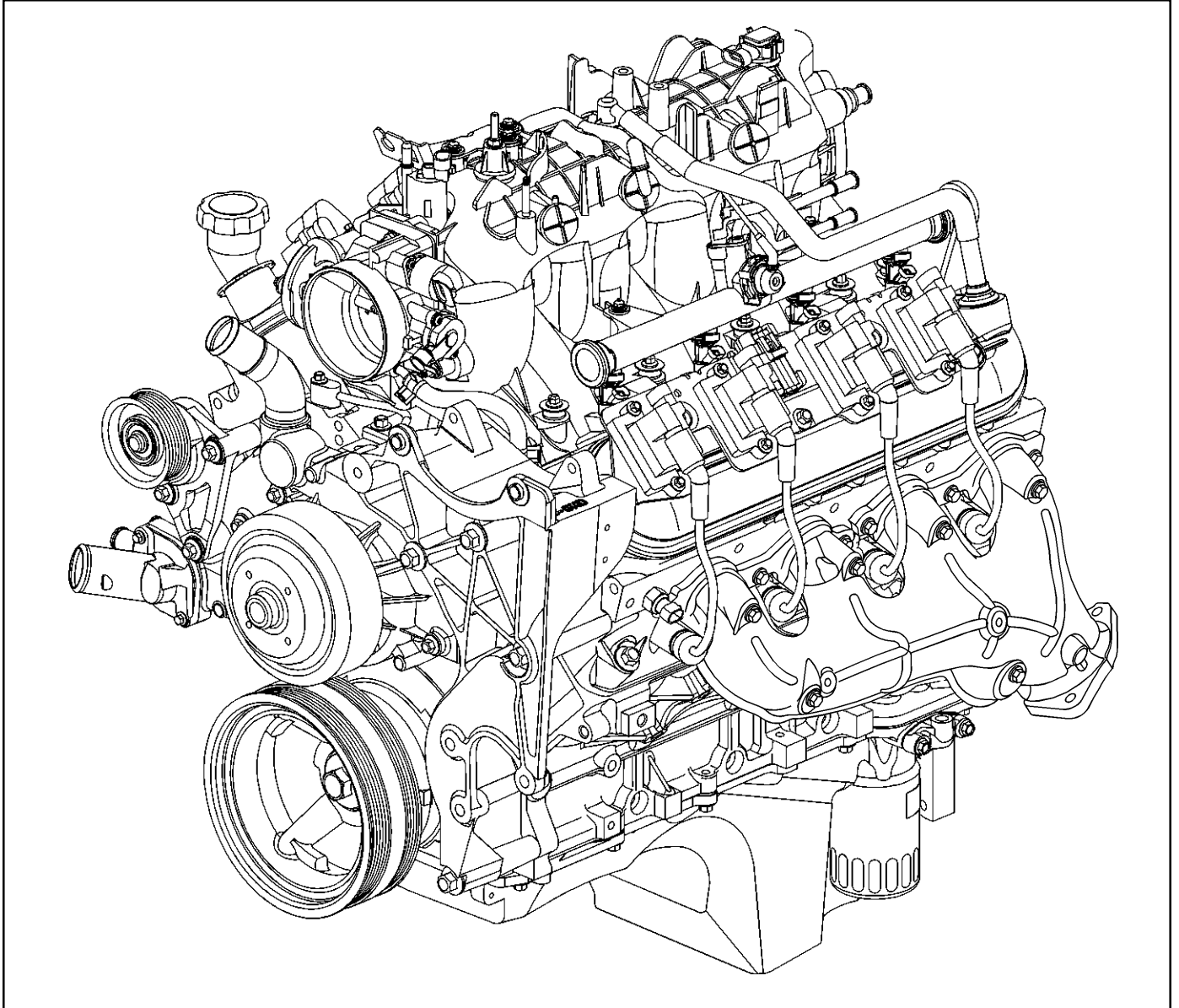


Engine Mechanical Service Manual



6.0L
(LQ4, LQ9)

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Engine Mechanical - 6.0L

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Bolts	10 N•m	89 lb in
Camshaft Retainer Bolts	25 N•m	18 lb ft
Camshaft Sensor Bolt	25 N•m	18 lb ft
Camshaft Sprocket Bolts	35 N•m	26 lb ft
Connecting Rod Bolts-First Design (First Pass)	20 N•m	15 lb ft
Connecting Rod Bolts-First Design (Final Pass)	60 degrees	
Connecting Rod Bolts-Second Design (First Pass)	20 N•m	15 lb ft
Connecting Rod Bolts-Second Design (Final Pass)	75 degrees	
Coolant Temperature Gauge Sensor	20 N•m	15 lb ft
Crankshaft Balancer Bolt (Installation Pass-to Ensure the Balancer is Completely Installed)	330 N•m	240 lb ft
Crankshaft Balancer Bolt (First Pass-Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes)	50 N•m	37 lb ft
Crankshaft Balancer Bolt (Final Pass)	140 degrees	
Crankshaft Bearing Cap Bolts (Inner Bolts-First Pass in Sequence)	20 N•m	15 lb ft
Crankshaft Bearing Cap Bolts (Inner Bolts-Final Pass in Sequence)	80 degrees	
Crankshaft Bearing Cap Side Bolts	25 N•m	18 lb ft
Crankshaft Bearing Cap Bolts (Outer Studs-First Pass in Sequence)	20 N•m	15 lb ft
Crankshaft Bearing Cap Bolts (Outer Studs-Final Pass in Sequence)	51 degrees	
Crankshaft Oil Deflector Nuts	25 N•m	18 lb ft
Crankshaft Position Sensor Bolt	25 N•m	18 lb ft
Cylinder Head Bolts (First Pass-all M11 Bolts in Sequence)	30 N•m	22 lb ft
Cylinder Head Bolts (Second Pass-all M11 Bolts in Sequence)	90 degrees	
Cylinder Head Bolts (Final Pass-all M11 Bolts in Sequence-Excluding the Medium Length Bolts at the Front and Rear of Each Cylinder Head)	90 degrees	
Cylinder Head Bolts (Final Pass-all M11 Medium Length Bolts at the Front and Rear of Each Cylinder Head in Sequence)	50 degrees	
Cylinder Head Bolts (M8 Inner Bolts in Sequence)	30 N•m	22 lb ft
Cylinder Head Coolant Plug	20 N•m	15 lb ft
Engine Block Coolant Drain Plugs	60 N•m	44 lb ft
Engine Block Heater	40 N•m	30 lb ft
Engine Block Oil Gallery Plugs	60 N•m	44 lb ft
Engine Coolant Air Bleed Pipe Bolts	12 N•m	106 lb in
Engine Flywheel Bolts (First Pass)	20 N•m	15 lb ft
Engine Flywheel Bolts (Second Pass)	50 N•m	37 lb ft
Engine Flywheel Bolts (Final Pass)	100 N•m	74 lb ft
Engine Front Cover Bolts	25 N•m	18 lb ft
Engine Rear Cover Bolts	25 N•m	18 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Engine Service Lift Bracket M10 Bolts	50 N•m	37 lb ft
Engine Service Lift Bracket M8 Bolt	25 N•m	18 lb ft
Engine Sight Shield Bolts	10 N•m	89 lb in
Engine Sight Shield Bracket Bolts	5 N•m	45 lb in
Engine Valley Cover Bolts	25 N•m	18 lb ft
Exhaust Manifold Bolts (First Pass)	15 N•m	11 lb ft
Exhaust Manifold Bolts (Final Pass)	25 N•m	18 lb ft
Exhaust Manifold Heat Shield Bolts	9 N•m	80 lb in
Fuel Rail Bolts	10 N•m	89 lb in
Fuel Rail Crossover Tube Bolts	3.8 N•m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N•m	37 lb ft
Ignition Coil-to-Bracket Bolts	8 N•m	71 lb in
Ignition Coil Bracket-to-Valve Rocker Arm Cover Studs	12 N•m	106 lb in
Intake Manifold Bolts (First Pass in Sequence)	5 N•m	44 lb in
Intake Manifold Bolts (Final Pass in Sequence)	10 N•m	89 lb in
Intake Manifold Wiring Harness Stud	10 N•m	89 lb in
Knock Sensors	20 N•m	15 lb ft
Oil Filter	30 N•m	22 lb ft
Oil Filter Fitting	55 N•m	40 lb ft
Oil Level Indicator Tube Bolt	25 N•m	18 lb ft
Oil Level Sensor	13 N•m	115 lb in
Oil Pan Baffle Bolts	12 N•m	106 lb in
Oil Pan Closeout Cover Bolt (Left Side)	9 N•m	80 lb in
Oil Pan Closeout Cover Bolt (Right Side)	9 N•m	80 lb in
Oil Pan Cover Bolts	12 N•m	106 lb in
Oil Pan Drain Plug	25 N•m	18 lb ft
Oil Pan M8 Bolts (Oil Pan-to-Engine Block and Oil Pan-to-Front Cover)	25 N•m	18 lb ft
Oil Pan M6 Bolts (Oil Pan-to-Rear Cover)	12 N•m	106 lb in
Oil Pressure Sensor	20 N•m	15 lb ft
Oil Pump-to-Engine Block Bolts	25 N•m	18 lb ft
Oil Pump Cover Bolts	12 N•m	106 lb in
Oil Pump Relief Valve Plug	12 N•m	106 lb in
Oil Pump Screen Nuts	25 N•m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N•m	106 lb in
Spark Plugs-New	20 N•m	15 lb ft
Spark Plugs-All Subsequent Installations	15 N•m	11 lb ft
Throttle Body Nuts	10 N•m	89 lb in
Throttle Body Studs	6 N•m	53 lb in
Valve Lifter Guide Bolts	12 N•m	106 lb in
Valve Rocker Arm Bolts	30 N•m	22 lb ft
Valve Rocker Arm Cover Bolts	12 N•m	106 lb in
Water Inlet Housing Bolts	15 N•m	11 lb ft
Water Pump Bolts (First Pass)	15 N•m	11 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Water Pump Bolts (Final Pass)	30 N•m	22 lb ft
Water Pump Cover Bolts	15 N•m	11 lb ft

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	V8	
Displacement	6.0L	364 CID
Bore	101.618-101.636 mm	4.0007-4.0014 in
Stroke	92.0 mm	3.622 in
Compression Ratio - LQ4	9.40:1	
Compression Ratio - LQ9	10.0:1	
Firing Order	1-8-7-2-6-5-4-3	
Spark Plug Gap	1.524 mm	0.060 in
Lubrication System		
Oil Capacity (without Oil Filter Change)	4.73 Liters	5.0 Quarts
Oil Capacity (with Oil Filter Change)	5.68 Liters	6.0 Quarts
Oil Pressure (Minimum-Hot)	41 kPa at 1,000 engine rpm 124 kPa at 2,000 engine rpm 165 kPa at 4,000 engine rpm	6.0 psig at 1,000 engine rpm 18.0 psig at 2,000 engine rpm 24.0 psig at 4,000 engine rpm
Oil Type	5W-30	
Camshaft		
End Play	0.025-0.305 mm	0.001-0.012 in
Journal Diameter	54.99-55.04 mm	2.164-2.166 in
Journal Diameter Out-of-Round	0.025 mm	0.001 in
Lobe Lift (Exhaust)	7.13 mm	0.281 in
Lobe Lift (Intake)	6.96 mm	0.274 in
Runout (Measured at the Intermediate Journals)	0.05 mm	0.002 in
Connecting Rod		
Connecting Rod Bearing Bore Diameter	56.505-56.525 mm	2.224-2.225 in
Connecting Rod Bearing Bore Out-of-Round - LQ4	0.004-0.008 mm	0.00015-0.0003 in
Connecting Rod Bearing Bore Out-of-Round - LQ9	0.006 mm	0.00023 in
Connecting Rod Bearing Clearance (Production)	0.023-0.065 mm	0.0009-0.0025 in
Connecting Rod Bearing Clearance (Service Limit)	0.023-0.076 mm	0.0009-0.003 in
Connecting Rod Side Clearance	0.11-0.51 mm	0.00433-0.02 in
Crankshaft		
Crankshaft Bearing Clearance (Production)	0.020-0.052 mm	0.0008-0.0021 in
Crankshaft Bearing Clearance (Service Limit)	0.020-0.065 mm	0.0008-0.0025 in
Crankshaft Connecting Rod Journal Diameter (Production)	53.318-53.338 mm	2.0991-2.0999 in
Crankshaft Connecting Rod Journal Diameter (Service Limit)	53.308 mm (Minimum)	2.0987 in (Minimum)
Crankshaft Connecting Rod Journal Taper (Production)	0.005 mm (Maximum for 1/2 of the Journal Length)	0.0002 in (Maximum for 1/2 of the Journal Length)
Crankshaft Connecting Rod Journal Taper (Service Limit)	0.02 mm (Maximum)	0.00078 in (Maximum)
Crankshaft Connecting Rod Journal Out-of-Round (Production)	0.005 mm	0.0002 in
Crankshaft Connecting Rod Journal Out-of-Round (Service Limit)	0.01 mm	0.0004 in
Crankshaft End Play	0.04-0.2 mm	0.0015-0.0078 in
Crankshaft Main Journal Diameter (Production)	64.993-65.007 mm	2.558-2.559 in
Crankshaft Main Journal Diameter (Service Limit)	64.993 mm	2.558 in
Crankshaft Main Journal Out-of-Round (Production)	0.003 mm	0.0001 in
Crankshaft Main Journal Out-of-Round (Service Limit)	0.008 mm	0.0003 in
Crankshaft Main Journal Taper (Production)	0.01 mm	0.0004 in
Crankshaft Main Journal Taper (Service Limit)	0.02 mm	0.00078 in
Crankshaft Reluctor Ring Runout (Measured 1.0 mm (0.04 in) Below the Tooth Diameter)	0.7 mm (Maximum)	0.028 in (Maximum)
Crankshaft Runout (at Rear Flange)	0.05 mm (Maximum)	0.002 in (Maximum)
Crankshaft Thrust Wall Runout	0.025 mm	0.001 in

Engine Mechanical Specifications (cont'd)

Crankshaft Thrust Wall Width (Production)	26.14-26.22 mm	1.029-1.032 in
Crankshaft Thrust Wall Width (Service Limit)	26.2 mm (Maximum)	1.0315 in (Maximum)
Cylinder Bore		
Cylinder Bore Diameter (Production)	101.618-101.636 mm	4.0007-4.0014 in
Cylinder Head		
Cylinder Head Engine Block Deck Flatness (Measured within a 152.4 mm (6.0 in) area)	0.08 mm	0.003 in
Cylinder Head Engine Block Deck Flatness (Measuring the Overall Length of the Cylinder Head)	0.1 mm	0.004 in
Cylinder Head Exhaust Manifold Deck Flatness	0.13 mm	0.005 in
Cylinder Head Height (Measured from the Head Deck to the Valve Rocker Arm Cover Seal Surface)	120.2 mm (Minimum)	4.732 in (Minimum)
Cylinder Head Intake Manifold Deck Flatness	0.08 mm	0.003 in
Engine Block		
Camshaft Bearing Bore Diameter	55.063-55.088 mm	2.168-2.169 in
Engine Block Cylinder Head Deck Surface Flatness (Measured within a 152.4 mm (6.0 in) area)	0.11 mm	0.004 in
Engine Block Cylinder Head Deck Surface Flatness (Measuring the Overall Length of the Block Deck)	0.22 mm	0.008 in
Engine Block Cylinder Head Deck Height (Measuring from the Centerline of Crankshaft to the Deck Face)	234.57-234.82 mm	9.235-9.245 in
Main Bearing Bore Diameter (Production)	69.871-69.889 mm	2.750-2.751 in
Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
Valve Lifter Bore Diameter (Production)	21.417-21.443 mm	0.843-0.844 in
Intake Manifold		
Intake Manifold Cylinder Head Deck Flatness (Measured within a 200 mm Area that Includes Two Runner Port Openings)	0.3 mm	0.118 in
Oil Pan and Front/Rear Cover Alignment		
Oil Pan to Rear of Engine Block Alignment (at Transmission Bellhousing Mounting Surface)	0.0-0.25 mm (Maximum)	0.0-0.01 in (Maximum)
Front Cover Alignment (at Oil Pan Surface)	0.0-0.5 mm	0.0-0.02 in
Rear Cover Alignment (at Oil Pan Surface)	0.0-0.5 mm	0.0-0.02 in
Piston		
Piston Diameter - LQ4 Measured at Size Point	101.58-101.598 mm	3.9992-3.9999 in
Piston Diameter - LQ9 Measured Over Skirt Coating	101.611-101.642 mm	4.000-4.001 in
Piston-to-Bore Clearance - LQ4 Production	0.02-0.056 mm	0.0008-0.0022 in
Piston-to-Bore Clearance - LQ4 Service Limit	0.02-0.081 mm	0.0008-0.0032 in
Piston-to-Bore Clearance - LQ9 Production	0.024-0.025 mm	0.00094-0.00098 in
Piston-to-Bore Clearance - LQ4 Service Limit With Skirt Coating Worn Off	0.024-0.080 mm	0.00094-0.0031 in
Piston Pin		
Piston Pin Diameter - Press Fit Pin	23.997-24.0 mm	0.9447-0.9448 in
Piston Pin Diameter - Full Floating Pin	23.952-23.955 mm	0.9429-0.9431 in
Piston Pin Fit in Connecting Rod - Press Fit Pin	0.020-0.043 mm (Interference)	0.00078-0.00169 in (Interference)
Piston Pin Fit in Connecting Rod - Full Floating Pin Production	0.007-0.020 mm	0.00027-0.00078 in
Piston Pin Fit in Connecting Rod - Full Floating Pin Service Limit	0.007-0.022 mm	0.00027-0.00086 in
Piston Pin to Piston Bore Clearance - LQ4 Production	0.007-0.020 mm	0.00027-0.00078 in
Piston Pin to Piston Bore Clearance - LQ4 Service Limit	0.007-0.021 mm	0.00027-0.00082 in
Piston Pin to Piston Bore Clearance - LQ9 Production Measured at Pin End	0.002-0.010 mm	0.00008-0.0004 in
Piston Pin to Piston Bore Clearance - LQ9 Service Limit Measured at Pin End	0.002-0.015 mm	0.00008-0.0006 in
Piston Rings		
Piston Compression Ring End Gap - LQ4 Production-Top (Measured in Cylinder Bore)	0.31-0.52 mm	0.0122-0.02 in
Piston Compression Ring End Gap - LQ4 Production-2nd (Measured in Cylinder Bore)	0.51-0.77 mm	0.02-0.03 in

Engine Mechanical Specifications (cont'd)

Piston Oil Ring End Gap - LQ4 Production - Measured in Cylinder Bore	0.31-0.87 mm	0.0122-0.034 in
Piston Compression Ring End Gap - LQ4 Service-Top (Measured in Cylinder Bore)	0.31-0.59 mm	0.0122-0.023 in
Piston Compression Ring End Gap - LQ4 Service-2nd (Measured in Cylinder Bore)	0.51-0.84 mm	0.02-0.033 in
Piston Oil Ring End Gap - LQ4 Service - Measured in Cylinder Bore	0.31-0.94 mm	0.0122-0.037 in
Piston Compression Ring End Gap - LQ9 Production-Top (Measured in Cylinder Bore)	0.31-0.52 mm	0.0122-0.02 in
Piston Compression Ring End Gap - LQ9 Production-2nd (Measured in Cylinder Bore)	0.51-0.77 mm	0.02-0.03 in
Piston Oil Ring End Gap - LQ9 Production - Measured in Cylinder Bore	0.31-0.87 mm	0.0122-0.034 in
Piston Compression Ring End Gap - LQ9 Service-Top (Measured in Cylinder Bore)	0.31-0.59 mm	0.0122-0.023 in
Piston Compression Ring End Gap - LQ9 Service-2nd (Measured in Cylinder Bore)	0.51-0.84 mm	0.02-0.033 in
Piston Oil Ring End Gap - LQ9 Service - Measured in Cylinder Bore	0.31-0.94 mm	0.0122-0.037 in
Piston Compression Ring Groove Clearance - LQ4 Production - Top	0.04-0.08 mm	0.00157-0.0031 mm
Piston Compression Ring Groove Clearance - LQ4 Production - 2nd	0.039-0.079 mm	0.0015-0.0031 in
Piston Oil Ring Groove Clearance - LQ4 Production	0.015-0.2 mm	0.0006-0.0079 in
Piston Compression Ring Groove Clearance - LQ4 Service - Top	0.04-0.08 mm	0.00157-0.0031 mm
Piston Compression Ring Groove Clearance - LQ4 Service - 2nd	0.039-0.079 mm	0.0015-0.0030 in
Piston Oil Ring Groove Clearance - LQ4 Service	0.015-0.2 mm	0.0006-0.0079 in
Piston Compression Ring Groove Clearance - LQ9 Production - Top	0.035-0.080 mm	0.0014-0.0031 mm
Piston Compression Ring Groove Clearance - LQ9 Production - 2nd	0.034-0.079 mm	0.0013-0.0030 in
Piston Oil Ring Groove Clearance - LQ9 Production	0.012-0.20 mm	0.00047-0.0079 in
Piston Compression Ring Groove Clearance - LQ9 Service - Top	0.035-0.080 mm	0.0014-0.0031 mm
Piston Compression Ring Groove Clearance - LQ9 Service - 2nd	0.034-0.079 mm	0.0013-0.0030 in
Piston Oil Ring Groove Clearance - LQ9 Service	0.012-0.20 mm	0.00047-0.0079 in
Valve System		
Valve Face Angle	45 Degrees	
Valve Lash	Net Lash - No Adjustment	
Valve Lift (Exhaust)	12.16 mm	0.479 in
Valve Lift (Intake)	11.79 mm	0.464 in
Valve Lifter	Hydraulic Roller	
Valve Margin	1.25 mm	0.05 in
Valve Rocker Arm Ratio	1.70:1	
Valve Seat Angle	46 Degrees	
Valve Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Valve Seat Width (Exhaust)	1.78 mm	0.07 in
Valve Seat Width (Intake)	1.02 mm	0.04 in
Valve Spring Free Length	52.9 mm	2.08 in
Valve Spring Installed Height (Exhaust)	45.75 mm	1.8 in
Valve Spring Installed Height (Intake)	45.75 mm	1.8 in
Valve Spring Pressure (Closed)	340 N at 45.75 mm	76 lb at 1.8 in
Valve Spring Pressure (Open)	980 N at 33.55 mm	220 lb at 1.32 in
Valve Stem Clearance (Production-Exhaust)	0.025-0.066 mm	0.001-0.0026 in
Valve Stem Clearance (Production-Intake)	0.025-0.066 mm	0.001-0.0026 in
Valve Stem Clearance (Service-Exhaust)	0.093 mm (Maximum)	0.0037 in (Maximum)
Valve Stem Clearance (Service-Intake)	0.093 mm (Maximum)	0.0037 in (Maximum)
Valve Stem Diameter (Production-Exhaust)	7.955-7.976 mm	0.3132-0.314 in
Valve Stem Diameter (Production-Intake)	7.955-7.976 mm	0.3132-0.314 in
Valve Stem Diameter (Service-Exhaust)	7.95 mm (Minimum)	0.313 in (Minimum)
Valve Stem Diameter (Service-Intake)	7.95 mm (Minimum)	0.313 in (Minimum)
Valve Stem Oil Seal Installed Height (Measured from the Valve Spring Shim to Top Edge of Seal Body - First Design Seal)	18.1-19.1 mm	0.712-0.752 in

GM SPO Group Numbers

Application	GM SPO Group Number
Camshaft	0.519
Camshaft Bearing	0.539
Camshaft Timing Chain	0.724
Connecting Rod	0.603
Connecting Rod Bearing Kit	0.616
Coolant Radiator	1.219
Crankshaft	0.646
Crankshaft Balancer	0.659
Crankshaft Bearing Kit	0.096
Crankshaft Oil Deflector	1.430
Crankshaft Front Oil Seal	0.213
Crankshaft Rear Oil Seal	0.137
Crankshaft Sprocket	0.728
Crankshaft Transmission Pilot Bearing	0.649
Cylinder Head	0.269
Cylinder Head Gasket	0.289
Engine Block	N.S.
Engine Coolant Air Bleed Pipe	0.1097
Engine Coolant Air Bleed Pipe Gasket	0.1097
Engine Cooling Thermostat	1.246
Engine Front Cover	0.206
Engine Front Cover Gasket	0.207
Engine Flywheel (Automatic Transmission)	0.666
Engine Flywheel (Manual Transmission)	0.666
Engine Rear Cover	0.137
Engine Rear Cover Gasket	0.137
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.27
Ignition Coil	2.17
Intake Manifold	3.265
Intake Manifold Gasket	3.270
Oil Filter	1.836
Oil Level Indicator	1.516
Oil Level Indicator Tube	1.516
Oil Pan	1.426
Oil Pan Gasket	1.429
Oil Pump	1.652
Oil Pump Screen	1.656
Oil Pan Cover	1.426
Oil Pan Cover Gasket	1.429
Piston with Pin	0.629
Piston with Ring Kit	0.643
Spark Plug	2.270
Starter Motor	2.041
Throttle Body	3.335
Throttle Body Gasket	3.336
Valley Cover	3.265
Valley Cover Gasket	3.270
Valve Lifter	0.459
Valve Lifter Guide	0.439
Valve Pushrod	0.426
Valve Rocker Arm	0.333

GM SPO Group Numbers (cont'd)

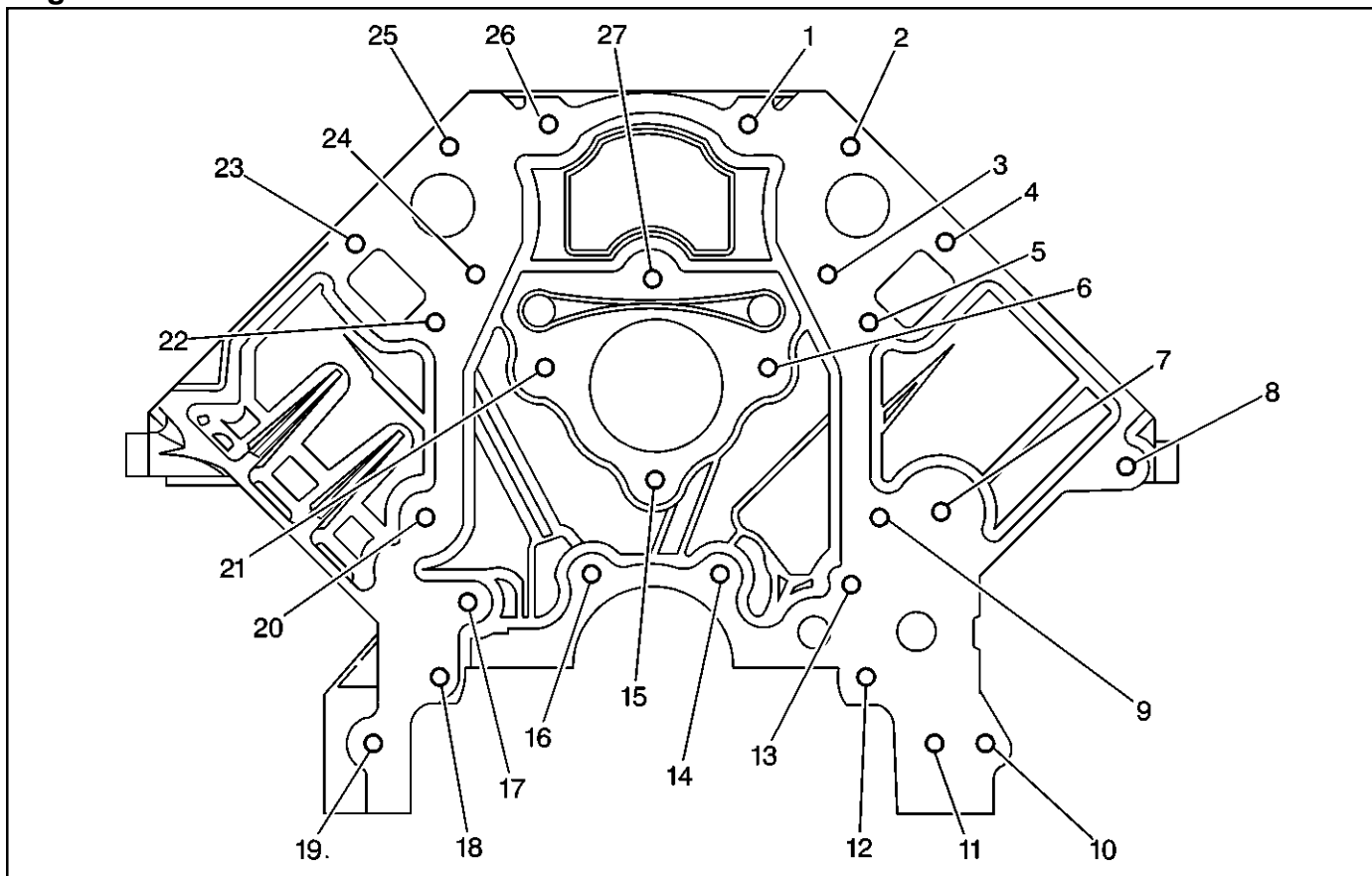
Application	GM SPO Group Number
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Gasket	0.423
Valve Rocker Arm Support	0.429
Valve Spring	0.303
Valve Spring Shim	0.303
Valve Stem Oil Seal	0.308
Water Pump Gasket	1.079
Water Pump with Gasket	1.069

Sealers, Adhesives and Lubricants

Application	Type of Material	GM Part Number
Coolant Sensor Threads	Sealant	12346004
Cylinder Head Core Hole Plugs	Threadlock	12345382
Cylinder Head Expansion Plugs	Threadlock	12345382
Cylinder Head M8 Bolt Threads	Threadlock	12345382
Engine Block Front Oil Gallery Plug	Threadlock	12345382
Engine Block Plug Sealing Washers	Sealant	12346004
Engine Flywheel Bolt Threads	Threadlock	12345382
Engine Oil	5W-30	12345610
Engine Oil Supplement	Fluorescent Dye	12345795
Exhaust Manifold Bolt Threads	Threadlock	12345493
Fuel Rail Bolt Threads	Threadlock	12345382
Ignition Coil and Bracket Assembly Bolts	Threadlock	12345382
Intake Manifold Bolt Threads	Threadlock	12345382
Oil Pan Surface at Front and Rear Covers	Sealant	12378190
Oil Pressure Sensor Threads	Sealant	12346004
Thread Repair Component Cleaner	Cleaner	12346139
Thread Repair Component Cleaner	Cleaner	12377981
Thread Repair Cutting Oil	Lubricant	1052864

Thread Repair Specifications

Engine Block-Front View

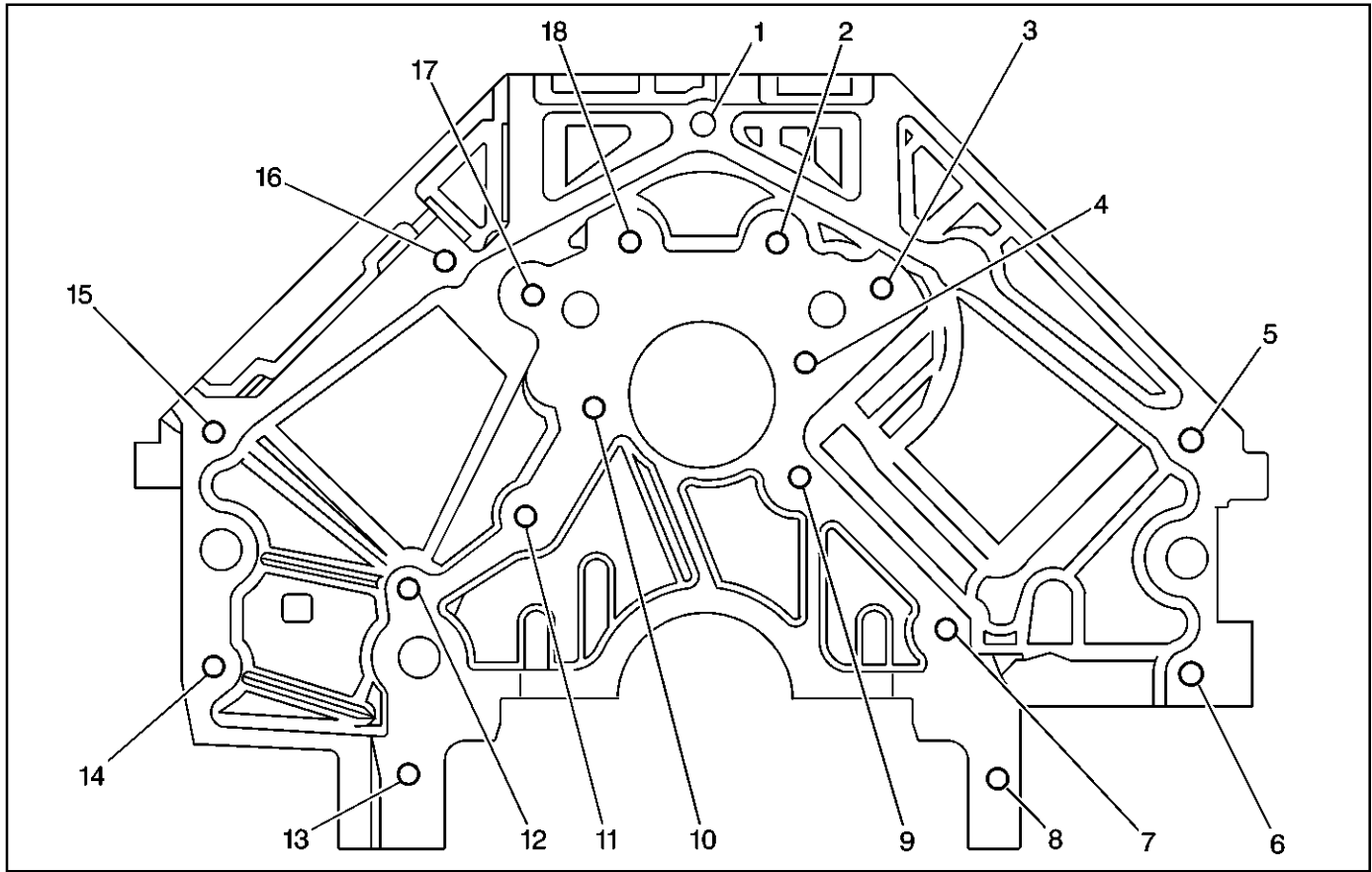


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Engine Block-Front View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1-6	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
7								
8	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	32.5 (1.28)	25.0 (0.984)
9	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
10	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	Thru	Thru
11-13	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
14	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
15	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
16	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
17-27	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block-Rear View

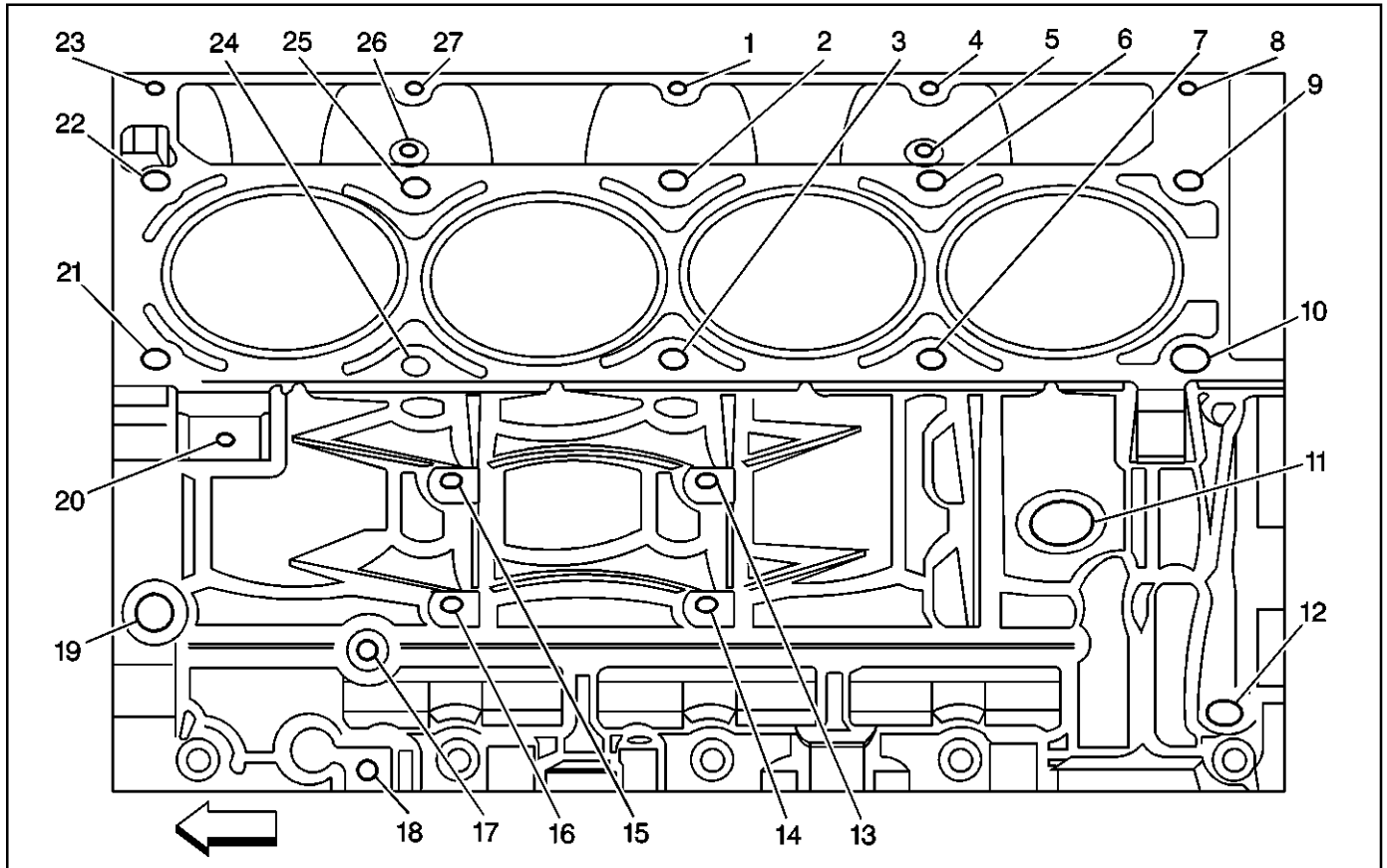


64590

Engine Block-Rear View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
2-4	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
5-6	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
7-13	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
14-16	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
17-18	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

Engine Block-Left Side View



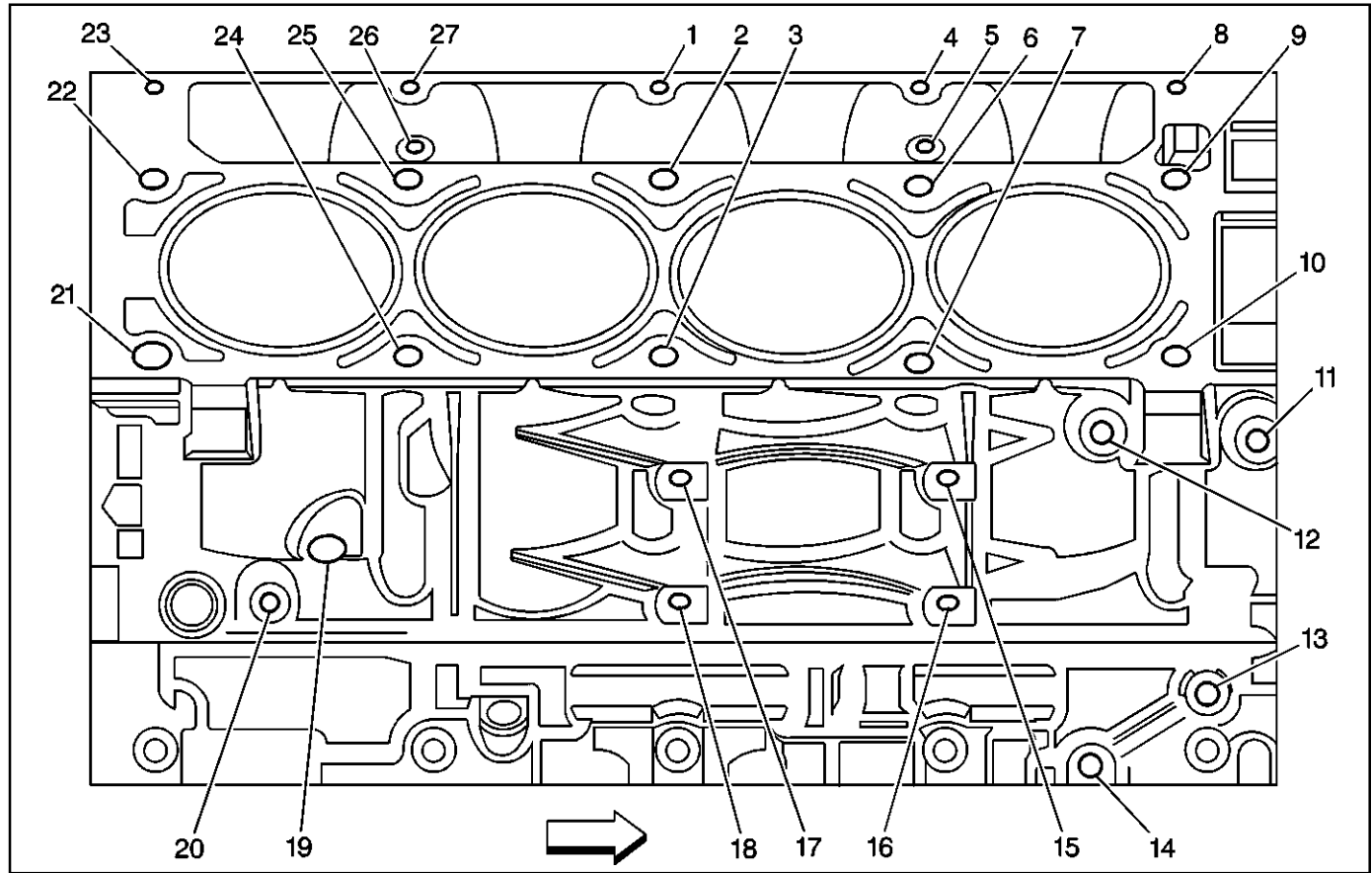
260170

Engine Block-Left Side View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
2-3	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
4	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
5	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	16.0 (0.629)
6-7	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
8	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
9	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
10	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
11	M28 X 1.25							
12	M16 X 1.5							
13-16	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	29.0 (1.14)	23.0 (0.905)
17-18	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
19	M16 X 1.5							
20	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
21	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
22	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
23	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
24-25	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
26	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	16.0 (0.629)
27	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	26.5 (1.04)	19.0 (0.784)

- Bolt holes 2, 3, 6, 7, 10, 21, 24 and 25 have a 85 mm (3.34 in) counterbore included in the 124.0 mm (4.88 in) drill depth.
- Bolt holes 9 and 22 have a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.

Engine Block-Right Side View



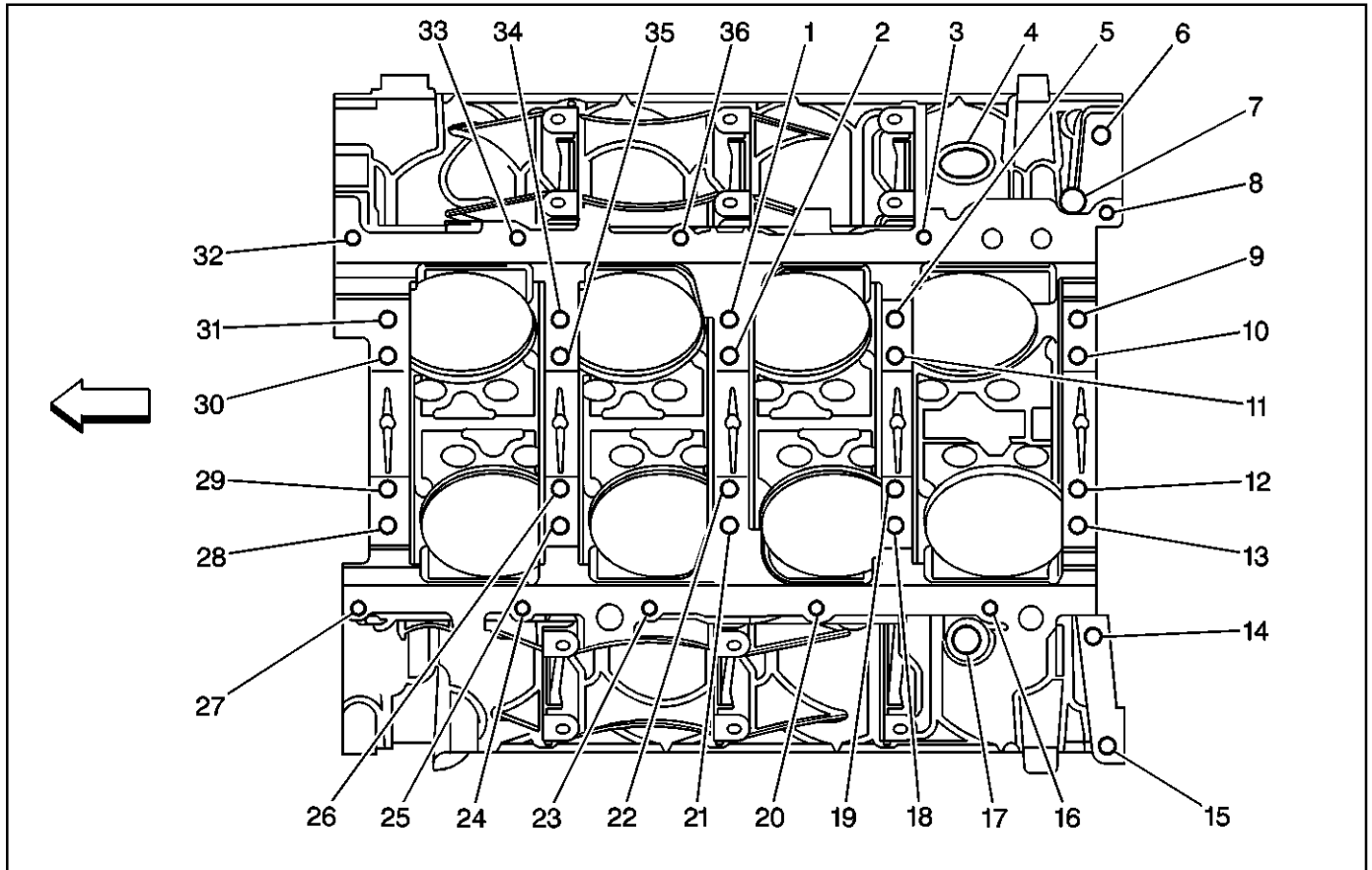
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Engine Block-Right Side View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
2-3	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
4	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
5	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.590)
6-7	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
8	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
9	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
10	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
11-14	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
15-18	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	29.0 (1.14)	23.0 (0.905)
19	M16 X 1.5							
20	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
21	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
22	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	69.0 (2.72)	60.0 (2.36)
23	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
24-25	M11 X 2.0	J 42385-108	J 42385-105		J 42385-106	J 42385-107	124.0 (4.88)	115.0 (4.52)
26	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.590)
27	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)

- Bolt holes 2, 3, 6, 7, 10, 21, 24 and 25 have a 85 mm (3.34 in) counterbore included in the 124.0 mm (4.88 in) drill depth.
- Bolt holes 9 and 22 have a 29 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.

Engine Block-Bottom View



260172

Engine Block-Bottom View

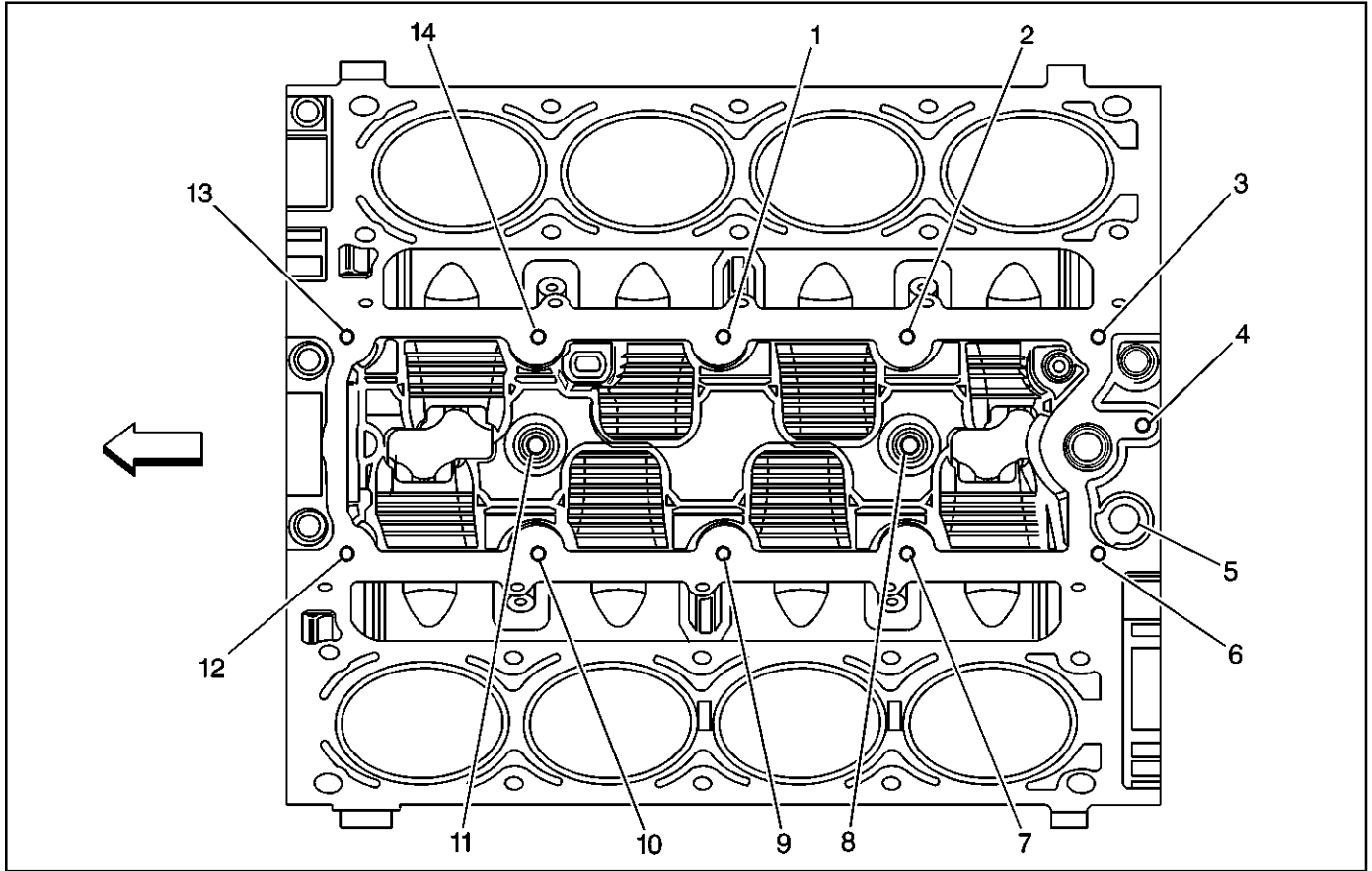
Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
2	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
3	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
4	M28 X 1.25							
5	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
6	N/A							
7	M16 X 1.5							
8	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
9	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
10-12	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
13	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
14-15	M10 X 1.5	J 42385-215	J 42385-101		J 42385-213	J 42385-214	42.5 (1.67)	37.0 (1.45)
16	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
17	M16 X 1.5							
18	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
19	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
20	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
21	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
22	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
23-24	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
25	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
26	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)

Engine Block-Bottom View (cont'd)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
27	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
28	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
29-30	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
31	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
32-33	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
34	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
35	M10 X 2.0	J 42385-104	J 42385-101		J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
36	M8 X 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

- Bolt holes 2, 10, 11, 12, 19, 22, 26, 29, 30 and 35 have a 20.5 mm (0.807 in) counterbore included in the 53.5 mm (2.10 in) drill depth.
- Bolt holes 1, 5, 9, 13, 18, 21, 25, 28, 31 and 34 have a 1.5 mm (0.059 in) counterbore included in the 31.0 mm (1.22 in) drill depth. Use sleeve J 42385-316 with the drill and tap.
- Bolt holes 14 and 15 have a 11.5 mm (0.452 in) counterbore included in the 42.5 mm (1.67 in) drill depth. Use sleeve J 42385-311 with the drill and tap.

Engine Block-Top View

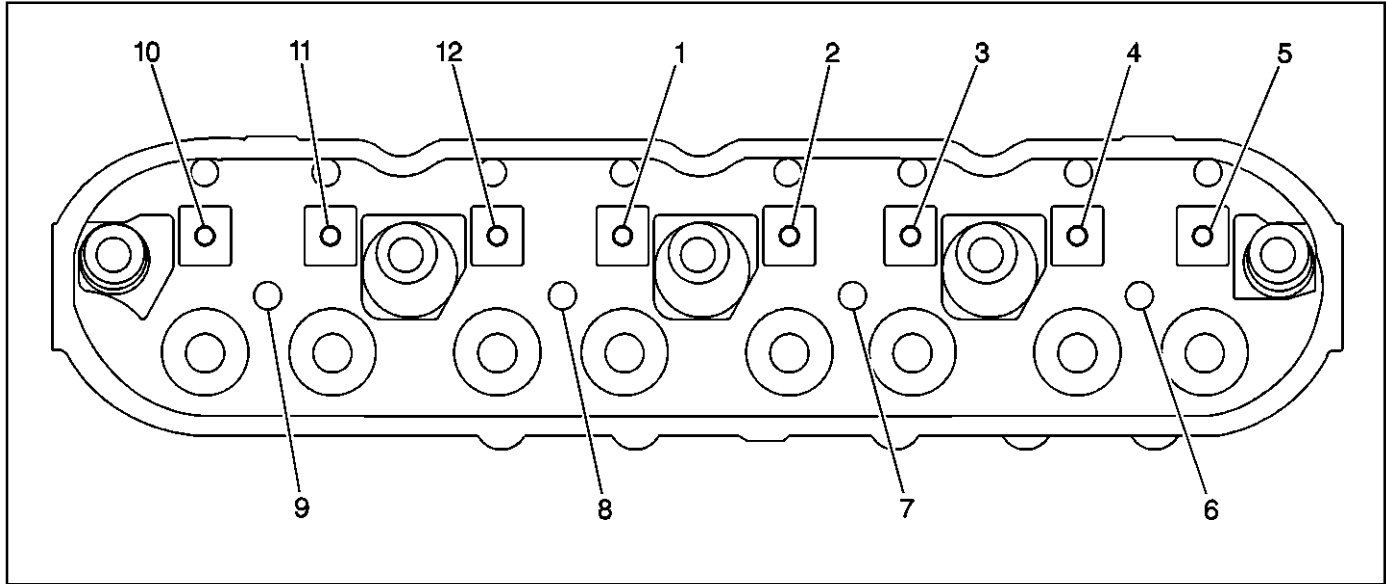


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Engine Block-Top View

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

Cylinder Head-Top View

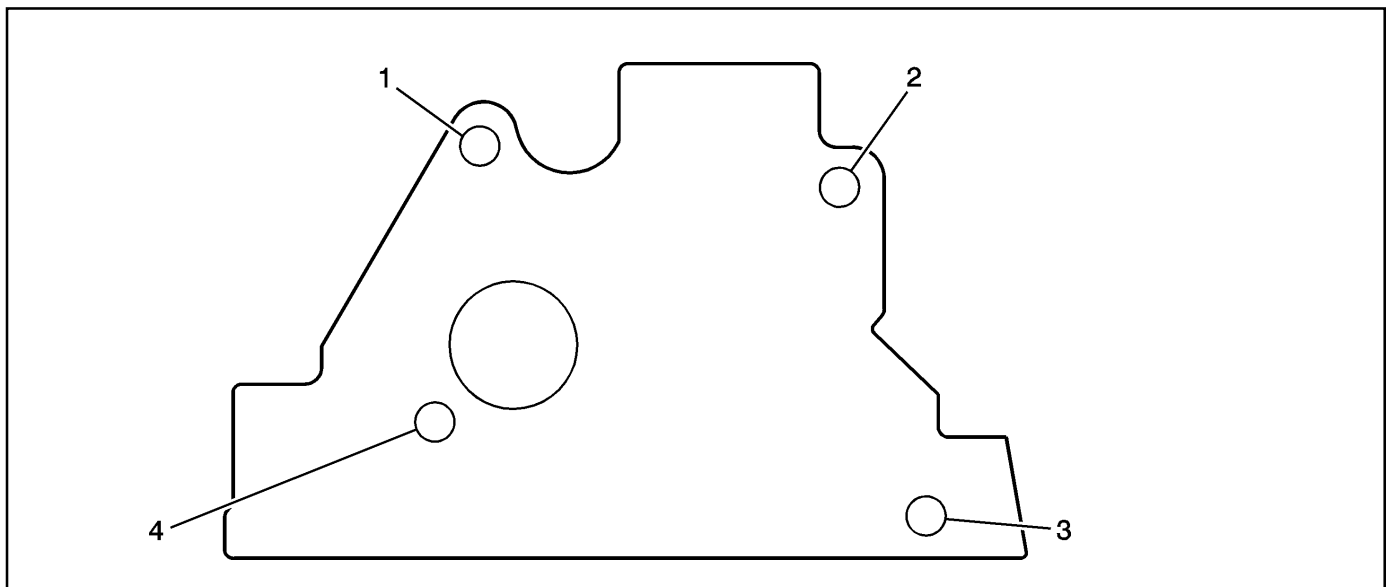


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Cylinder Head-Top View

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

Cylinder Head-End View

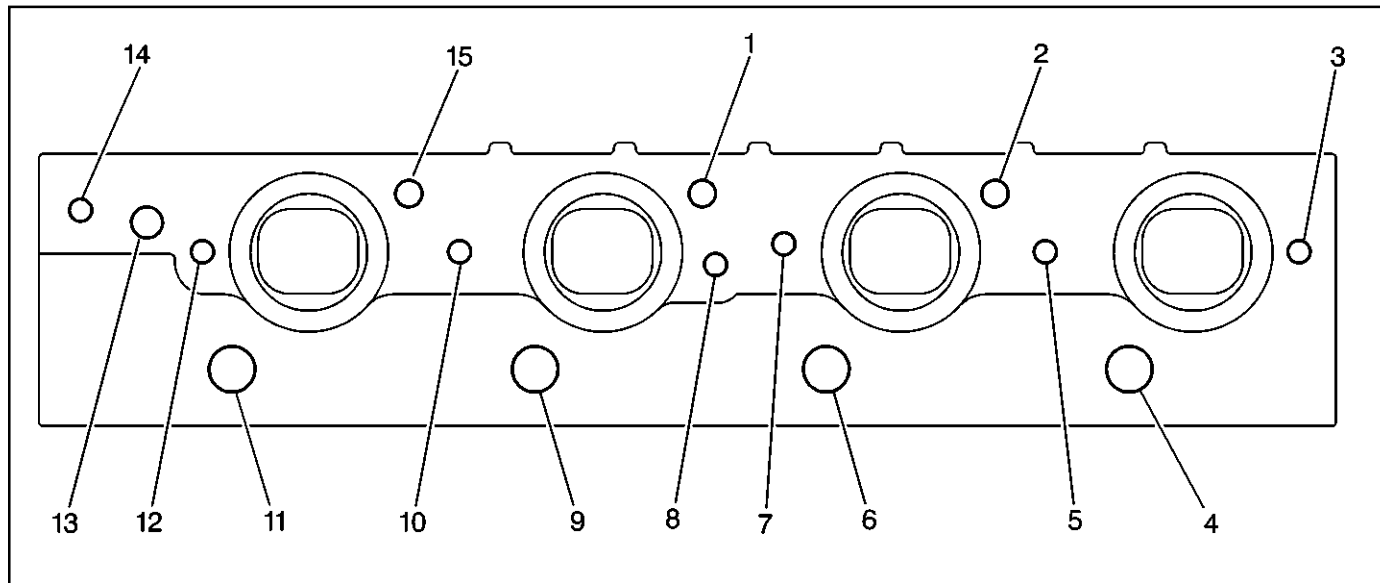


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Cylinder Head-End View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1-4	M10 X 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)

Cylinder Head-Exhaust Manifold Deck View

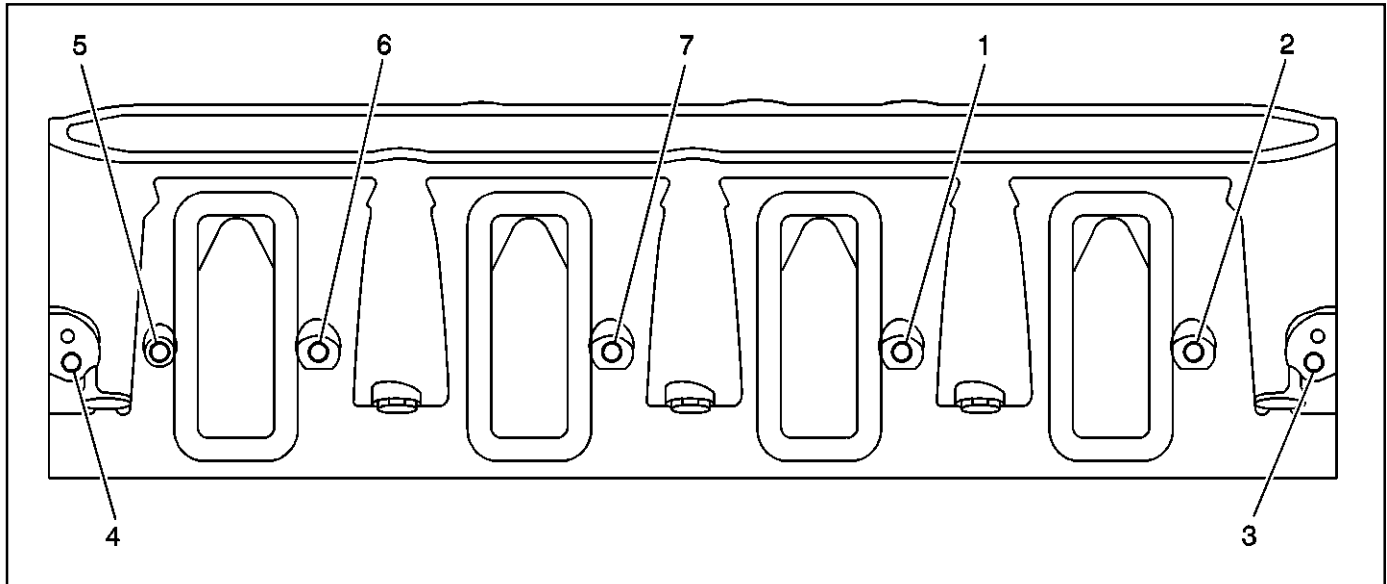


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Cylinder Head-Exhaust Manifold Deck View

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

Cylinder Head-Intake Manifold Deck View



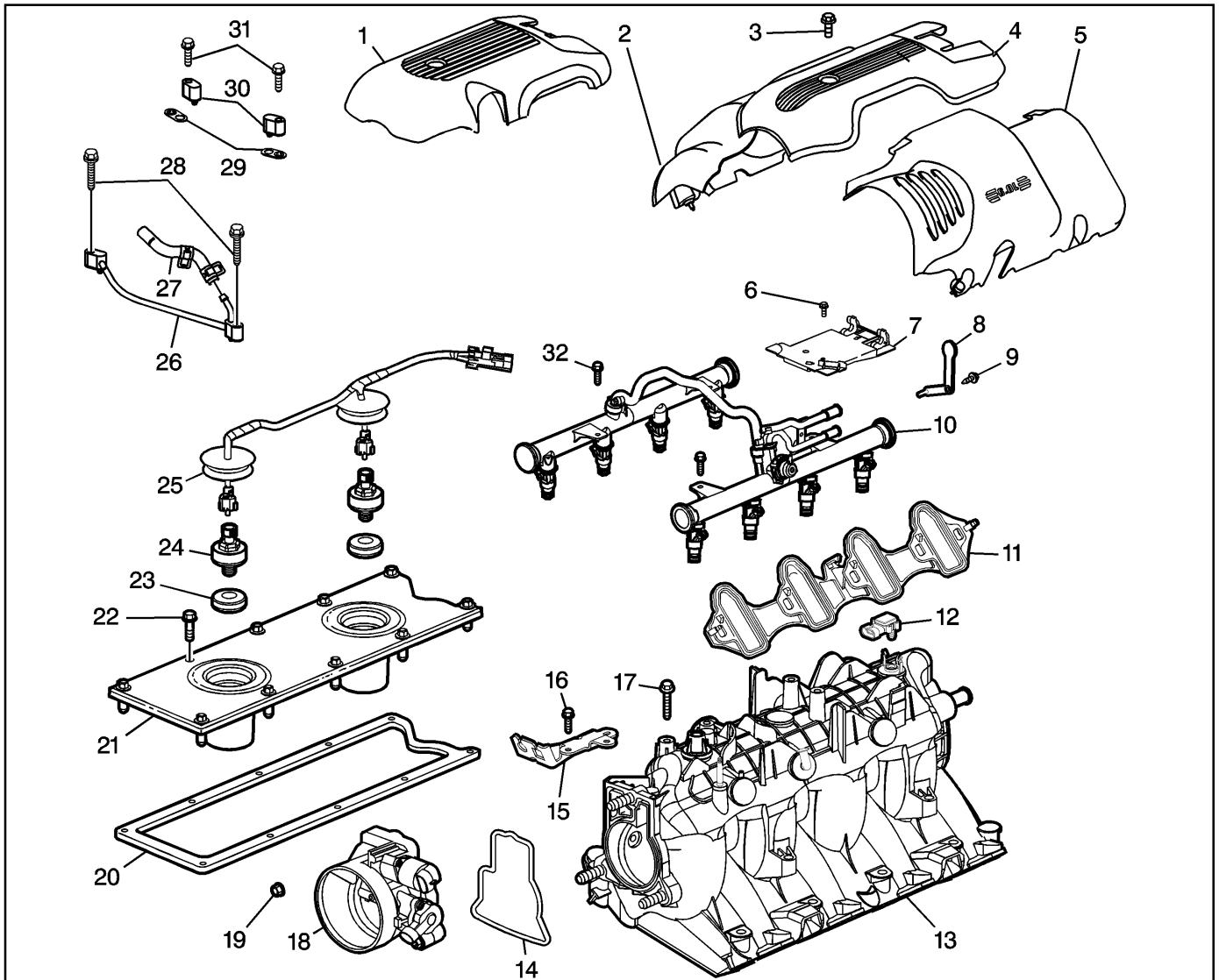
260169

Cylinder Head-Intake Manifold Deck View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum) mm (in)	Tap Depth (Maximum) mm (in)
1-2	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	Thru	Thru
3-4	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	22.5 (0.885)	15.0 (0.688)
5-7	M6 X 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	Thru	Thru

Component Locator
Disassembled Views

Intake Manifold/Upper Engine



Legend

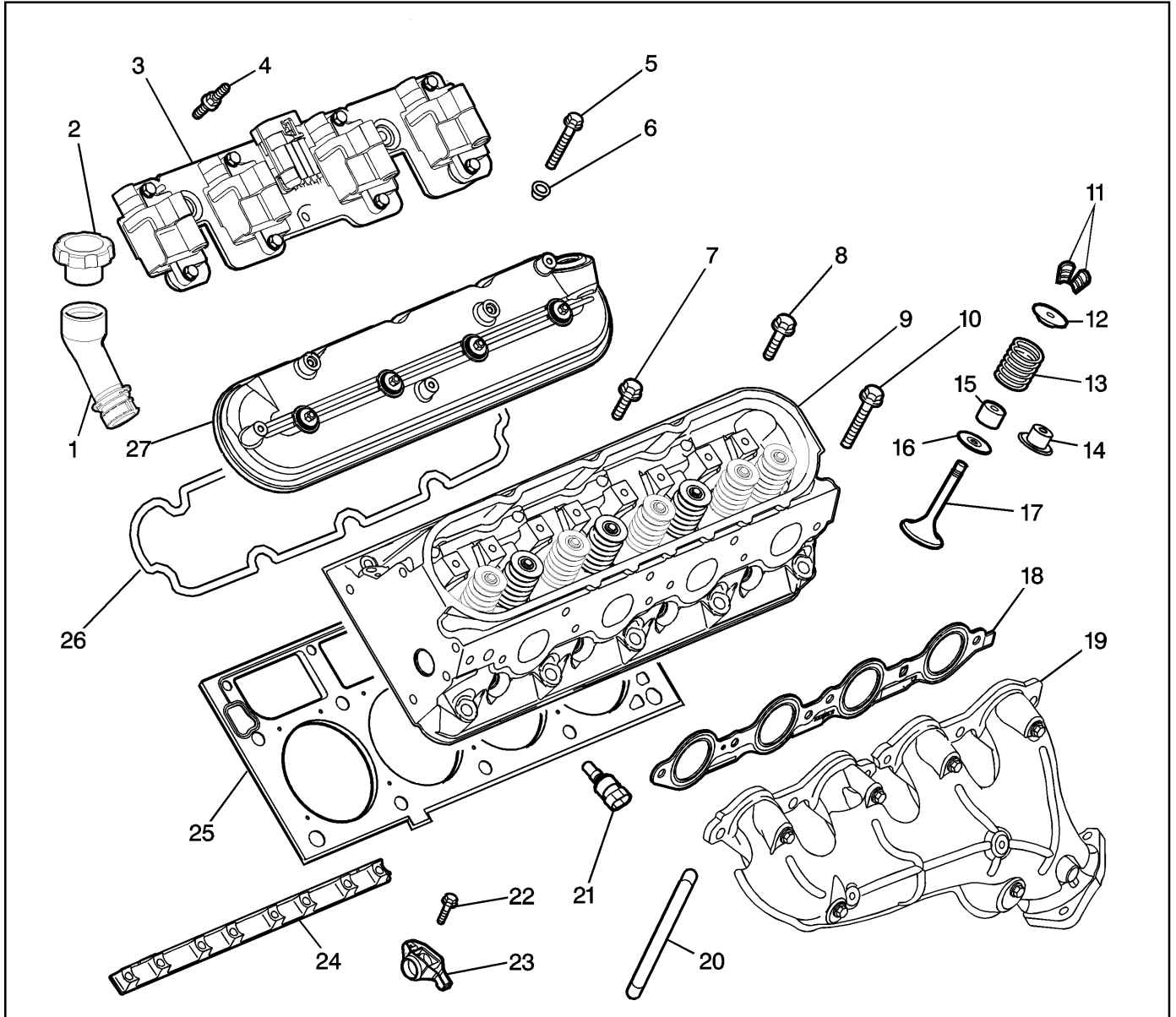
790768

- | | |
|--|---|
| (1) Engine Sight Shield (4.8,5.3L) | (15) Throttle Cable Bracket |
| (2) Engine Sight Shield (Right Side 6.0L) | (16) Throttle Cable Bracket Bolt |
| (3) Engine Sight Shield Bolt | (17) Intake Manifold Bolt |
| (4) Engine Sight Shield (Center 6.0L) | (18) Throttle Body |
| (5) Engine Sight Shield (Left Side 6.0L) | (19) Throttle Body Nut |
| (6) Engine Sight Shield Bracket Bolt | (20) Valley Cover Gasket |
| (7) Engine Sight Shield Bracket | (21) Valley Cover |
| (8) Fuel Rail Stop Bracket | (22) Valley Cover Bolt |
| (9) Fuel Rail Stop Bracket Bolt | (23) Knock Sensor Oil Seal |
| (10) Fuel Rail (with Injectors) | (24) Knock Sensor |
| (11) Intake Manifold Gasket | (25) Knock Sensor Wire Harness |
| (12) Manifold Absolute Pressure (Map) Sensor | (26) Engine Coolant Air Bleed Pipe |
| (13) Intake Manifold | (27) Engine Coolant Air Bleed Pipe Hose |
| (14) Throttle Body Gasket | (28) Engine Coolant Air Bleed Pipe Bolt |

(29) Engine Coolant Air Bleed Pipe/Cover Gasket
(30) Engine Coolant Air Bleed Pipe Cover

(31) Engine Coolant Air Bleed Pipe/Cover Bolt
(32) Fuel Rail Bolt

Cylinder Head/Upper Engine

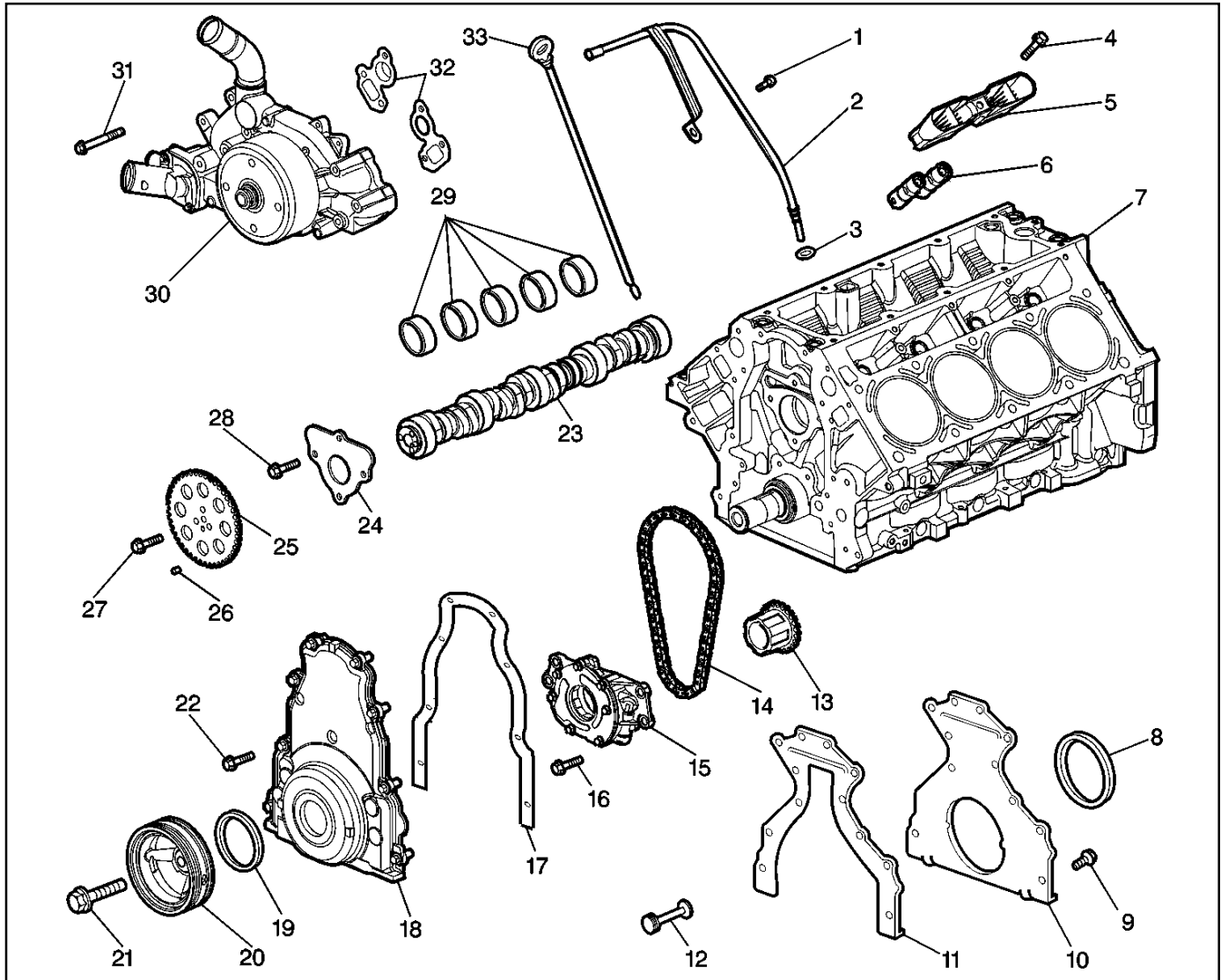


Legend

741561

- | | |
|---|--|
| (1) Oil Fill Tube | (15) Valve Stem Oil Seal (First Design) |
| (2) Oil Fill Tube Cap | (16) Valve Spring Shim (First Design) |
| (3) Ignition Coil and Bracket Assembly | (17) Valve |
| (4) Ignition Coil and Bracket Assembly Bolt | (18) Exhaust Manifold Gasket |
| (5) Valve Rocker Arm Cover Bolt | (19) Exhaust Manifold (with Heat Shield) |
| (6) Valve Rocker Arm Cover Bolt Grommet | (20) Push Rod |
| (7) Cylinder Head Bolt (Short) | (21) Coolant Temperature Sensor |
| (8) Cylinder Head Bolt (Medium) | (22) Valve Rocker Arm Bolt |
| (9) Cylinder Head | (23) Valve Rocker Arm |
| (10) Cylinder Head Bolt (Long) | (24) Valve Rocker Arm Pivot Support |
| (11) Valve Stem Keys | (25) Cylinder Head Gasket |
| (12) Valve Spring Cap | (26) Valve Rocker Arm Cover Gasket |
| (13) Valve Spring | (27) Valve Rocker Arm Cover |
| (14) Valve Stem Oil Seal (Second Design) | |

Lower Front of Engine

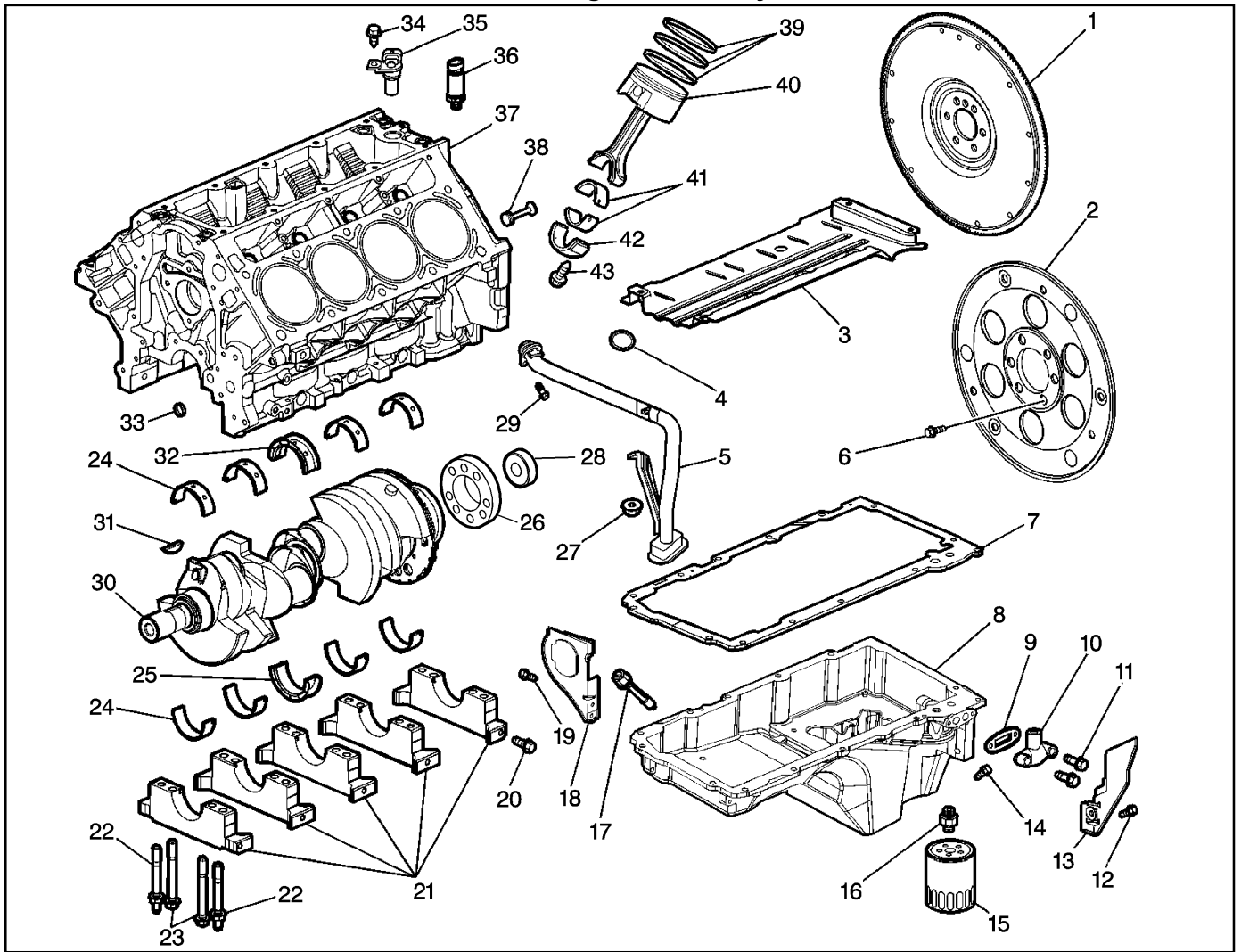


260163

Legend

- | | |
|--|-------------------------------------|
| (1) Oil Level Indicator Tube Bolt | (17) Engine Front Cover Gasket |
| (2) Oil Level Indicator Tube | (18) Engine Front Cover |
| (3) Oil Level Indicator Tube O-ring Seal | (19) Crankshaft Front Oil Seal |
| (4) Valve Lifter Guide Bolt | (20) Crankshaft Balancer |
| (5) Valve Lifter Guide | (21) Crankshaft Balancer Bolt |
| (6) Valve Lifter | (22) Engine Front Cover Bolt |
| (7) Engine Block | (23) Camshaft |
| (8) Crankshaft Rear Oil Seal | (24) Camshaft Retainer |
| (9) Engine Rear Cover Bolt | (25) Camshaft Sprocket |
| (10) Engine Rear Cover | (26) Camshaft Sprocket Locating Pin |
| (11) Engine Rear Cover Gasket | (27) Camshaft Sprocket Bolt |
| (12) Engine Block Rear Oil Gallery Plug | (28) Camshaft Retainer Bolt |
| (13) Crankshaft Sprocket | (29) Camshaft Bearings |
| (14) Timing Chain | (30) Water Pump |
| (15) Oil Pump Assembly | (31) Water Pump Bolt |
| (16) Oil Pump Bolt | (32) Water Pump Gaskets |
| | (33) Oil Level Indicator |

Lower Engine Assembly



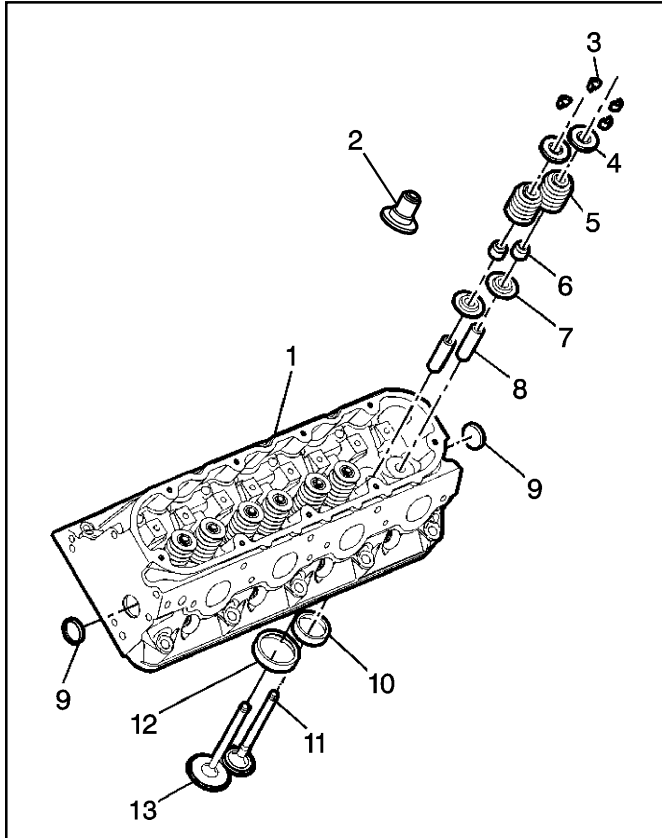
642273

Legend

- | | |
|--|---|
| (1) Flywheel (Manual Transmission) | (17) Oil Level Sensor |
| (2) Flywheel (Automatic Transmission) | (18) Oil Pan Closeout Cover (Right Side) |
| (3) Crankshaft Oil Deflector | (19) Oil Pan Closeout Cover Bolt (Right Side) |
| (4) Oil Pump Screen O-Ring Seal | (20) Crankshaft Bearing Cap Side Bolt |
| (5) Oil Pump Screen | (21) Crankshaft Bearing Caps |
| (6) Flywheel Bolt | (22) Crankshaft Bearing Cap Bolt/Stud |
| (7) Oil Pan Gasket | (23) Crankshaft Bearing Cap Bolt |
| (8) Oil Pan | (24) Crankshaft Bearing |
| (9) Oil Pan Cover Gasket | (25) Crankshaft Thrust Bearing (Lower) |
| (10) Oil Pan Cover | (26) Spacer |
| (11) Oil Pan Cover Bolt | (27) Oil Pump Screen Nut |
| (12) Oil Pan Closeout Cover Bolt (Left Side) | (28) Clutch Pilot Bearing |
| (13) Oil Pan Closeout Cover (Left Side) | (29) Oil Pump Screen Bolt |
| (14) Oil Pan Drain Plug | (30) Crankshaft |
| (15) Oil Filter | (31) Crankshaft Sprocket Key |
| (16) Oil Filter Adapter | (32) Crankshaft Thrust Bearing (Upper) |

-
- | | |
|--|---|
| (33) Engine Block Front Oil Gallery Plug | (39) Piston Rings |
| (34) Camshaft Position Sensor Bolt | (40) Piston and Connecting Rod Assembly |
| (35) Camshaft Position Sensor | (41) Connecting Rod Bearings |
| (36) Oil Pressure Sensor | (42) Connecting Rod Cap |
| (37) Engine Block | (43) Connecting Rod Bolt |
| (38) Engine Block Rear Oil Gallery Plug | |
-

Cylinder Head Assembly (Aluminum)

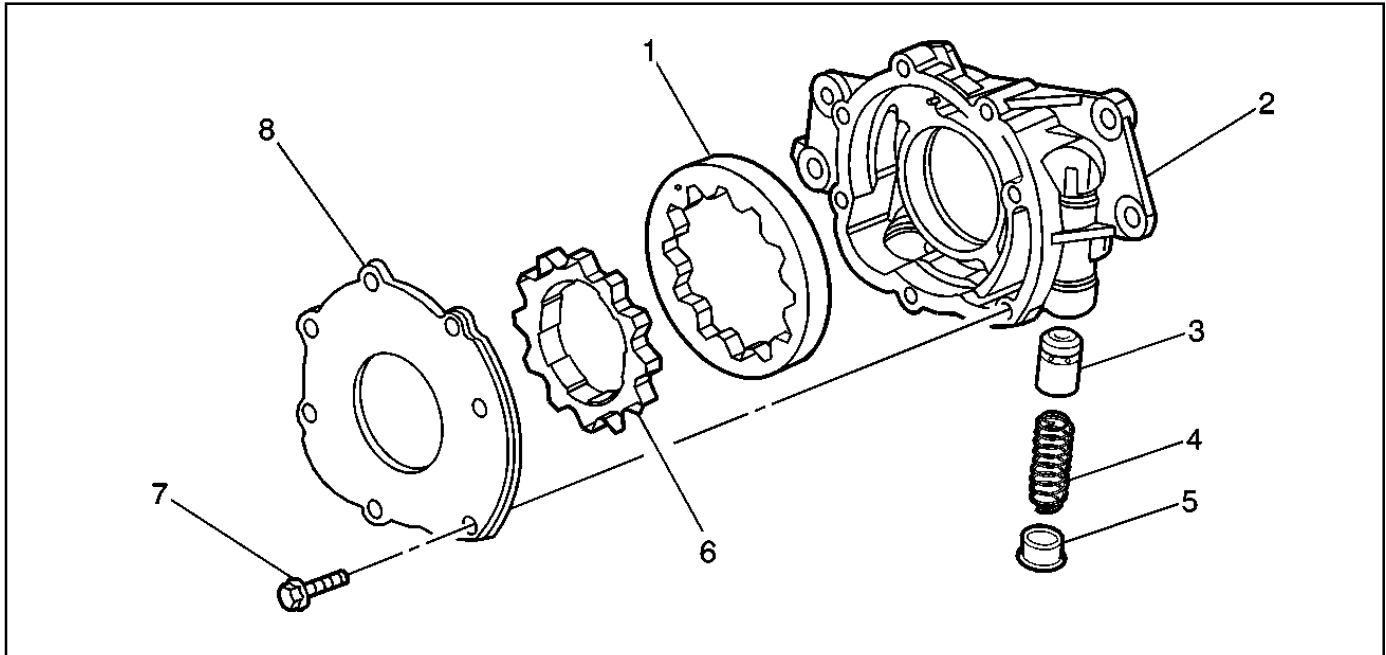


721939

Legend

- (1) Cylinder Head
- (2) Valve Stem Oil Seal and Shim Assembly (Second Design)
- (3) Valve Stem Keys
- (4) Valve Spring Cap
- (5) Valve Spring
- (6) Valve Stem Oil Seal (First Design)
- (7) Valve Spring Shim (First Design)
- (8) Valve Guide
- (9) Cylinder Head Expansion Plugs
- (10) Exhaust Valve Seat
- (11) Exhaust Valve
- (12) Intake Valve Seat
- (13) Intake Valve

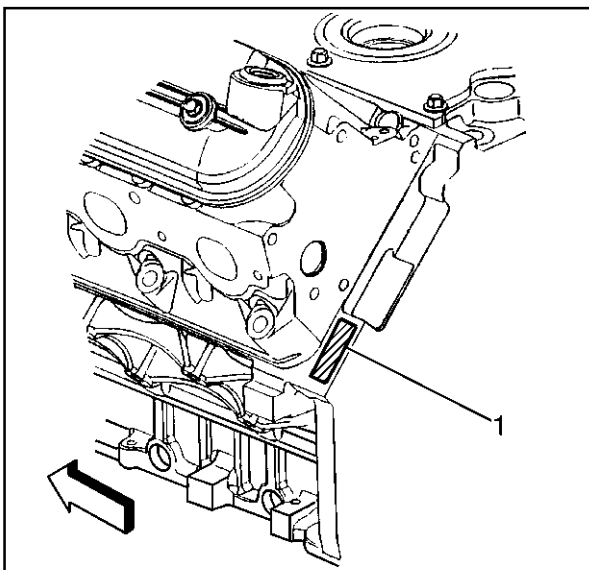
Oil Pump Assembly



64190

Legend

- | | |
|----------------------------------|----------------|
| (1) Driven Gear | (5) Plug |
| (2) Oil Pump Housing | (6) Drive Gear |
| (3) Pressure Relief Valve | (7) Cover Bolt |
| (4) Pressure Relief Valve Spring | (8) Cover |



260136

Engine Identification

The engine identification numbers and bar-coded label (1) are located at the left rear of the engine block. A second bar-coded label may be located on the right side of the oil pan.

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Repair Instructions

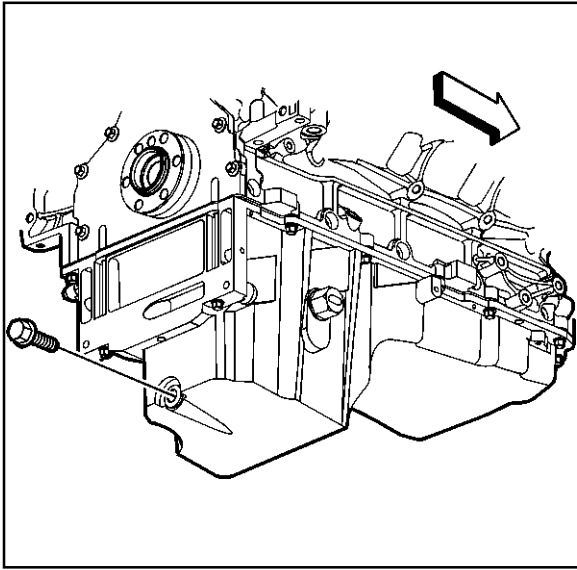
Draining Fluids and Oil Filter Removal

Tools Required

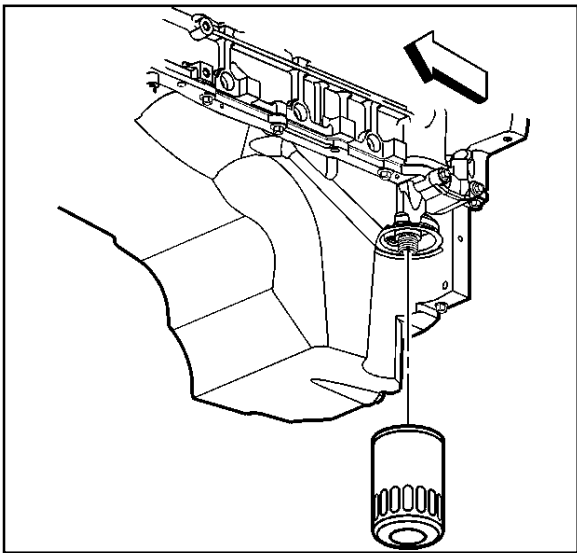
J 41712 Oil Pressure Sensor Socket

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

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

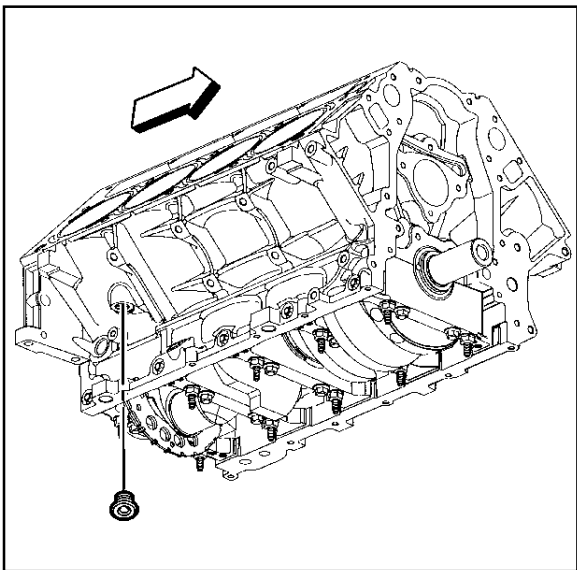


260111



260117

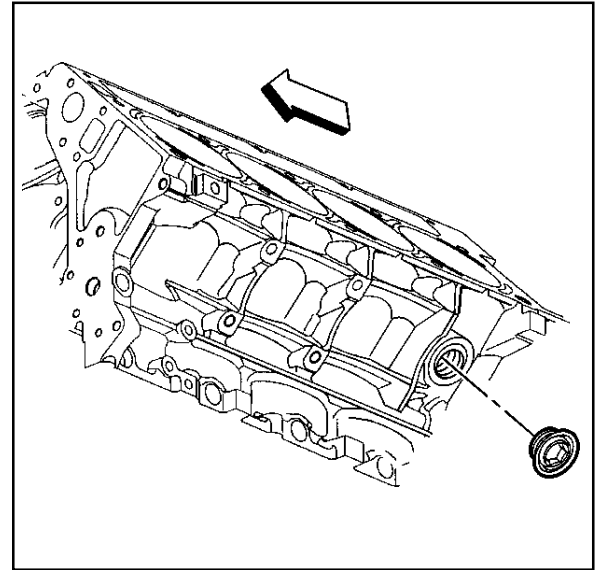
2. Remove the engine oil filter.



63164

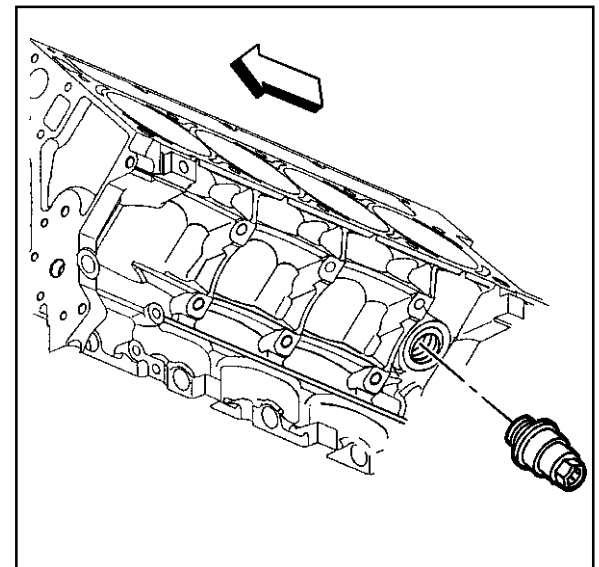
3. Remove the right rear engine block coolant drain plug and allow the coolant to drain.

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



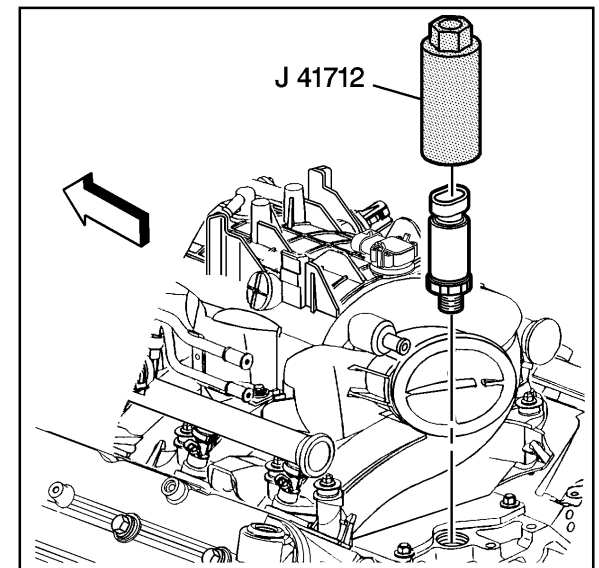
260138

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

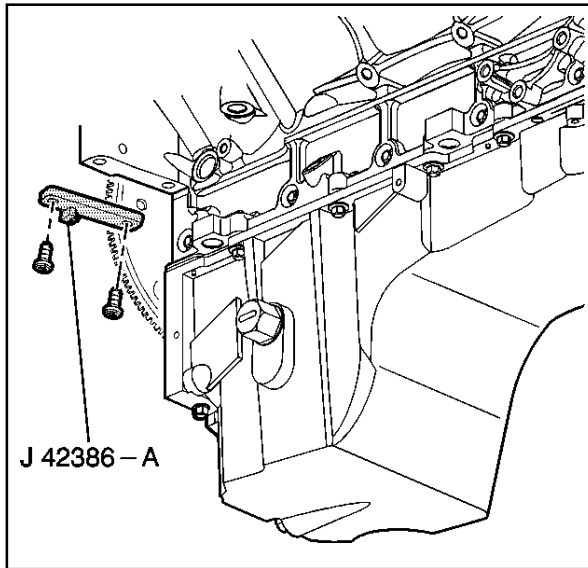


260137

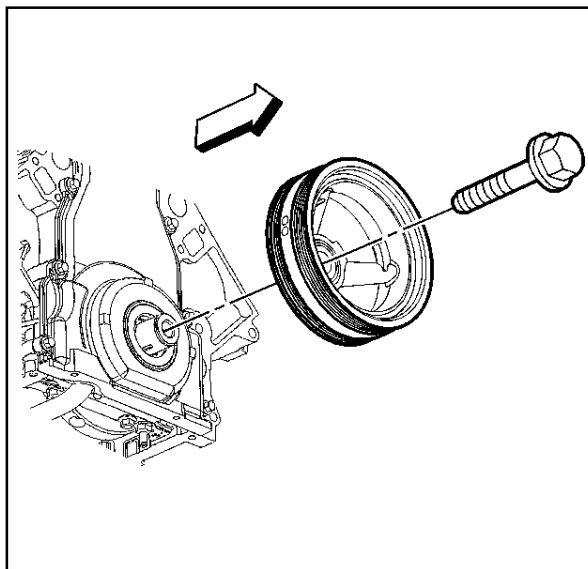
- 6. Use the J 41712 or equivalent in order to remove the oil pressure sensor, if required.



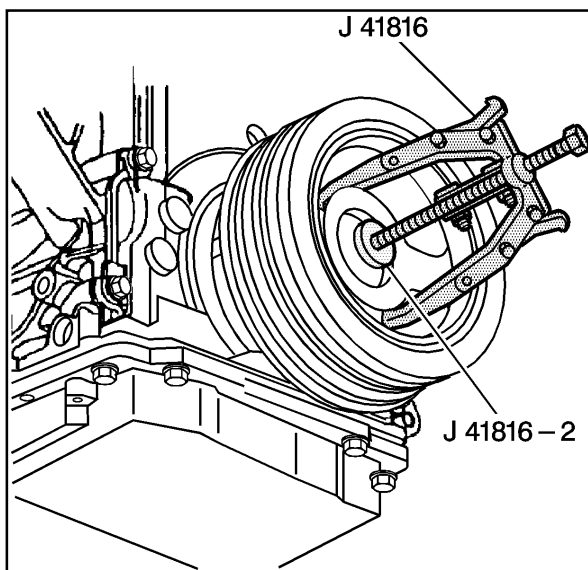
260089



260126



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156164

Crankshaft Balancer Removal

Tools Required

- J 41816 Crankshaft Balancer Remover
- J 41816-2 Crankshaft End Protector
- J 42386-A Flywheel holding tool

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

Important:

- Do not reuse the crankshaft balancer bolt. Install a NEW bolt during final assembly.
- Make sure teeth of the flywheel holding tool mesh with the teeth of the engine flywheel.

1. Install the J 42386-A and bolts.

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

Tighten

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

2. Remove the crankshaft balancer bolt.

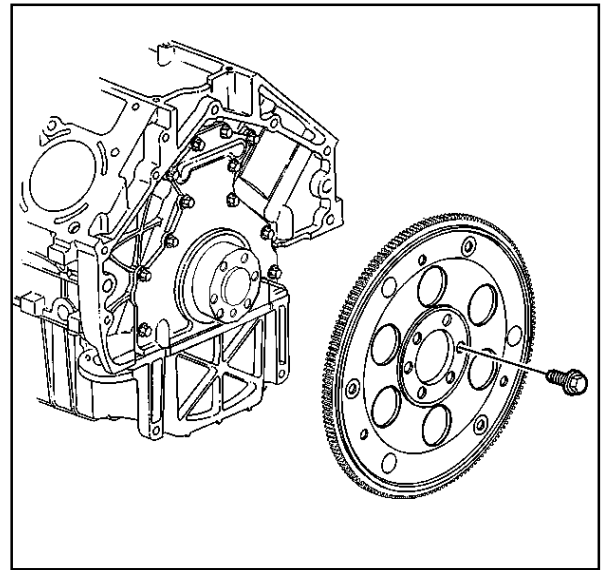
Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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

Engine Flywheel Removal

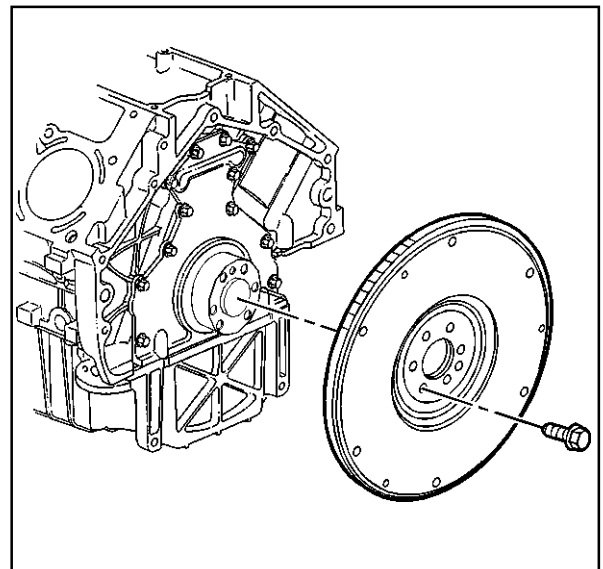
Important: Note the position and direction of the engine flywheel before removal. The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure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

1. Remove the engine flywheel bolts.
2. Remove the automatic transmission engine flywheel, if applicable.



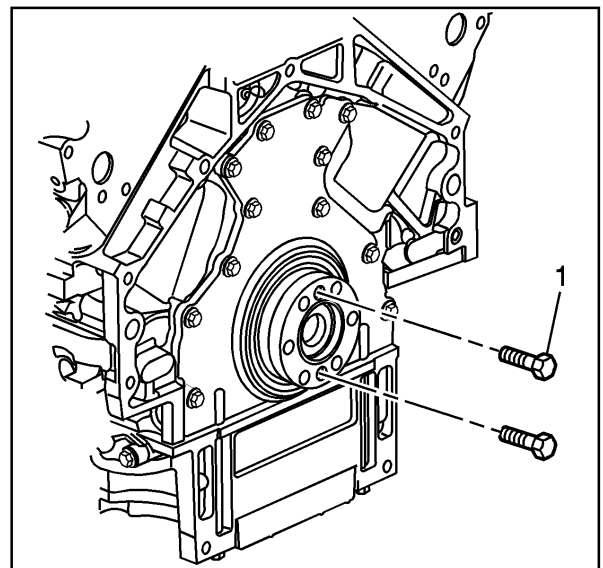
178458

3. Remove the manual transmission flywheel, if applicable.

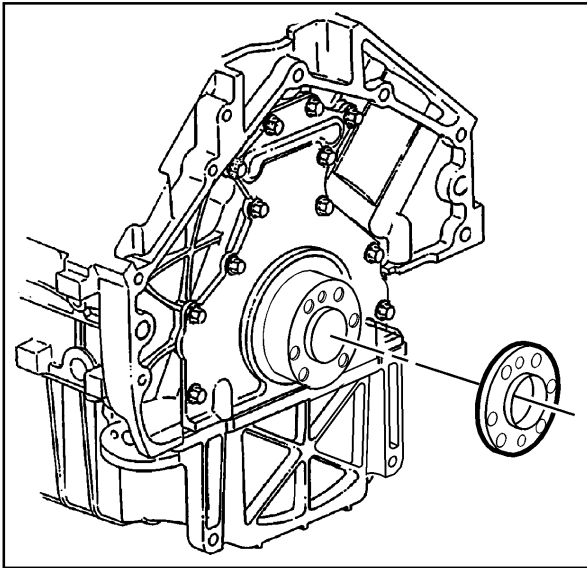


156166

4. Install two M11 x 1.5 mm bolts (1) into the threaded holes of the spacer, if applicable.
5. Rotate the bolts clockwise to remove the spacer.

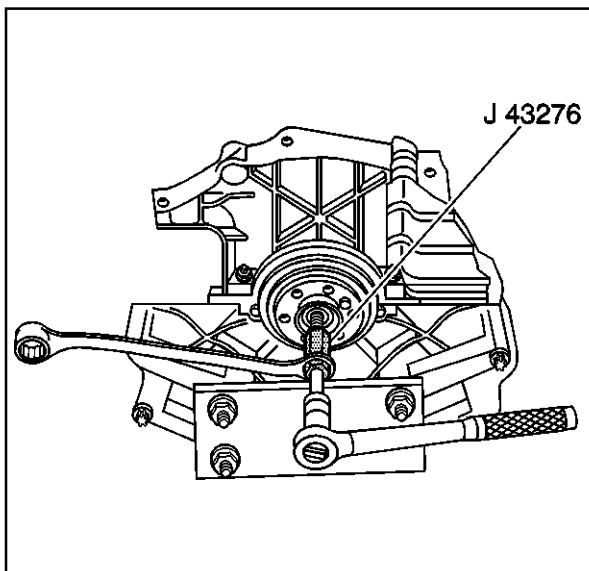


642281



642276

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



353275

Clutch Pilot Bearing Removal

Tools Required

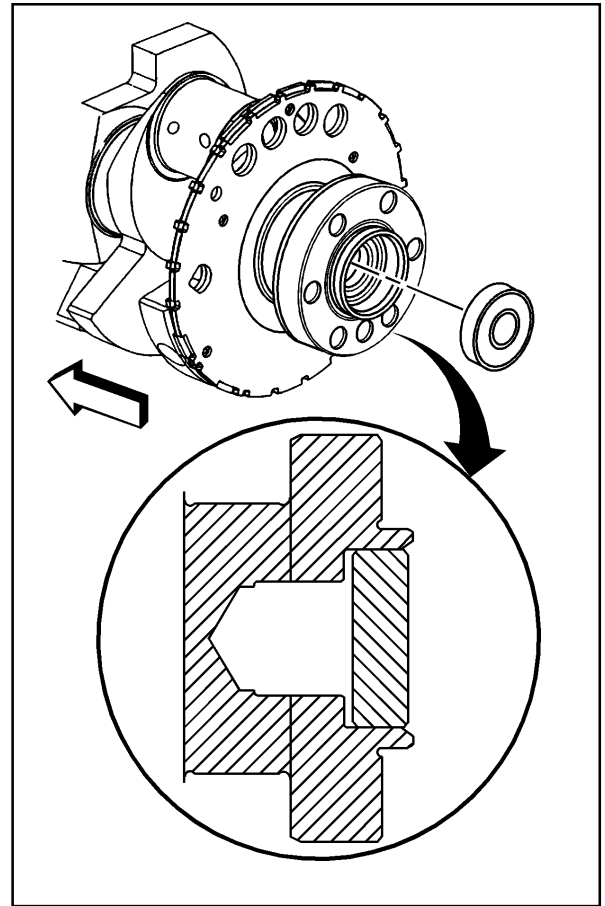
J 43276 Clutch Pilot Bearing Remover

Notice: When using the *J 43276* Clutch Pilot Bearing Remover, always secure the *J 43276-1* Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the *J 43276-1* tool body to rotate. Failing to do so will cause damage to the *J 43276-1* tool body.

Important: The flywheel spacer, if applicable, must be removed prior to clutch bearing removal.

1. Remove the clutch pilot bearing using the *J 43276*.
 - 1.1. Install the *J 43276-1* into the clutch pilot bearing.
 - 1.2. Using a wrench secure the *J 43276-1*.
 - 1.3. Insert the *J 43276-2* into the *J 43276-1*.
 - 1.4. Rotate the *J 43276-2* clockwise into the *J 43276-1* until the clutch pilot bearing is completely removed from the crankshaft.
 - 1.5. Rotate the *J 43276-2* counterclockwise to remove the *J 43276-2* from the *J 43276-1*.
 - 1.6. Remove the *J 43276-1* from the tool body.

2. Discard the pilot bearing.



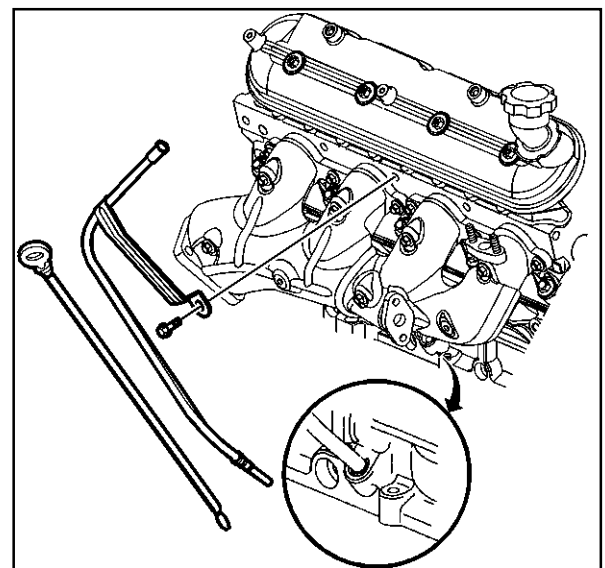
642283

Oil Level Indicator and Tube Removal

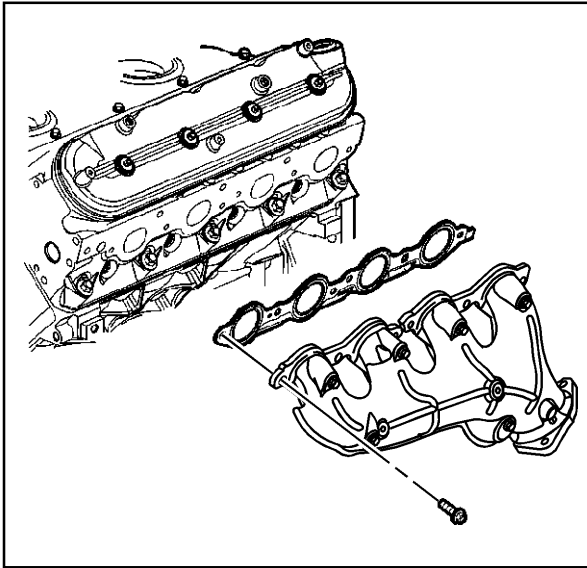
1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

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

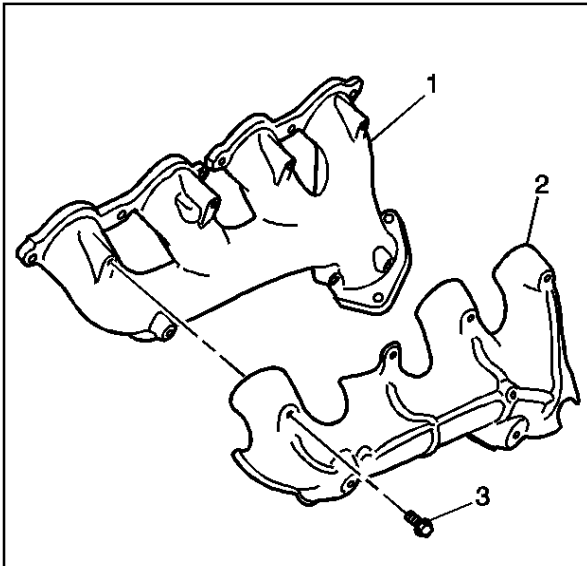
4. Remove the O-ring seal from the tube, if required.



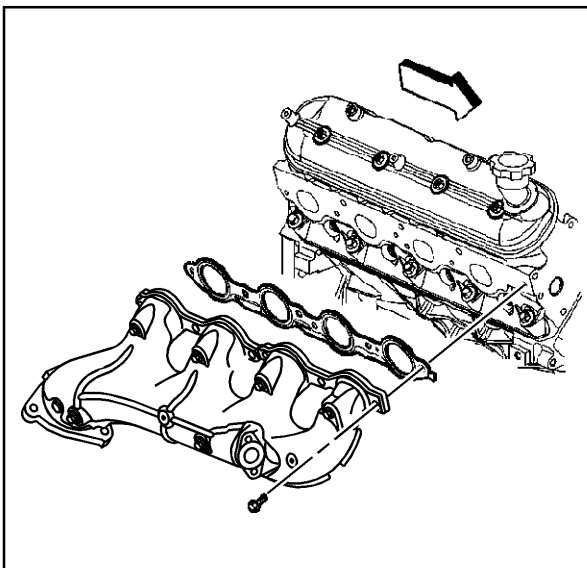
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Exhaust Manifold Removal-Left

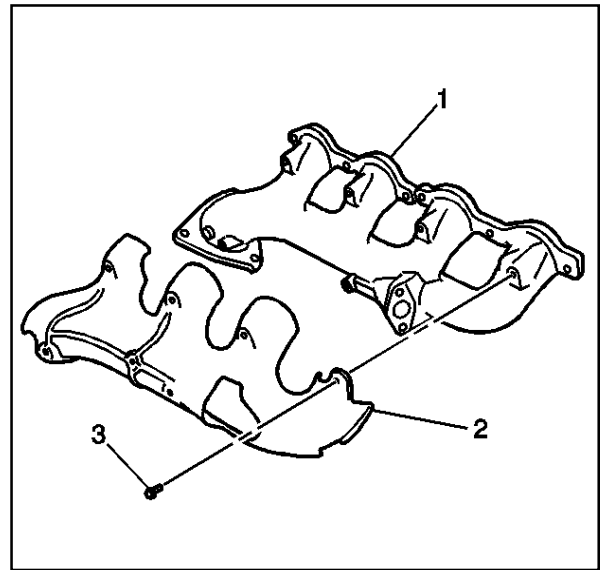
1. Remove the spark plug wires from the spark plugs.
Do not remove the spark plug wires from the ignition coil unless required.
2. Remove the exhaust manifold, bolts and gasket.
3. Discard the gasket.

4. Remove the heat shield (2) and bolts (3) from the manifold (1), if required.

Exhaust Manifold Removal-Right

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

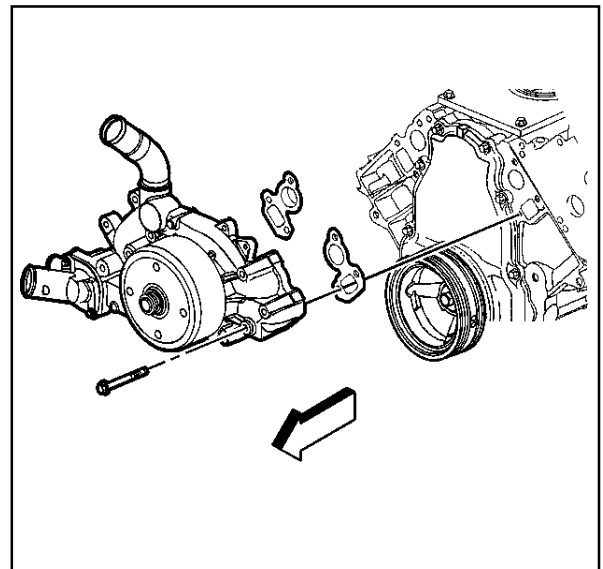
4. Remove the heat shield (2) and bolts (3) from the manifold (1), if required.



492768

Water Pump Removal

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

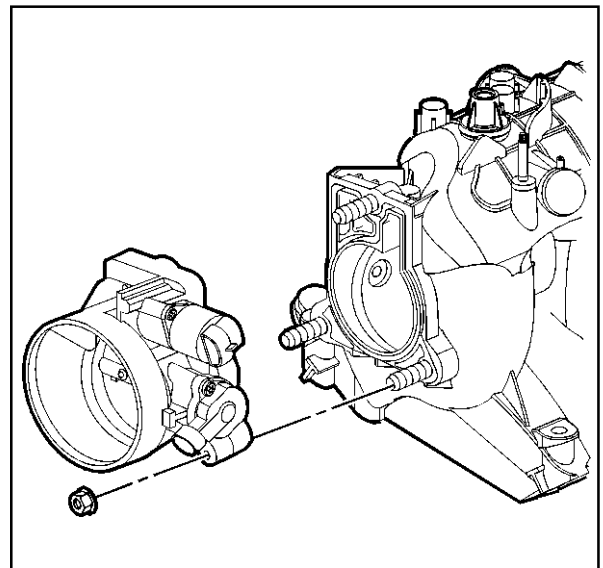


260121

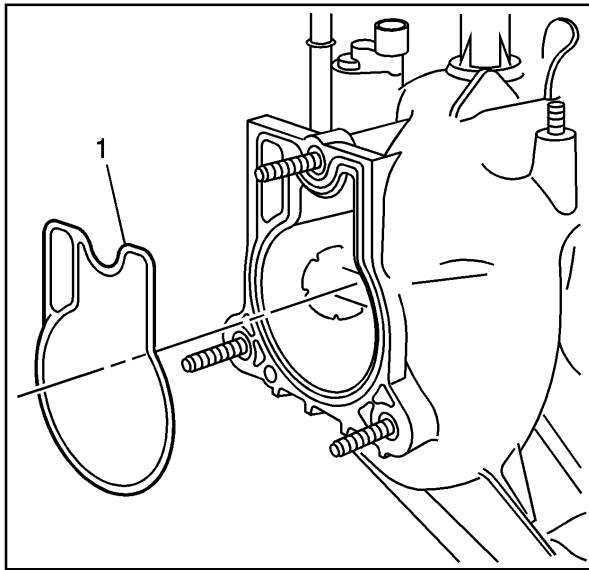
Throttle Body Removal

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

1. Remove the engine sight shield and bolts, if required.
2. Remove the engine sight shield mounting bracket and bolts, if required.
3. Remove the electrical wire harness connectors from the throttle body.
4. Remove the engine coolant air bleed hose and clamp.
5. Remove the throttle body nuts.
6. Remove the throttle body.

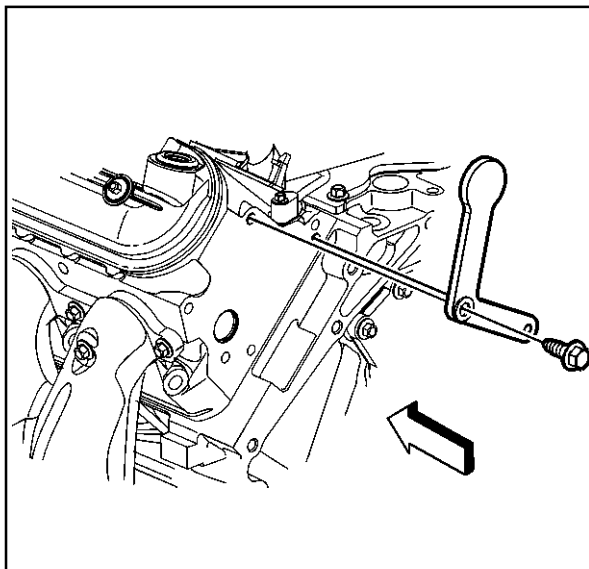


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7. Remove throttle body gasket (1).
8. Discard the gasket.
9. Remove the throttle body studs, if required.



260098

Fuel Rail and Injectors Removal

Caution: The fuel rail stop bracket must be installed onto the engine assembly. The stop bracket serves as a protective shield for the fuel rail in the event of a vehicle frontal crash. If the fuel rail stop bracket is not installed and the vehicle is involved in a frontal crash, fuel could be sprayed possibly causing a fire and personal injury from burns.

Notice:

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

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

1. Remove the fuel rail stop bracket and bolt, if required.
2. Remove the vacuum hose from the fuel pressure regulator.

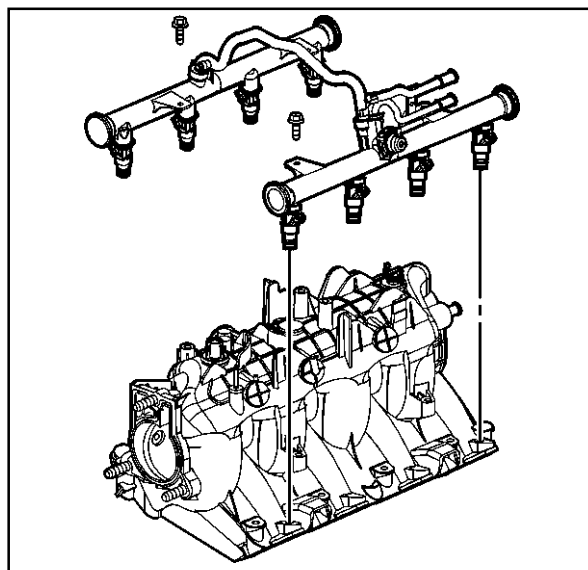
3. Loosen the crossover tube-to-right fuel rail retaining bolt.
4. Remove the fuel rail bolts.

Important: Do not separate the fuel injectors from the fuel rail unless component service is required.

Use cleanliness and care when handling the fuel system components.

Do not allow dirt or debris to enter the fuel injectors or fuel rail components, cap ends as necessary.

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



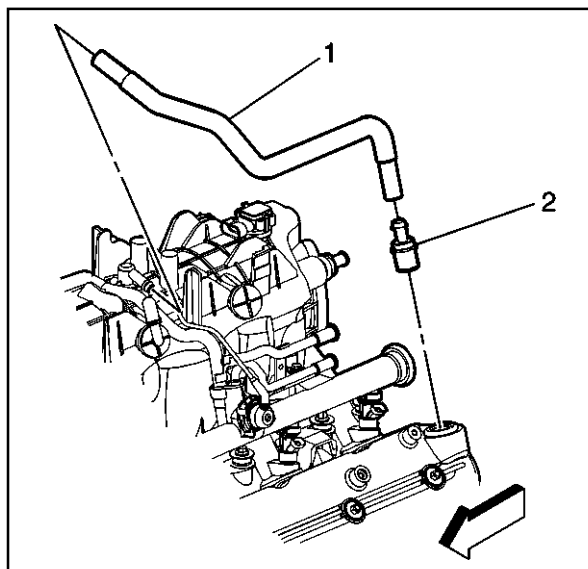
260176

Intake Manifold Removal

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

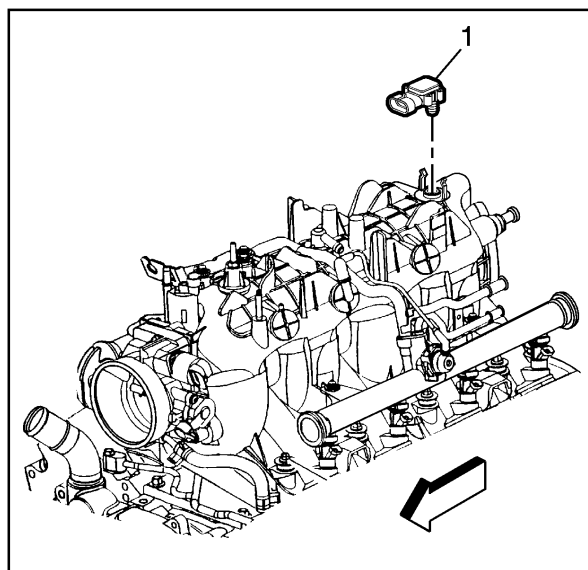
DO NOT reuse the intake manifold-to-cylinder head gaskets.

1. Remove the Positive Crankcase Ventilation (PCV) hose (1) and valve (2).

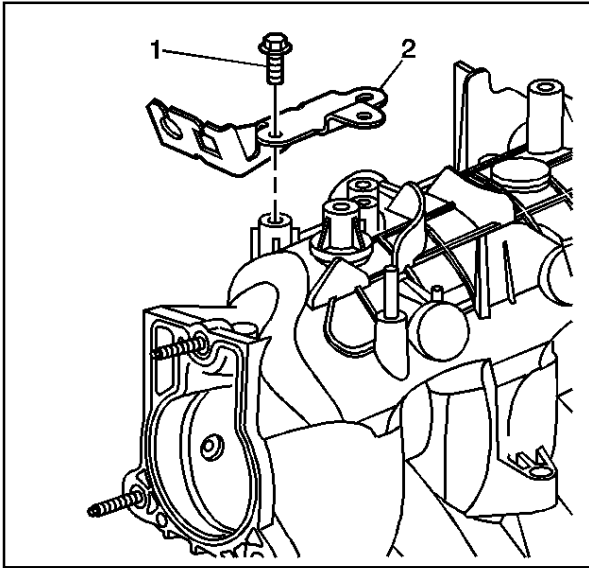


260078

2. Remove the Manifold Absolute Pressure (MAP) sensor (1), if required.
3. Remove the engine coolant air bleed clamp and hose from the throttle body.

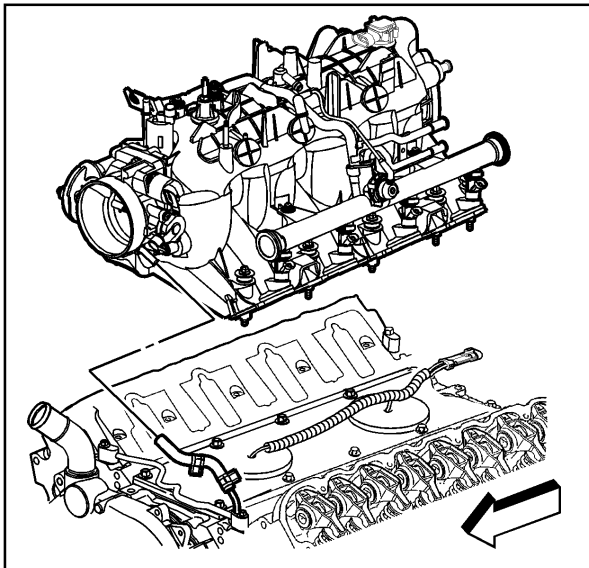


260159



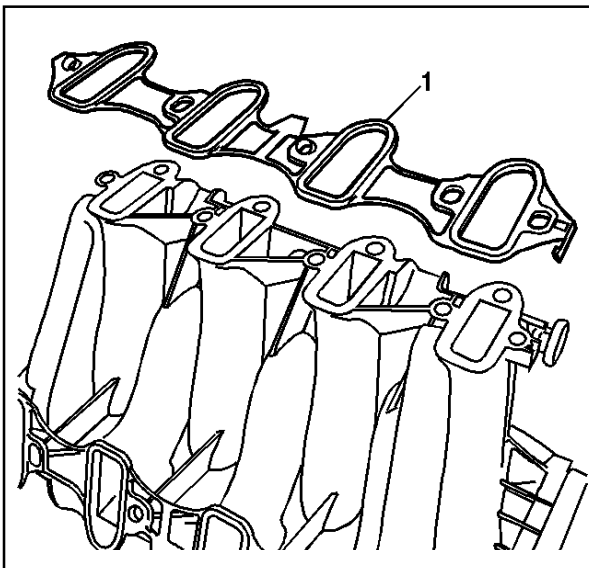
492765

4. Remove the accelerator control cable bracket (2) and bolts (1), if required.



642285

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

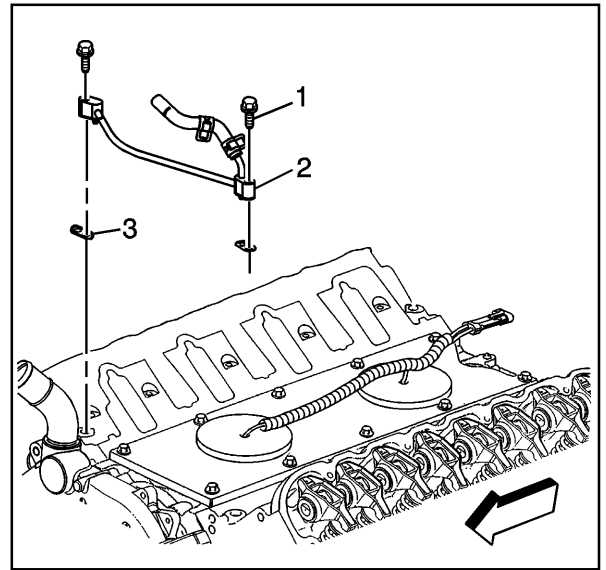


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7. Separate the intake manifold-to-cylinder head gaskets (1) from the manifold.
8. Discard the intake manifold gaskets.

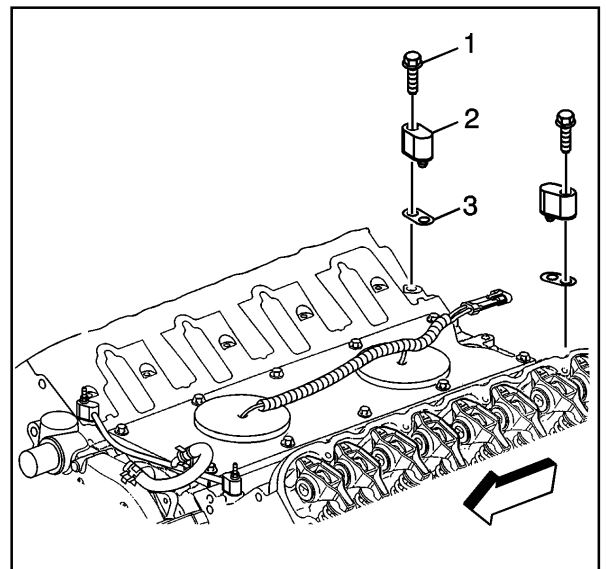
Coolant Air Bleed Pipe Removal

1. Remove the engine coolant air bleed pipe bolts (1).
2. Remove the pipe (2) and gaskets (3).



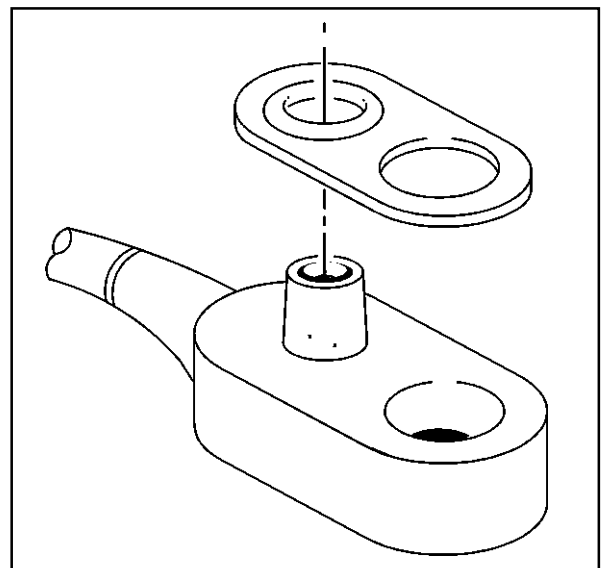
741555

3. Remove the engine coolant air bleed pipe hole cover bolts (1) and covers (2).

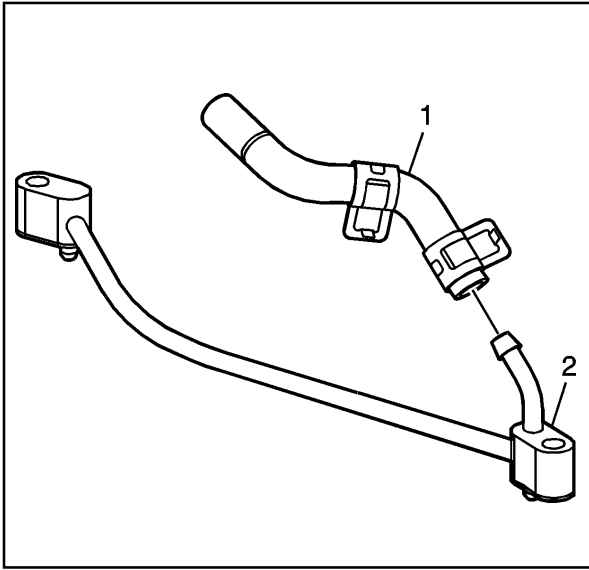


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4. Remove the gaskets from the pipe and covers.
5. Discard the gaskets.

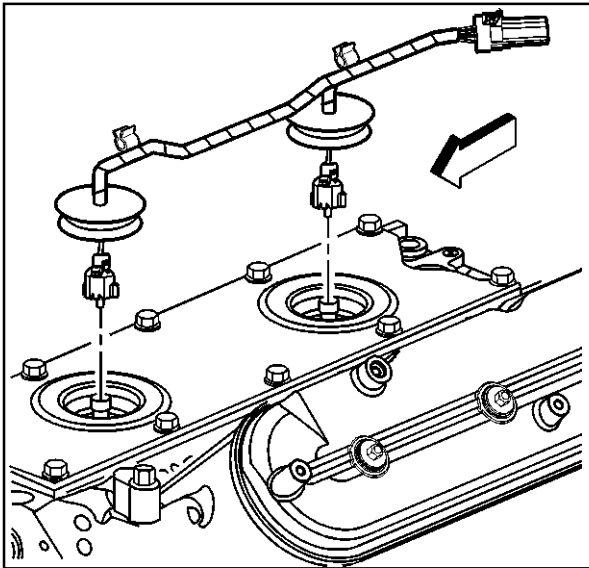


64262



790766

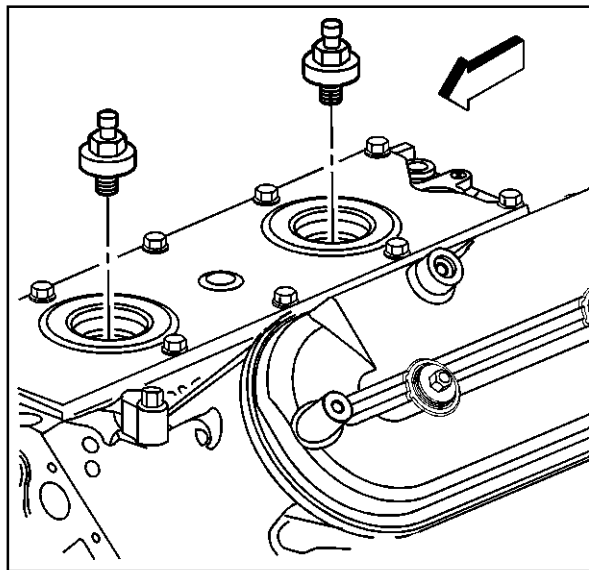
6. Remove the hose (1) from the pipe (2).



309859

Engine Valley Cover Removal

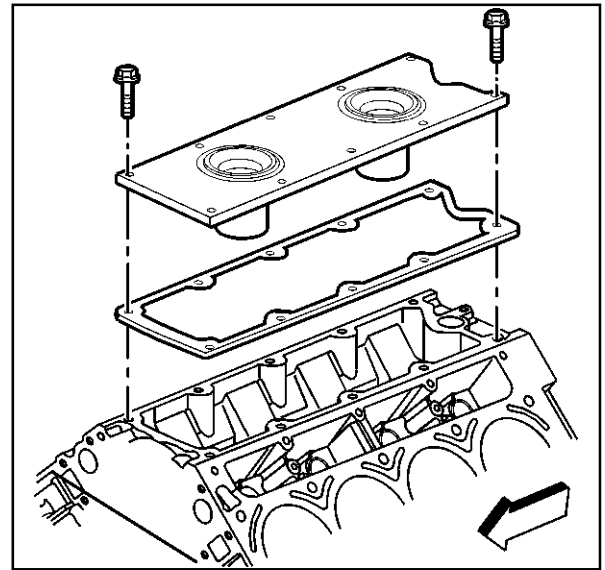
1. Remove the knock sensor wire harness.



309864

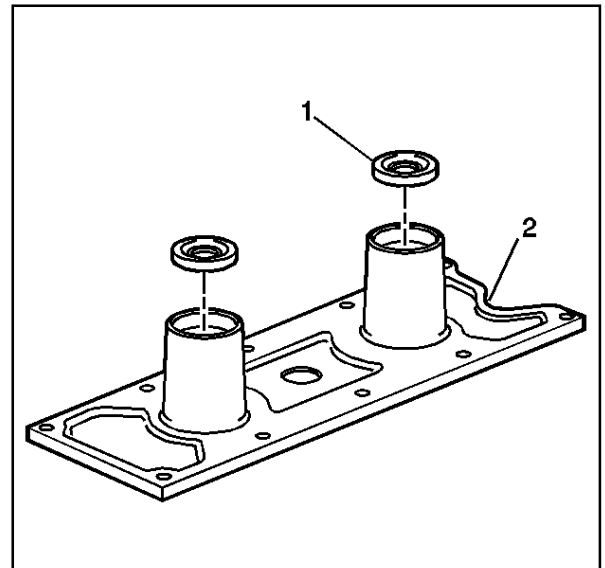
2. Remove the knock sensors.

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



65048

6. Remove the knock sensor oil seals (1) from the cover (2).



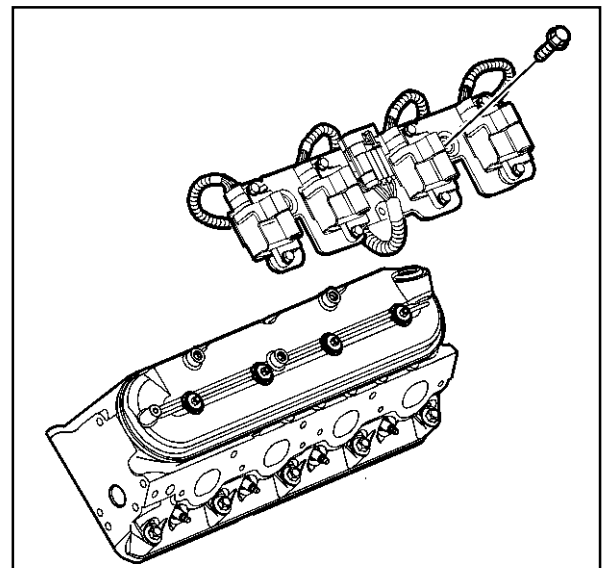
490851

Valve Rocker Arm Cover Removal (Left Side)

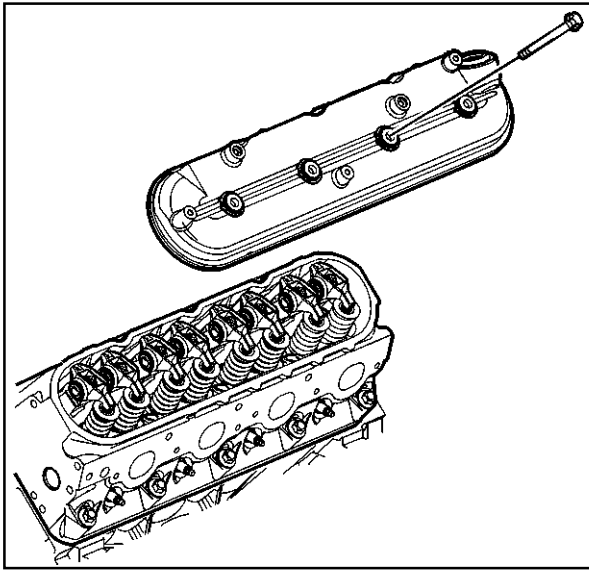
Important: Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.

Do not remove the Positive Crankcase Ventilation (PCV) valve grommet from the cover unless service is required.

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

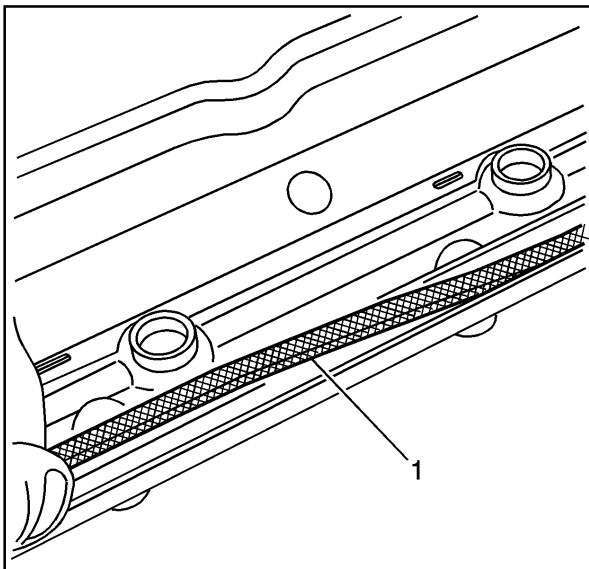


260083



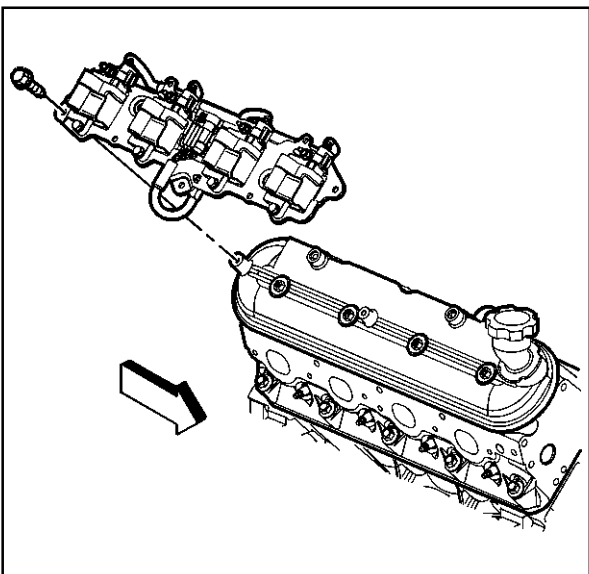
260085

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



490696

5. Remove the gasket (1) from the cover.
6. Discard the gasket.
The bolt grommets may be reused if not damaged.



260090

Valve Rocker Arm Cover Removal (Right Side)

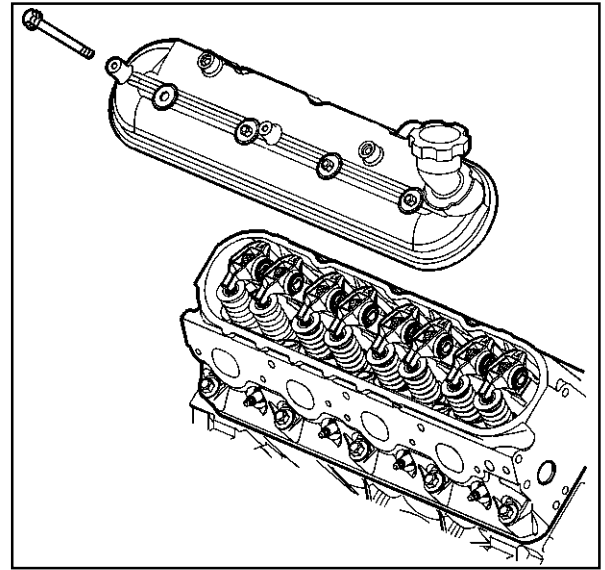
Important: Do not remove the ignition coils from the valve rocker arm cover unless required.

Do not remove the oil fill tube from the cover unless service is required.

If the oil fill tube has been removed from the cover, install a NEW tube during assembly.

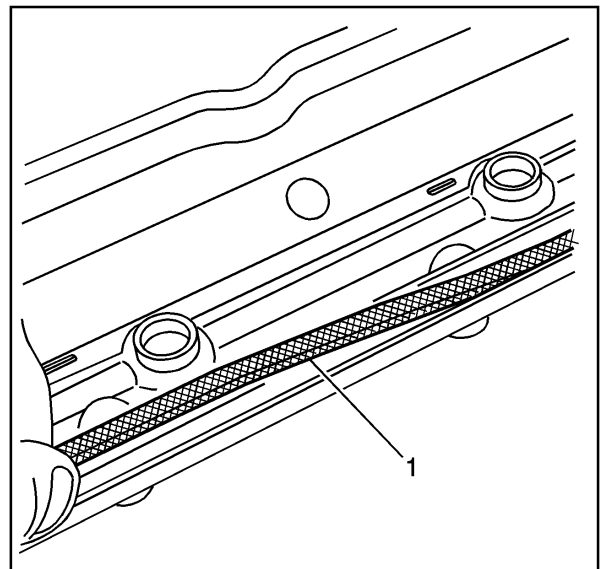
1. Remove the ignition coil bracket bolts from the valve rocker arm cover (if required).
2. Remove the ignition coil and bracket assembly and bolts.

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



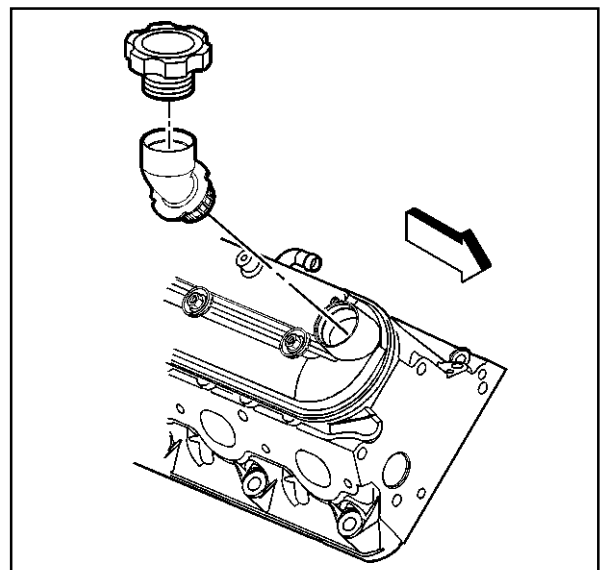
260084

5. Remove the gasket (1) from the cover.
6. Discard the gasket.
The bolt grommets may be reused if not damaged.

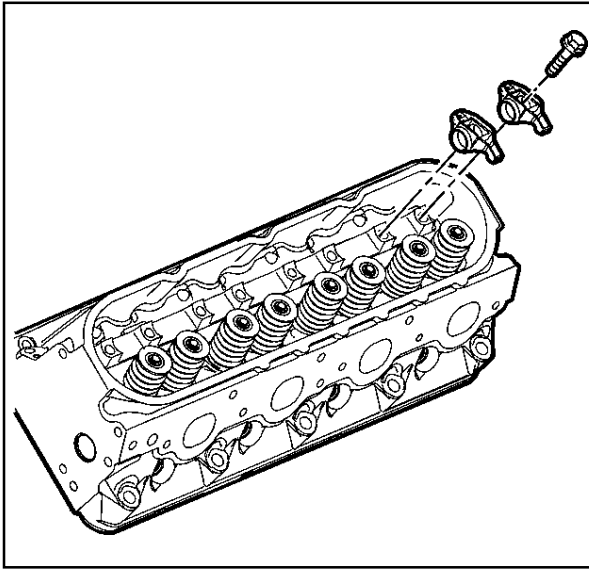


490696

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



260110

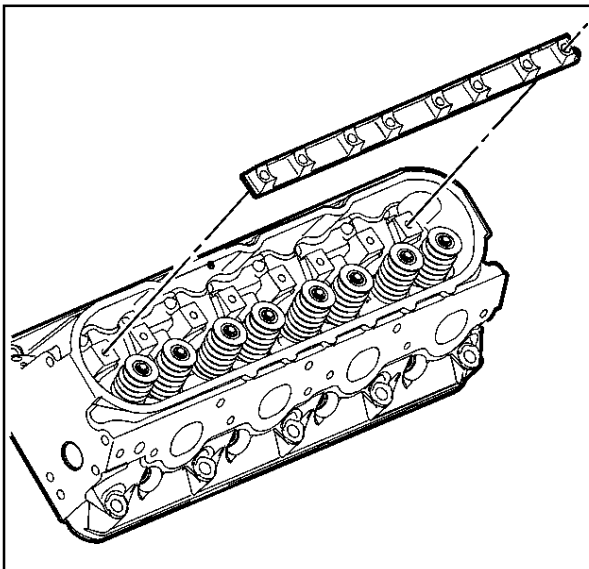


260140

Valve Rocker Arm and Push Rod Removal

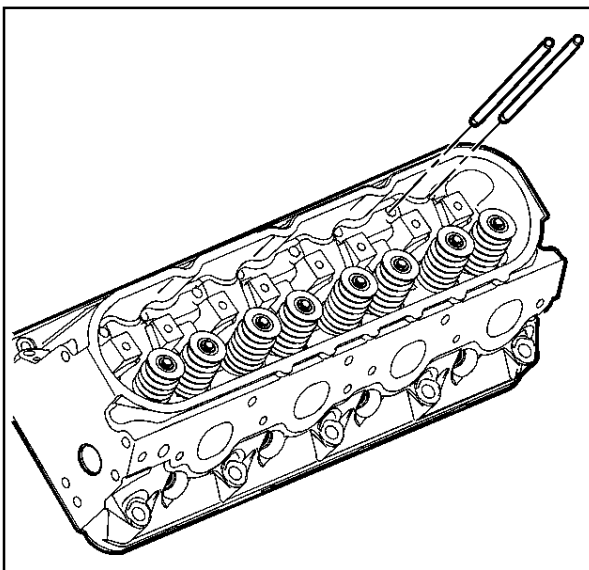
Important: Place valve rocker arms, valve pushrods, and pivot support, in a rack so they can be installed in the same location from which they were removed.

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



260141

3. Remove the valve rocker arm pivot support.



260142

4. Remove the pushrods.

Cylinder Head Removal - Left Side

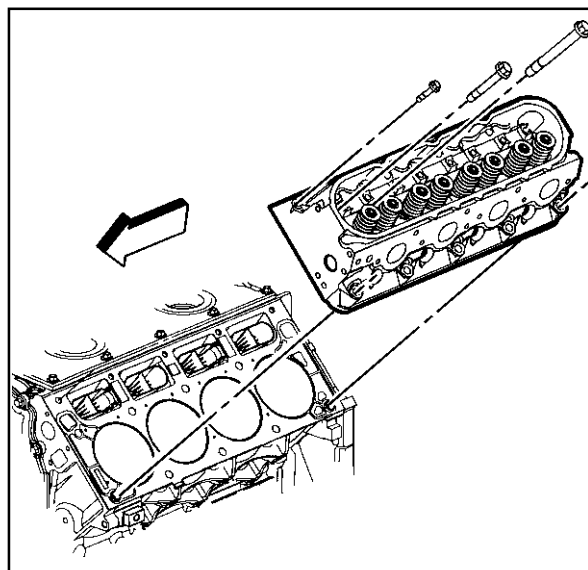
1. Remove the spark plugs from the left cylinder head.

Important: The M11 cylinder head bolts are NOT reusable. Install NEW M11 cylinder head bolts during assembly.

2. Remove the cylinder head bolts.

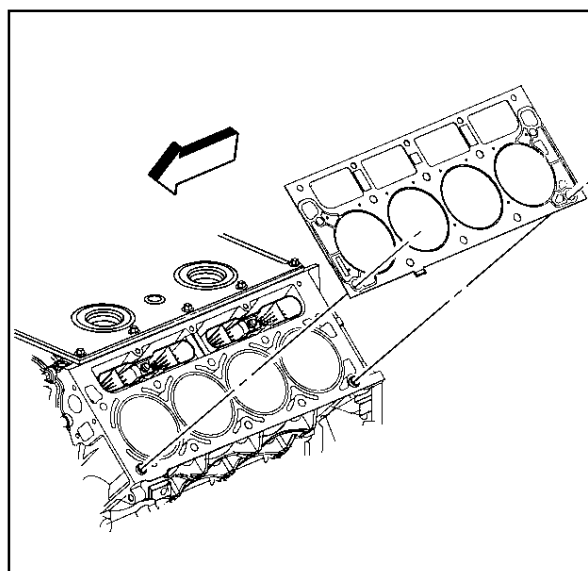
Notice: After removal, place the cylinder head on two wood blocks to prevent damage.

3. Remove the cylinder head.



260146

4. Remove the gasket.
5. Discard the gasket.
6. Discard the M11 cylinder head bolts.



63169

Cylinder Head Removal - Right Side

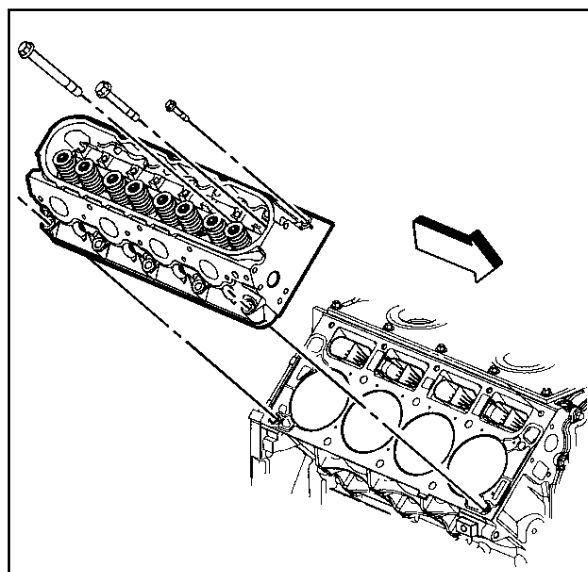
1. Remove the spark plugs from the left cylinder head.

Important: The M11 cylinder head bolts are NOT reusable. Install NEW M11 cylinder head bolts during assembly.

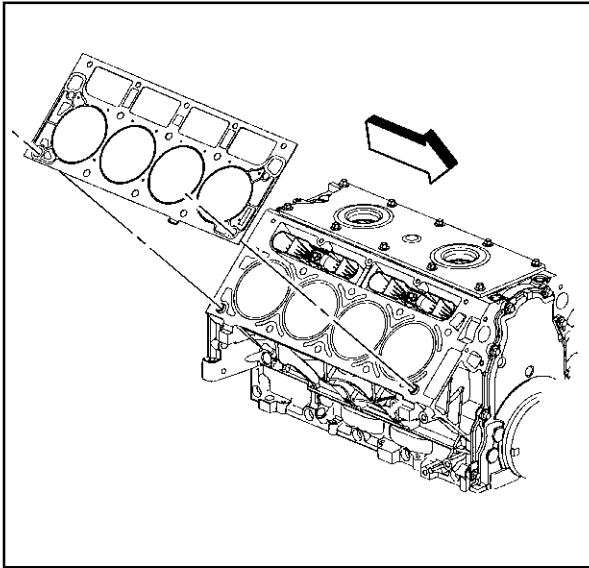
2. Remove the cylinder head bolts.

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

3. Remove the cylinder head.

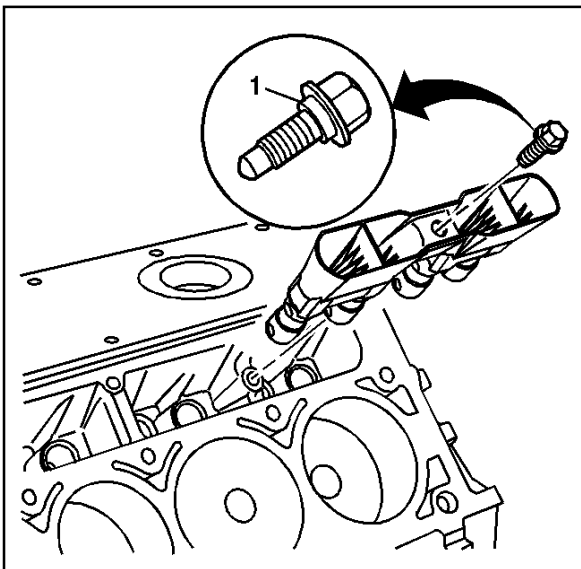


260149



63170

4. Remove the gasket.
5. Discard the gasket.
6. Discard the M11 cylinder head bolts.



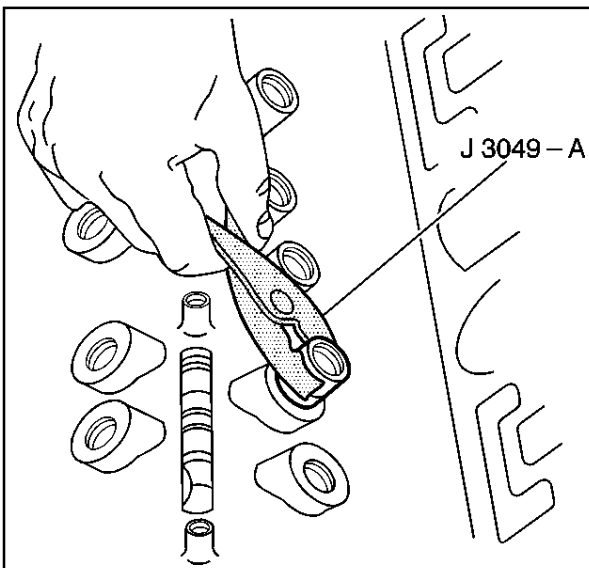
63230

Valve Lifter Removal

Tools Required

J 3049 Valve Lifter Remover

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

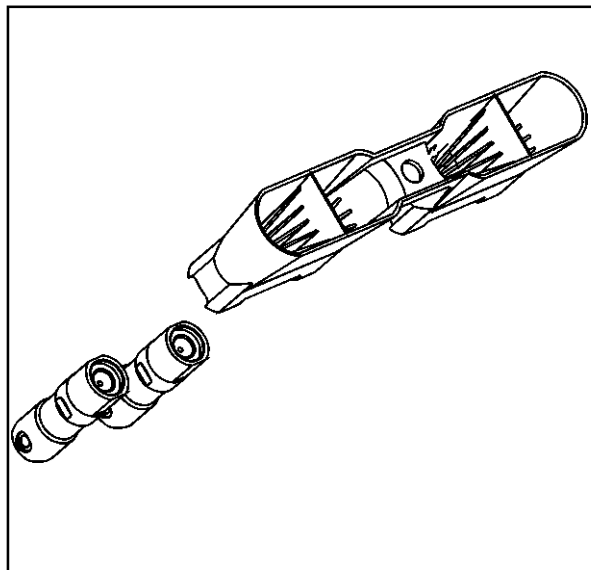


31350

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

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

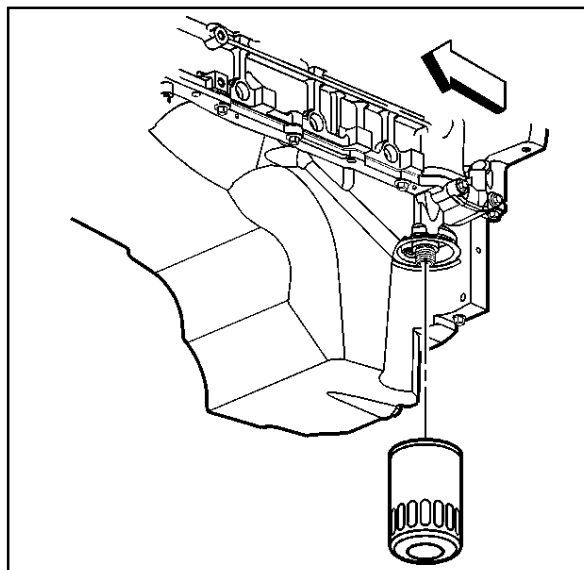
4. Remove the valve lifters from the guide.
5. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to *Separating Parts*.



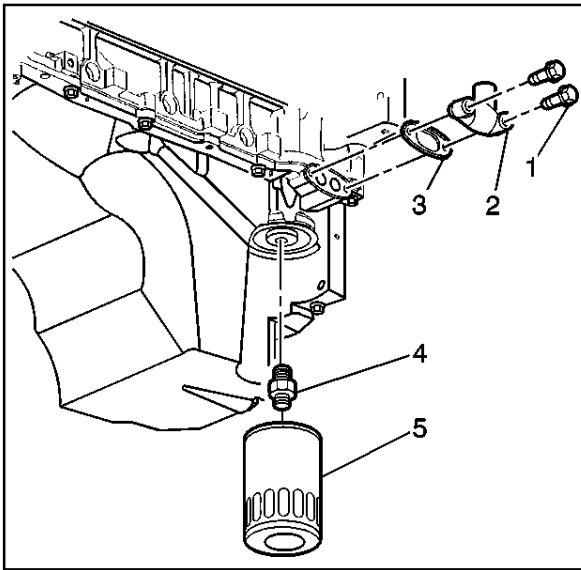
63233

Oil Filter, Adapter and Pan Cover Removal

1. Remove the oil filter.

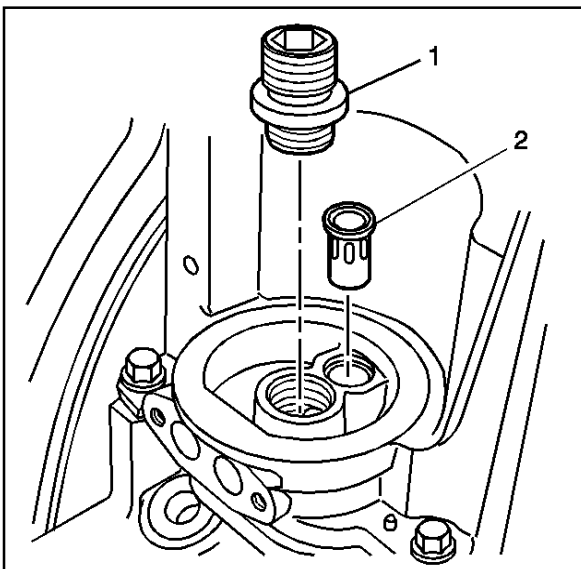


260117



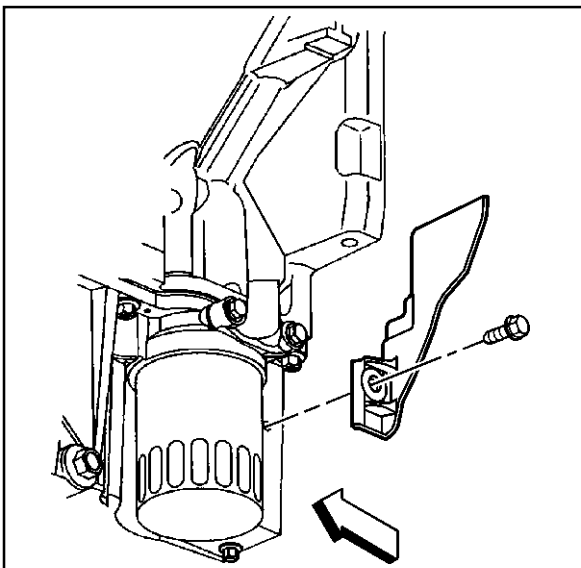
260125

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



490699

4. Remove the oil filter fitting (1) and bypass valve (2), if required.



178477

Oil Pan Removal

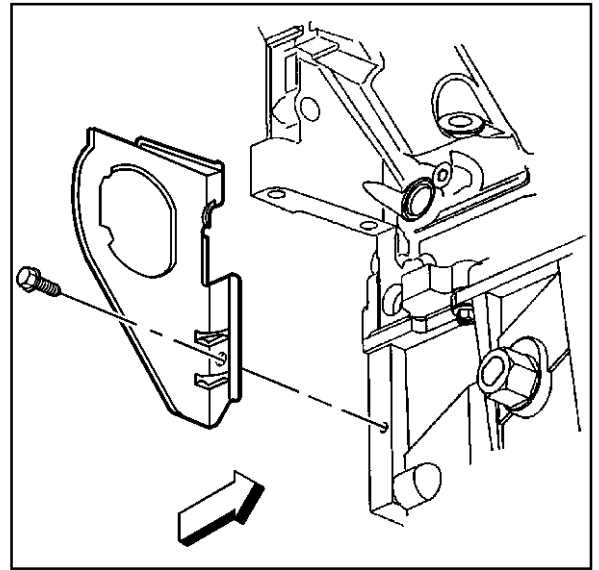
Important: The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing a new gasket, it is not necessary to install new oil pan gasket rivets.

DO NOT reuse the oil pan gasket. When installing the oil pan, install a NEW oil pan gasket.

It is not necessary to remove the oil level sensor prior to oil pan removal. Remove the oil level sensor if service is required.

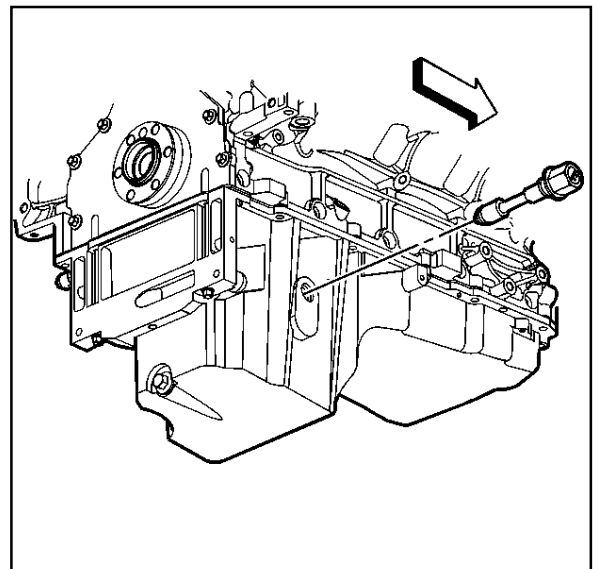
1. Remove the left closeout cover and bolt.

- 2. Remove the right closeout cover and bolt.



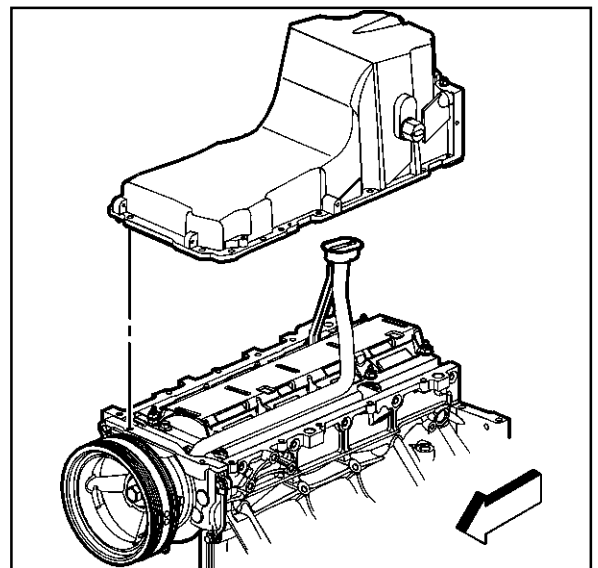
178480

- 3. Remove the oil level sensor from the oil pan, if applicable.

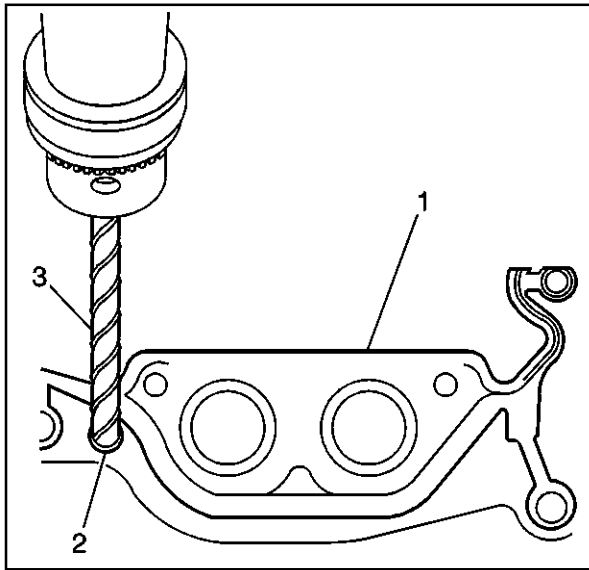


260123

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



260108

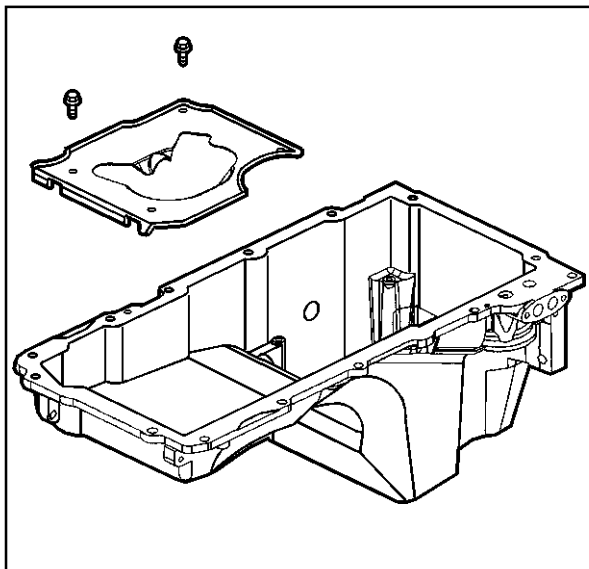


384699

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

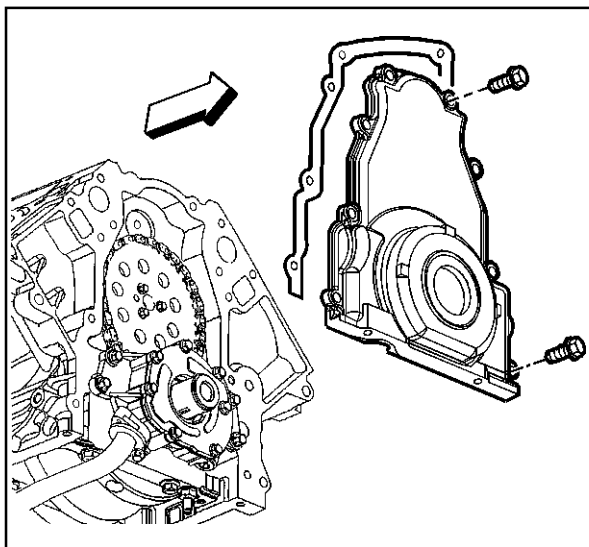
Use care not to gouge, score or damage the oil pan sealing service.

6. Drill (3) out the retaining rivets (2), if required.
7. Remove the oil pan gasket (1) from the oil pan.
8. Discard the gasket and rivets.



260180

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

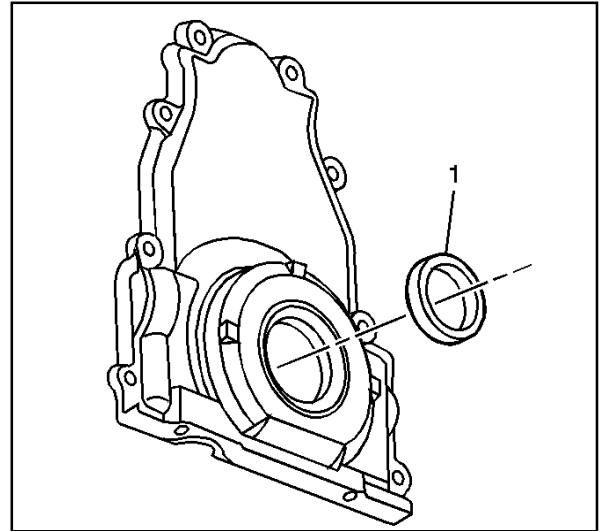


64278

Engine Front Cover Removal

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

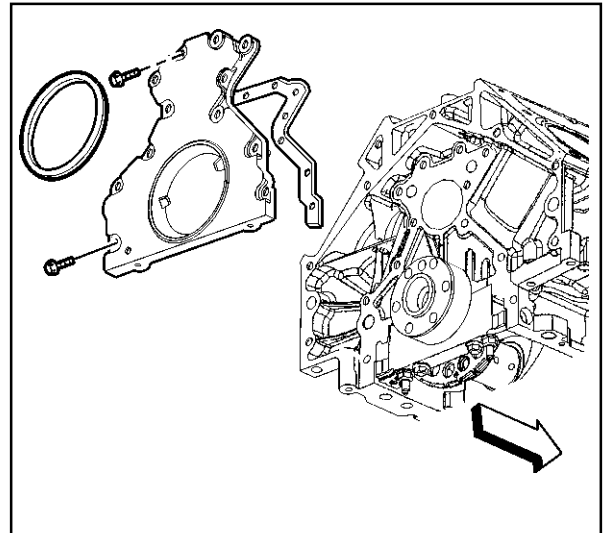
4. Remove the crankshaft front oil seal (1) from the cover.



490689

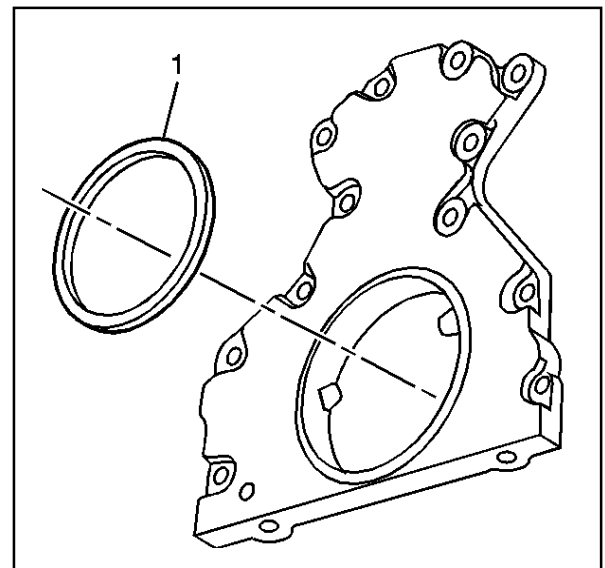
Engine Rear Cover Removal

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

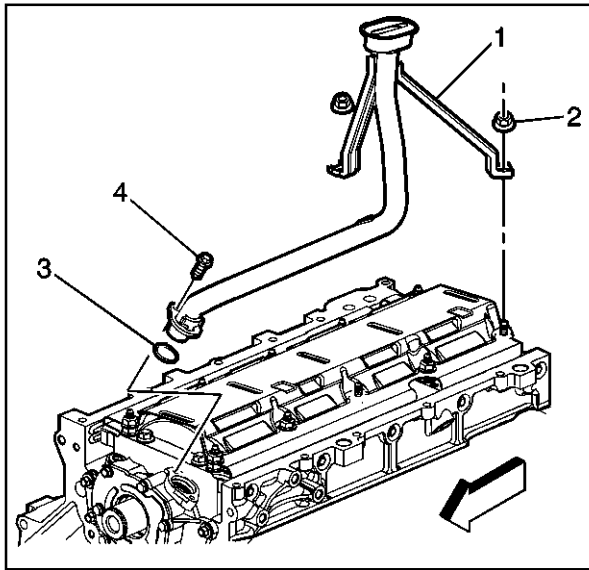


64282

4. Remove the crankshaft rear oil seal (1) from the cover.



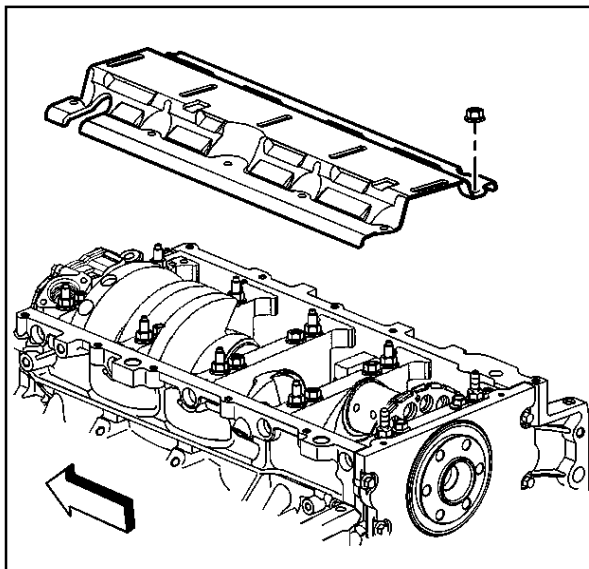
490692



260109

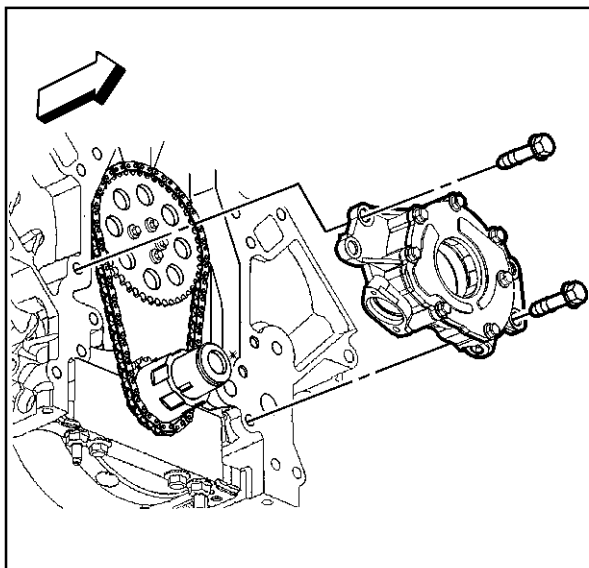
Oil Pump, Pump Screen and Deflector Removal

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



260099

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



64281

7. Remove the oil pump bolts.

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

8. Remove the oil pump.

Timing Chain and Sprockets Removal

Tools Required

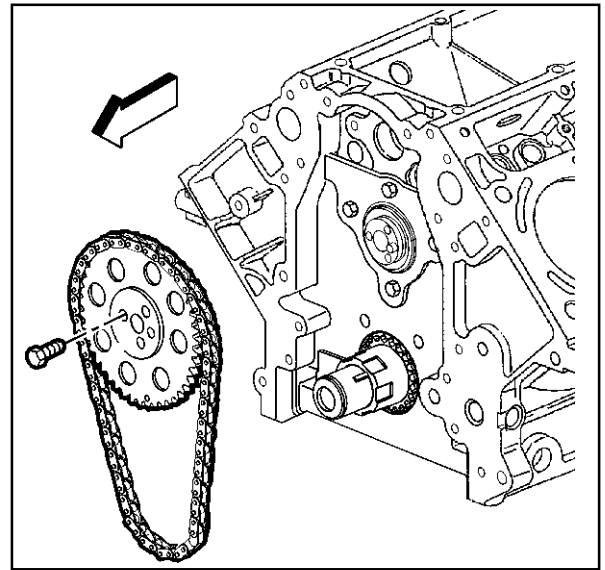
J 8433-1 Puller Bar

J 41816-2 Crankshaft Pilot

J 41558 Crankshaft Sprocket Remover

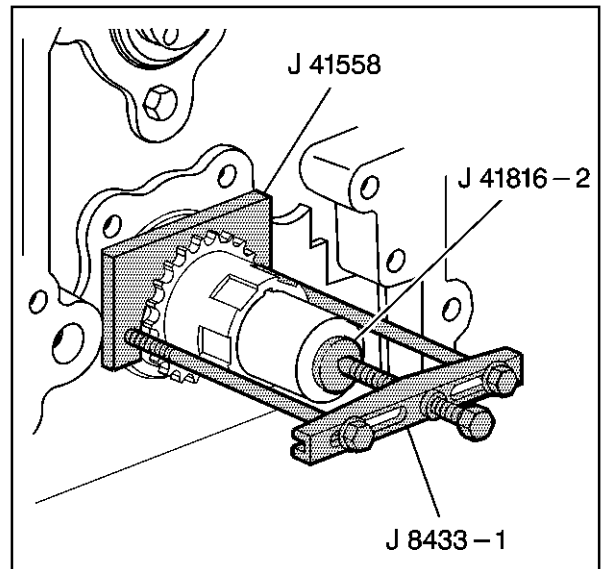
Notice: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

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



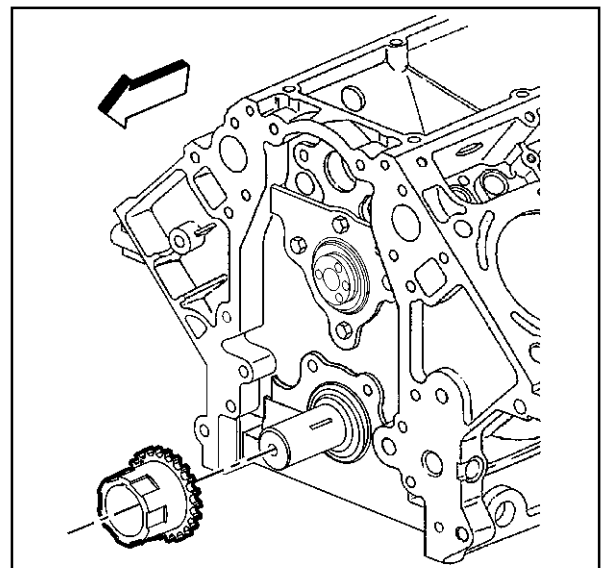
63263

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

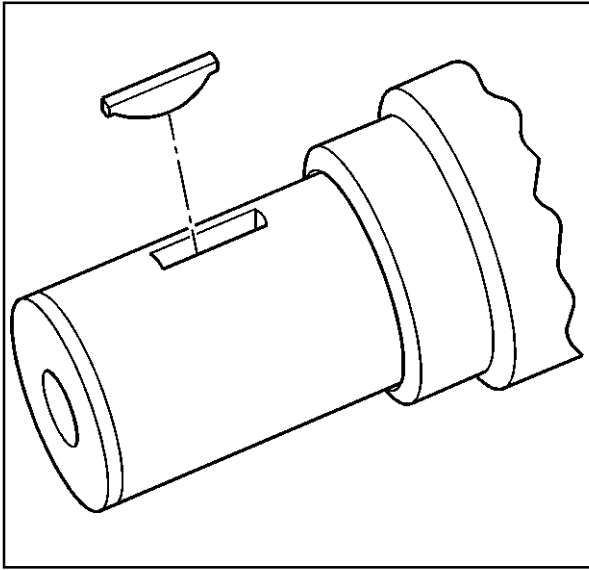


63189

4. Remove the crankshaft sprocket.

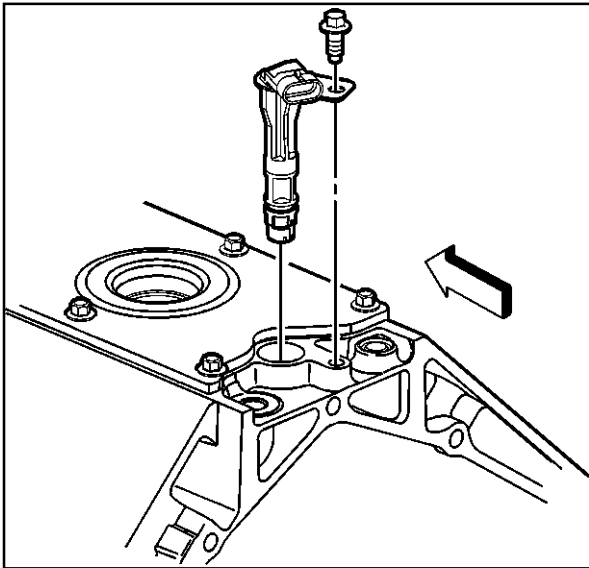


156150



156149

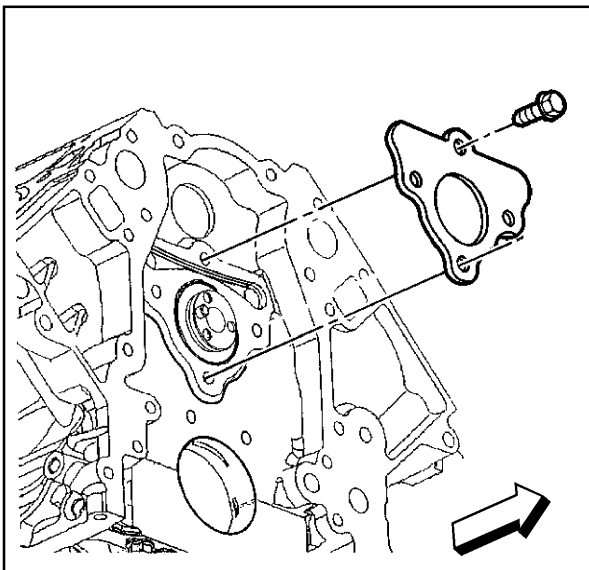
5. Remove the crankshaft sprocket key, if required.



260128

Camshaft Removal

1. Remove the camshaft sensor bolt and the sensor.

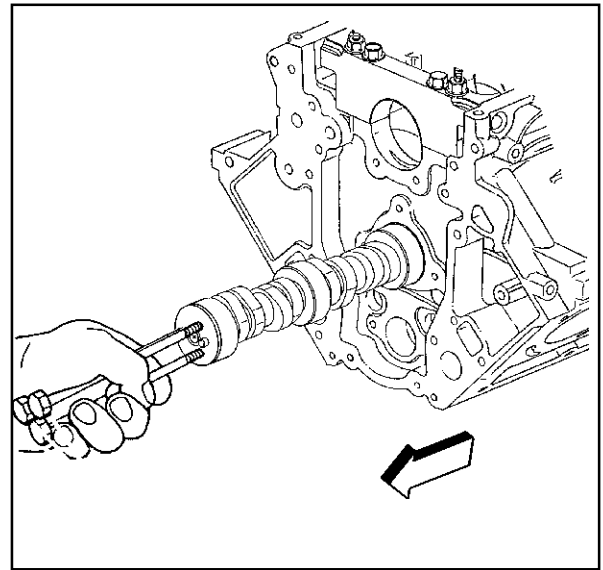


63211

2. Remove the camshaft retainer bolts and the retainer.

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

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



63212

Piston, Connecting Rod and Bearing Removal

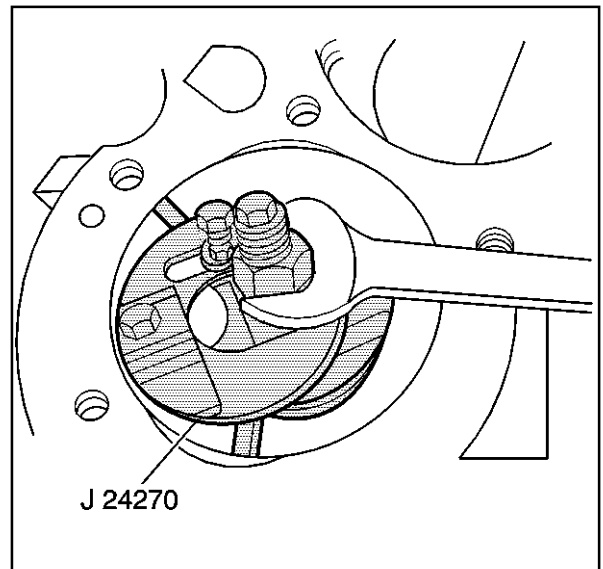
Tool Required

J 41556 Connecting Rod Guide

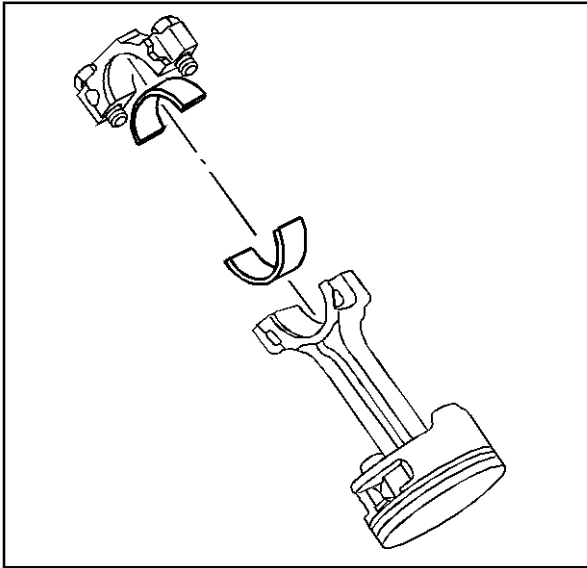
J 24270 Cylinder Bore Ridge Reamer

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

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



11497



53223

Important: Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps **MUST** be assembled to their original position and direction.

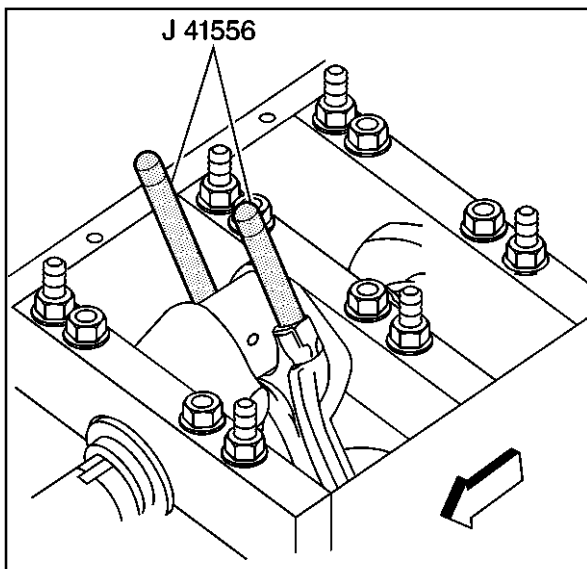
A stamping mark on the side of the connecting rod at the crank journal may effect component geometry.

Mark the top of the piston to the specific cylinder bore.

2. Remove the connecting rod bolts.

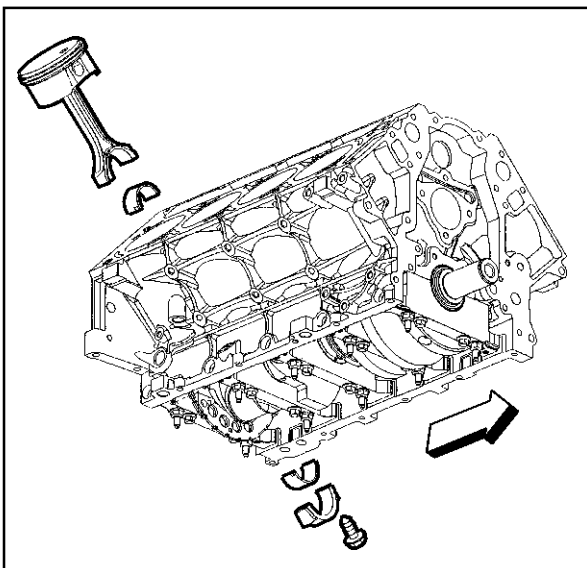
Important: Mark, sort or organize the connecting rod bearings so they may be installed to their original position and location.

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



63186

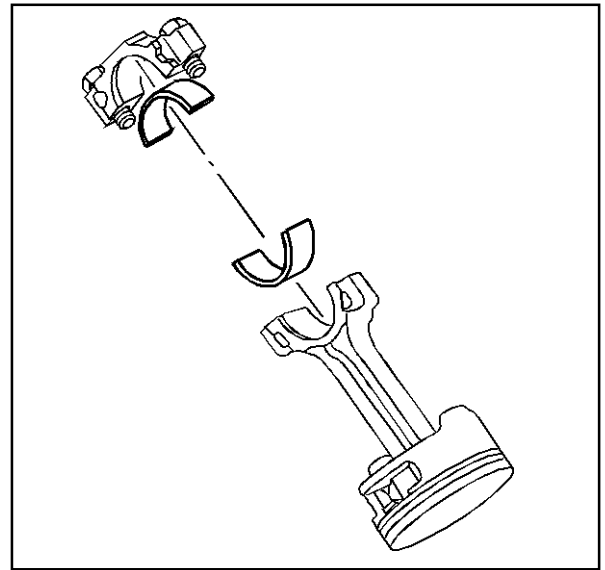
4. Install the *J 41556* to the connecting rod.



64285

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

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



53223

Crankshaft and Bearings Removal

Tools Required

J 41818 Crankshaft Bearing Cap Remover

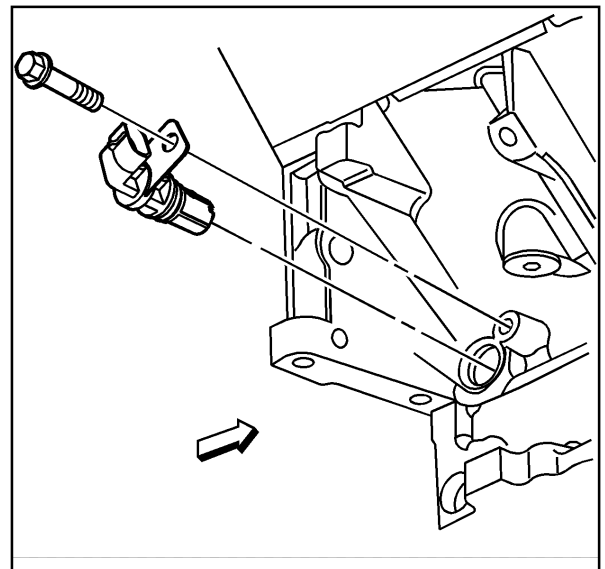
J 6125-1B Slide Hammer

Important: The crankshaft bearing caps are machined with the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps **MUST** be installed to their original position and direction.

Do not reuse the bearing cap M8 side bolts.

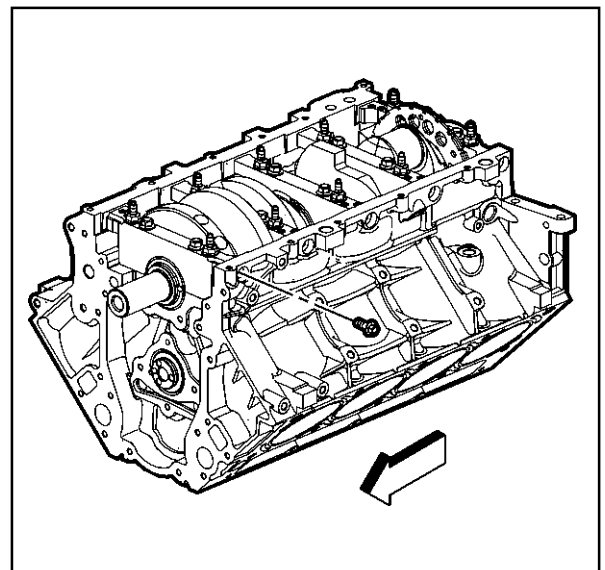
Remove the bearing cap M8 side bolts prior to cap removal.

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

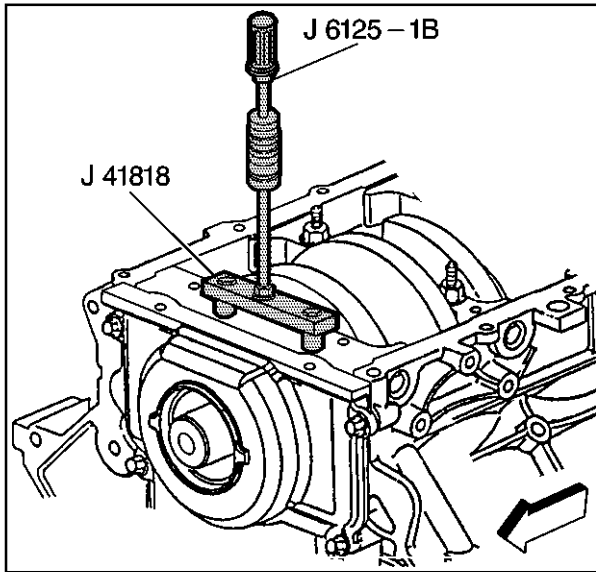


55322

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



156155



63188

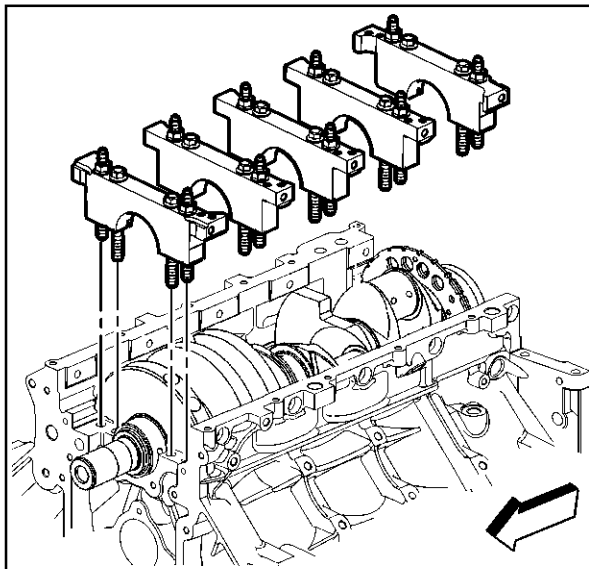
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the *J 41818*.

Tighten

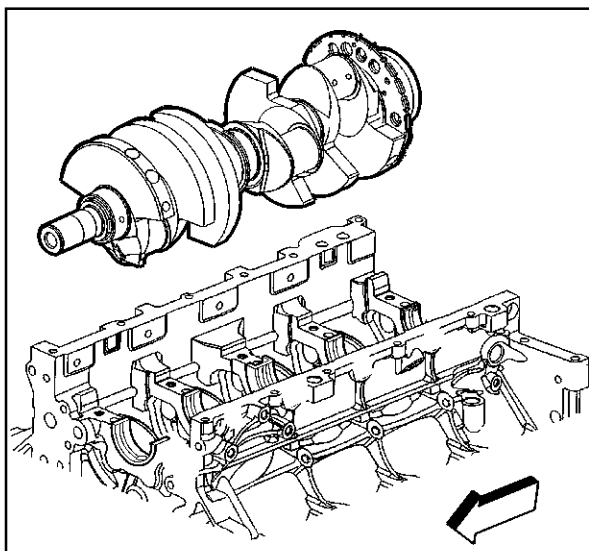
Tighten the *J 41818* bolts to 11 N·m (100 lb in).

6. Install the *J 6125-1B* to the *J 41818* in order to remove the crankshaft bearing caps.



156152

7. Remove the bearing caps.

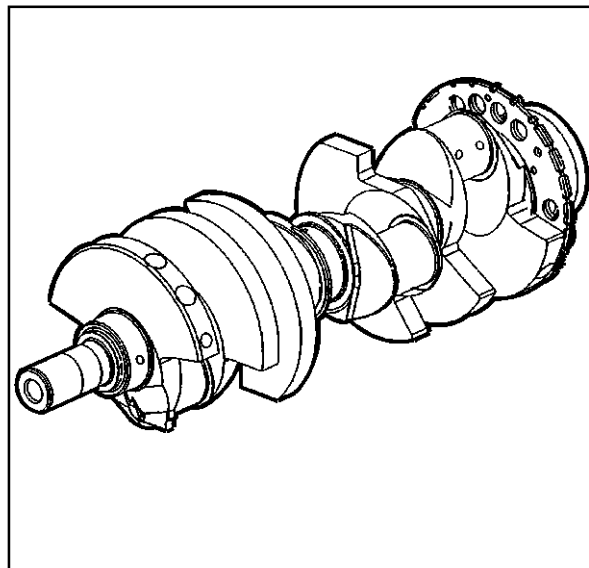


156151

8. Remove the crankshaft.

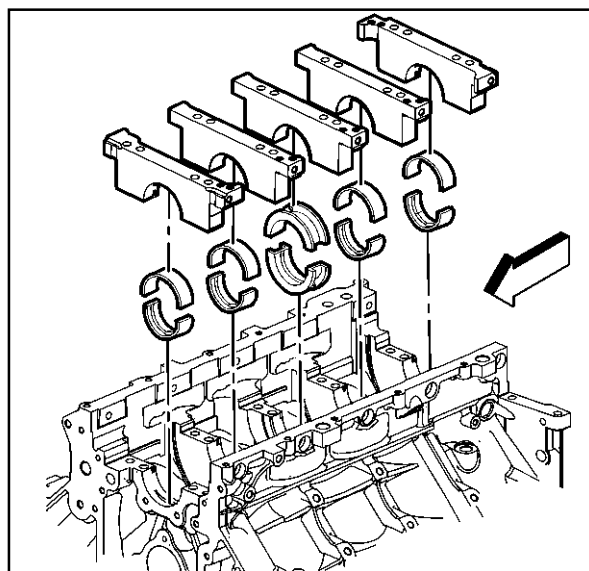
Important: Use care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may effect On-Board Diagnostics (OBD) system performance.

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



156153

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



64293

Engine Block Plug Removal

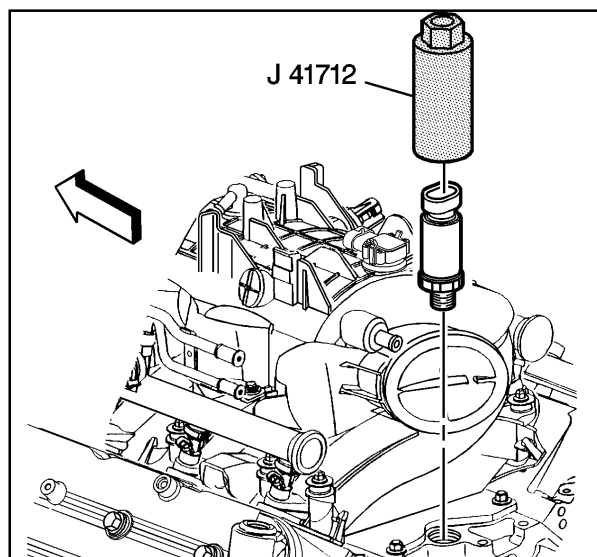
Tools Required

J 41712 Oil Pressure Sensor Socket

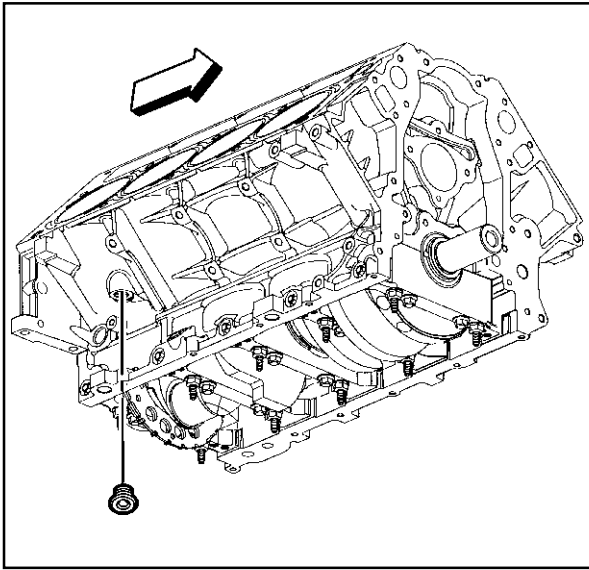
Important: Do not remove the engine block front oil gallery plug unless service is required.

If the front oil gallery plug is removed for service, a NEW oil gallery plug must be installed.

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

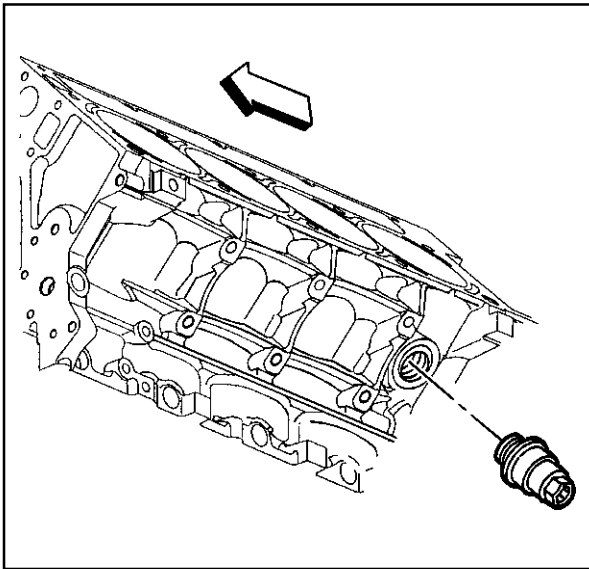


260089



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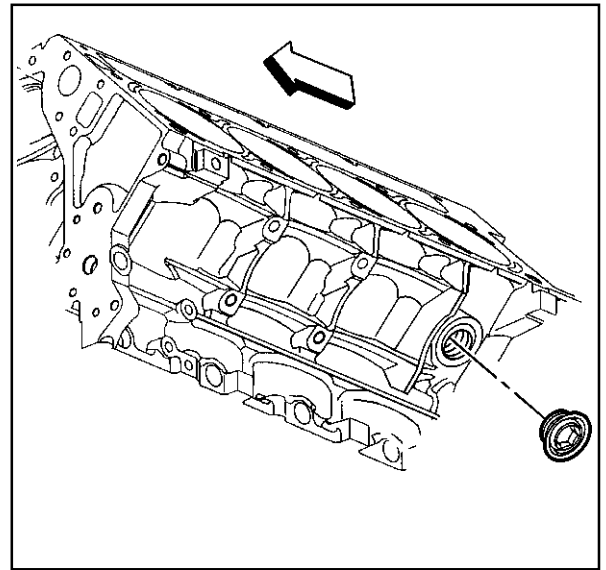
2. Remove the engine block right rear coolant plug.



260137

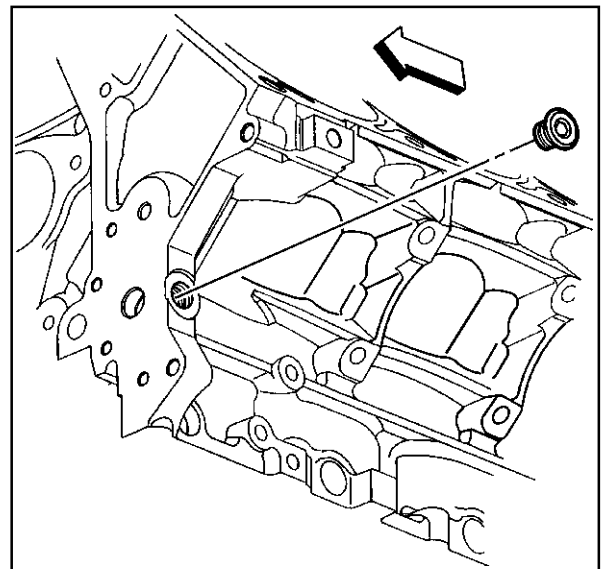
3. Remove the engine block coolant heater, if applicable.

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



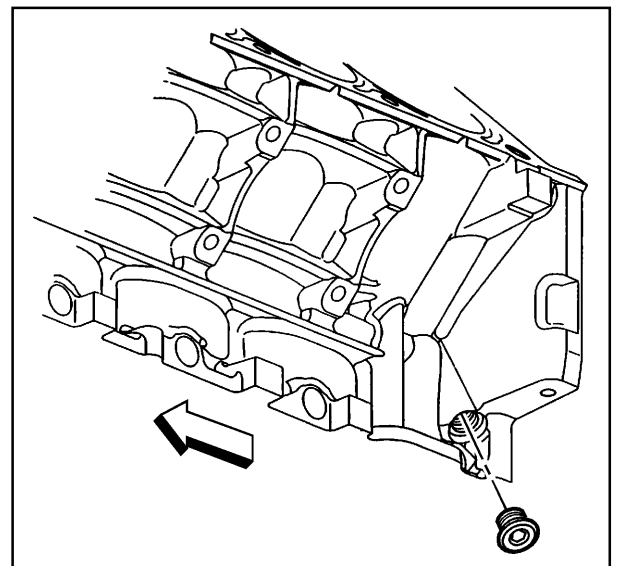
260138

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

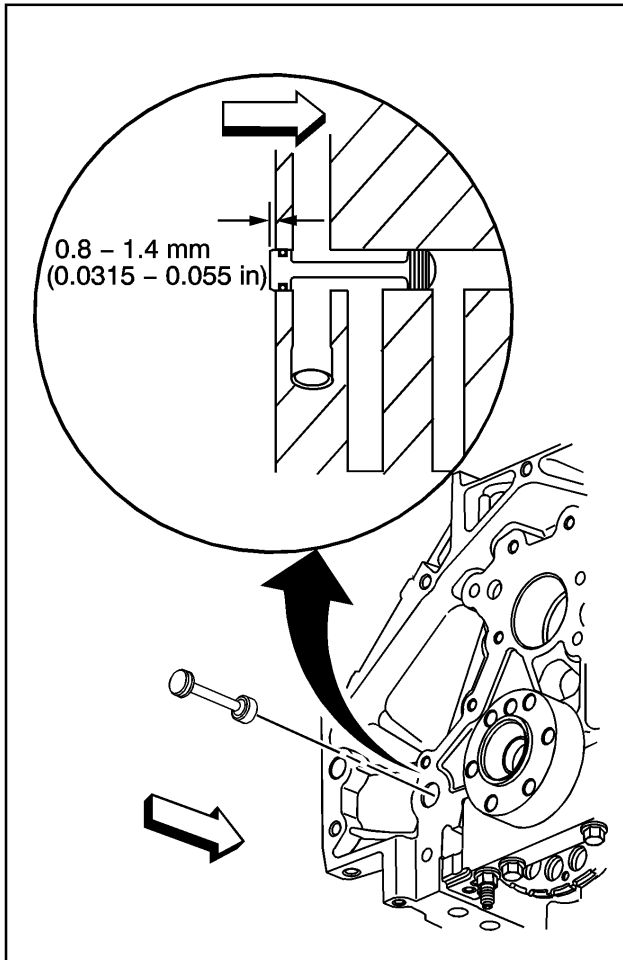


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6. Remove the engine block left rear oil gallery plug.
7. Inspect the block plug sealing washers.
If the block plug and heater sealing washers are not damaged, they may be used during assembly.

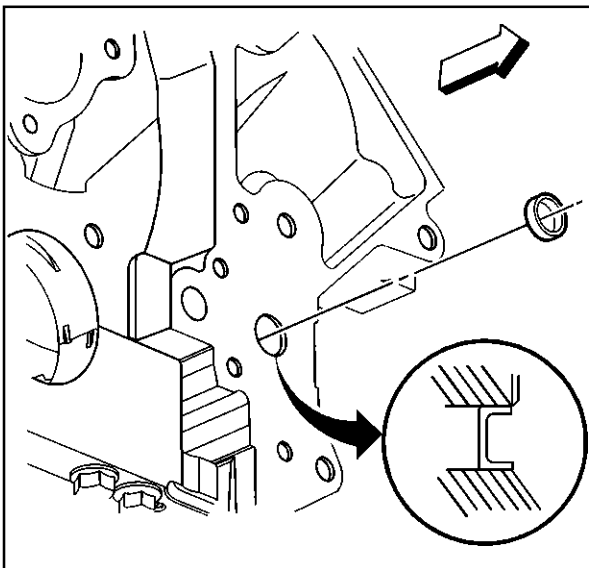


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8. Remove the engine block rear oil gallery plug.
9. Inspect the O-ring seal of the rear oil gallery plug.
If the O-ring seal is not cut or damaged, the plug and O-ring seal may be used during assembly.



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Important: Remove the front oil gallery plug only if service is required.

If the front oil gallery plug is removed, a NEW oil gallery plug must be installed.

10. Remove the engine block front oil gallery plug.

Engine Block Clean and Inspect

Tools Required

J 8087 Cylinder Bore Checking Gauge

J 42385-100 Thread Repair Kit

1. Clean the following areas:

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

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

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

Refer to *Cleanliness and Care*.

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

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

Refer to *Replacing Engine Gaskets*.

- The coolant passages
- The oil galleries
- The main bearing caps
- The engine block cylinder head bolt holes for thread locking material

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

2. Inspect the following areas:

- The cylinder walls for excessive scratches, gouging or ring ridge
- The coolant jacket for cracks
- The valve lifter bores for excessive scoring or wear
- The crankshaft bearing for webs for cracks
- The gasket sealing surfaces for excessive scratching or gouging

Refer to *Replacing Engine Gaskets*.

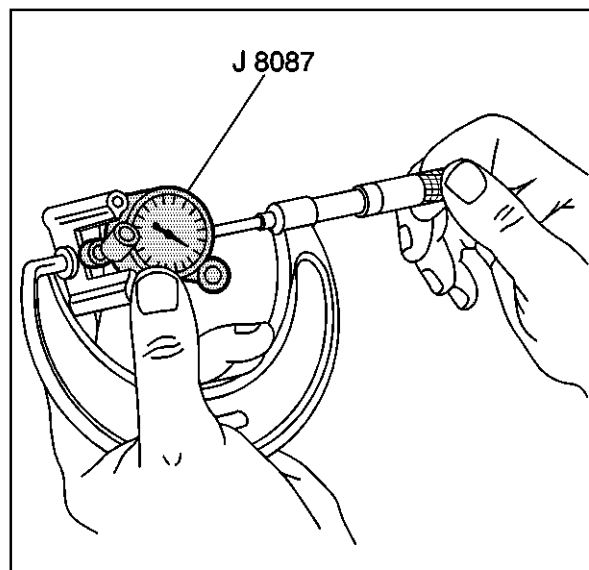
- The oil galleries for restrictions
- All threaded bolt holes for damage

3. Measure the following areas:

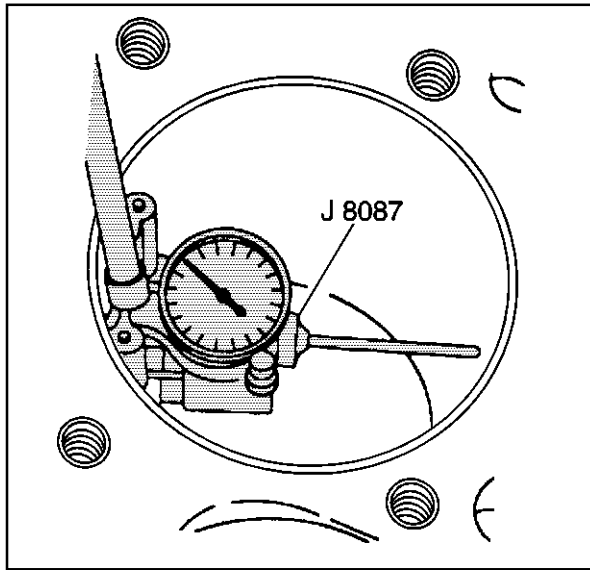
- The cylinder bores for taper
- The cylinder bores for excessive ring ridge at the top of the cylinder

Measuring Cylinder Taper, Out-of-Round and Oversize

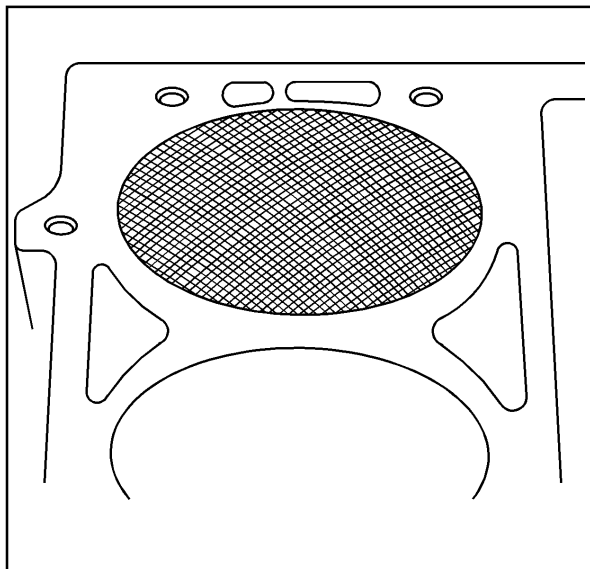
1. Adjust the micrometer to 101.62 mm (4.0 in).



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2. Insert the bore gauge into the micrometer and zero the bore gauge dial.
3. Use a bore gauge and measure the cylinder bore for taper, out-of-round and oversize.

Slide the bore gauge up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the center line of the crankshaft at the top, center and bottom of the bore.

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

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

Cylinder Boring and Honing

Boring Procedure

Important: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available.

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

Honing Procedure

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

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

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100 grit stone.
4. Perform final cylinder honing with a 240 grit stone and obtain a 45 degree crosshatch pattern.

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

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

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

6. The finish marks should be clean but not sharp.

The finish marks should also be free from imbedded particles and torn or folded metal.

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

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

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

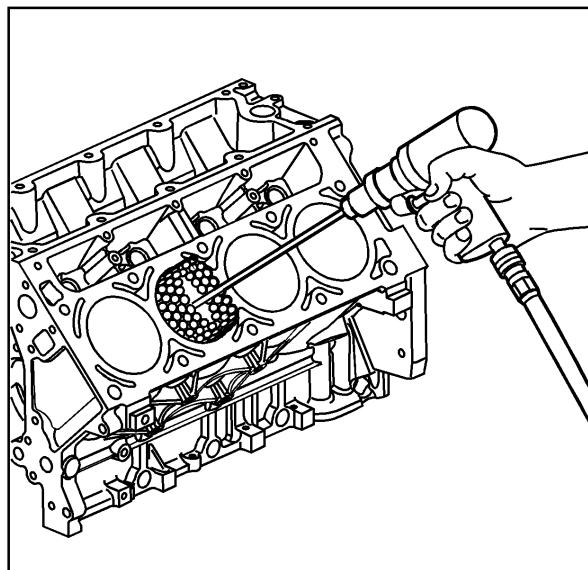
After washing the cylinder bore, dry the bore with a clean rag.

10. Perform the final measurements of the piston and the cylinder bore.
11. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
12. Apply clean engine oil to each cylinder bore in order to prevent rusting.

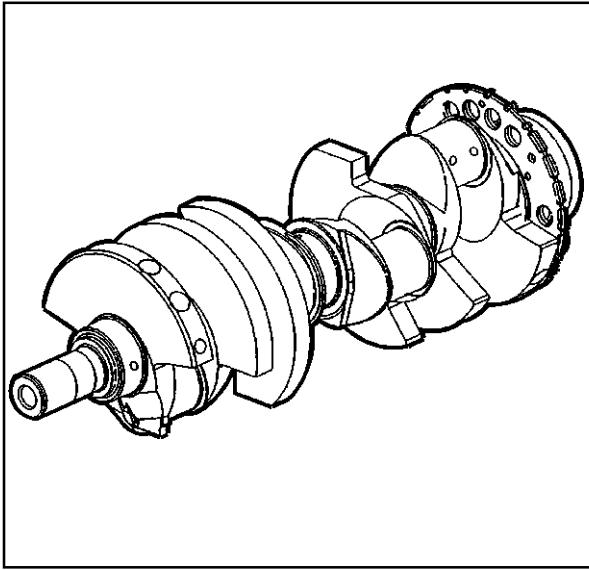
Deglazing Procedure

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

A 240 grit stone is preferred for final honing. If a 240 grit is not available use a 220 grit stone as a substitute.



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Crankshaft and Bearings Clean and Inspect

Tools Required

J 6125-1B Slide Hammer

J 7872 Magnetic Base Dial Indicator Set

J 36660-A Torque Angle Meter

J 41818 Crankshaft Bearing Cap Remover

Cleaning Procedure

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

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

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

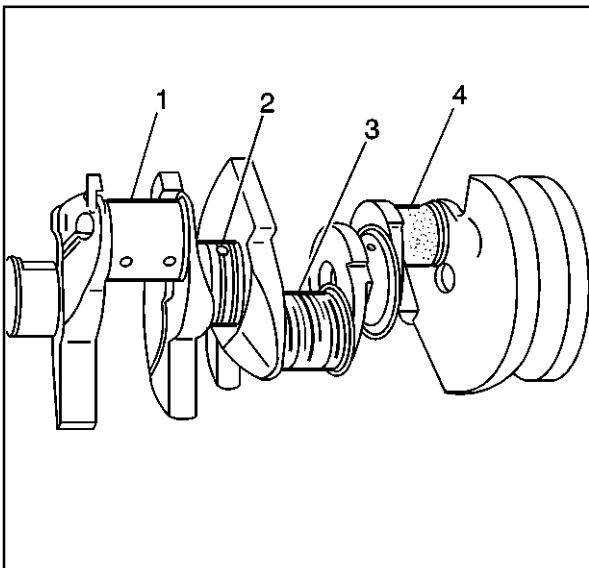
3. Dry the crankshaft with compressed air.

Inspection procedure

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

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

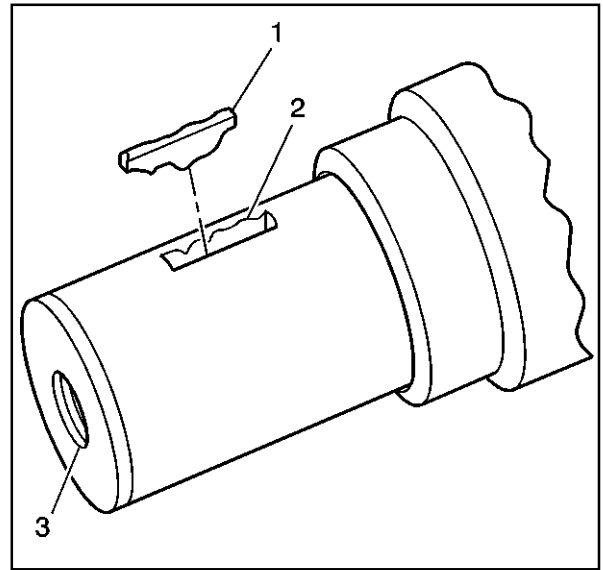
1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the crankshaft position reluctor ring lobes for damage.



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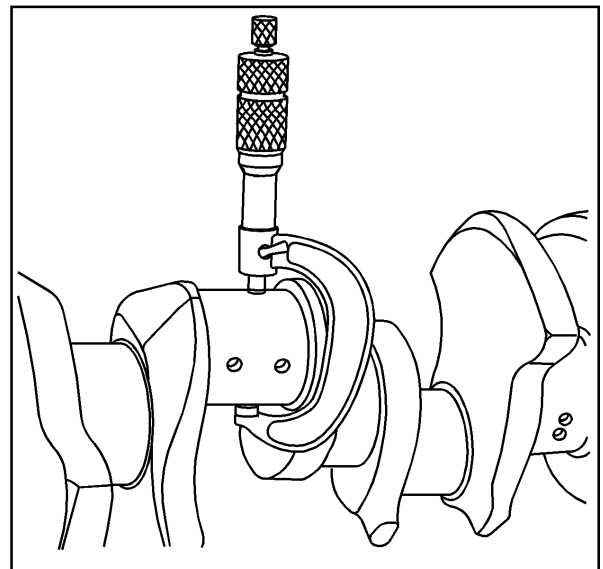
3. Inspect the crankshaft journals for wear (1).
Journals should be smooth with no signs of scoring, wear or damage.
4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

7. Inspect the crankshaft key (1), keyway (2) and threaded hole (3) for damage.



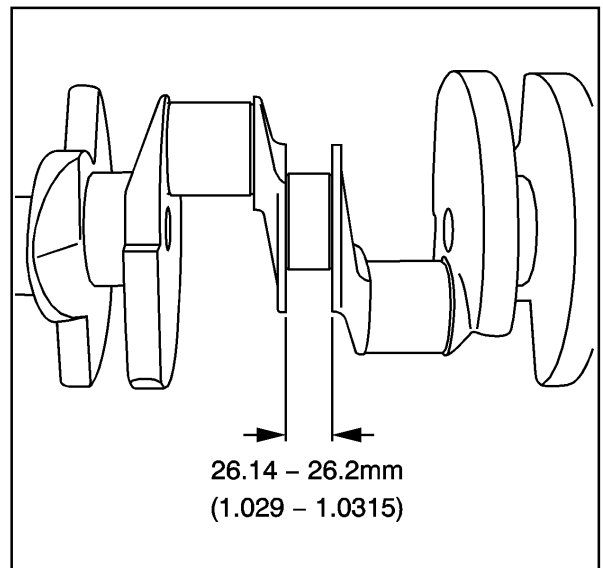
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8. Measure the crankpins for the out-of-round.
9. Measure the crankpins for taper.

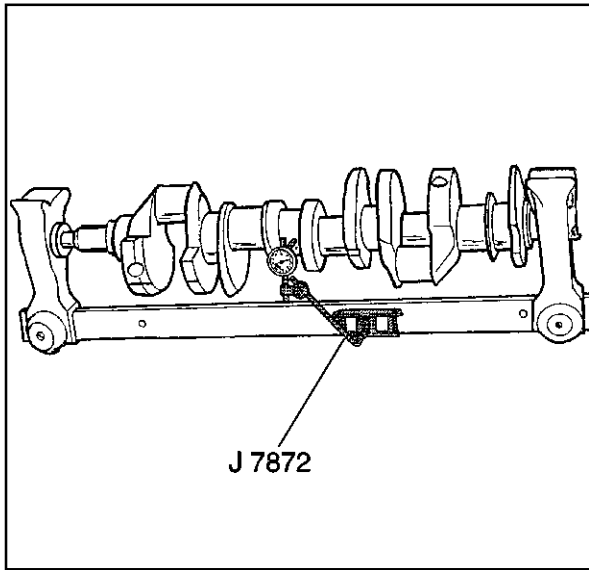


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10. Measure the crankshaft thrust wall width.
A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.

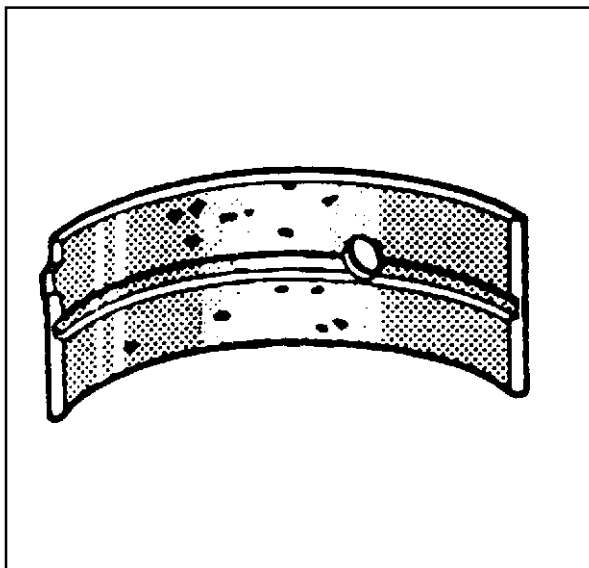


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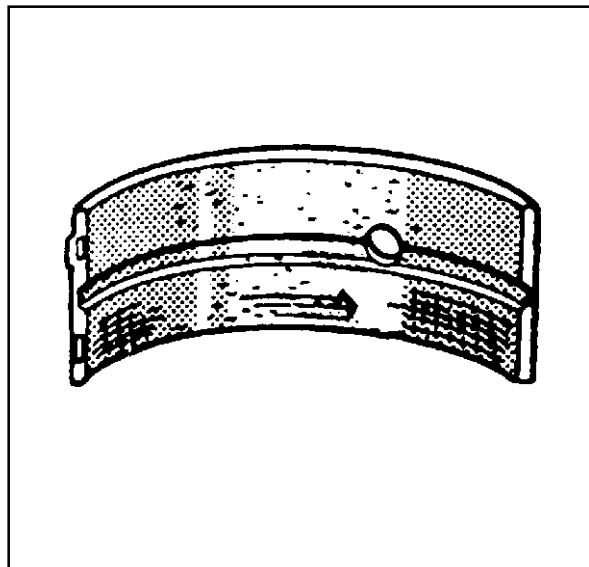
11. Measure the crankshaft runout.
Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.
12. Use the *J 7872* in order to measure the crankshaft runout at the front and rear intermediate journals.
13. Use the *J 7872* in order to measure the runout of the crankshaft rear flange.
14. Use the *J 7872* in order to measure out the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.
If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.



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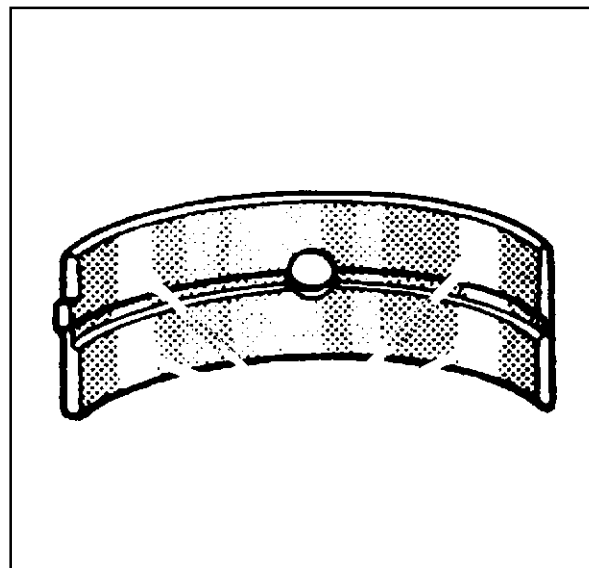
15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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

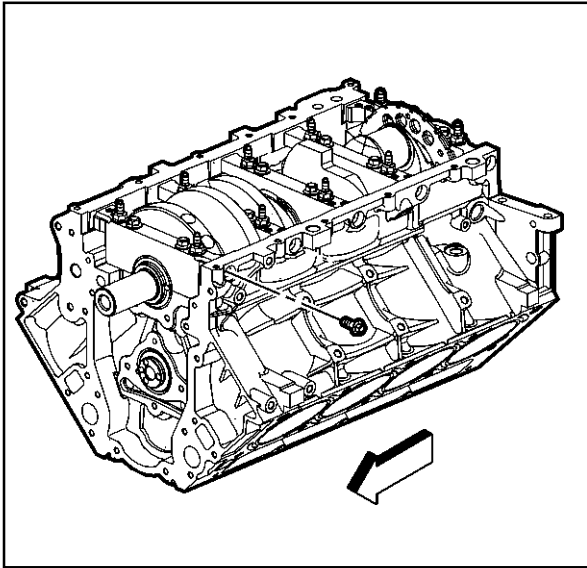


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- 18. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.
 If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.
 Generally, if the lower half is suitable for use, the upper half should also be suitable for use.



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Measuring Main Bearing Clearance

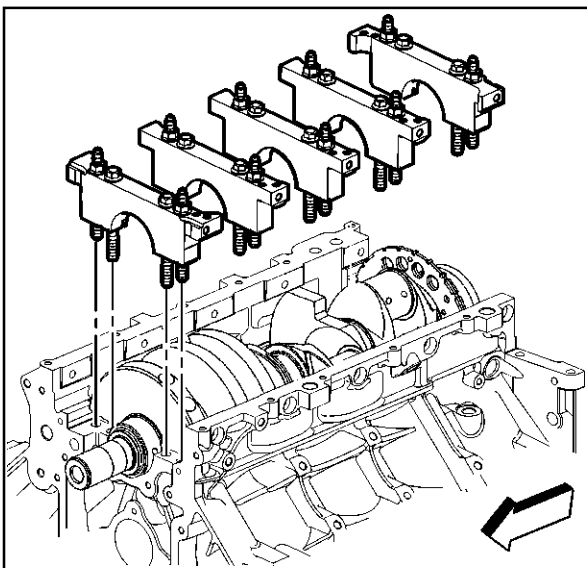
Important: The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.

Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and bearing surface.

The crankshaft bearing clearances are critical. Excessive bearing clearance may effect crankshaft position sensor signals and may effect On-Board Diagnostics (OBD) system operation.

Important: Remove the bearing cap side bolts prior to cap removal.

1. Remove the bearing cap M8 side bolts.



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2. Remove the bearing cap M10 bolts and studs.

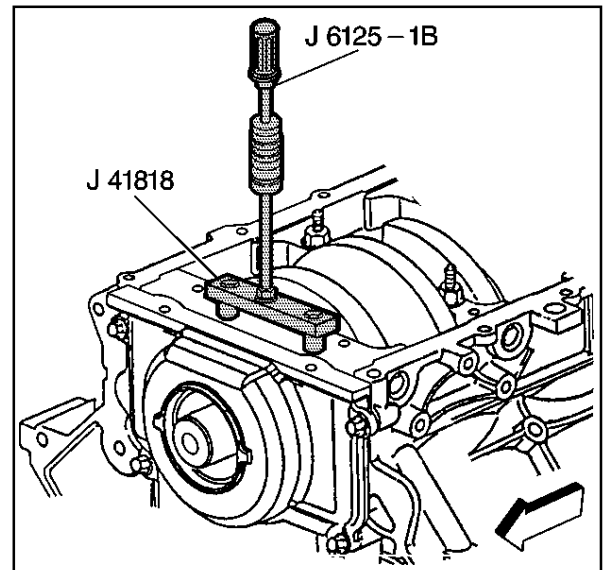
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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

Tighten

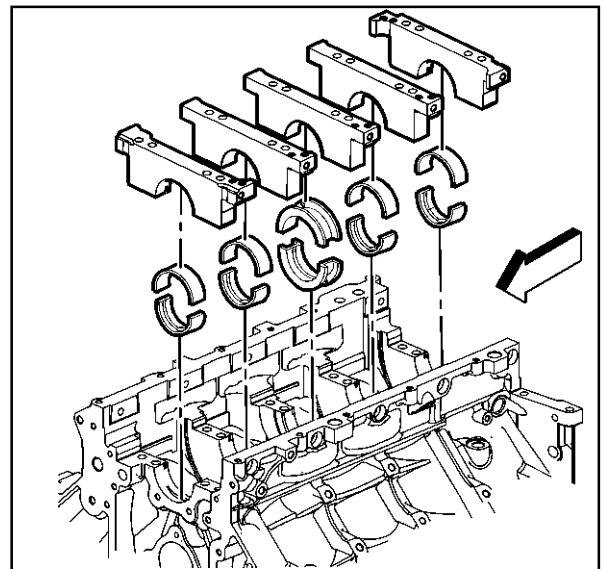
Tighten the *J 41818* bolts to 11 N·m (100 lb in).

4. Install the *J 6125-1B* to the *J 41818* in order to remove the bearing cap.



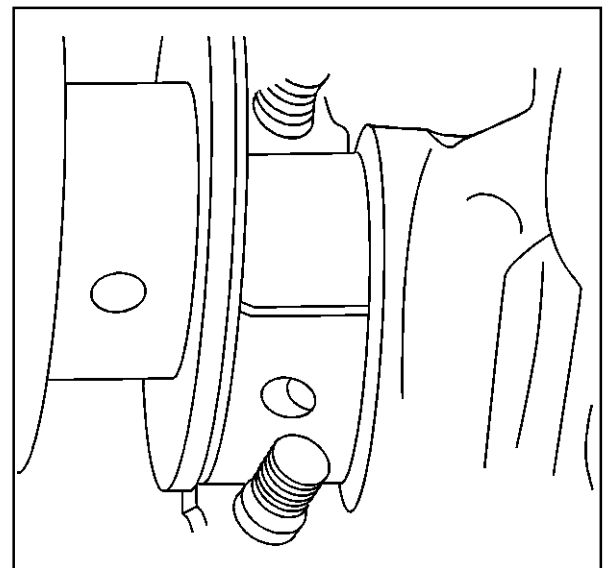
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5. Remove the bearing cap and lower bearing.

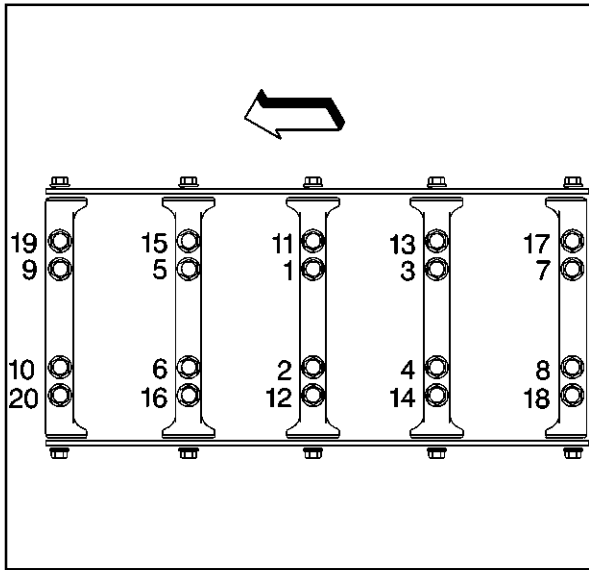


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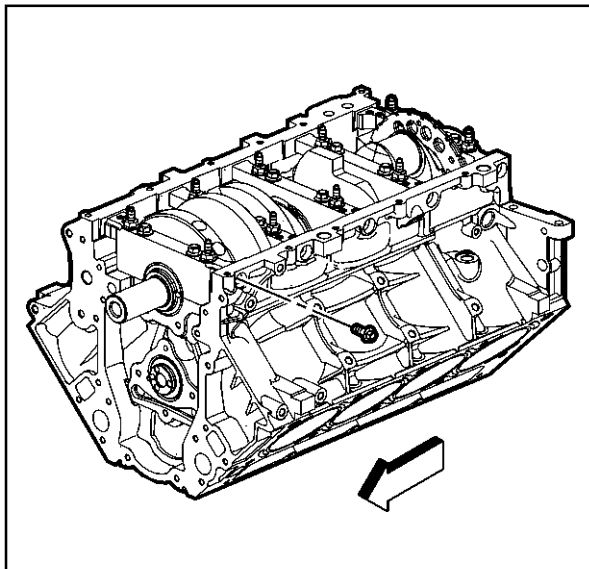
6. Install gauging plastic onto the crankshaft journal.
Install the gauging plastic the full width of the crankshaft bearing journal.



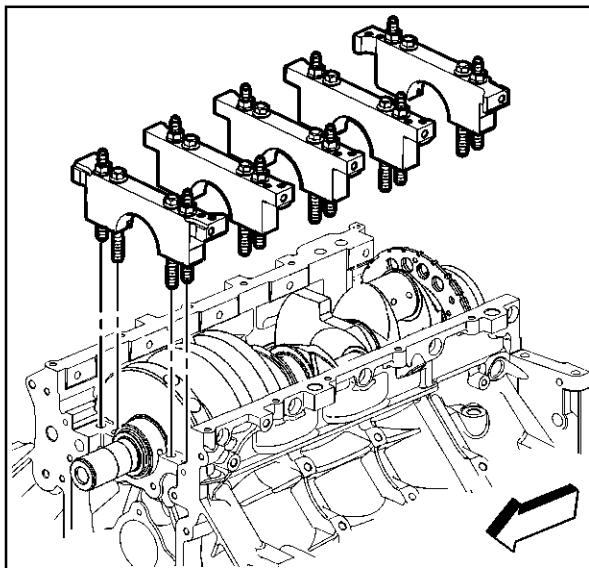
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7. Install the bearing, bearing cap, bolts and bolt/studs.

Tighten

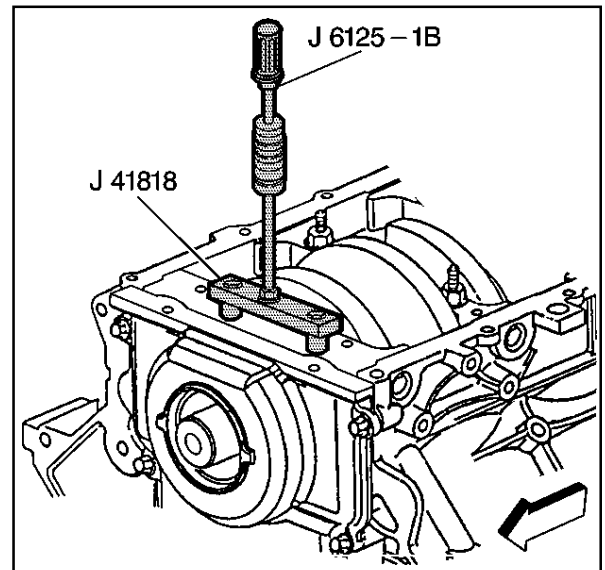
- 7.1. Tighten the inner bolts (1-10) a first pass in sequence to 20 N·m (15 lb ft).
- 7.2. Tighten the inner bolts (1-10) a final pass in sequence to 80 degrees using the *J 36660-A*.
- 7.3. Tighten the outer bolt/studs (11-20) a first pass in sequence to 20 N·m (15 lb ft).
- 7.4. Tighten the outer bolt/studs (11-20) a final pass in sequence to 53 degrees using the *J 36660-A*.
- 7.5. Tighten the side cap bolts to 25 N·m (18 lb ft).
Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.

Important: Remove the bearing cap side bolts prior to cap removal.

8. Remove the bearing cap M8 side bolts.

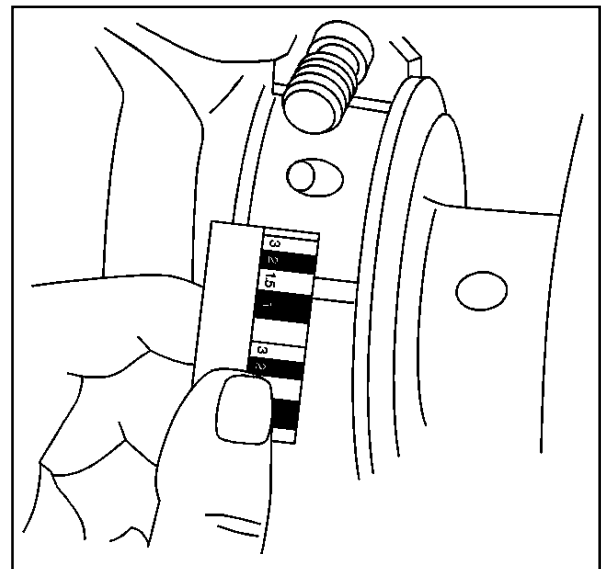
9. Remove the bearing cap bolts and bolt/studs.

10. Use the *J 41818* and the *J 6125-1B* in order to remove the bearing cap.



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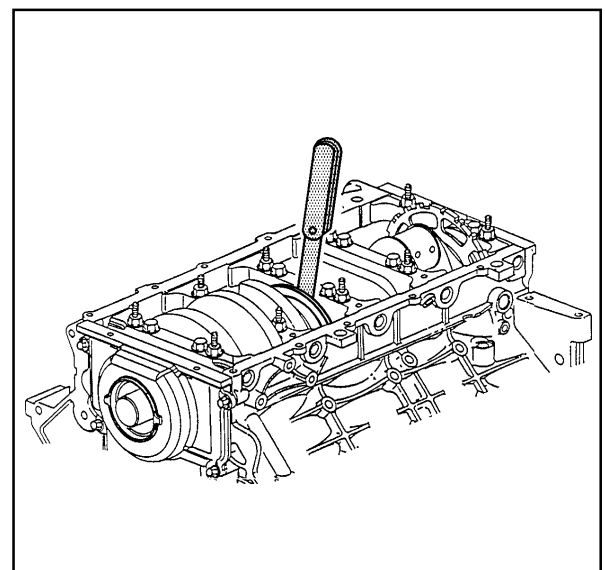
11. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
 - If the gauging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
 - If the bearing clearance is greater than 0.052 mm (0.0021 in), select and install an undersized bearing set, and measure the clearance with gauging plastic.
 - If clearance cannot be brought to specifications, replace the crankshaft or grind the crankshaft for use with the next undersized bearing.



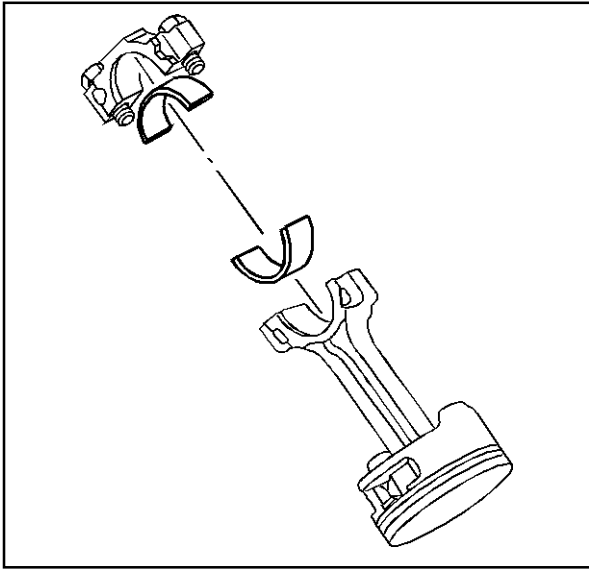
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12. Measure the crankshaft end play.
 - 12.1. Thrust the crankshaft forward or rearward.
 - 12.2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

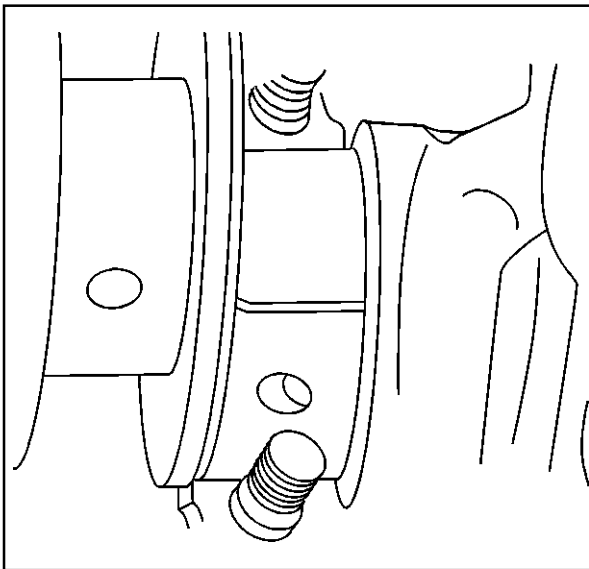
The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).
 - 12.3. If the bearing clearance is not within specifications:
 - Inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.
 - Replace the thrust bearings and measure the end play.
 - If the correct measurements cannot be obtained, repair the crankshaft thrust surfaces or replace the crankshaft.



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Measuring Connecting Rod Bearing Clearance

Important: Connecting rod bearings are a precision insert type. Connecting rods are of powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required.

Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

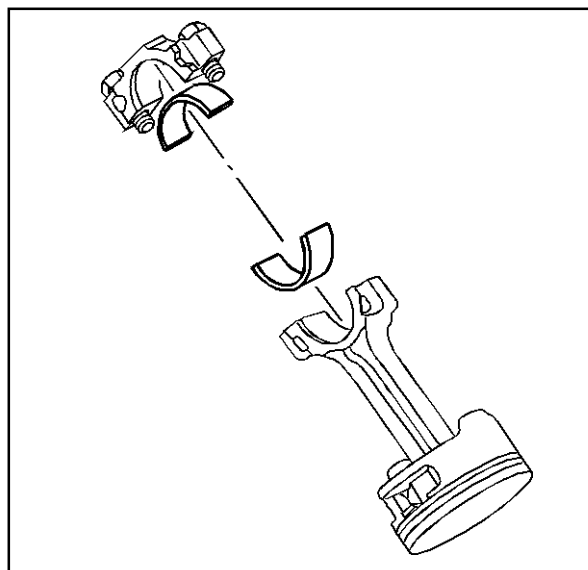
1. Remove the bearing cap, bearing half and bolts.
2. Install the gauging plastic onto the connecting rod bearing journal. Install the gauging plastic the full width of the journal.

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

3. Install the bearing cap, bearing and bolts.

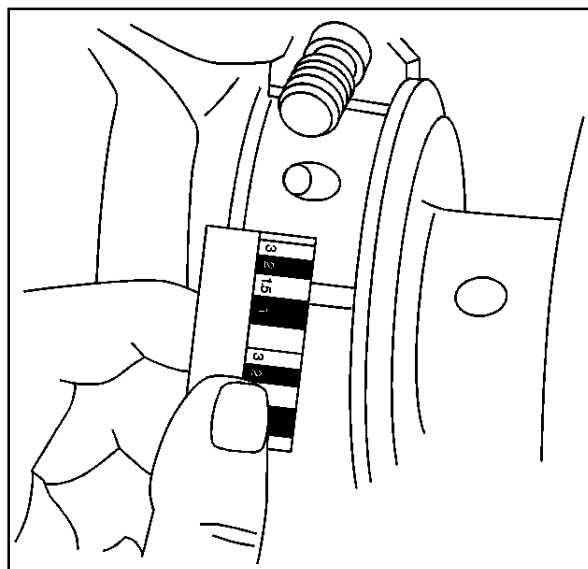
Tighten

- 3.1. Tighten the connecting rod bolts first pass to 20 N·m (15 lb ft).
- 3.2. Tighten the first design connecting rod bolts a final pass to 60 degrees using the *J 36660-A*.
- 3.3. Tighten the second design connecting rod bolts a final pass to 75 degrees using the *J 36660-A*.
4. Remove the bearing cap, bearing and bolts.



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5. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
The connecting rod bearing clearance should be 0.023-0.076 mm (0.0009-0.003 in).



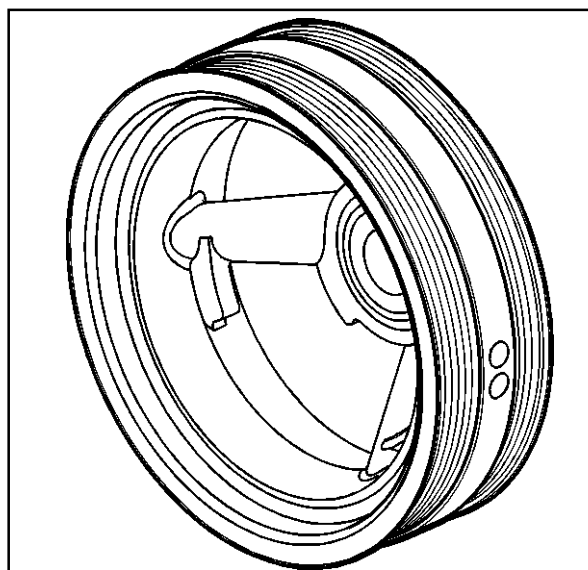
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Crankshaft Balancer Clean and Inspect

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following.
 - Worn, grooved or damaged hub seal surface
A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

Important: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves.

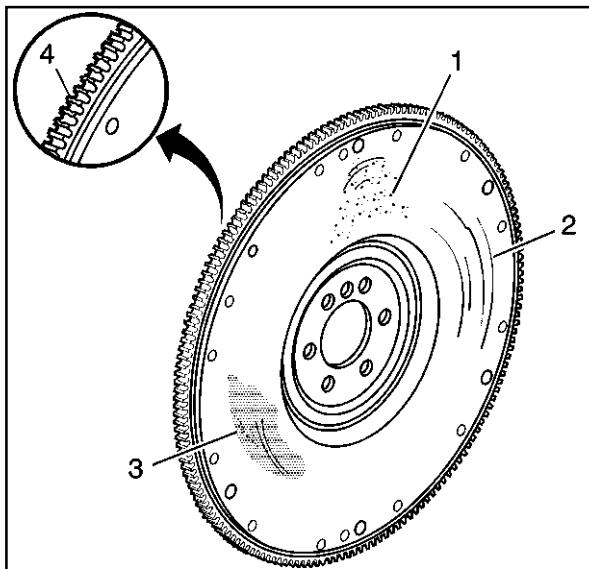


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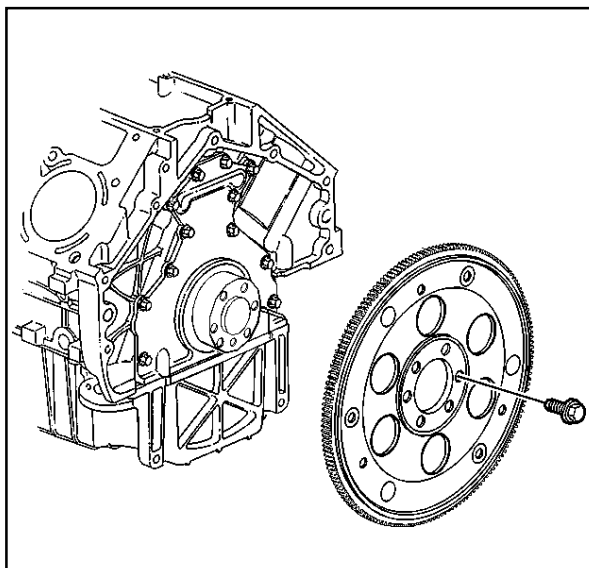
The balancer belt grooves should be free of any nicks, gouges or other damage that may not allow the belt to track properly.

Minor imperfections may be removed with a fine file.

- Worn, chunking or deteriorated rubber between the hub and pulley.



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Engine Flywheel Clean and Inspect

1. Clean the flywheel in solvent.

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

2. Dry the flywheel with compressed air.
3. Inspect the manual transmission flywheel for the following:

- Pitted surfaces (1)
- Grooves or scoring (2)
- Rusted surface (3)
- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.

- Missing, bent or damaged pressure plate locating pins
- The two locating pins are installed into the flywheel and spaced 170 degrees apart.

4. Inspect the automatic transmission flywheel for the following:

- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations

Important: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.

- Welded areas that retain the ring gear onto the flywheel for cracking

Piston and Connecting Rod Disassemble

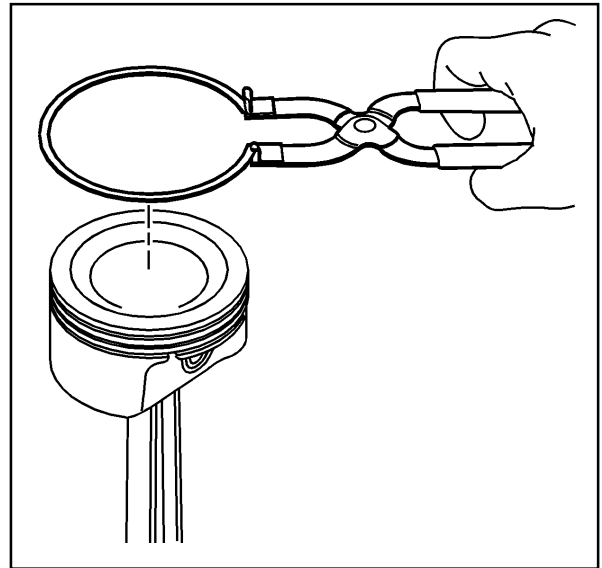
Important: Certain LQ9 engines will use a full-floating piston and pin design. In those applications, the pin is retained in the piston by retaining clips.

Press Fit Piston Pin

Tools Required

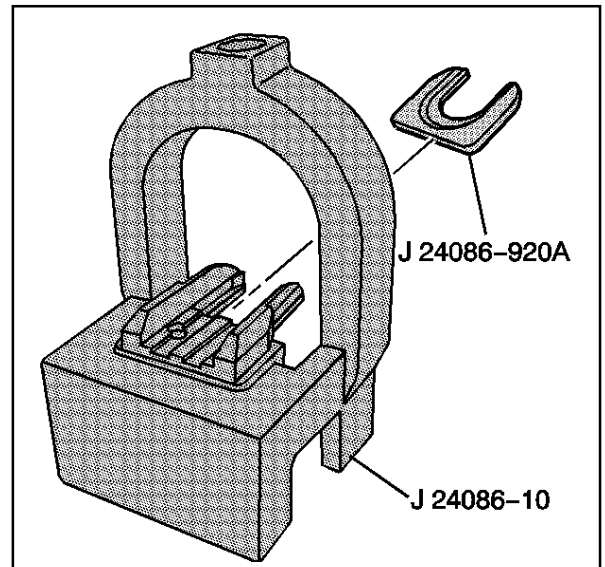
J 24086-C Piston and Pin Remover/Installer

1. Using piston ring pliers, remove the piston rings from the piston.

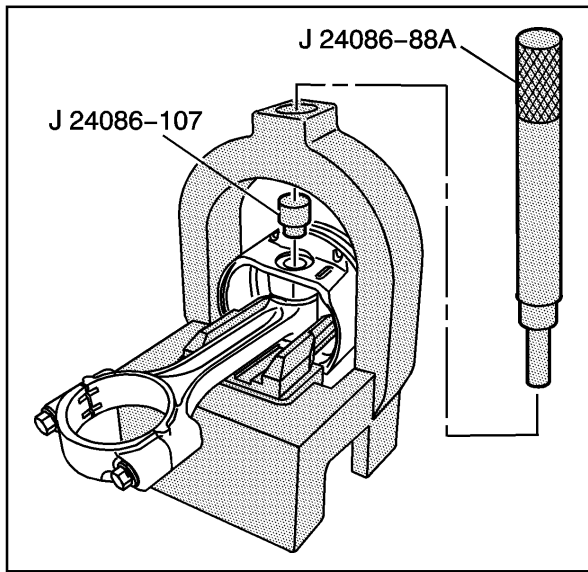


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2. Install fork insert *J 24086-920A* into fixture *J 24086-10*.

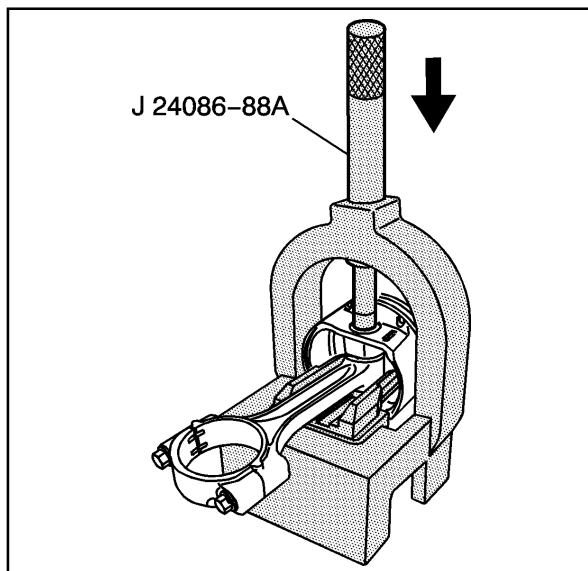


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3. Install the piston and connecting rod assembly onto *J 24086-10*.
4. Install *J 24086-107* into the piston pin and *J 24086-88A* through the fixture and into *J 24086-107*.



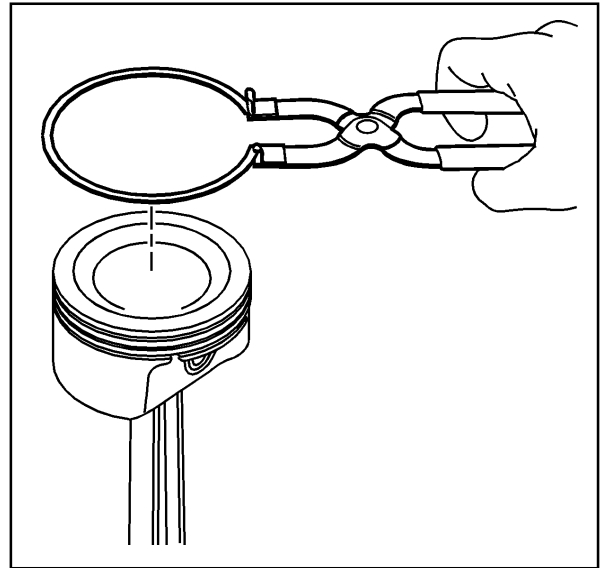
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Notice: After the installer hub bottoms on the support assembly, do not exceed 35,000 kPa (5,000 psi) pressure, this could cause damage to the tool.

5. Press the piston pin from the piston and connecting rod assembly.

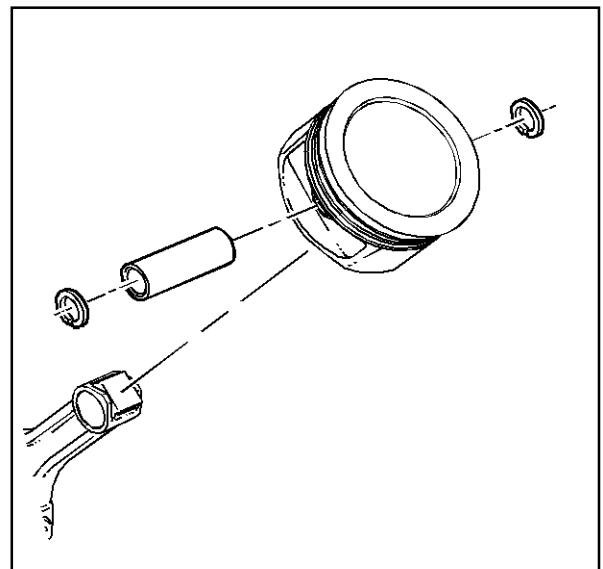
Full-Floating Piston Pin

1. Using piston ring pliers, remove the piston rings from the piston.

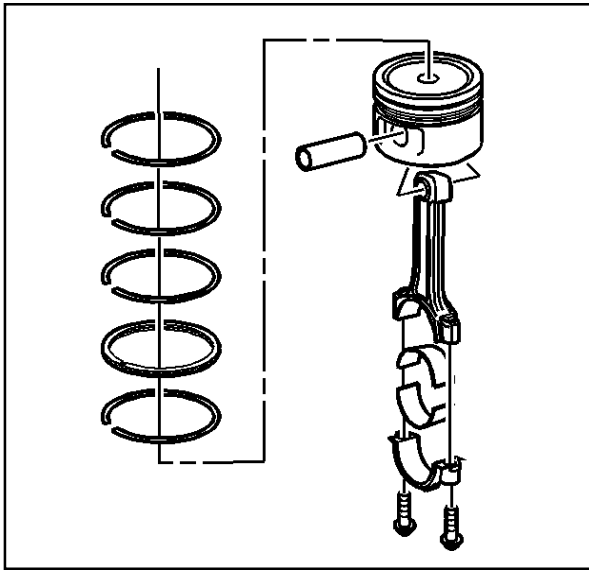


490763

2. Remove the piston pin retaining clips.
3. Remove the pin from the piston and connecting rod.
4. The piston and pin are a matched set and are not to be serviced separately. Mark, sort or organize the piston and the matching piston pin. Refer to *Separating Parts*.



35866



64180

Piston, Connecting Rod and Bearings Clean and Inspect

Piston and Pin

Important: Replace the pistons and the pins that are damaged or show signs of excessive wear.

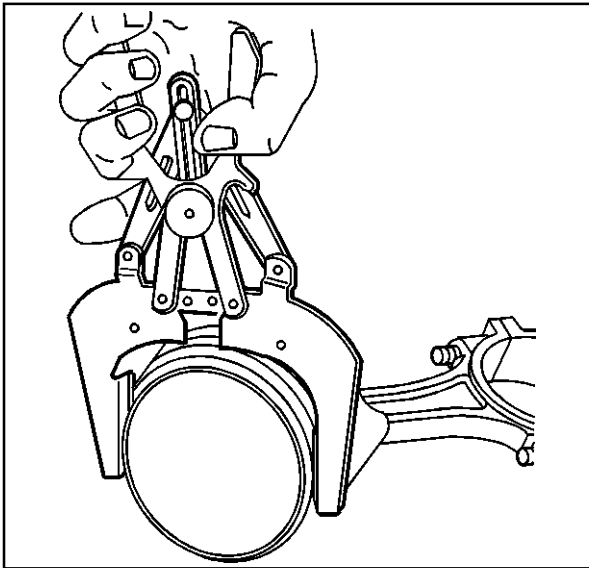
The piston and the pin are a matched set. If service is required, replace the piston and the pin as an assembly.

Do not wire brush any part of the piston.

1. Clean the varnish from the piston and the pin with cleaning solvent.

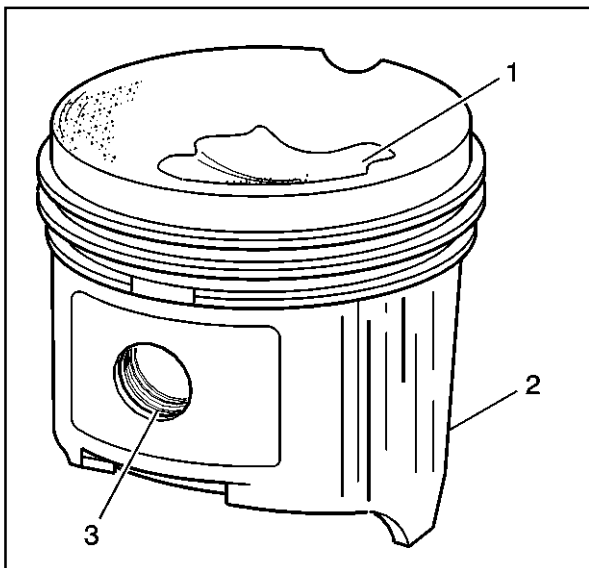
Caution: *Wear safety glasses in order to prevent eye damage.*

2. Dry the piston and the pin with compressed air.



4977

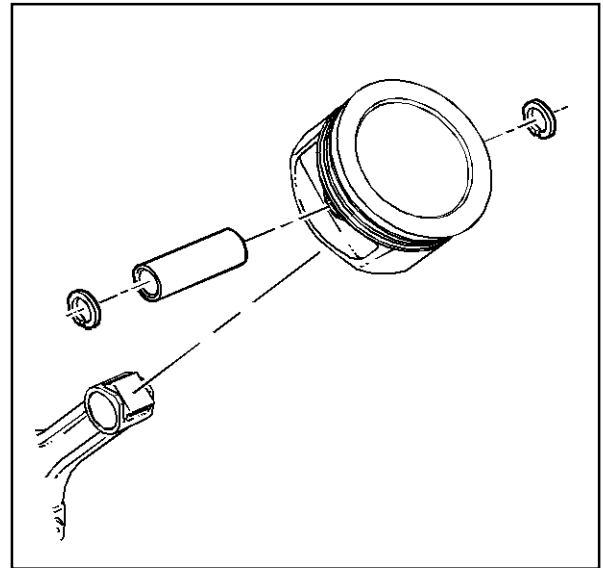
3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.



156168

5. Inspect the piston and the pin for the following:
 - Cracks in the piston ring lands, the piston skirt or the pin bosses
 - Piston ring grooves for nicks, burrs or warpage which may cause the piston ring to bind
Minor imperfections may be removed from the piston with a fine file.
 - Scuffed or damaged skirts (2)
 - Eroded areas at the top of the piston (1)
 - Scoring to the piston pin bore (3) or the piston pin

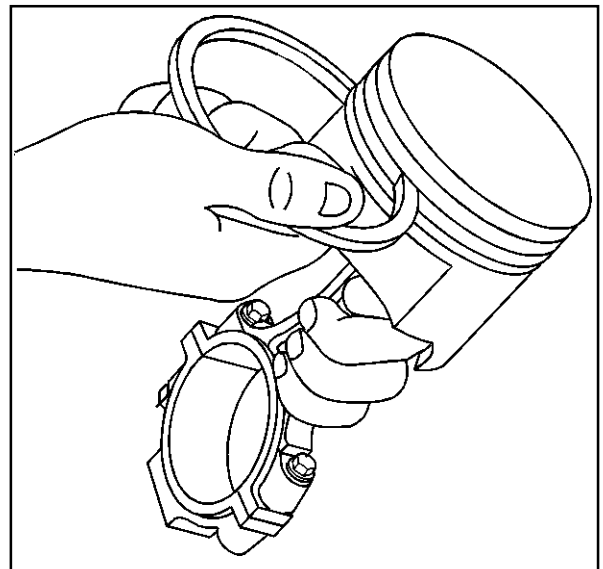
6. For certain applications, inspect for bent pin retaining clips or damage to the clip groove of the piston.



35866

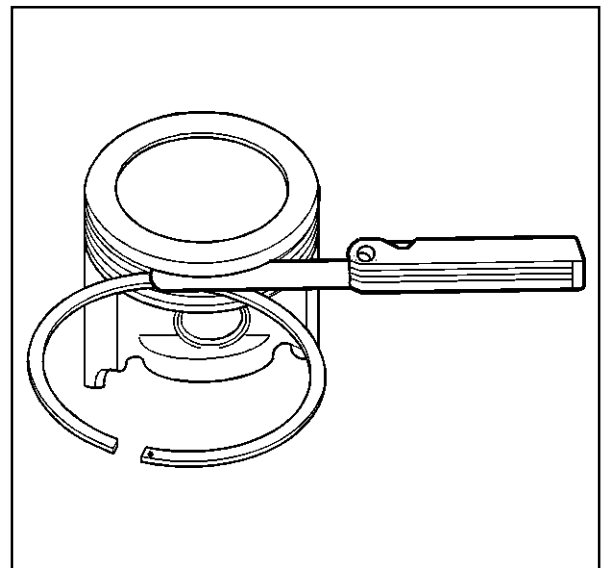
Important: Measurements of components should be taken with the components at normal room temperature.

7. Measure the piston ring-to-piston ring groove side clearance
 - 7.1. Insert the edge of the piston ring into the piston ring groove.
 - 7.2. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR ring groove imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, replace the piston ring.

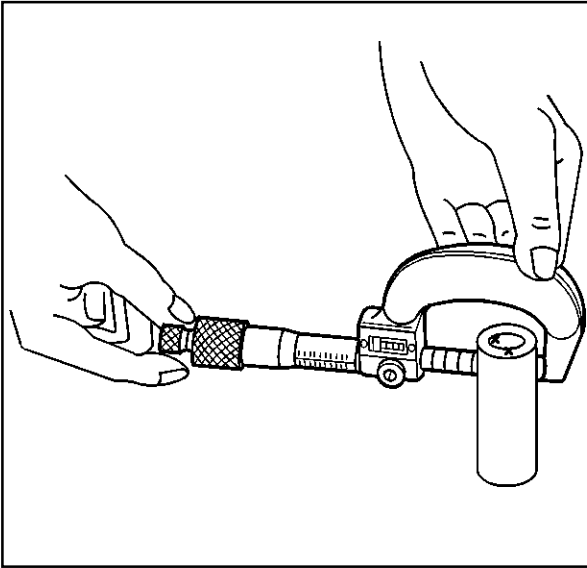


4969

8. Measure the piston ring side clearance with a feeler gauge.
9. If side clearance is not within specifications, try another piston ring set. Refer to *Engine Mechanical Specifications*.
10. If proper piston ring-to-piston ring groove side clearance cannot be achieved, replace the piston and pin assembly.

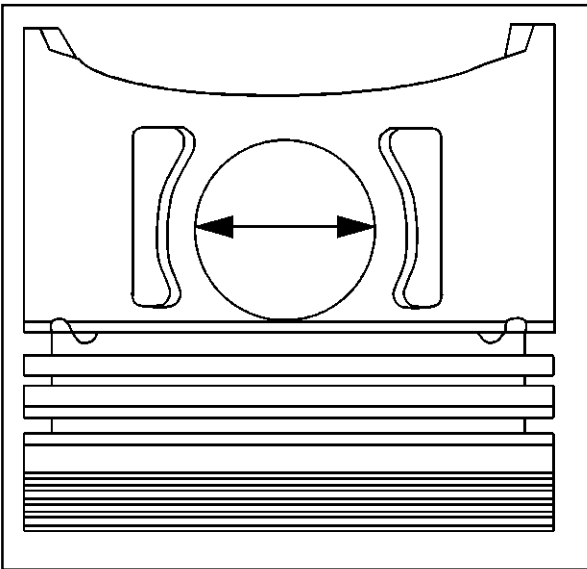


22934



4976

11. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin.



4975

12. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.

Important: The piston and pin are a matched set. If the clearance is not within specifications, replace the piston and pin as an assembly.

13. To determine the proper piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter. Refer to *Engine Mechanical Specifications*.

Connecting Rod and Bearings

Important: The powdered metal connecting rod and cap are machined for the proper clearances. The connecting rod and the cap must be used as an assembly with no repair or modifications to either mating surface.

Do not attempt to repair the connecting rod or the cap mating surfaces. If service is required, the connecting rod and the cap must be replaced as an assembly.

1. Clean the connecting rod and the cap in solvent.

Important: Replace the connecting rod if the bolt hole threads are damaged. Do not attempt to repair the bolt hole threads of the connecting rod.

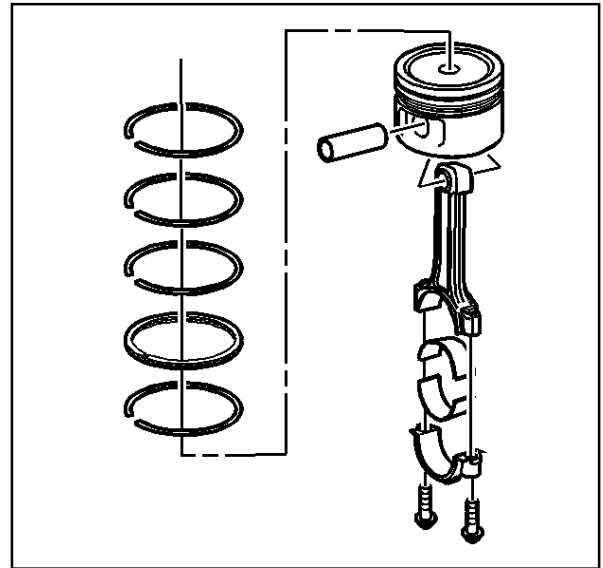
2. Clean the connecting rod threaded bolt holes.

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

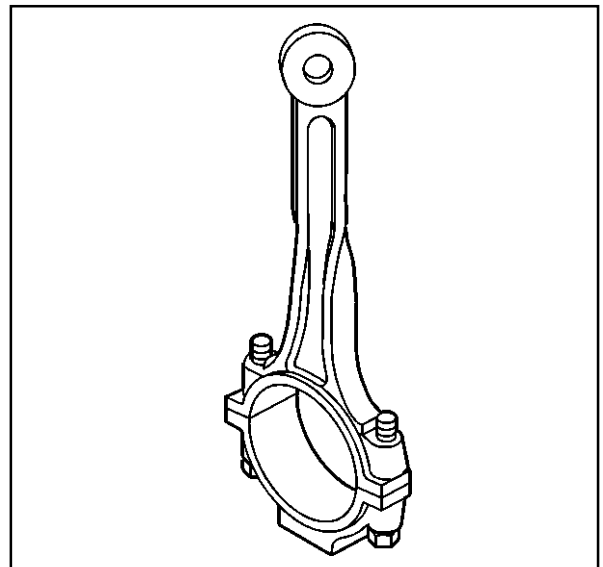
3. Dry the connecting rod with compressed air.

4. Inspect the connecting rod for the following:

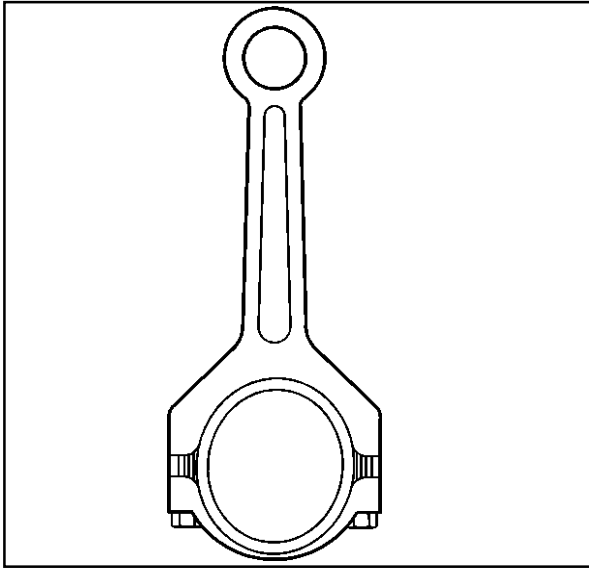
- Twisting
- Nicks or gouging in the bearing bore
- Damage to the bearing locating slots in the bearing bore
- Proper fit of the connecting rod and the cap mating surfaces



64180



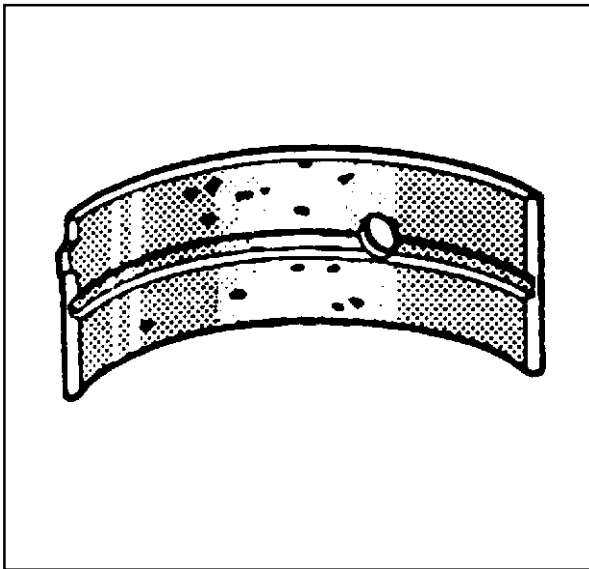
156169



156167

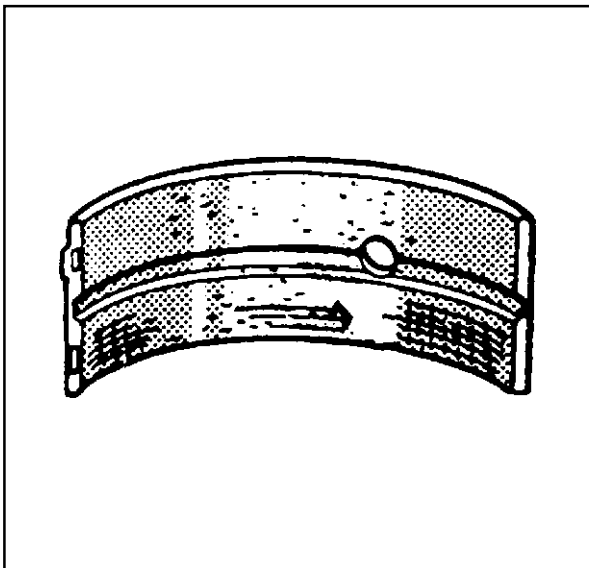
5. Measure the connecting rod bearing bore for out-of-round.

If the measurement exceeds 0.008 mm (0.0003 in), replace the connecting rod assembly.



52051

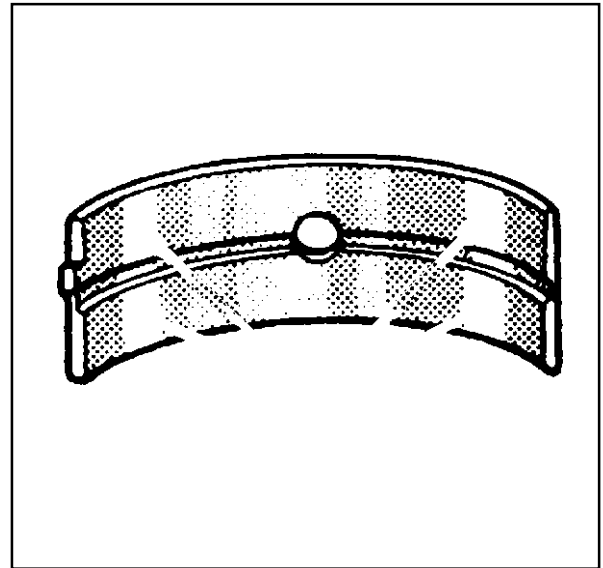
6. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



52053

7. Inspect the connecting rod bearings for excessive scoring or discoloration.
8. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

9. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing.



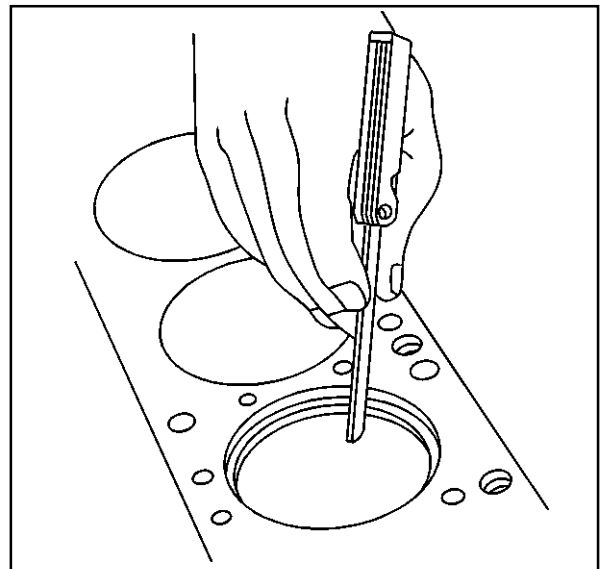
52056

Measuring Piston Ring End Gap

Important: Do not attempt to file the end of the piston ring for fit in the cylinder bore.

Important: Measure the piston ring in the cylinder in which the piston ring will be used.

1. Place the piston ring into the cylinder bore.
2. Push the piston ring into the bore 6.5 mm (0.25 in) below the piston ring travel area.
3. Insert a feeler gauge and measure the piston ring end gap. Refer to *Engine Mechanical Specifications*.



4968

Piston and Connecting Rod Assemble

Important:

- Assemble the piston for the specific cylinder with the connecting rod for the corresponding crankshaft journal.
- Certain LQ9 engines will use a full-floating piston and pin design. In these applications, the pin is retained in the piston by retaining clips.

Press Fit Piston Pin

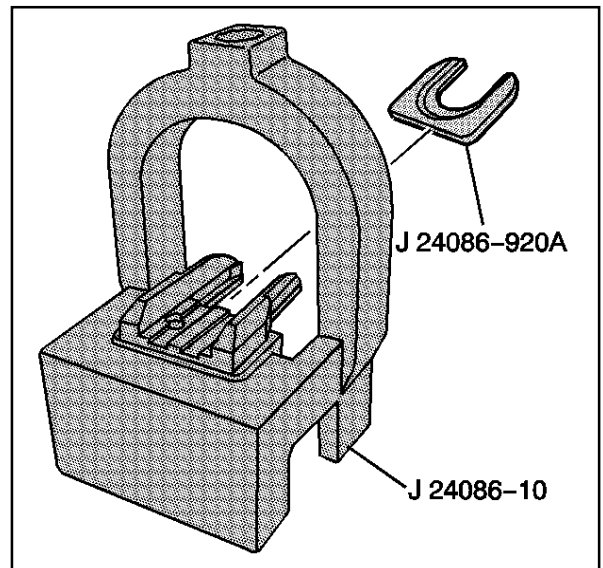
Tools Required

J 24086-C Piston Pin Remover/Installer Set

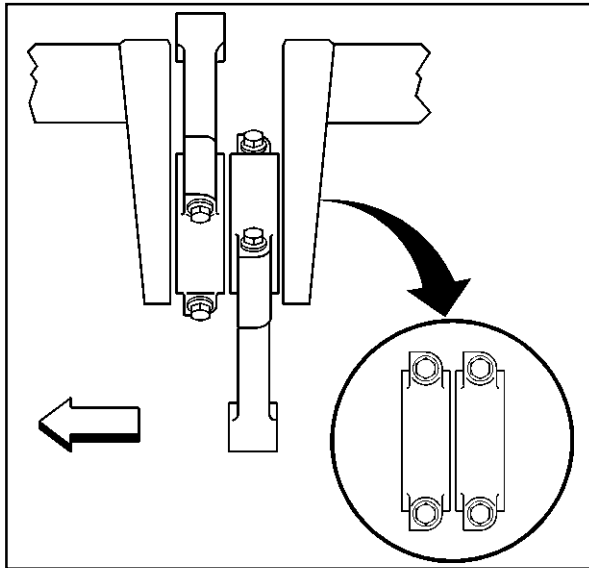
J 24086-10 Piston Pin Remover/Installer Base

J 24086-9 Adjustable Installer

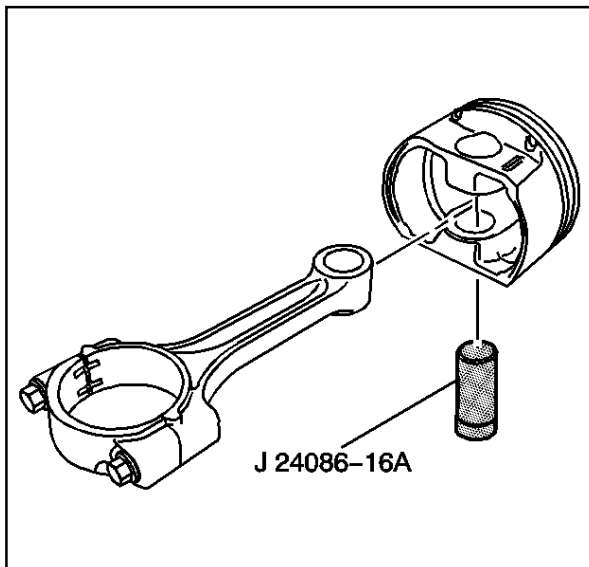
1. Install fork insert *J 24086-920A* into fixture *J 24086-10* Piston Pin Remover/Installer Base.



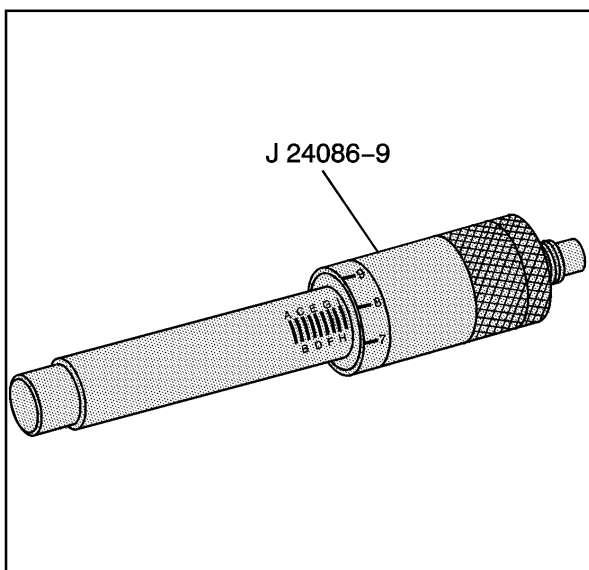
533477



63227



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533486

Caution: Avoid contact with **HOT** components. Wear safety glasses and protective gloves to avoid personal injury.

Notice: Applying excessive heat to the connecting rod may damage or distort the rod. Rod temperature **SHOULD NOT** exceed 315 C (600 F). At this temperature the end of the connecting rod will turn a straw color upon visual inspection.

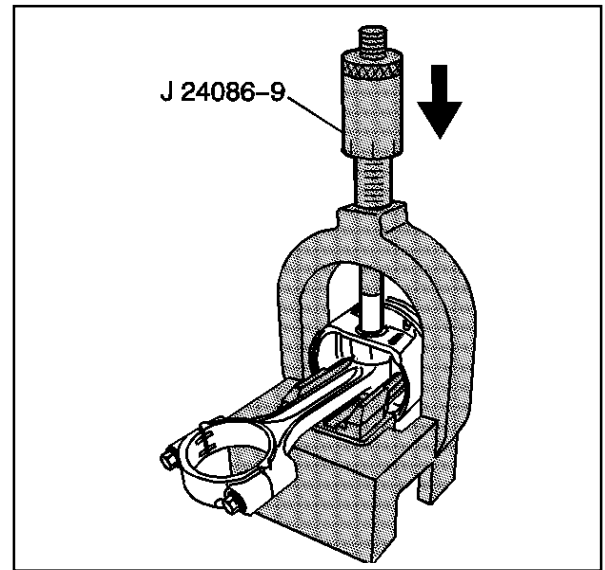
2. Use a torch and apply **MILD** heat to the pin end of the connecting rod.
Mild heating of the connecting rod will ease in piston and pin assembly.
3. With the piston and connecting rod properly assembled, both the flat flange area of the connecting rod and the alignment mark on the top of the piston will be facing the front of the engine.

4. Assemble the piston, connecting rod and adapter J 24086-16A and install onto fixture J 24086-10.

5. Adjust installation pin J 24086-9 to I-8.

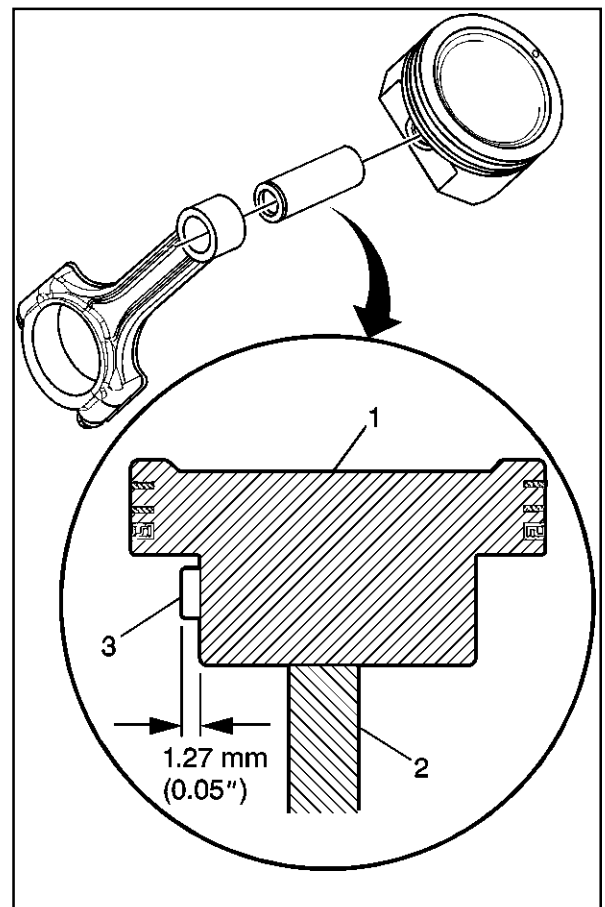
Notice: After the installer hub bottoms on the support assembly, do not exceed 35,000 kPa (5,000 psi) pressure, this could cause damage to the tool.

6. Insert pin *J 24086-9* through fixture *J 24086-10* and to the piston pin.
7. Press pin *J 24086-9* until the installer bottoms on fixture *J 24086-10*.

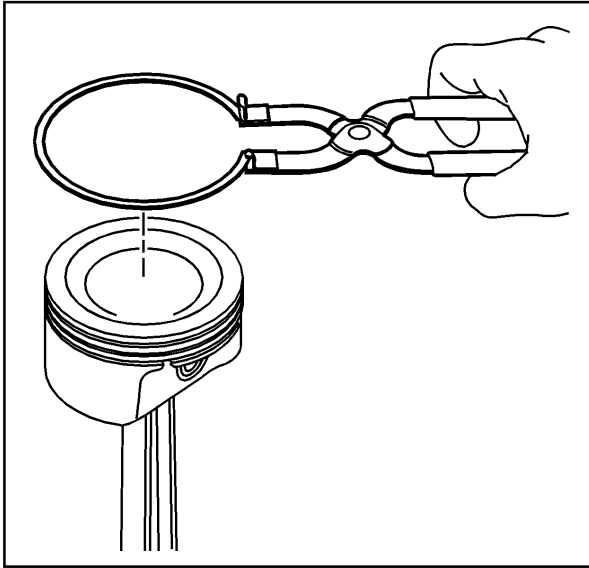


533483

8. Measure the piston (1), pin (3) and connecting rod (2) for proper assembly.
 - 8.1. Place the piston and connecting rod assembly onto a table or other flat surface.
Lay the flat top of the piston (1) onto the table surface.
 - 8.2. Slide the connecting rod (2) and pin (3) to one side and hold firmly against the inside of the piston (1).
 - 8.3. Measure the pin (3) for proper installation.
A properly installed piston pin should protrude 1.27 mm (0.05 in) from the side of the piston.



63156



490763

Important: When installing the piston rings onto the piston, use a ring expanding plier type tool. Do not roll the piston rings into the grooves of the piston.

Use a caution and care to expand the piston rings only slightly larger than the Outside Diameter (OD) of the piston.

9. Using piston ring pliers, install the piston rings onto the piston.
 - 9.1. Install the oil control ring spacer in the groove.
 - 9.2. Install the lower oil control ring.

The oil control rings do not have a dimple or orientation mark and may be installed in either direction.
 - 9.3. Install the upper oil control ring.
 - 9.4. Stagger the three oil control ring end gaps a minimum of 90 degrees.
 - 9.5. Using piston ring pliers, install the lower compression ring.

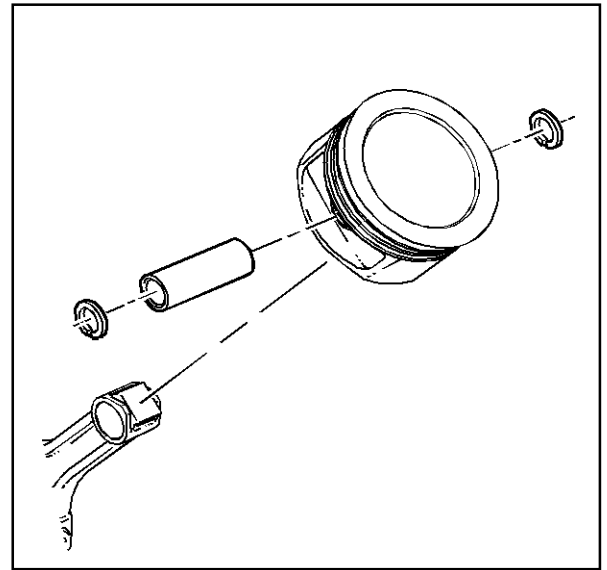
The lower compression ring has a dimple or orientation mark and must face the top of the piston.
 - 9.6. Using piston ring pliers, install the upper compression ring.

The upper compression ring does not have a dimple or orientation mark and may be installed in either direction.
 - 9.7. Stagger the compression ring end gaps a minimum of 25 mm (1.0 in).

Full-Floating Piston Pin

Important: With the piston and connecting rod properly assembled, both the flat flange area of the connecting rod and the alignment mark on the top of the piston will be facing the front of the engine.

1. Install the pin to the piston and connecting rod.
2. Install the retaining clips.



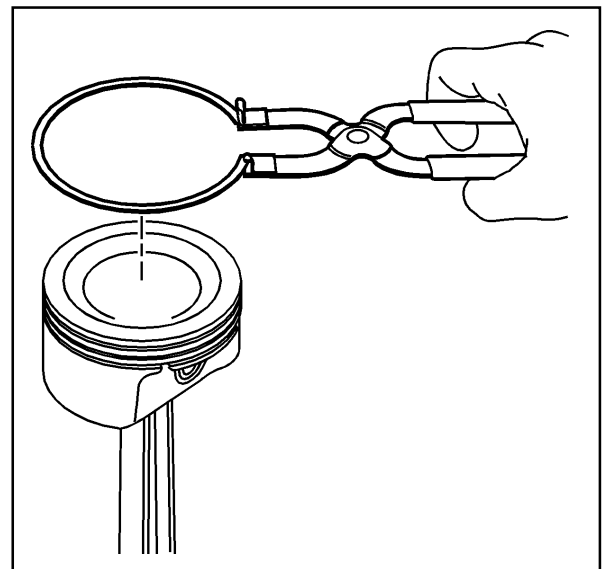
35866

Important: When installing the piston rings onto the piston, use a ring expanding plier type tool. Do not roll the piston rings into the grooves of the piston.

Use a caution and care to expand the piston rings only slightly larger than the Outside Diameter (OD) of the piston.

3. Using piston ring pliers, install the piston rings onto the piston.
 - 3.1. Install the oil control ring spacer in the groove.
 - 3.2. Install the lower oil control ring.

The oil control rings do not have a dimple or orientation mark and may be installed in either direction.
 - 3.3. Install the upper oil control ring.
 - 3.4. Stagger the three oil control ring end gaps a minimum of 90 degrees.

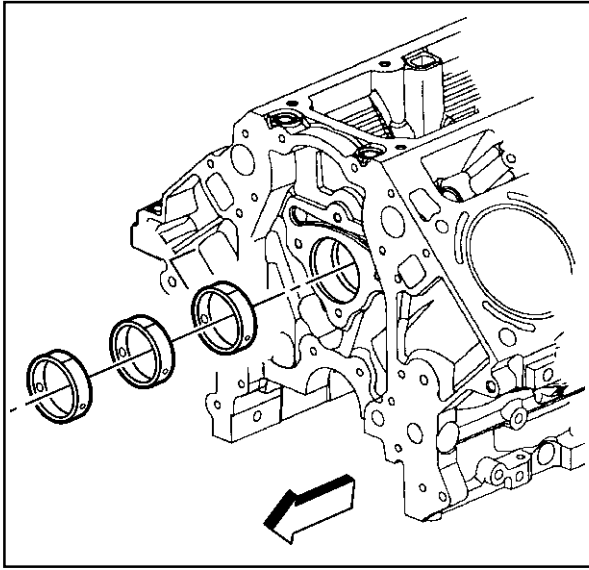


490763

- 3.5. Using piston ring pliers, install the lower compression ring.

The lower compression ring has a dimple or orientation mark and must face the top of the piston.
- 3.6. Using piston ring pliers, install the upper compression ring.

The upper compression ring does not have a dimple or orientation mark and may be installed in either direction.
- 3.7. Stagger the compression ring end gaps a minimum of 25 mm (1.0 in).



63163

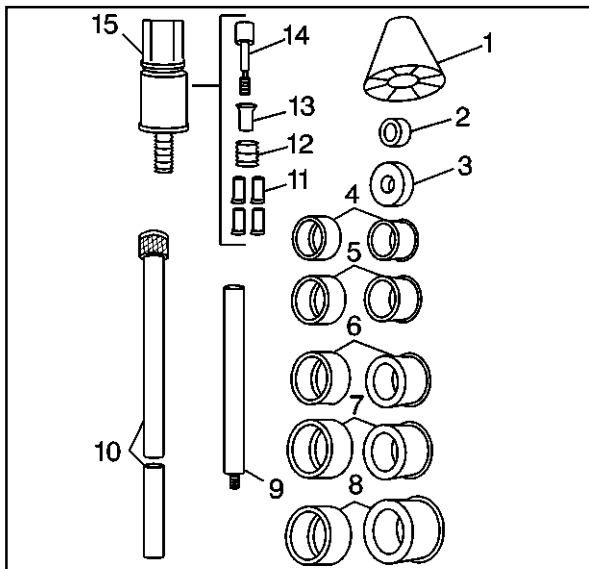
Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Remover/Installer

Important: A loose camshaft bearing may be caused by an enlarged, out-of-round or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores.
Refer to *Camshaft and Bearings Clean and Inspect*.
2. Repair or replace the components as required.



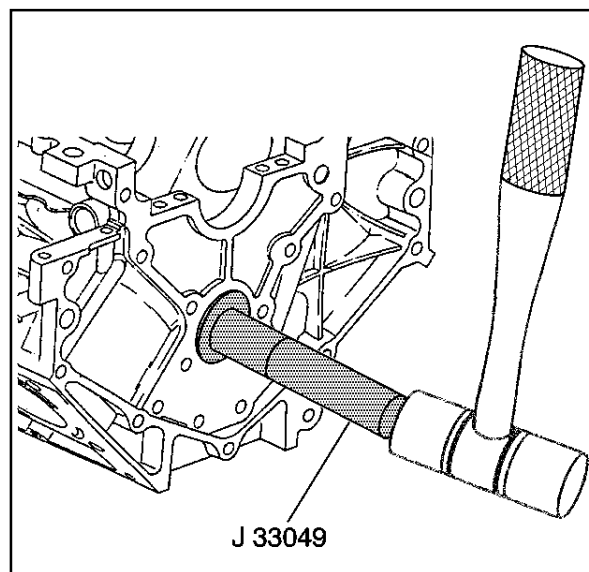
66100

3. Select the expanding driver (4-8) and washer (2 or 3) from the tool usage information.
4. Assemble the tool.

5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing to align the tool.
8. Drive the bearing from the block bore.

Important: To remove the front camshaft bearing, operate the tool from the rear of the block using the guide cone (1) in the rear camshaft bearing bore.

9. Repeat the above procedures to remove the remaining bearings.

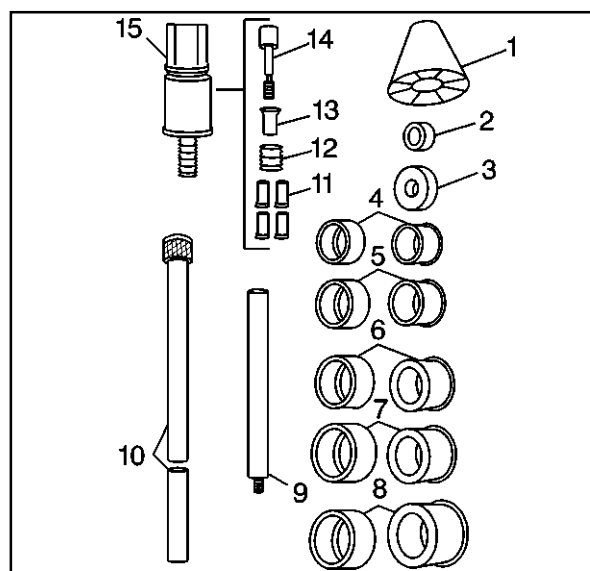


63219

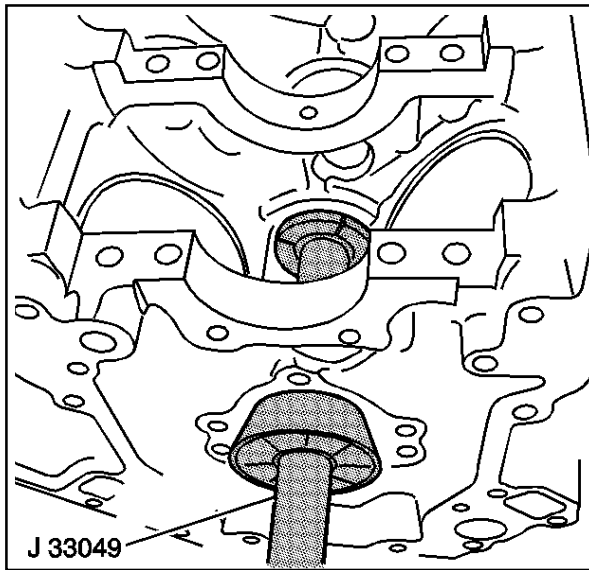
Tool Usage Information

Bearing, Expander and Expander Driver Information

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14) and expander assembly (15).
- Expander bearing driver number one inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the expander assembly and the small washer.
- Expander bearing driver number two inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number one expanding driver and the small washer.
- Expander bearing driver number three inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number two expanding driver and the large washer.
- Expander bearing driver number four inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number three expanding driver and the large washer.
- Expander bearing driver number five inside diameter is 54.61-60.325 mm (2.15-2.375 in) and is used with number four expanding driver and the large washer.
- Expander bearing driver number six inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number five expanding driver and the large washer.



66100



64183

Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

Important: To install or remove the expanding driver, always push on or pull from the ends.

Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Check to insure that the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. Place the guide cone over the driving bar (with the small end of the cone facing the driver assembly).
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly (with driving washer) onto the driving bar.

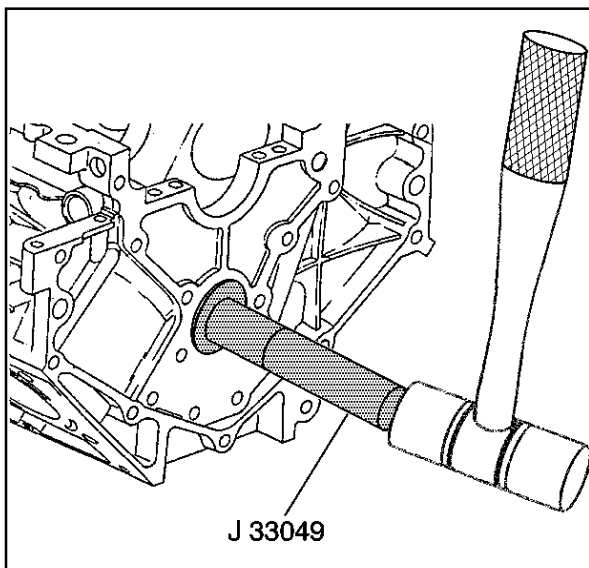
It may be necessary to install the driver bar extension for removal of the inner bearings.

7. Insert the tool into an inner camshaft bearing and tighten until snug.

Operate the tool from the front or rear of the engine block.

On some engine blocks the nut on the expander assembly is inaccessible except from either end. In this case, you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone into the front or rear camshaft bearing (this will properly align the tool).
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.



63219

11. For the two end bearings (front and rear), remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

Camshaft and Bearings Clean and Inspect

Tools Required

J 7872 Magnetic Base Dial Indicator Set

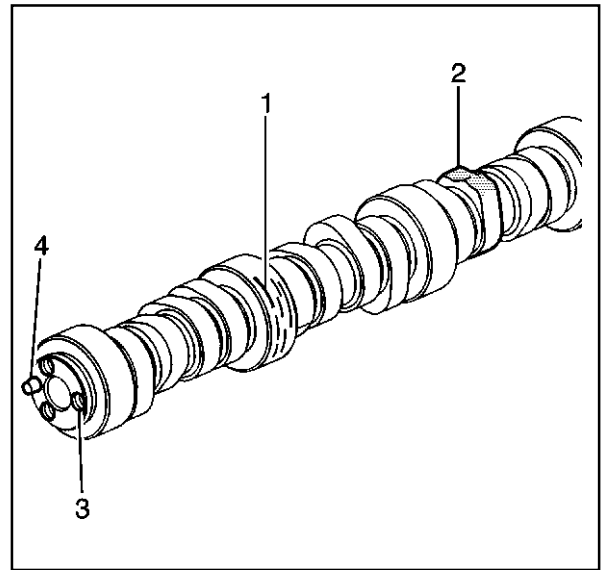
J 8520 Camshaft Lobe Lift Indicator

1. Clean the components in solvent.

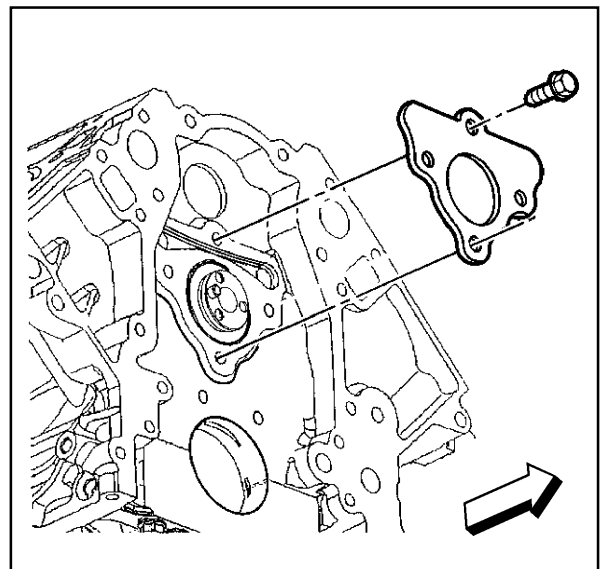
Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the threaded bolt holes (3) in the front of the camshaft for damaged threads or debris.
6. Inspect the camshaft sprocket pin (4) for damage.
7. Inspect the camshaft position reluctor ring for nicks or damage.
8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

If the camshaft retainer plate sealing gasket is not cut or damaged, it may be reused.



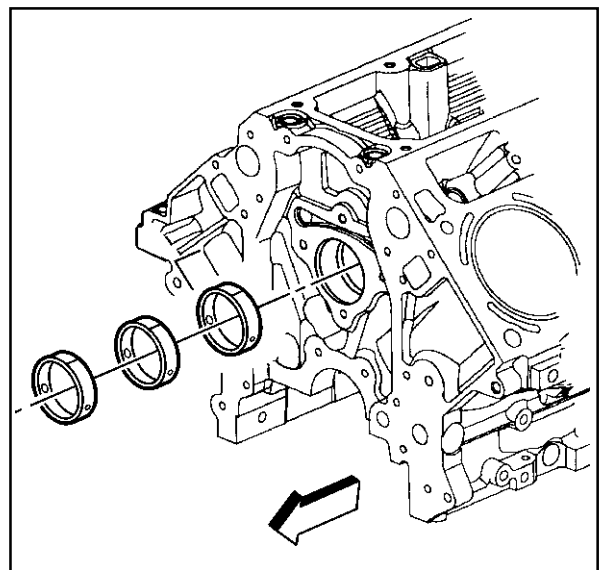
188095



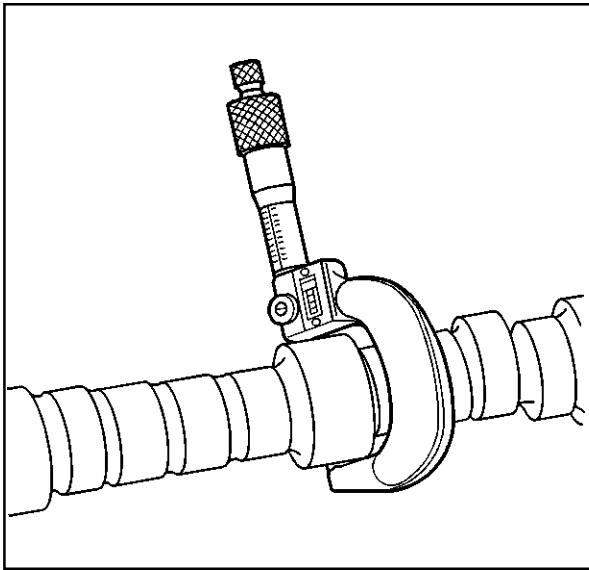
63211

9. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
10. Inspect the camshaft bearings for excessive wear or scoring.

Bearings with excessive scoring or wear must be replaced.

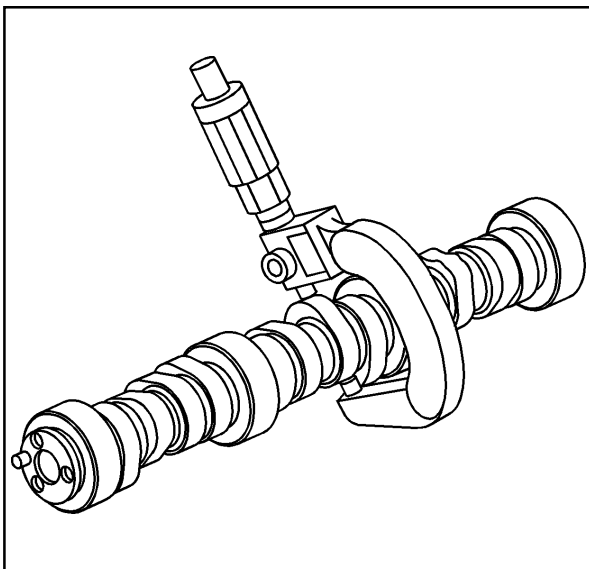


63163



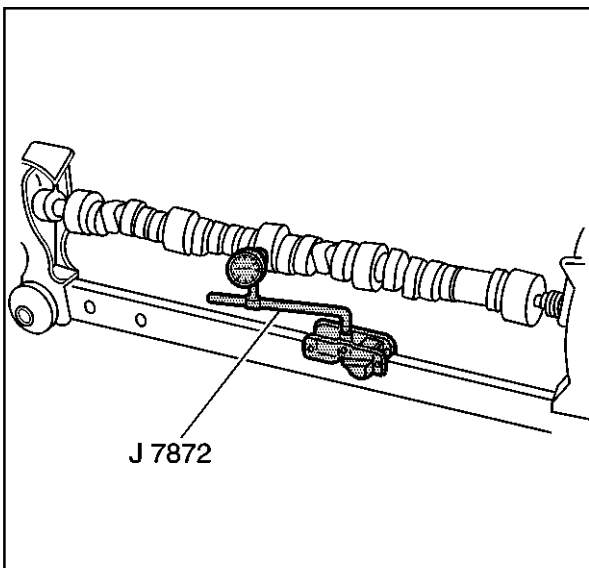
35212

11. Measure the camshaft journals for wear and out-of-round with a micrometer.
 - If the camshaft bearing journals are more than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
 - If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the camshaft.



260130

12. Measure the camshaft lobes for wear with a micrometer.
 - A camshaft with an intake lobe that measures 46.31 mm (1.823 in) or less must be replaced.
 - A camshaft with an exhaust lobe that measures 46.31 mm (1.823 in) or less must be replaced.



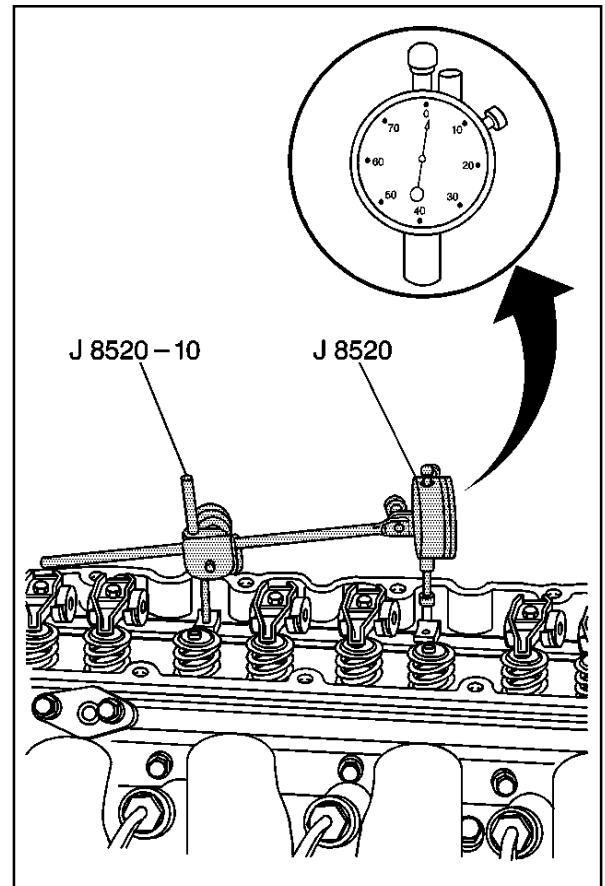
64297

13. Measure the camshaft runout.
 - 13.1. Mount the camshaft on wooden V-blocks or between centers on a fixture.
 - 13.2. Check the runout of the intermediate camshaft bearing journals using the J 7872.
 - 13.3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift

Important: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

1. Measure camshaft lobe lift using *J 8520*.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the *J 8520* and position onto the stud.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise until the dial indicator obtains its highest and lowest readings.
8. Compare the total lift shown to the specifications:
 - The proper lobe lift for intake lobes is 6.96 mm (0.274 in).
 - The proper lobe lift for exhaust lobes is 7.13 mm (0.281 in).



64967

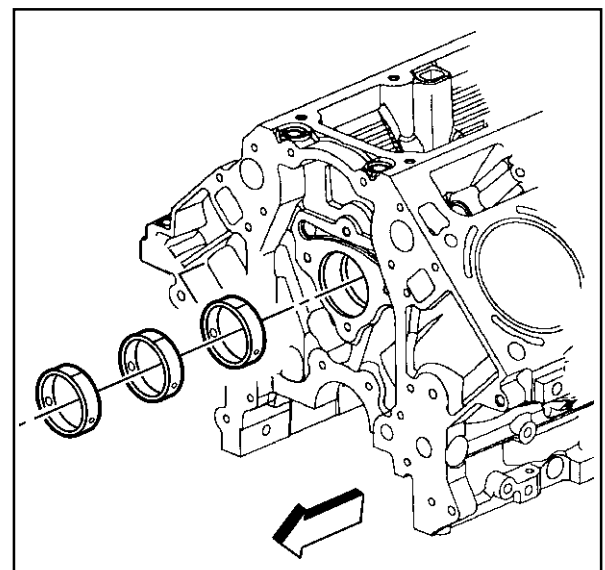
Camshaft Bearing Installation

Tools Required

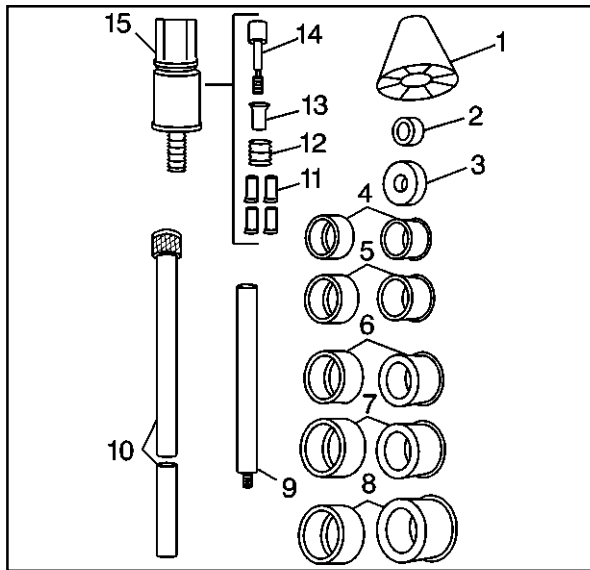
J 33049 Camshaft Bearing Remover/Installer

Important: A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores.
2. Repair or replace the components as required.

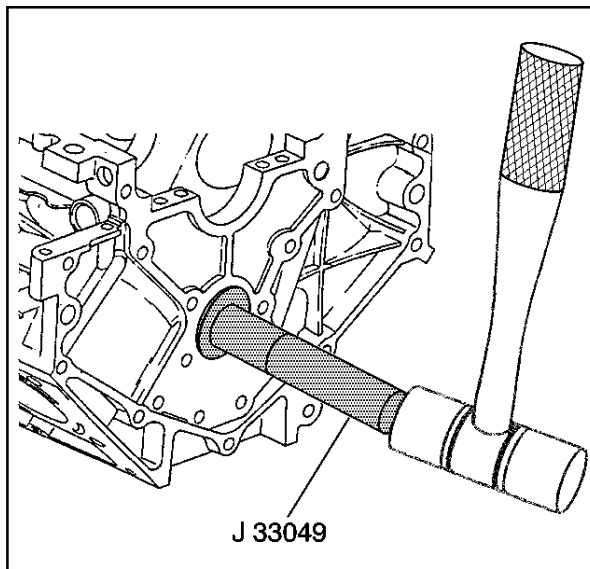


63163



66100

3. Select the expanding driver (4-6) and washer (2 or 3) from the tool usage information.
Refer to *Camshaft Bearing Removal*.
4. Assemble the tool.

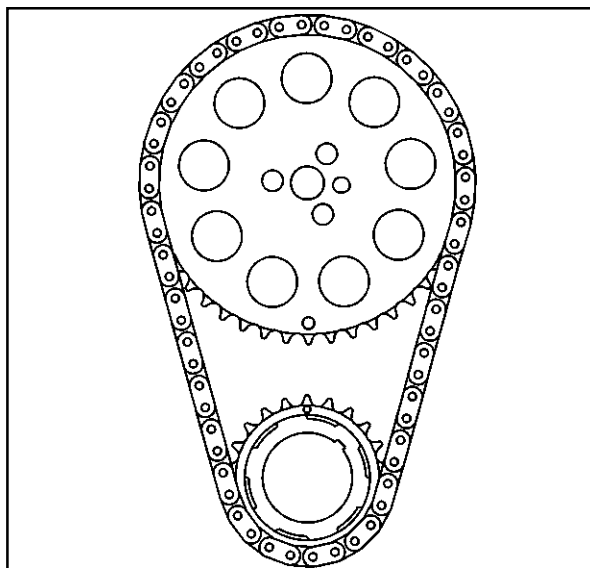


63219

5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing to align the tool.
8. Drive the bearing from the engine block bore.

Important: To remove the front camshaft bearing, operate the tool from the rear of the engine block, using the guide cone in the rear camshaft bearing bore.

9. Repeat the above procedures to remove the remaining bearings.



156158

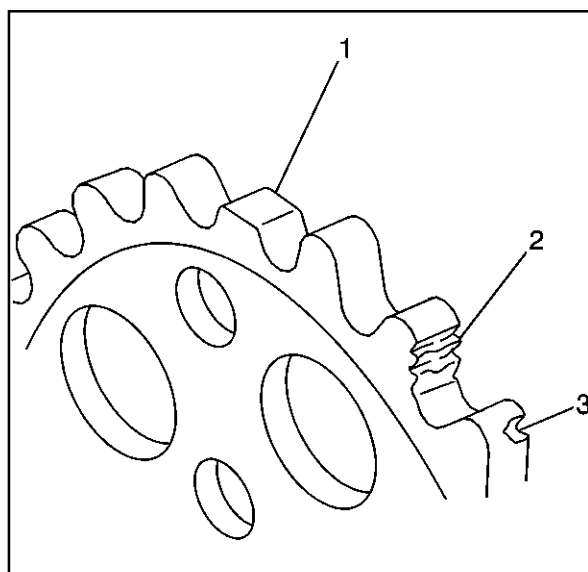
Timing Chain and Sprockets Clean and Inspect

1. Clean the components in solvent.

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

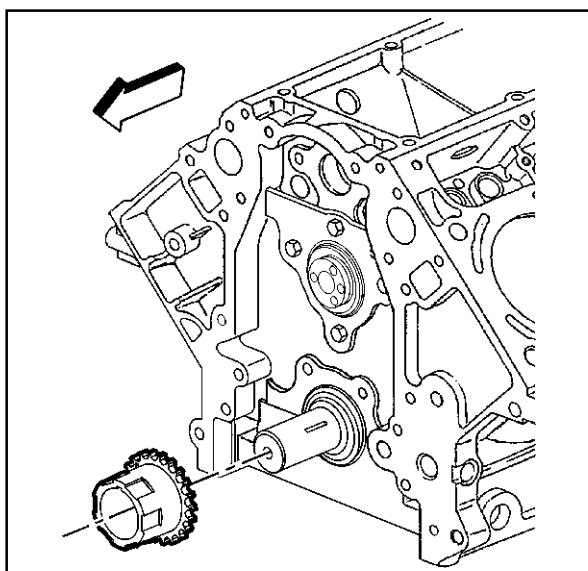
2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.

4. Inspect the camshaft and crankshaft sprockets for the following:
 - Worn teeth (1)
 - Damaged teeth (2)
 - Chipped teeth (3)
 - Worn valleys between the sprocket teeth



188097

5. Inspect the crankshaft sprocket keyway for wear.
6. Inspect the crankshaft sprocket oil pump drive splines for wear.



156150

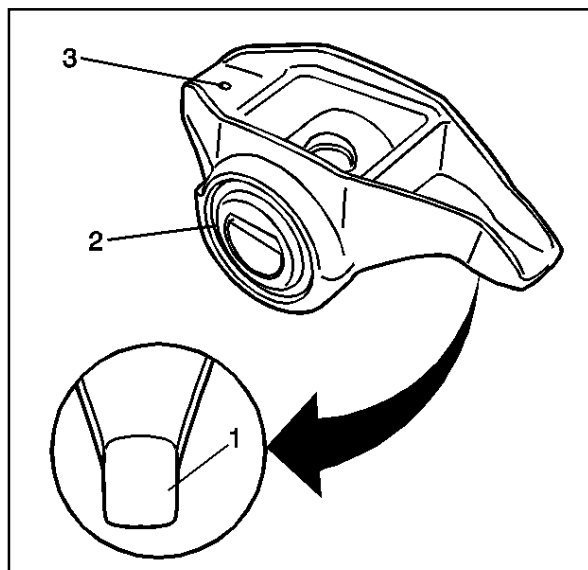
Valve Rocker Arm and Push Rods Clean and Inspect

Important: Parts that are to be reused must be marked, sorted or organized for assembly.

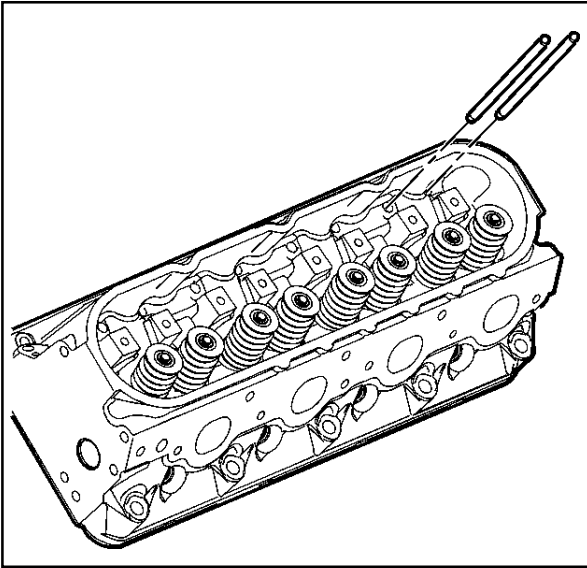
1. Mark, sort or organize the components for assembly.
2. Clean the components with cleaning solvent.

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

3. Dry the components with compressed air.
4. Inspect the valve rocker arm bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.

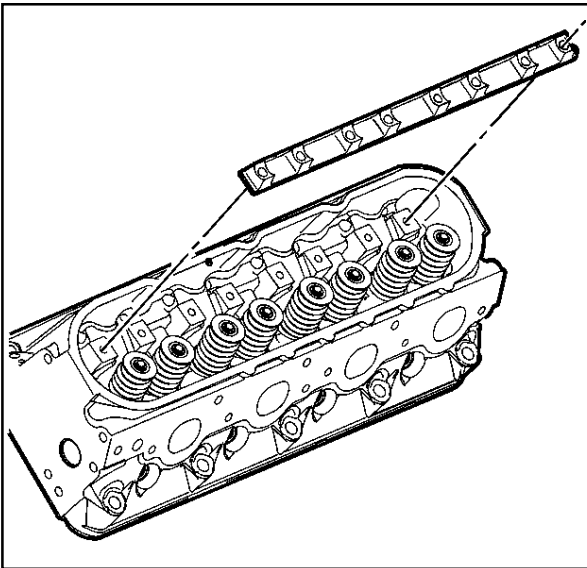


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260142

6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.



260141

9. Inspect the pivot supports for cracks, wear or other damage.

Valve Lifters and Guides Clean and Inspect

Important: Components that are to be reused must be marked, sorted or organized for assembly.

1. Mark, sort or organize the components for assembly.
2. Clean the components with cleaning solvent.

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

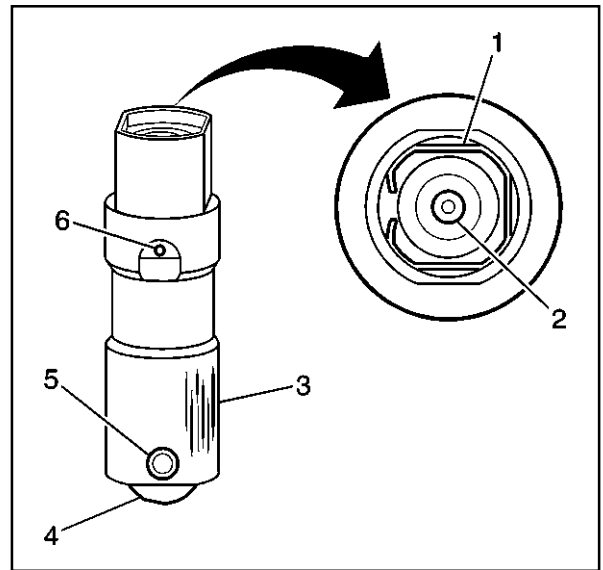
3. Dry the components with compressed air.
4. Inspect the valve lifters for the following:

- Bent or broken clip (1)
- Worn pushrod socket (2)
- Scuffed or worn sides (3)

If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

- Flat spots on the roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)
- Worn or damaged roller bearing

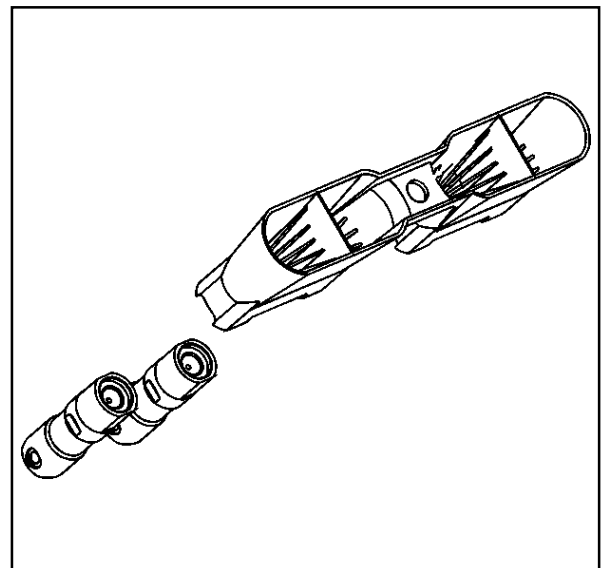
The roller should rotate freely with no binding or roughness.



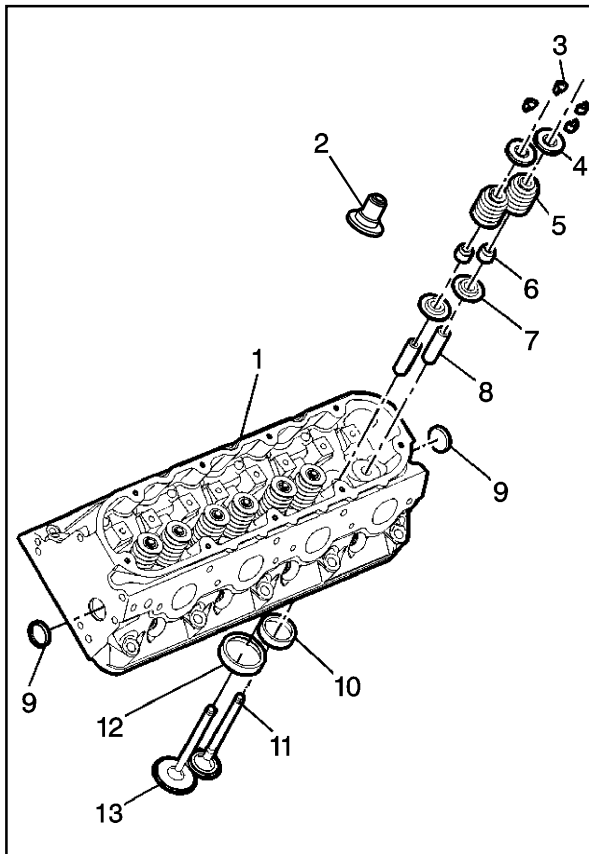
178485

5. Inspect the valve lifter guides for the following:

- For cracks or damage
- Excessive wear in the lifter mounting bores.



63233



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Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor

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

Mark, sort or organize the cylinder head components for assembly. Return the components to their original location during assembly.

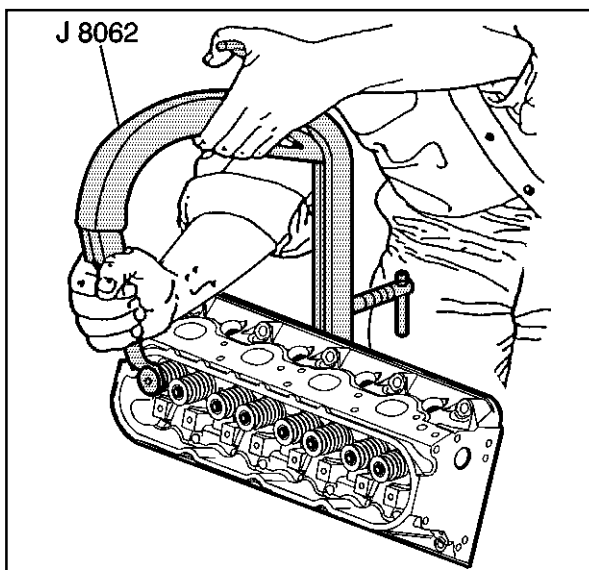
Do not remove the cylinder head expansion plugs (9) (aluminum heads only) unless service is required.

Do not attempt to replace worn valve guides (8). Worn valve guides should be reamed and sleeved for proper clearance to the valve stem.

A second design valve stem oil seal and shim assembly may be used on later engines.

A separate spring shim is not required with the second design seal and shim assembly.

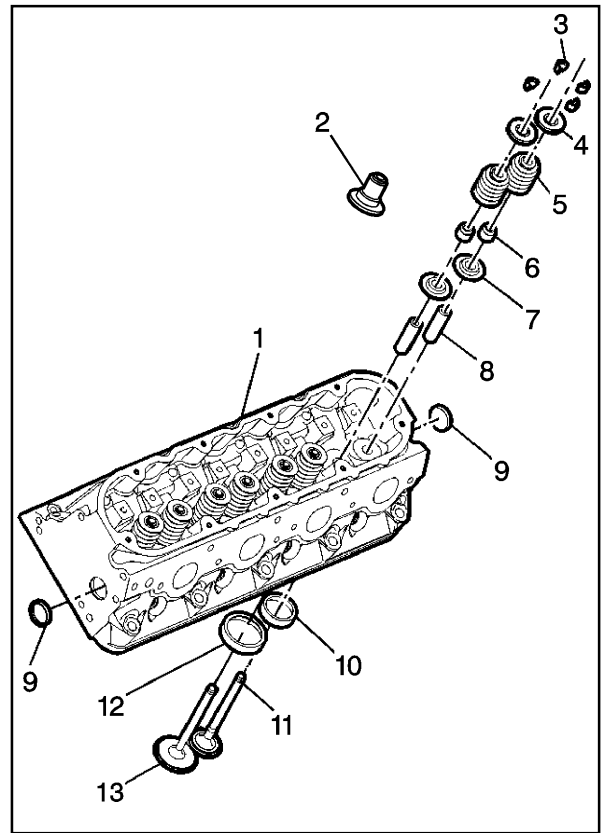
1. Remove the spark plugs from the cylinder heads.



260151

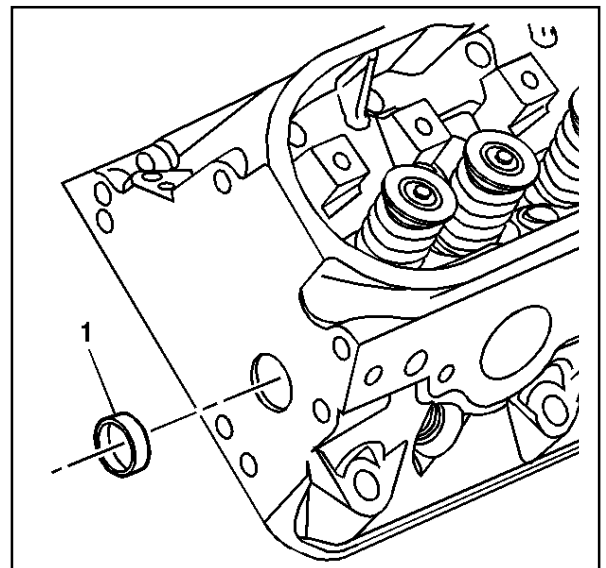
2. Use the *J 8062* in order to compress the valve springs.

3. Remove the valve stem keys (3).
4. Remove the valve spring cap (4).
5. Remove the valve spring (5).
6. Remove the valves (11 and 13).
7. Remove the valve stem oil seal (6) (first design).
8. Remove the valve spring shim (7) (first design).
9. Remove the valve stem oil seal and shim assembly (2) (second design). Refer to *Separating Parts*.

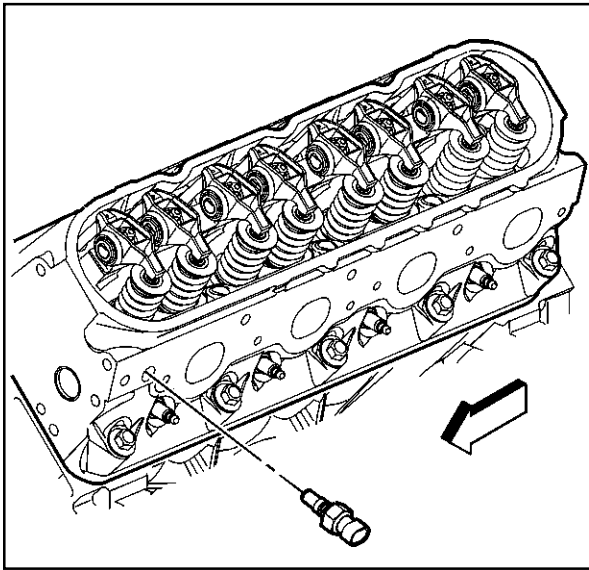


721939

10. Remove the cylinder head expansion plugs (1), if required.

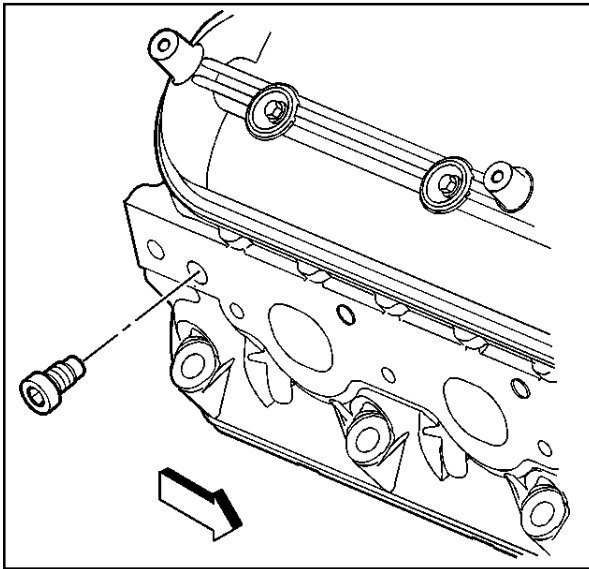


490662



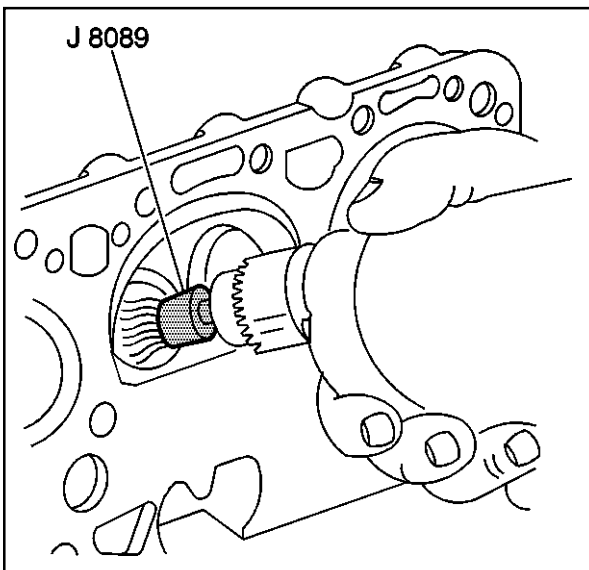
260086

11. Remove the coolant sensor from the left cylinder head, if required.



260157

12. Remove the coolant plug from the right cylinder head, if required.



4957

Cylinder Head Clean and Inspect

Tools Required

J 8089 Carbon Removing Brush

J 9666 Valve Spring Tester

Important: When cleaning a cylinder head in a thermal type oven, do not exceed 204 C (400 F).

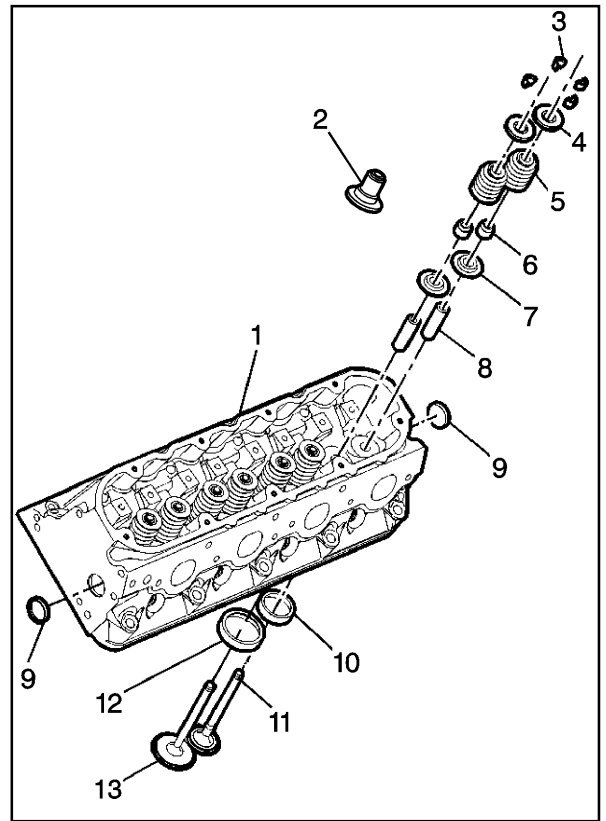
1. Clean the following components:

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

Important: Be careful not to scuff the chamber.

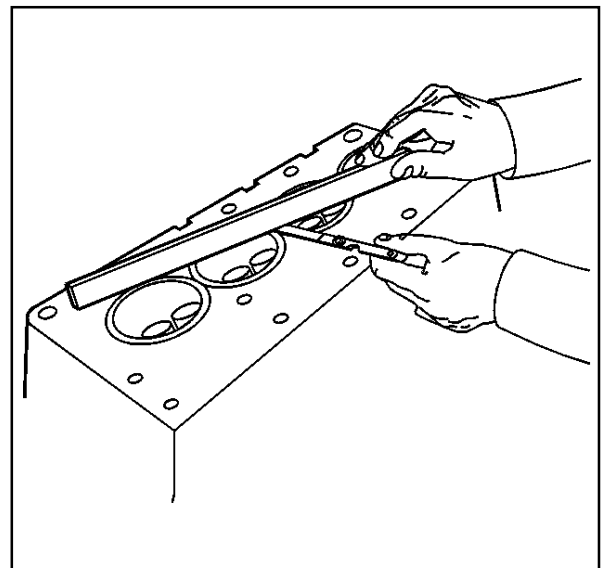
- Use the *J 8089* in order to remove the carbon from the combustion chambers.
- Gasket surfaces
Refer to *Replacing Engine Gaskets*.
- Valve stems and heads on a buffing wheel
- Bolt hole threads. Remove all dirt, debris or threadlocking material from the bolt holes.

2. Inspect the following:
 - Worn or loose valve seats (10 or 12)
 - The cylinder head for cracks in the exhaust ports and combustion chambers
 - The cylinder head for external cracks in the water chambers
 - The gasket surfaces for excessive scratches or gouging
Refer to *Replacing Engine Gaskets*.
 - The bolt hole threads for debris or damaged threads
Refer to *Thread Repair* or *Thread Repair Specifications*.

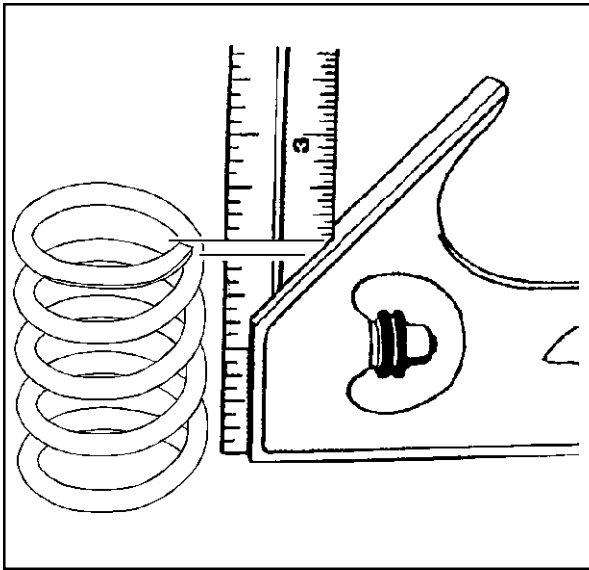


721939

3. Inspect the cylinder head for warpage. Refer to *Engine Mechanical Specifications*.

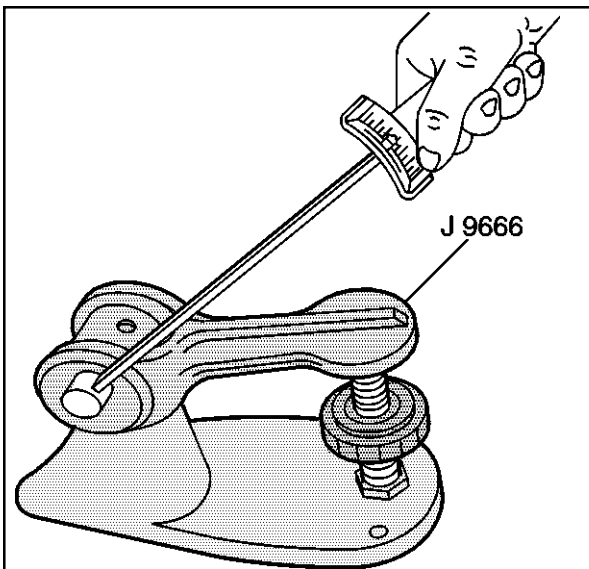


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40075

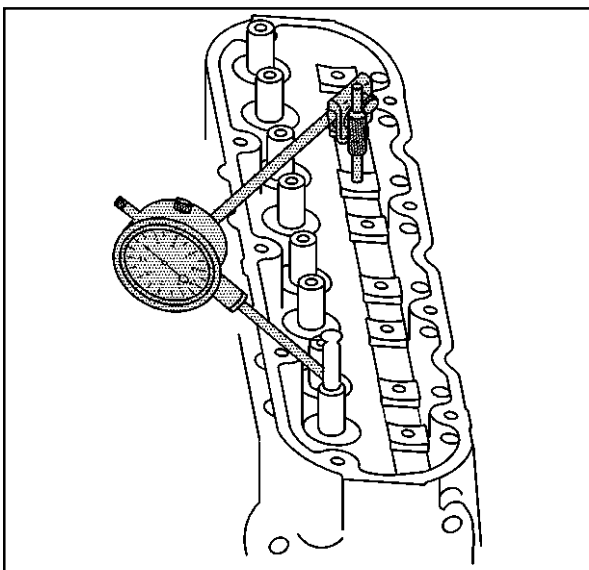
4. Inspect the valve springs for squareness.



4960

5. Use the *J 9666* in order to measure the valve spring tension.

Replace the spring if the spring tension is less than 310 N (70 lb) at 45.75 mm (1.80 in).



65822

Valve Guide Reaming/Valve and Seat Grinding

Valve Guide Reaming

Tools Required

J 37378-1 Valve Guide Reamer

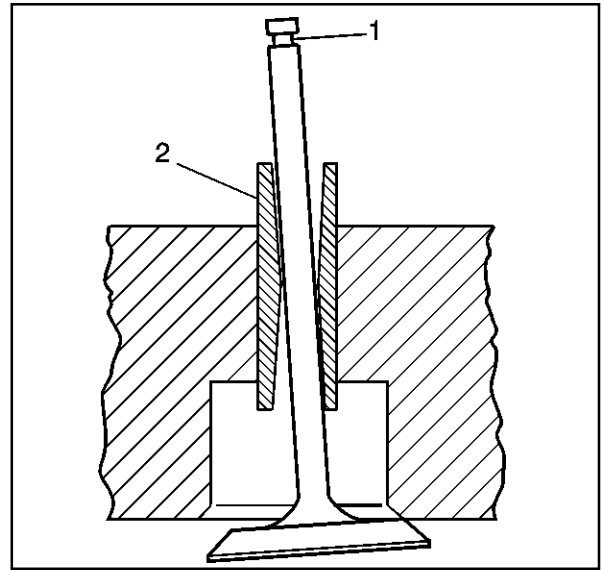
Important: Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage and/or excessive engine oil consumption. Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

1. Measure the valve stem-to-guide clearance using a dial indicator. Position the tip of the dial indicator at the top of the valve guide.

Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gauge to measure the guide bore.

2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the components replaced.

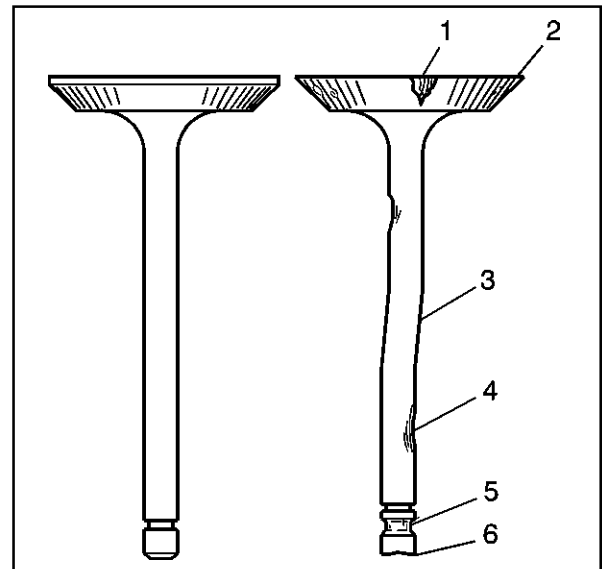
Refer to *Engine Mechanical Specifications*.



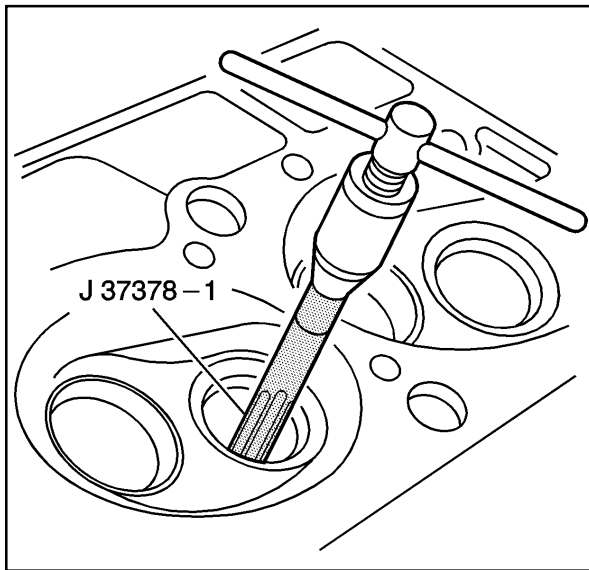
156172

3. Inspect the valve stems for excessive scoring, wear or damage.
 - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
 - A valve guide that is worn and has excessive stem-to-guide clearance should be reamed and valves with oversize stems installed.
4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the valve guide must be reamed oversize and a valve with oversize stem installed.

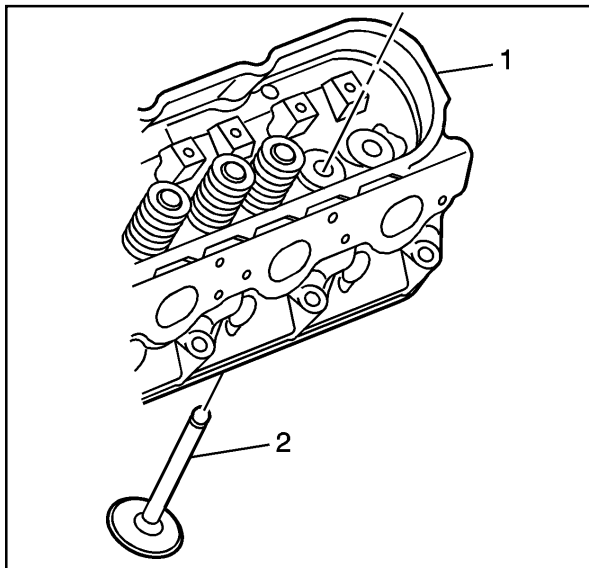


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572270

5. Ream the valve guide using the *J 37378-1*.
6. Clean the guide bore of all metal shavings and debris.



572278

7. Install the valve (2) (with oversize stem) into the cylinder head (1).
8. Inspect the valve for the proper fit.
Move the valve back and forth in the guide. The valve should move freely with no resistance or drag.

Valve and Seat Grinding

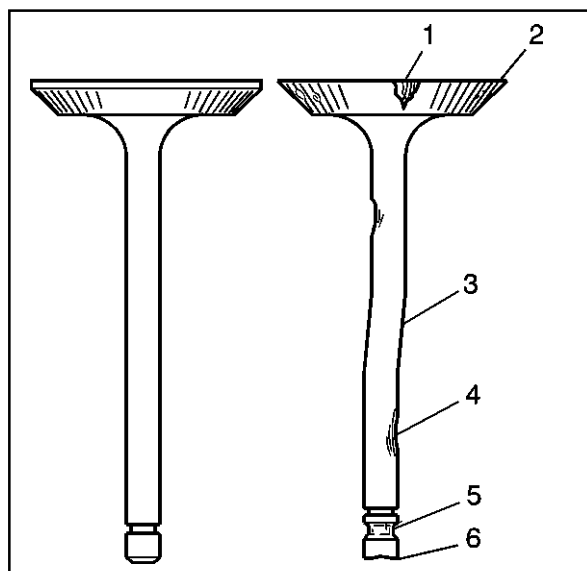
Important:

- Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of equipment are available for grinding valve seats.
- Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.
- The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.

- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.
- Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment should be carefully followed to obtain the proper results.
- DO NOT reface intake valves. Intake valves with excessive wear or damage MUST be replaced.

1. Inspect the valve for the following:

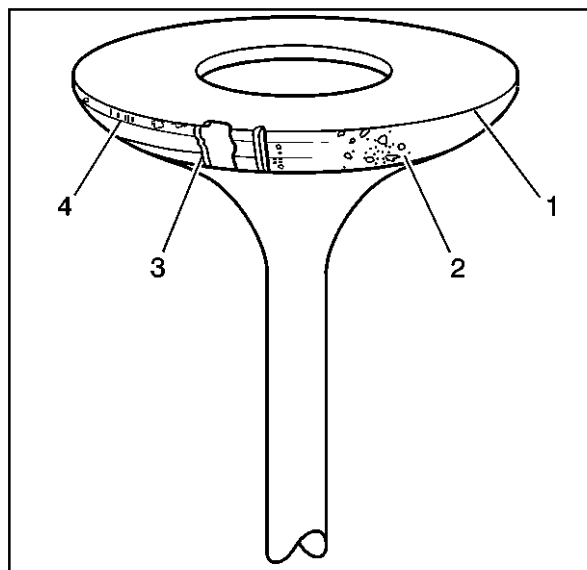
- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)



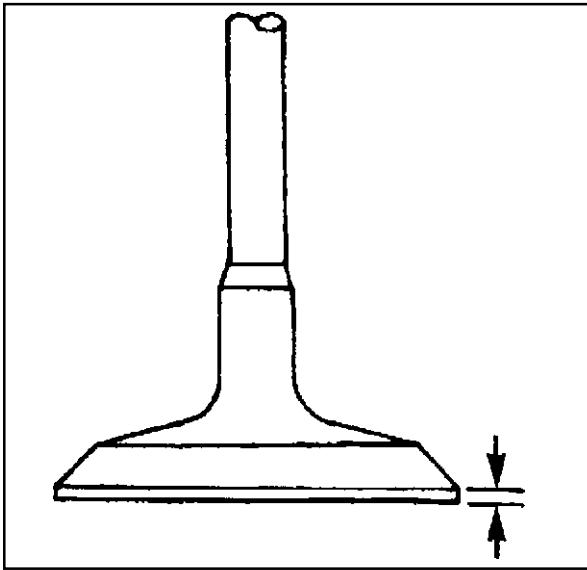
156174

2. Inspect the valve face for the following:

- Worn or no margin (1 or 4)
- Pitted surfaces (2)
- Burnt or eroded areas (3)

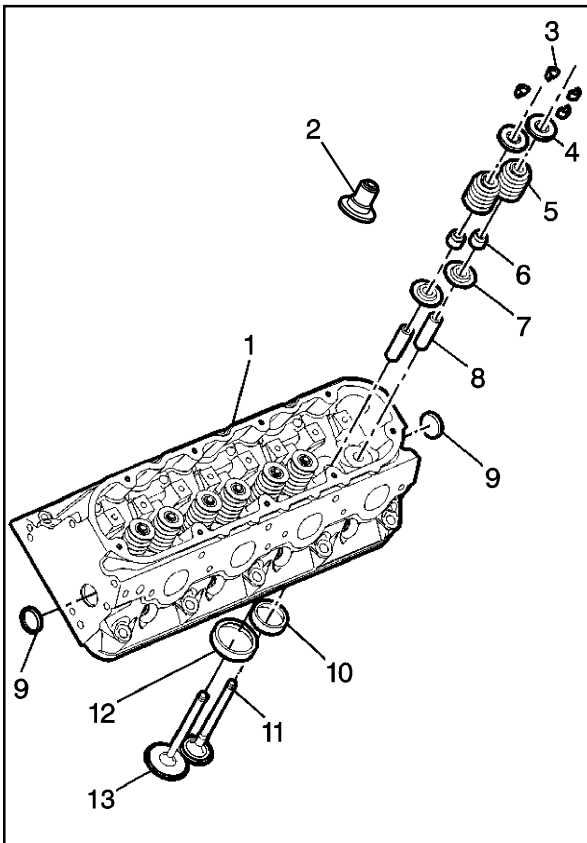


156173



4955

3. Inspect the valve margin.
The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.
4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring to obtain the proper spring installed height. Refer to *Cylinder Head Disassemble*.



721939

7. Inspect for a loose valve seat (10 or 12) in the cylinder head (1). The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide (8) bores with a suitable tool. Remove all carbon or dirt from the bores.
The valve guide must be clean for the seat grinding tool to obtain proper results.
9. Grind the valve seat.
The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.
10. Inspect the valve seats.
 - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
 - If the valve seat has been ground, it may be necessary to shim the valve spring to attain the proper spring installed height.
Refer to *Cylinder Head Disassemble*.

Cylinder Head Assemble

Tools Required

J 8062 Valve Spring Compressor

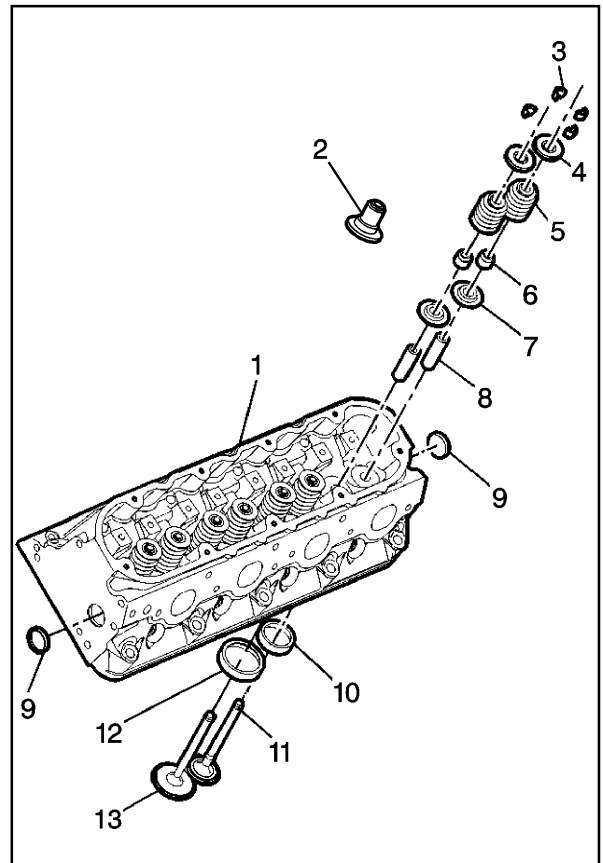
J 42078 Valve Stem Oil Seal Installer

1. Clean the cylinder head valve spring seat and/or shim area.

Important: When reusing the valves and related components, install the parts to their original location.

2. Install the valves (11 and 13) into the proper guides. Refer to *Separating Parts*.
3. Install the valve spring shim (7) (first design).
4. Install the valve stem oil seal and shim assembly (second design).

J 42078 is not required for installation of the second design seal and shim assembly. A separate spring shim is not required with the second design seal and shim assembly.



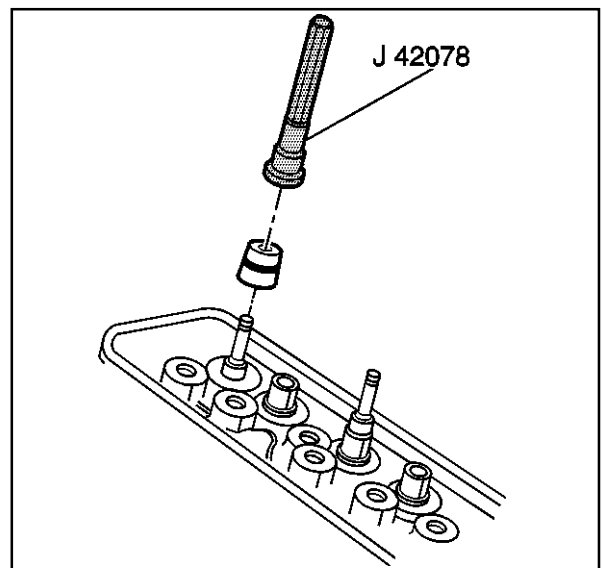
721939

Important: The valve stem oil seal alignment and position on the valve guide is critical.

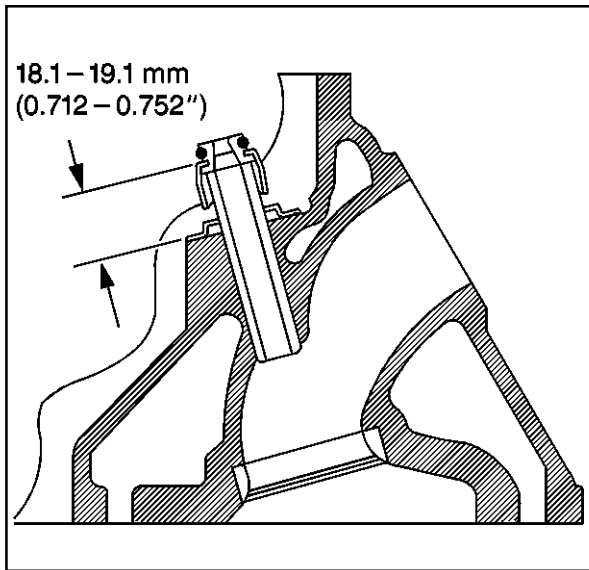
An improperly installed valve stem oil seal may lead to excessive oil consumption, increased emissions or component damage.

5. Install the valve stem oil seal onto the guide.
 - 5.1. Lubricate the valve guide and valve stem oil seal with clean engine oil.
 - 5.2. Install the valve stem oil seal onto the valve stem. Push the seal down until the seal contacts the valve guide.
 - 5.3. Use the J 42078 in order to install the valve stem oil seal.

Push or lightly tap the tool until the tool bottoms against the valve spring shim or spring seat.

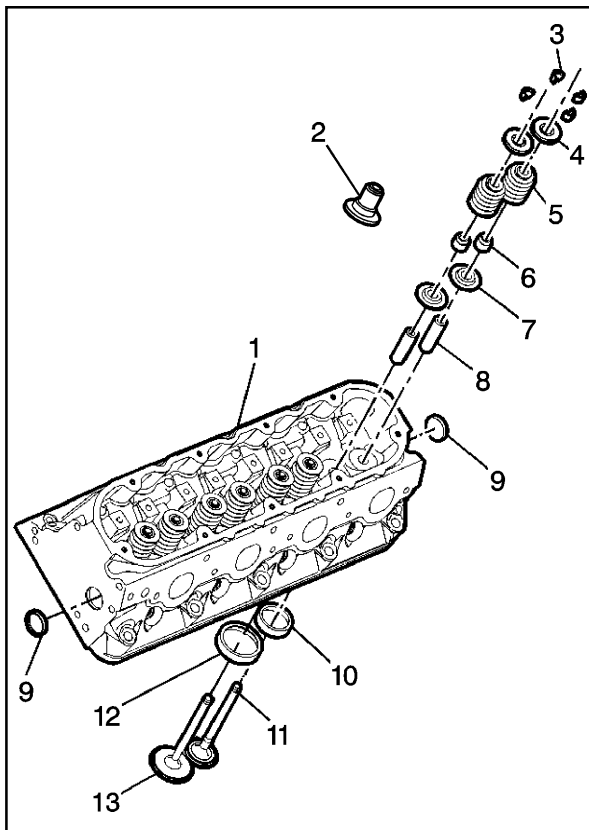


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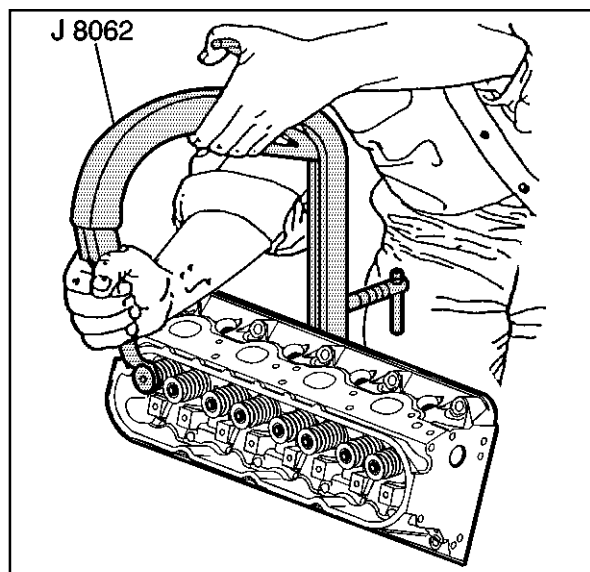
6. Measure the valve stem oil seals, first design, for the properly installed height.
There should be a 18.1-19.1 mm (0.712-0.752 in) gap between the top edge of the oil seal body and the valve spring seat surface.



721939

7. Install the valve spring (5).
8. Install the valve spring cap (4).

9. Compress the valve spring using the *J 8062*.
10. Install the valve stem keys.
 - 10.1. Use grease to hold the keys in place and remove the *J 8062*.
 - 10.2. Make sure the keys seat properly in the groove of the valve stem.
 - 10.3. Tap the end to the valve stem with a plastic faced hammer to seat the keys (if necessary).



260151

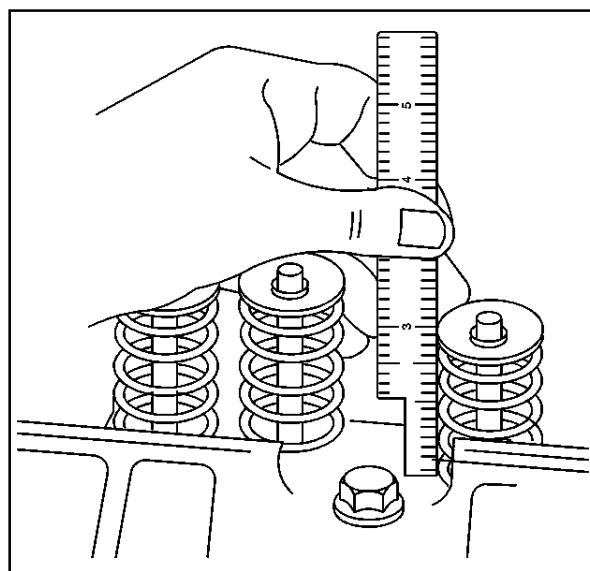
11. Measure the valve spring installed height using a ruler. Measure from the base of the spring to the top of the spring.

If the installed height exceeds 46.25 mm (1.82 in), install a valve seat spring shim of approximately 0.5 mm (0.02 in) thick.

Do not shim the valve spring to obtain less than the specified height.

Do not assemble the components without a spring shim on the cylinder head (aluminum head).

12. Install the remaining valves, springs and other components.



64315

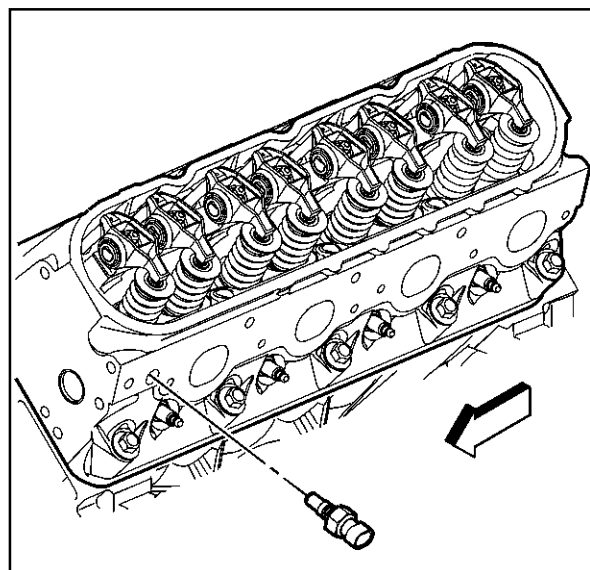
13. Install sealant GM P/N 12346004 or equivalent to the threads of the coolant sensor.

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

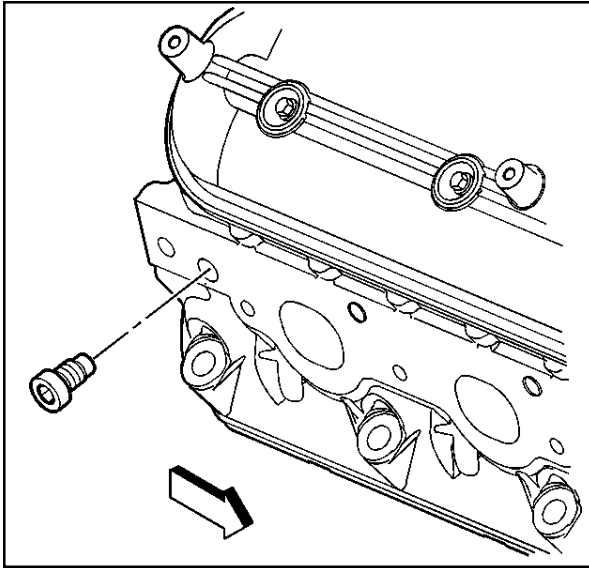
14. Install the coolant sensor into the left cylinder head.

Tighten

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



260086

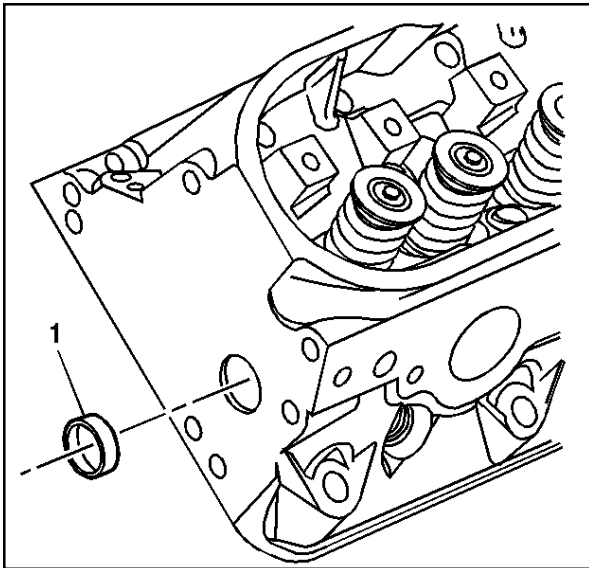


260157

15. Install the coolant plug to the right cylinder head.

Tighten

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

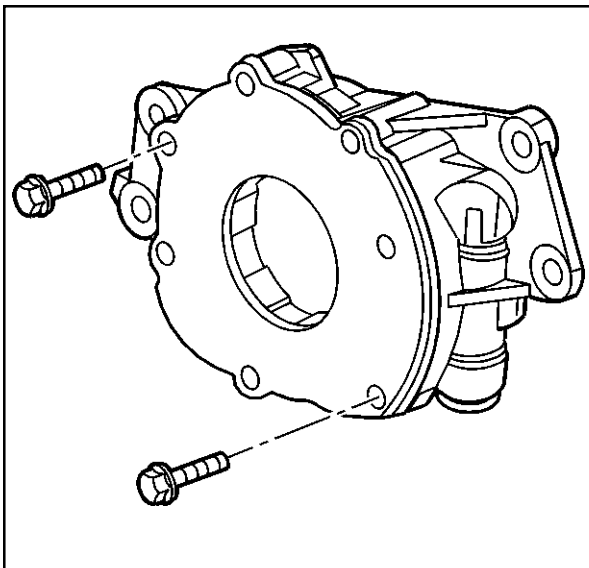


490662

16. Apply threadlock GM P/N 12345382 or equivalent to the sides of the cylinder head expansion plugs (1) (if applicable).

17. Install the expansion plugs into the cylinder head (aluminum head).

A properly installed plug should be slightly below flush with the face of the head.



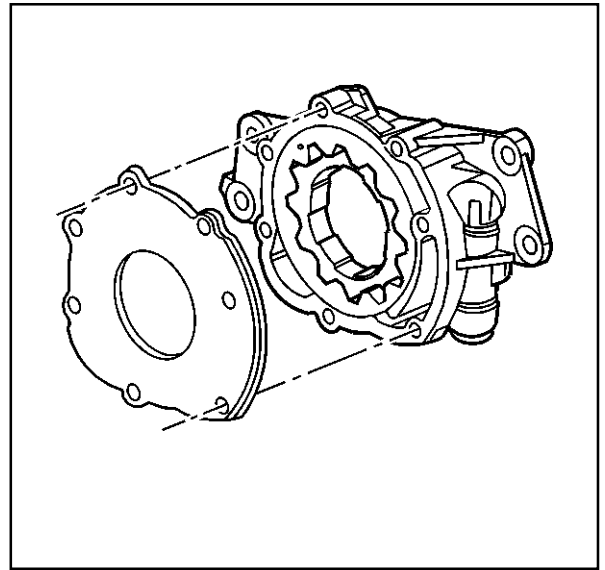
65055

Oil Pump Disassemble

Important: The internal parts of the oil pump assembly are not serviced separately (excluding the spring). If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts.

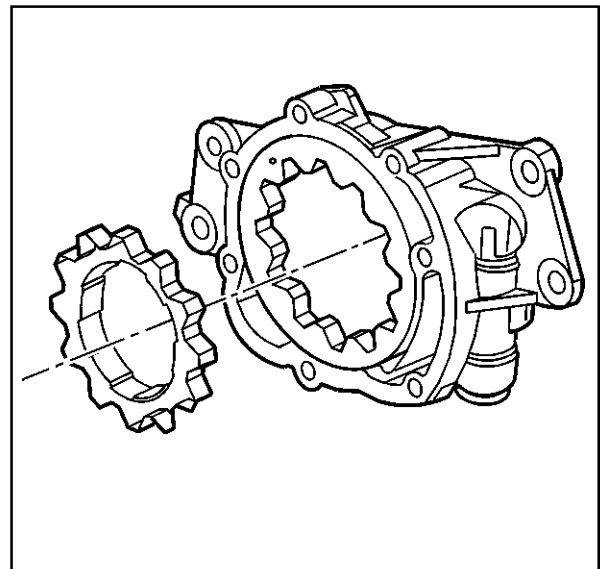
2. Remove the oil pump cover.



65057

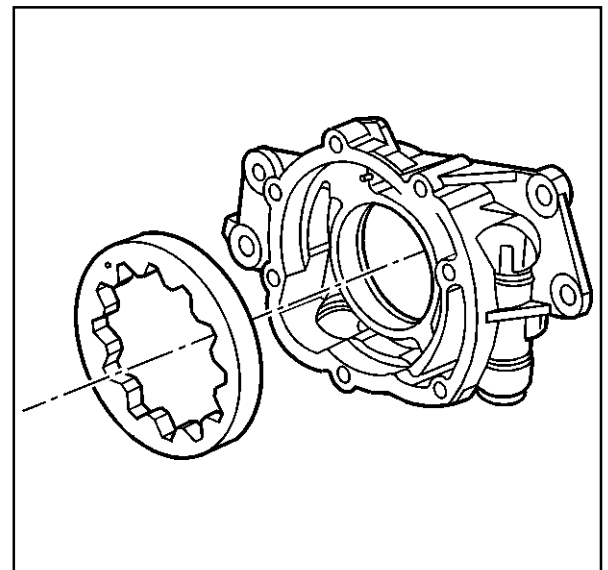
Important: Mark or identify the gears for assembly. Refer to *Separating Parts*.

3. Remove the drive gear.

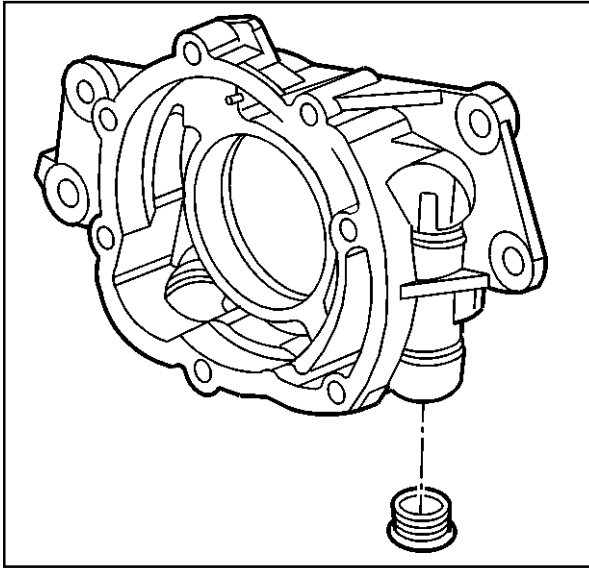


65058

4. Remove the driven gear.

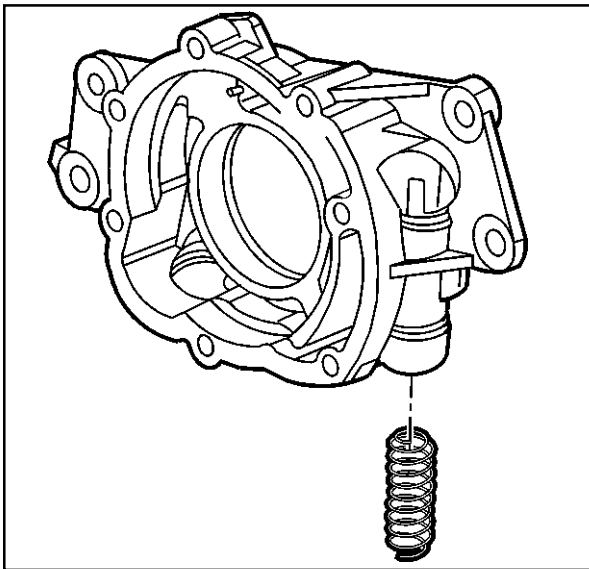


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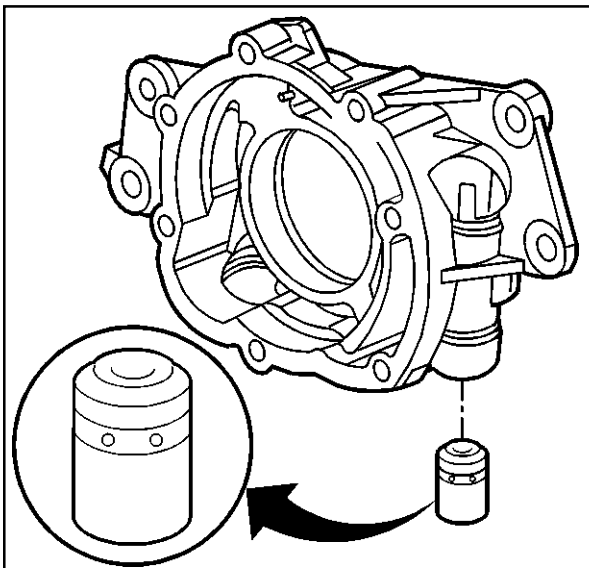
65064

5. Remove the pressure relief valve plug.



65068

6. Remove the pressure relief valve spring.



65076

7. Remove the pressure relief valve.
8. Inspect the oil pump components. Refer to *Oil Pump Clean and Inspect*.

Oil Pump Clean and Inspect

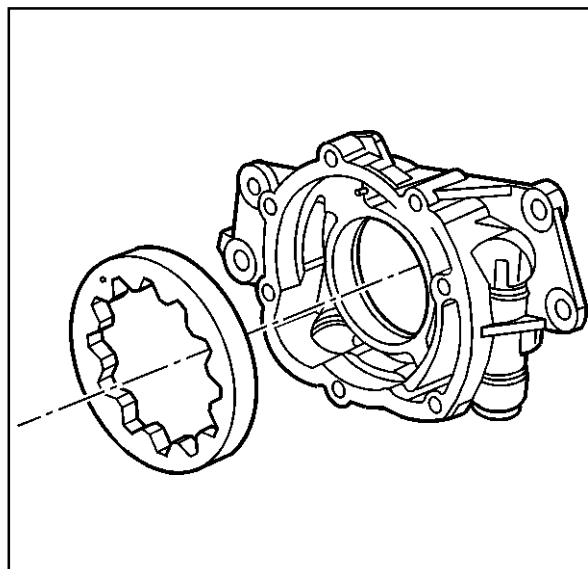
Important: The internal parts of the oil pump assembly are not serviced separately (excluding the spring). If the oil pump components are worn or damaged, replace the oil pump as an assembly.

The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.

1. Clean the parts in solvent.

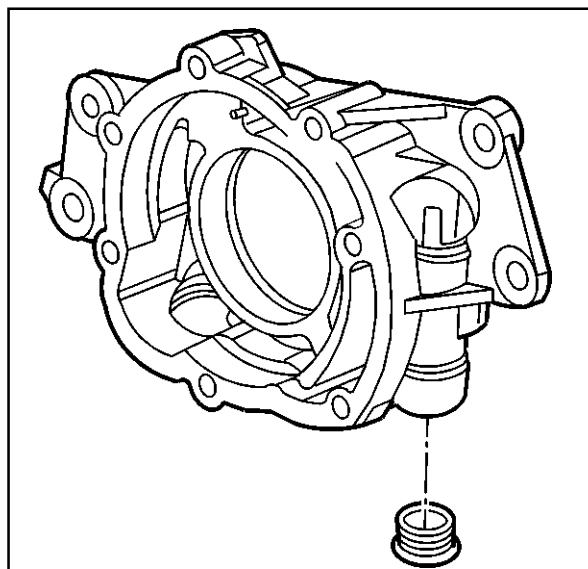
Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the parts with compressed air.
3. Inspect the oil pump housing and the cover for cracks, excessive wear, scoring or casting imperfections.



65060

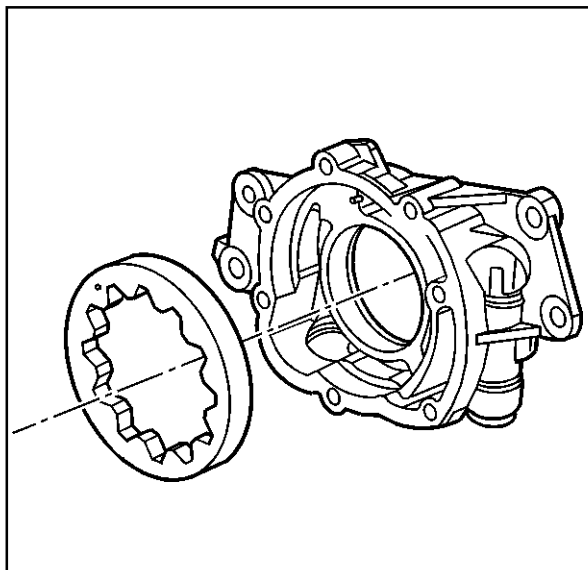
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.



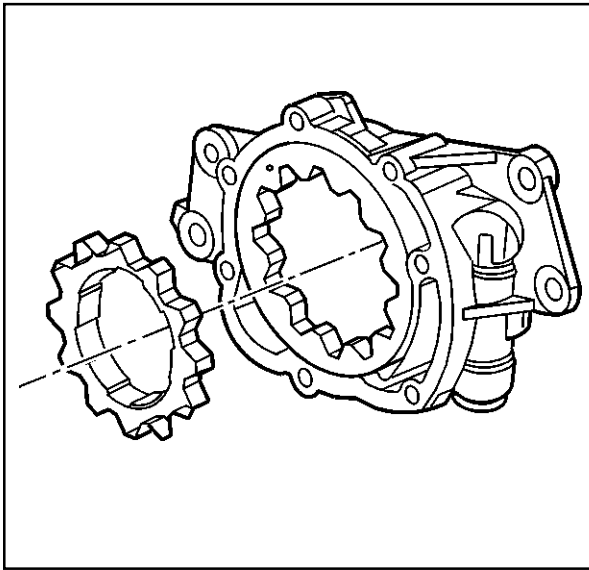
65064

8. Inspect the drive gear and driven gear for chipping, galling or wear.

Minor burrs or imperfections on the gears may be removed with a fine oil stone.

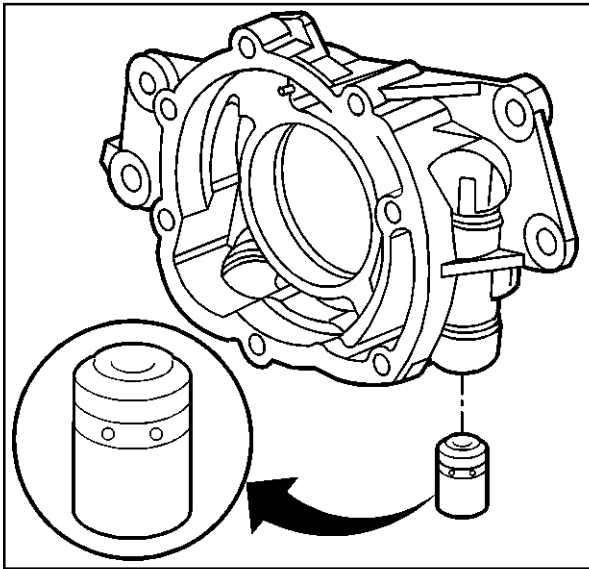


65060



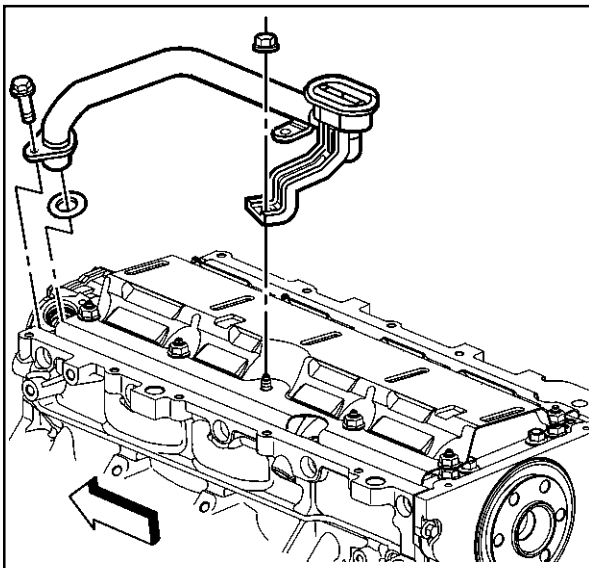
65058

9. Inspect the drive gear splines for excessive wear.



65076

10. Inspect the pressure relief valve and bore for scoring or wear.
The valve must move freely in the bore with no restrictions.



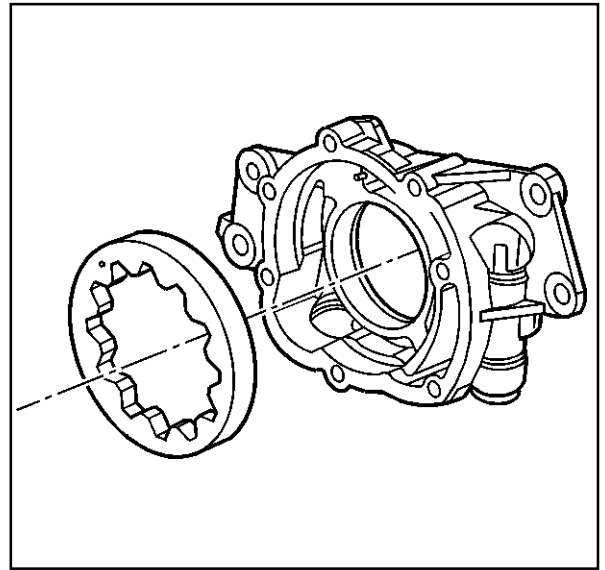
64268

11. Inspect the oil pump screen for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.

Oil Pump Assemble

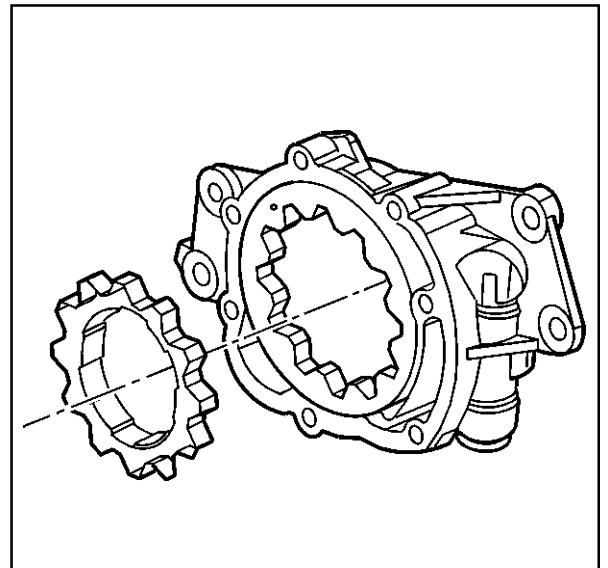
Important: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

1. Install the driven gear into the pump housing.
Install the driven gear with the orientation mark facing the pump cover.



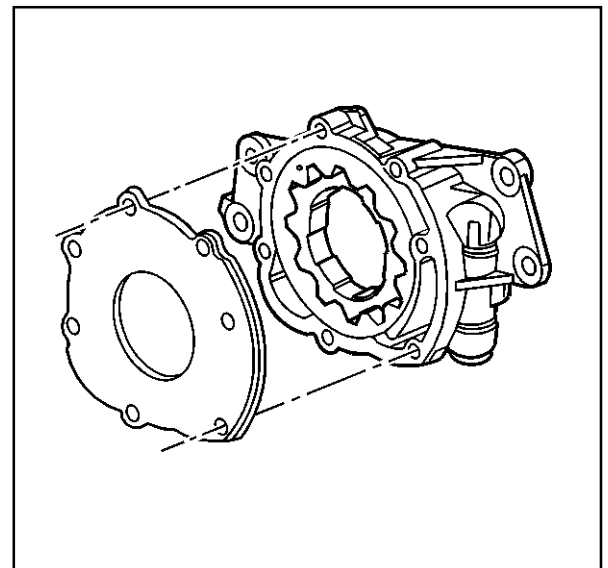
65060

2. Install the drive gear into the pump housing.

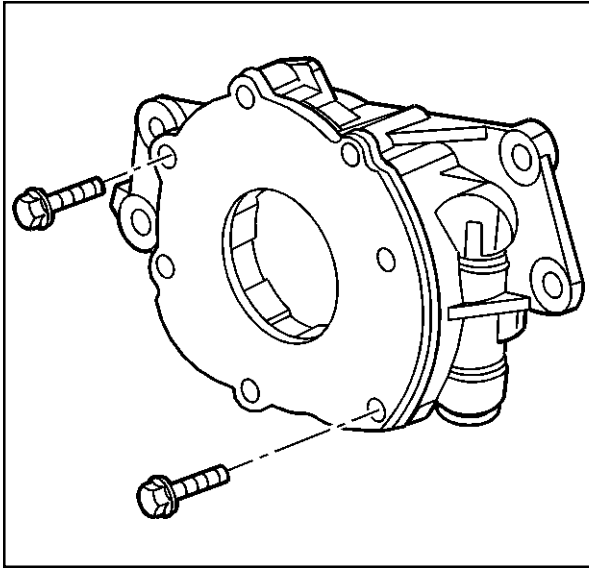


65058

3. Install the oil pump cover.



65057



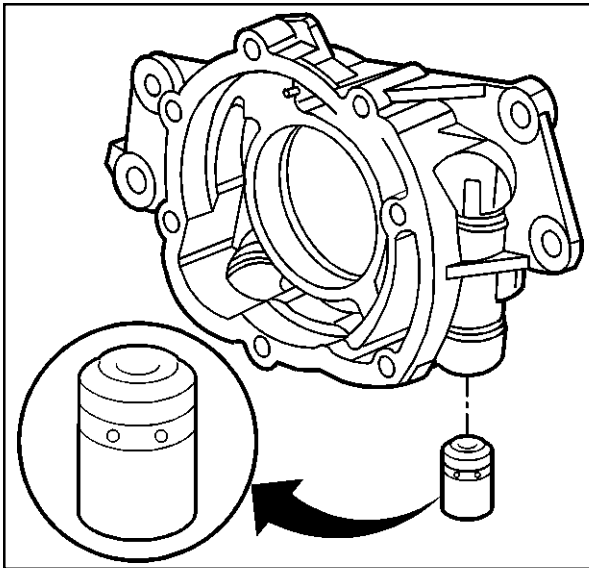
65055

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

4. Install the pump cover bolts.

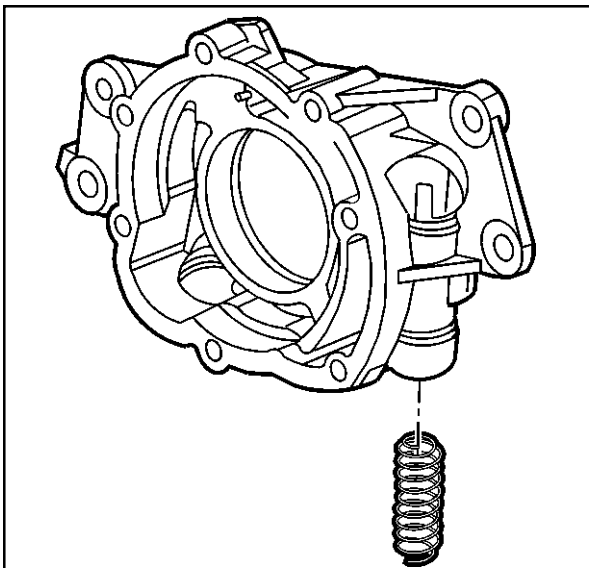
Tighten

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



65076

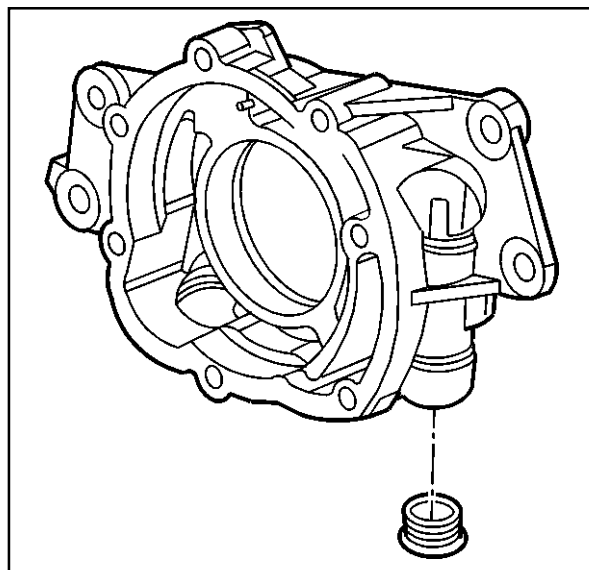
5. Install the regulator valve.



65068

6. Install a NEW regulator valve spring.

7. Install the pressure relief valve plug.
Tighten
 Tighten the pressure relief valve plug to 12 N·m (106 lb in).
8. Inspect the oil pump for smoothness of operation by rotating the drive gear.



65064

Engine Front Cover Clean and Inspect

Important: Do not reuse the crankshaft oil seal. Install a NEW crankshaft oil seal during assembly.

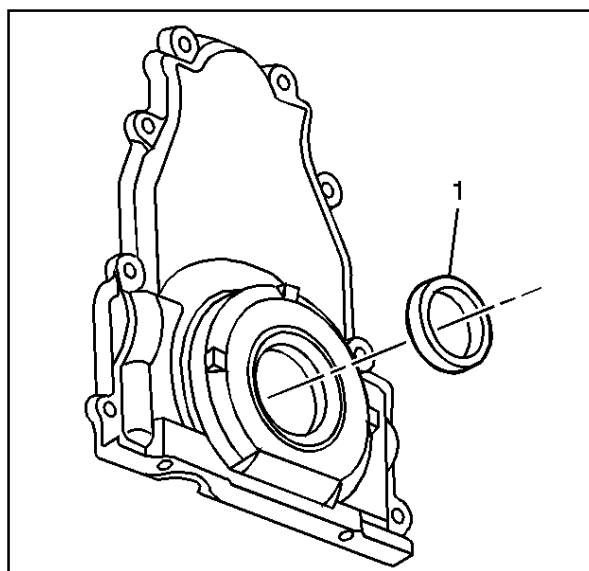
Do not reuse the front cover-to-engine block gasket. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (1) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface.

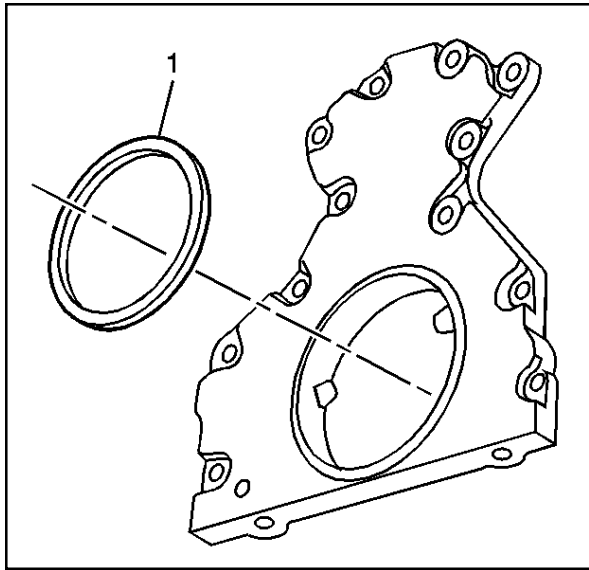
Refer to *Replacing Engine Gaskets*.

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

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.



490689



490692

Engine Rear Cover Clean and Inspect

Important: Do not reuse the crankshaft oil seal. Install a NEW crankshaft oil seal during assembly.

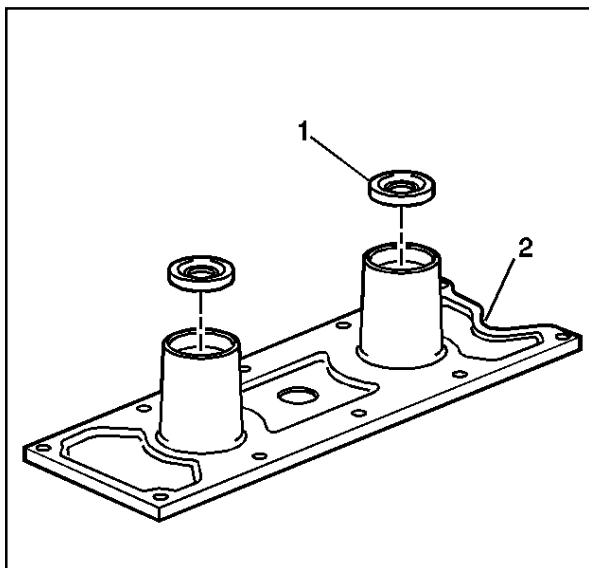
Do not reuse the rear cover-to-engine block gasket. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (1) from the rear cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface.

Refer to *Replacing Engine Gaskets*.

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

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.



490851

Engine Valley Cover Clean and Inspect

Important: Do not reuse the valley cover knock sensor oil seals. Install NEW oil seals during assembly.

Do not reuse the valley cover gasket. Install a NEW gasket during assembly.

1. Remove the knock sensor oil seals (1) from the valley cover (2).
2. Clean the valley cover in solvent.

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

3. Dry the valley cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
Refer to *Replacing Engine Gaskets*.
5. Inspect the valley cover oil seal bores for excessive scratches or gouging.

Valve Rocker Arm Cover Clean and Inspect

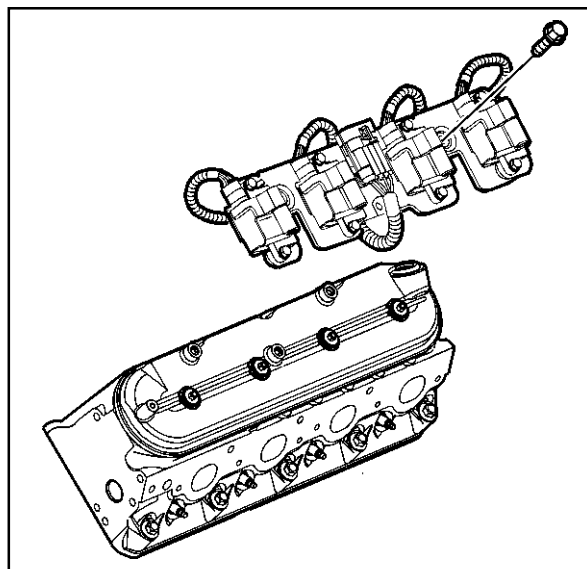
Important: Do not reuse the valve rocker arm cover gasket. Install a NEW gasket during assembly.

Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.

Do not remove the oil fill tube or crankcase vent valve grommet from the covers unless service is required.

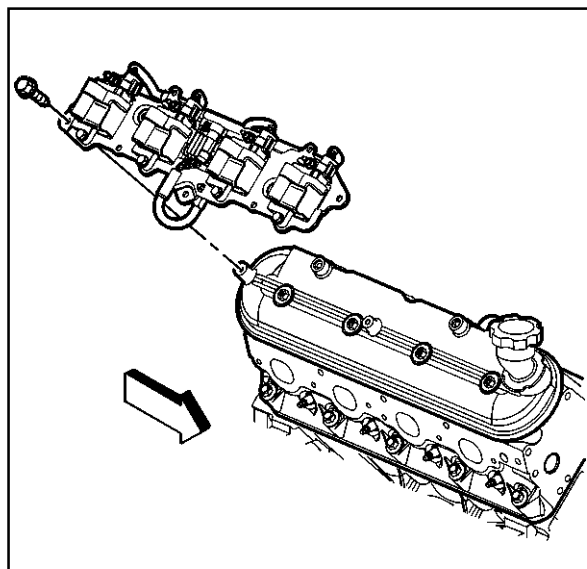
If the fill tube or crankcase vent valve grommet have been removed from the rocker arm covers, install a NEW tube or grommet during assembly.

1. Remove the ignition coil and bracket assembly, bolts and wire harness from the left cover, if required.



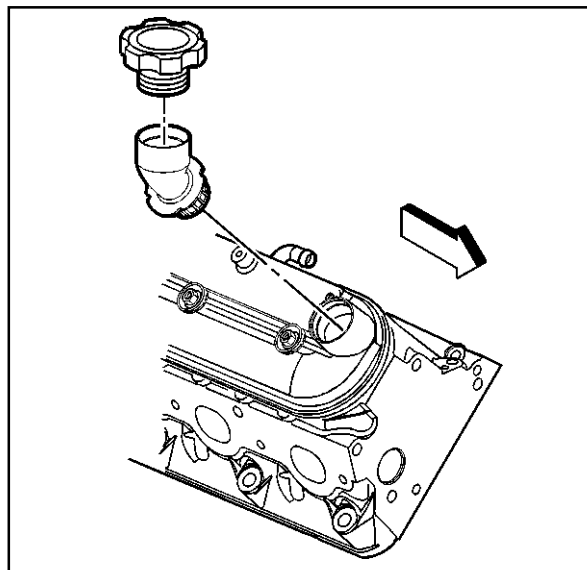
260083

2. Remove the ignition coil and bracket assembly, bolts and wire harness from the right cover, if required.

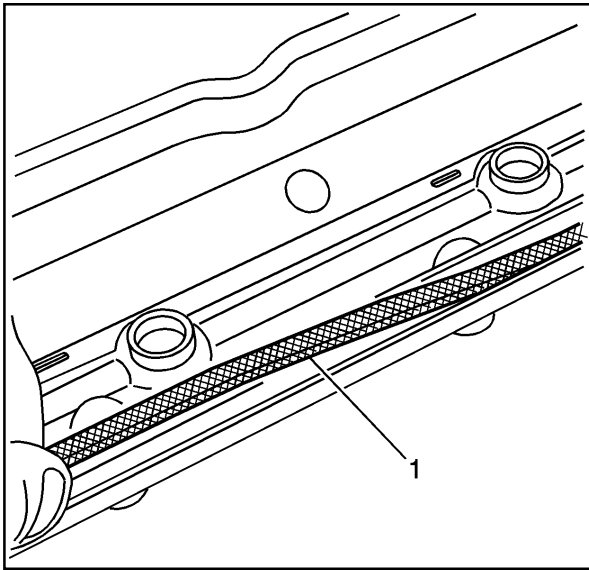


260090

3. Inspect the tube for a loose fit or damage.
4. Remove the oil fill cap and tube from the right cover, if required.

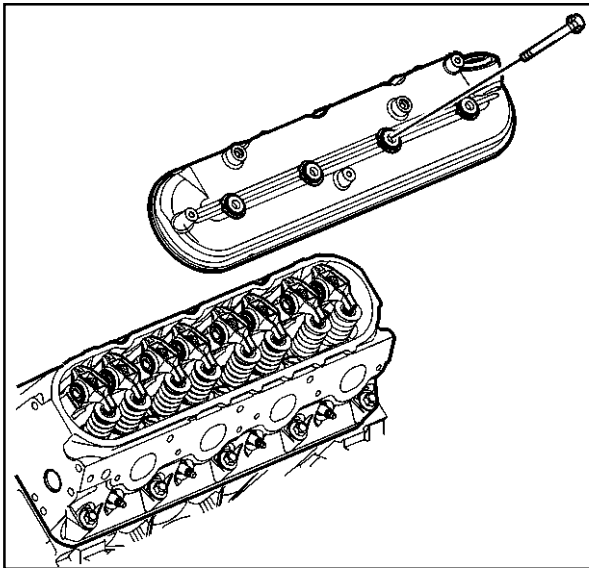


260110



490696

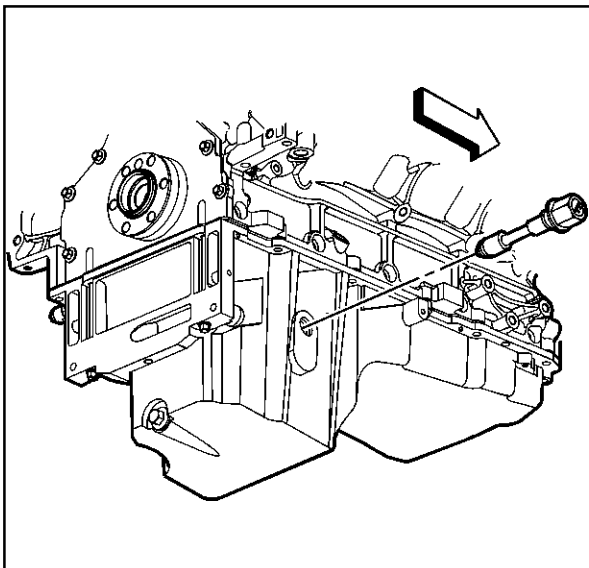
5. Remove the gaskets (1) from the covers.
6. Remove the cover mounting bolts (with grommets).
Cover mounting bolts and grommets that are not damaged may be reused during assembly.
7. Clean the covers in solvent.



260085

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

8. Dry the covers with compressed air.
9. Inspect the ventilation system passages for restrictions.
10. Inspect the gasket grooves for damage.
11. Inspect the coil bracket threaded bolt holes for damaged or debris.



260123

Oil Pan Clean and Inspect

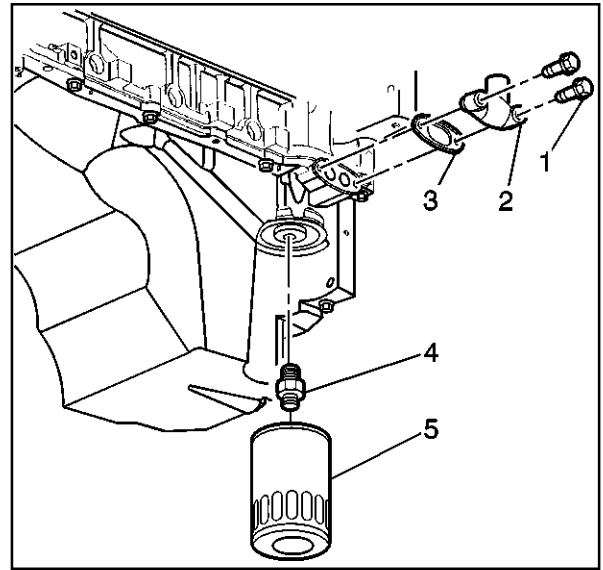
Important: Do not reuse the oil pan cover gasket. Install a NEW cover gasket during assembly.

Do not reuse the oil pan-to-engine block gasket. Install a NEW gasket during assembly.

When installing a NEW oil pan gasket, it is not necessary to install rivots that retain the NEW gasket to the pan.

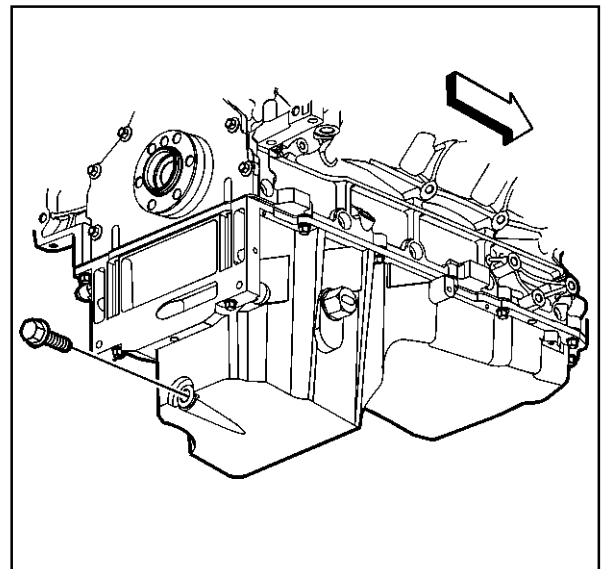
1. Remove the oil level sensor from the pan (if applicable).

- Remove the oil pan cover (2), gasket (3) and bolts (1), if required.



260125

- Remove the oil pan drain plug and O-ring seal.

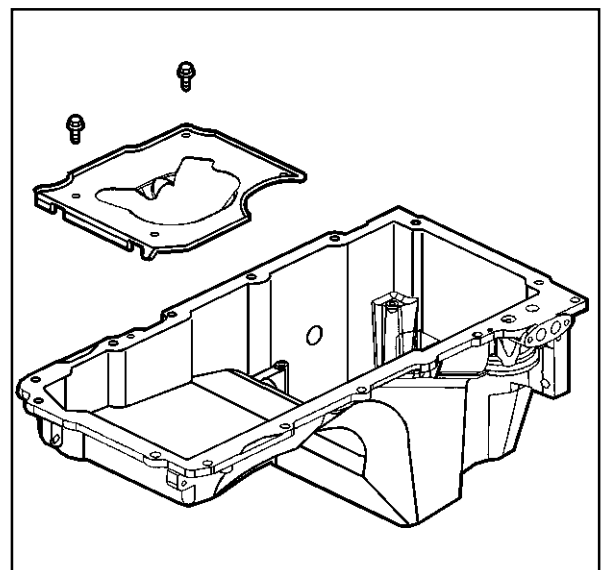


260111

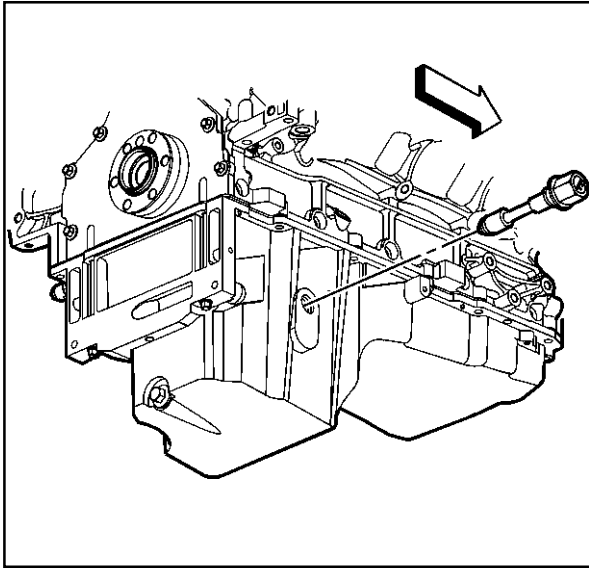
- Remove the oil pan baffle and bolts.
- Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.
- Clean the oil pan gasket surfaces. Refer to *Replacing Engine Gaskets*.

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

- Dry the oil pan with compressed air.
- Inspect the gasket sealing surfaces for excessive scratches or gouging. Refer to *Replacing Engine Gaskets*.

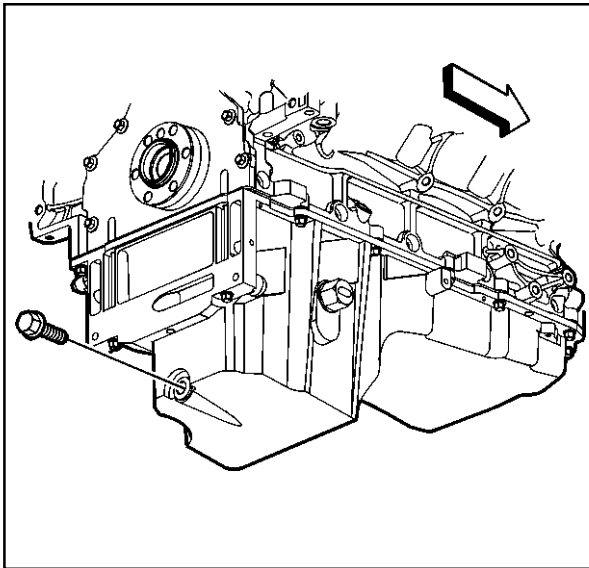


260180



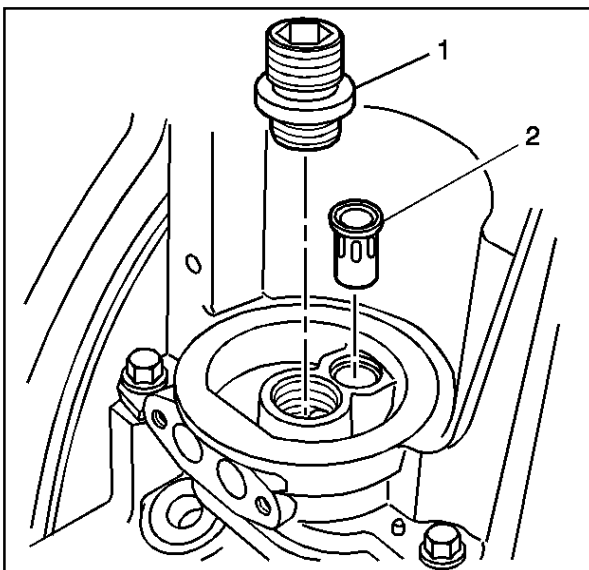
260123

9. Inspect the oil level sensor seal surface and threads for damage (if applicable).



260111

10. Inspect the oil pan drain plug and threaded drain hole for damaged threads.
The drain plug O-ring seal may be reused if not cut or damaged.



490699

11. Inspect the oil filter sealing surface for scratches or gouging.
12. Inspect the oil filter fitting (1) for a loose fit or damaged threads.
13. Inspect the oil passages for restrictions.
14. Inspect the oil filter bypass valve (2) for proper operation.

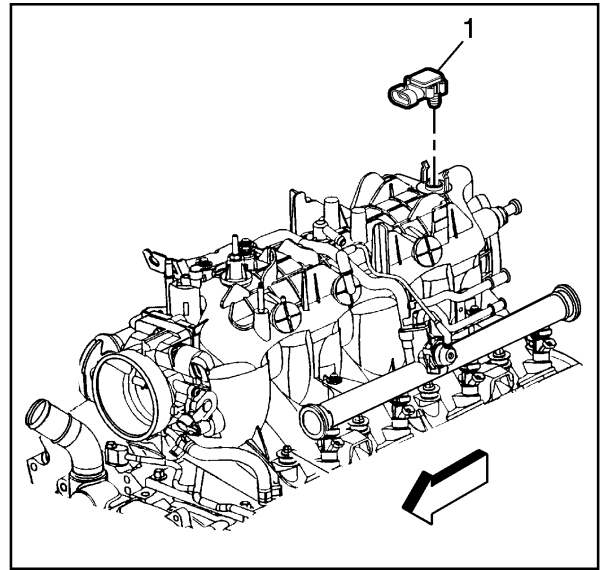
Lightly push the bypass valve into the bore. The valve spring should reseat the valve to the proper position.

Intake Manifold Clean and Inspect

Cleaning Procedure

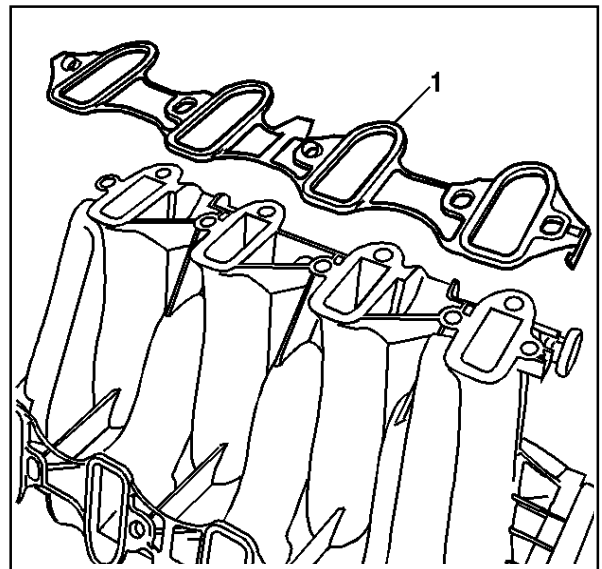
Important: Do not reuse the intake manifold-to-cylinder head sealing gaskets.

1. Remove the Manifold Absolute Pressure (MAP) sensor (1) from the rear of the intake. The MAP sensor is to be reinstalled upon completion of the cleaning and inspection procedures.
2. Inspect the sealing grommet on the MAP sensor. The grommet should not be torn or damaged.



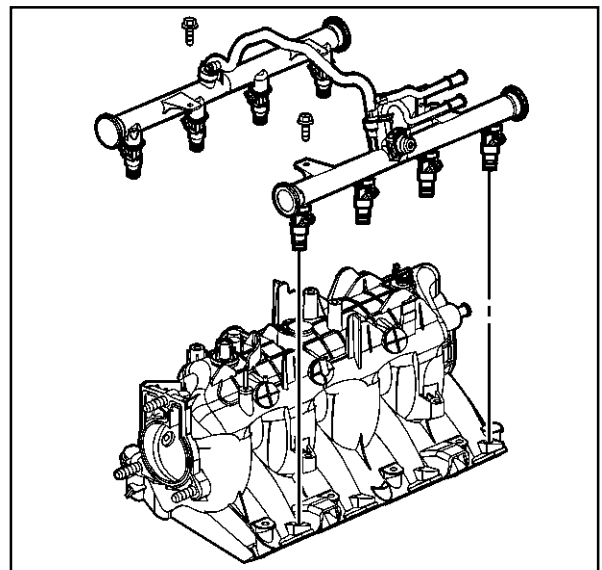
260159

3. Remove and discard the intake manifold-to-cylinder head gaskets (1).

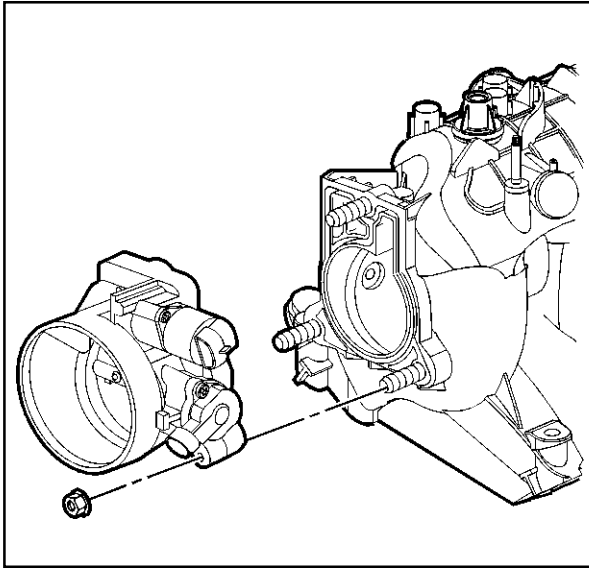


492770

4. Remove the fuel rail with injectors. Refer to *Fuel Rail and Injectors Removal*.

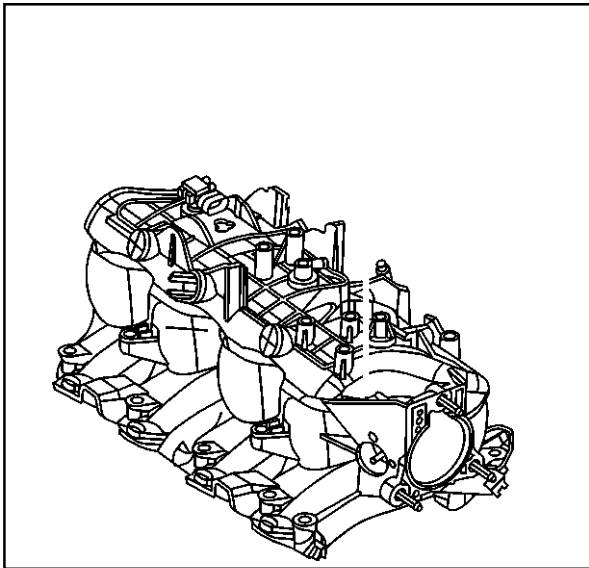


260176



260174

5. Remove the throttle body and gasket. Refer to *Throttle Body Removal*.

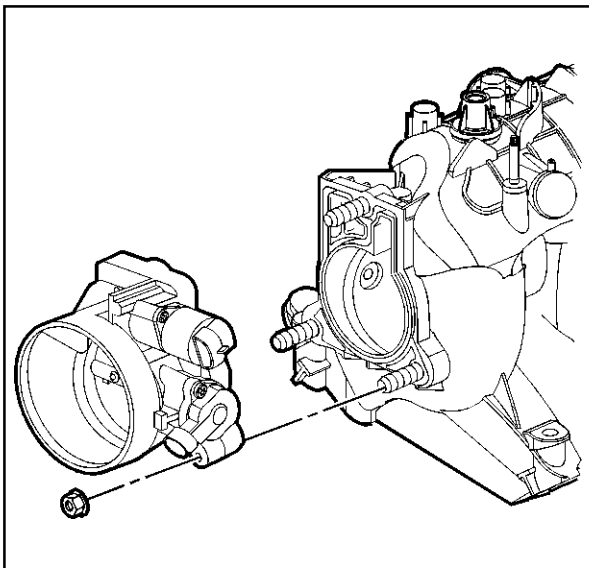


389993

6. Clean the intake manifold in solvent.
 - Clean the intake manifold gasket surfaces.
 - Clean the intake manifold internal passages.

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

7. Dry the intake manifold with compressed air.

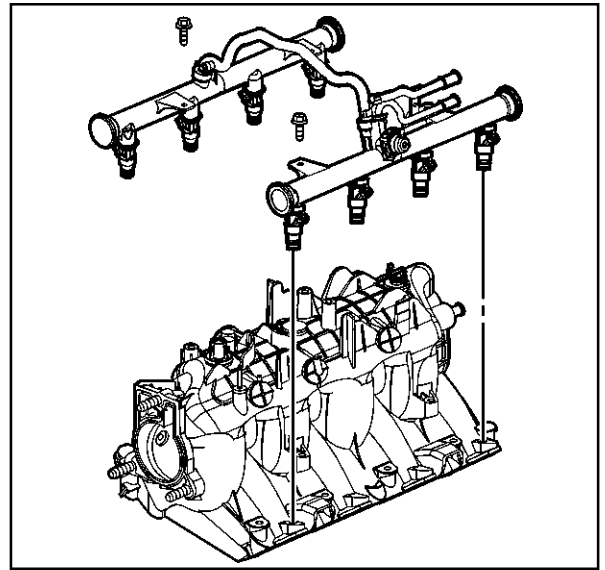


260174

Inspection Procedure

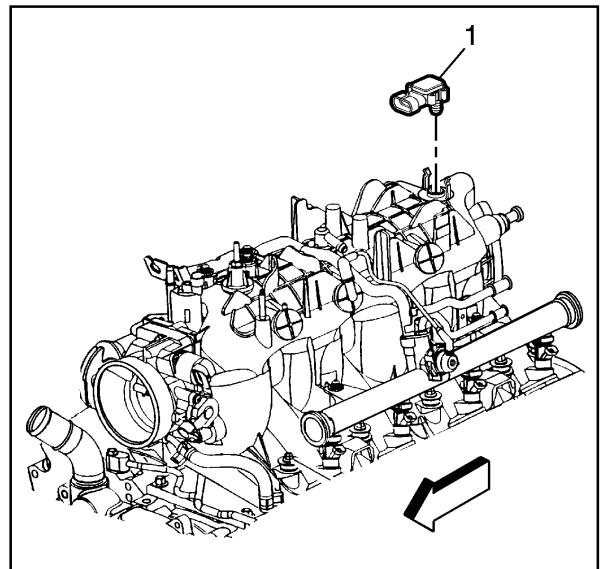
1. Inspect the throttle body studs and stud inserts for looseness or damaged threads.
2. Inspect the wire harness stud and stud insert for looseness or damaged threads.

3. Inspect the fuel rail bolt inserts for looseness or damaged threads.
4. Inspect the intake manifold vacuum passages for debris or restrictions.



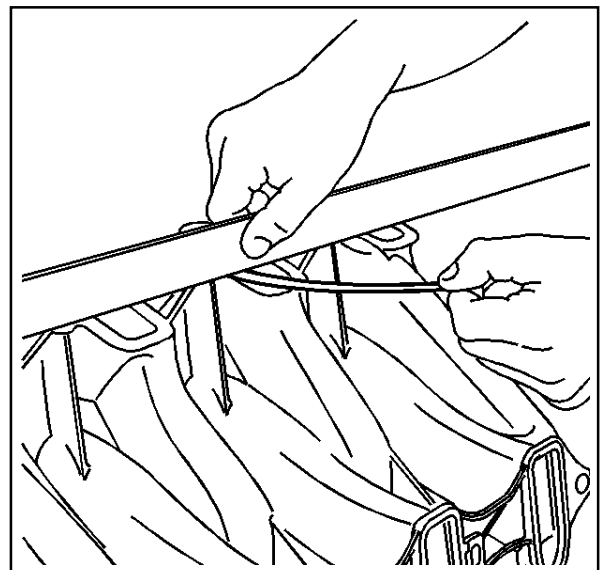
260176

5. Inspect for damaged or broken vacuum fittings, damaged MAP sensor (1) mounting bore or broken MAP sensor retaining tabs.
6. Inspect the composite intake manifold assembly for cracks or other damage.
7. Inspect all the gasket sealing surfaces for damage.

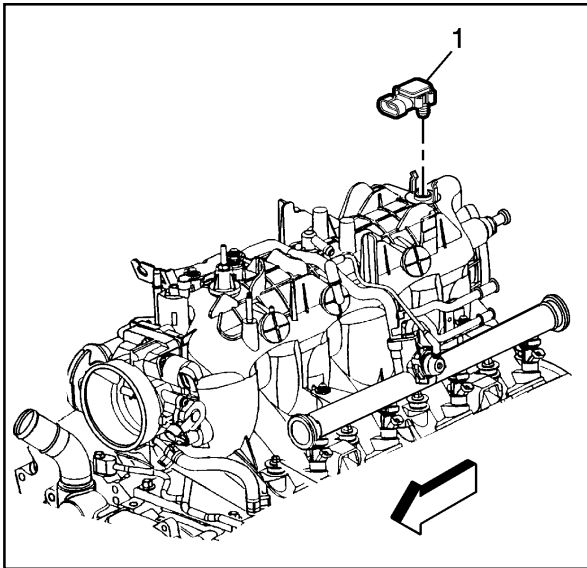


260159

8. Inspect the fuel injector bores for excessive scoring or damage.
9. Inspect the intake manifold cylinder head deck for warpage.
 - 9.1. Locate a straight edge across the intake manifold cylinder head deck surface. Position the straight edge across a minimum of two runner port openings.
 - 9.2. Insert a feeler gauge between the intake manifold and the straight edge. An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

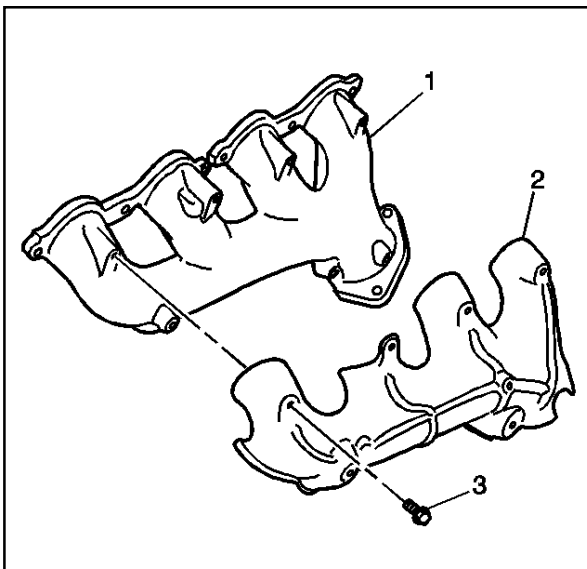


492779



260159

10. Install the MAP sensor (1).



492766

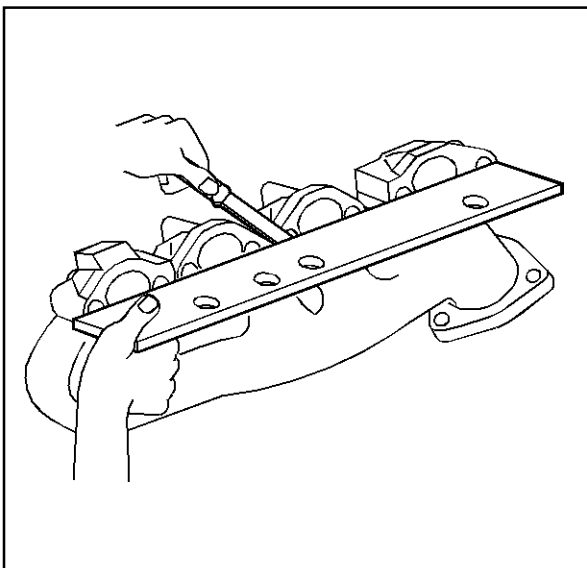
Exhaust Manifold Clean and Inspect

Important: Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. A improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) system performance.

1. Clean the exhaust manifold (1) and heat shield (2) in solvent.

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

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for loose or damaged heat shield (2).
5. Inspect the take down studs for damaged threads.



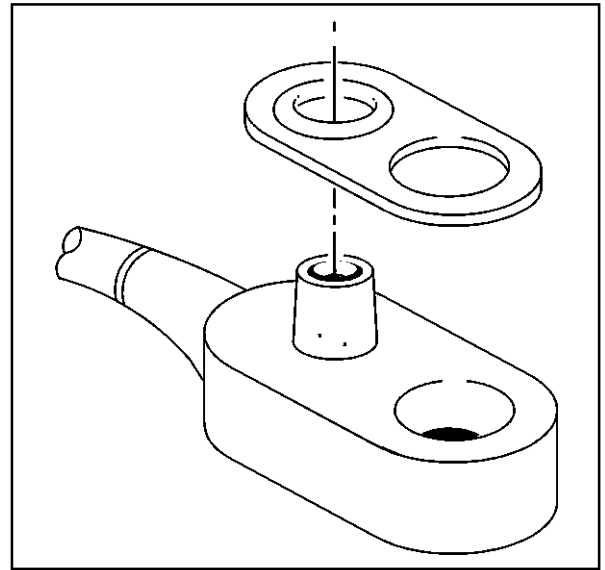
66607

6. Use a straight edge and a feeler gauge and measure the exhaust manifold cylinder head deck for warpage. An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the two front or two rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may effect OBD system performance. Exhaust manifolds not within specifications must be replaced.

Coolant Air Bleed Pipe Clean and Inspect

Important: Do not reuse the engine coolant air bleed pipe gaskets. Upon installation of the engine coolant air bleed pipe, install NEW gaskets.

1. Remove the sealing gaskets from the pipe.
2. Remove the sealing gaskets from the covers.

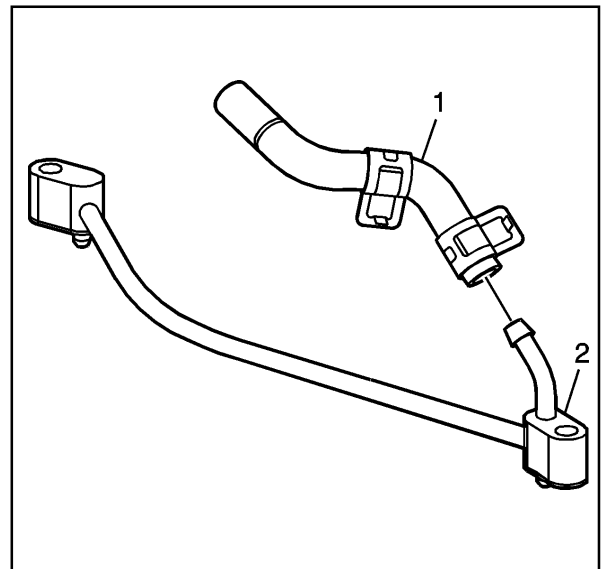


64262

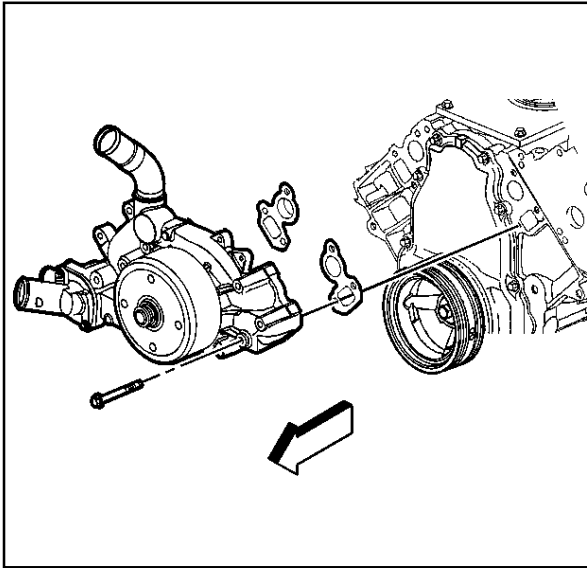
3. Clean the pipe (2), hose (1) and covers in solvent.

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

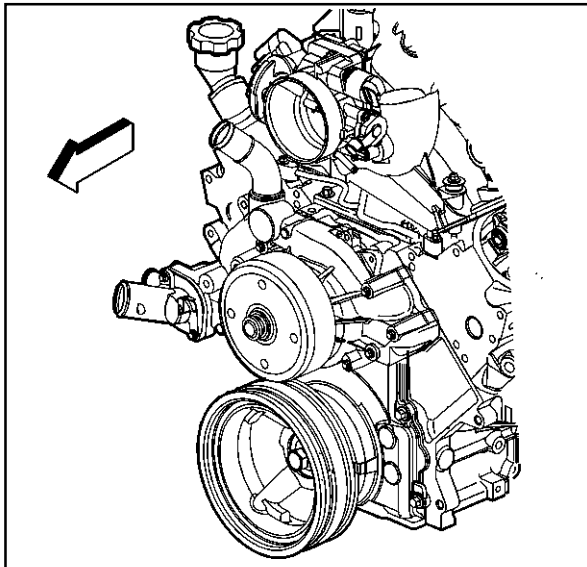
4. Dry the pipe and covers with compressed air.
5. Inspect the pipe and covers for damage or restrictions.
6. Inspect the gasket and hose sealing surfaces for damage.
7. Inspect the hose (1) for restrictions, cracking or wear. The hose may be reused if not damaged.



790766



260121



260124

Water Pump Clean and Inspect

1. Remove the old gasket from the water pump sealing surfaces. Refer to Replacing Engine Gaskets.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:

- Gasket and hose sealing surfaces for excessive scratches or gouging
- Restrictions within the internal coolant passages
- Excessive side-to-side play in the pulley shaft
- Leakage at the water outlet housing or rear cover gasket
- Leakage at the water pump vent hole

A stain around the vent hole is acceptable. If leakage occurs (dripping) with the engine running and the cooling system pressurized, replace the water pump.

4. Inspect the water pump pulley for wear or damage in the belt tracking area.

Thread Repair

Tools Required

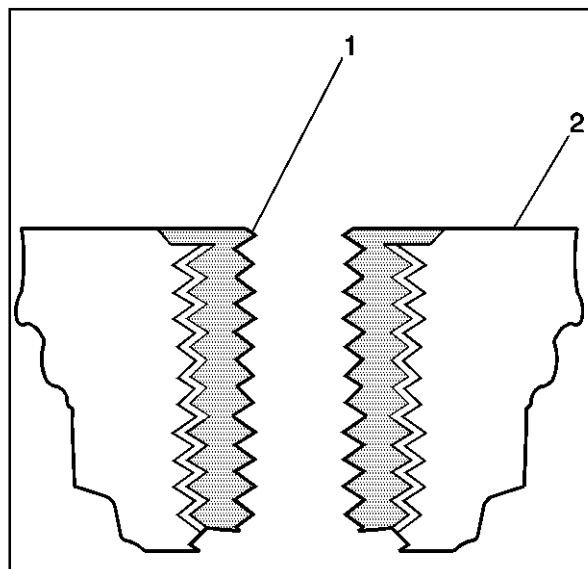
J 42385-100 Head/Main Bolt Thread Repair Kit

J 42385-200 General Threads Kit

J 42385-300 Fixtures/Hardware Kit

General Thread Repair

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert into place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.



320675

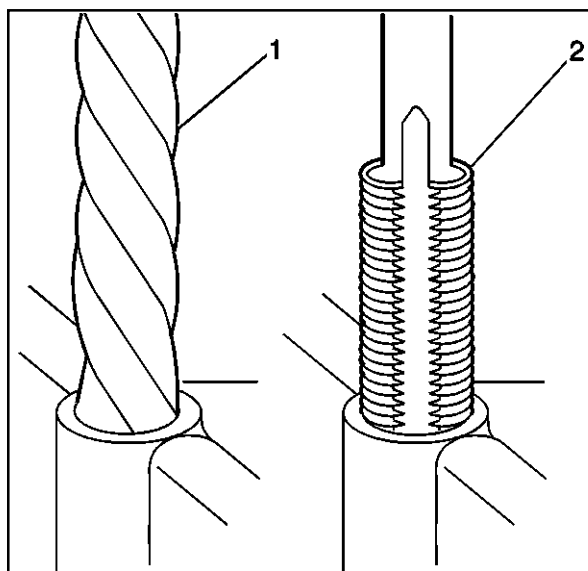
Caution: Wear safety glasses in order to avoid eye damage.

Important: The use of a cutting type fluid GM P/N 1052864, WD-40, or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

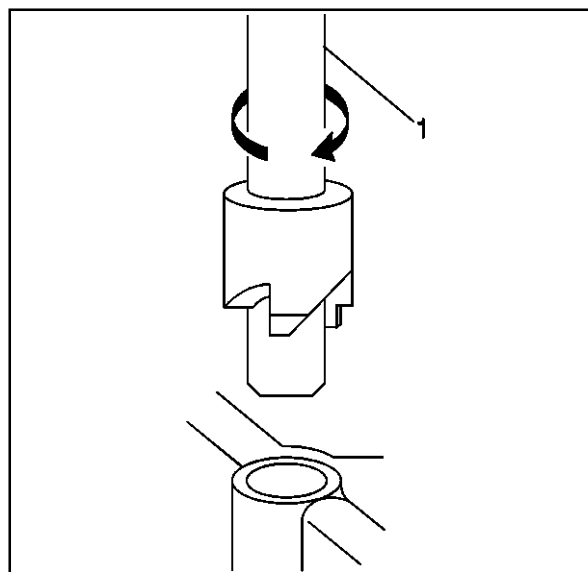
Driver oil MUST be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

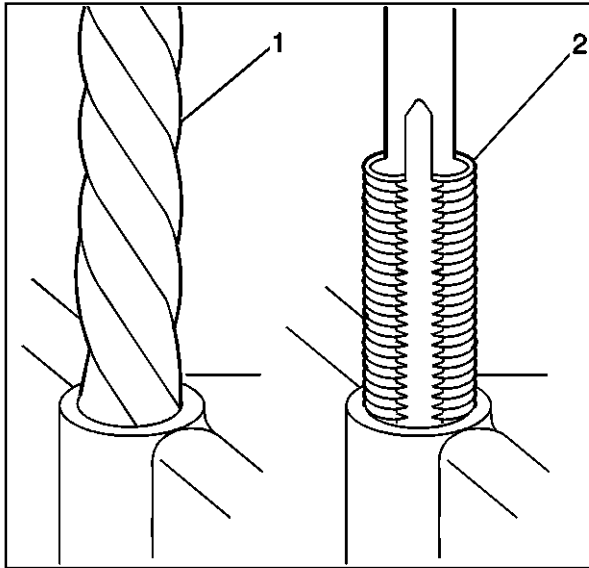
1. Drill out the threads of the damaged hole (1).
 - M6 inserts require minimum drill depth of 15 mm (0.59 in).
 - M8 inserts require minimum drill depth of 20 mm (0.79 in).
 - M10 inserts require minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.
3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.



320670



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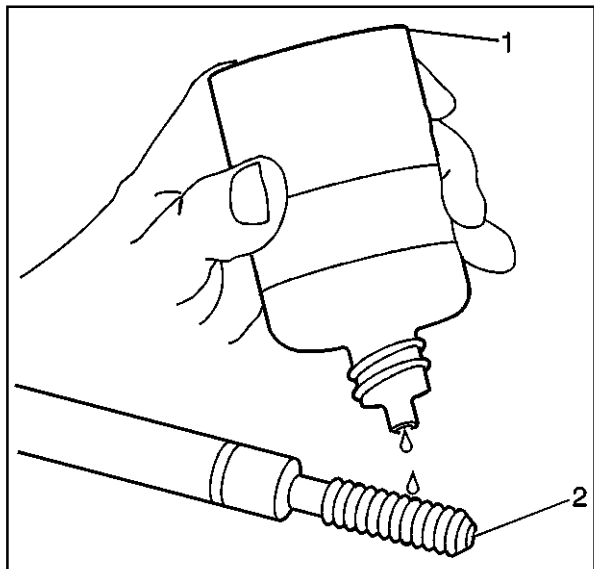


320670

5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require minimum tap depth of 23.5 mm (0.93 in).

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

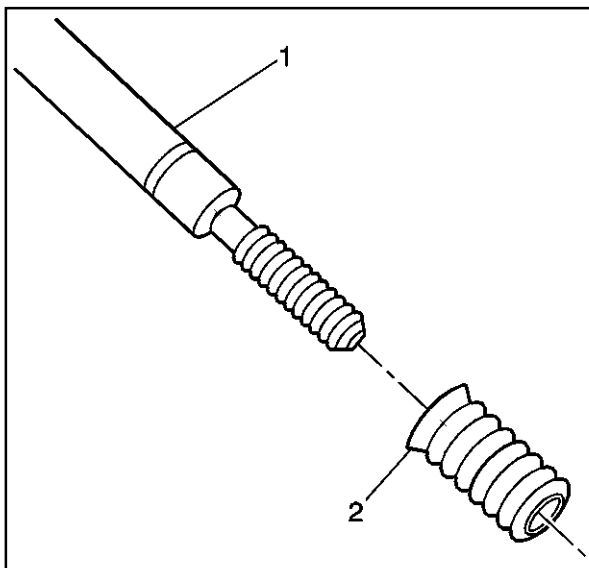
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, P/N 12377981, or equivalent into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.



313562

Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

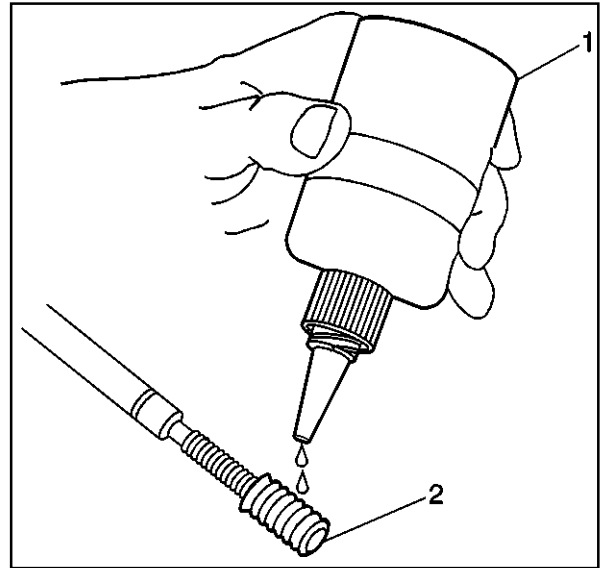
9. Lubricate the threads of the installer tool (2) with the driver oil (1).



313567

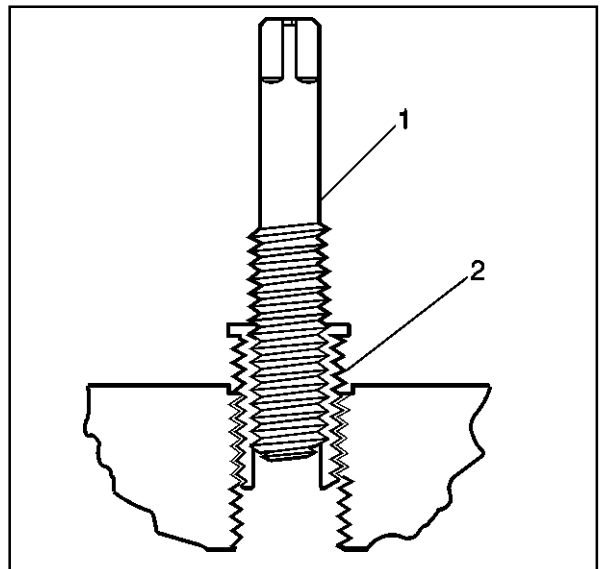
10. Install the insert (2) onto the driver tool (1).

11. Apply threadlock Loctite[®] 277, J 42385-109 (1), or equivalent to the insert OD threads (2).



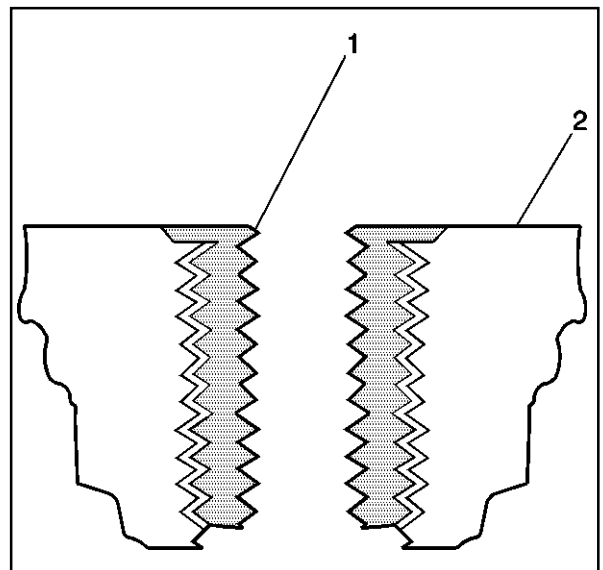
313572

12. Install the insert (2) into the hole.
 Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.
 The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

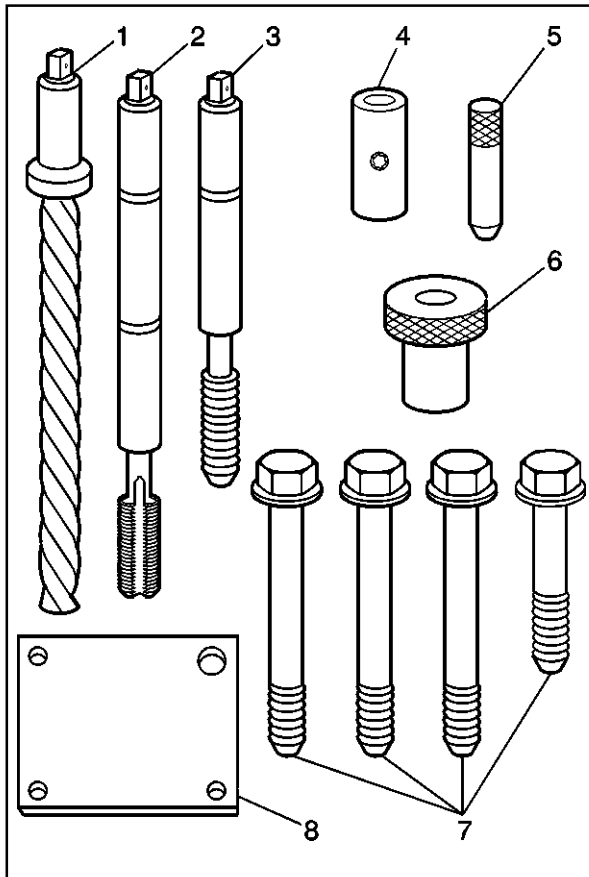


320673

13. Inspect the insert for proper installation into the hole.
 A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).



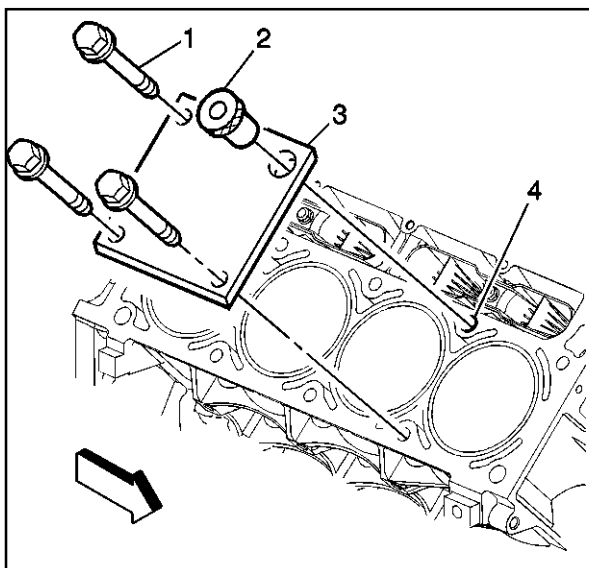
320675



313560

Cylinder Head Bolt Hole Thread Repair

- The cylinder head bolt hole thread repair kit consists of the following items:
 - The Drill (1)
 - The Tap (2)
 - The Installer (3)
 - The Sleeve (4)
 - The Alignment Pin (5)
 - The Bushing (6)
 - The Bolts (7)
 - The Fixture Plate (8)



313574

Caution: *Wear Safety Glasses in order to avoid eye damage.*

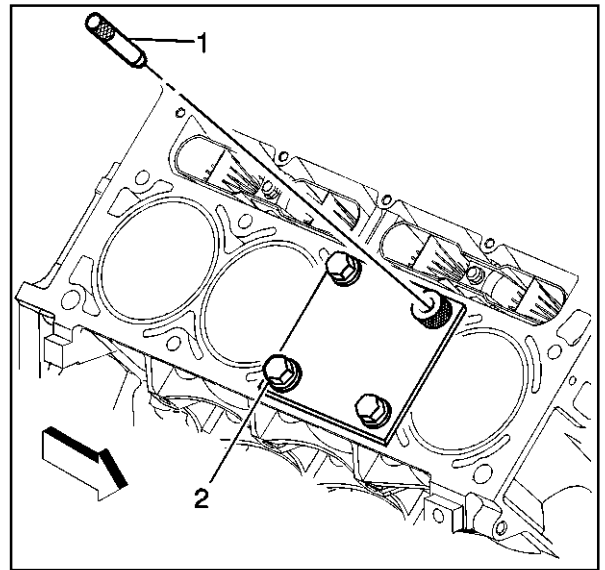
Important: The use of a cutting type fluid GM P/N 1052864, WD-40, or equivalent is recommended when performing the drilling and tapping procedures.

Driver oil **MUST** be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

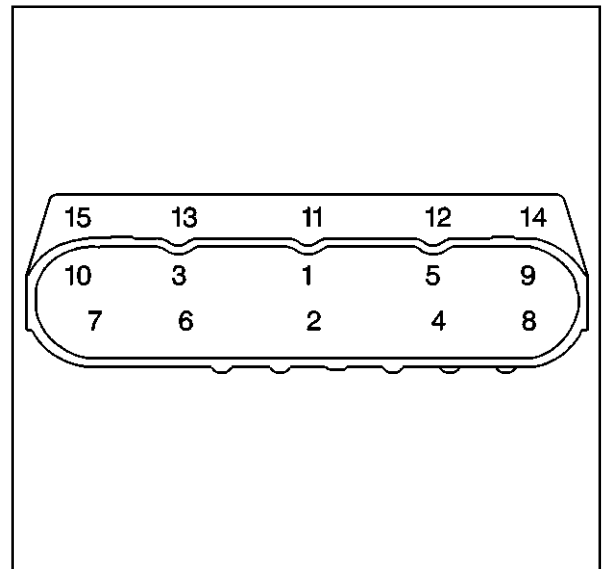
- Install the fixture plate (3), bolts (1) and bushing (2) onto the engine block deck.
Position the fixture plate and bushing over the hole that is to be repaired (4).

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.



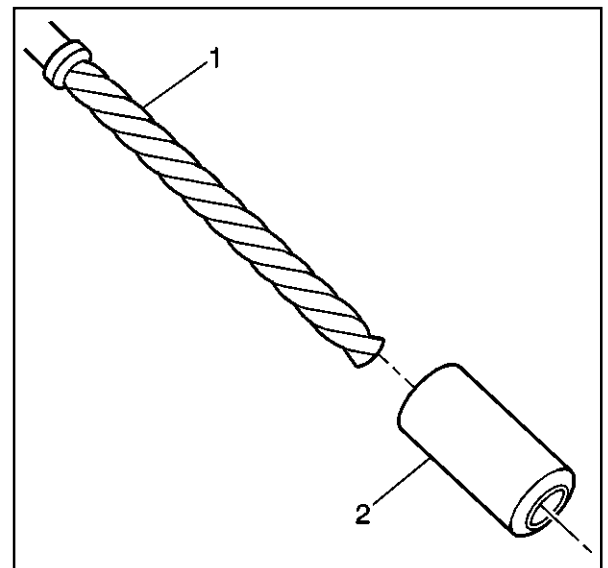
313577

6. Cylinder head bolt holes 1-8 are the deep holes and will be drilled without the drill sleeve.
Cylinder head bolt holes 9 and 10 are the shallower holes, drilling MUST be done with the drill sleeve in place.

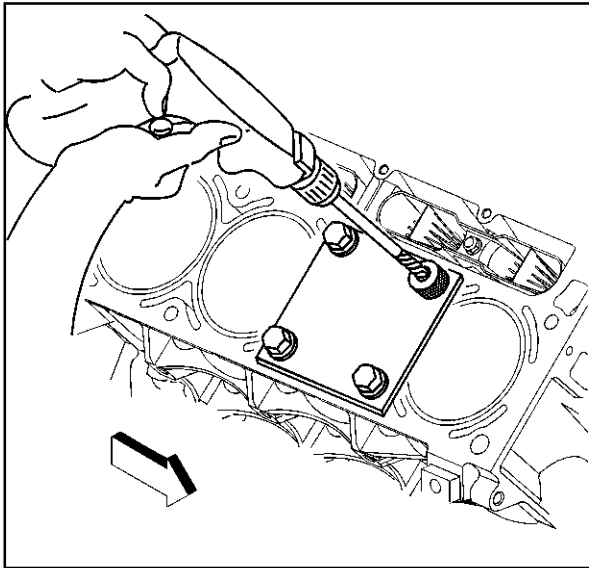


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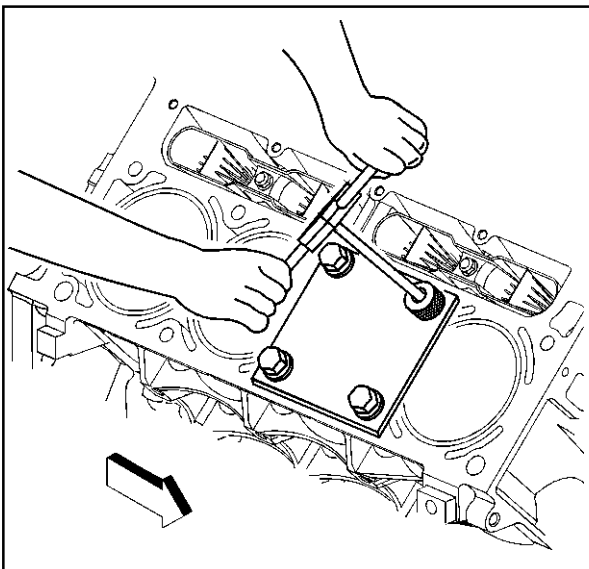
7. Install the sleeve (2) onto the drill (1), if required.



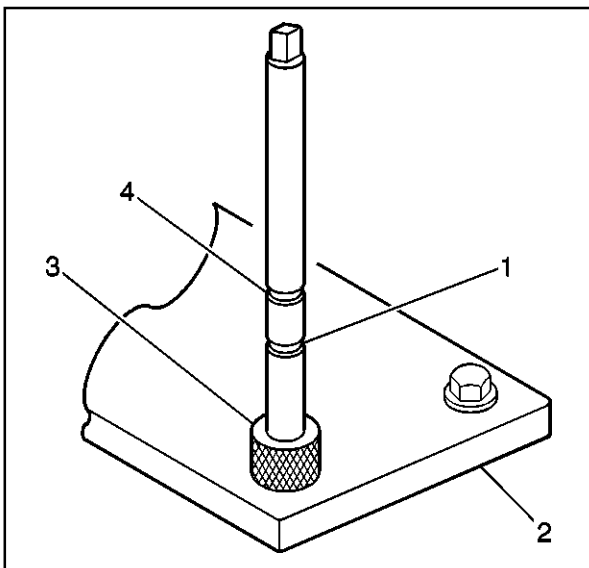
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Important: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

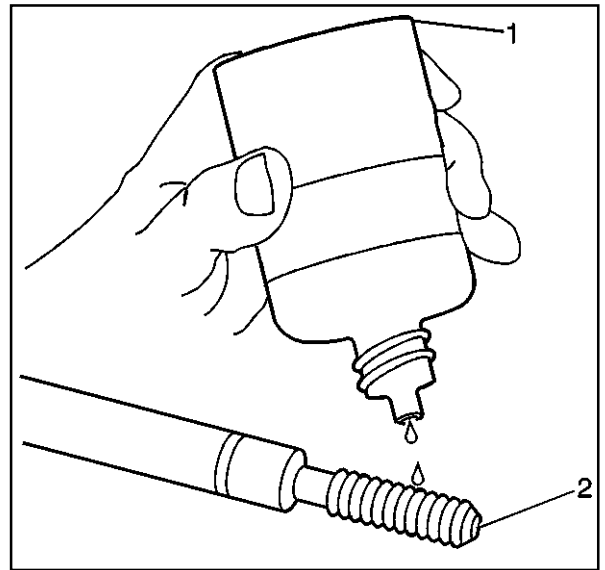
8. Drill out the threads of the damaged hole.
Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.
9. Using compressed air, clean out any chips.

10. Using a tap wrench, tap the threads of the drilled hole.

11. In order to tap the new threads to the proper depth, rotate the tap into the hole until the marks (1 or 4) on the tap align with the top of the drill bushing (3).
For the deeper cylinder head bolt holes (1-8), rotate the tap until the upper mark on the tap (4) aligns with the top of the drill bushing.
For the shallower cylinder head bolt holes (9 and 10), rotate the tap until the lower mark on the tap (1) aligns with the top of the drill bushing.
12. Remove the fixture plate (2), bushing (3) and bolts.
13. Using compressed air, clean out any chips.
14. Spray cleaner GM P/N 12346139, GM P/N 12377981, or equivalent into the hole.
15. Using compressed air, clean any cutting oil and chips out of the hole.

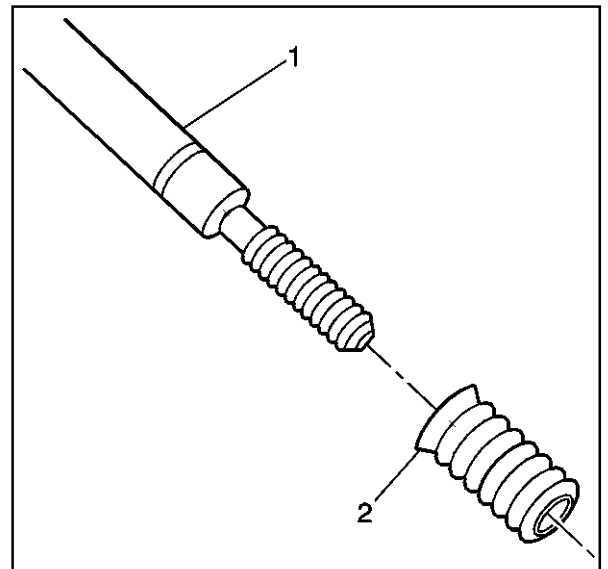
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

- 16. Lubricate the threads of the installer tool (2) with the driver oil (1).



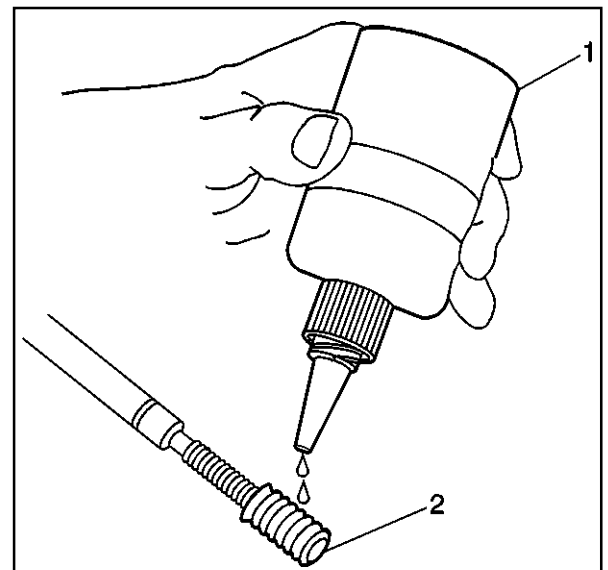
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- 17. Install the insert (2) onto the driver tool (1).

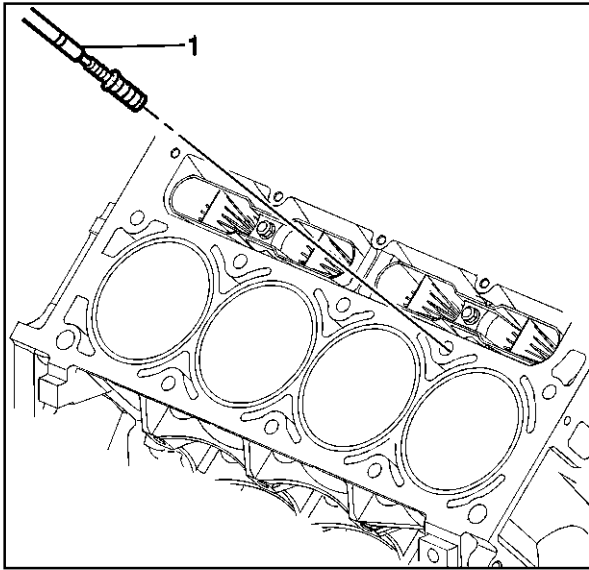


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- 18. Apply threadlock Loctite 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

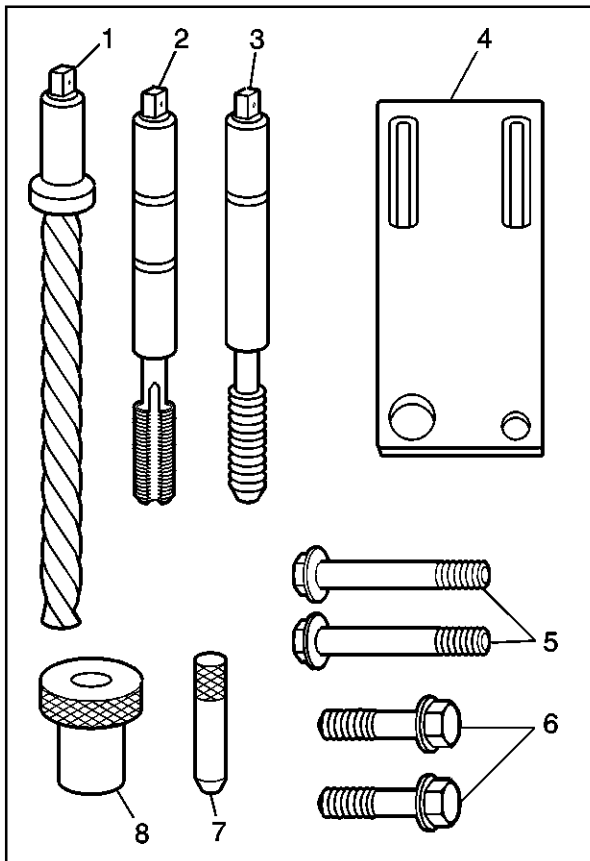


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19. Install the insert and driver (1) into the hole. Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block. The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

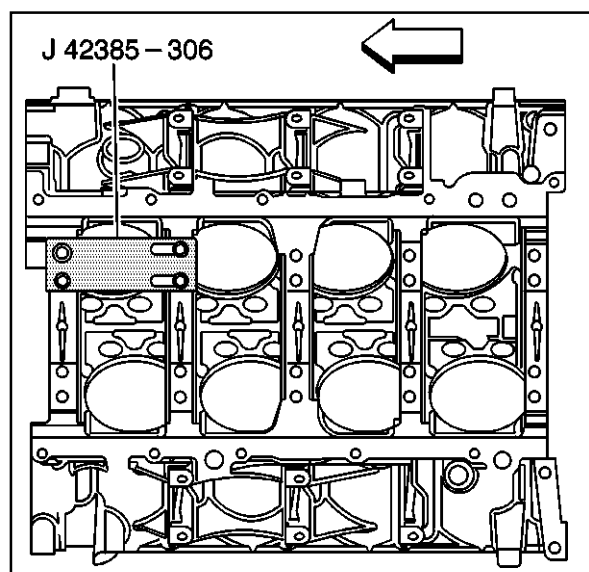


313556

Main Cap Bolt Hole Thread Repair

- The main cap bolt hole thread repair kit consists of the following items:
 - The Drill (1)
 - The Tap (2)
 - The Installer (3)
 - The Fixture Plate (4)
 - The Long Bolts (5)
 - The Short Bolts (6)
 - The Alignment Pin (7)
 - The Bushing (8)

2. Install the fixture plate, bolt and bushing onto the engine block.
Position the fixture plate and bushing over the hole that is to be repaired.
3. Position the alignment pin in the desired hole and tighten the fixture plate retaining bolts.

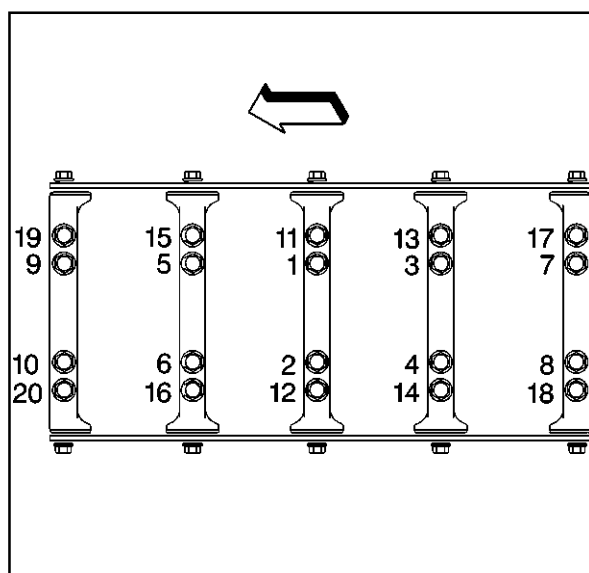


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4. Drill out the damaged hole.
The outer bolt hole locations (11-20) have the shallower counterbores. Use sleeve J 42385-316 with the drill.
Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

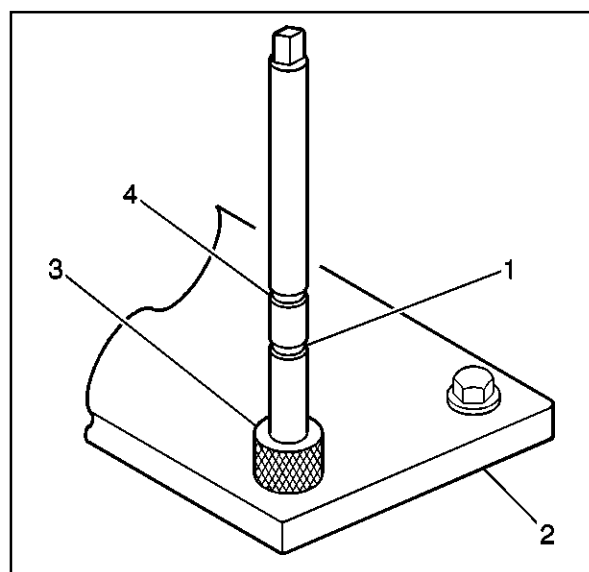
Caution: Wear safety glasses in order to prevent eye damage.

5. Using compressed air, clean out any chips.

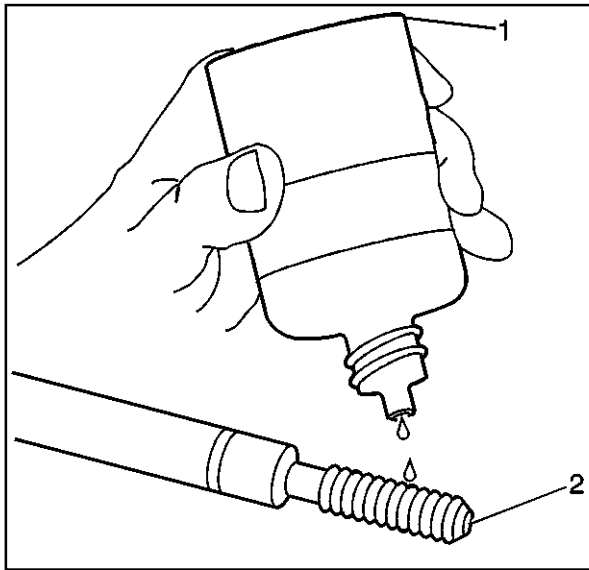


63214

6. Using a tap wrench, tap the threads of the drilled hole.
In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.
For the deeper main cap holes (1-10), rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).
For the shallower main cap holes (11-20), rotate the tap until the lower mark (1) on the tap aligns with the top of the bushing (3).
7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139, or equivalent into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.



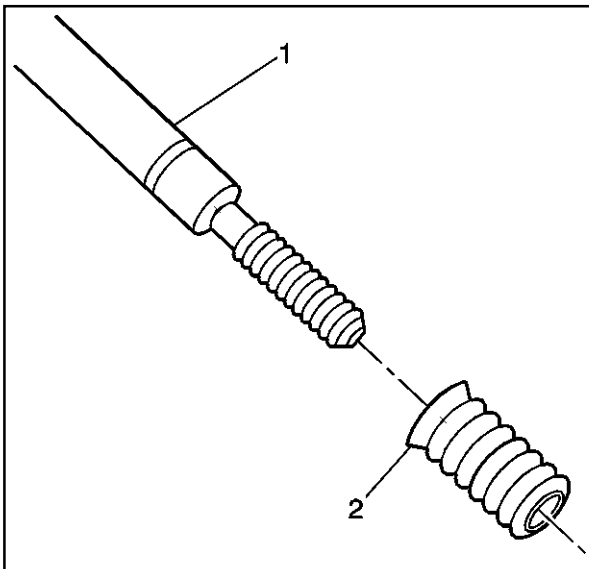
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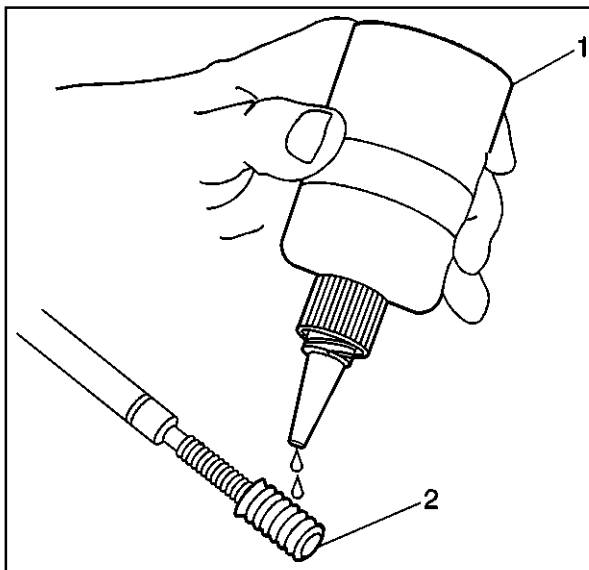
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

10. Lubricate the threads of the installer tool (2) with the driver oil (1).



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11. Install the insert (2) onto the driver tool (1).



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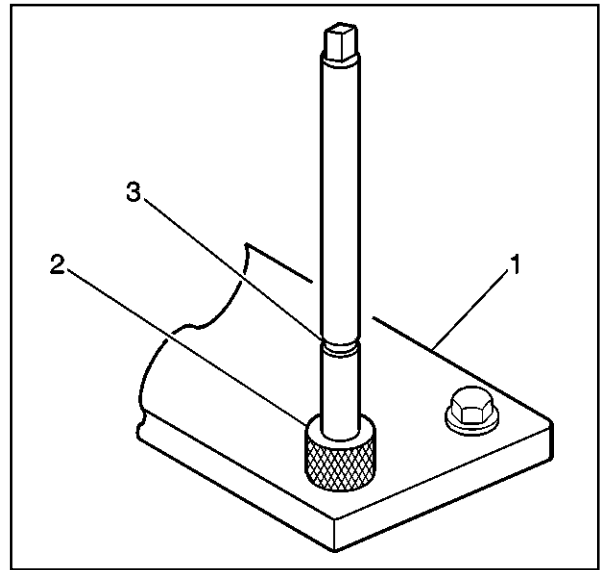
12. Apply threadlock Loctite 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

Important: The fixture plate and bushing remain installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

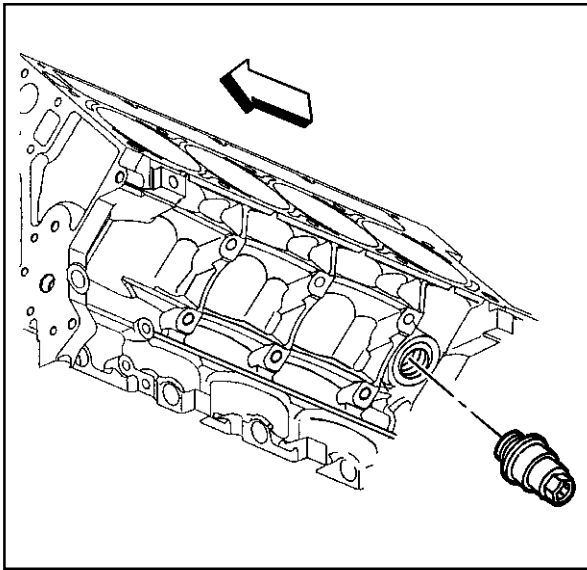


377635

Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all the components. Refer to *Cleanliness and Care*.
- Use the proper tools to measure components when checking for excessive wear. Components that are not within the manufacturers specifications, must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position and direction. Refer to *Separating Parts*.
- During assembly, lubricate all the moving parts with clean engine oil. This will provide initial lubrication when the engine is first started.

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260137

Engine Block Plug Installation

Tools Required

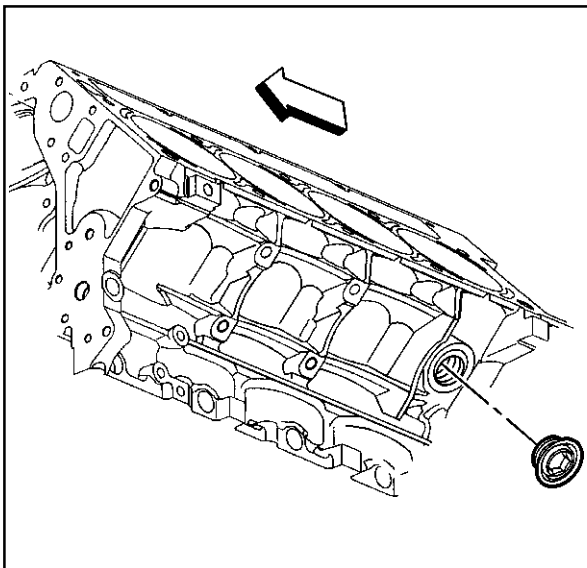
J 41712 Oil Pressure Sensor Socket or equivalent.

Important:

- Engine block plug (oil gallery and coolant) sealing washers may be reused if not bent, scored or otherwise damaged.
 - Apply the proper amount and type of sealant to the sealing washer as recommended in the service procedure.
1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block coolant heater sealing washer (if applicable). Refer to *Sealers, Adhesives and Lubricants*.
 2. Install the engine block coolant heater (if applicable) to the engine block.

Tighten

Tighten the block coolant heater to 40 N·m (30 lb ft).



260138

3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block left rear coolant drain plug sealing washer (if applicable).
4. Install the engine block left rear coolant drain plug (if applicable).

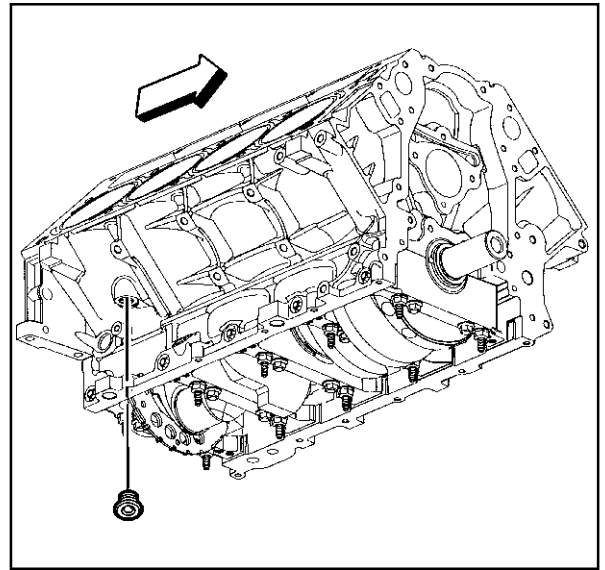
Tighten

Tighten the block left rear coolant drain plug to 60 N·m (44 lb ft).

5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block right rear coolant drain plug sealing washer.
6. Install the engine block right rear coolant drain plug.

Tighten

Tighten the block right rear coolant drain plug to 60 N·m (44 lb ft).

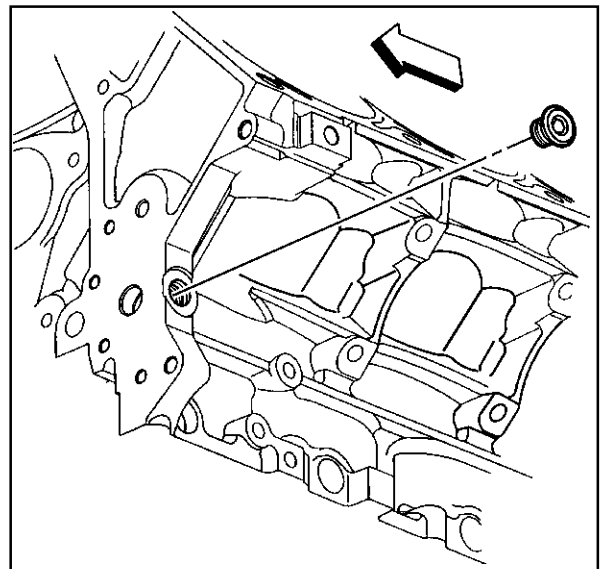


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7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block left front oil gallery plug sealing washer.
8. Install the engine block left front oil gallery plug.

Tighten

Tighten the block left front oil gallery plug to 60 N·m (44 lb ft).

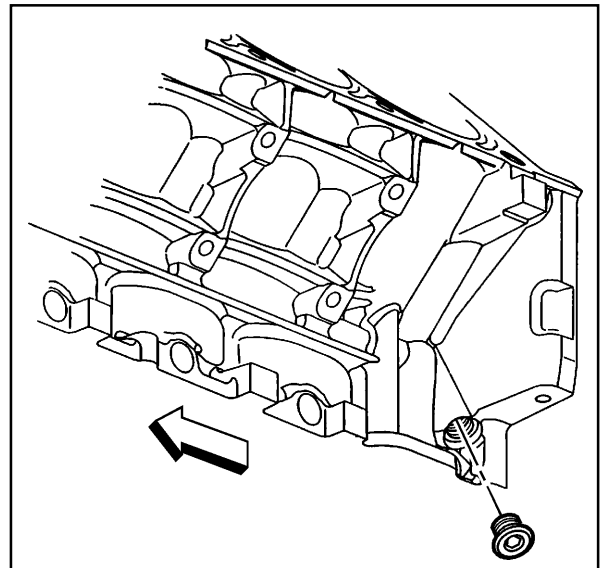


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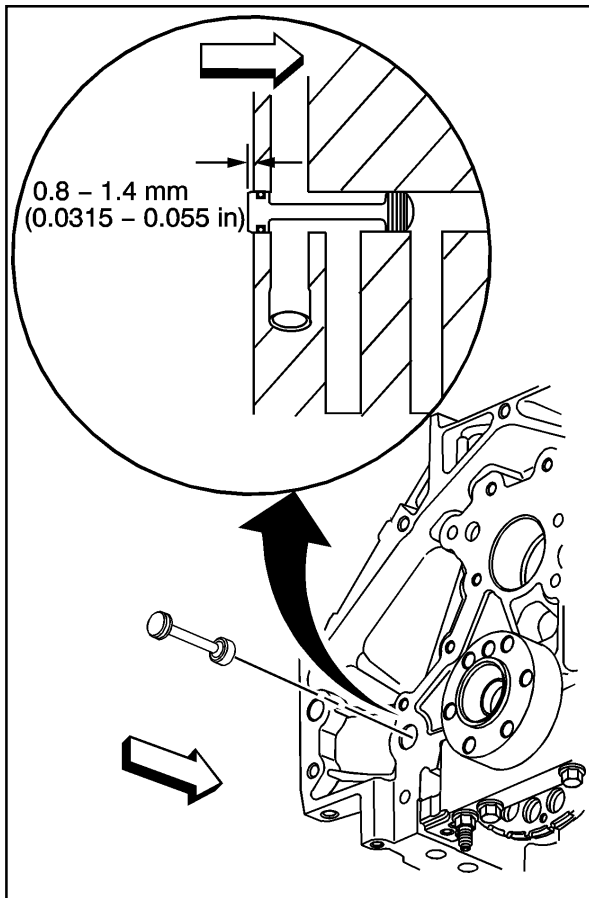
9. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block left rear oil gallery plug sealing washer.
10. Install the engine block left rear oil gallery plug.

Tighten

Tighten the block left rear oil gallery plug to 60 N·m (44 lb ft).

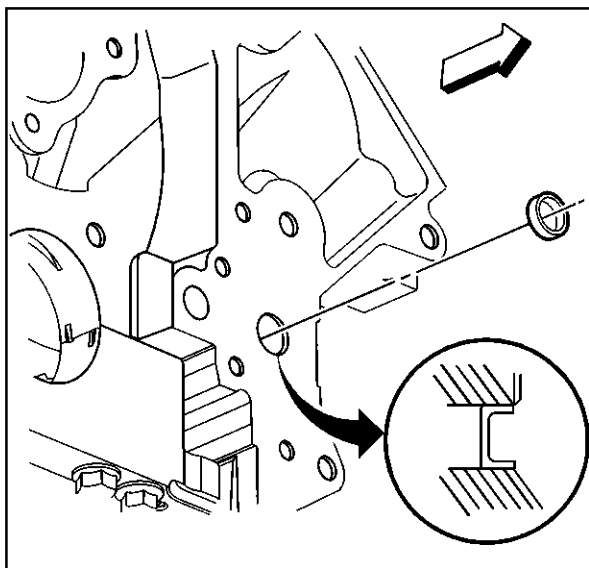


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11. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be reused.
12. Lubricate the O-ring seal with clean engine oil.
13. Install the block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.



64295

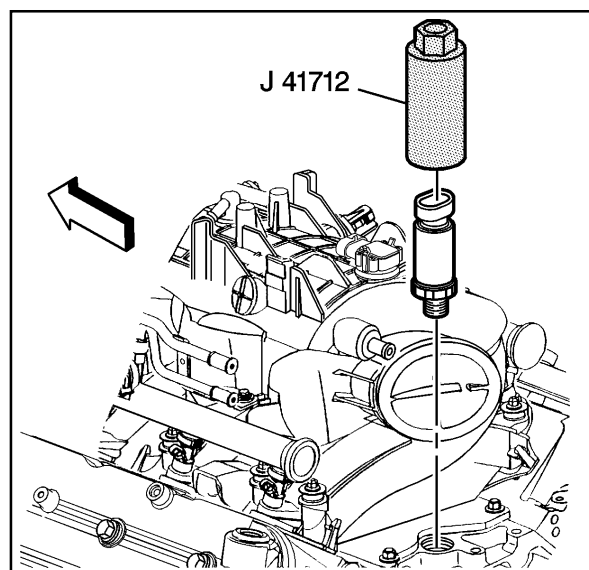
Important: The engine block front oil gallery plug should not be removed unless service is required.

14. Apply sealant GM P/N 12345382 or equivalent to the sides of the NEW front oil gallery plug.
15. Install a NEW engine block front oil gallery plug (if required). Install the front oil gallery plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.

16. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil pressure sensor.
17. Use the *J 41712* or equivalent in order to install the oil pressure sensor.

Tighten

Tighten the oil pressure sensor to 20 N·m (15 lb ft).



260089

Crankshaft and Bearings Installation

Tools Required

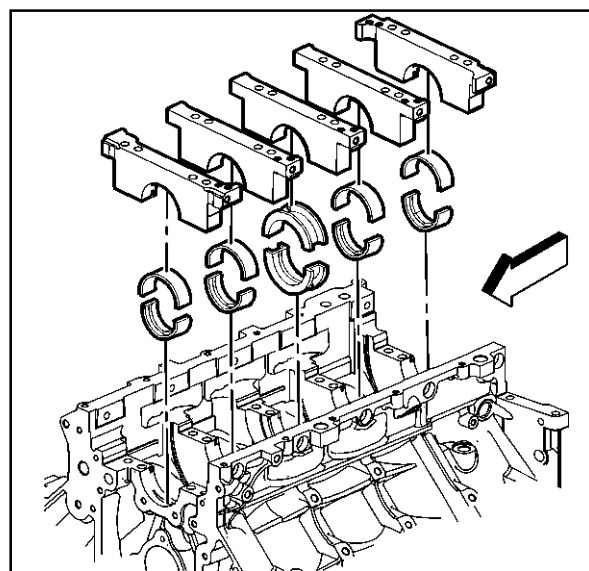
J 36660 Torque Angle Meter

Important:

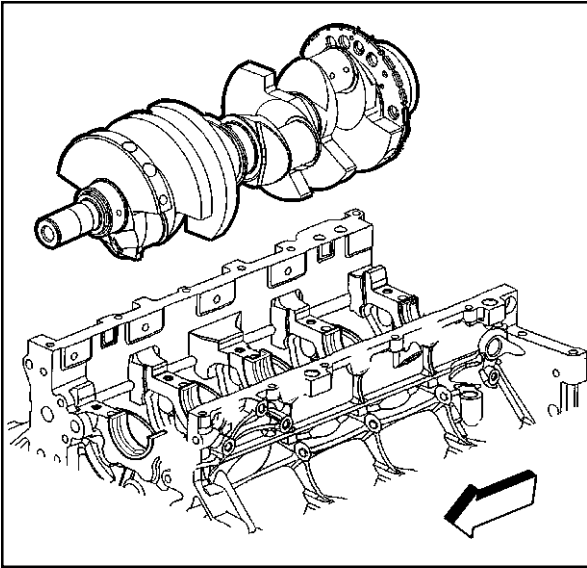
- Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may effect crankshaft position sensor signals and/or On-Board Diagnostics (OBD) system performance.
- Crankshaft bearing caps must be installed to the proper location and direction.
- When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
- Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.
- To prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.

The crankshaft bearing cap M8 side bolts have a sealant patch applied to the bolt flange.

1. Install the crankshaft thrust bearings to the engine block and bearing caps.
2. Install the remaining crankshaft bearings to the engine block and bearing caps.
3. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.



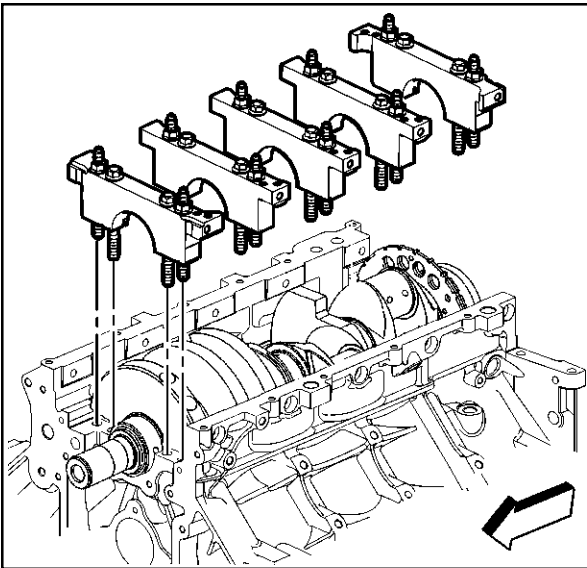
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Notice: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

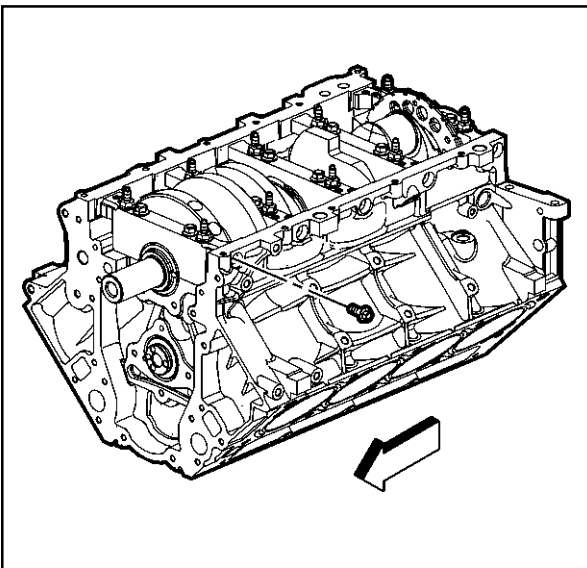
4. Install the crankshaft.



156152

Important: The bearing caps must be installed in the proper location and direction.

5. Install the crankshaft bearing caps (with bearings) into the engine block.
6. Start the M10 bolts and studs.
7. Tap the bearing caps into place with a plastic-faced hammer.



156155

8. Install the NEW M8 bearing cap side bolts.

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

9. Tighten the bearing cap bolts and studs.

Tighten

Tighten the inner M10 bearing cap bolts first pass in sequence to 20 N·m (15 lb ft).

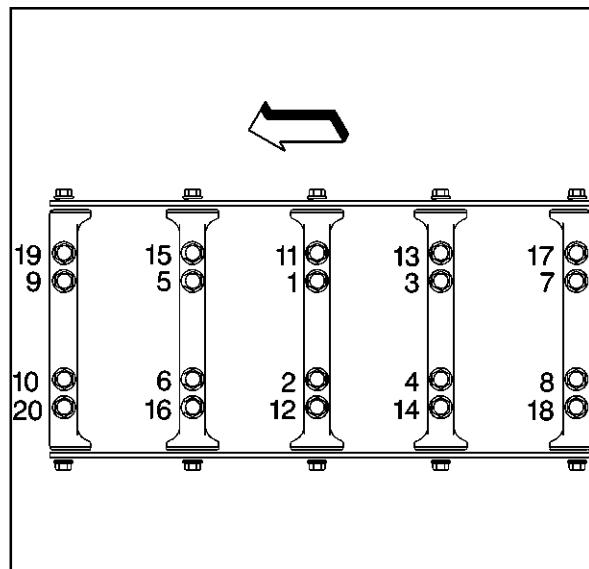
Important: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft **MUST** be in the forward direction.

10. Using a plastic faced hammer, tap the crankshaft rearward then forward to align the thrust bearings.

Tighten

- 10.1. Tighten the inner M10 bolts final pass in sequence 80 degrees using the *J 36660*.
- 10.2. Tighten the outer M10 bolts first pass in sequence 20 N·m (15 lb ft).
- 10.3. Tighten the outer M10 bolts final pass in sequence 53 degrees using the *J 36660*.
- 10.4. Tighten the bearing cap side M8 bolts to 25 N·m (18 lb ft).

Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.



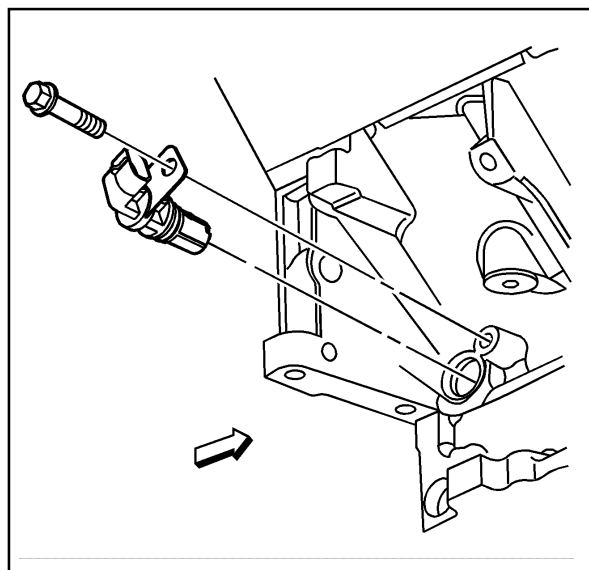
63214

11. Install the crankshaft position sensor.
 - 11.1. Inspect the crankshaft position sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used.
 - 11.2. Coat the O-ring seal with clean engine oil.
 - 11.3. Install the sensor. Align the notch in the sensor retaining bracket with the bolt hole in the engine block.

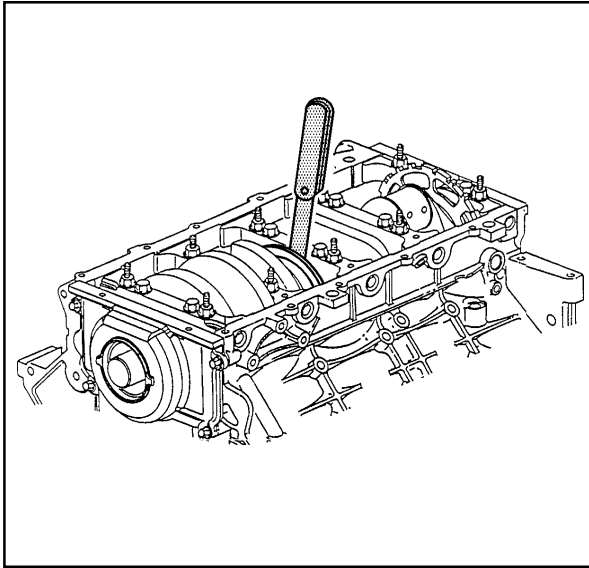
- 11.4. Install the sensor bolt.

Tighten

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

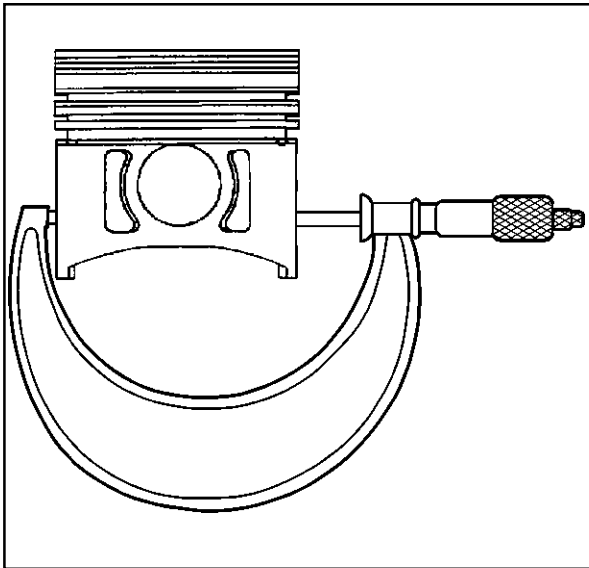


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12. Measure the crankshaft end play.
 - 12.1. Thrust the crankshaft forward or rearward.
 - 12.2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.
The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).
 - 12.3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.



188016

Piston, Connecting Rod and Bearing Installation

Tools Required

- J 41556* Connecting Rod Guide
- J 8037* Piston Ring Compressor
- J 36660* Torque Angle Meter

Piston Selection

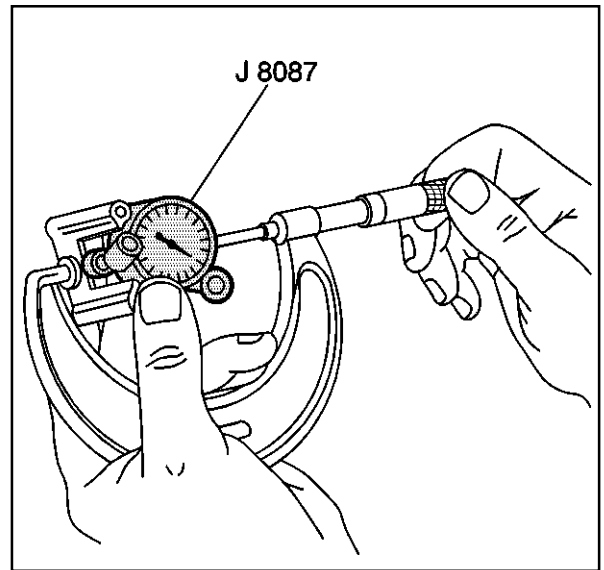
Important: Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

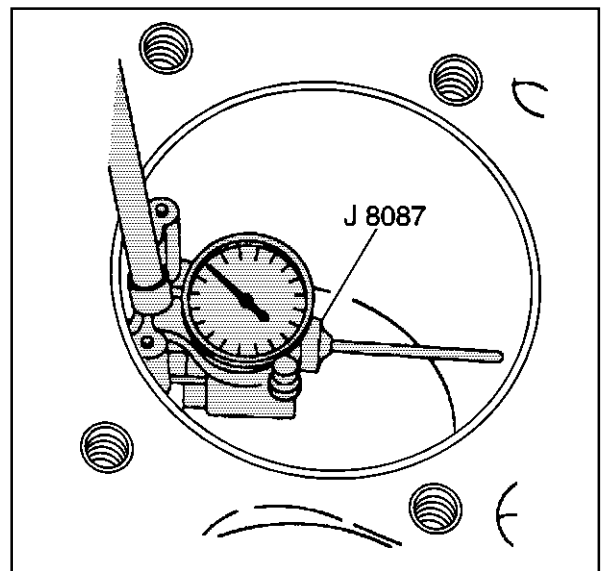
1. Inspect the engine block cylinder bore for scoring or other damage.
2. Inspect the piston and the piston pin. Refer to *Piston, Connecting Rod and Bearings Clean and Inspect*.
3. With the micrometer at a right angle to the piston, measure the piston. Refer to *Piston, Connecting Rod and Bearings Clean and Inspect*.
4. Record the piston diameter.

5. Adjust the micrometer to the recorded piston diameter.
6. Insert the bore gauge into the micrometer and zero the bore gauge dial.

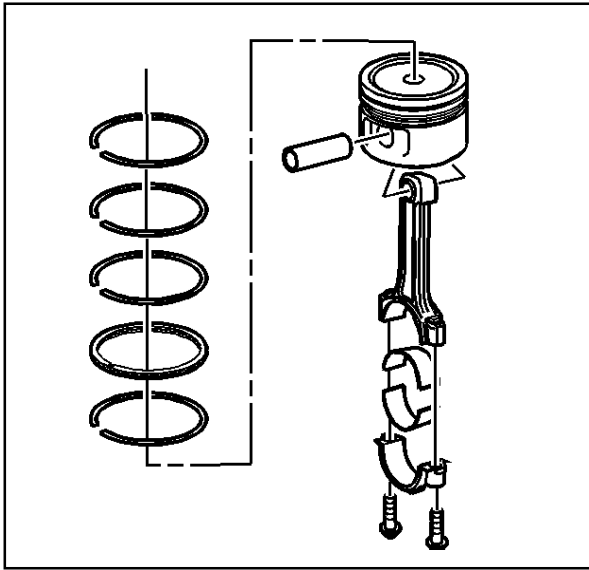


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7. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.
8. Record the cylinder bore diameter.
9. Subtract the piston diameter from the cylinder bore diameter in order to determine the piston-to-bore clearance. Refer to *Engine Mechanical Specifications*.
10. If the proper clearance cannot be obtained, select another piston and measure the clearances.
If the proper fit cannot be obtained, the cylinder bore may require boring and honing for an oversize piston or engine block replacement.



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Installation Procedure

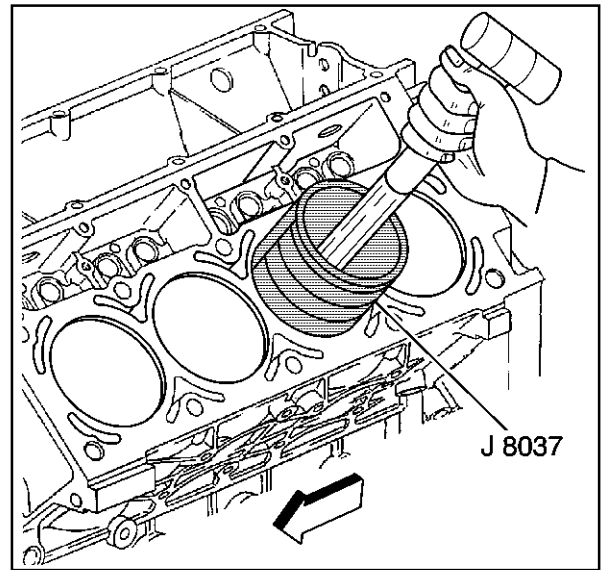
Important: The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore.

The piston alignment mark **MUST** face the front of the engine block.

1. Lightly lubricate the following components with clean engine oil:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces
2. Stagger the oil control ring end gaps a minimum of 90 degrees.
3. Stagger the compression ring end gaps a minimum of 25 mm (1.0 in).
4. Install the *J 41556* to the connecting rod.
5. Install the *J 8037* onto the piston and compress the piston rings.

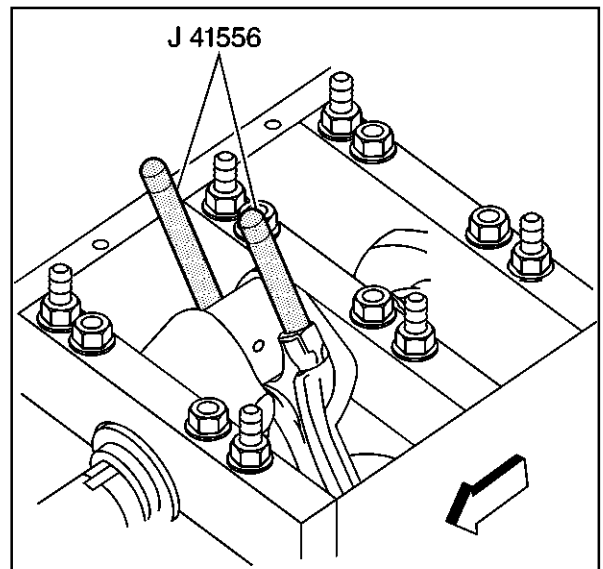
Important: The piston alignment mark MUST face the front of the engine block.

6. Install the piston and connecting rod assembly into the proper cylinder bore.
 - 6.1. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all of the piston rings enter the cylinder bore.
 - 6.2. Use the *J 41556* to guide the connecting rod end onto the crankshaft journal.

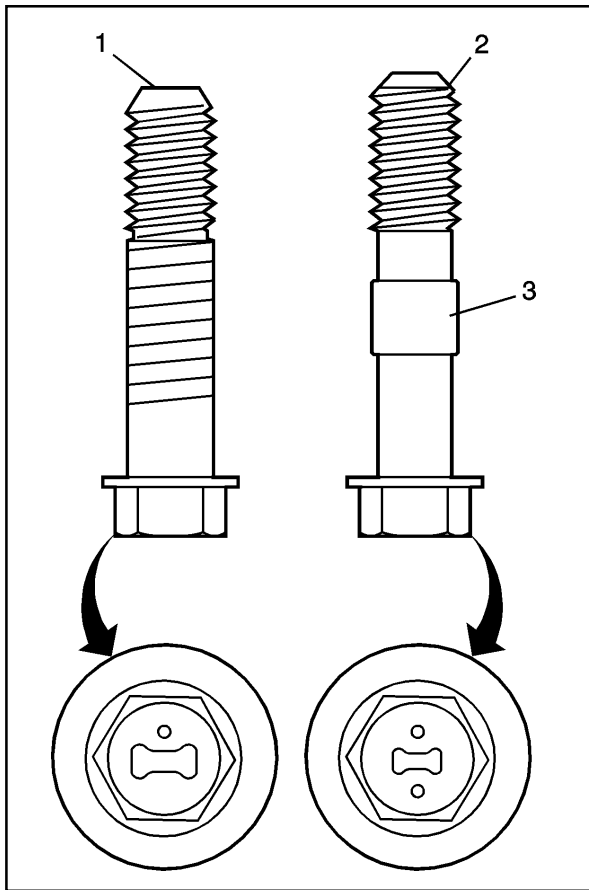


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7. Remove the *J 41556*.



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8. Identify the type of connecting rod bolt.
- The first design connecting rod bolt (1) can be identified by a single dimple/mark on the head of the bolt and no retaining sleeve on the bolt shank.
 - The second design connecting rod bolt (2) can be identified by two dimple/marks on the head of the bolt and a retaining sleeve (3) on the bolt shank.

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

Important:

- When replacing connecting rod bolts, both bolts **MUST** be of the same design for each connecting rod assembly.

The use of different design connecting rod bolts on the same connecting rod assembly may lead to uneven clamploads and/or connecting rod bearing bore distortion.

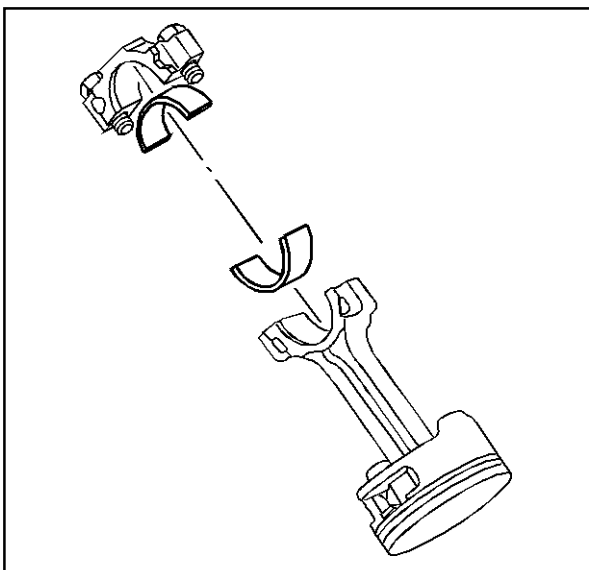
- Position the connecting rod cap onto the connecting rod properly.

Align the flat side of the connecting rod cap with the flat side of the connecting rod.

9. Install the bearing, cap and bolts.

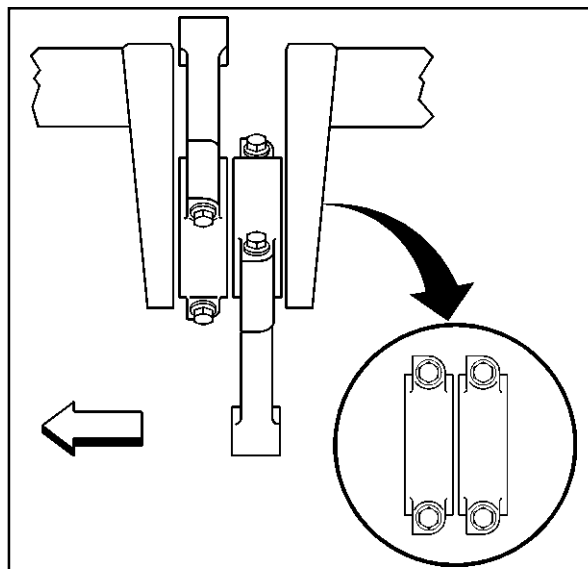
Tighten

- 9.1. Tighten the first design bolts a first pass evenly to 20 N·m (15 lb ft).
- 9.2. Tighten the first design bolts a final pass to 60 degrees using the *J 36660*.
- 9.3. Tighten the second design bolts a first pass evenly to 20 N·m (15 lb ft).
- 9.4. Tighten the second design bolts a final pass to 75 degrees using the *J 36660*.



53223

10. Inspect the connecting rods for proper orientation onto the crankshaft journal.
11. With the pistons and connecting rods installed, use a soft faced mallet and lightly tap each connecting rod assembly parallel to the crankpin to make sure that the rods have side clearance.
12. Measure the connecting rod side clearance using a feeler gauge or dial indicator. Connecting rod side clearance should be within 0.11-0.51 mm (0.0043-0.02 in).



63227

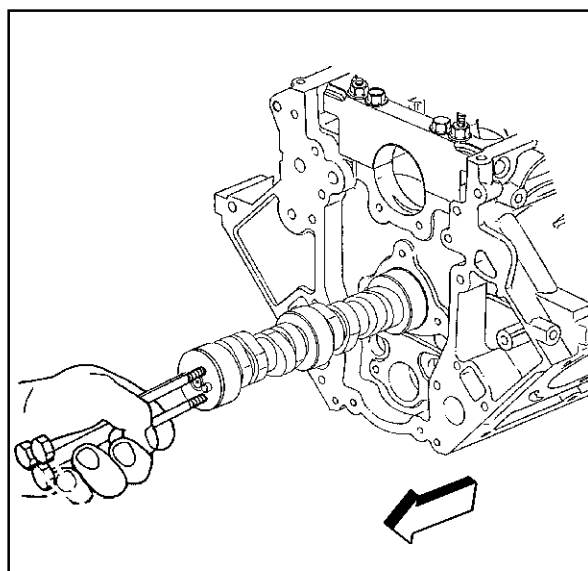
Camshaft Installation

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

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

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

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



63212

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

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

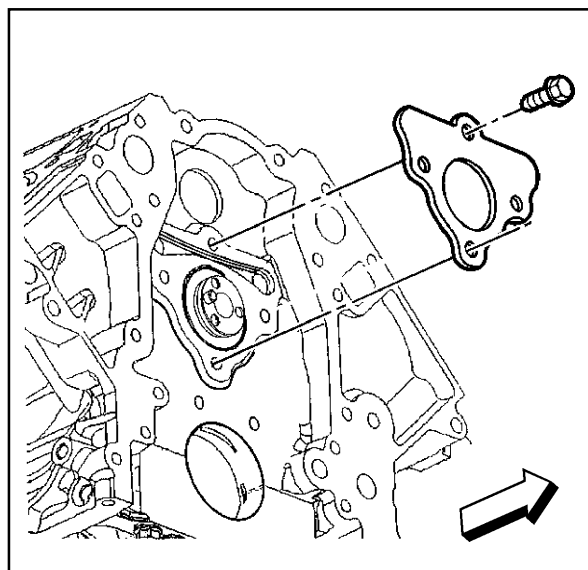
The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer and the bolts.

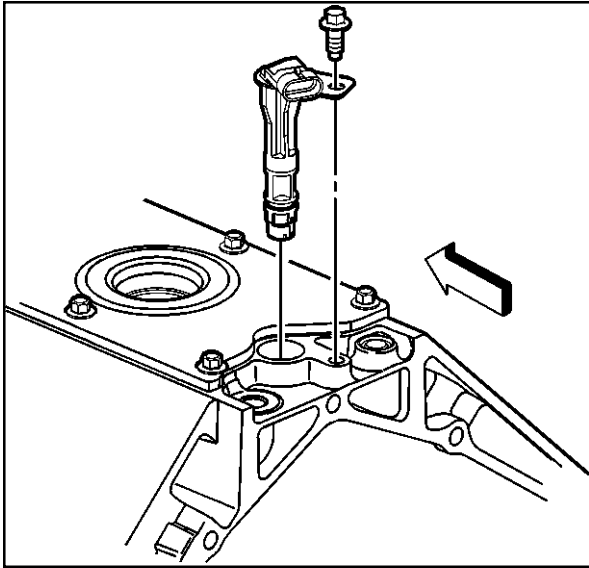
Tighten

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

6. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be reused.
7. Lubricate the O-ring seal with clean engine oil.



63211

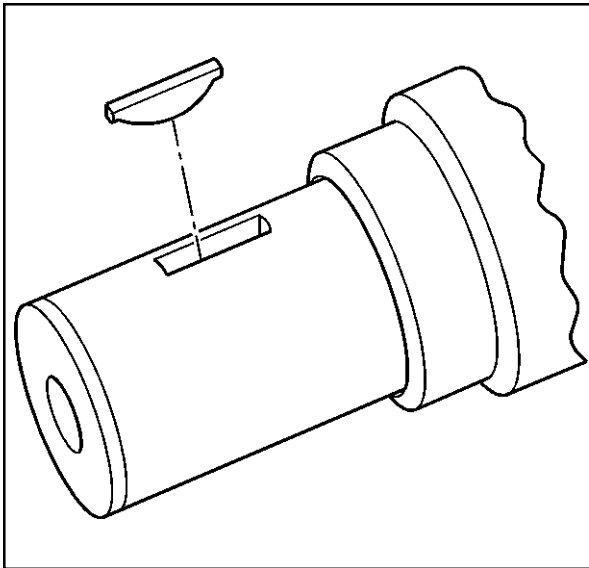


260128

8. Install the camshaft sensor and bolt.

Tighten

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

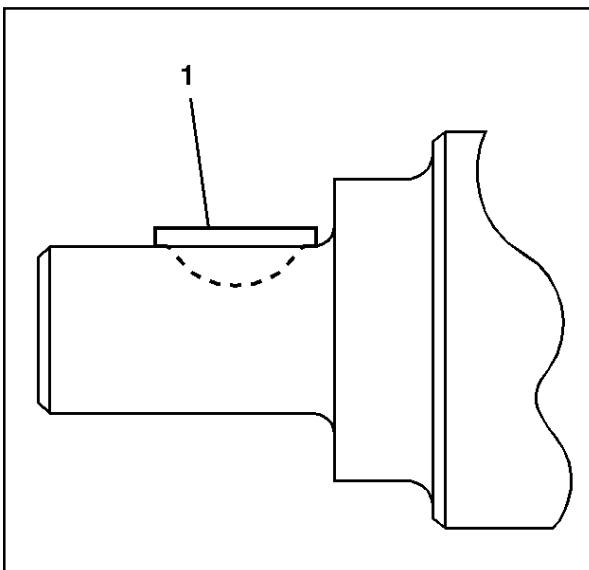


156149

Timing Chain and Sprockets Installation**Tools Required**

J 41665 Crankshaft Balancer and Sprocket Installer

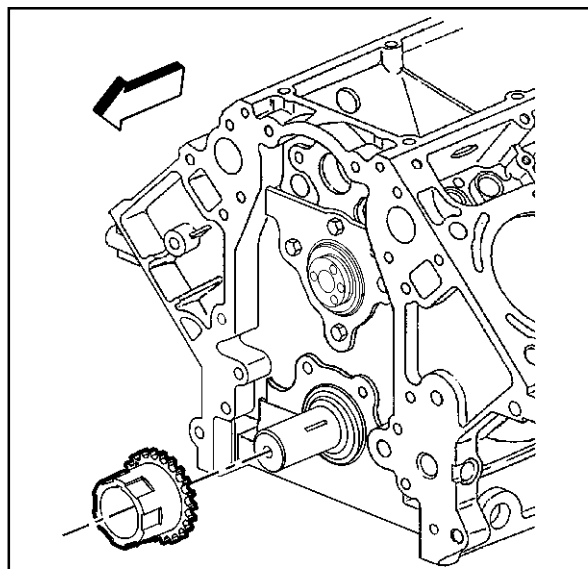
1. Install the key into the crankshaft keyway (if previously removed).



490871

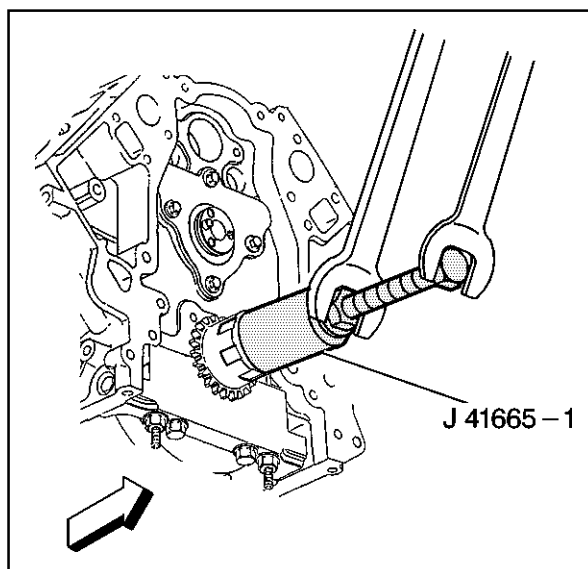
2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.

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



156150

4. Use the *J 41665* in order to install the crankshaft sprocket.
- Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.



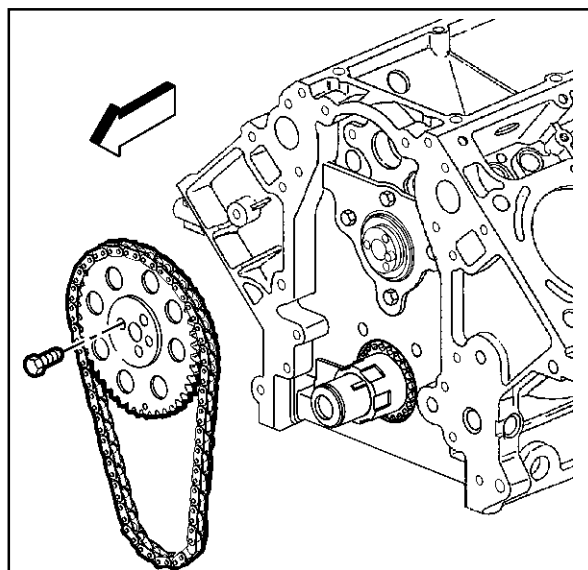
63199

Important:

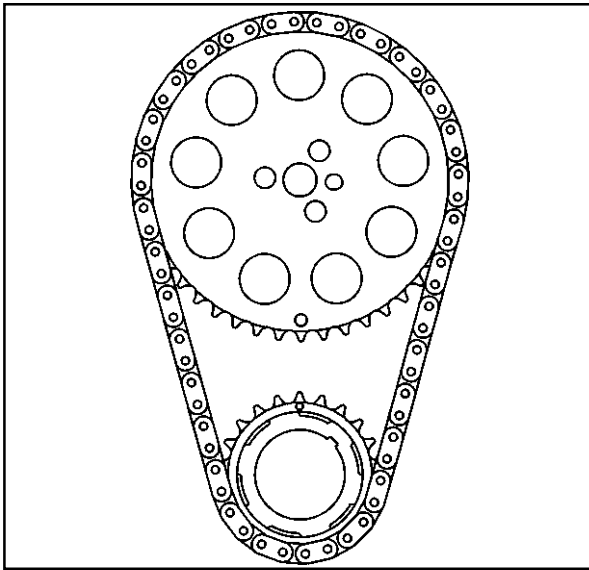
- Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

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

6. Install the camshaft sprocket and timing chain.



63263



156158

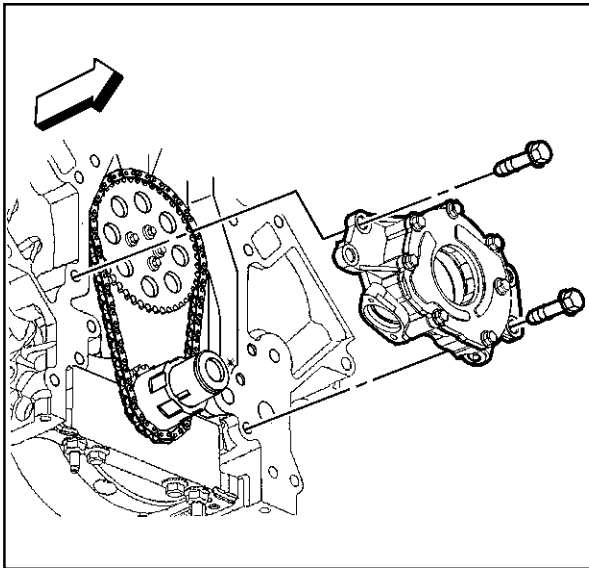
- If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

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

- Install the camshaft sprocket bolts.

Tighten

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



64281

Oil Pump, Pump Screen and Deflector Installation

Important: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

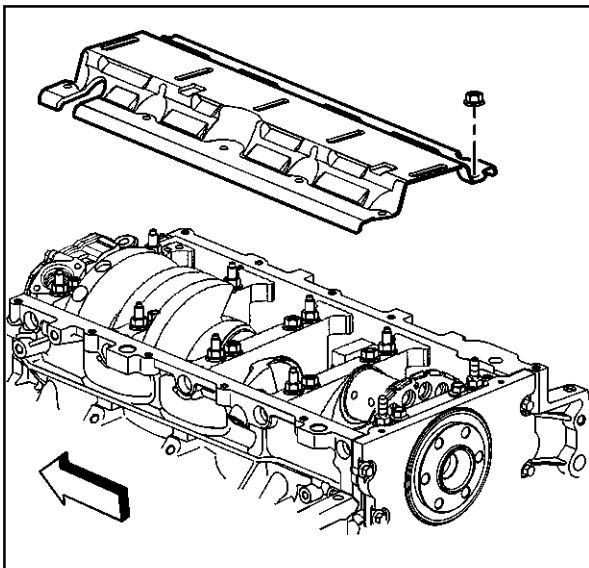
- Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
- Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

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

- Install the oil pump bolts.

Tighten

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



260099

- Install the crankshaft oil deflector.

5. Lubricate a NEW oil pump screen O-ring seal (3) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

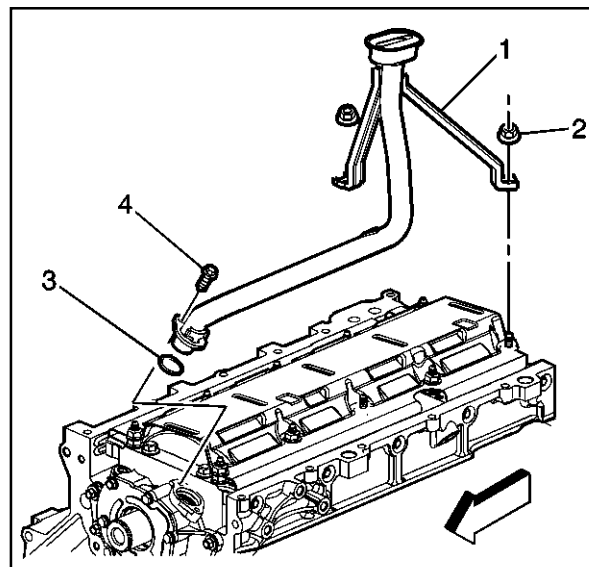
Important: Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.

Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.

7. Install the oil pump screen (1).
8. Install the oil pump screen bolt (4) and the deflector nuts (2).

Tighten

- 8.1. Tighten the oil pump screen bolt (4) to 12 N·m (106 lb in).
- 8.2. Tighten the crankshaft oil deflector nuts (2) to 25 N·m (18 lb ft).



260109

Engine Rear Cover Installation

Tools Required

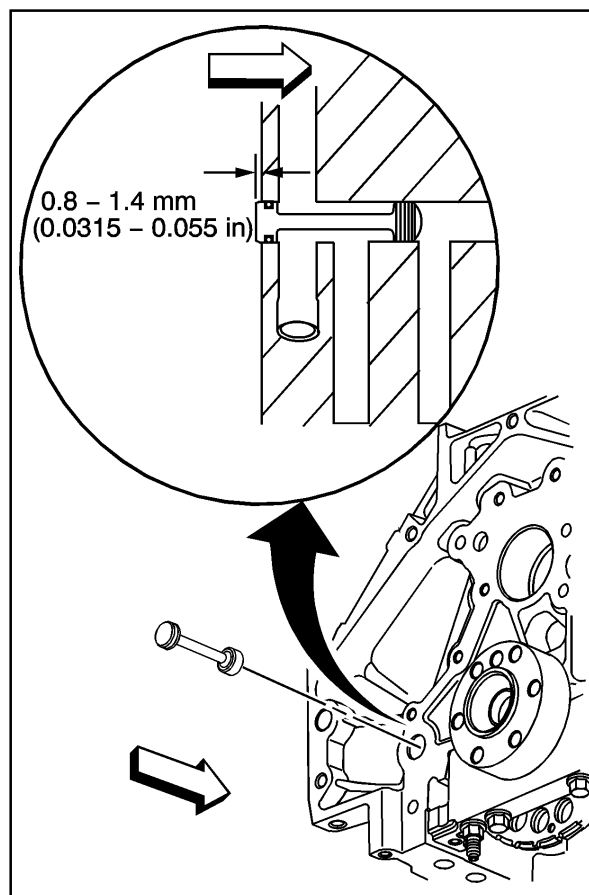
J 41480 Front/Rear Cover Alignment (Oil Pan Surface)

J 41476 Front/Rear Cover Alignment (Crankshaft Oil Seal Area)

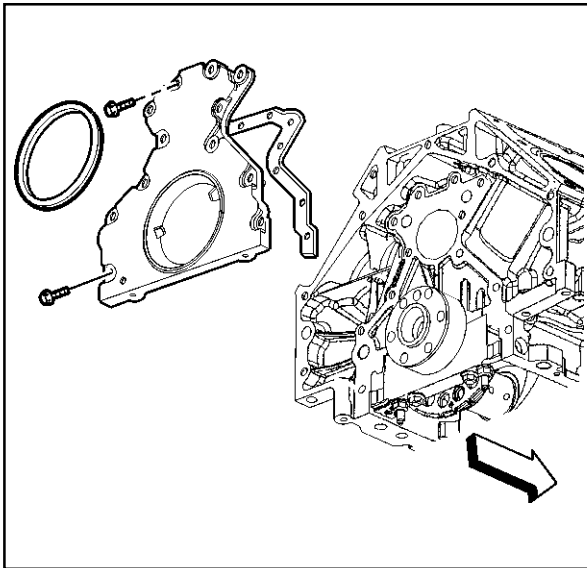
Important:

- Do not reuse the crankshaft rear oil seal or the engine rear cover gasket.
- Do not apply any type sealant to the rear cover gasket (unless specified).
- The special tools in this procedure are used to properly align the engine rear cover at the oil pan surface and to center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned. Install the rear cover without the crankshaft oil seal.
 - The crankshaft rear oil seal **MUST** be centered in relation to the crankshaft.
 - The oil pan sealing surface at the rear cover and engine block **MUST** be aligned within specifications.
 - An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.

1. Inspect the rear oil gallery plug for proper installation.

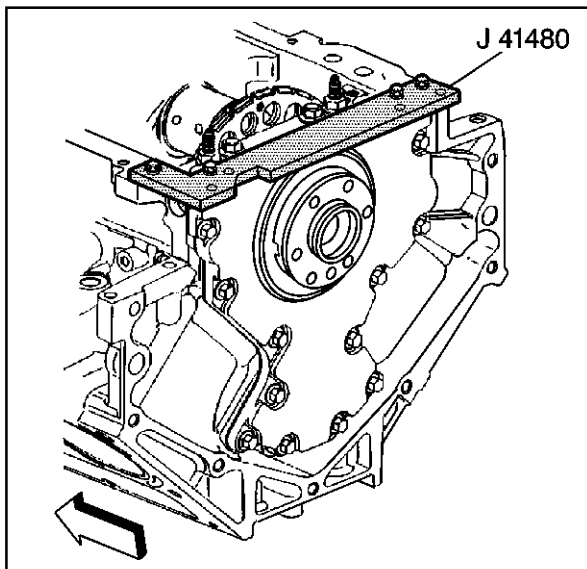


63228



64282

2. Install the rear cover gasket, rear cover and bolts.
3. Tighten the bolts finger tight. Do not overtighten.



64204

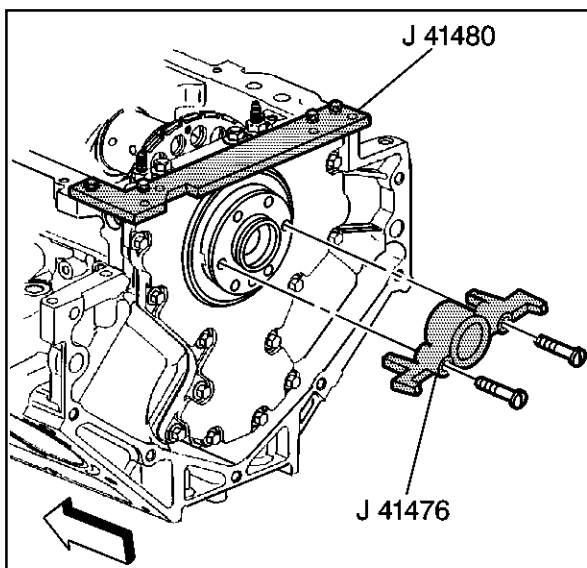
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Start the *J 41480* tool-to-rear cover bolts. Do not tighten the bolts at this time.

4. Install the *J 41480* and bolts.

Tighten

Tighten the tool-to-engine block bolts to 25 N·m (18 lb ft).



63243

Important: To properly align the rear cover, the *J 41476* must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface.

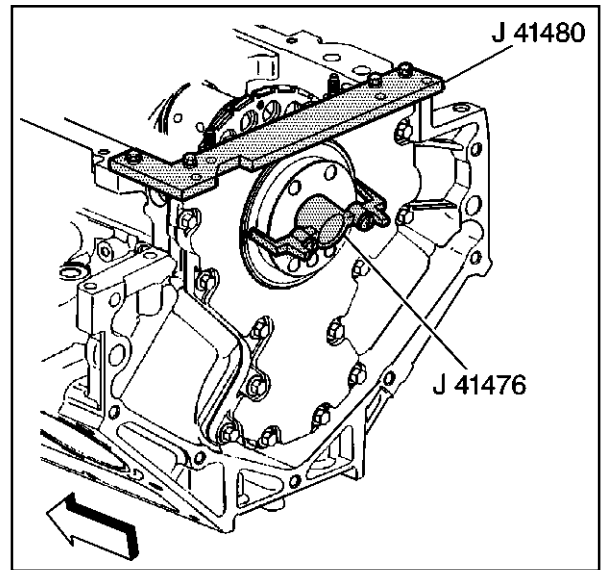
5. Rotate the crankshaft until two opposing flywheel bolt holes are parallel to the oil pan surface.

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

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

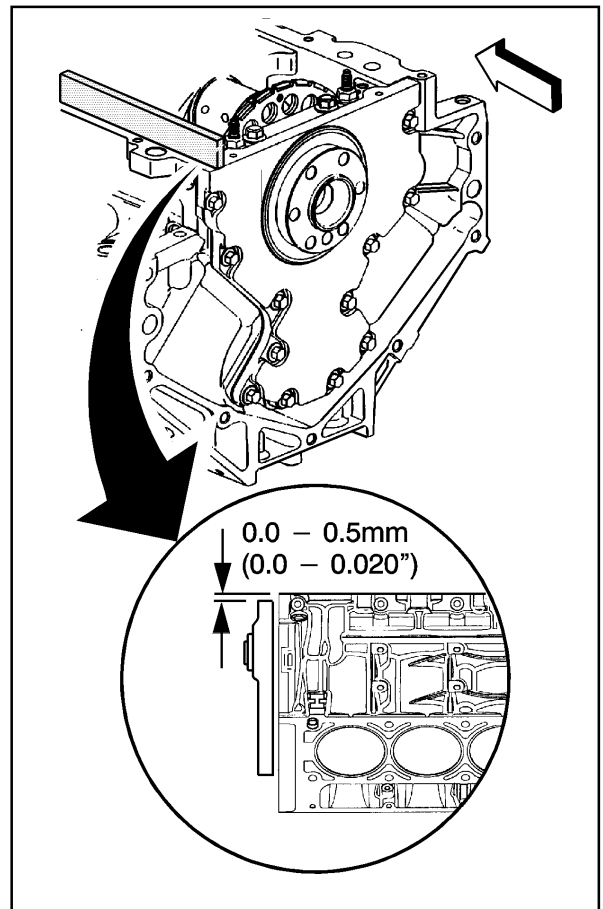
Tighten

- 6.1. Tighten the tool mounting bolts until snug. Do not overtighten.
- 6.2. Tighten the *J 41480* tool-to-rear cover bolts evenly to 12 N·m (106 lb in).
- 6.3. Tighten the rear cover bolts to 25 N·m (18 lb ft).
7. Remove the tools.

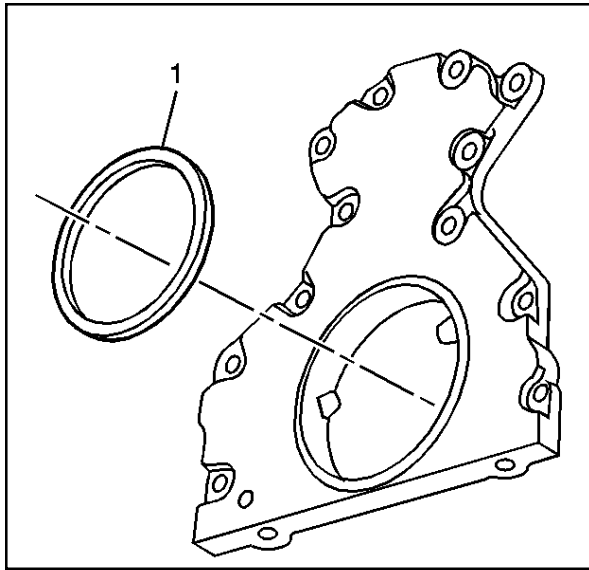


65286

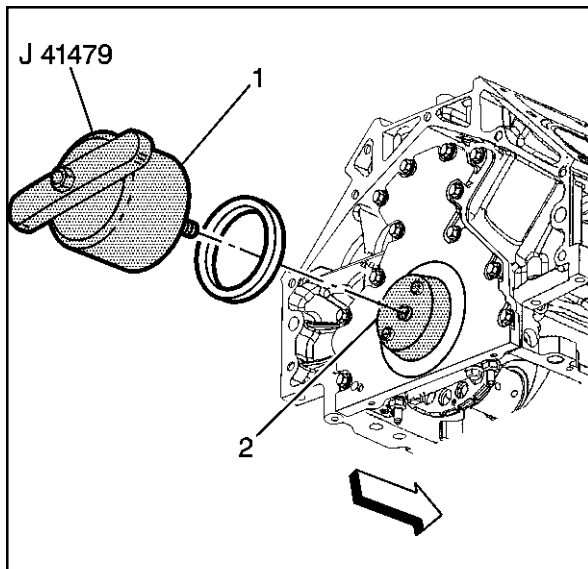
8. Measure the oil pan surface for flatness (rear cover-to-engine block).
 - 8.1. Place a straight edge onto the engine block and rear cover oil pan sealing surfaces. Avoid contact with the portion of the gasket that protrudes into the oil pan surface.
 - 8.2. Insert a feeler gauge between the rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
10. If the correct rear cover-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear cover.



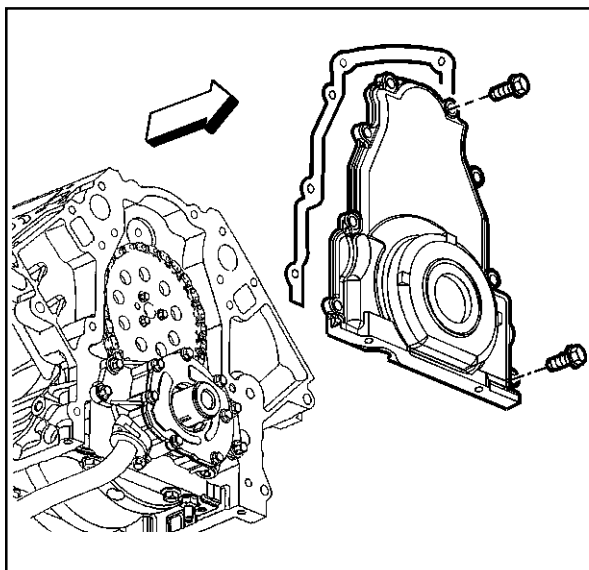
63240



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64278

Crankshaft Rear Oil Seal Installation

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer

Important:

- The flywheel spacer (if applicable) must be removed prior to oil seal installation.
 - Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.
 - Do not reuse the crankshaft rear oil seal.
1. Lubricate the outside diameter (OD) of the oil seal (1) with clean engine oil.
DO NOT allow oil or other lubricants to contact the seal surface.
 2. Lubricate the rear cover oil seal bore with clean engine oil.
DO NOT allow oil other lubricants to contact the crankshaft surface.
 3. Install the *J 41479* cone (2) and bolts onto the rear of the crankshaft.
 4. Tighten the bolts until snug. Do not overtighten.
 5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
 6. Thread the *J 41479* threaded rod into the tapered cone until the tool (1) contacts the oil seal.
 7. Align the oil seal onto the tool (1).
 8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
 9. Remove the tool.

Engine Front Cover Installation

Tools Required

J 41480 Front/Rear Cover Alignment (Oil Pan Surface)

J 41476 Front/Rear Cover Alignment (Crankshaft Oil Seal Area)

Important:

- Do not reuse the crankshaft oil seal or the engine front cover gasket.
- Do not apply any type sealant to the front cover gasket (unless specified).
- The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.

- All gasket surfaces should be free of oil or other foreign material during assembly.
 - The crankshaft front oil seal MUST be centered in relation to the crankshaft.
 - The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.
 - An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.
1. Install the front cover gasket, cover and bolts onto the engine.
 2. Tighten the cover bolts finger tight. Do not overtighten.

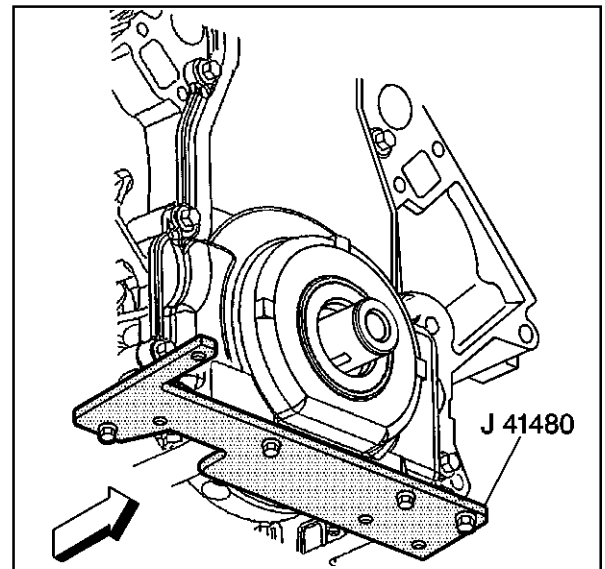
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

3. Install the *J 41480*.

Tighten

Tighten the tool-to-engine block bolts to 25 N·m (18 lb ft).



63182

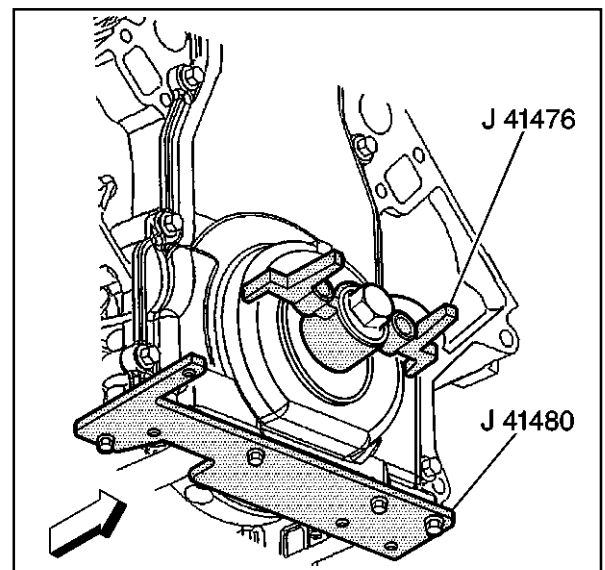
Important: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

4. Install the *J 41476*.
5. Install the crankshaft balancer bolt.

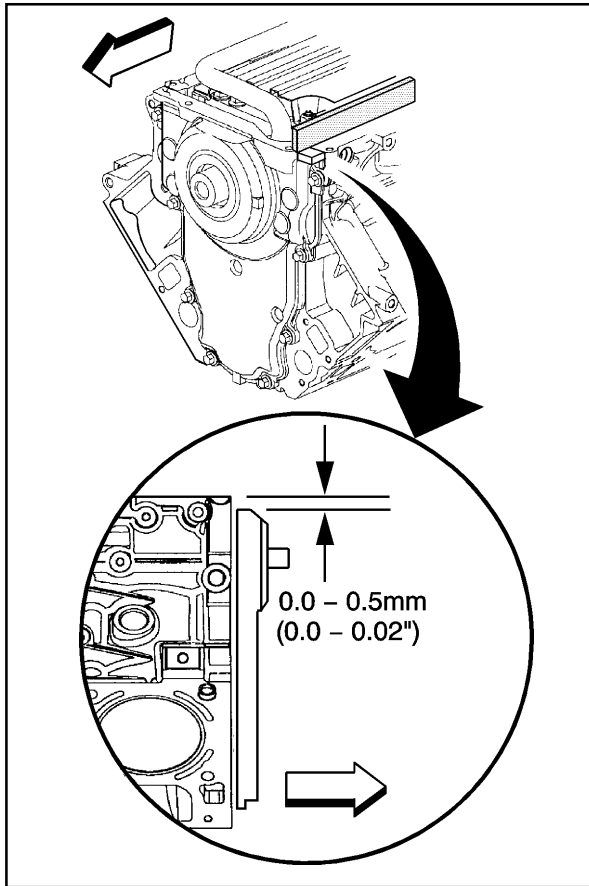
Tighten

- 5.1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
- 5.2. Tighten the *J 41480*.
- 5.3. Tighten the engine front cover bolts to 25 N·m (18 lb ft).

6. Remove the tools.

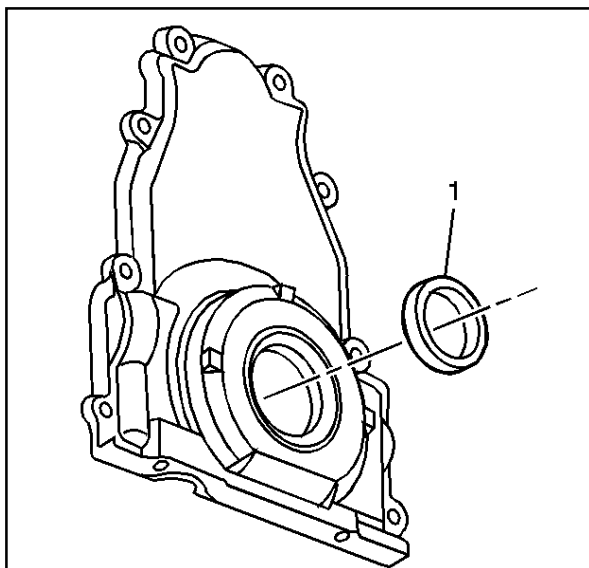


63185



63242

7. Measure the oil pan surface flatness (front cover-to-engine block).
 - 7.1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.
Avoid contact with the portion of the gasket that protrudes into the oil pan surface.
 - 7.2. Insert a feeler gauge between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no more than 0.5 mm (0.02 in) below flush.
8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.



490689

Crankshaft Front Cover Oil Seal Installation

Tools Required

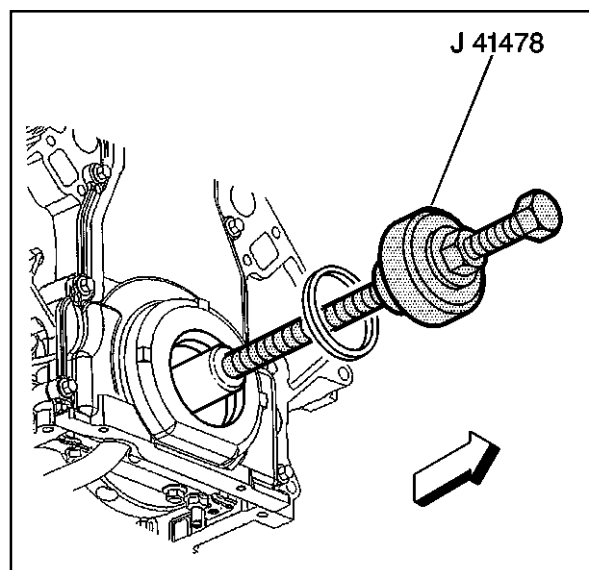
J 41478 Crankshaft Front Oil Seal Installer

Important: Do not lubricate the oil seal sealing surface.

Do not reuse the crankshaft front oil seal.

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

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



63177

Oil Pan Installation

Important:

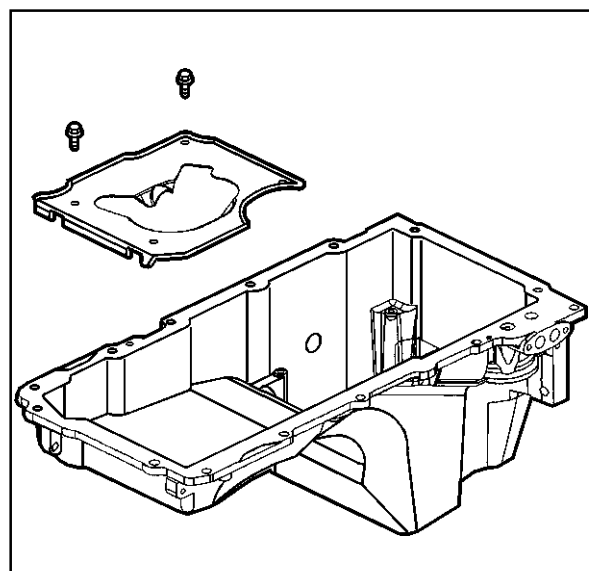
- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.
- Do not reuse the oil pan gasket.
- It is not necessary to rivet the NEW gasket to the oil pan.
- It is not necessary to remove the oil level sensor (if applicable) prior to oil pan installation.

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

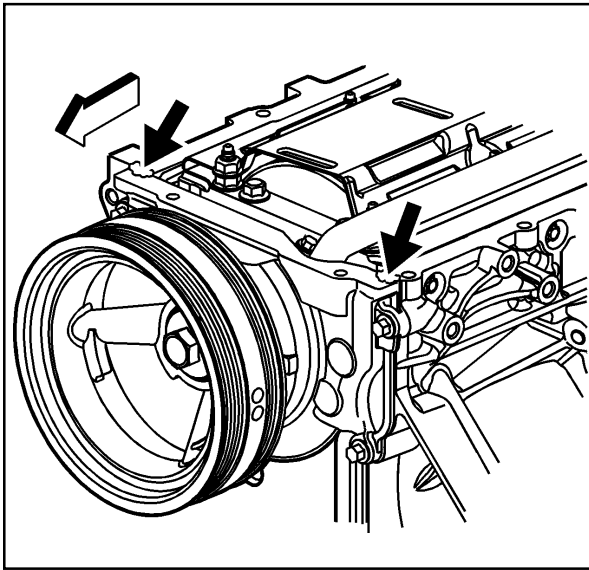
1. Install the oil pan baffle and bolts (if previously removed).

Tighten

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

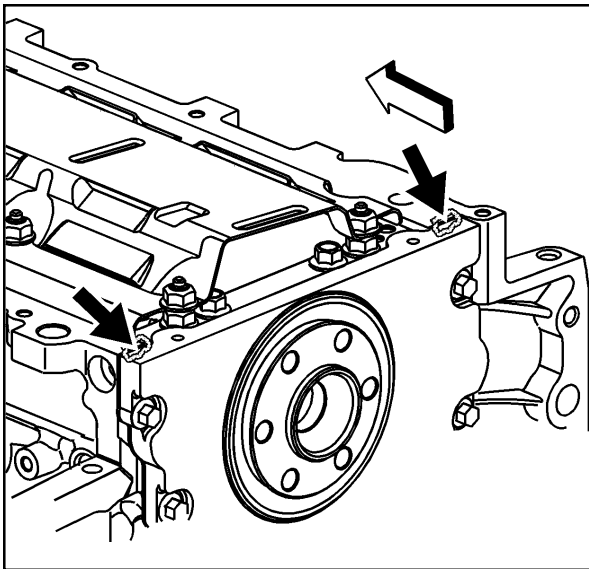


260180



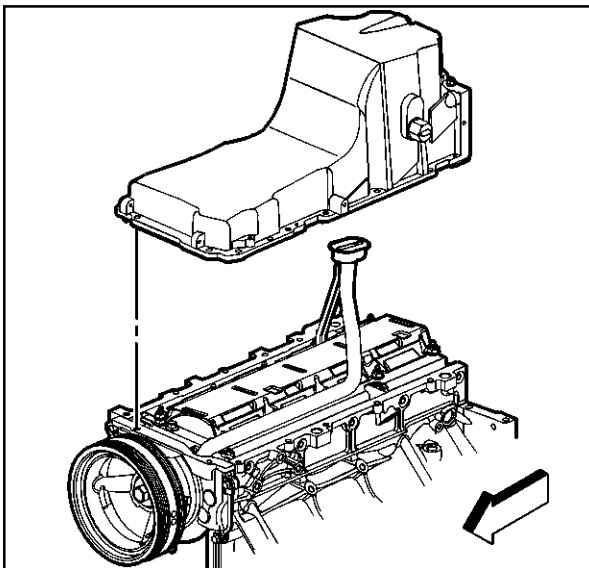
260107

2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to *Sealers, Adhesives and Lubricants*.



63175

3. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrude into the oil pan surface. Refer to *Sealers, Adhesives and Lubricants*.



260108

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

4. Pre-assemble the oil pan gasket to the pan.
 - 4.1. Install the gasket onto the oil pan.
 - 4.2. Install the oil pan bolts to the pan and through the gasket.
5. Install the oil pan, gasket and bolts to the engine block.
6. Tighten bolts finger tight. Do not overtighten.
7. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

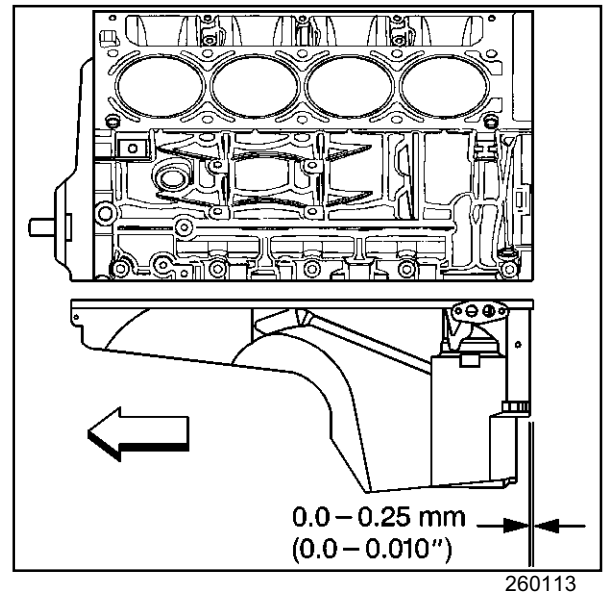
8. Align the oil pan until the rear of the engine block and rear of the oil pan are flush or even.

Tighten

- 8.1. Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N·m (19 lb ft).
 - 8.2. Tighten the oil pan-to-rear cover bolts to 12 N·m (106 lb in).
9. Measure the oil pan-to-engine block alignment.
 - 9.1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

Important: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

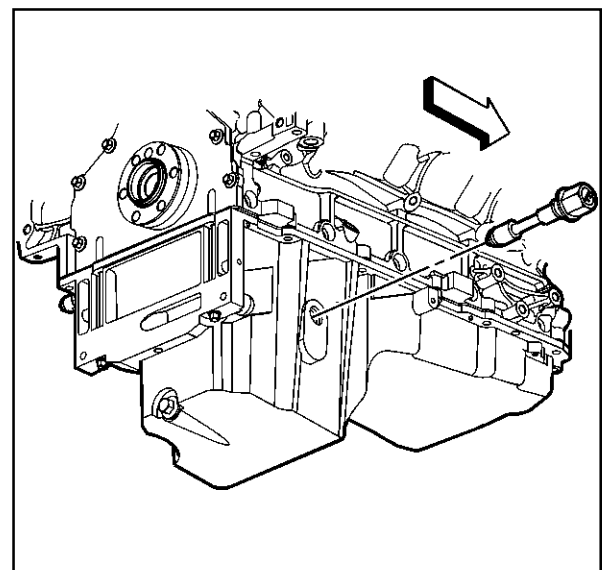
- 9.2. Insert a feeler gauge between the straight edge and the oil pan transmission housing mounting surface and check to make sure that there is no more than a 0.25 mm (0.01 in) gap between the pan and straight edge.
- 9.3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

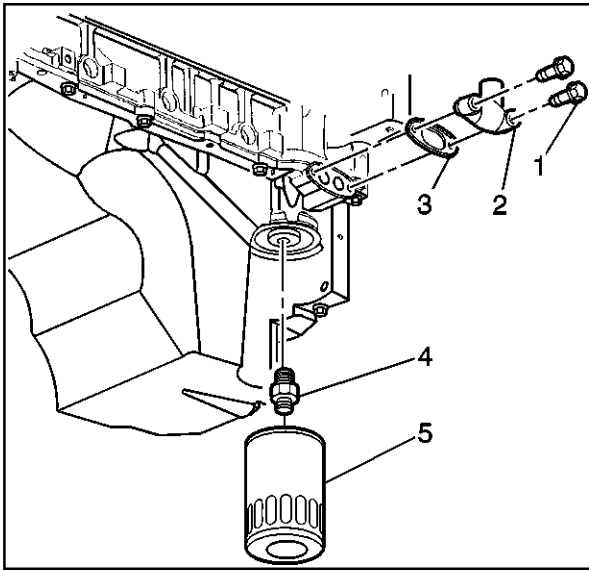


10. Install the oil level sensor (if applicable).

Tighten

Tighten the oil level sensor (if applicable) to 13 N·m (115 lb in).





260125

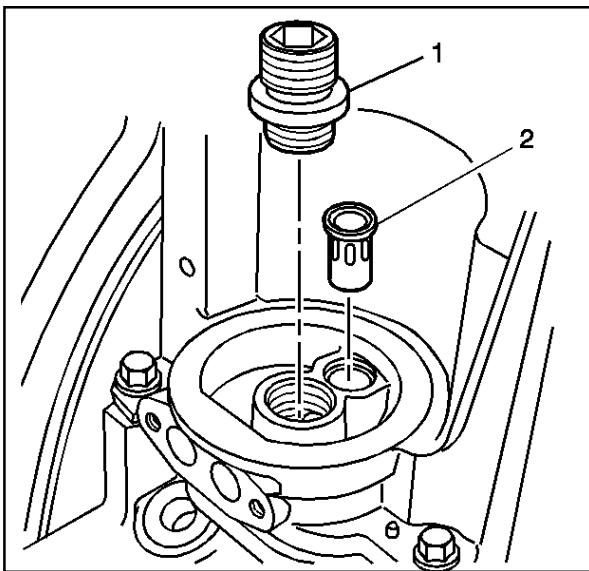
Oil Filter, Adapter and Pan Cover Installation

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

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

Tighten

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

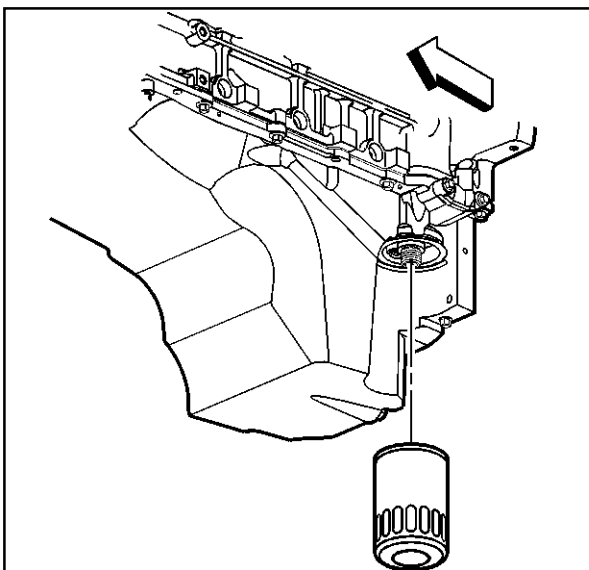


490699

2. Install a new oil filter bypass valve (2) into the oil pan (if required).
3. Install the oil filter fitting (1).

Tighten

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



260117

4. Lubricate the oil filter seal with clean engine oil.
5. Install the oil filter.

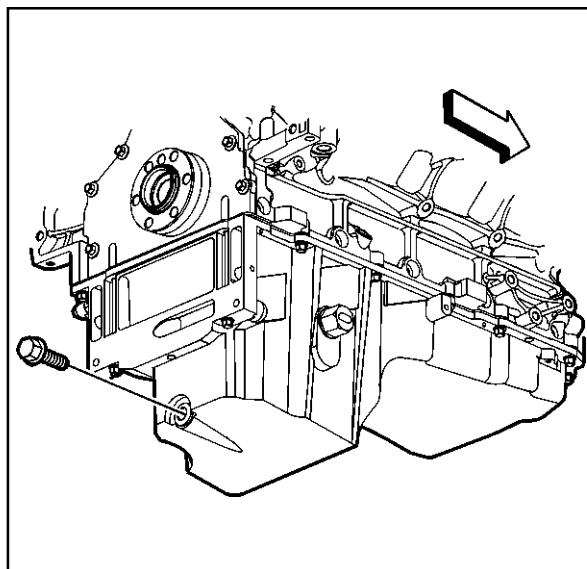
Tighten

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

6. Install the oil pan drain plug.

Tighten

Tighten the oil pan drain plug to 25 N·m (18 lb ft).



260111

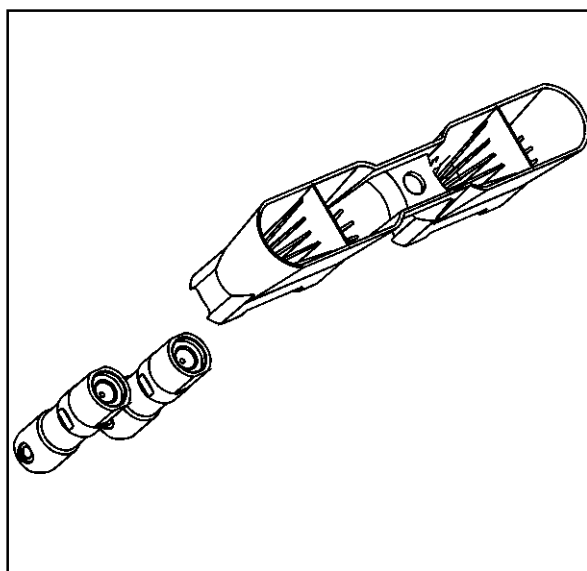
Valve Lifter Installation

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

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

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

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



63233

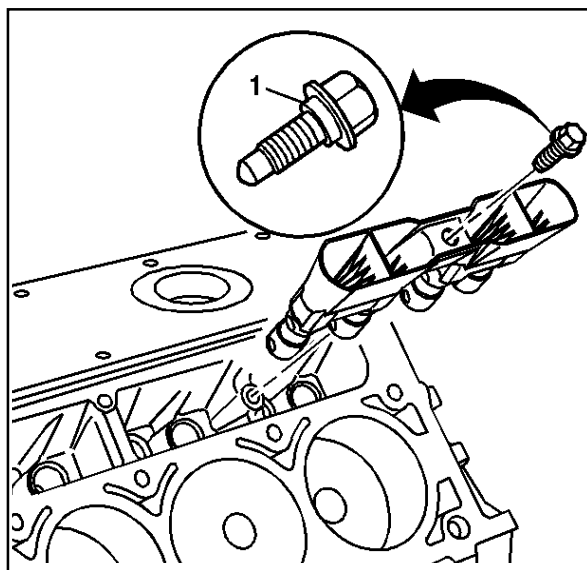
3. Install the valve lifters and guide assembly to the engine block.

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

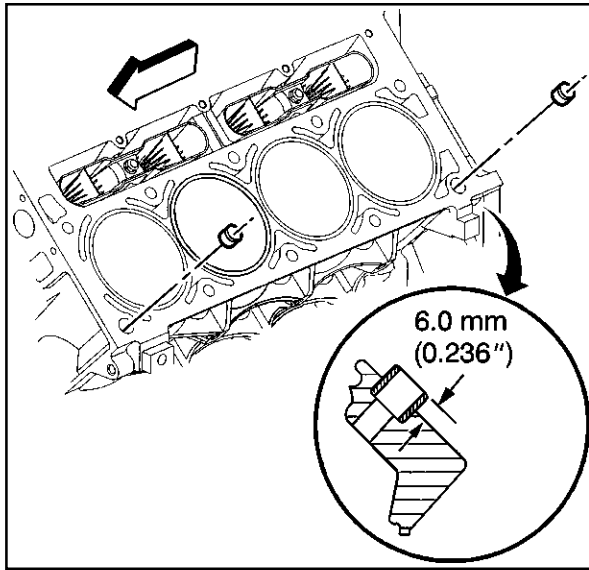
4. Install the valve lifter guide bolt (1).

Tighten

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



63230



63235

Cylinder Head Installation (Left Side)

Tools Required

J 36660 Torque Angle Meter

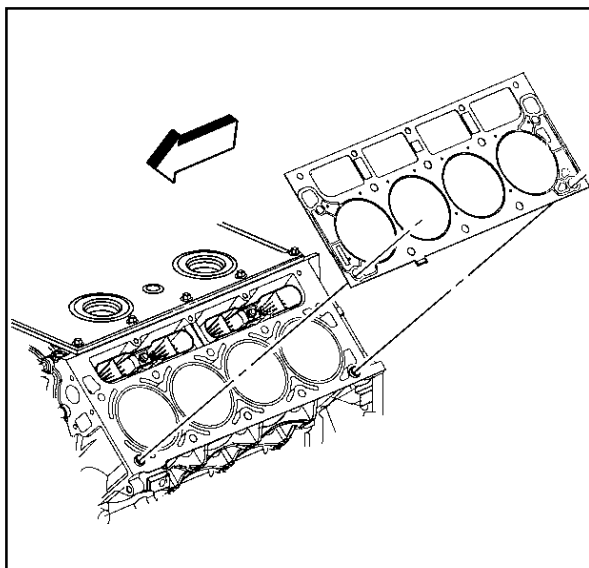
J 42385-100 Thread Repair Kit

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

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

Important:

- Do not reuse the M11 cylinder head bolts. Install NEW M11 cylinder head bolts during assembly.
 - Do not use any type of sealant on the cylinder head gasket (unless specified).
 - The cylinder head gaskets must be installed in the proper direction and position.
1. Clean the engine block cylinder head bolt holes (if required).
Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.
 2. Spray cleaner GM P/N 12346139, P/N 12377981 or equivalent, into the hole.
 3. Clean the cylinder head bolt holes with compressed air.
 4. Check the cylinder head locating pins for proper installation.

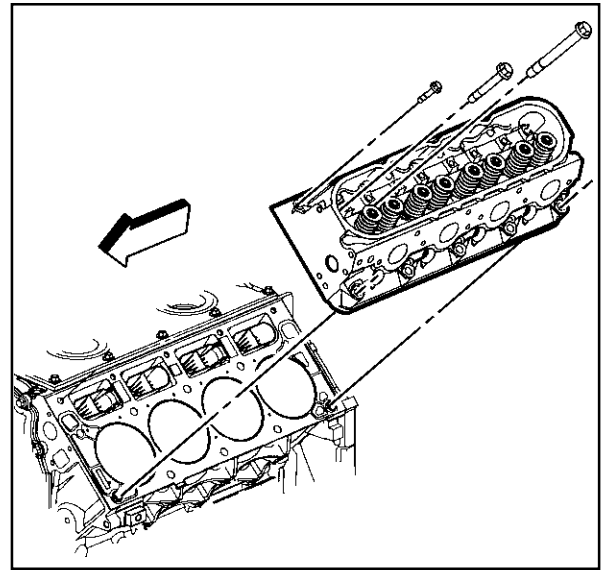


63169

Important: When properly installed, the tab on the left cylinder head gasket will be located left of center or closer to the front of the engine.

5. Install the NEW left cylinder head gasket onto the locating pins.

6. Install the cylinder head onto the locating pins and the gasket.
7. Install the NEW M11 cylinder head bolts.
8. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the M8 cylinder head bolts. Refer to *Sealers, Adhesives and Lubricants*.
9. Install the M8 cylinder head bolts.



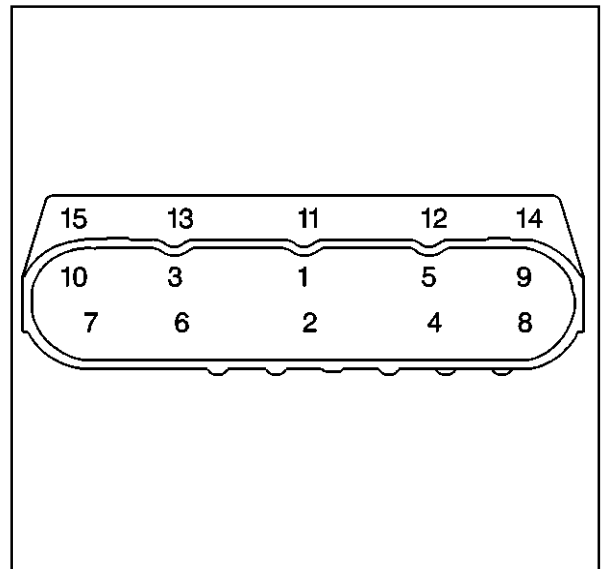
260146

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

10. Tighten the cylinder head bolts.

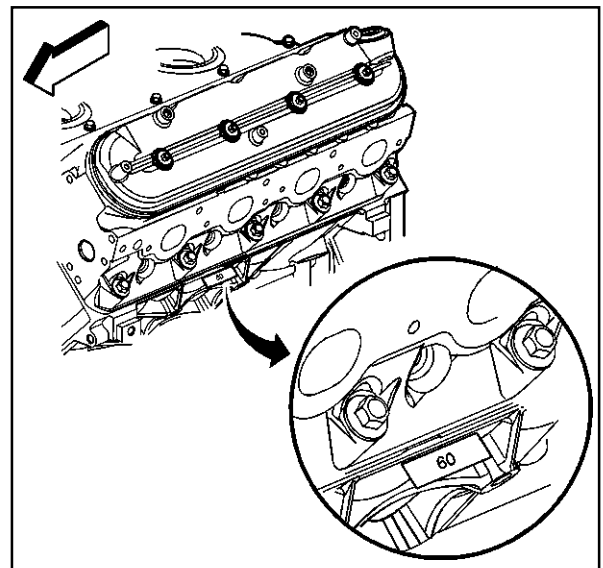
Tighten

- 10.1. Tighten the M11 cylinder head bolts a first pass in sequence to 30 N·m (22 lb ft).
- 10.2. Tighten the M11 cylinder head bolts a second pass in sequence to 90 degrees using the *J 36660-A*.
- 10.3. Tighten the M11 cylinder head bolts (1-8) to 90 degrees and the M11 cylinder head bolts (9 and 10) to 50 degrees a final pass in sequence using the *J 36660-A*.
- 10.4. Tighten the M8 cylinder head bolts (11-15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

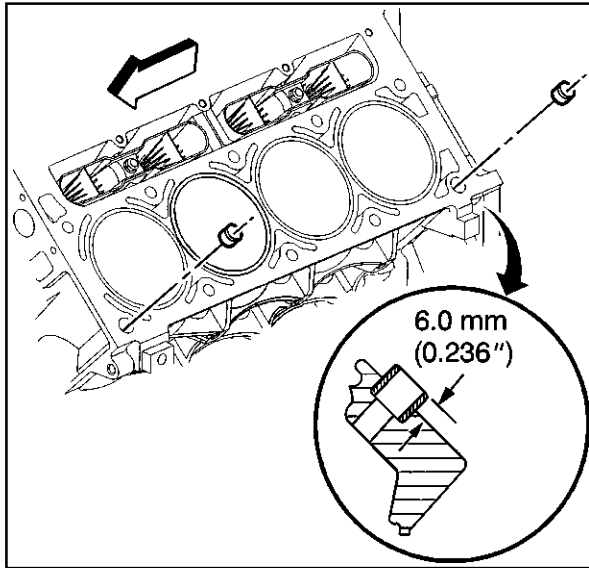


260150

11. The cylinder head gasket displacement can be verified by markings visible on the top side of the left gasket locating tab. Some 6.0L head gaskets may have 60 stamped onto the locating tab.



384697



63235

Cylinder Head Installation (Right Side)

Tools Required

J 36660 Torque Angle Meter

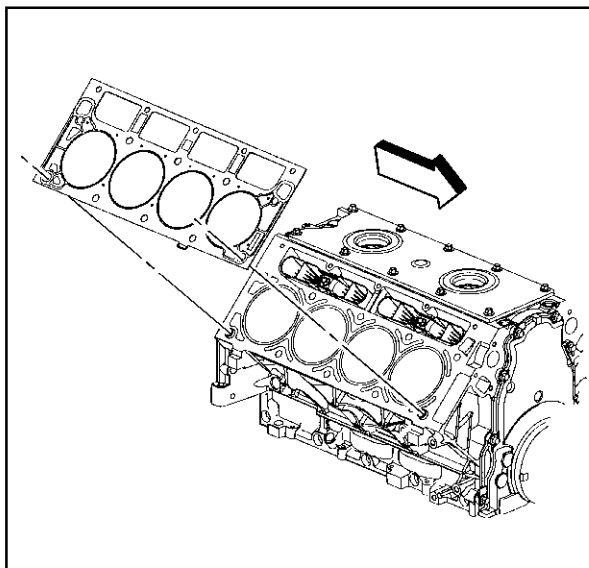
J 42385-100 Thread Repair Kit

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

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

Important:

- Do not reuse the M11 cylinder head bolts. Install NEW M11 cylinder head bolts during assembly.
 - Do not use any type of sealant on the cylinder head gasket (unless specified).
 - The cylinder head gaskets must be installed in the proper direction and position.
1. Clean the engine block cylinder head bolt holes (if required).
Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.
 2. Spray cleaner GM P/N 12346139, P/N 12377981 or equivalent, into the hole.
 3. Clean the cylinder head bolt holes with compressed air.
 4. Check the cylinder head locating pins for proper installation.

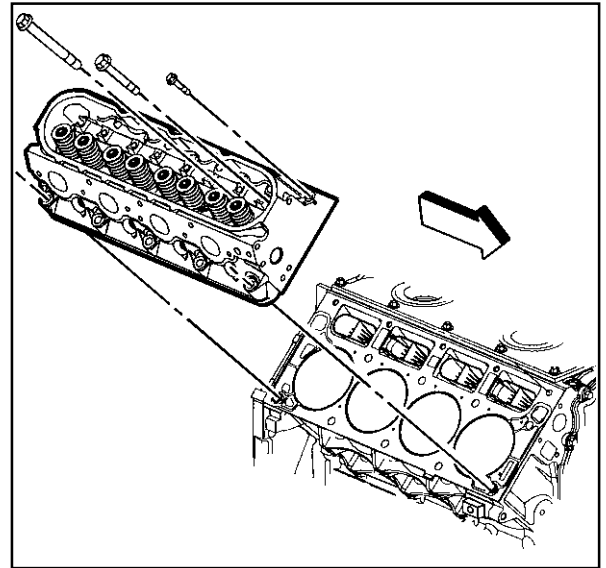


63170

Important: When properly installed, the tab on the left cylinder head gasket will be located left of center or closer to the front of the engine.

5. Install the NEW left cylinder head gasket onto the locating pins.

6. Install the cylinder head onto the locating pins and the gasket.
7. Install the NEW M11 cylinder head bolts.
8. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the M8 cylinder head bolts. Refer to *Sealers, Adhesives and Lubricants*.
9. Install the M8 cylinder head bolts.



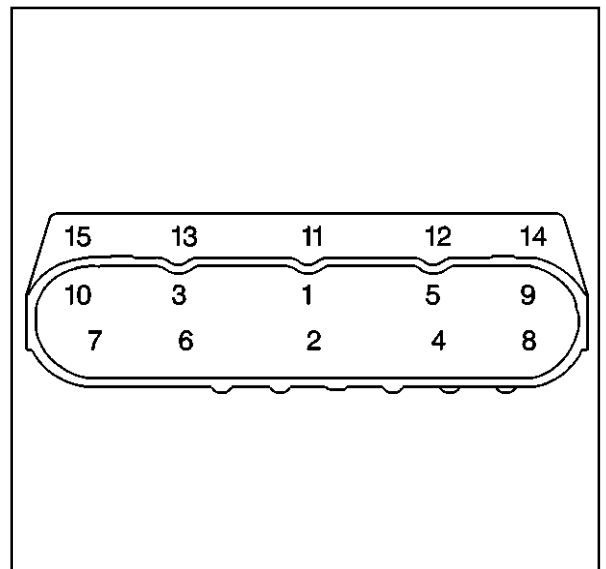
260149

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

10. Tighten the cylinder head bolts.

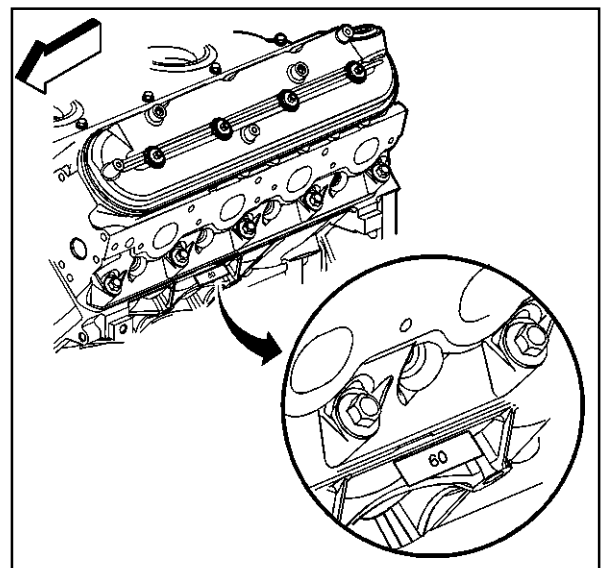
Tighten

- 10.1. Tighten the M11 cylinder head bolts a first pass in sequence to 30 N·m (22 lb ft).
- 10.2. Tighten the M11 cylinder head bolts a second pass in sequence to 90 degrees using the *J 36660-A*.
- 10.3. Tighten the M11 cylinder head bolts (1-8) to 90 degrees and the M11 cylinder head bolts (9 and 10) to 50 degrees a final pass in sequence using the *J 36660-A*.
- 10.4. Tighten the M8 cylinder head bolts (11-15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

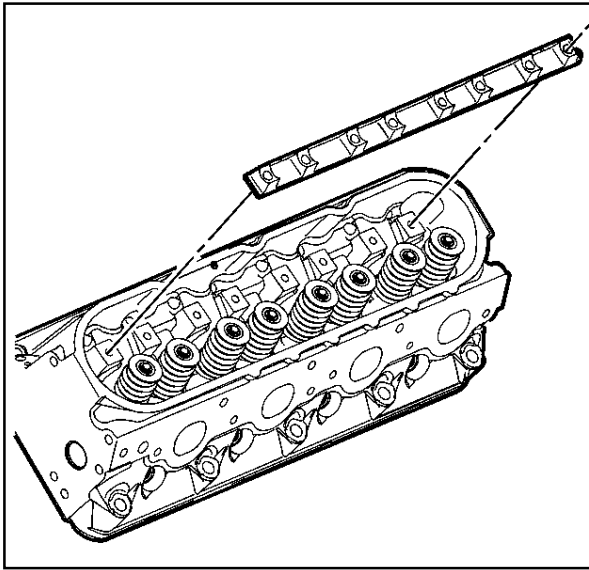


260150

11. The cylinder head gasket displacement can be verified by markings visible on the top side of the left gasket locating tab. Some 6.0L head gaskets may have 60 stamped onto the locating tab.



384697



260141

Valve Rocker Arm and Push Rod Installation

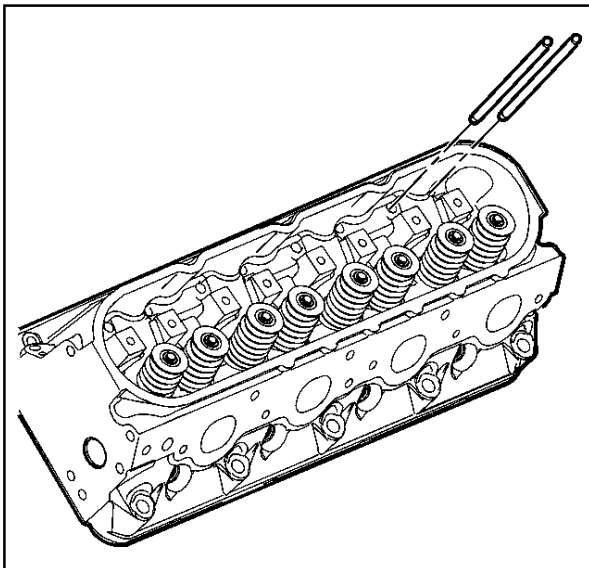
Important: When reusing the valve train components, always install the components to the original location and position.

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

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

Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.

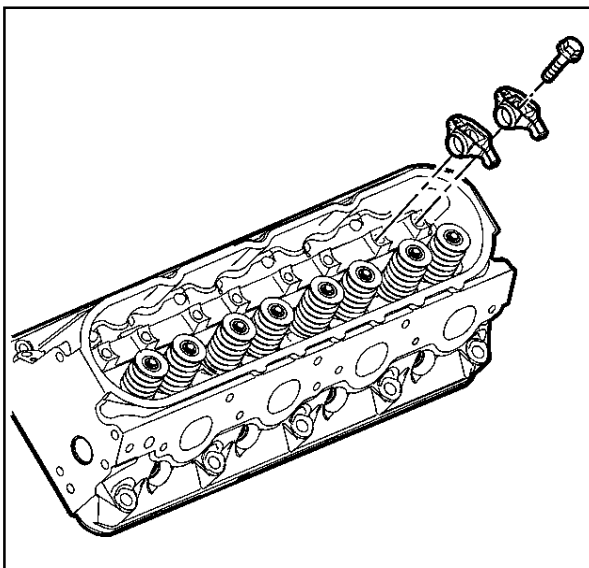
3. Install the valve rocker arm pivot support.



260142

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

4. Install the pushrods.



260140

Important: Make sure that the pushrods seat properly to the ends of the rocker arms.

DO NOT tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.

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

In this position, cylinder number one rocker arms will be off lobe lift, and crankshaft sprocket key will be at the 1:30 position. If viewing from the rear of the engine, the additional crankshaft pilot hole (non-threaded) will be in the 10:30 position.

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

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

Cylinders 2, 4, 6 and 8 are right bank.

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

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

Tighten

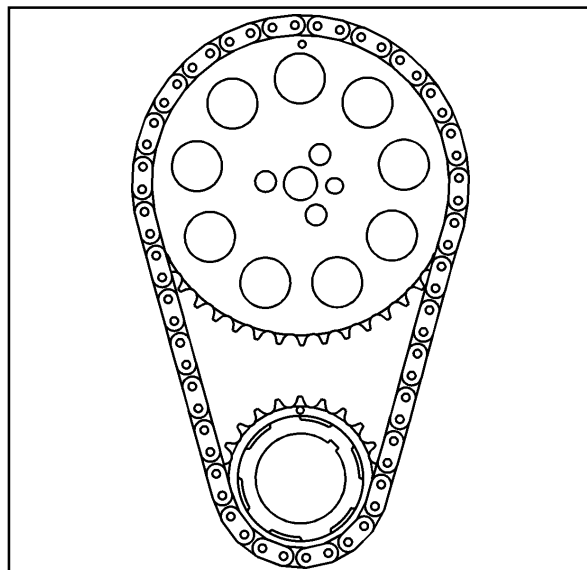
- Tighten exhaust valve rocker arm bolts 1, 2, 7 and 8 to 30 N·m (22 lb in).
- Tighten intake valve rocker arm bolts 1, 3, 4 and 5 to 30 N·m (22 lb ft)

8. Rotate the crankshaft 360 degrees.

Tighten the following valve rocker arm bolts:

Tighten

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

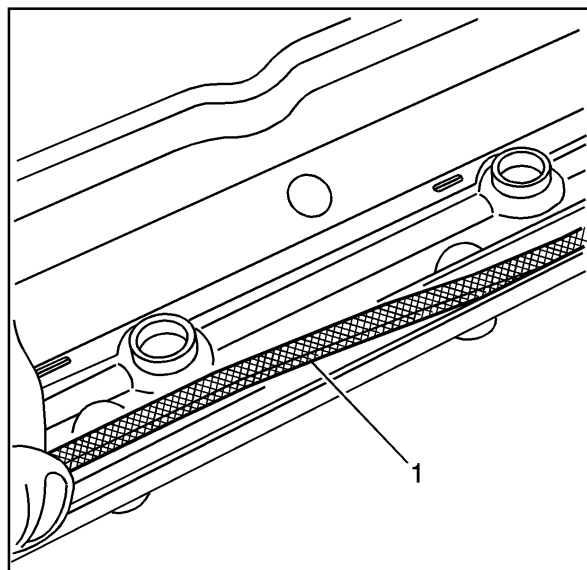


661566

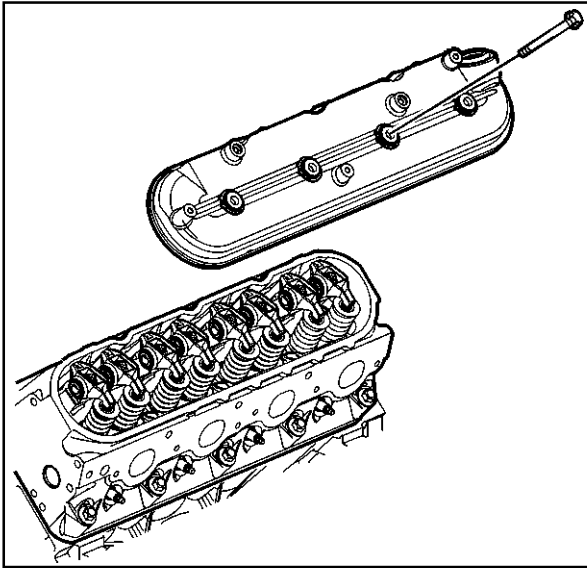
Valve Rocker Arm Cover Installation - Left

Important:

- All gasket surfaces should be free of oil or other foreign material during assembly.
 - DO NOT reuse the valve rocker arm cover gasket.
 - The valve rocker arm cover bolt grommets may be reused.
 - If the vapor vent grommet has been removed from the valve rocker arm cover, install a NEW vapor vent grommet during assembly.
1. Install NEW cover gasket (1) into the valve rocker arm cover.



490696



260085

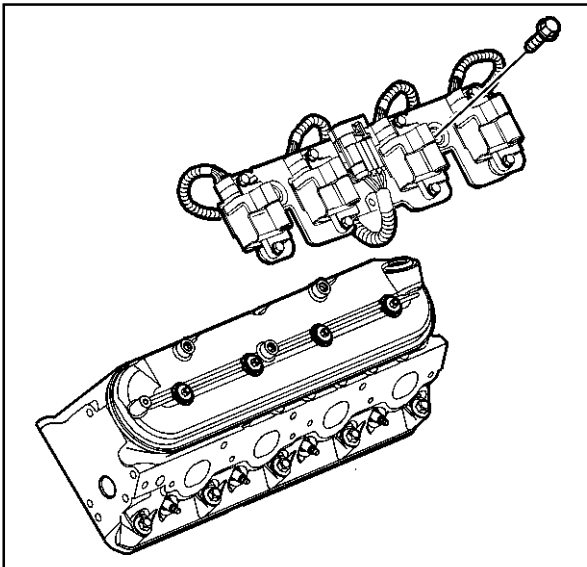
2. Install the valve rocker arm cover onto the cylinder head.

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

3. Install the cover bolts with grommets.

Tighten

Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).



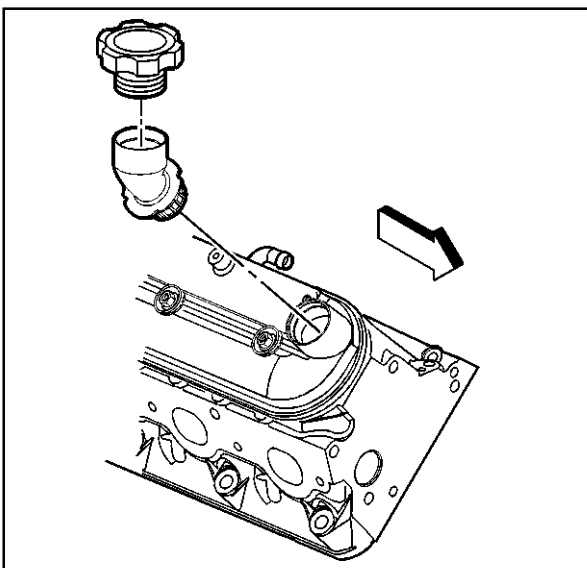
260083

4. Apply threadlock GM P/N 12345382 or equivalent to the threads of the bracket bolts.

5. Install the ignition coils and bracket assembly and bolts.

Tighten

Tighten the ignition coil and bracket assembly bolts to 12 N·m (106 lb in).



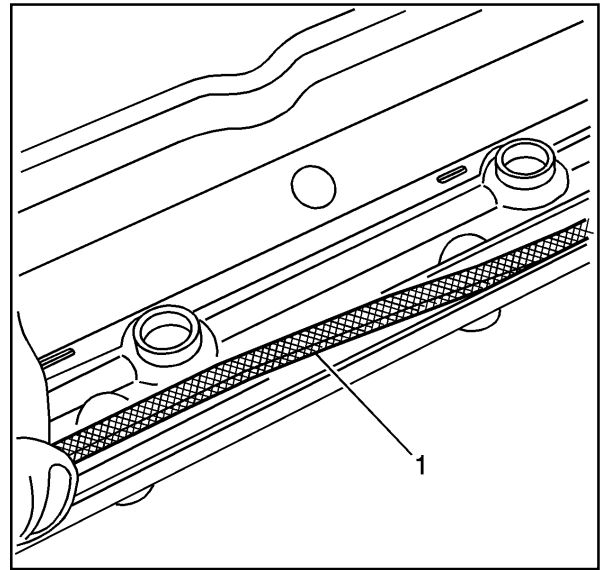
260110

Valve Rocker Arm Cover Installation - Right

Important:

- All gasket surfaces should be free of oil or other foreign material during assembly.
 - DO NOT reuse the valve rocker arm cover gasket.
 - Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.
 - The valve rocker arm cover bolt grommets may be reused.
 - If the oil fill tube has been removed from the valve rocker arm cover, install a NEW oil fill tube during assembly.
1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.

2. Insert the NEW oil fill tube into the rocker arm cover and rotate the tube clockwise until locked in the proper position.
3. Install the oil fill cap into the tube and rotate clockwise until locked in the proper position.
4. Install a NEW cover gasket (1) into the valve rocker arm cover.



490696

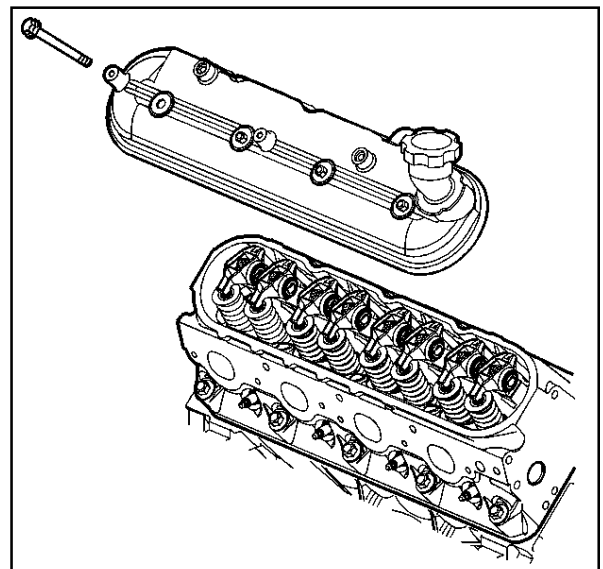
5. Install the valve rocker arm cover onto the cylinder head.

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

6. Install the cover bolts with grommets.

Tighten

Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).

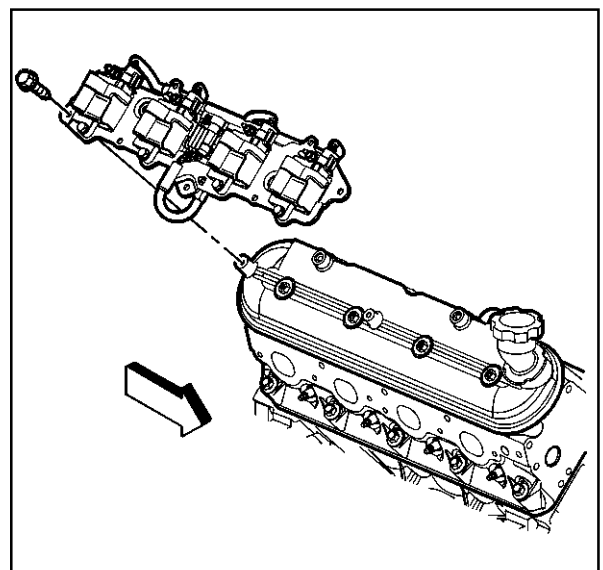


260084

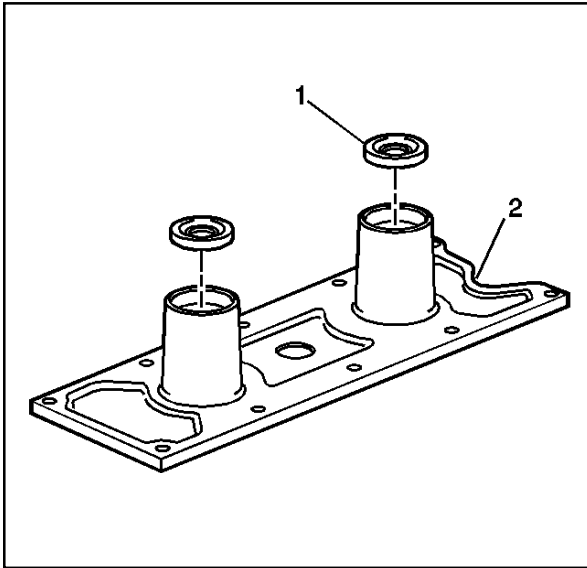
7. Apply threadlock GM P/N 12345382 or equivalent to the threads of the bracket bolts.
8. Install the ignition coil and bracket assembly and bolts.

Tighten

Tighten the ignition coil and bracket assembly bolts to 12 N·m (106 lb in).



260090



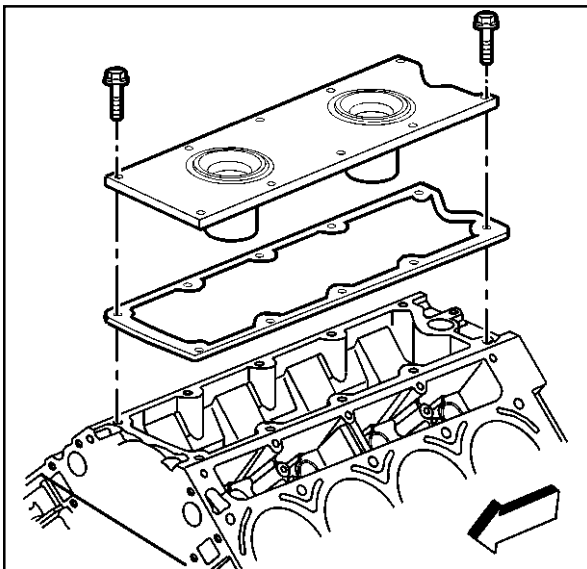
490851

Engine Valley Cover Installation

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

1. Install NEW knock sensor oil seals (1) into the valley cover (2).

Lubricate the seal surfaces with clean engine oil.



65048

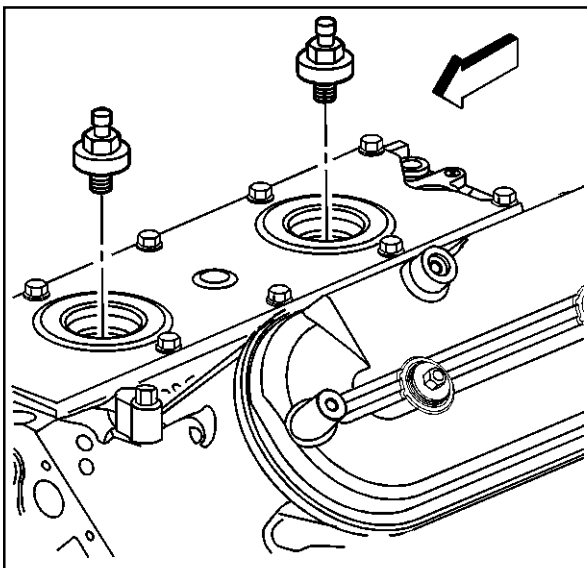
2. Install the valley cover and NEW gasket.

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

3. Install the valley cover bolts.

Tighten

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



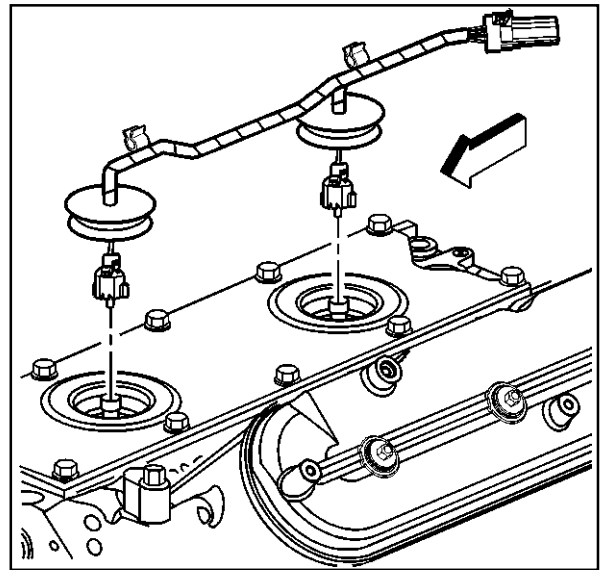
309864

4. Install the knock sensors.

Tighten

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

5. Install the knock sensor wire harness.



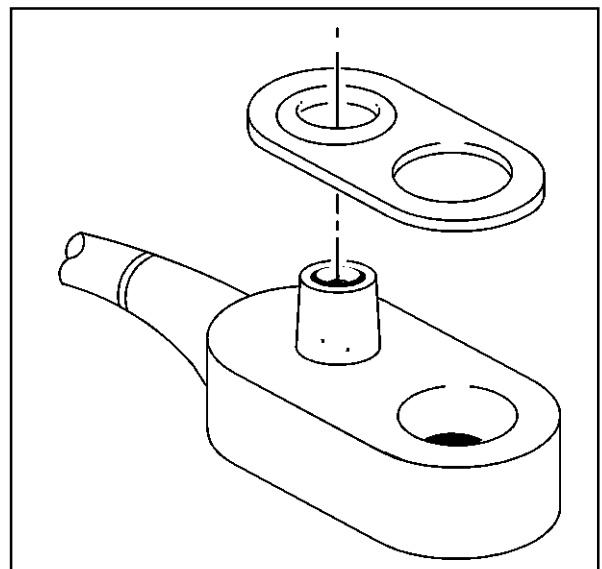
309859

Coolant Air Bleed Pipe Installation

Important: Install the pipe gaskets properly onto the pipe and covers.

Position the gasket O-ring seal onto the nipple portion of the pipe.

1. Install the gaskets onto the engine coolant air bleed pipe and covers.



64262

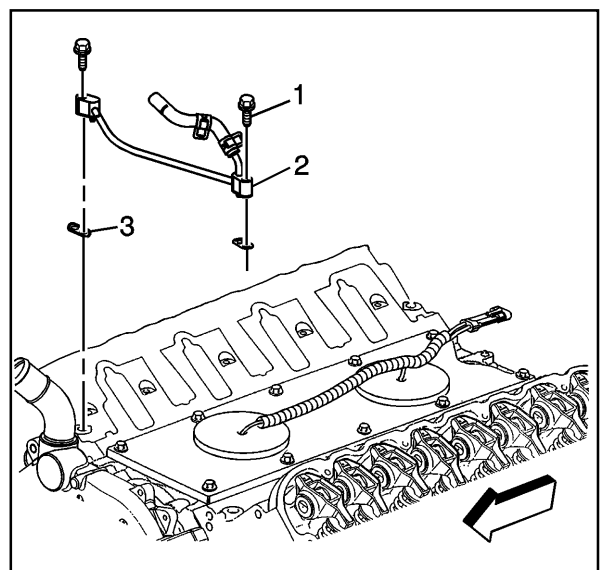
2. Install the pipe (2) and gaskets (3) onto the cylinder heads.

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

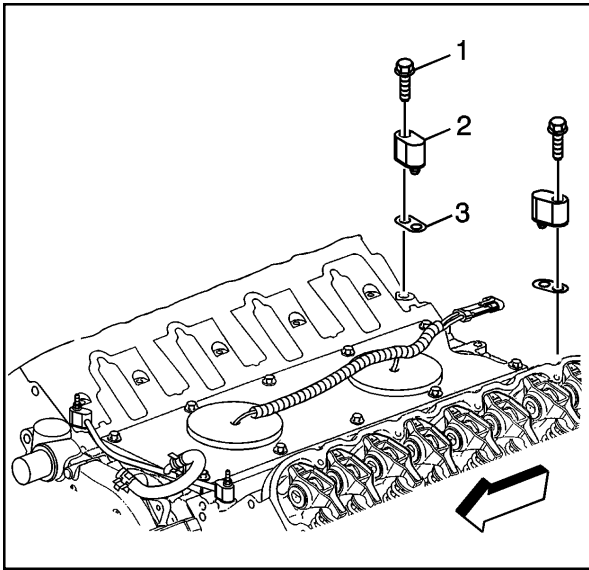
3. Install the pipe bolts (1).
Install the two pipe studs to the front of the engine.

Tighten

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



741555

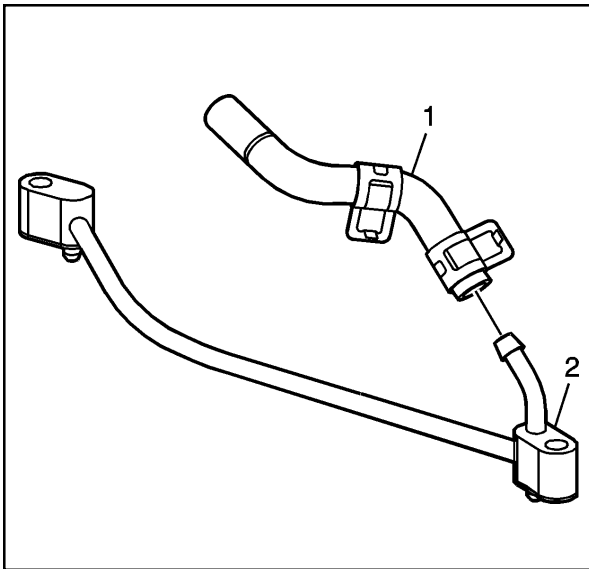


639609

4. Install the covers (2), gaskets (3) and bolts (1) onto the rear of the engine.

Tighten

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



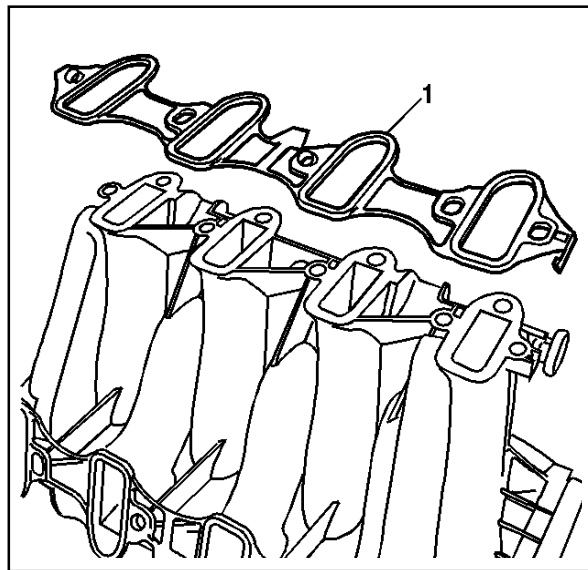
790766

5. Install the hose and clamp (1) onto the pipe (2).

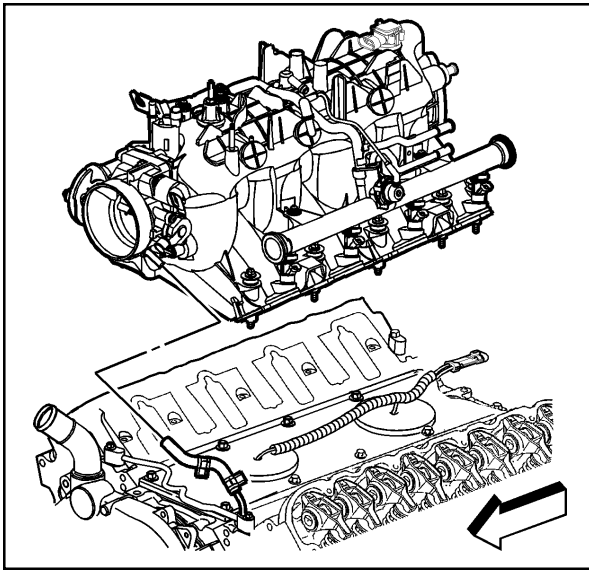
Intake Manifold Installation

Important:

- The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.
 - DO NOT reuse intake manifold gaskets. Install NEW intake manifold-to-cylinder head gaskets.
1. Install NEW intake manifold-to-cylinder head gaskets (1).

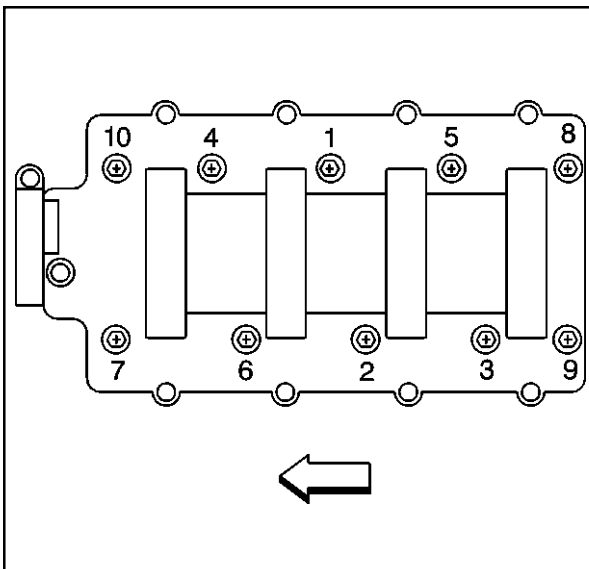


492770



642285

2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the intake manifold bolts. Refer to *Sealers, Adhesives and Lubricants*.



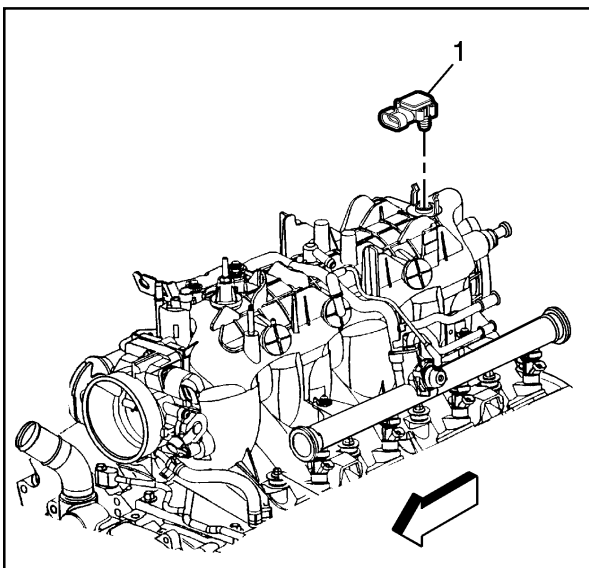
63222

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

4. Install the intake manifold.

Tighten

- Tighten the intake manifold bolts first pass in sequence to 5 N·m (44 lb in).
- Tighten the intake manifold bolts final pass in sequence to 10 N·m (89 lb in).

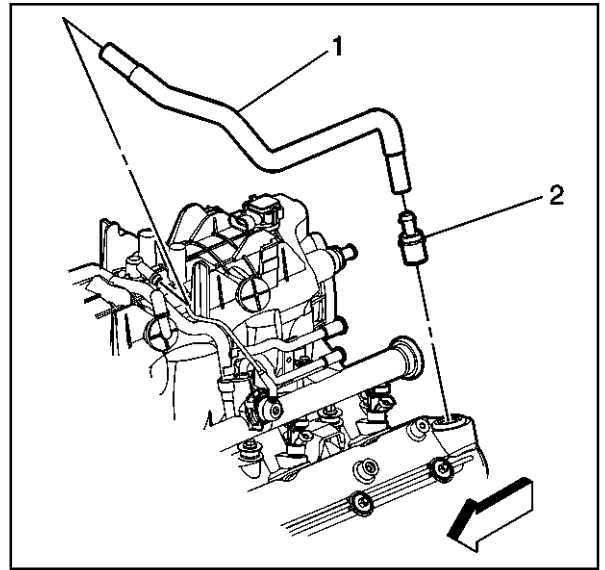


260159

5. Install the Manifold Absolute Pressure (MAP) sensor (1), if previously removed.

The electrical connector end of the sensor should be facing the front of the engine.

6. Install the Positive Crankcase Ventilation (PCV) valve (2) and hose (1).
7. Install the engine coolant air bleed hose and clamp onto the throttle body.

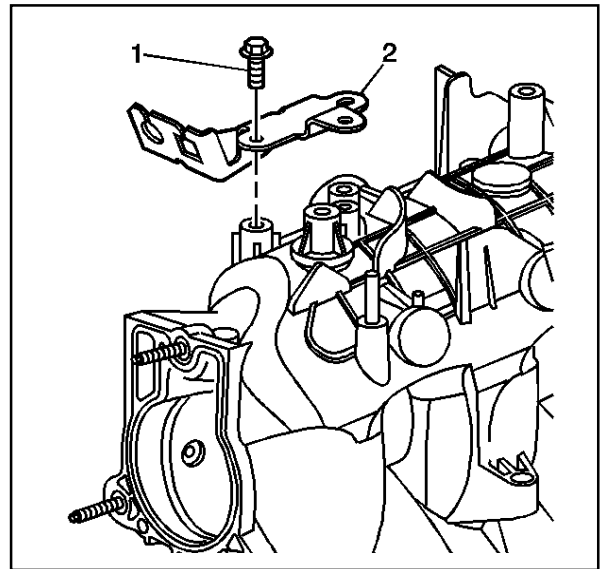


260078

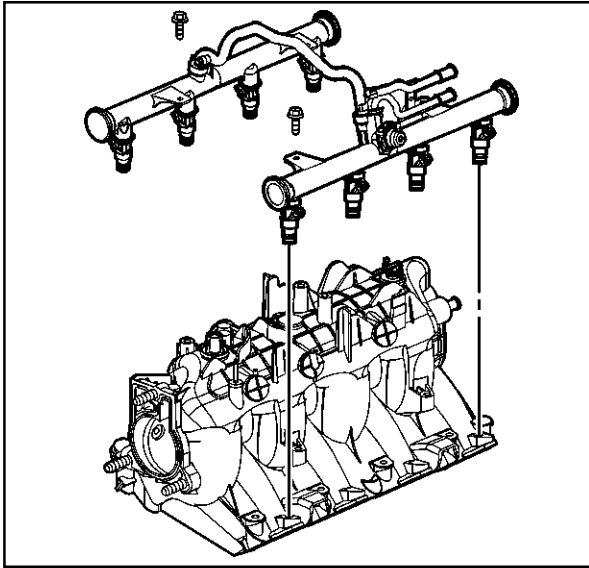
8. Install the accelerator control cable bracket (2) and bolts (1), if applicable.

Tighten

Tighten the accelerator control cable bracket bolts to 10 N·m (89 lb in).



492765



260176

Fuel Rail and Injectors Installation

Caution: The fuel rail stop bracket must be installed onto the engine assembly. The stop bracket serves as a protective shield for the fuel rail in the event of a vehicle frontal crash. If the fuel rail stop bracket is not installed and the vehicle is involved in a frontal crash, fuel could be sprayed possibly causing a fire and personal injury from burns.

Important: DO NOT reuse fuel injector O-ring seals. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals with clean engine oil.
2. Install the O-ring seals onto the fuel injectors.
3. Install a new O-ring seal to the right side of the crossover tube.
4. Assemble the crossover tube and bolt to the right fuel rail.
5. Install the fuel rail (with fuel injectors) into the intake manifold.

Press evenly on both sides of the fuel rail until all of the injectors are seated in their bores.

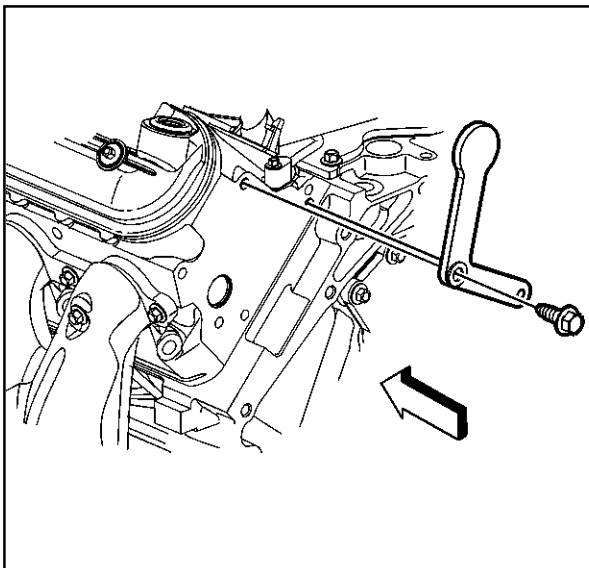
6. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the fuel rail bolts. Refer to *Sealers, Adhesives and Lubricants*.

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

7. Install the fuel rail bolts.

Tighten

- Tighten the fuel rail bolts to 10 N·m (89 lb in).
- Tighten the crossover tube right side retaining bolt to 3.8 N·m (34 lb in).



260098

8. Install the fuel rail stop bracket and bolt.

Tighten

Tighten the fuel rail stop bracket bolt to 50 N·m (37 lb ft).

Throttle Body Installation

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

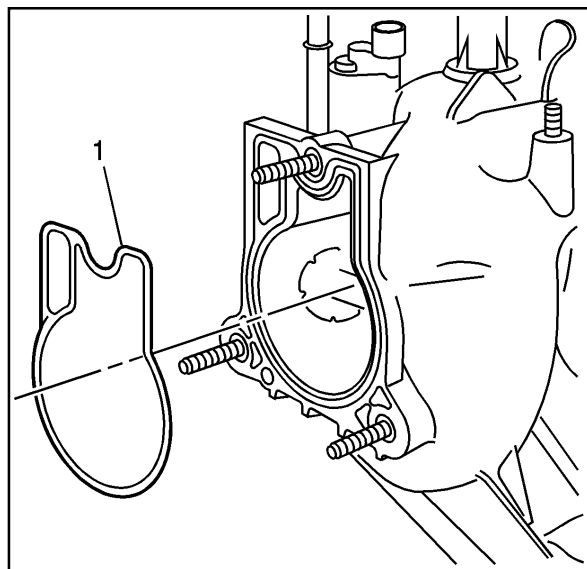
1. Install the throttle body studs, if required.

Tighten

Tighten the throttle body studs to 6 N·m (53 lb in).

Important: DO NOT reuse the throttle body gasket. Install a NEW throttle body gasket during assembly.

2. Install the throttle body gasket (1) to the intake manifold.



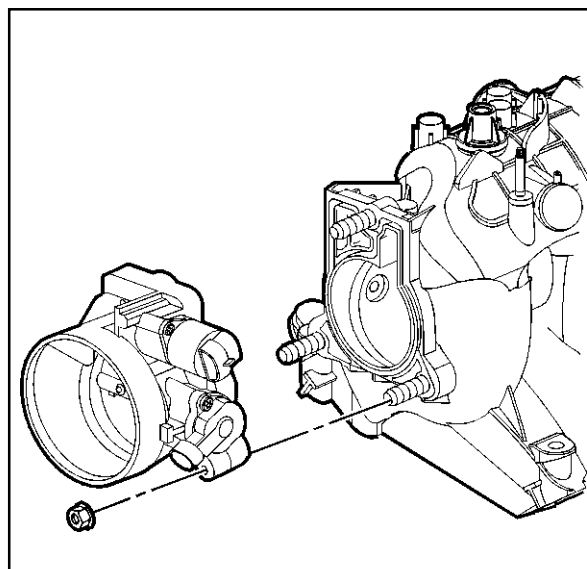
492774

3. Install the throttle body and nuts.

Tighten

Tighten the throttle body nuts to 10 N·m (89 lb in).

4. Install the engine coolant air bleed hose and clamp to the throttle body.



260174

Water Pump Installation

Notice: DO NOT use cooling system seal tabs (or similar compounds) unless otherwise instructed. The use of cooling system seal tabs (or similar compounds) may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

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

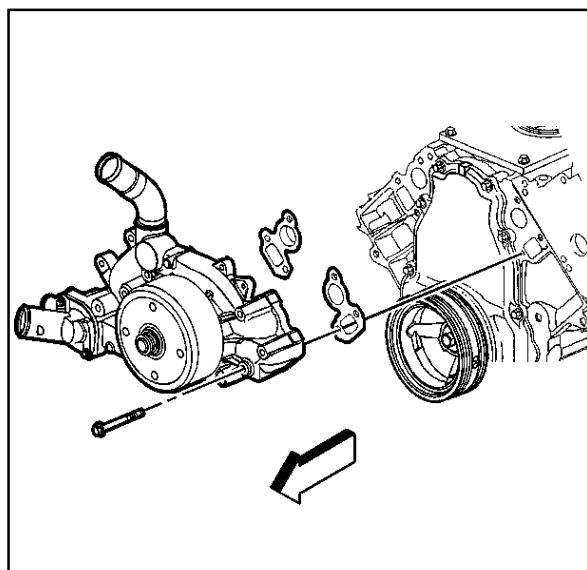
1. Install the water pump and NEW gaskets.

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

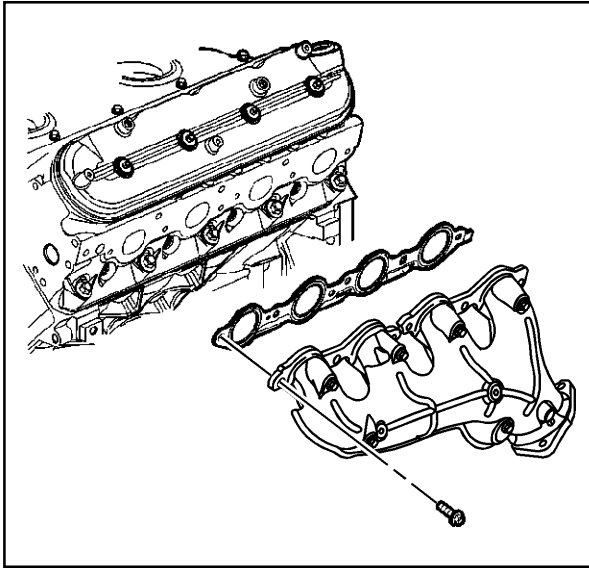
2. Install the water pump bolts.

Tighten

- Tighten the water pump bolts first pass to 15 N·m (11 lb ft).
- Tighten the water pump bolts final pass to 30 N·m (22 lb ft).



260121



741552

Exhaust Manifold Installation - Left

Important:

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect engine emissions and/or On-Board Diagnostic (OBD) system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

Important: Do not apply sealant to the first three threads of the bolt.

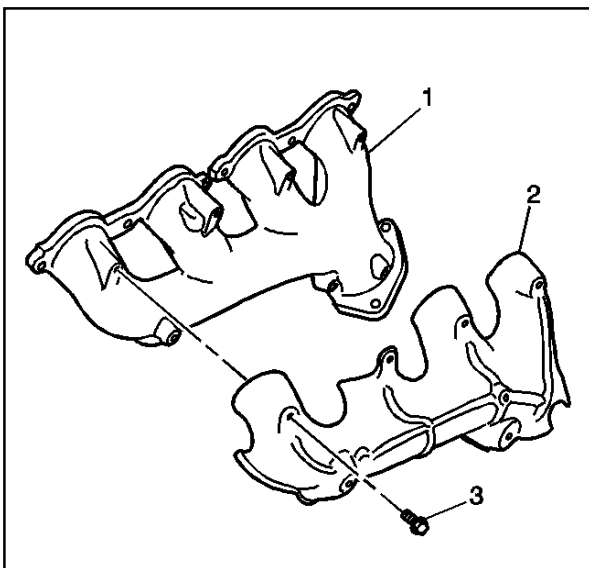
1. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts. Refer to *Sealers, Adhesives and Lubricants*.
2. Install the exhaust manifold and NEW exhaust manifold gasket.

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

3. Install the exhaust manifold bolts.

Tighten

- Tighten the exhaust manifold bolts a first pass to 15 N·m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
- Tighten the exhaust manifold bolts a final pass to 25 N·m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.



492766

4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.
5. Install the heat shield (2) and bolts (3).

Tighten

Tighten the heat shield bolts to 9 N·m (80 lb in).

Exhaust Manifold Installation - Right

Important:

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect engine emissions and/or On-Board Diagnostic (OBD) system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

Important: Do not apply sealant to the first three threads of the bolt.

1. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts. Refer to *Sealers, Adhesives and Lubricants*.
2. Install the exhaust manifold and NEW exhaust manifold gasket.

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

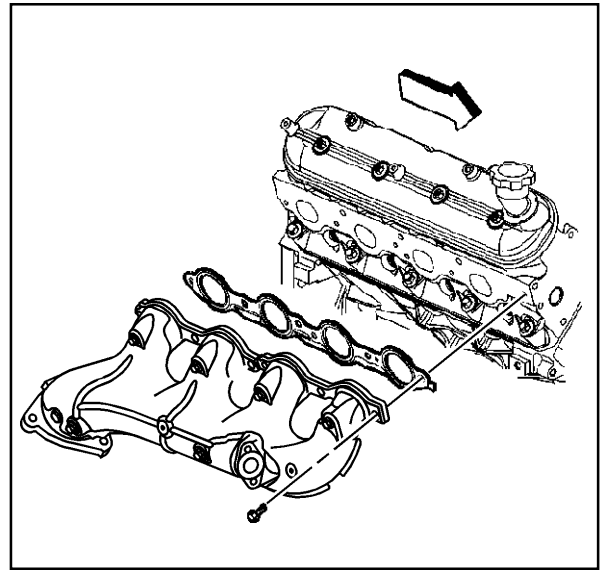
3. Install the exhaust manifold bolts.

Tighten

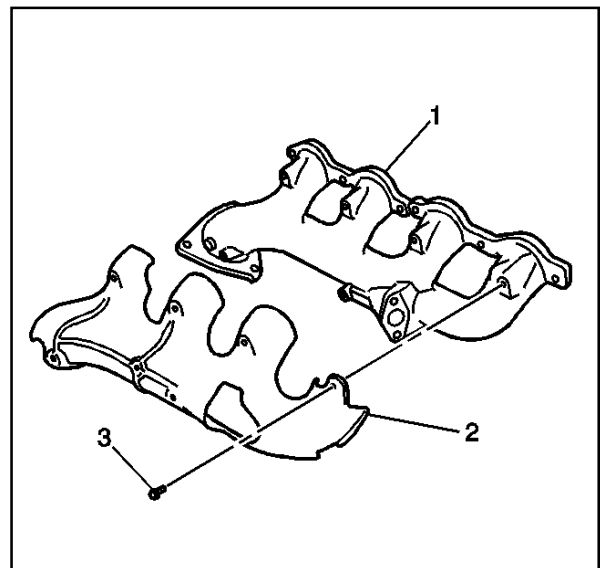
- Tighten the exhaust manifold bolts a first pass to 15 N·m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
 - Tighten the exhaust manifold bolts a final pass to 25 N·m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.
 5. Install the heat shield (2) and bolts (3).

Tighten

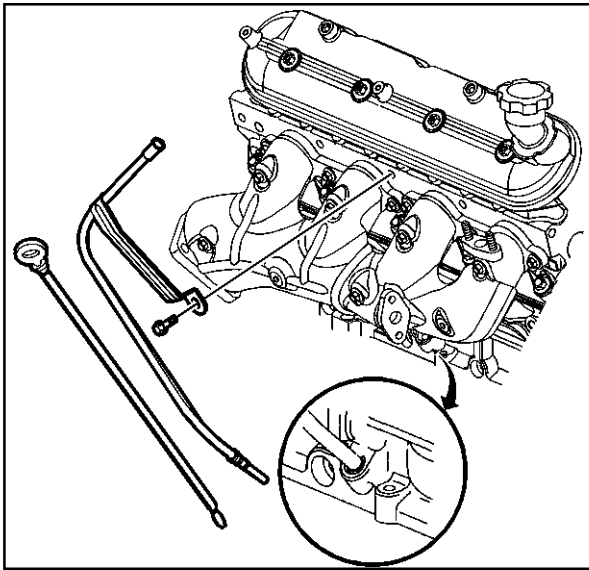
Tighten the heat shield bolts to 9 N·m (80 lb in).



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Oil Level Indicator and Tube Installation

1. Inspect the O-ring seal for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be reused.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube.
4. Install the oil level indicator tube into the engine block and rotate into proper position.

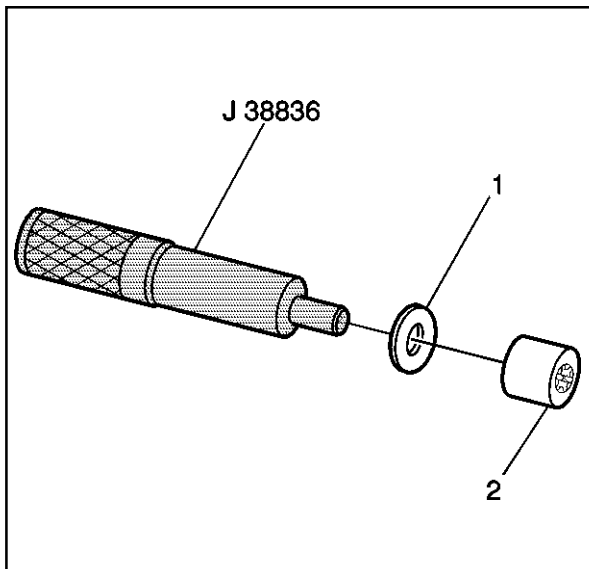
Notice: All gasket surfaces should be free of oil or other foreign material during assembly.

5. Install the tube bolt.

Tighten

Tighten the oil level indicator tube bolt to 25 N·m (18 lb ft).

6. Install the oil level indicator into the tube.



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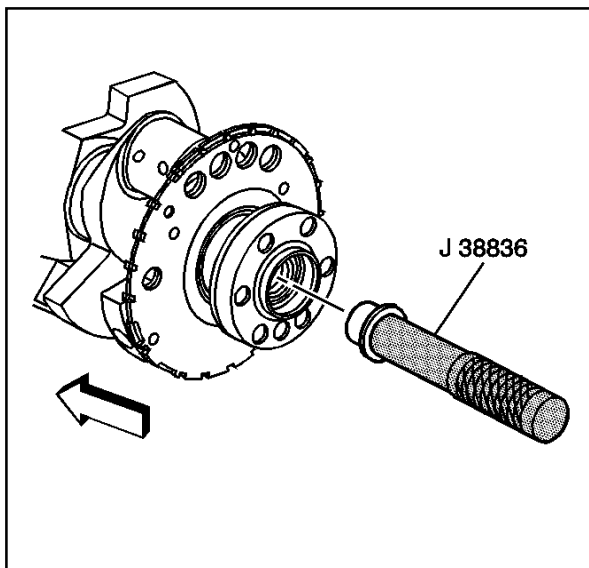
Clutch Pilot Bearing Installation

Tools Required

J 38836 Pilot Bushing Installer/Clutch

Important: The flywheel spacer (if applicable) must be removed prior to pilot bearing installation.

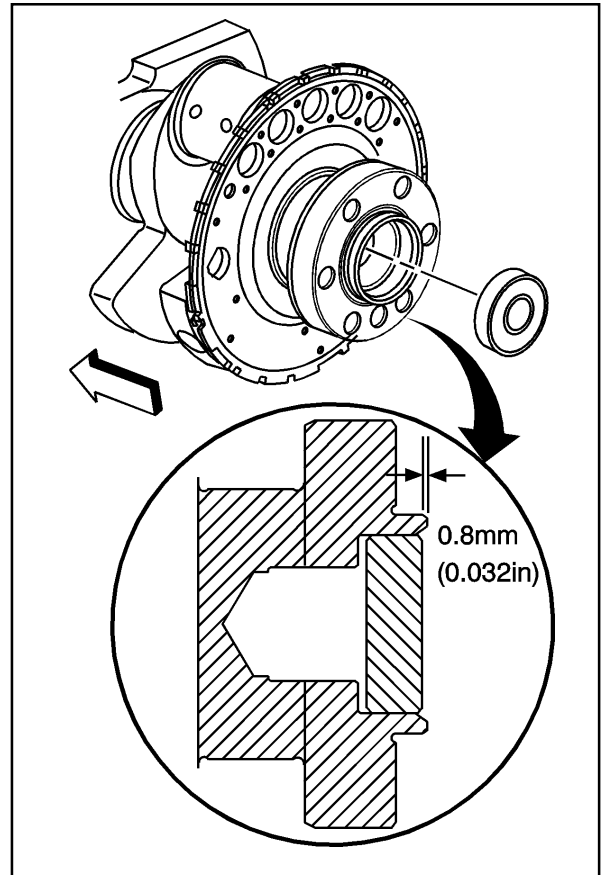
1. Install a 5/8 washer (1) onto the J 38836 or equivalent.
2. Install the new pilot bearing (2) onto the tool.



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3. Install the new pilot bearing into the crankshaft using the J 38836.

4. Inspect the clutch pilot bearing for proper installation.

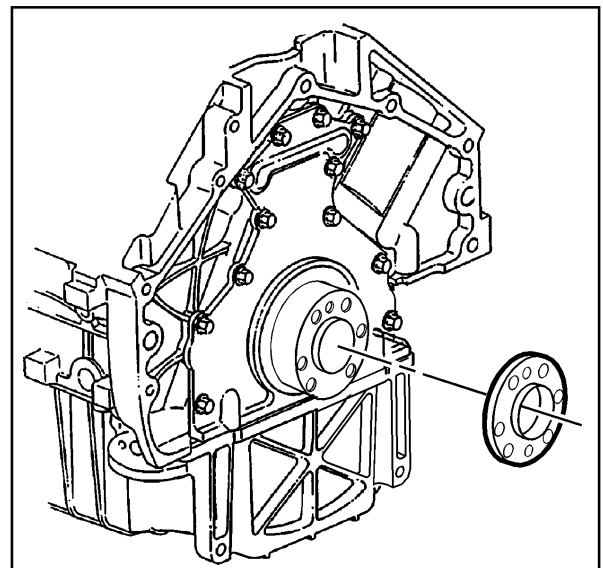


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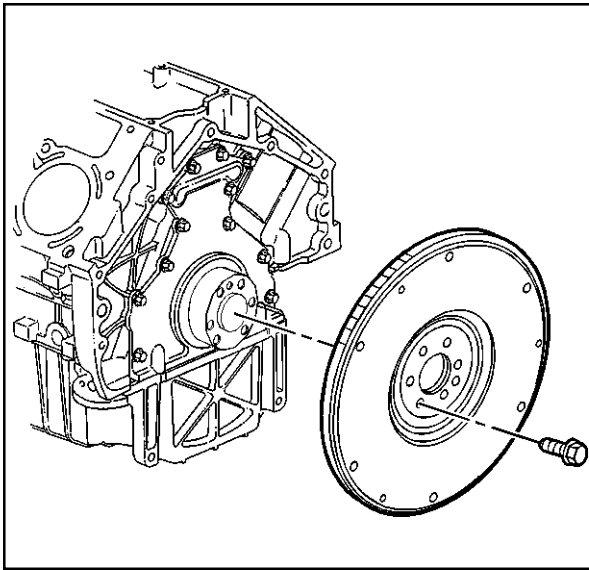
Engine Flywheel Installation

Important:

- The flywheel does not use a locating pin for alignment, and will not initially seat against the crankshaft flange or spacer (if applicable), but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three-stage tightening process.
 - Certain applications require a spacer and longer bolts for proper flywheel position.
1. Install the spacer (if applicable) onto the rear of the crankshaft.
A longer flywheel bolt must be used on applications using a flywheel spacer.

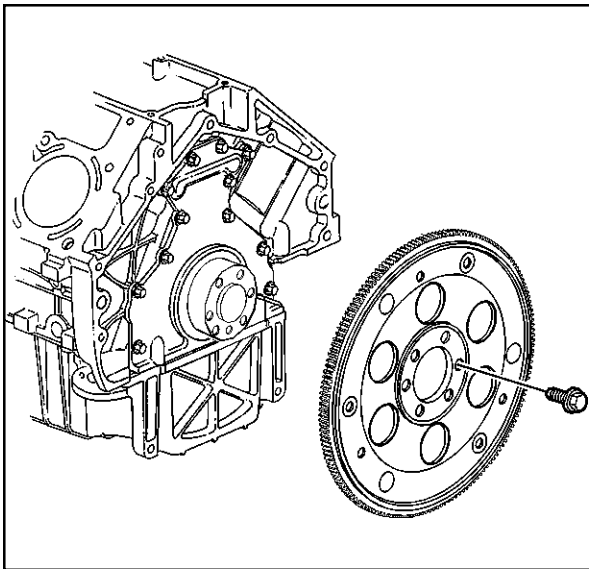


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2. Install the manual transmission engine flywheel to the crankshaft (if applicable).

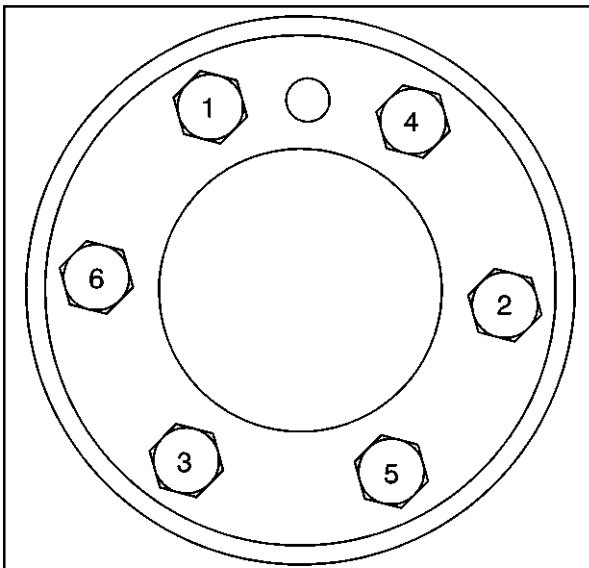


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3. Install the automatic transmission engine flywheel to the crankshaft (if applicable).

Important: A longer flywheel bolt must be used on applications using a flywheel spacer.

4. Apply threadlock GM P/N 12345385 or equivalent to the threads of the flywheel bolts.



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

5. Install the engine flywheel bolts.

Tighten

- Tighten the engine flywheel bolts first pass in sequence to 20 N·m (15 lb ft).
- Tighten the engine flywheel bolts second pass in sequence to 50 N·m (37 lb ft).
- Tighten the engine flywheel bolts final pass in sequence to 100 N·m (74 lb ft).

Crankshaft Balancer Installation

Tools Required

J 41665 Crankshaft Balancer and Sprocket Installer

J 36660-A Torque Angle Meter

J 42386-A Flywheel Holding Tool

Important:

- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third and fourth passes tighten the new bolt to the proper torque.
- The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW crankshaft balancer bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.
- Make sure the teeth of the tool engage the engine flywheel teeth.

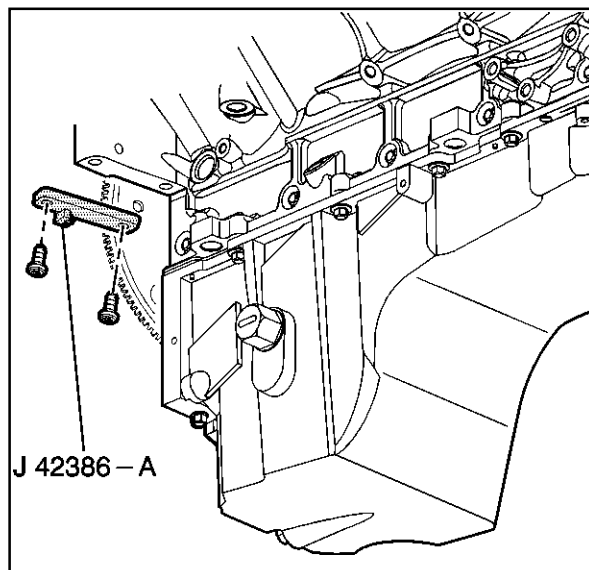
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the J 42386-A and bolts.

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

Tighten

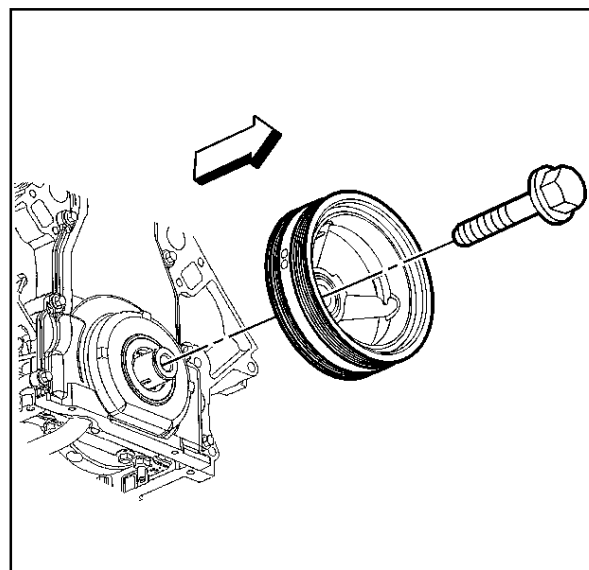
Tighten the J 42386-A bolts to 50 N·m (37 lb ft).



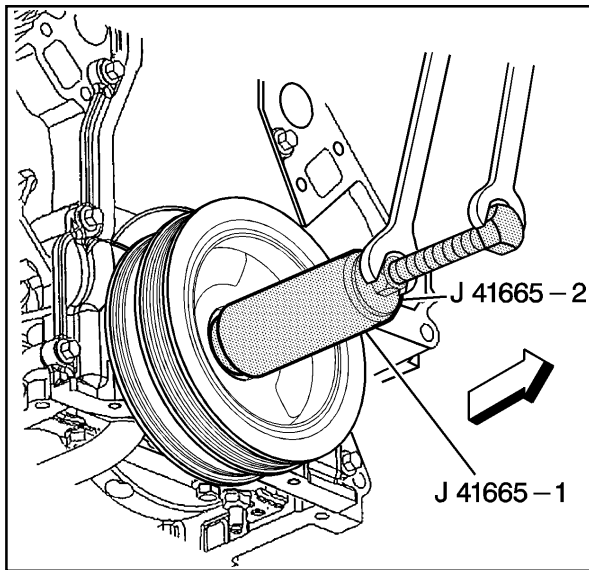
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Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Install the balancer onto the end of the crankshaft.

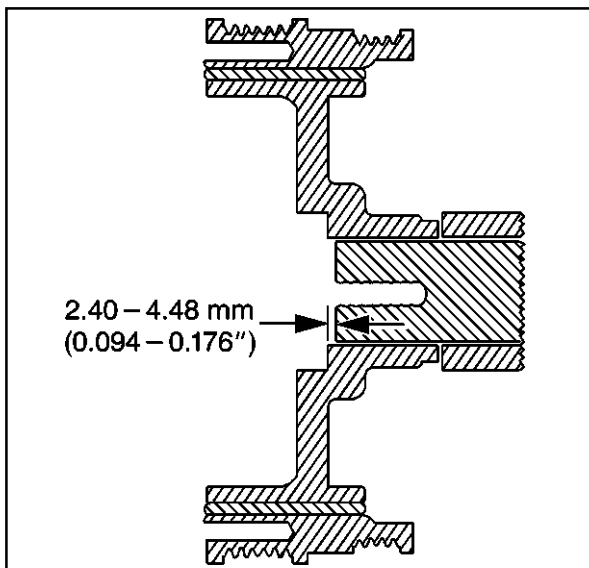


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3. Use the J 41665 in order to install the balancer.
 - 3.1. Assemble the threaded rod, nut, washer and installer.
Insert the smaller end of the installer into the front of the balancer.
 - 3.2. Use a wrench and hold the hex end of the threaded rod.
 - 3.3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
 - 3.4. Remove the tool and reverse the installation tool.
Position the larger end of the installer against the front of the balancer.
 - 3.5. Use a wrench and hold the hex end of the threaded rod.
 - 3.6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
 - 3.7. Remove the balancer installation tool.



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4. Install the used crankshaft balancer bolt.

Tighten

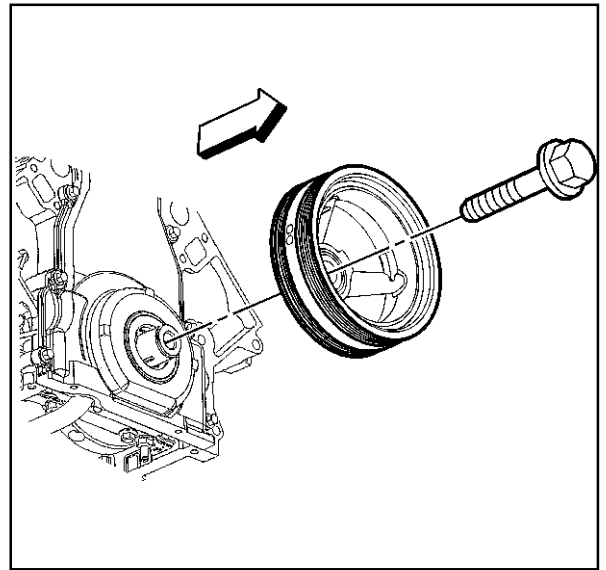
Tighten the crankshaft balancer bolt to 330 N·m (240 lb ft).
5. Remove the used crankshaft balancer bolt.

Important: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.
6. Measure for a correctly installed balancer.
If the balancer is not installed to the proper dimensions, install the J 41665 and repeat the installation procedure.

7. Install the NEW crankshaft balancer bolt.

Tighten

- Tighten the crankshaft balancer bolt a first pass to 50 N·m (37 lb ft).
 - Tighten the crankshaft balancer bolt a second pass to 140 degrees using the *J 36660-A*.
8. Remove the *J 42386-A*.

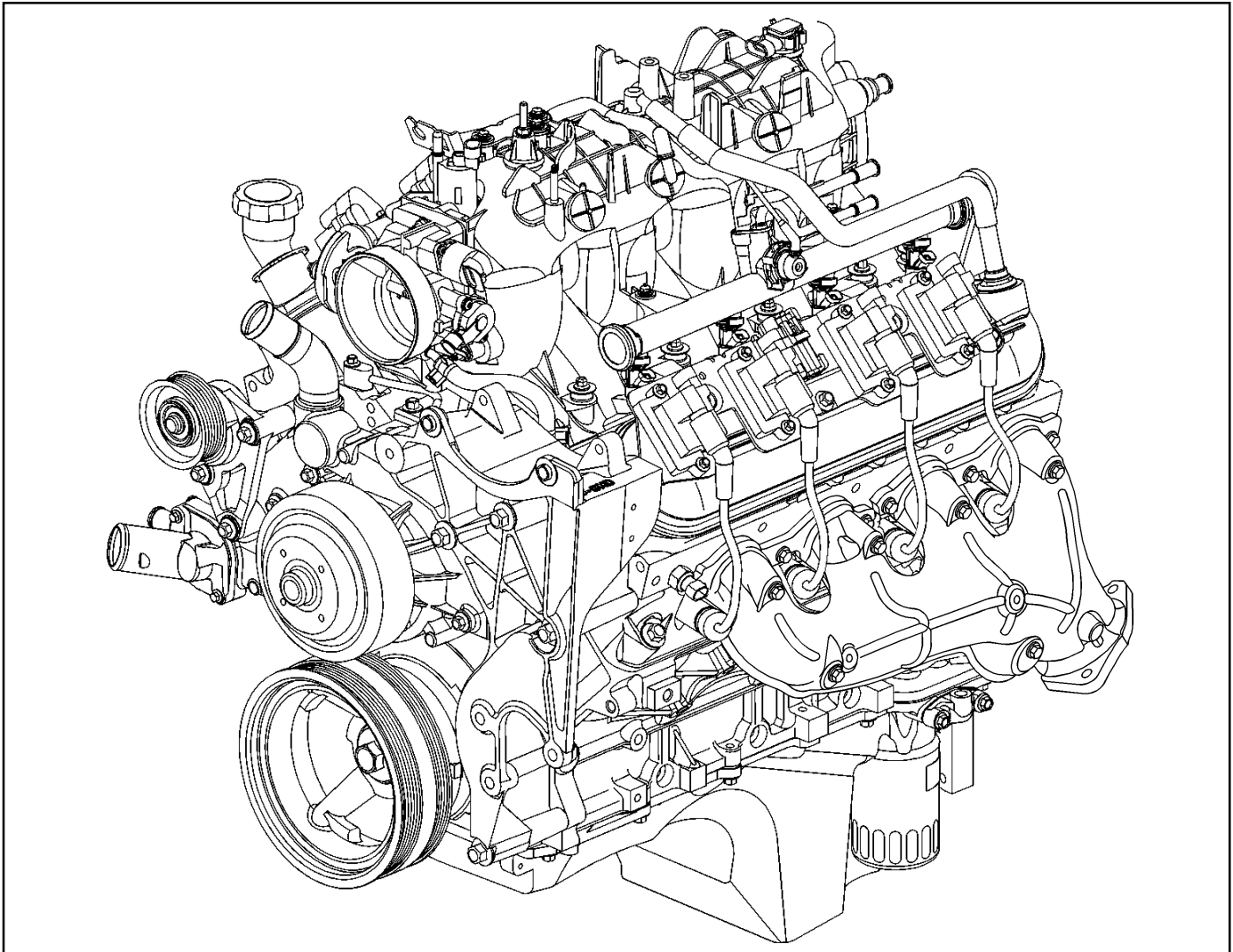


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Description and Operation

Engine Component Description

6.0L Engine



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Camshaft and Drive System

A billet steel one piece camshaft is supported by five bearings pressed into the engine block. The camshaft has a machined camshaft sensor reluctor ring incorporated between the fourth and fifth bearing journals. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the camshaft timing chain. The splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket splines drive the oil pump driven gear. A retaining plate mounted to the front of the engine block maintains camshaft location.

Crankshaft

The crankshaft is cast nodular iron. The crankshaft is supported by five crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance.

The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A crankshaft position reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately. All crankshafts will have a short rear flange (at the crankshaft rear oil seal area). Some applications require a spacer between the rear of the crankshaft and the flywheel for proper flywheel positioning. Longer bolts are required in applications using the spacer.

Cylinder Heads

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. Passages for the engine coolant air bleed system are at the front of each cylinder head. The valve rocker arm covers are retained to the cylinder head by four center mounted rocker arm cover bolts.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V configuration with five crankshaft bearing caps. The engine block is cast iron. The five crankshaft bearing caps each have four vertical M10 and two horizontal M8 mounting bolts. The camshaft is supported by five camshaft bearings pressed into the block.

Exhaust Manifolds

The exhaust manifolds are a one piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a one piece composite design that incorporates brass threaded inserts for mounting the fuel rail, throttle cable bracket, throttle body, wire harness stud, engine sight shield and shield bracket. Each side of the intake manifold is sealed to the cylinder head by a nonreusable silicone sealing gasket and nylon carrier assembly. The cable or electronically actuated throttle body (if applicable) bolts to the front of the intake manifold. The throttle body is sealed by a one piece push in place silicone gasket. The fuel rail assembly with eight separate fuel injectors is retained to the intake by four bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. A fuel rail stop bracket is retained to the rear of the left cylinder head by a mounting bolt. The Manifold Absolute Pressure (MAP) sensor is installed and retained to the top rear of the intake manifold and sealed by an O-ring seal. There are no coolant passages within the intake manifold.

Oil Pan

The structural oil pan is cast aluminum. Incorporated into the design are the oil filter mounting boss, drain plug opening, oil level sensor mounting bore (if applicable) and oil pan baffle. The oil pan transfer cover and oil level sensor mount to the sides of the oil pan. The alignment of the structural oil pan to the rear of the engine block and transmission bell housing is critical.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons are two compression rings and one oil control ring assembly. The piston is a low friction, lightweight design with a flat or recessed top and barrel shaped skirt. The piston pins are chromium steel, have floating fit in the piston and are retained by a press fit in the connecting rod. Some applications will have full-floating pistons/pins retained by internal clips. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance.

Valve Rocker Arm Cover Assemblies

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the ignition coils and bracket

assemblies. Incorporated into the rocker covers are the oil fill tube, the Positive Crankcase Ventilation (PCV) system passages and the engine fresh air passages.

Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve lifter guides position and retain the valve lifters. The valve rocker arms for each bank of cylinders are mounted on pedestals (pivot supports). Each rocker arm is retained on the pivot support and cylinder head by a bolt. Valve lash is net build.

Product Information

Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes utilize metric threads.
- Cylinder head, connecting rod, crankshaft balancer and main bearing cap bolts now apply a torque angle strategy.
- Certain fasteners should not be reused. Bolts, studs or other fasteners that must be replaced will be called out in the specific service procedure.
- Refer to *Fastener Tightening Specifications and Thread Repair Specifications*.

Disassembly and Assembly Procedure Revisions

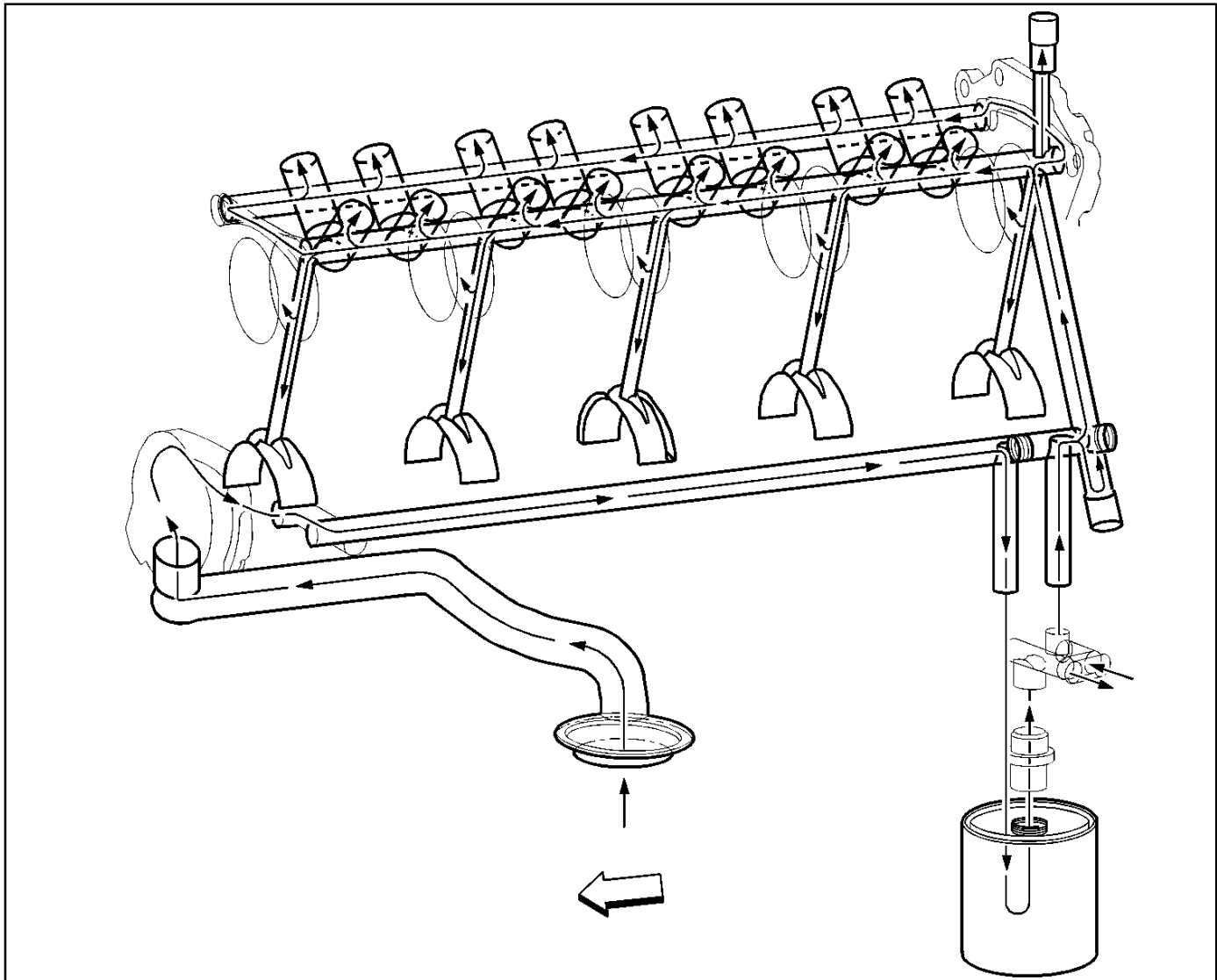
For certain applications, a spacer plate has been added between the flywheel and rear of the crankshaft. It is necessary to remove the spacer plate prior to removal and installation of the crankshaft rear oil seal and clutch pilot bearing.

Engine Mechanical Diagnostic Procedure Revisions

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Diagnostic Starting Point - Engine Mechanical* in Engine Mechanical.

Lubrication Description

Lubrication Flow Schematic



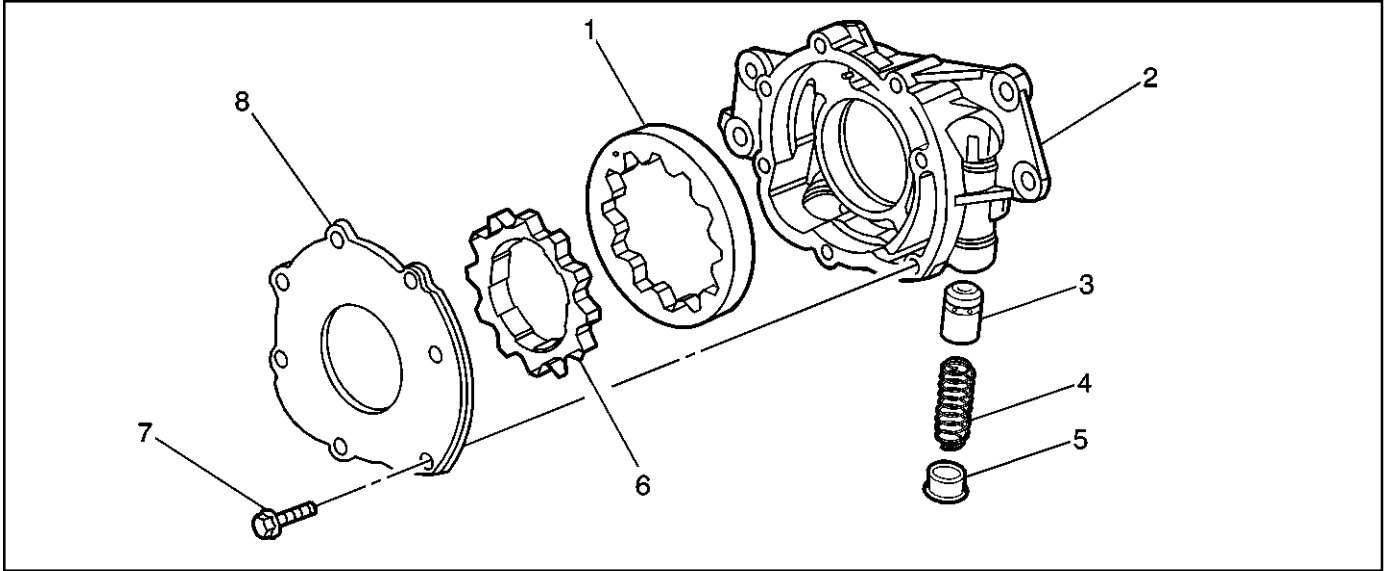
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Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block oil galleries. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range. Pressurized oil is directed through the lower gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan (at the oil filter boss) which will permit oil flow in the event the filter becomes restricted. At the rear of the block, oil is then directed to the upper main oil galleries which are drilled just above the camshaft assembly. From there, oil is then directed to the crankshaft and camshaft bearings. Oil that has entered the upper main oil galleries also pressurizes

the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. Oil pressure and crankcase level are each monitored by individual sensors.

An external oil cooler is available on certain applications. Oil is directed from the oil pump, through the lower main oil gallery to the full flow oil filter. Oil is then directed through the oil pan outlet oil gallery (located in the left rear of the oil pan) and to the external oil cooler via a hose assembly. Oil flows through the oil cooler and returns to the engine at the oil pan inlet oil gallery (located in the left rear of the oil pan). Oil is then directed to the upper main oil galleries and the remainder of the engine assembly.

Lower Front of Engine



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Legend

- | | |
|----------------------------------|----------------|
| (1) Driven Gear | (5) Plug |
| (2) Oil Pump Housing | (6) Drive Gear |
| (3) Pressure Relief Valve | (7) Cover Bolt |
| (4) Pressure Relief Valve Spring | (8) Cover |

Separating Parts

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When disassembling the engine, internal components **MUST** be separated, marked or organized in a way to ensure reinstallation to the original location and position.

Separate, mark or organize the following components:

- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to crankshaft journal
- Connecting rod to the bearing cap
- Crankshaft and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, guides, pushrods pivot supports and rocker arms
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block crankshaft bearing cap location and direction
- Oil pump drive and driven gears

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Replacing Engine Gaskets

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.

- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion or the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.
Do not use any other method or technique to remove the sealant or the gasket material from a part.
- Do not use abrasive pads, sand paper or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.
This fine grit is abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.
- Tighten fasteners to the proper specifications. **DO NOT** overtighten the fasteners.

Use of RTV and Anaerobic Sealer

Sealant Types

Important: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant (or equivalent) as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
 - Gasket eliminator
 - Pipe
 - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Any other surfaces where a different type of sealant is specified in the service procedure.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

Important: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch (within 3 minutes). Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.

The surfaces to be sealed must be clean and dry.

Important: Do not allow the gasket eliminator sealant to enter any blind threaded holes, as the gasket eliminator sealant may prevent the fasteners from clamping properly, seating properly or cause damage when the fastener is tightened.

- Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.

Important: Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than five minutes, may result in incorrect shimming and sealing of the joint.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.
- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

Important: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than five minutes, may result in incorrect clamp load of assembled components.

- Tighten fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

Important: Do not allow the pipe sealant to enter any blind threaded holes, as the pipe sealant may prevent the fasteners from clamping properly, seating properly or cause damage when the fastener is tightened.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners

Tools and Equipment

- Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.
- To properly service the engine assembly, the following items should be readily available:
 - Approved eye protection and safety gloves
 - A clean, well-lit work area
 - A suitable parts cleaning tank
 - A compressed air supply
 - Trays or storage containers to keep parts and fasteners organized
 - An adequate set of hand tools
 - Approved engine repair stand
 - An approved engine lifting device that will adequately support the weight of the components

Special Tools

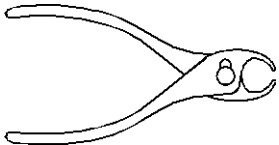
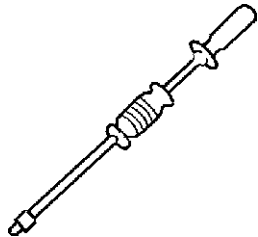
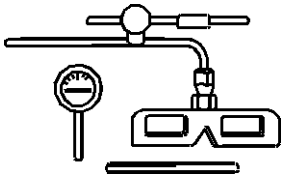
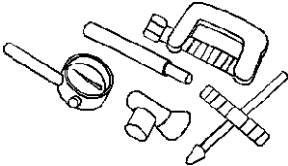
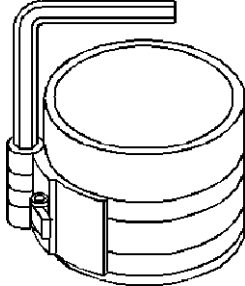
Illustration	Tool Number/Description
	<p>J 3049-A Valve Lifter Remover</p>
	<p>J 6125-1B Slide Hammer</p>
	<p>J 7872 Magnetic Base Dial Indicator Set</p>
	<p>J 8001 Dial Indicator Set</p>
	<p>J 8037 Piston Ring Compressor</p>

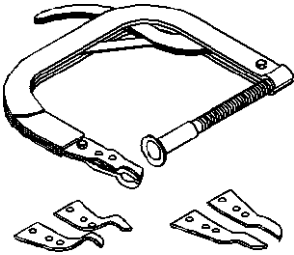
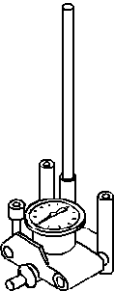
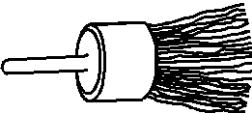
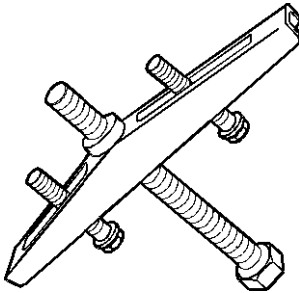
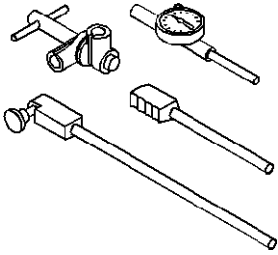
Illustration	Tool Number/Description
	<p>J 8062 Valve Spring Compressor (head off vehicle)</p>
	<p>J 8087 Cylinder Bore Checking Gauge</p>
	<p>J 8089 Carbon Removal Brush</p>
	<p>J 8433-1 Pulley Puller</p>
	<p>J 8520 Camshaft Lobe Lift Dial Indicator Set</p>

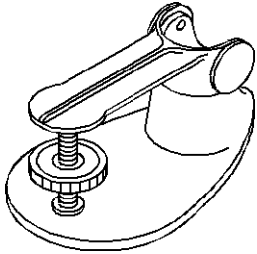
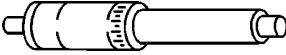
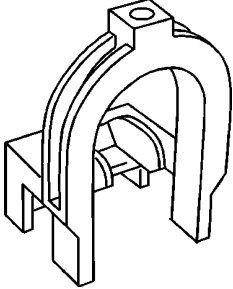
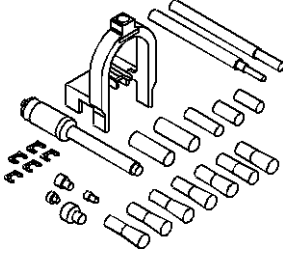
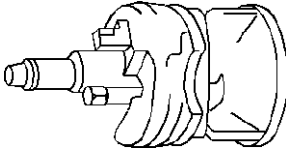
Illustration	Tool Number/Description
	<p>J 9666 Valve Spring Tester</p>
	<p>J 24086-9 Adjustable Installer</p>
	<p>J 24086-10 Piston Pin Remover Installer Base</p>
	<p>J 24086-C Piston Pin Remover/ Installer</p>
	<p>J 24270 Cylinder Ridge Remover</p>

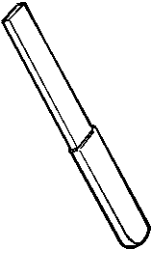
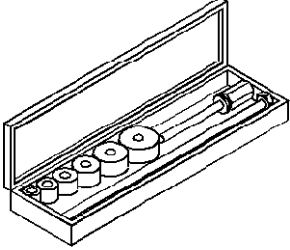
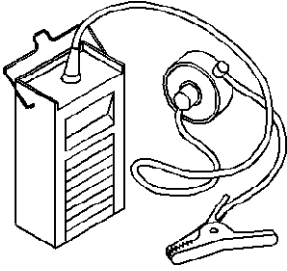
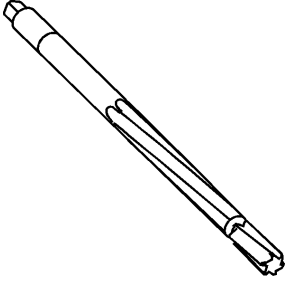
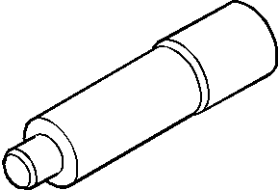
Illustration	Tool Number/Description
	<p>J 28410 Gasket Remover</p>
	<p>J 33049 Camshaft Bearing Remover/Installer</p>
	<p>J 36660-A Torque Angle Meter</p>
	<p>J 37378-1 Valve Guide Reamer</p>
	<p>J 38836 Pilot Bushing Installer/ Clutch</p>

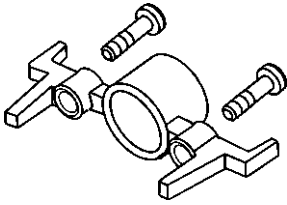
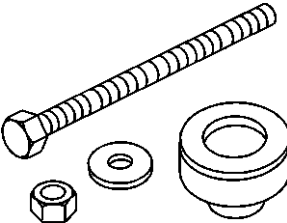
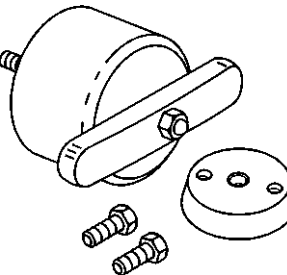
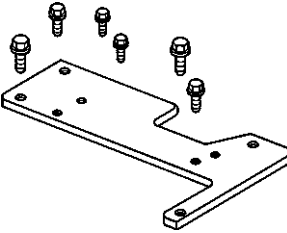
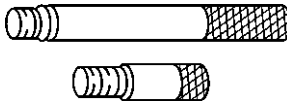
Illustration	Tool Number/Description
	<p>J 41476 Front and Rear Cover Alignment (at crankshaft seal area)</p>
	<p>J 41478 Crankshaft Front Oil Seal Installer</p>
	<p>J 41479 Crankshaft Rear Oil Seal Installer</p>
	<p>J 41480 Front and Rear Cover Alignment (at the oil pan surface)</p>
	<p>J 41556 Connecting Rod Guide</p>

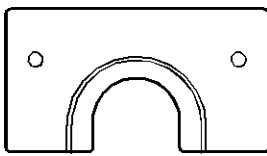
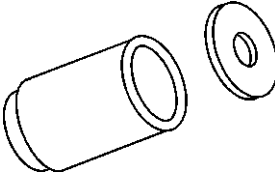
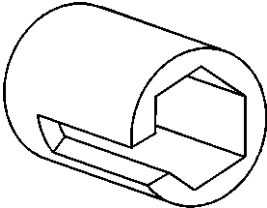
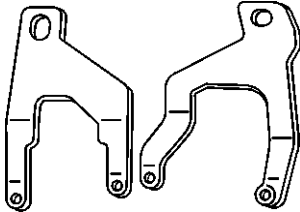
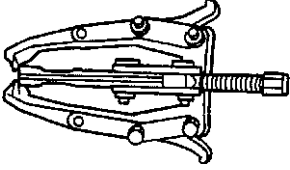
Illustration	Tool Number/Description
	<p>J 41558 Crankshaft Sprocket Remover</p>
	<p>J 41665 Crankshaft Balancer and Sprocket Installer</p>
	<p>J 41712 Oil Pressure Sensor Socket</p>
	<p>J 41798 Engine Lifting Brackets</p>
	<p>J 41816 Crankshaft Balancer Remover</p>

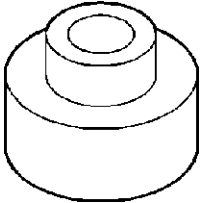
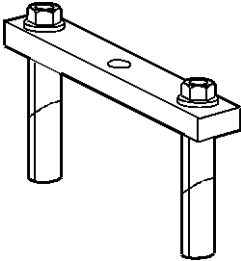
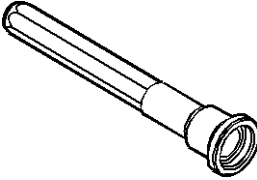
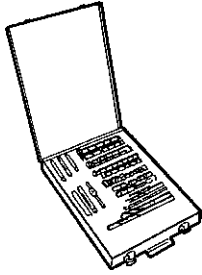
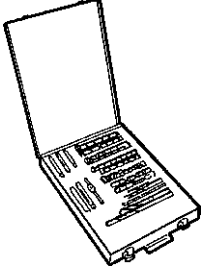
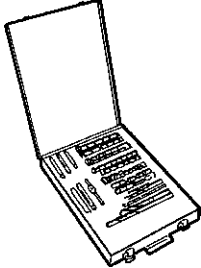

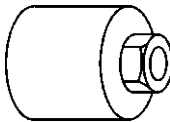
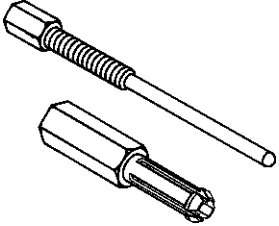
Illustration	Tool Number/Description
	<p>J41816-2 Crankshaft End Protector</p>
	<p>J41818 Crankshaft Bearing Cap Remover</p>
	<p>J42078 Valve Stem Oil Seal Installer</p>
	<p>J42385-100 Thread Repair Kit (Cylinder Head/Main Bearing Bolt)</p>
	<p>J42385-200 Thread Repair Kit (General Threads)</p>

Illustration	Tool Number/Description
	<p>J42385-300 Thread Repair Kit (Fixtures and Hardware)</p>
	<p>J42386-A Flywheel Holding Tool</p>
	<p>J42907 Oil Pressure Testing Tool</p>
	<p>J43276 Clutch Pilot Bearing Remover</p>

Diagnostic Information and Procedures

Base Engine Misfire Diagnosis

Checks	Action
<p>Engine Performance diagnosis procedures are covered in Engine Controls and should be consulted for diagnosis of any Drivability, Emissions or Malfunctioning Indicator Lamp (MIL) concerns.</p> <p>The following diagnosis covers common concerns and possible causes.</p> <p>When the proper diagnosis is made, the concern should be corrected by adjustment, repair or replacement as required.</p> <p>Refer to the appropriate section of the service manual for each specific procedure.</p> <p>This diagnostic table will assist in engine misfire diagnosis due to a mechanical concern such as a faulty engine camshaft, worn or damaged bearings or bent valve pushrod.</p> <p>This table will not isolate a crossed fuel injector wire, faulty fuel injector or any other drivability component failure that may cause a misfire.</p> <p>The On-Board Diagnostic System checks must be performed first.</p> <p>When using this table to make a Base Engine Misfire diagnosis, begin with the preliminary information below and then proceed to the specific category.</p>	
<p>Preliminary</p>	<ol style="list-style-type: none"> 1. Perform a visual inspection of the following: <ul style="list-style-type: none"> • A loose or improperly installed engine flywheel or crankshaft balancer • Worn, damaged or misaligned accessory drive system components 2. Listen to the engine for any abnormal internal engine noises. 3. Inspect the engine for acceptable oil pressure. 4. Verify if the engine has excessive oil consumption. 5. Verify if the engine has excessive coolant consumption. 6. Perform a compression test on the engine.
<p>Intake Manifold Leaks</p>	<p>An intake manifold that has a vacuum leak may cause a misfire.</p> <p>Inspect for the following:</p> <ul style="list-style-type: none"> • Improperly installed or damaged vacuum hoses • Faulty or improperly installed intake manifold and/or gaskets • Cracked or damaged intake manifold • Improperly installed MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged • Loose or Improperly installed throttle body or damaged gasket • Warped intake manifold • Warped or damaged cylinder head sealing surface
<p>Coolant Consumption</p>	<p>Coolant consumption may or may not cause the engine to overheat.</p> <p>Inspect for the following:</p> <ul style="list-style-type: none"> • External coolant leaks • Faulty cylinder head gasket • Warped cylinder head • Cracked cylinder head • Damaged engine block
<p>Oil Consumption</p>	<p>Oil consumption may or may not cause the engine to misfire.</p> <ol style="list-style-type: none"> 1. Remove the spark plugs and inspect for an oil fouled spark plug. 2. Perform a cylinder compression test. 3. If the compression test indicates worn valves or valve guides, inspect the following: <ul style="list-style-type: none"> • Worn, brittle or improperly installed valve stem oil seals • Worn valve guides

Base Engine Misfire Diagnosis (cont'd)

Checks	Action
	<ul style="list-style-type: none"> • Worn valve stems • Worn or burnt valves or valve seats <p>4. If the compression test indicates worn or damaged piston rings, inspect the following:</p> <ul style="list-style-type: none"> • Broken or improperly seated piston rings • Excessive piston ring end gap • Excessive cylinder bore wear or taper • Cylinder damage • Piston damage
Abnormal Internal Engine Noises	<ol style="list-style-type: none"> 1. Start the engine and determine if the noise is timed to the engine camshaft speed or the crankshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft speed and one knock per flash is the engine camshaft speed. 3. If the noise is timed to the engine camshaft speed, inspect the following: <ul style="list-style-type: none"> • Missing or loose valve train components • Worn or loose valve rocker arms • Worn or bent valve pushrods • Faulty valve springs • Bent or burnt valves • Worn engine camshaft lobes • Worn or damaged camshaft timing chain and/or sprockets <p>Important: A slight COLD knock or piston slapping noise could be considered normal if not present after the engine has reached normal operating temperatures.</p> 4. If the knock is timed to the crankshaft speed, inspect the following: <ul style="list-style-type: none"> • Worn crankshaft or connecting rod bearings • Piston ro cylinder damage • Worn piston or piston pin • Faulty connecting rod • Excessive carbon build-up on the top of the piston
No Abnormal Internal Engine Noise	<ol style="list-style-type: none"> 1. Inspect for a worn or improperly installed camshaft timing chain and/or sprockets. 2. Remove the valve rocker arm cover on the side of the engine with the cylinder that is misfiring. 3. Inspect for the following: <ul style="list-style-type: none"> • Loose valve rocker arm studs • Bent valve push rods • Faulty valve springs • Faulty valve lifters (bleeding down) • Worn or improperly seated valves • Worn engine camshaft lobes

Engine Compression Test

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.
5. Block the throttle plate wide open.
6. Start with the compression gauge at zero and crank the engine through four compression strokes (four puffs).
7. Make the compression check the same for each cylinder. Record the reading.
The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi).
(1035 x 70% = 725) (150 x 70% = 105).
8. If any cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil

into the combustion chamber through the spark plug hole.

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

Engine Noise Diagnosis

Symptoms	Cause
<p>There are four steps to diagnosing engine noise. You must determine the following:</p> <ul style="list-style-type: none"> • The type of noise For example, is the noise a light rattle/tapping or a low rumble/knocking? • The exact operating condition under which the noise exists Note factors such as ambient temperature, the amount of engine warm-up time, the engine temperature, the engine RPM and other specifics. • At what rate the noise occurs, and at what location in the engine Remember, engine noises are generally synchronized to either engine speed (crankshaft, engine flywheel, connecting rods, crankshaft balancer or pistons and related components) or one-half engine speed (valve train noise such as valve rocker arms, valve lifters and camshaft timing chain). Try to determine the rate at which the noise is occurring. • Compare the engine sounds to other engines, and make sure you are not trying to correct a normal condition. 	
<p>Noise on Start-Up but Only Lasts a Few seconds</p>	<ul style="list-style-type: none"> • Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. • Worn or dirty valve lifters • Excessive piston-to-cylinder bore clearance • Excessive piston pin-to-bore clearance • Excessive crankshaft bearing clearance
<p>Knocks Cold and Continues for 1 to 2 Minutes</p>	<ul style="list-style-type: none"> • Loose or broken crankshaft balancer or accessory drive components • Excessive piston-to-bore clearance A cold piston knock which appears in 1.5 minutes should be considered acceptable. • A cold engine knock usually disappears when the specific cylinders secondary ignition circuit is grounded out.

Engine Noise Diagnosis

Symptoms	Cause
Intermittent Noise on Idle, Disappearing When Engine Speed is Increased	<ul style="list-style-type: none"> • Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. • Lower than specified oil pressure Install an oil pressure gauge and measure the engine oil pressure. • Dirty or worn valve lifter
Valve Train Noise (Rattle/Tapping)	<p>The following conditions may cause a valve train type noise:</p> <ul style="list-style-type: none"> • Lower than specified oil pressure • Worn or faulty oil pump • Loose oil pump-to-engine block bolts • Loose valve rocker arm attachments • Worn valve rocker arm bearings • Worn valve rocker arm and/or pushrod • Broken valve spring • Sticking valves • Worn, dirty or faulty valve lifters • Worn camshaft lifter lobes • Worn valve guides or valve stems • Bent, broken or damaged timing chain sprocket teeth
Knocks at Idle Hot (Rumble/Knocking)	<p>The following conditions may cause a valve train type noise:</p> <ul style="list-style-type: none"> • Malfunctioning accessory drive system components • Loose or broken crankshaft balancer • Detonation or spark knock Check for proper operation of the cooling, knock and ignition control components. • Excessive connecting rod bearing clearance • Excessive piston pin-to-bore clearance • Bent connecting rod • Excessive crankshaft main or thrust bearing clearance • Loose torque converter bolts • Cracked or damaged flywheel • Exhaust leak at the manifold
Exhaust System Noise and/or Leakage	<p>Exhaust system noise and/or leakage may be caused by the following conditions:</p> <ul style="list-style-type: none"> • Improperly installed or misaligned exhaust system components • A cracked or broken exhaust manifold • Damaged or worn gaskets and/or seals • Burned or rusted out exhaust system components • A broken or loose exhaust clamp and/or bracket

Valve Train Diagnosis

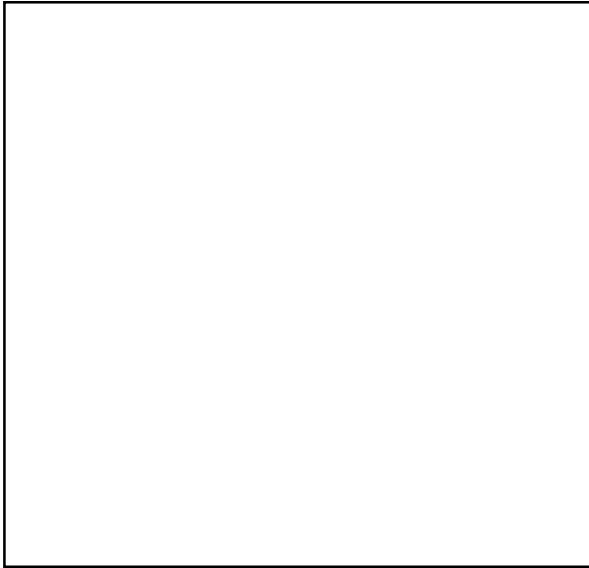
Symptoms	Cause
<p>A light tapping noise at one-half engine speed, or any varying frequency, may indicate a valve train problem. Tapping noises will typically increase with increased engine speed. Before attempting to diagnose a valve train noise, check for the proper oil level and thoroughly warm up the engine. By doing this, you will bring all engine components to a normal state of expansion. While sitting in the driver's seat, run the engine at various speeds and listen for any abnormal engine noise. Whenever Valve Lifter Diagnosis is necessary, always use a listening device such as an engine stethoscope, or listening ears <i>J 39565</i>. These tools will help to isolate any lifter noise and identify noises that could be mis-diagnosed as lifter noise.</p>	
<p>A light tapping noise similar to valve train noise may be caused by the following components:</p>	<ul style="list-style-type: none"> • Fuel Injectors • Detonation
<p>The Cause of Valve Train Noise May Include the Following Conditions:</p>	<ul style="list-style-type: none"> • Lower than specified oil pressure • Worn or faulty oil pump • Loose valve rocker arm attachments (causing excessive valve lash) • Worn or damaged valve rocker arm bearings • Worn valve rocker arm and/or pushrod • Broken valve spring • Sticking valves • Worn, dirty or faulty valve lifters • Broken valve lifter guide • Worn camshaft lifter lobes • Worn valve guides or valve stems • Worn or damaged valve keys • Bent pushrods • Excessive play in the camshaft timing chain • Bent, broken or damaged timing chain sprocket teeth

Diagnostic Table

Step	Action	Value(s)	Yes	No
DEFINITION: A light tapping noise at one-half engine speed, or any varying frequency.				
1	Is there valve train noise?	—	Go to Step 2	System OK
2	Check for a high engine oil level. An engine with the oil level above the FULL mark allows the crankshaft counterweights to churn the oil into foam. When the foamy oil is pumped into the lifters, the lifters become noisy. A solid column of oil ensures proper lifter operation. Is the engine oil level too high?	—	Drain the oil to the proper level. System OK	Go to Step 3
3	Check for a low engine oil level. An engine with the oil level below the ADD mark may allow the oil pump to pump air at high engine RPM. Is the oil level too low?	—	Add oil as required. System OK	Go to Step 4
4	Check for the proper engine oil pressure. Refer to <i>Engine Mechanical Specifications</i> and <i>Oil Pressure Diagnosis and Testing</i> . Is the engine oil pressure within specifications?	—	Go to Step 7	Go to Step 5
5	1. Check the oil pump screen for damage or a loose fit to the oil pump. 2. Inspect for a missing or damaged oil pump screen O-ring seal. Is the oil pump screen loose or is the screen or O-ring seal damaged?	—	Repair as required System OK	Go to Step 6
6	Check for a damaged oil pump or loose mounting bolts. Refer to <i>Oil Pump, Pump Screen and Deflector Installation</i> . Is the oil pump damaged or are the bolts loose?	—	Repair as required. System Ok	Go to Step 10
7	Remove and inspect the valve lifters, rocker arms and pushrods. Refer to <i>Valve Rocker Arm and Pushrods Clean and Inspect</i> and <i>Valve Lifters and Guides Clean and Inspect</i> . Are the components worn or damaged?	—	Replace the components as required. System OK	Go to Step 8
8	Perform a camshaft lobe lift test. Refer to <i>Camshaft and Bearings Clean and Inspect</i> and <i>Engine Mechanical Specifications</i> . Is the engine camshaft lobes within specifications?	—	Camshaft OK Go to Step 9	Replace the camshaft and valve lifters. System OK
9	Remove the engine front cover and inspect the camshaft timing chain and sprockets for excessive wear or damage. Refer to <i>Timing Chain and Sprockets Clean and Inspect</i> . Are the components worn or damaged?	—	Replace the components as required. System OK	Go to Step 10
10	Perform a complete disassembly of the engine and inspect all components. Are the components worn or damaged?	—	Replace the components as required.	System Ok

Oil Consumption Diagnosis

Symptoms	Cause
<p>Excessive oil consumption (not due to leaks) is the use of 0.95 L (1.0 qts) or more of engine oil within 2,414 kilometers (1,500 miles).</p> <p>The causes of excessive oil consumption may include the following conditions:</p>	
<p>Preliminary</p>	<ul style="list-style-type: none"> • External oil leaks Refer to <i>Oil Leak Diagnosis</i>. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or mis-fitted to the cylinder bore



416607

Oil Pressure Diagnosis and Testing

Tools Required

J 21867 Pressure Hose and Gauge Assembly

J 42907 Oil Pressure Testing Tool

1. With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and measure for a low engine oil level.
2. Add the recommended grade engine oil, and fill the crankcase until the oil level measures FULL on the oil level indicator.
3. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gauge or the oil indicator light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following:
 - Oil diluted by water or glycol (antifreeze)
 - Foamy oil
6. Remove the oil filter and install the *J 42907*.
7. Install *J 21867* or equivalent to the *J 42907*.
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to *Engine Mechanical Specifications*.
10. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
 - Oil pump worn or dirty
 - Oil pump-to-engine block bolts loose
 - Oil pump screen loose, plugged or damaged
 - Oil pump screen O-ring seal missing or damaged
 - Malfunctioning oil pump pressure regulator valve
 - Excessive bearing clearance
 - Cracked, porous or restricted oil galleries
 - Oil gallery plugs missing or incorrectly installed
 - Broken valve lifters
11. If the oil pressure reading on the *J 21867* or equivalent is within specifications, inspect for the following:
 - Plugged or incorrect oil filter and/or malfunctioning oil bypass valve
 - Malfunctioning oil pressure gauge or sensor

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
<p>Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.</p>				
1	<ol style="list-style-type: none"> Operate the vehicle until it reaches normal operating temperature. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. Wait (15 minutes). Check for drippings. <p>Are drippings present?</p>	—	Go to Step 2	System OK
2	<p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 3
3	<ol style="list-style-type: none"> Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. Check for leaks at the following locations: <ul style="list-style-type: none"> Sealing surfaces Fittings Cracked or damaged components <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 4
4	<ol style="list-style-type: none"> Completely clean the entire engine and surrounding components. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. Wait (15 minutes). Identify the type of fluid and the approximate location of the leak. <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 5
5	<ol style="list-style-type: none"> Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. Check for leaks at the following locations: <ul style="list-style-type: none"> Sealing surfaces Fittings Cracked or damaged components <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 6
6	<ol style="list-style-type: none"> Completely clean the entire engine and surrounding components. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. Identify the type of fluid and the approximate location of the leak, from the discolorations in the powder surface. 			

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
6	Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 7
7	<ol style="list-style-type: none"> 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 8
8	<p>Use <i>J 28428-E</i>, Dye and Light Kit, in order to identify the type of fluid and the approximate location of the leak. Refer to manufacturer's instructions when using the tool.</p> <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	Go to Step 9
9	<ol style="list-style-type: none"> 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: <ul style="list-style-type: none"> • Sealing surfaces • Fittings • Cracked or damaged components <p>Can you identify the type of fluid and the approximate location of the leak?</p>	—	Go to Step 10	System OK
10	<ol style="list-style-type: none"> 1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: <ul style="list-style-type: none"> • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. <p>Is there mechanical damage, or customer modifications to the engine?</p>	—	Go to Step 11	System OK
11	<p>Repair or replace all damaged or modified components.</p> <p>Does the engine still leak oil?</p>	—	Go to Step 1	—

Symptoms - Drive Belt

Important: Review the system operation in order to familiarize yourself with the system functions. Refer to *Drive Belt System Description*.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the drive belts.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect the drive belt for excessive wear, shredding or missing sections.
- Inspect the drive belt for contamination of excessive dirt, oil, coolant or other substances that may affect the drive belt operation.

Intermittent

- Drive belt symptoms may be from intermittent failure of an accessory drive component.

Drive Belt Chirping Diagnosis

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt(s) or the pulleys. It may be necessary to spray a small amount of water on the drive belt(s) in order to duplicate the customer's concern. If spraying water on the drive belt(s) duplicates the symptom, cleaning the belt pulleys may be the probable solution.

A loose or improper installation of a body component, a suspension component or other items of the vehicle may cause the chirping noise.

Test Description

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

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise, do not proceed further with this table.
3. The noise may be an internal engine noise.
Removing the drive belt and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt(s), the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component

- Drive belt symptoms may occur from changes in load of the accessory drive components.
- Ambient temperatures, moisture or engine operating temperature can affect the drive belt operation.

Symptoms List

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

- *Drive Belt Chirping Diagnosis*
- *Drive Belt Squeal Diagnosis*
- *Drive Belt Whine Diagnosis*
- *Drive Belt Rumbling Diagnosis*
- *Drive Belt Vibration Diagnosis*
- *Drive Belt Falls Off Diagnosis*
- *Drive Belt Excessive Wear Diagnosis*

pulley or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley .using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure for that pulley.

10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Value(s)	Yes	No
<p>Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.</p> <p>DEFINITION: The following items are indications of chirping:</p> <ul style="list-style-type: none"> • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • It usually occurs on cold damp mornings. 				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	—	Go to <i>Engine Noise Diagnosis</i>	Go to Step 4
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	—	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	—	Go to Step 15	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	—	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	—	Go to Step 15	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	—	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	—	Go to Step 15	Go to Step 10
10	Inspect for improper, loose or missing fasteners Did you find the condition?	—	Go to Step 11	Go to Step 12
11	Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Did you complete the repair?	—	Go to Step 15	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	—	Go to Step 13	Go to Step 14
13	Replace the bent pulley. Did you complete the repair?	—	Go to Step 15	Go to Step 14
14	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the repair?	—	Go to Step 15	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to Step 3

Drive Belt Squeal Diagnosis

Diagnostic Aids

A loose or improper installation of a body component, a suspension component or other items of the vehicle may cause the chirping noise.

If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid or a generator failing are suggested items to inspect.

Test Description

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

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise, do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt(s), the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. This test is to verify that an accessory drive component does not have a seized bearing. With the belt removed, test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the

- load on the components to verify that the components operate properly.
5. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping, which could cause a squeal noise.
6. This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner from working properly. Also, if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
7. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure for that pulley.
8. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle, compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Value(s)	Yes	No
<p>Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.</p> <p>DEFINITION: The following items are indications of drive belt squeal:</p> <ul style="list-style-type: none"> • A loud screeching noise that is caused by a slipping drive belt (this is unusual for a drive belt with multiple ribs) • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement, snapping the throttle or slipping on a seized pulley or a faulty accessory drive component. 				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	—	Go to <i>Engine Noise Diagnosis</i>	Go to Step 4
4	Inspect for an accessory drive component seized bearing or faulty accessory drive component. Did you find and correct the condition?	—	Go to Step 9	Go to Step 5

Drive Belt Squeal Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
5	Test the drive belt tensioner for proper operation. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 6
6	Inspect for the correct drive belt length. Refer to <i>Drive Belt Replacement</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 7
7	Inspect for a misalignment of a pulley. Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
8	Inspect for the correct pulley size. Did you find and correct the condition?	—	Go to Step 9	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to Step 3

Drive Belt Whine Diagnosis

Diagnostic Aids

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

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid or a generator failing are suggested items to inspect.

Test Description

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

- This test is to verify that the noise is being caused by the drive belt(s) or the accessory drive components.

When removing the drive belt(s), the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt(s) removed.

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

Drive Belt Whine Diagnosis

Step	Action	Value(s)	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.				
DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Verify that there is a whine noise. Does the engine make the whine noise?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	—	Go to <i>Engine Noise Diagnosis</i>	Go to Step 4
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	—	Go to Step 5	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	—

Drive Belt Rumbling Diagnosis

Diagnostic Aids

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

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

If replacing the drive belt(s), completing the diagnostic table, and the noise is only heard when the drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

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

- 2 This test is to verify that the symptom is present during

diagnosing. Other vehicle components may cause a similar symptom.

3. This test is to verify that the drive belt(s) is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belt the water pump may not be operating and the engine may overheat. Also, DTC's may set when the engine is operating with the drive belt removed.
4. Inspecting the drive belt(s) is to ensure that it is not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plies of the belt separating and may be seen at the edge of the belt, or felt as a lump in the belt.
5. Small amounts of pilling is a normal condition and acceptable. When the pilling is severe, the drive belt does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Value(s)	Yes	No
<p>Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.</p> <p>DEFINITION:</p> <ul style="list-style-type: none"> • A low pitch tapping, knocking or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: <ul style="list-style-type: none"> - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove - The separation of the drive belt - A damaged drive belt 				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	—	Go to <i>Engine Noise Diagnosis</i>	Go to Step 4
4	Inspect the drive belt(s) for damage, separation or sections of missing ribs. Did you find and repair the condition?	—	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	—	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the repair?	—	Go to Step 8	Go to Step 7

Drive Belt Rumbling Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
7	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	—	Go to Step 8	—
8	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to Diagnostic Aids

Drive Belt Vibration Diagnosis

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as, but not limited to the A/C system overcharged, the power steering system restricted or the incorrect fluid or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

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

- This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system or the drivetrain.
- This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also, DTC's may set when the engine is operating with the drive belt removed.
- The drive belt(s) may cause a vibration. While the drive

belt(s) is removed, inspect the condition of the belt.

- Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer or washer was installed.
- This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.
- This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known good water pump.
- Accessory drive component brackets that are bent, cracked or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Value(s)	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.				
DEFINITION:				
<ul style="list-style-type: none"> The vibration is engine-speed related. The vibration may be sensitive to accessory load. 				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Verify that the vibration is engine related. Does the engine make the vibration?	—	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	—	Go to <i>Engine Related Vibration</i> in Vibration and Diagnosis	Go to Step 4
4	Inspect the drive belt(s) for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	—	Go to Step 5	Go to Step 6

Drive Belt Vibration Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
5	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	—	Go to Step 11	—
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	—	Go to Step 7	Go to Step 8
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Did you complete the repair?	—	Go to Step 11	—
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to <i>Fan Clutch Replacement</i> in Engine Cooling. Did you find and correct the condition?	—	Go to Step 11	Go to Step 9
9	Inspect for bent water pump shaft, if the water pump is belt driven. Refer to <i>Water Pump Replacement (4.3L Engine)</i> in Engine Cooling. Did you find and correct the condition?	—	Go to Step 11	Go to Step 10
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	—	Go to Step 11	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to Step 3

Drive Belt Falls Off Diagnosis

Diagnostic Aids

If the drive belt(s) repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied and released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

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

Test Description

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

2. This inspection is to verify the condition of the drive belt. Damage may have occurred to the drive belt when the drive belt fell off. The drive belt may have been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing or damaged belt plies.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley or the pulley bent inward or outward from a

previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure of that pulley.

5. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
7. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer or washer was installed. Missing, loose or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

Step	Action	Value(s)	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.				
DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Inspect for a damaged drive belt. Did you find the condition?	—	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Does the drive belt continue to fall off?	—	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	—	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	—	Go to Step 12	Go to Step 6
6	Inspect for a bent or cracked bracket. Did you find and repair the condition?	—	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	—	Go to Step 8	Go to Step 9
8	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Does the drive belt continue to fall off?	—	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Does the drive belt tensioner operate correctly?	—	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <i>Drive Belt Tensioner Replacement</i> . Does the drive belt continue to fall off?	—	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	—	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	—	System OK	Go to Step 2

Drive Belt Excessive Wear Diagnosis

Diagnostic Aids

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

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

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt(s) fall off.

Test Description

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

- This inspection is to verify the drive belt(s) is correctly installed on all of the drive belt pulleys. Wear on the

drive belt(s) may be caused by mis-positioning the drive belt(s) by one groove on a pulley.

- The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.
- This inspection is to verify the drive belt(s) is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt(s) should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

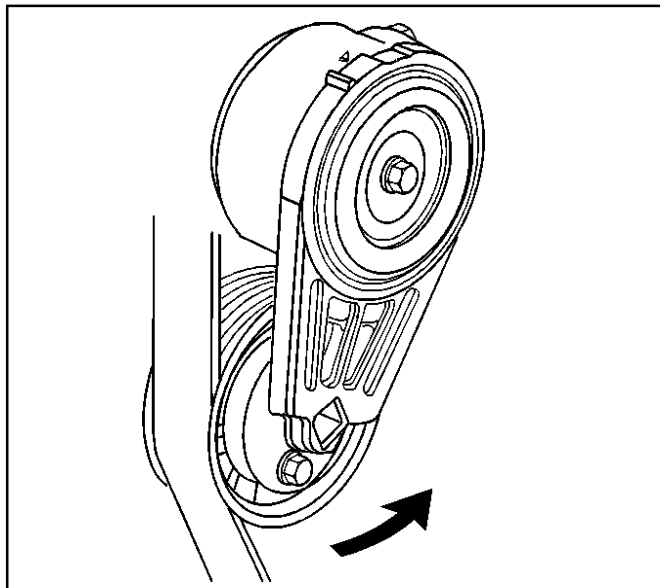
Step	Action	Value(s)	Yes	No
<p>Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.</p>				
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	—	Go to Step 2	Go to <i>Symptoms Drive Belt</i>
2	Inspect the drive belt(s) for the proper installation. Refer to <i>Drive Belt Replacement</i> . Did you find the condition?	—	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	—	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose or wiring harness. Did you find and repair the condition?	—	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	—	Go to Step 6	—
6	Operate the system in order to verify the repair. Does the drive belt continue to fall off?	—	System OK	—

Drive Belt Tensioner Diagnosis

Inspection Procedure

Important

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



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2. Position a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
3. Move the drive belt tensioner through it's full travel.
 - The movement should feel smooth
 - There should be no binding
 - The tensioner should return freely
4. If any binding is observed, replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
5. Install the drive belt. Refer to *Drive Belt Replacement*.

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

1. Remove the drive belt. Refer to *Drive Belt Replacement*.