacement - Left Side](#).
21. Lower the vehicle.
22. Remove the charged air cooler pipes. Refer to [Charge Air Cooler Inlet Pipe Replacement](#) and [Charge Air Cooler Outlet Pipe Replacement](#).
23. Remove the radiator inlet hose. Refer to [Radiator Inlet Hose Replacement](#).
24. Remove the upper fan shroud. Refer to [Engine Coolant Fan Upper Shroud Replacement](#).
25. Remove the lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#).
26. Remove the radiator outlet hose. Refer to [Radiator Outlet Hose Replacement](#).
27. Remove the outlet heater hose pipe bolt from the bracket.
28. Remove the outlet heater hose pipe nut.
29. Move the heater hose and secure aside.

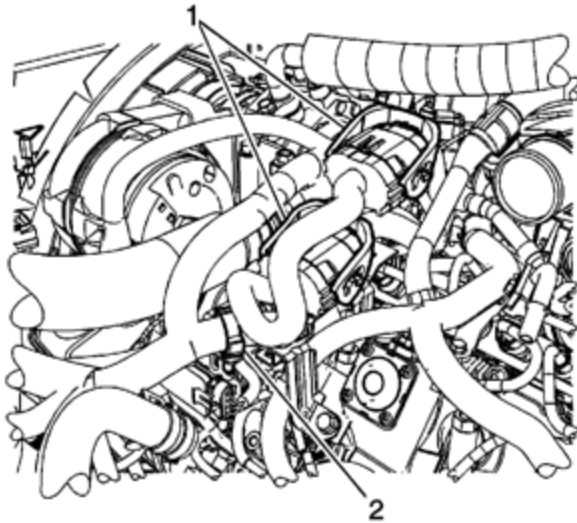
30. Remove the radiator support. Refer to [Radiator Support Replacement](#).



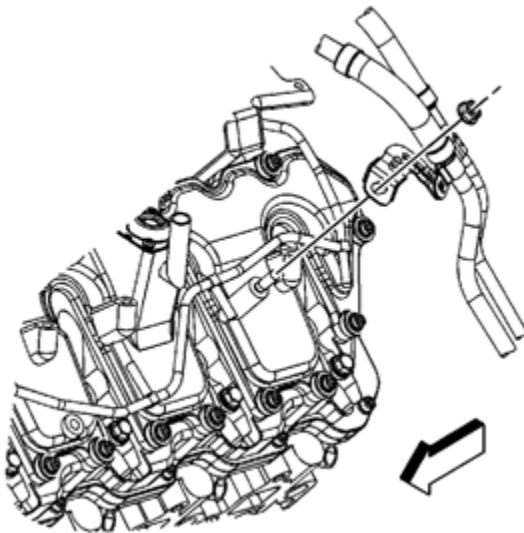
31. Disconnect the following electrical connectors:
- Generator connector (1)
 - A/C refrigerant switch (2)
 - Dual generator harness connector (3), if equipped
 - A/C compressor clutch (4)
32. Remove the harness clip from the oil fill pipe.



33. Remove the battery cable to the generator.
34. If equipped, remove the battery cable to the auxiliary generator.
35. Remove the battery cable harness clip from the upper air intake tube.
36. Remove the battery cable junction block bolt (1) from the power steering pump.
37. Move and secure the battery cables out of the way.



38. Disconnect the main engine electrical harness connectors. Lift up on the latches (1) in order to disconnect the connectors.
39. Open the harness clip (2).
40. Remove the main engine electrical harness connectors.

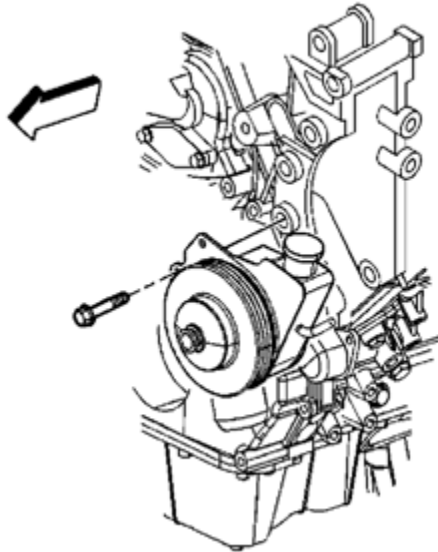


41. Using [J 41769](#) , disconnect the fuel lines at the engine.
42. Remove the nut and the fuel line bracket from the upper valve rocker arm cover stud.
43. Secure the fuel lines out of the way.
44. Remove the drive belt. Refer to [Drive Belt Replacement](#).
45. Disconnect the suction hose from the accumulator.

The compressor end can remain on the compressor.

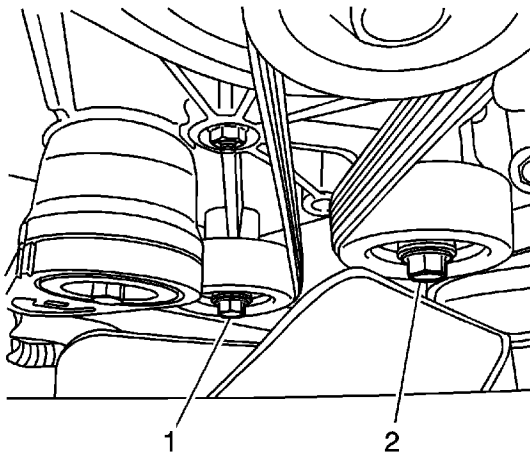
46. Remove the A/C compressor. Refer to [Air Conditioning Compressor Replacement](#).

47. Move the wiring harness to the left side of the vehicle and secure out of the way.

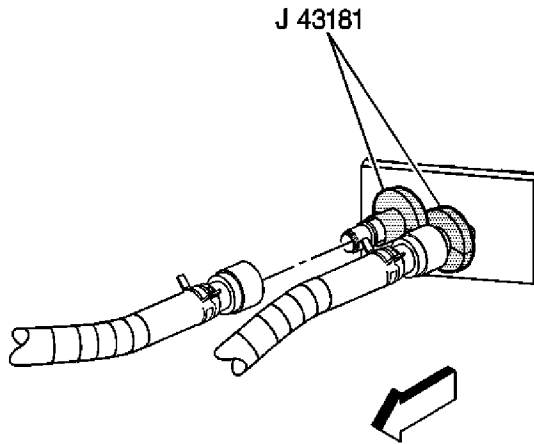


48. Remove the bolts retaining the power steering pump front bracket to the power steering pump and the air conditioner compressor mounting bracket. Position the power steering pump aside.
49. Remove the air conditioning and power steering pump mounting bracket. Refer to [Air Conditioning \(A/C\) Compressor and Power Steering Pump Bracket Replacement](#).

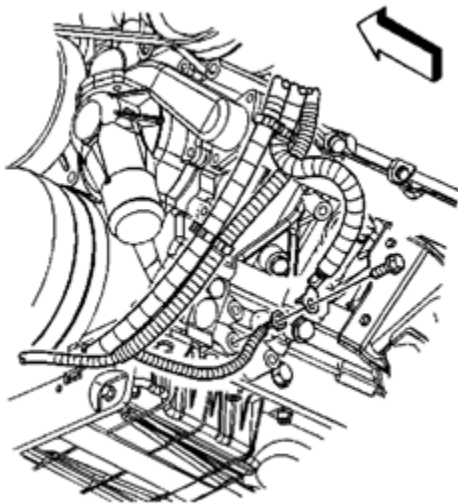
When the battery cables are removed from the engine the power steering pump can be removed further out of the way.



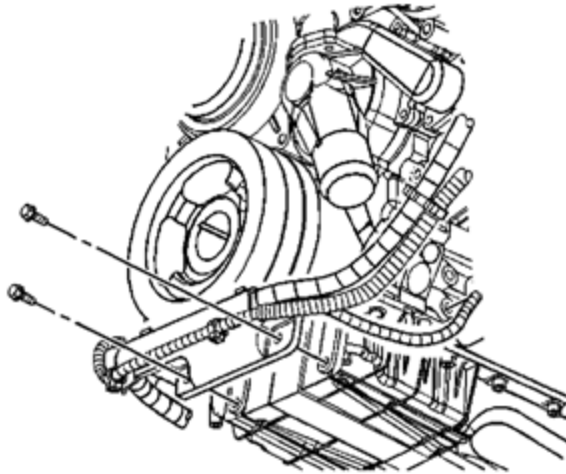
50. Remove the right idler pulley bolt (1) and pulley.
51. Remove the generator bracket. Refer to [Generator Bracket Replacement](#).



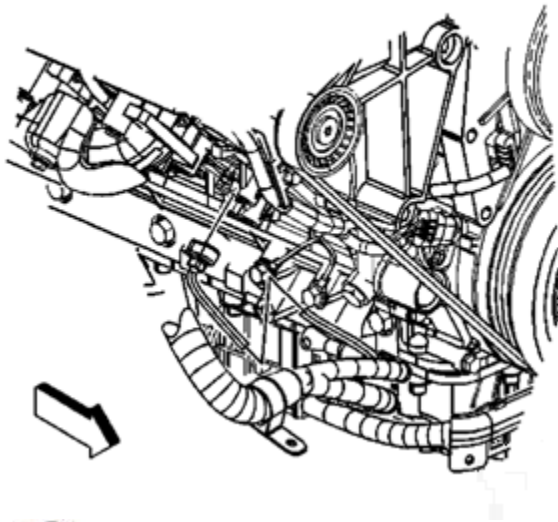
52. Use the [J 43181](#) in order to disconnect the inlet heater hose from the heater core inlet.
53. Remove the bolt and the ground wires at the rear of the left cylinder head.
54. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
55. Remove the oil pan skid plate. Refer to [Oil Pan Skid Plate Replacement](#).
56. Remove the engine shield from the vehicle, if equipped. Refer to [Engine Shield Replacement](#).



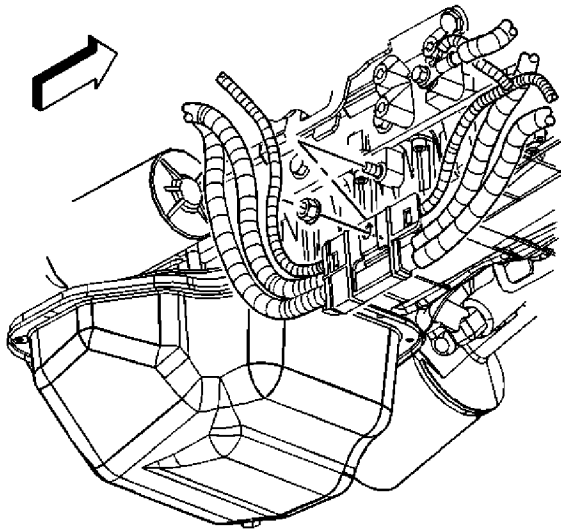
57. Remove the bolt for the battery negative cable and the engine wiring harness ground wire from the left side of the engine.



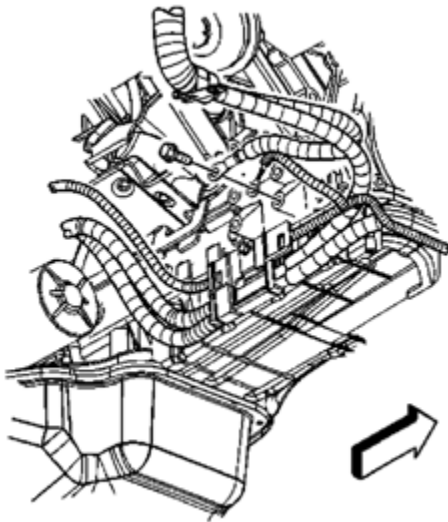
58. Remove the bolts holding the battery cable channel retainer to the lower crankcase.



59. Disconnect the cord for the engine coolant heater.
60. Remove the starter. Refer to [Starter Replacement](#).

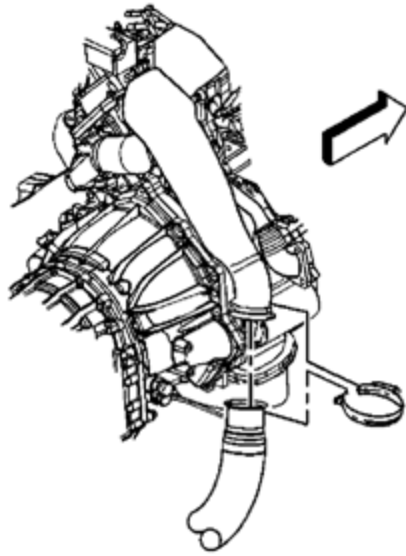


61. Remove the nut holding the battery cable bracket to the right side of the lower crankcase.

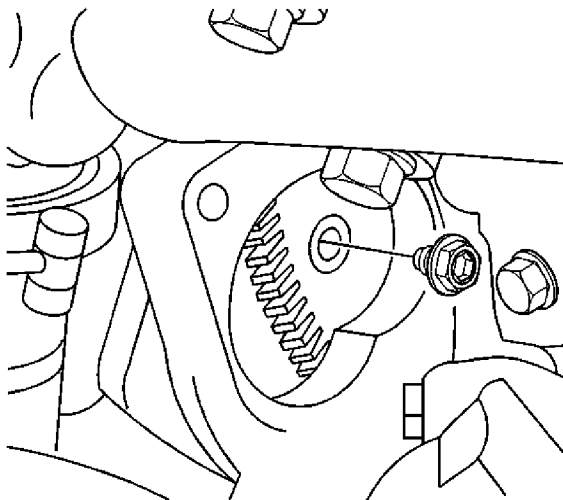


62. Remove the bolt holding the auxiliary battery negative cable and the engine wiring harness ground wires to the right side of the engine.

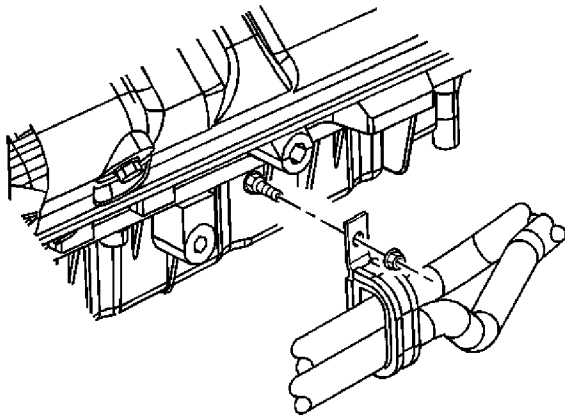
63. Move and secure the battery cables out of the way.



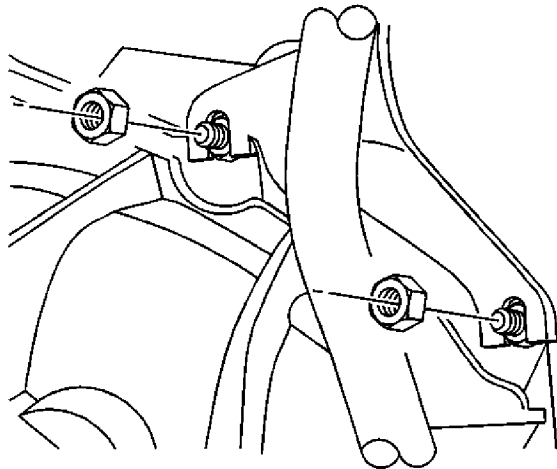
64. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#).
65. Drain the engine oil. Refer to [Engine Oil and Oil Filter Replacement](#).
66. Remove the exhaust pipe to the exhaust outlet clamp. Move the clamp onto the exhaust pipe.
67. If vehicle is 4-wheel drive (4WD) equipped, remove the front differential carrier assembly. Refer to [Differential Carrier Assembly Replacement](#).



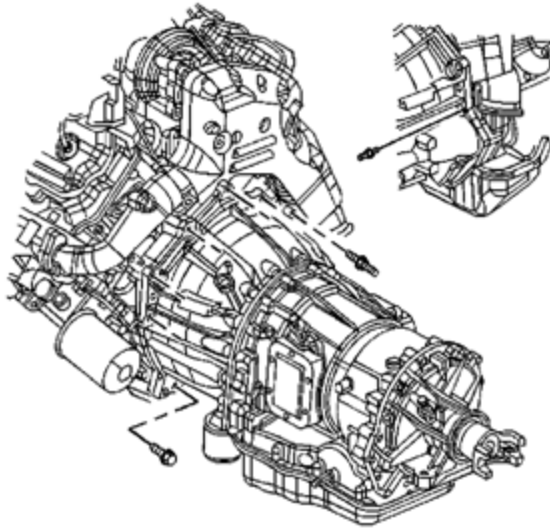
68. If equipped with an automatic transmission, mark the flywheel and torque converter relationship for assembly purposes.
69. Remove the torque converter bolts through the starter opening.



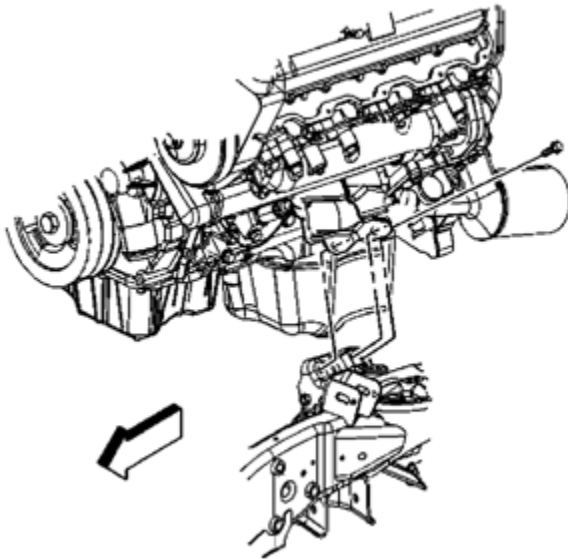
70. If equipped with an automatic transmission, remove the transmission oil line clip nut.



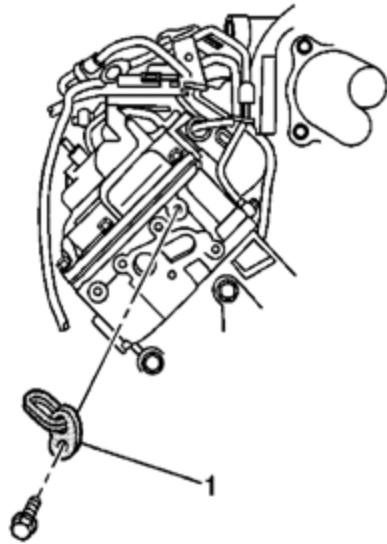
71. If equipped with an automatic transmission, remove the nuts retaining transmission fluid fill tube bracket.



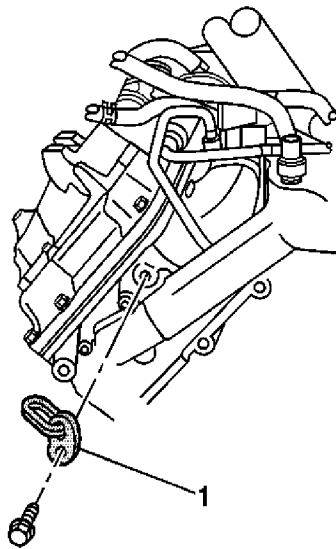
72. Remove the transmission to engine stud and bolts (automatic transmission shown). Note the location of the studs and any brackets attached to the studs.



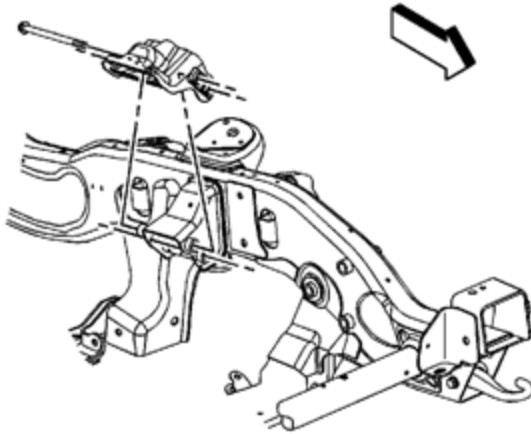
73. Lower the vehicle to work through the wheelhouse opening.
74. Remove the engine mount to frame bracket bolts (left side shown).
75. Lower the vehicle.
76. Remove the upper exhaust gas recirculation cooling pipe. Refer to [Exhaust Gas Recirculation Cooling Pipe Replacement - Upper](#).



77. Install the [J 36857](#) (1) to the rear of the left cylinder head with a suitable bolt.

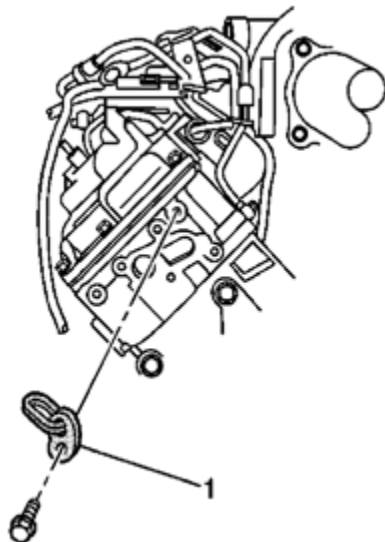


78. Install the [J 36857](#) (1) to the front of the right cylinder head with a suitable bolt.
79. Install a suitable lifting device. The engine will have to be angled in order to remove. Use a load positioning sling to assist in angling the engine.



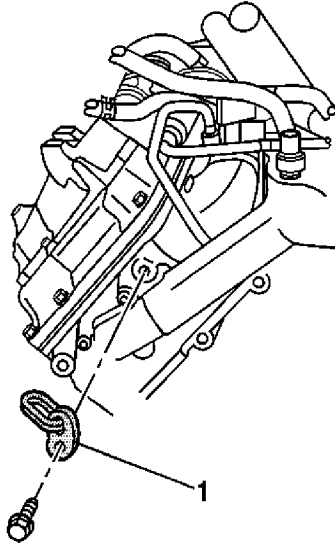
80. Raise the vehicle off of the engine mounts.
81. Remove the left and right engine mount frame brackets, if equipped.
82. Remove the engine from the vehicle.
83. In order to secure the engine to an engine stand remove the following and follow the special procedures:
 - Refer to [Engine Flywheel Removal](#).
 - Refer to [Exhaust Outlet Removal](#).
 - Refer to [Upper Oil Pan Removal](#).
 - Refer to [Engine Flywheel Housing Removal](#).
 - Refer to [Engine Mounting to Stand](#).

Installation Procedure





1. Install the [J 36857](#) (1) to the rear of the left cylinder head with a suitable bolt.

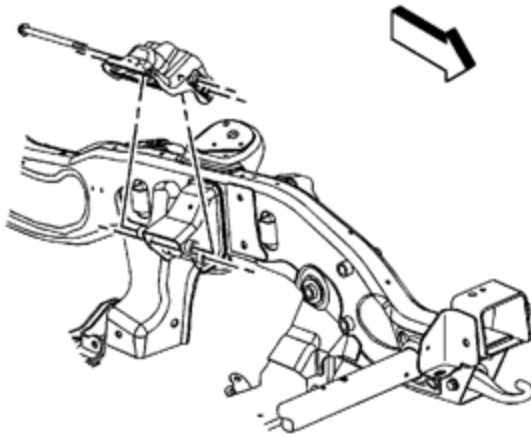


2. Install the [J 36857](#) (1) to the front of the right cylinder head with a suitable bolt.
3. Install a suitable lifting device. The engine will have to be angled in order to install. Use a load positioning sling to assist in angling the engine.
4. Remove the engine from the stand. Refer to [Engine Removal from Stand](#).
5. Install the following:
 - Refer to [Engine Flywheel Installation](#).
 - Refer to [Exhaust Outlet Installation](#).
 - Refer to [Upper Oil Pan Installation](#).
 - Refer to [Engine Flywheel Housing Installation](#).
6. Install the engine in the vehicle.

Note: Do not draw the engine to the transmission using the transmission bolts. If everything is aligned properly the engine and transmission will come together easily.

7. Loosely install 2 transmission to engine bolts.

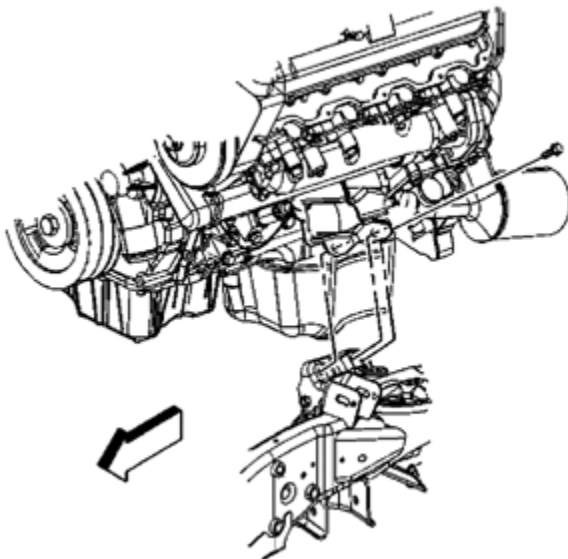
Caution: Refer to [Fastener Caution](#) in the Preface section.



8. Install the left and right side engine mount frame brackets, if equipped.

Tighten

Tighten the through-bolts to 75 N·m (55 lb ft).

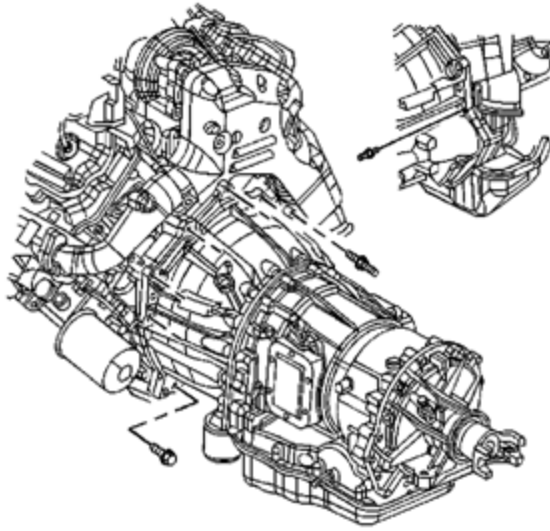


9. Install the engine mount to frame bracket bolts (left side shown).

Tighten

Tighten the bolts to 65 N·m (50 lb ft).

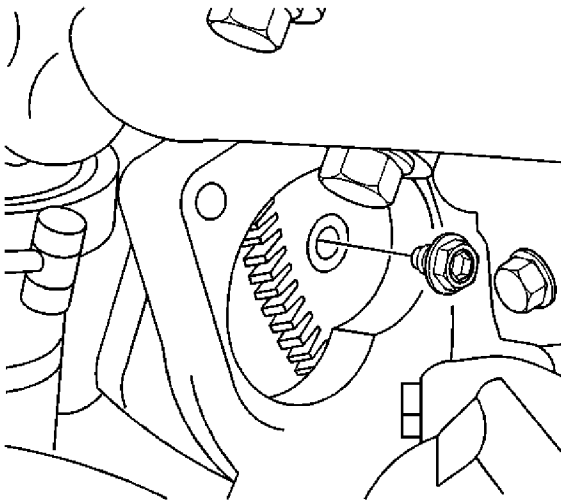
10. Remove the [J 36857](#) from the cylinder heads.
11. Raise the vehicle.



12. Install the transmission to engine bolts (automatic transmission shown).

Tighten

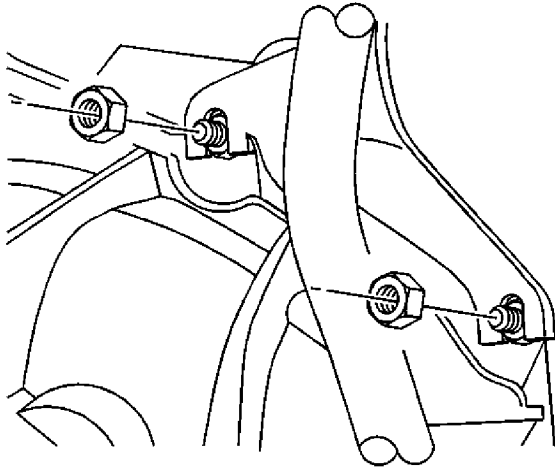
Tighten the studs and bolts to 50 N·m (37 lb ft).



13. If equipped with an automatic transmission install the torque convertor bolts.

Tighten

Tighten the bolts to 60 N·m (44 lb ft).

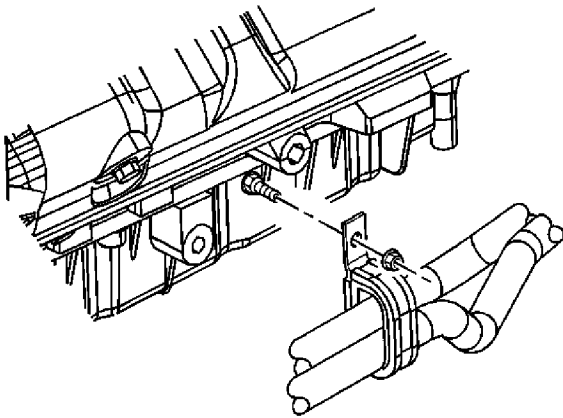


14. If equipped with an automatic transmission, install the nuts retaining the transmission fluid fill tube bracket.

Tighten

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

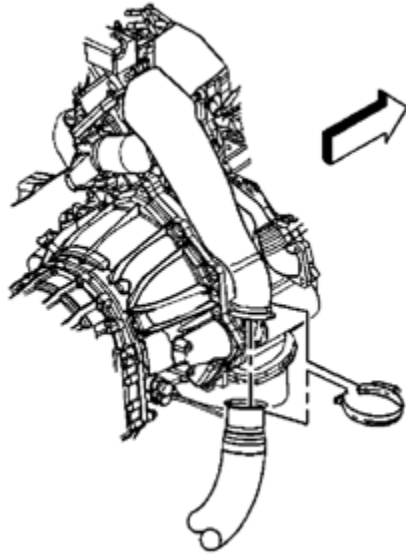
15. If the vehicle is 4WD equipped, install the front differential carrier assembly. Refer to [Differential Carrier Assembly Replacement](#).



16. If equipped with an automatic transmission, install the nut retaining the transmission oil cooler line clip.

Tighten

Tighten the nut to 9 N·m (80 lb in).

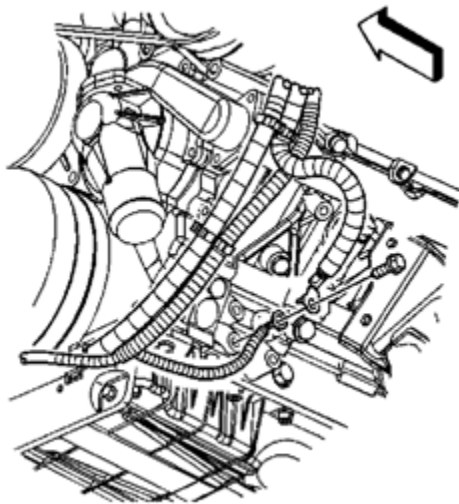


17. Install the exhaust pipe to the exhaust outlet.
18. Install the exhaust manifold pipe to the exhaust outlet clamp.

Tighten

Tighten the clamp to 40 N·m (30 lb ft).

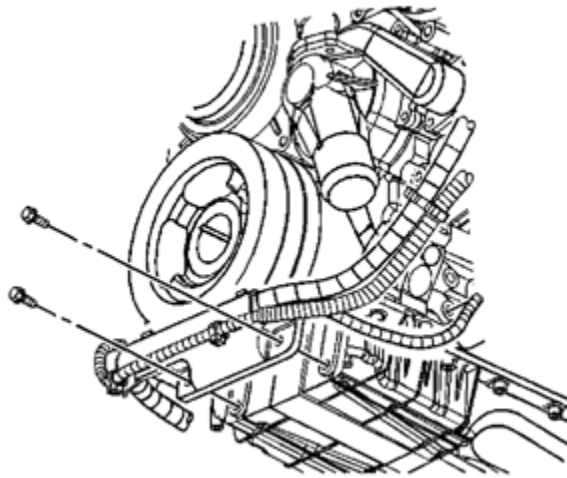
19. Lower the vehicle to work through the front fender wheelhouse openings.



20. Install the bolt retaining the battery negative cable and the engine wiring harness ground wire to the left side of the engine.

Tighten

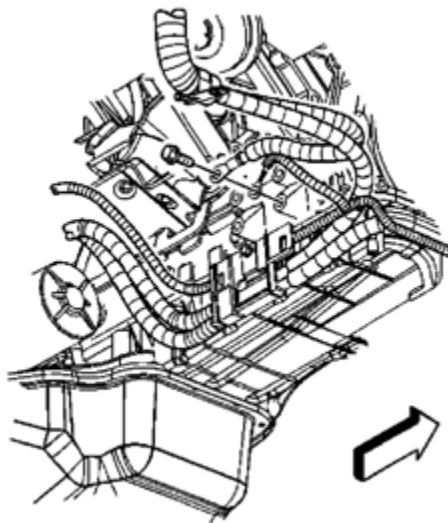
Tighten the bolt to 34 N·m (25 lb ft).



21. Install the bolts holding the battery cable channel retainer to the lower crankcase.

Tighten

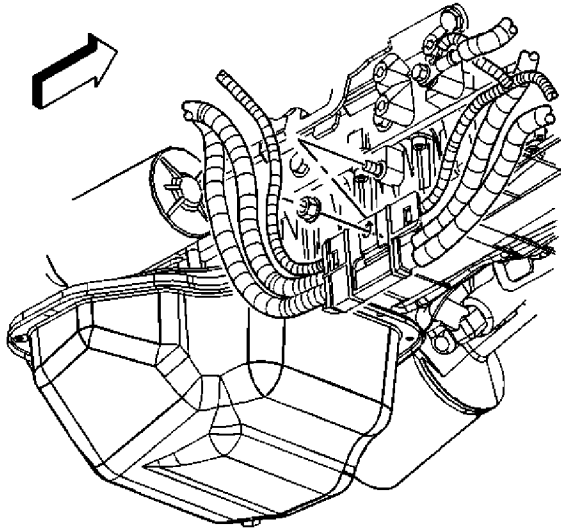
Tighten the bolts to 12 N·m (106 lb ft).



22. Install the bolts holding the auxiliary battery negative cable and the engine wiring harness ground wires to the right side of the engine.

Tighten

Tighten the bolts to 34 N·m (25 lb ft).

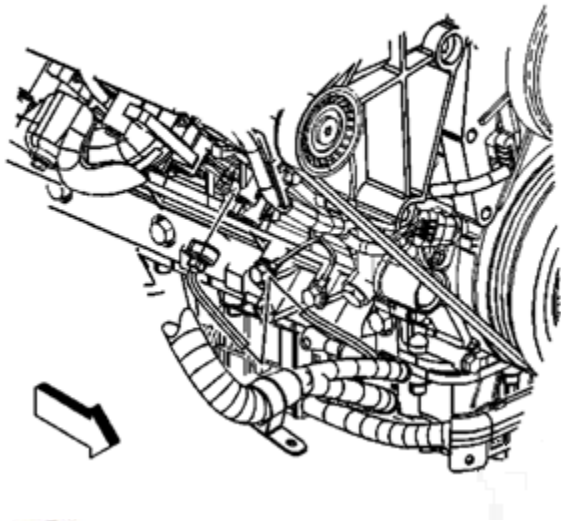


23. Install the nut holding the battery cable bracket to the right side of the lower crankcase.

Tighten

Tighten the nut to 8 N·m (71 lb in).

24. Install the starter. Refer to [Starter Replacement](#).

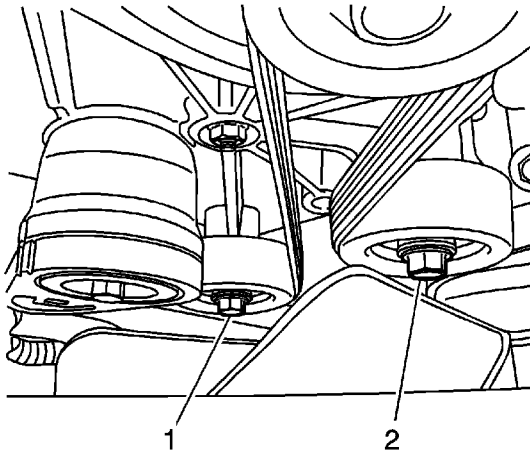


25. Connect the cord for the engine coolant heater.
26. Install the engine oil pan skid plate. Refer to [Oil Pan Skid Plate Replacement](#).
27. Install the engine shield. Refer to [Engine Shield Replacement](#).
28. Lower the vehicle.
29. Install the bolt and the ground wires at the rear of the left cylinder head.

Tighten

Tighten the bolt to 34 N·m (25 lb ft).

30. Install the upper exhaust gas recirculation cooling pipe. Refer to [Exhaust Gas Recirculation Cooling Pipe Replacement - Upper](#).
31. Install the generator bracket. Refer to [Generator Bracket Replacement](#).

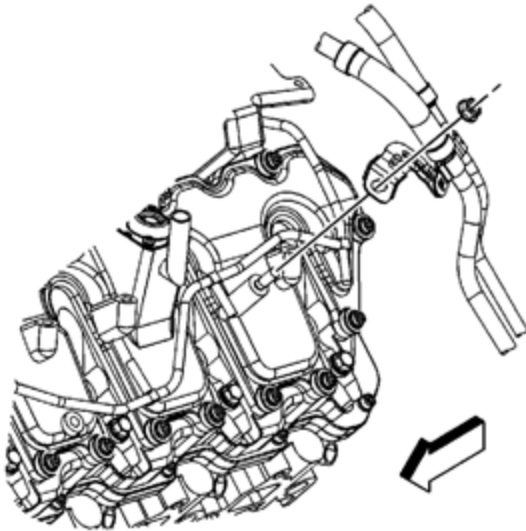


32. Install the right idler pulley and bolt (1).

Tighten

Tighten the bolt to 43 N·m (32 lb ft).

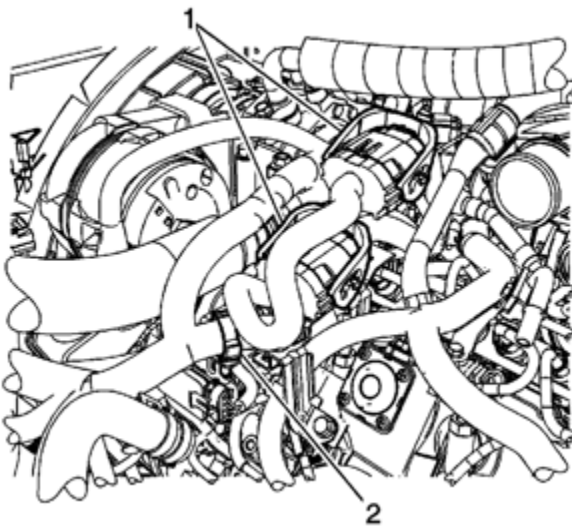
33. Install the air conditioning compressor and the power steering pump mounting bracket. Refer to [Air Conditioning \(A/C\) Compressor and Power Steering Pump Bracket Replacement](#).
34. Install the A/C compressor. Refer to [Air Conditioning Compressor Replacement](#).
35. Position the engine wiring harness on the engine.
36. Install the A/C suction hose to the accumulator.
37. Install the drive belt. Refer to [Drive Belt Replacement](#).



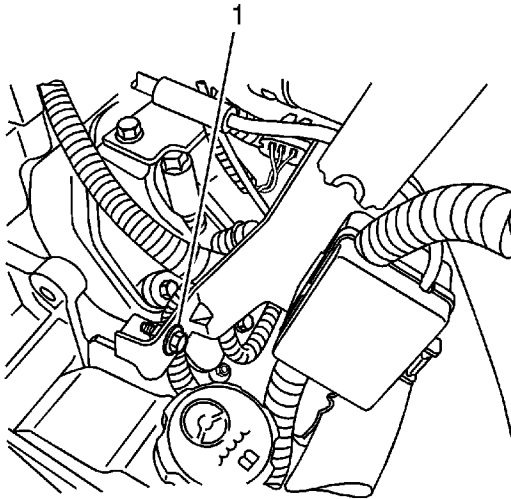
38. Connect the fuel hoses at the engine.
39. Install the nut and the fuel hose bracket to the valve rocker arm cover stud.

Tighten

Tighten the nut to 21 N·m (15 lb ft).



40. Connect the main engine electrical harness connectors.
41. Push down on the latches (1) in order to connect the connectors.
42. Close the harness clip (2).



43. Install the cable junction block and bolt (1) to the power steering pump.

Tighten

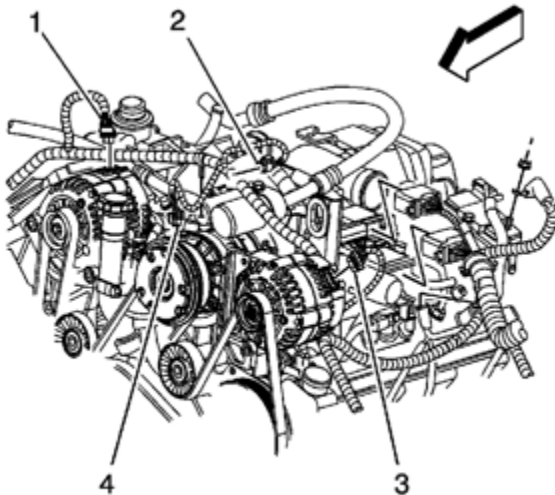
Tighten the bolt to 9 N·m (80 lb in).

44. If equipped, install the battery cable to the auxiliary generator.
45. Install the battery cable to the generator.

Tighten

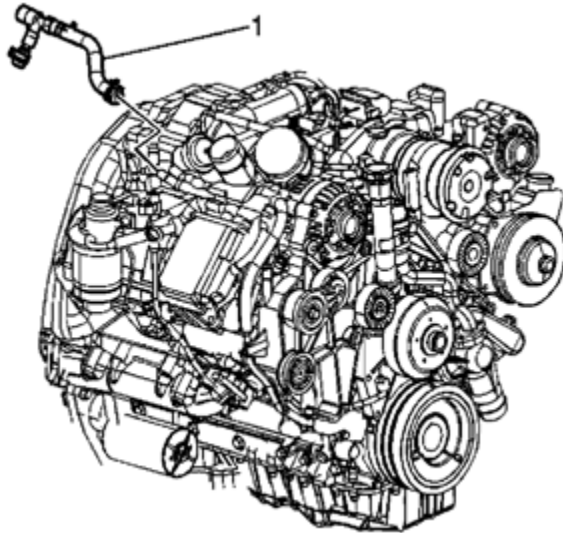
Tighten the nut to 9 N·m (80 lb in).

46. Install the battery cable harness clip to the upper air intake tube.



47. Connect the following electrical connectors:

- Generator connector (1)
 - A/C refrigerant switch (2)
 - Dual generator harness connector (3), if equipped
 - A/C compressor clutch (4)
48. Install the harness clip to the oil fill pipe.
 49. Install the radiator support. Refer to [Radiator Support Replacement](#).
 50. Install the radiator outlet hose. Refer to [Radiator Outlet Hose Replacement](#).
 51. Install the lower fan shroud. Refer to [Engine Coolant Fan Lower Shroud Replacement](#).
 52. Install the upper fan shroud. Refer to [Engine Coolant Fan Upper Shroud Replacement](#).



53. Connect the inlet heater hose (1) to the heater core inlet.

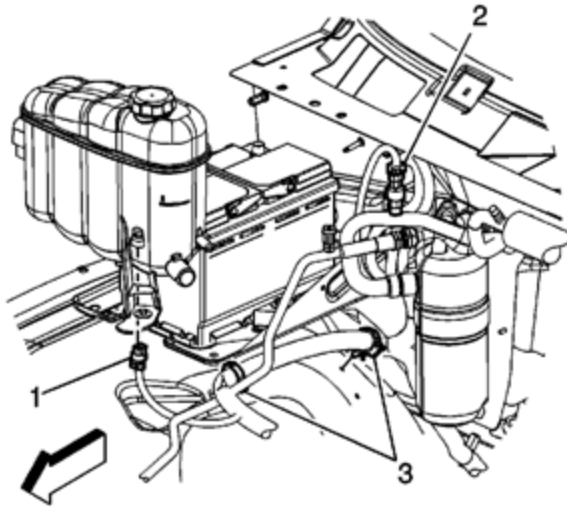
Firmly push to quick connector onto the heater core pipe until you hear an audible click.

54. Install the outlet heater hose to the outlet radiator hose.
55. Install the bolt retaining the heater hose pipe to the bracket.

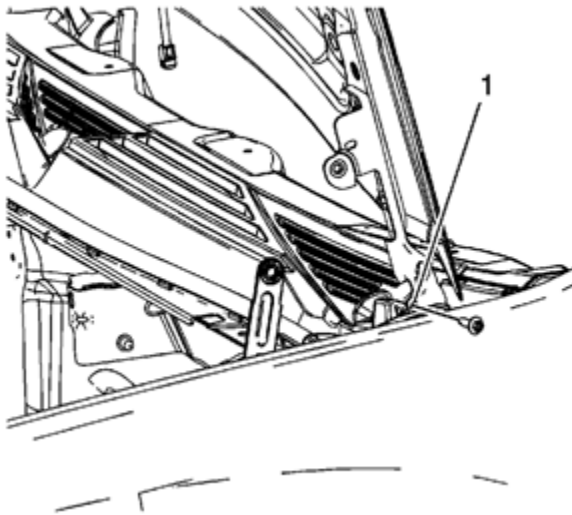
Tighten

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

56. Install the radiator inlet hose. Refer to [Radiator Inlet Hose Replacement](#).
57. Install the charged air cooler pipes and hoses to the turbocharger and the charged air cooler. Refer to [Charge Air Cooler Inlet Pipe Replacement](#) and [Charge Air Cooler Outlet Pipe Replacement](#).
58. Install both fender wheelhouse inner panels (1). Refer to [Front Wheelhouse Liner Replacement - Right Side](#) and [Front Wheelhouse Liner Replacement - Left Side](#).
59. Install both front tires and wheels. Refer to [Tire and Wheel Removal and Installation](#).
60. Install the surge tank. Refer to [Radiator Surge Tank Replacement](#).
61. Install the air cleaner. Refer to [Air Cleaner Assembly Replacement](#).

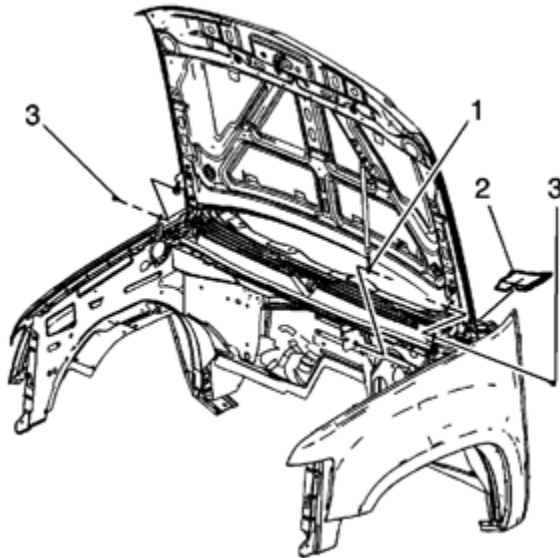


62. Connect the following engine wire harness connectors:
 - Install the engine wire harness clips to the wheelhouse inner panel (3).
 - A/C pressure cycling switch (2)
 - Surge tank switch (1)
63. Connect the batteries negative cables. Refer to [Battery Negative Cable Disconnection and Connection](#).
64. Fill the engine coolant. Refer to [Cooling System Draining and Filling](#).
65. Prelube the engine. Refer to [Engine Prelubing](#).
66. Operate the engine, inspect for coolant, oil, fuel, and exhaust leaks.
67. Inspect for proper oil pressure.
68. Inspect for proper engine operation.



Note: There is a positive stop which limits the hood from being opened too far.

69. With the aid of the assistant raise the hood slightly until the hood hinge bolts can be removed from the service position notch (1).

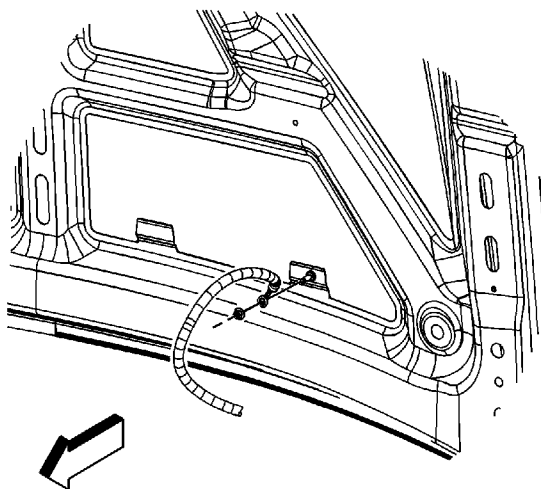


70. With the aid of an assistant lower the hood and install the hood hinge bolts (2) to the hood hinges.

Tighten

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

71. Install the air inlet grille end caps (1), push down the end cap in order to engage the retainers. (left side shown, right side similar).



72. Install the ground strap to the hood stud.

73. Install the ground strap nut at the hood stud.

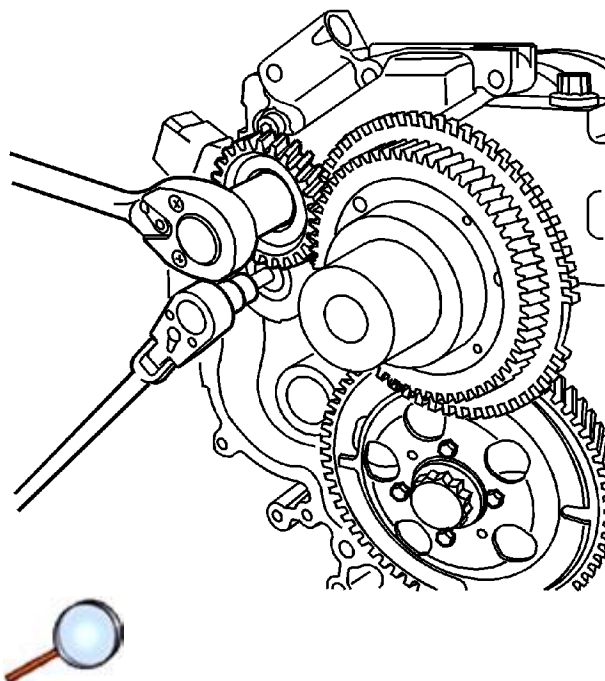
Tighten

Tighten the nut to 9 N·m (80 lb in).

74. Close the hood.
75. Road test the vehicle for normal operation.
76. Inspect for coolant, oil, or exhaust leaks.

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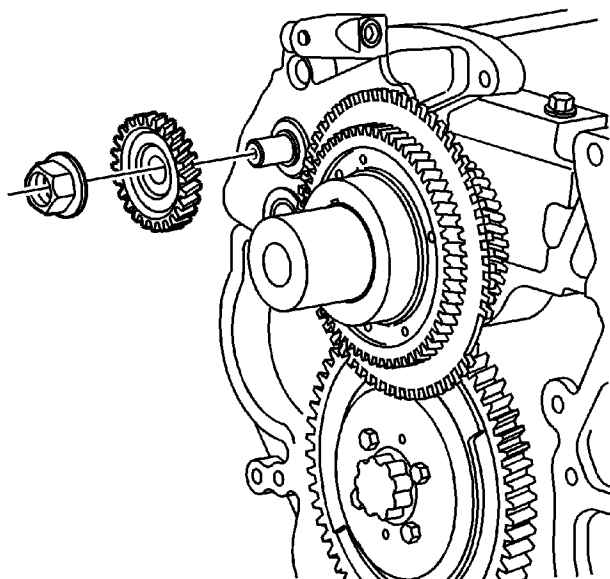
Oil Pump Removal



Caution: Do not use an impact driver to remove or install the oil pump driven gear nut. Use of an impact driver may shear the oil pump drive gear pin in the crankshaft.

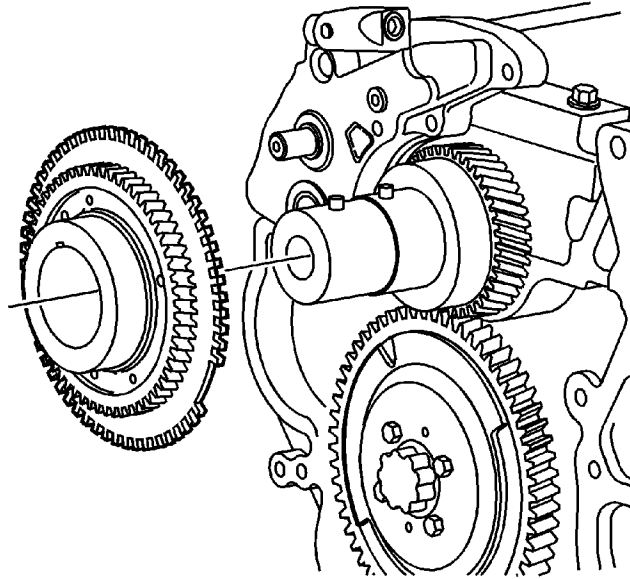
Note: Look for an "L" on the end of the oil pump shaft. If there is an "L" present, the nut and shaft have left hand threads. Service the nut accordingly.

1. While holding the secondary oil pump shaft with a hex driver, remove the oil pump driven gear nut.



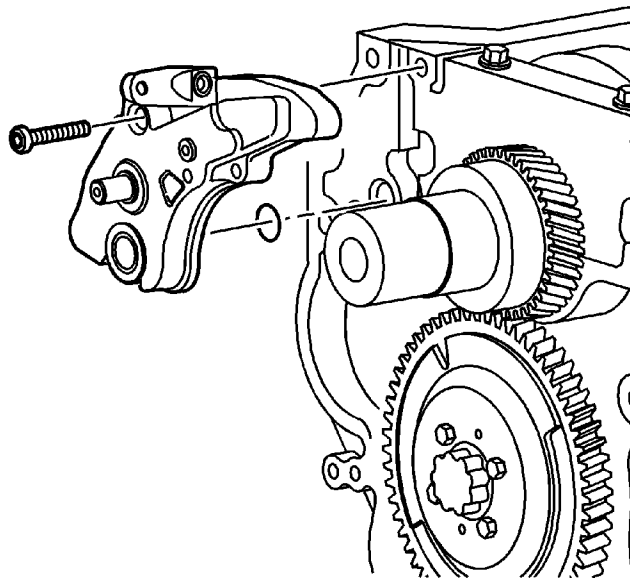


2. Remove the oil pump driven gear.



Note: Do not damage the crankshaft sensor reluctor teeth.

3. Remove the oil pump drive gear and crank sensor reluctor assembly.



4. Remove the oil pump bolts.
5. Remove the oil pump.
6. Remove the O-ring and discard.