

///MARINEPOWERTM

The Force Behind The Fun.TM

6.0 L

ENGINE SERVICE MANUAL



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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	
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

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

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)

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)

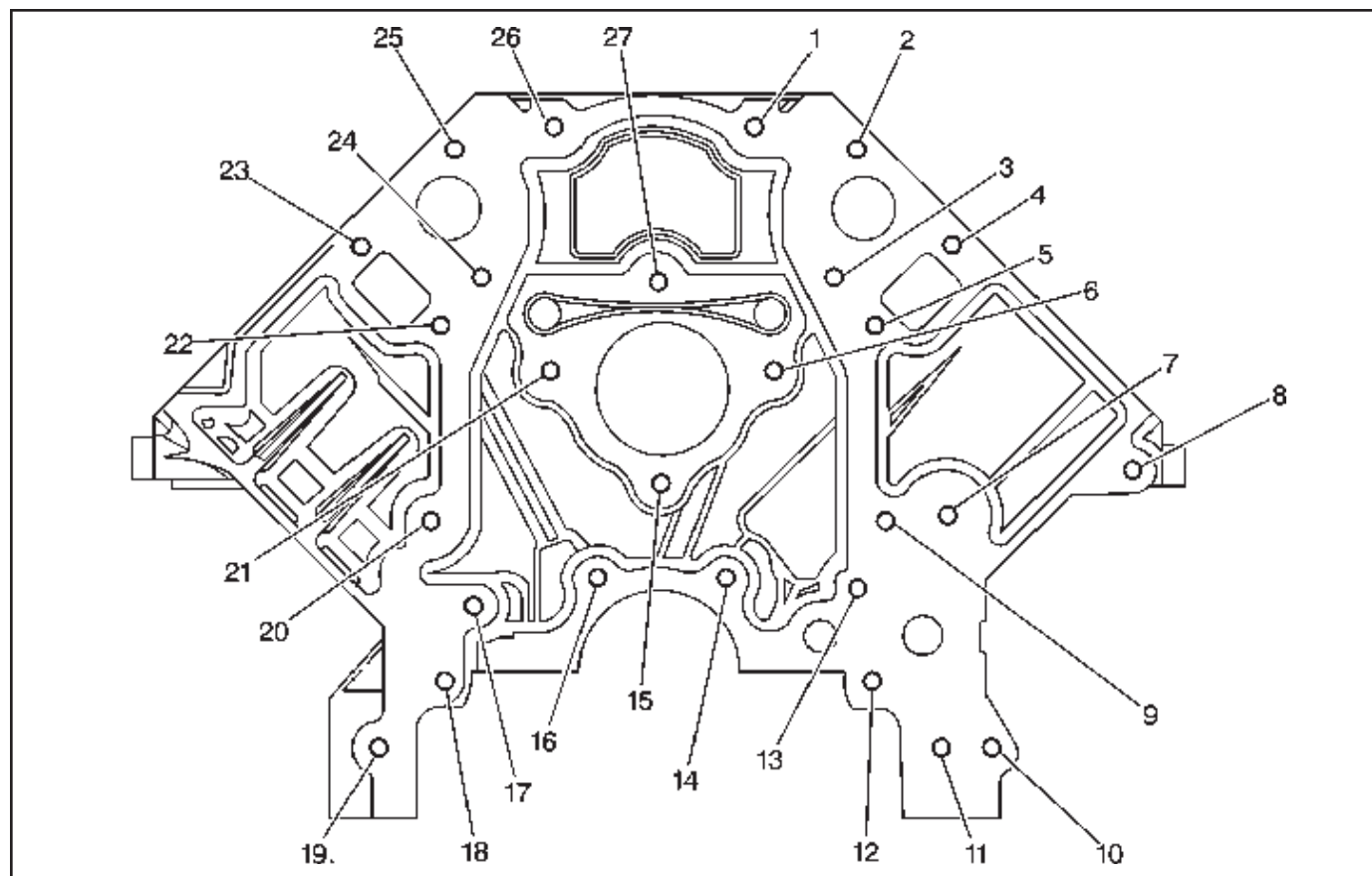
Application	GM SPO Group Number
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Gasket	0.423
Valve Rocker Arm Support	0.429
Valve Spring	0.303
Valve Spring Shim	0.303
Valve Stem Oil Seal	0.308
Water Pump Gasket	1.079
Water Pump with Gasket	1.069

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

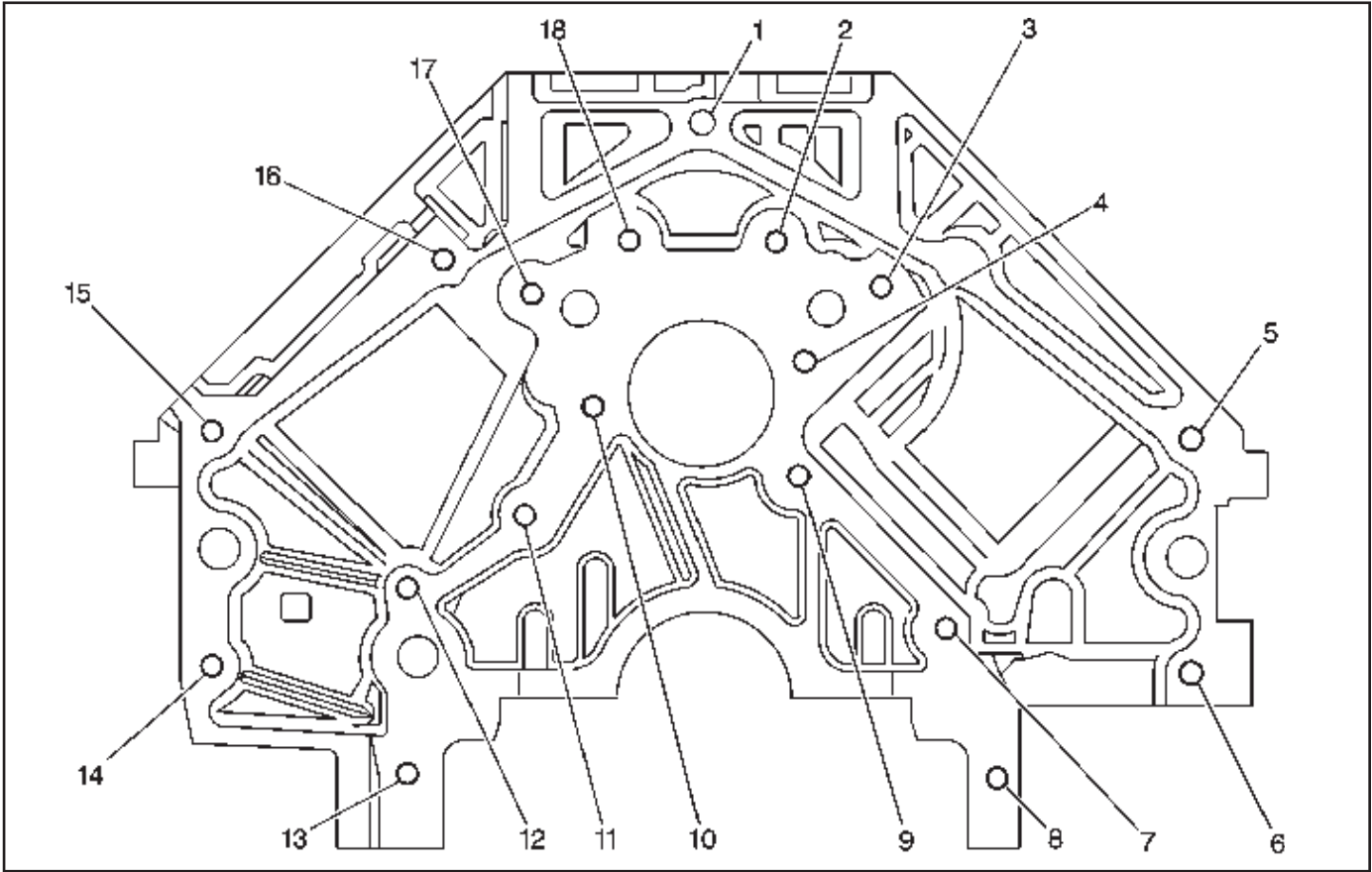


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Engine Block-Front View

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

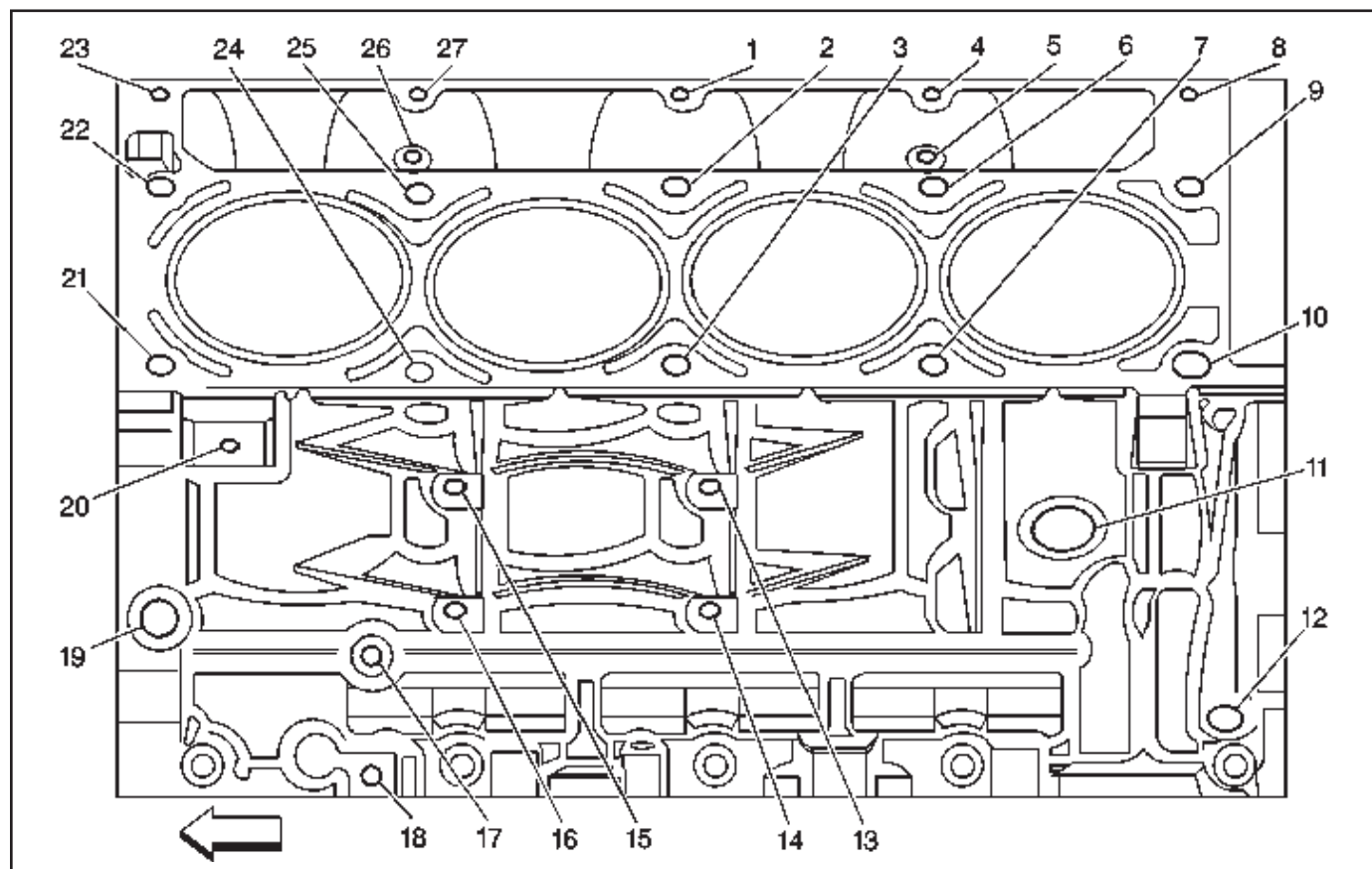


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Engine Block-Rear View

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

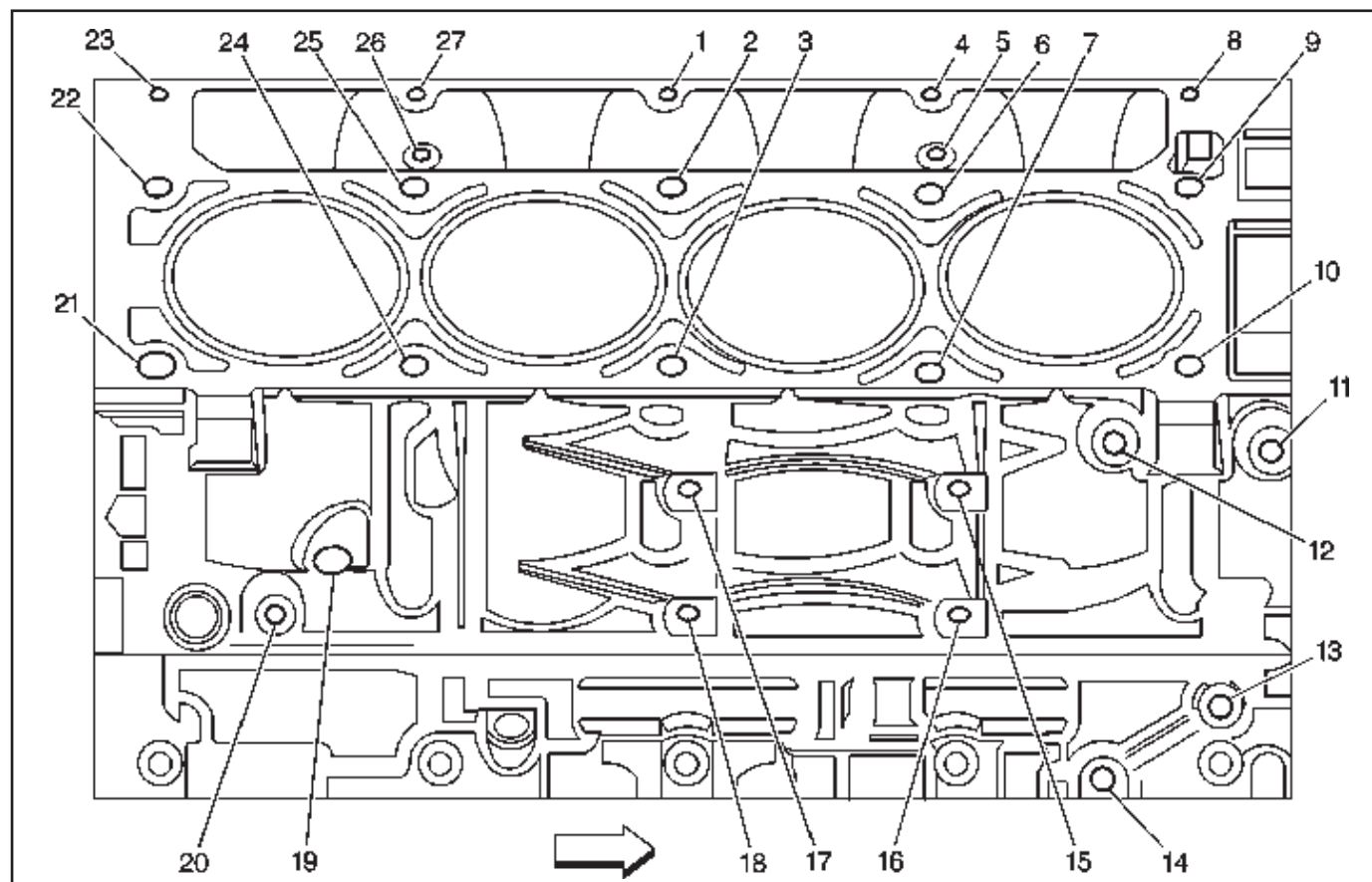


Engine Block-Left Side View

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

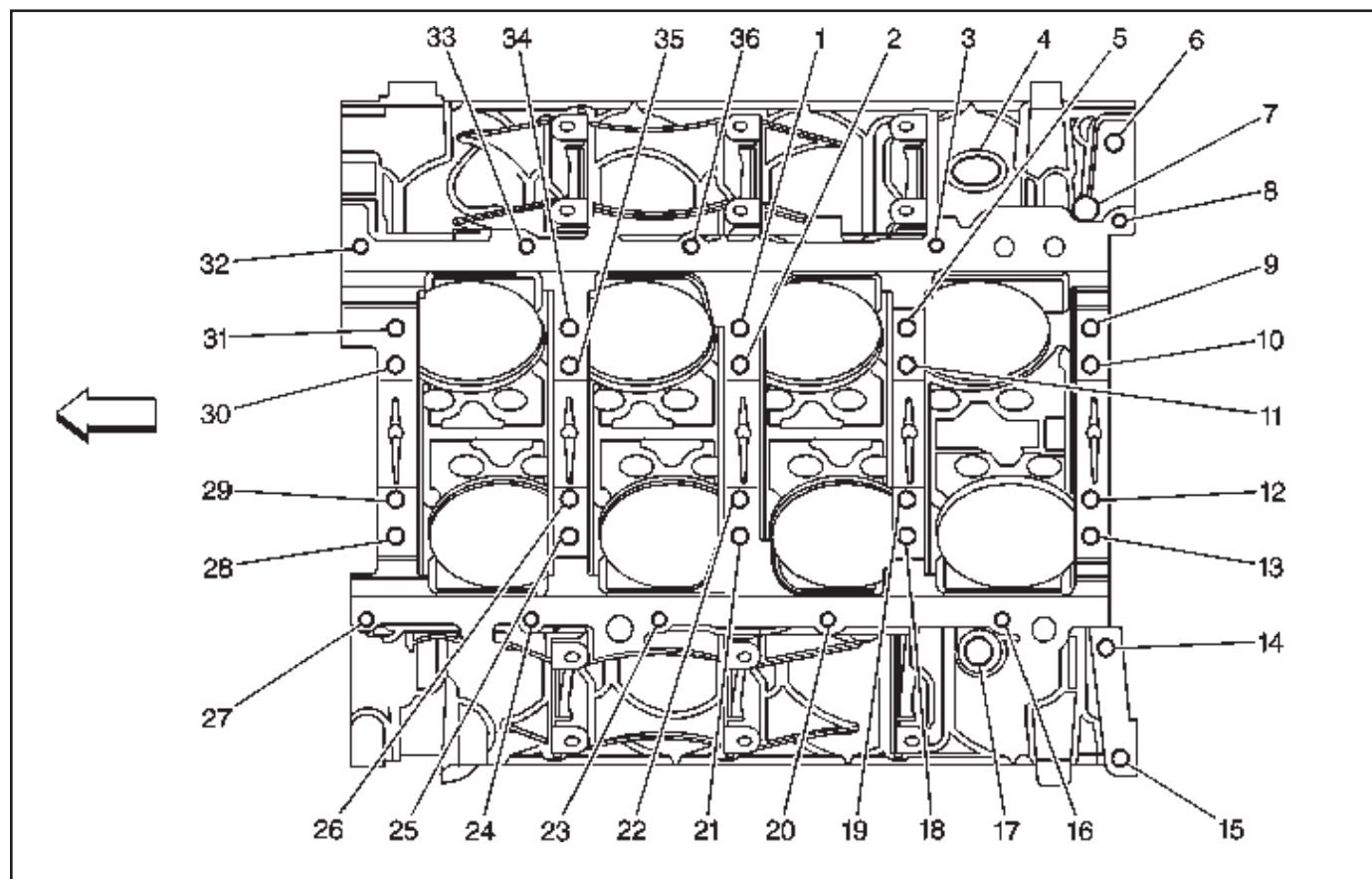


Engine Block-Right Side View

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



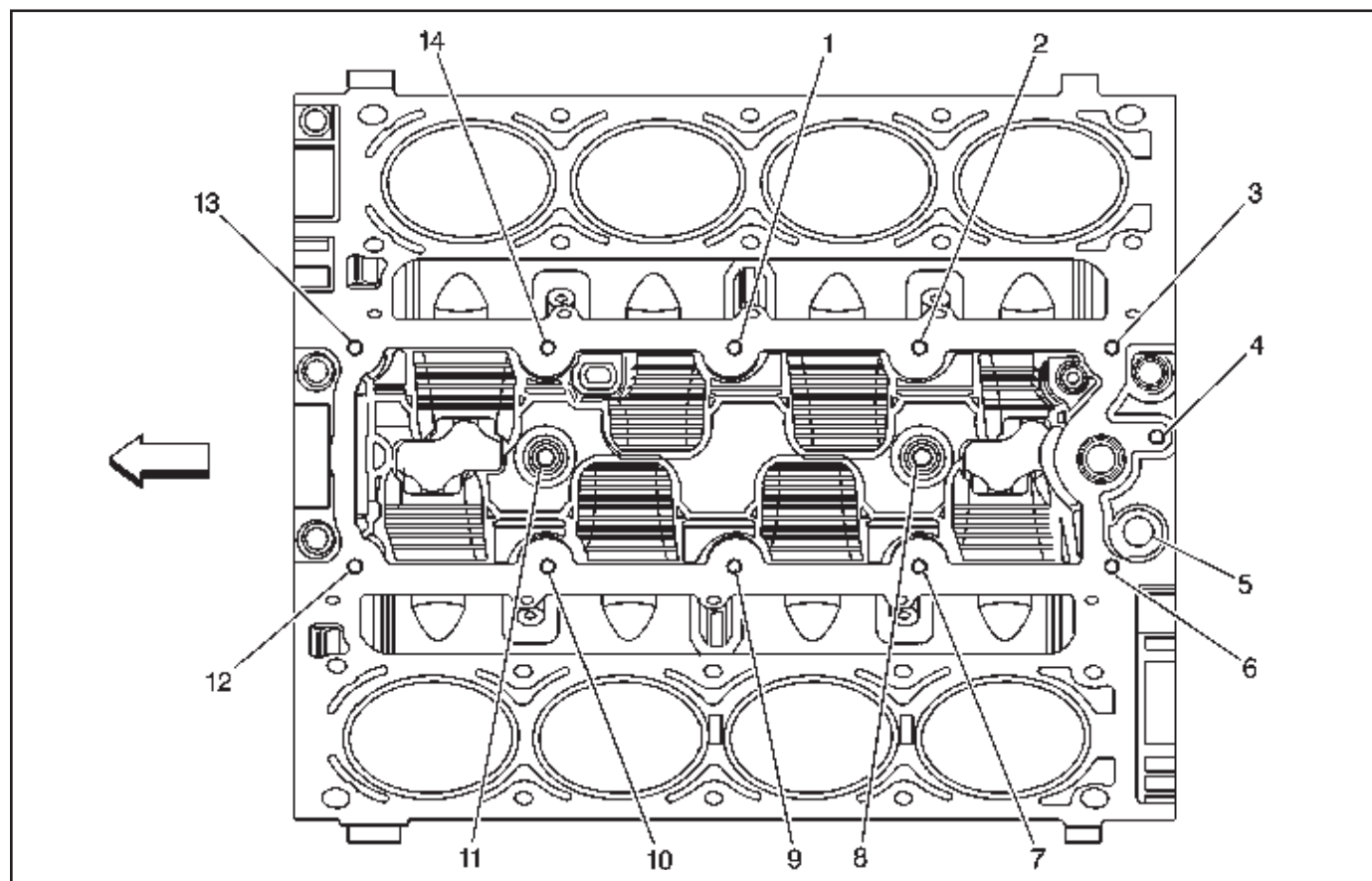
Engine Block-Bottom View

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)
<ul style="list-style-type: none"> 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

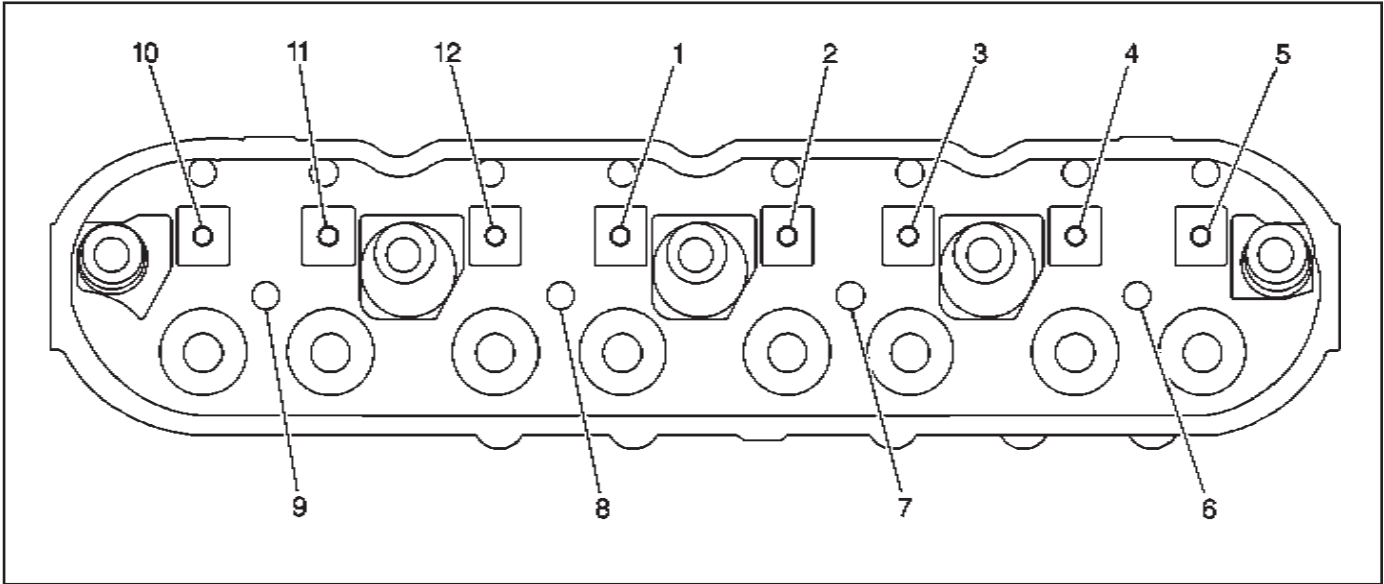


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Engine Block-Top View

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)

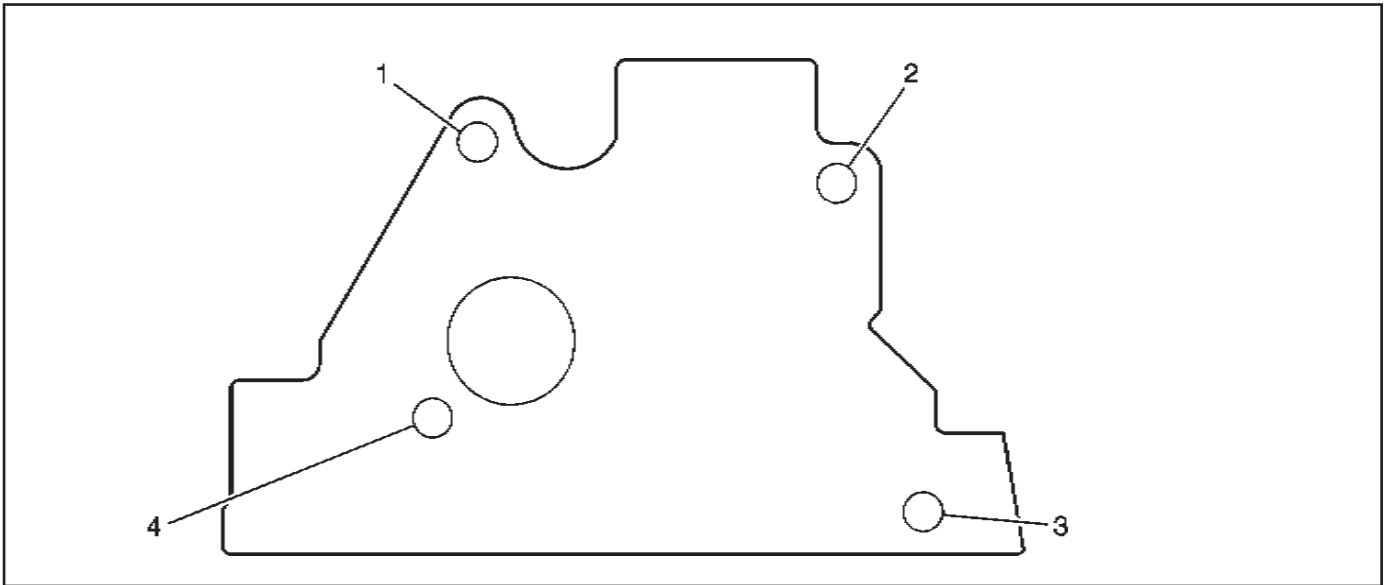
Cylinder Head-Top View



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)

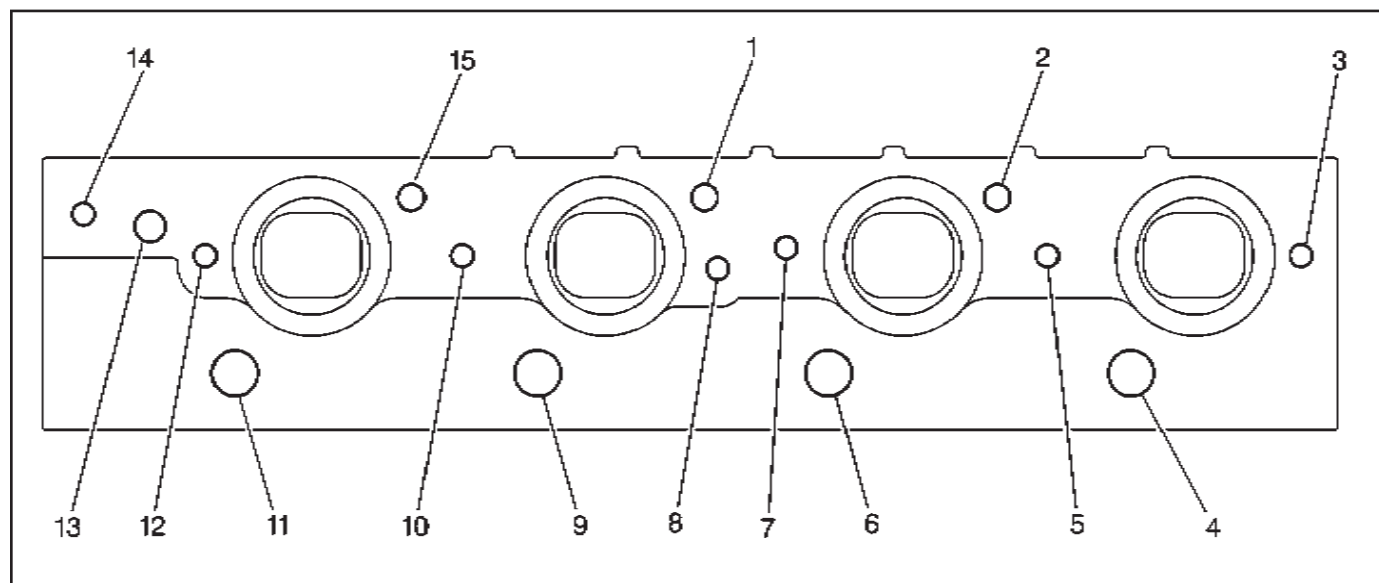
Cylinder Head-End View



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

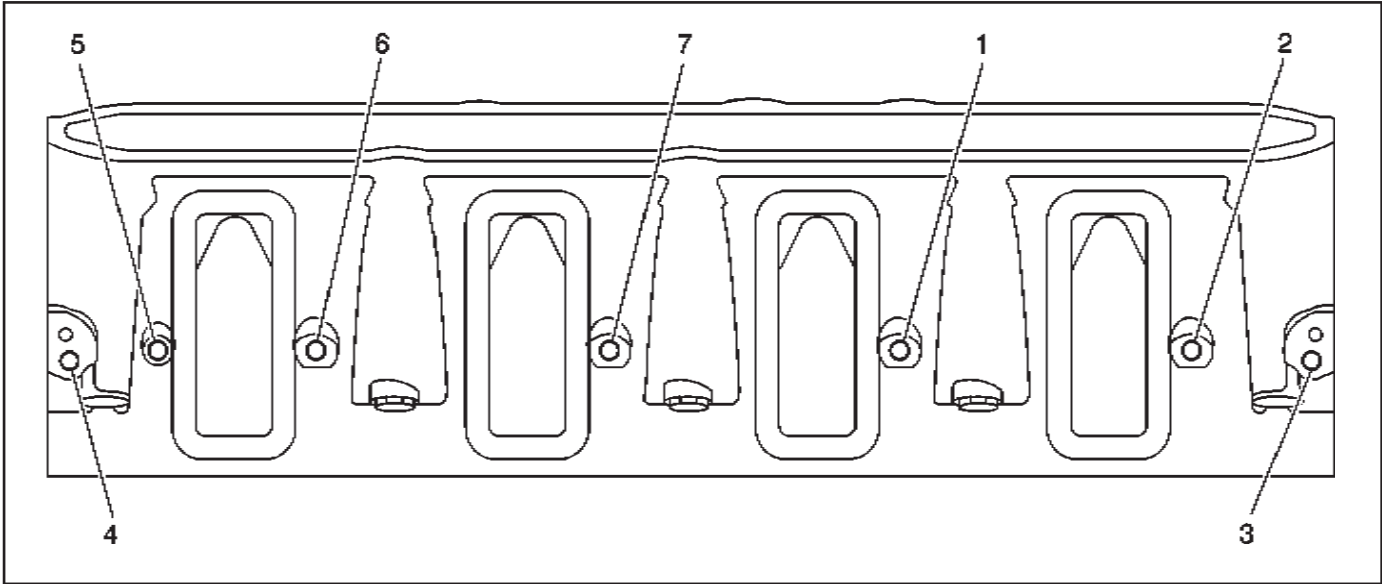


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Cylinder Head-Exhaust Manifold Deck View

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



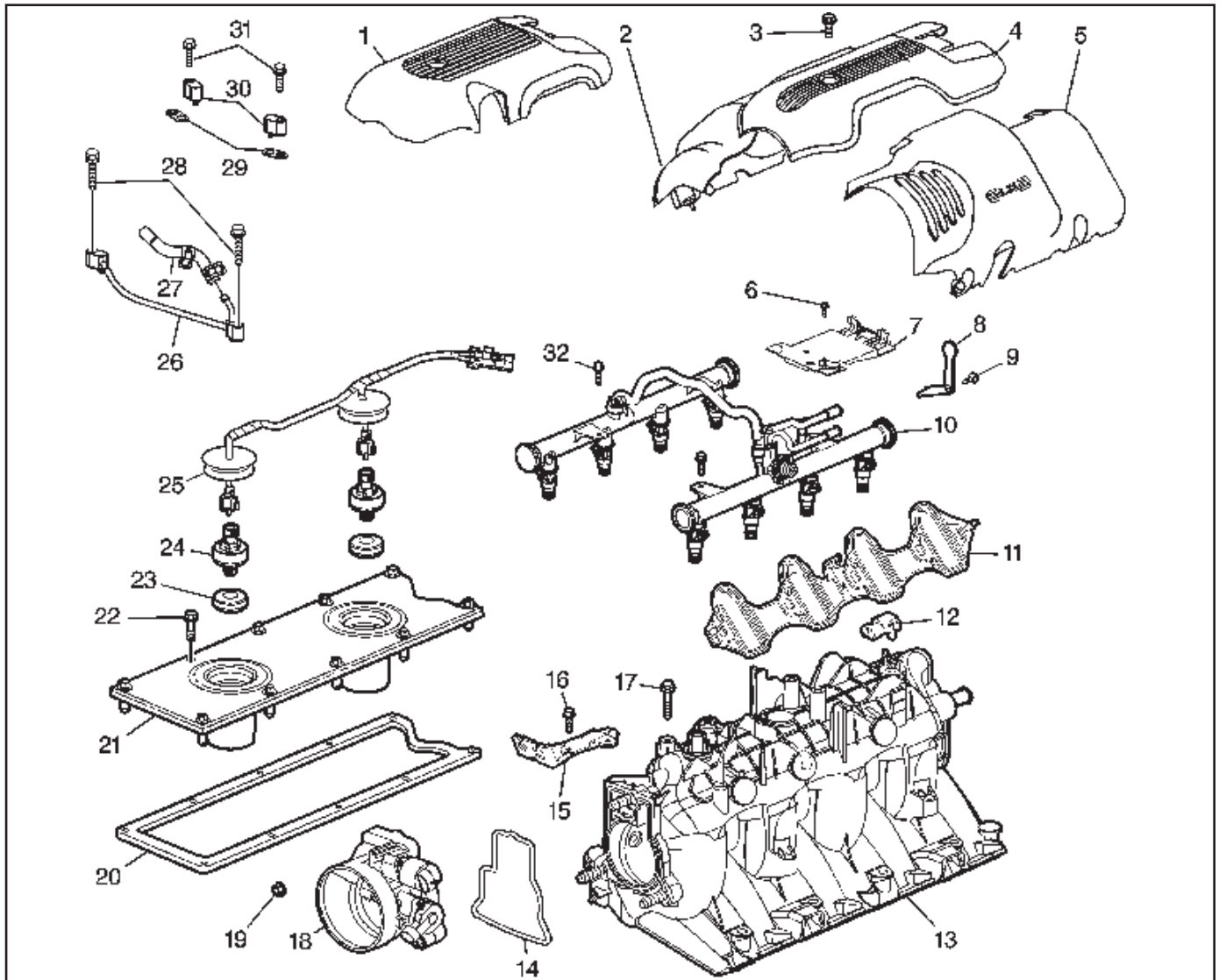
Cylinder Head-Intake Manifold Deck View

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



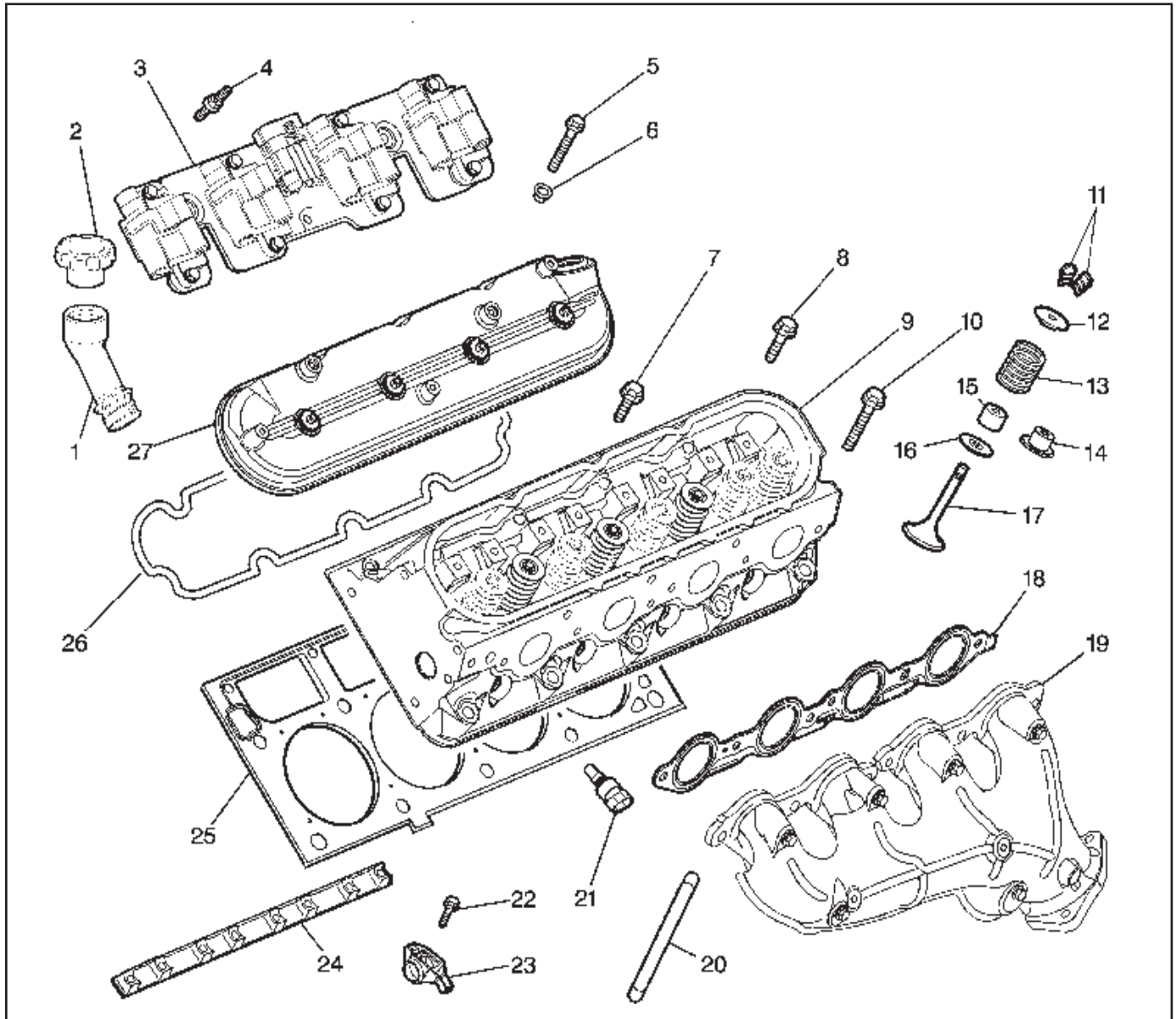
Legend

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

Cylinder Head/Upper Engine

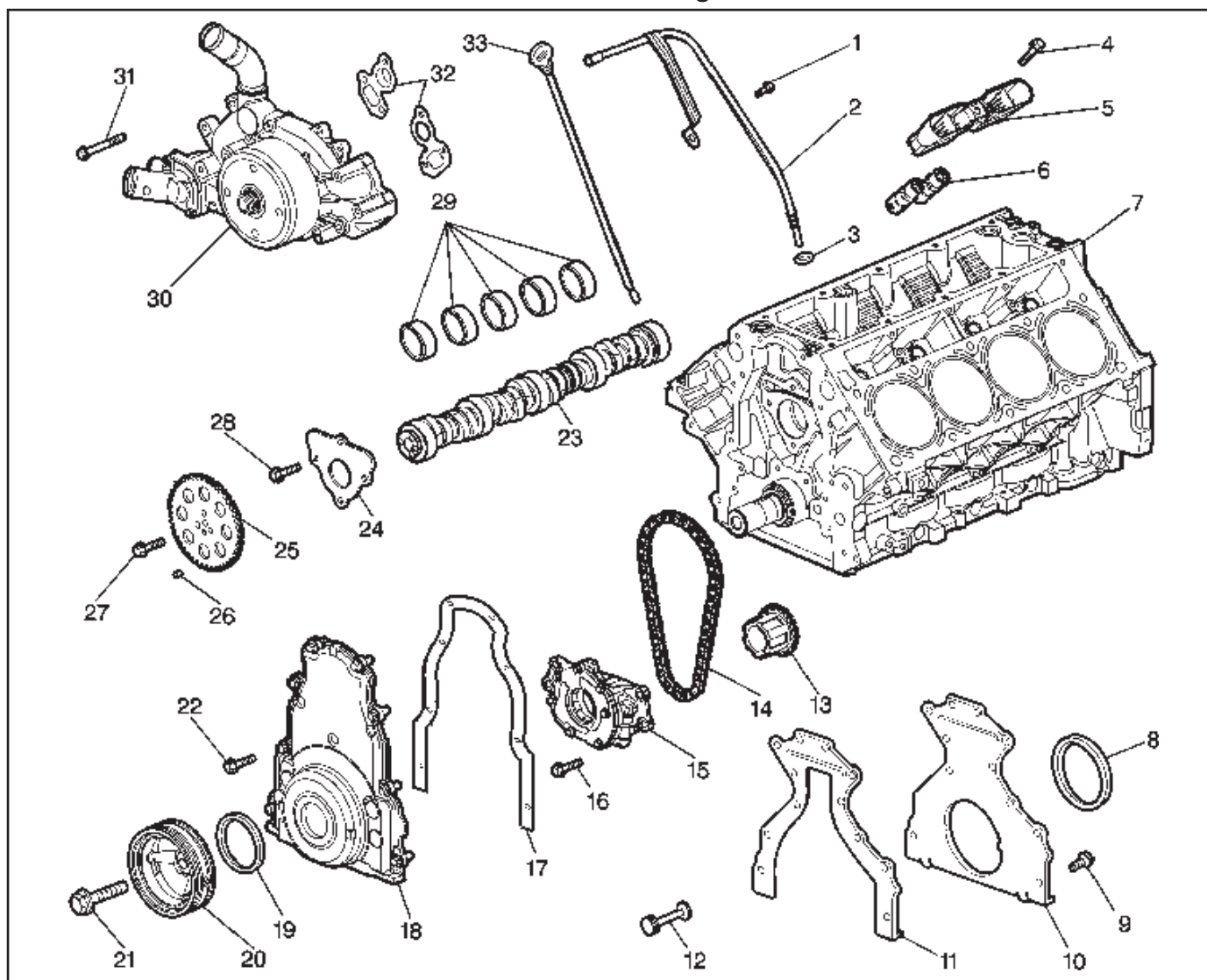


741561

Legend

- | | |
|---|--|
| (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

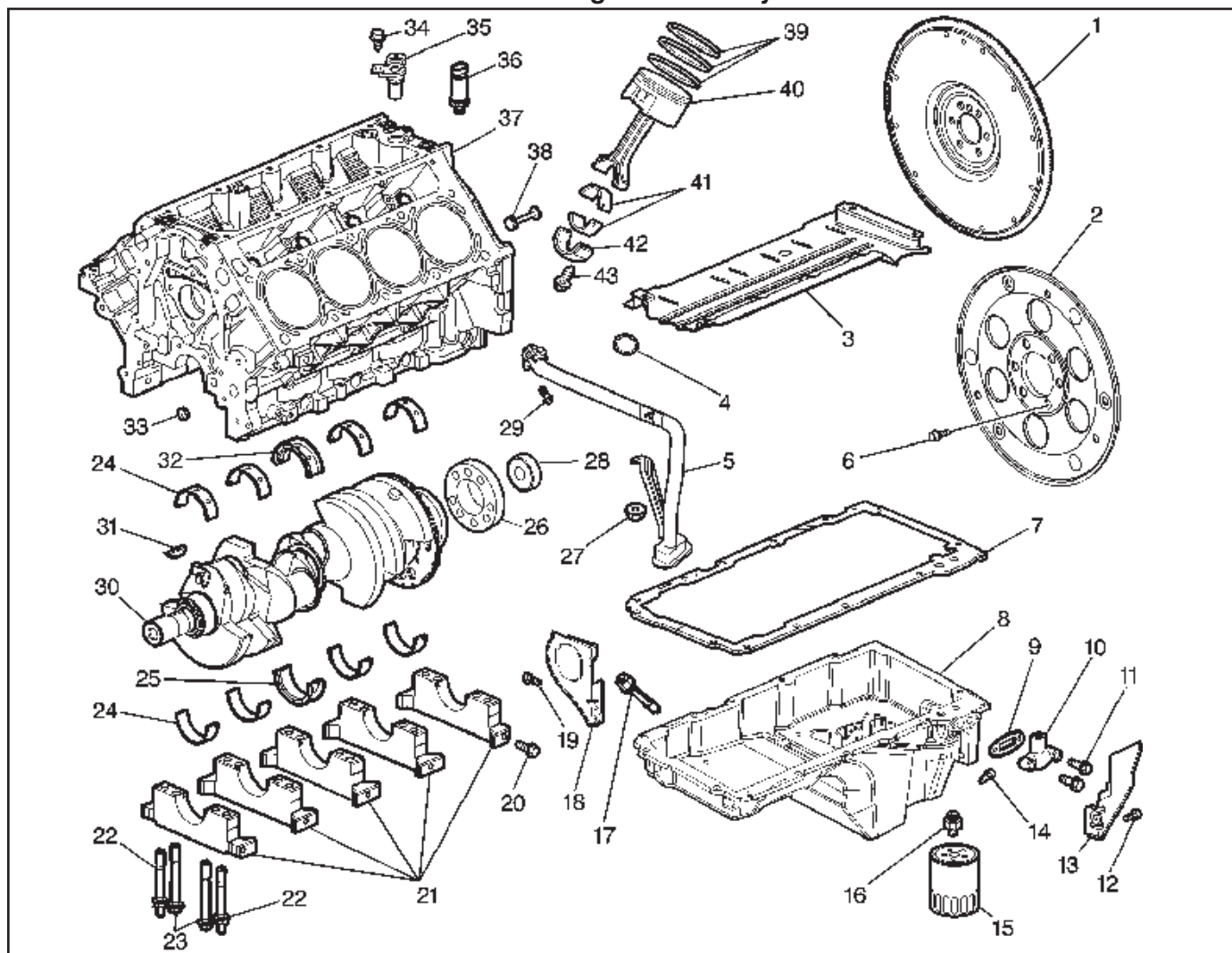


260163

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

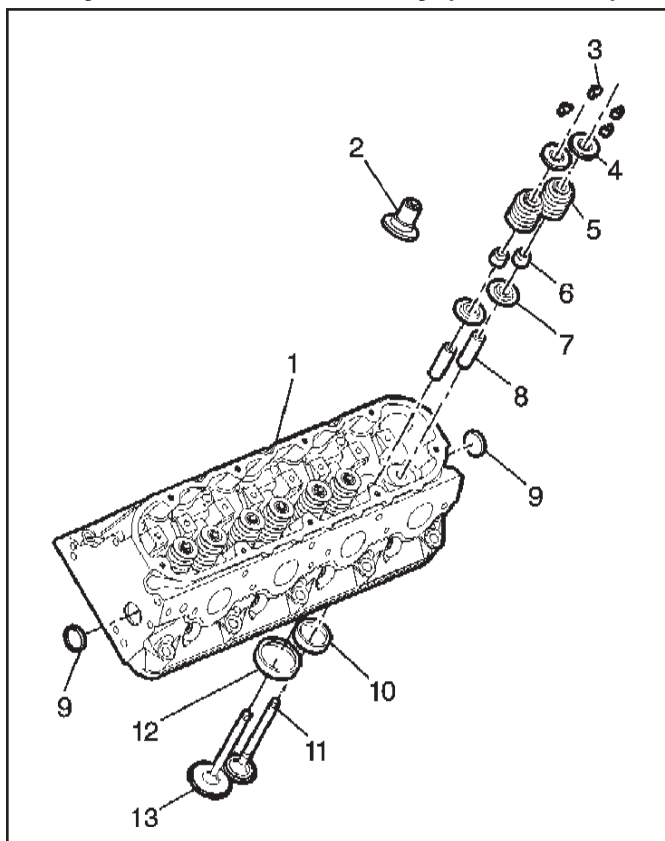


642273

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	

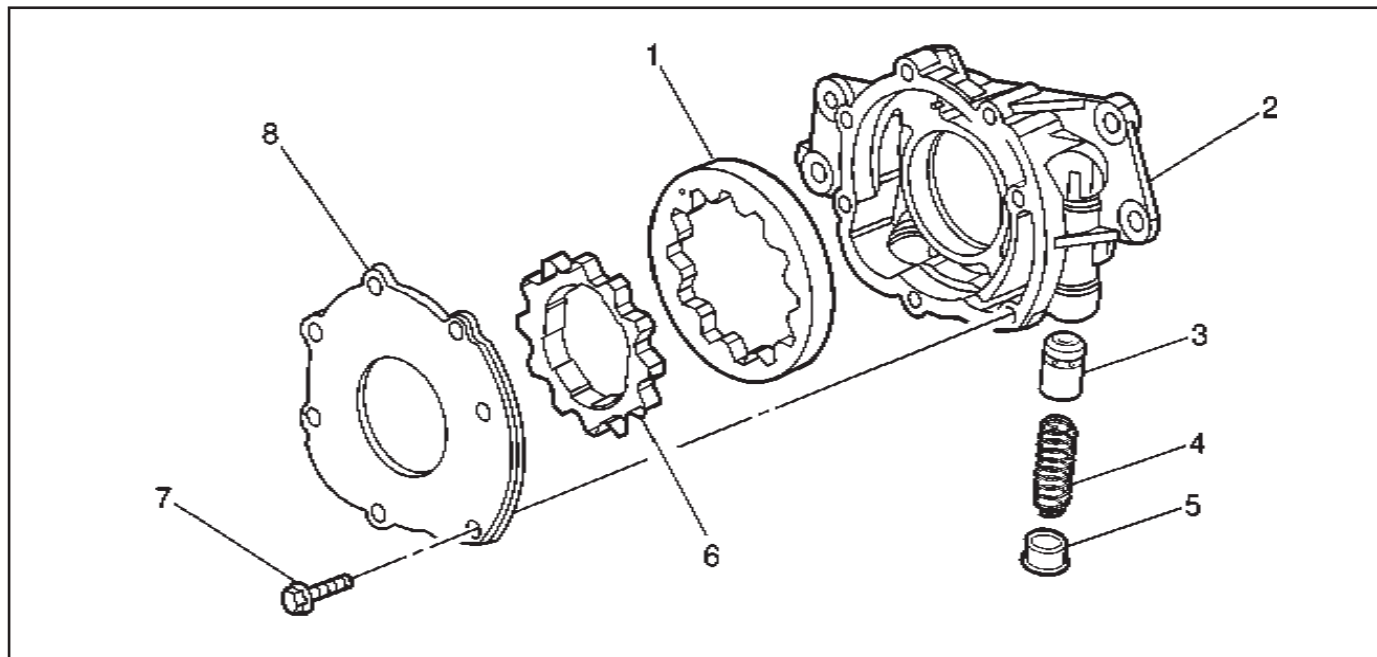
Cylinder Head Assembly (Aluminum)

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

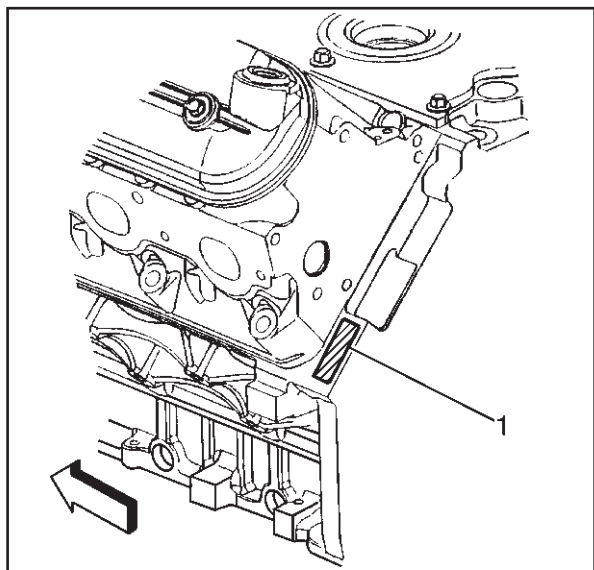
Oil Pump Assembly



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 |

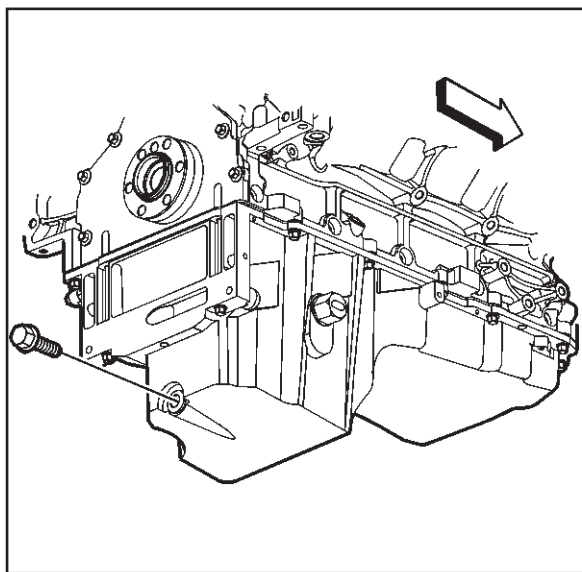


260136

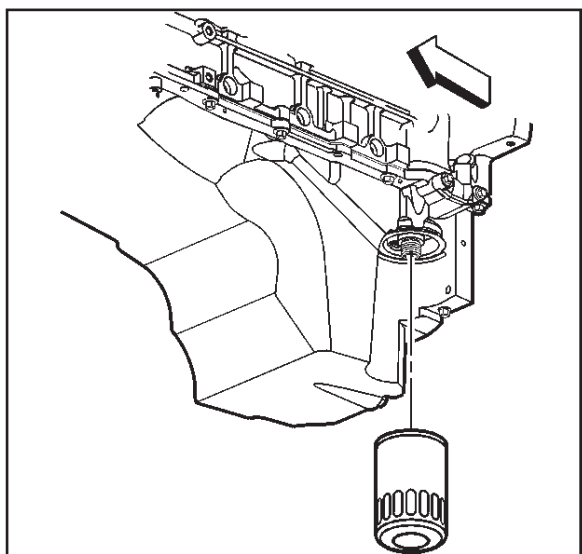
Engine Identification

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

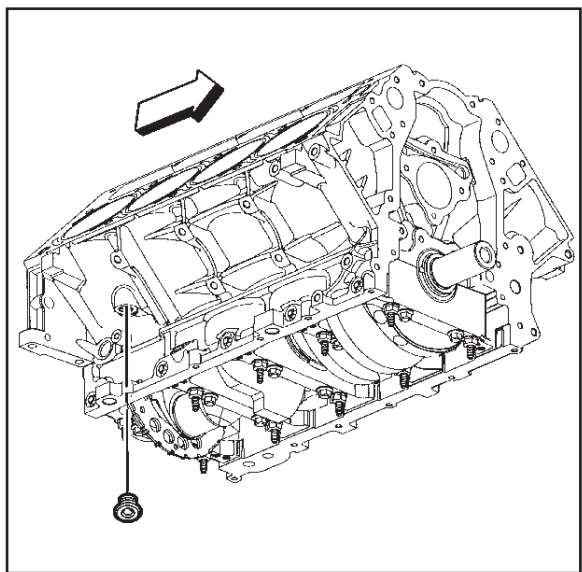
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260111



260117



63164

Repair Instructions

Draining Fluids and Oil Filter Removal

Tools Required

J 41712 Oil Pressure Sensor Socket

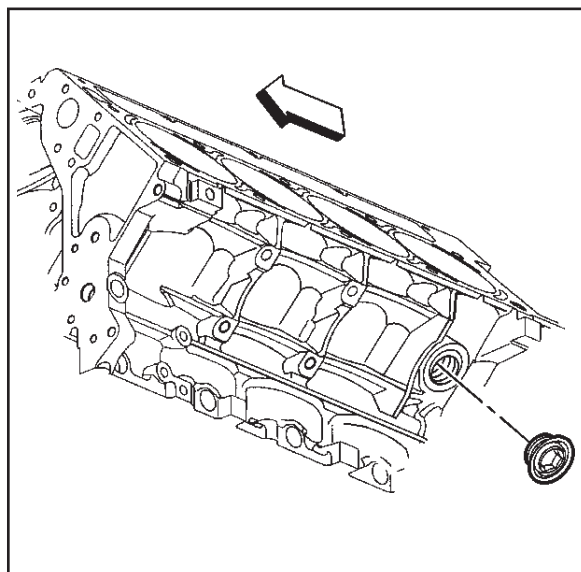
Important: In order to completely drain the oil from the oil pan internal baffling, the bottom of the oil pan must be level during the oil drain procedure.

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

2. Remove the engine oil filter.

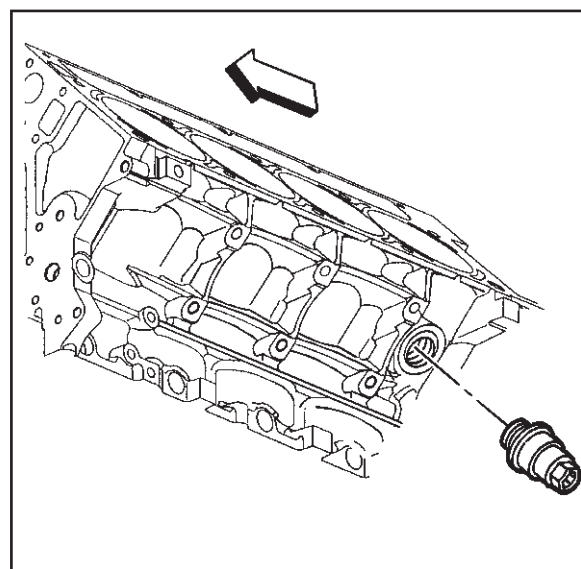
3. Remove the right rear engine block coolant drain plug and allow the coolant to drain.

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



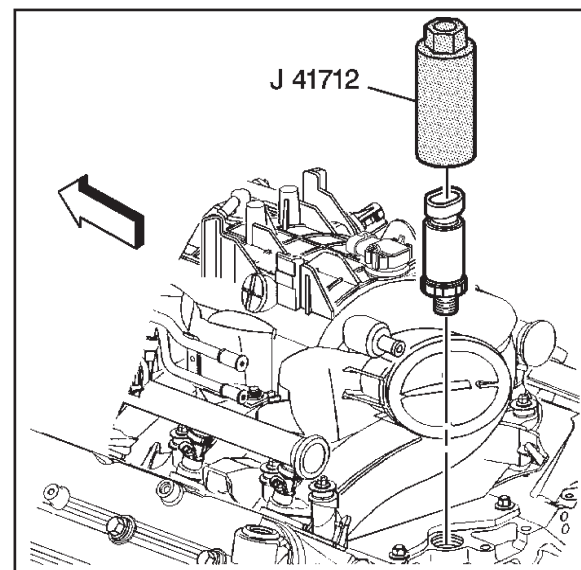
260138

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

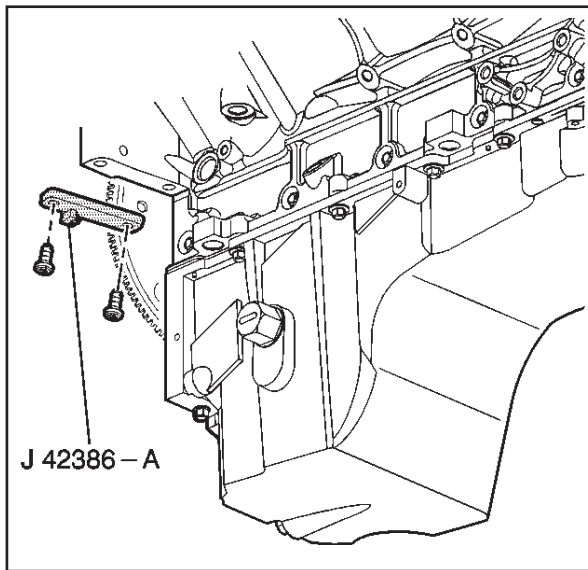


260137

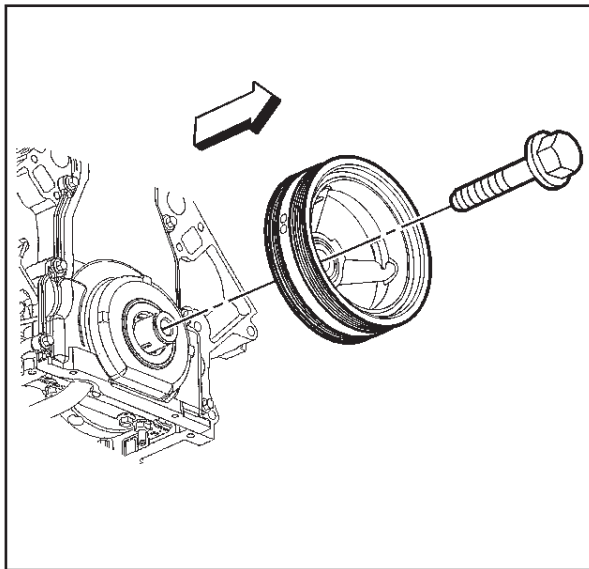
6. Use the *J 41712* or equivalent in order to remove the oil pressure sensor, if required.



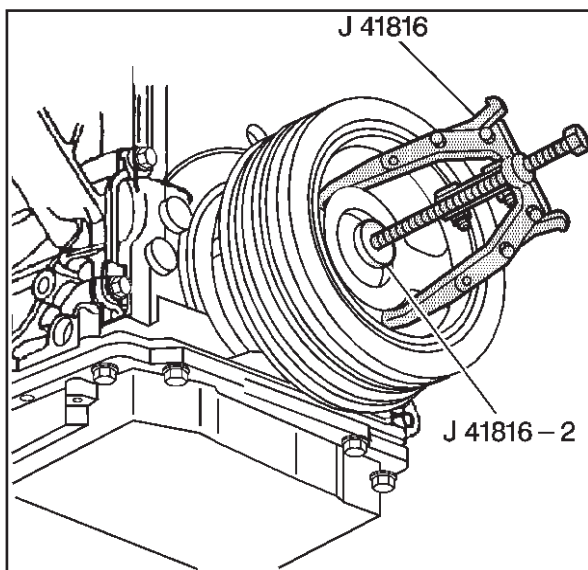
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260126



260154



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).

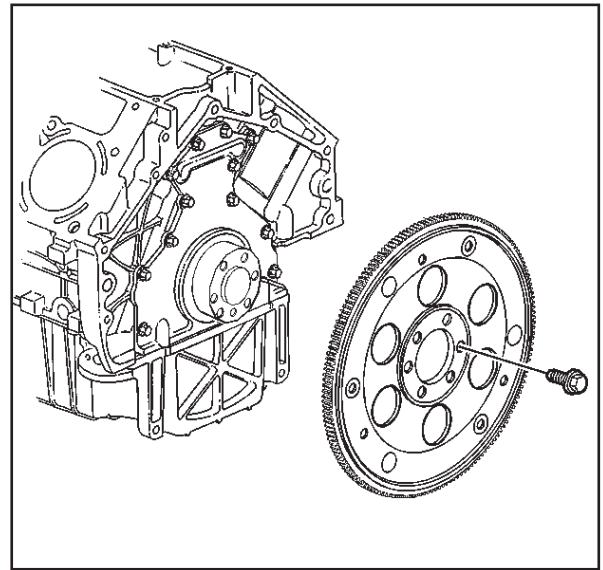
2. Remove the crankshaft balancer bolt.
Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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

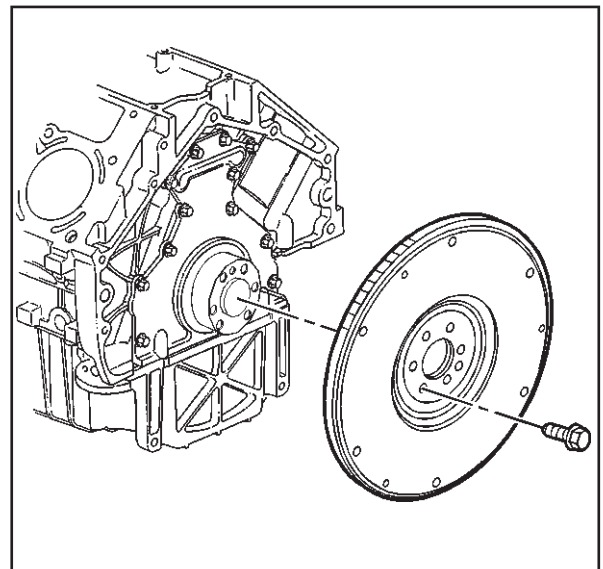
Important: Note the position and direction of the engine flywheel before removal. The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure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

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



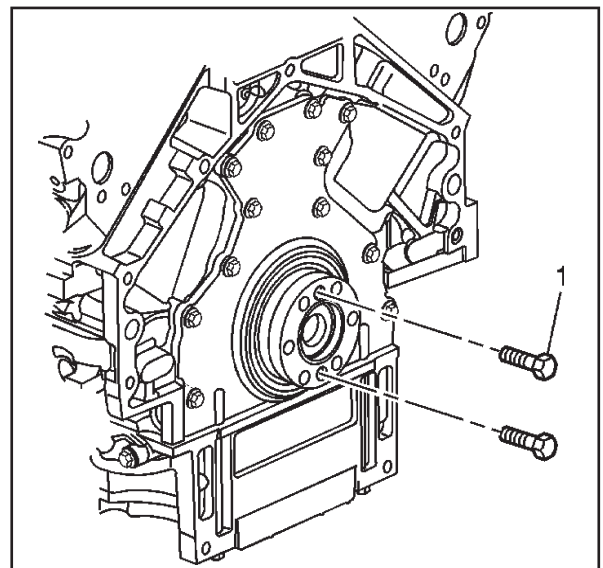
178458

3. Remove the manual transmission flywheel, if applicable.

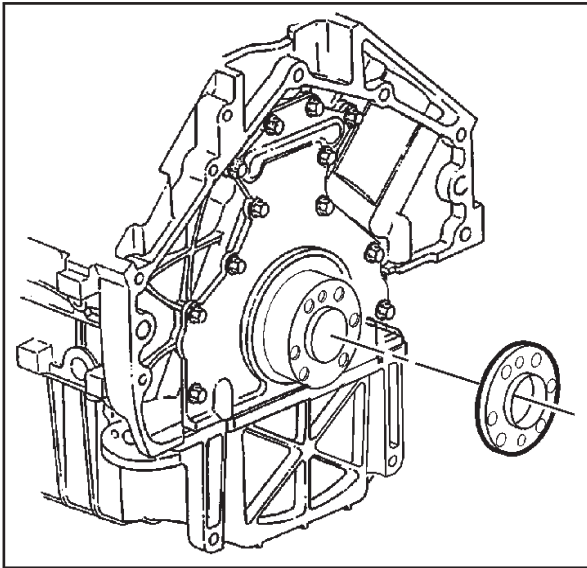


156166

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.

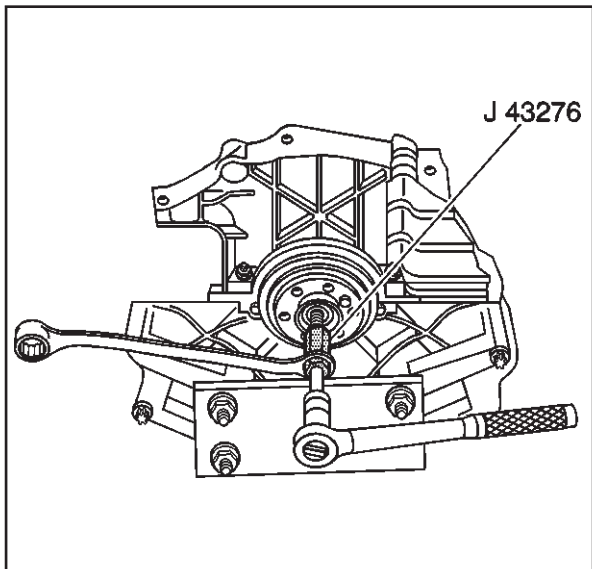


642281



642276

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



353275

Clutch Pilot Bearing Removal

Tools Required

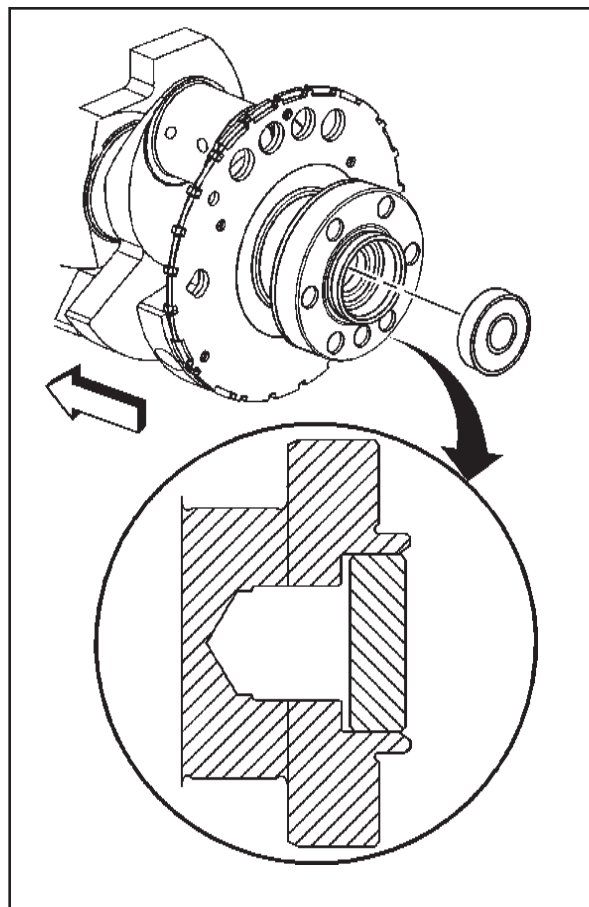
J 43276 Clutch Pilot Bearing Remover

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.



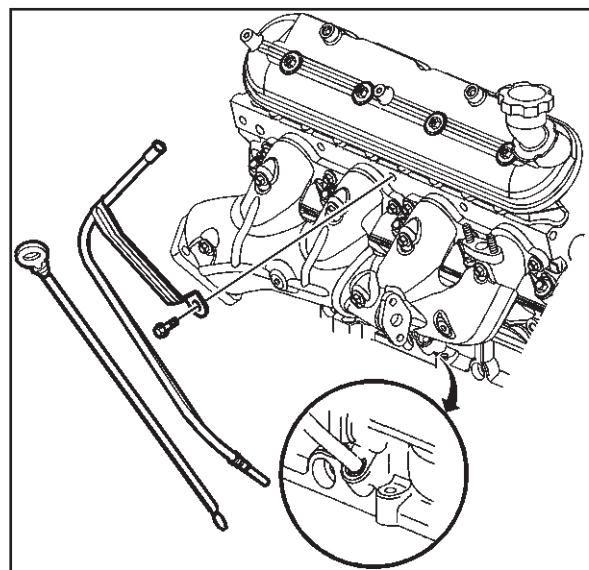
642283

Oil Level Indicator and Tube Removal

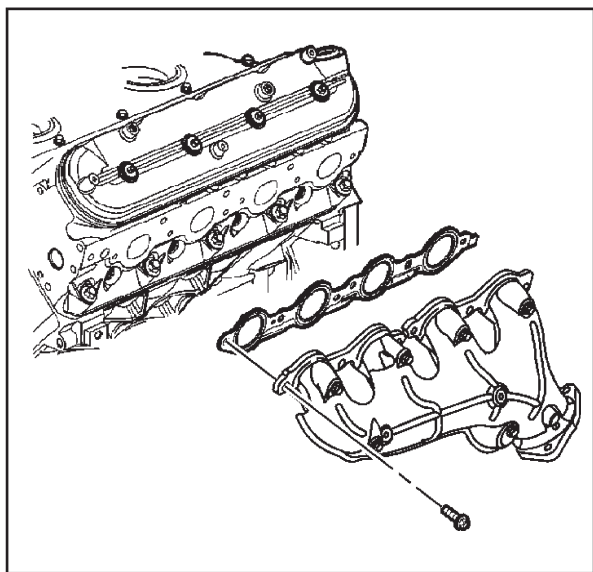
1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

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.



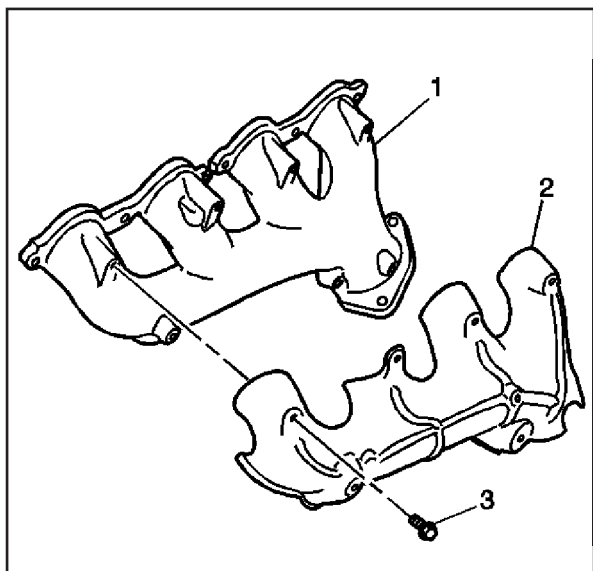
260114



741552

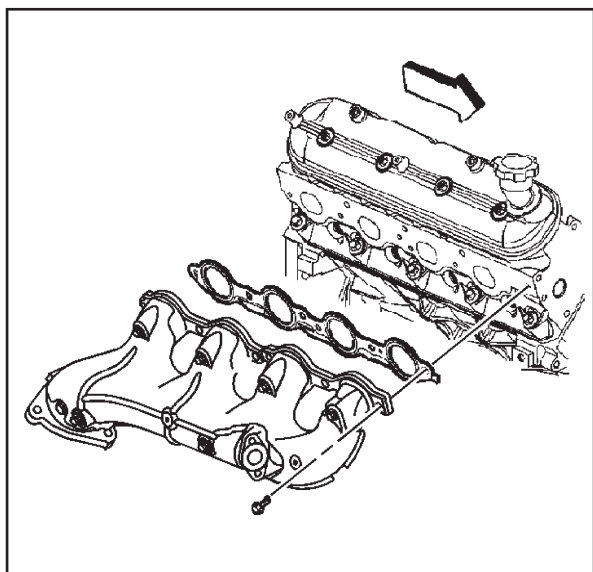
Exhaust Manifold Removal-Left

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.



492766

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

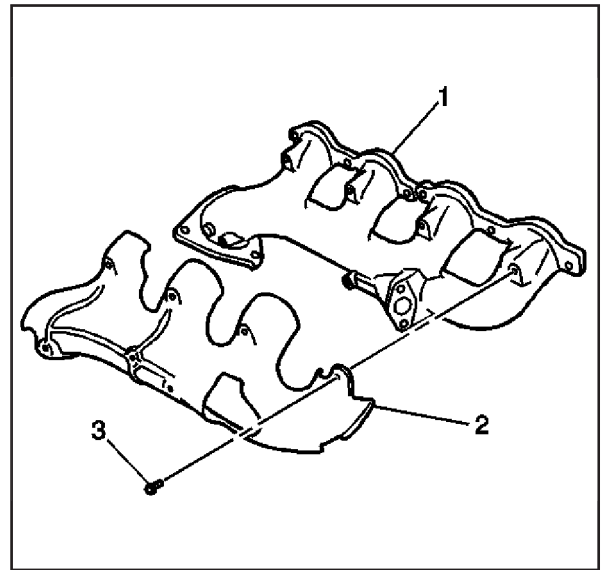


741554

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.

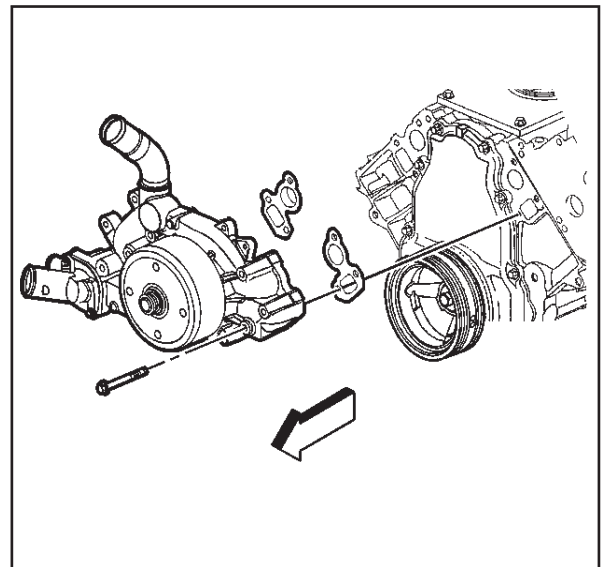
4. Remove the heat shield (2) and bolts (3) from the manifold (1), if required.



492768

Water Pump Removal

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

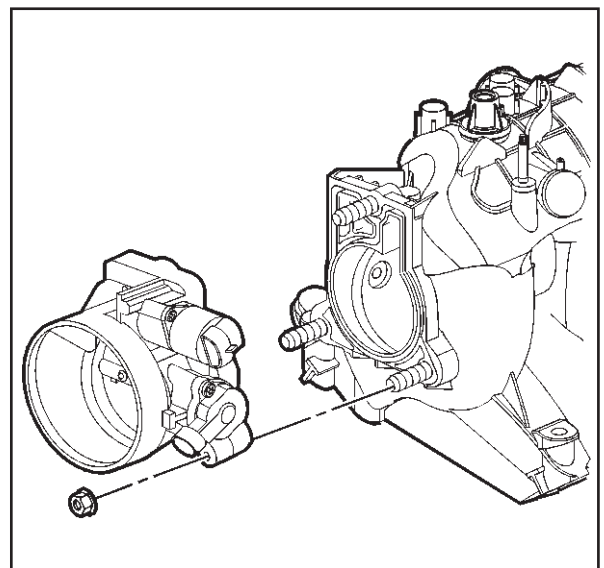


260121

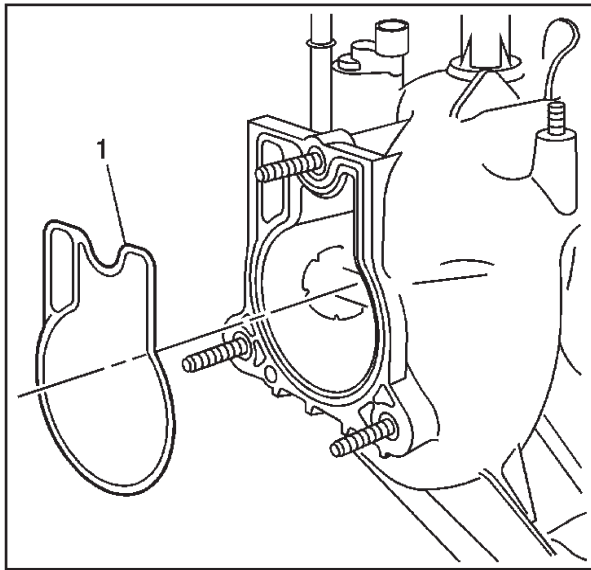
Throttle Body Removal

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.

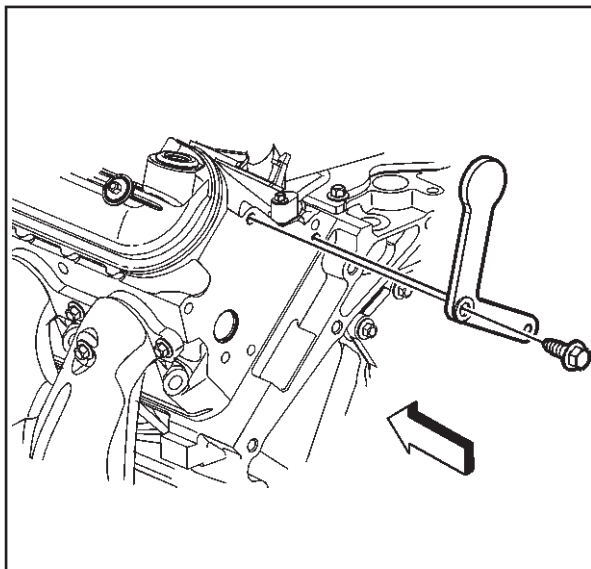


260174



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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

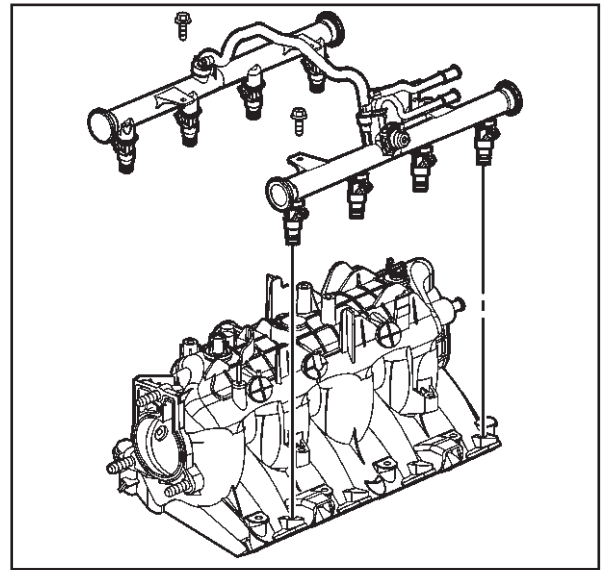
3. Loosen the crossover tube-to-right fuel rail retaining bolt.
4. Remove the fuel rail bolts.

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.



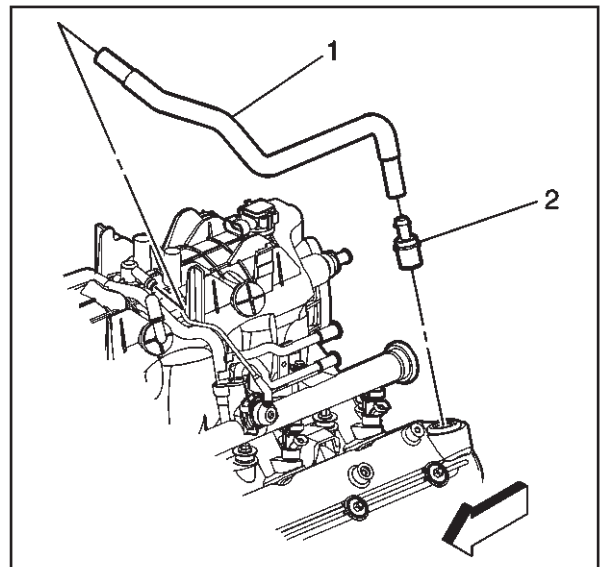
260176

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.

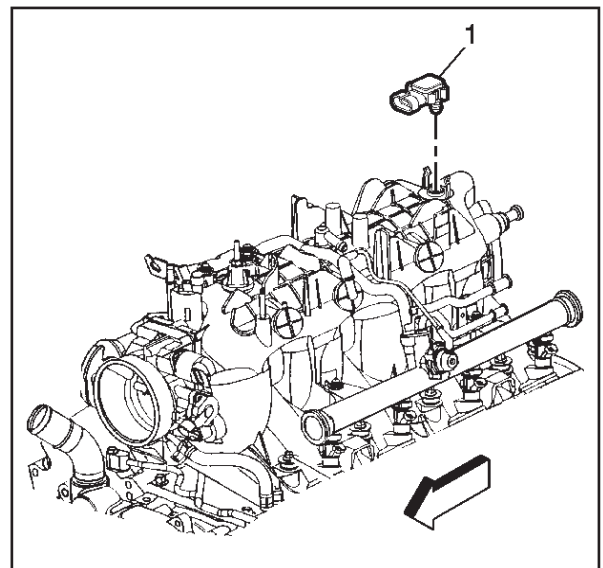
DO NOT reuse the intake manifold-to-cylinder head gaskets.

1. Remove the Positive Crankcase Ventilation (PCV)

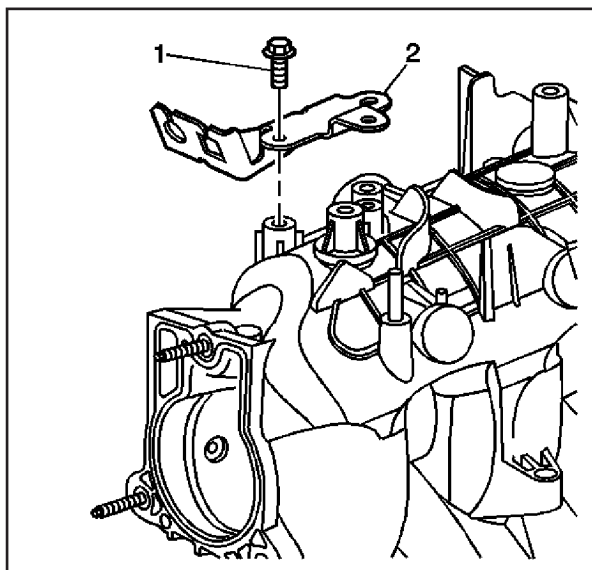


260078

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.

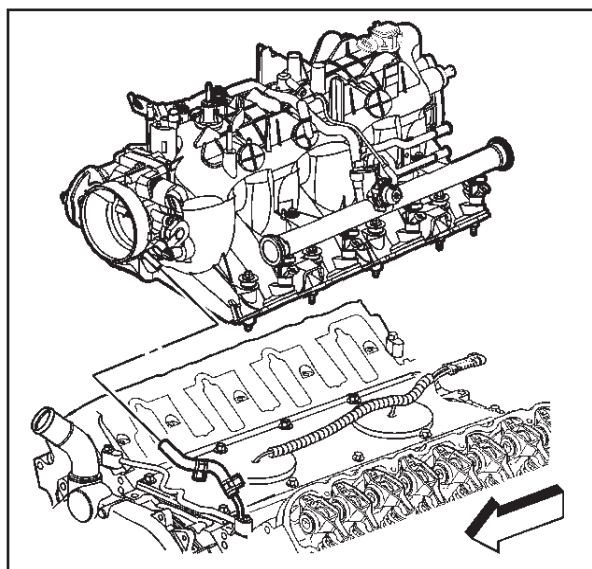


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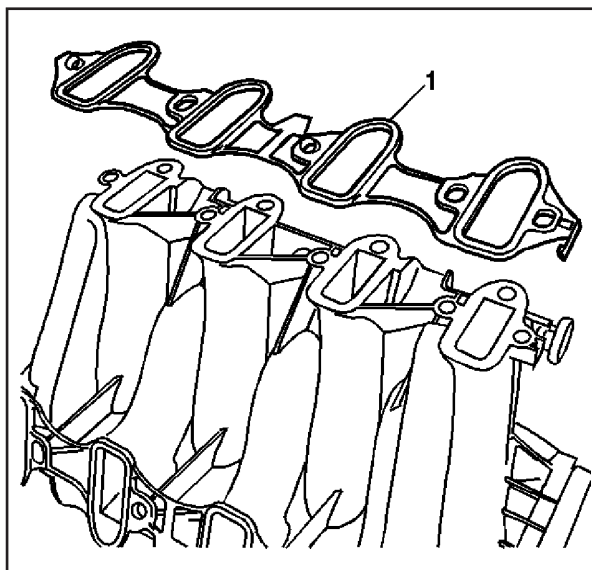
492765

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.

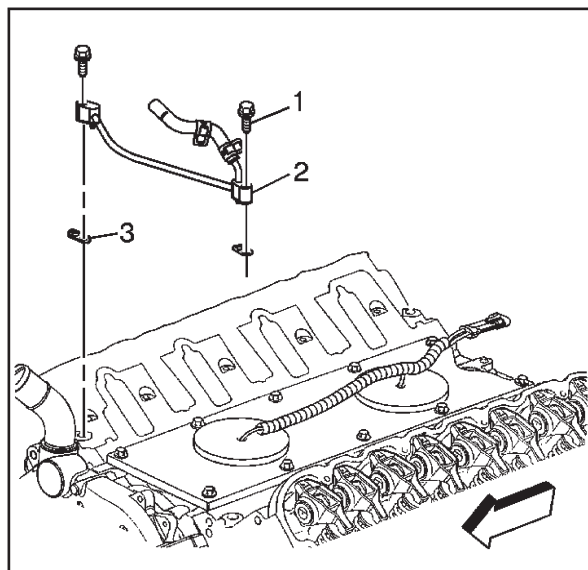


492770

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

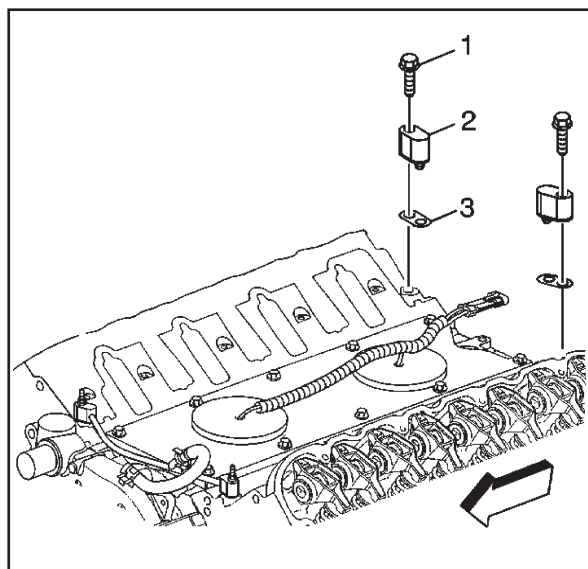
Coolant Air Bleed Pipe Removal

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



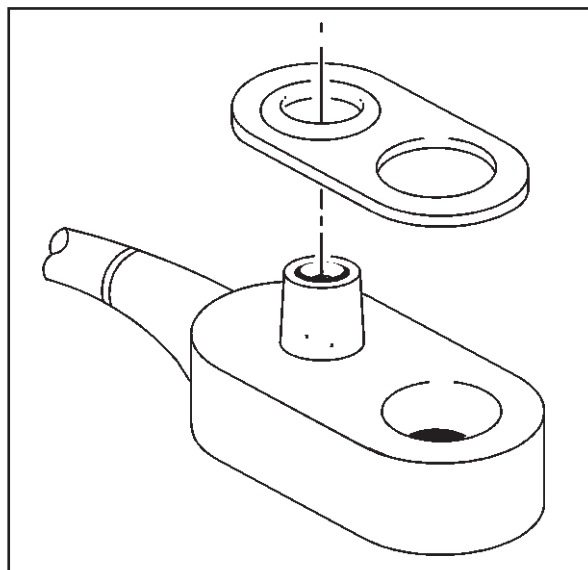
741555

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

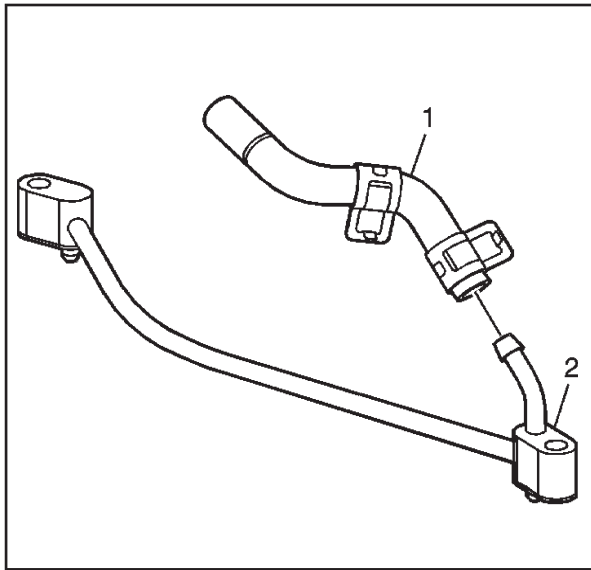


639609

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

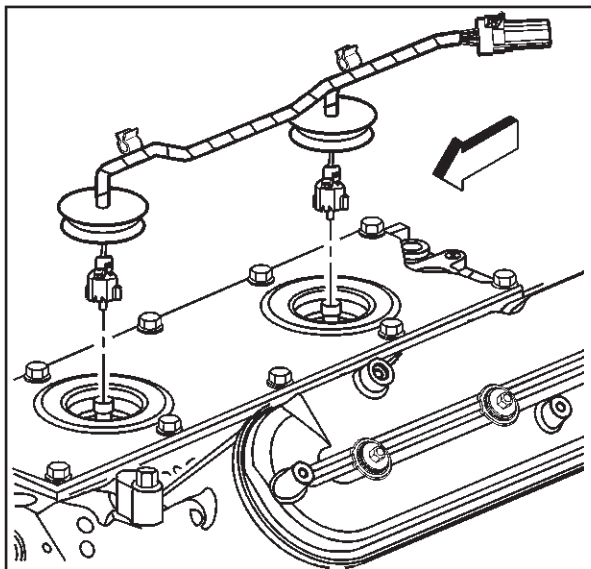


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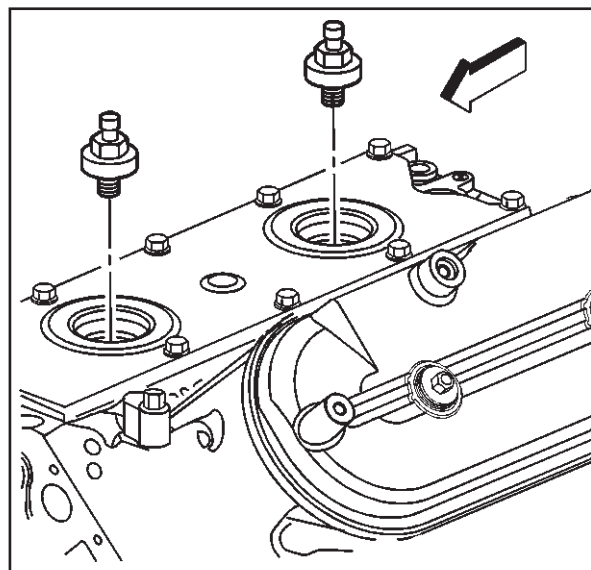
6. Remove the hose (1) from the pipe (2).



309859

Engine Valley Cover Removal

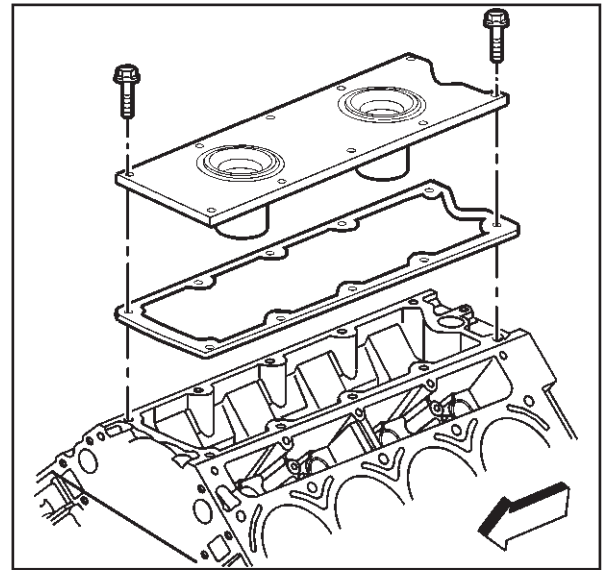
1. Remove the knock sensor wire harness.



309864

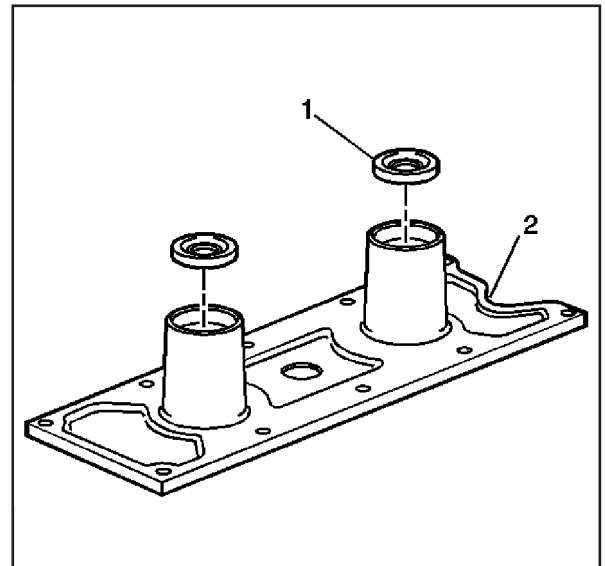
2. Remove the knock sensors.

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).



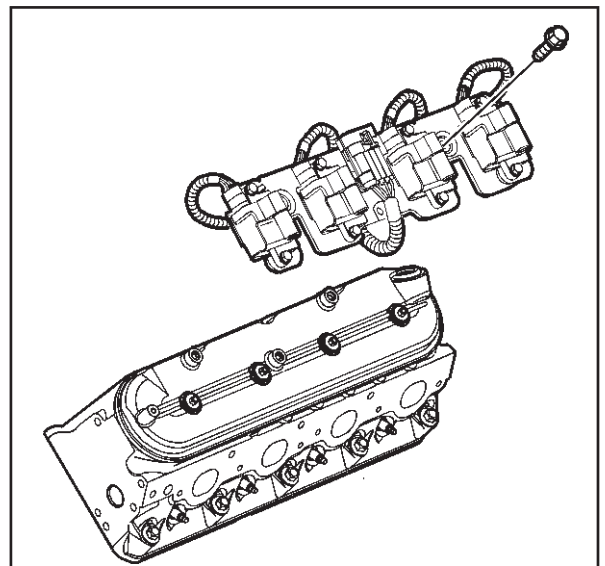
490851

Valve Rocker Arm Cover Removal (Left Side)

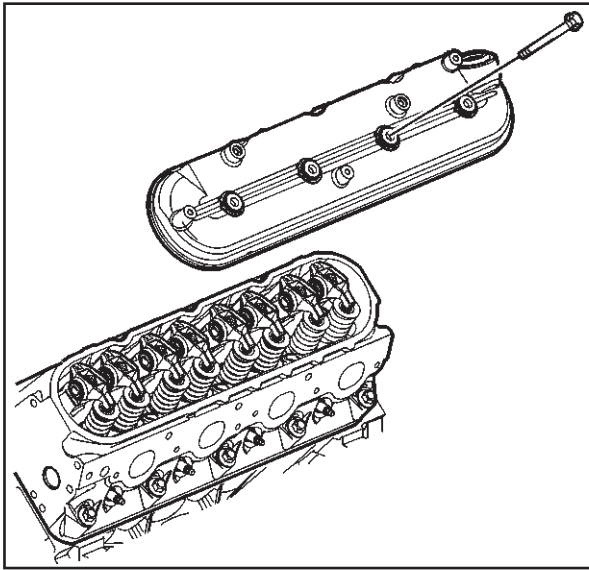
Important: Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.

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.

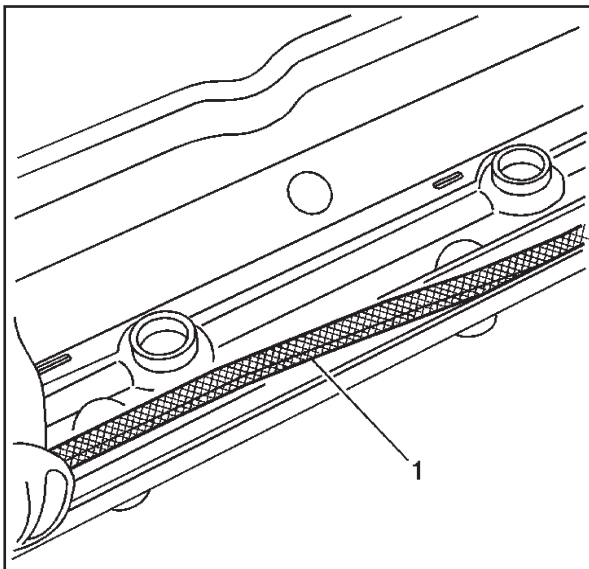


260083



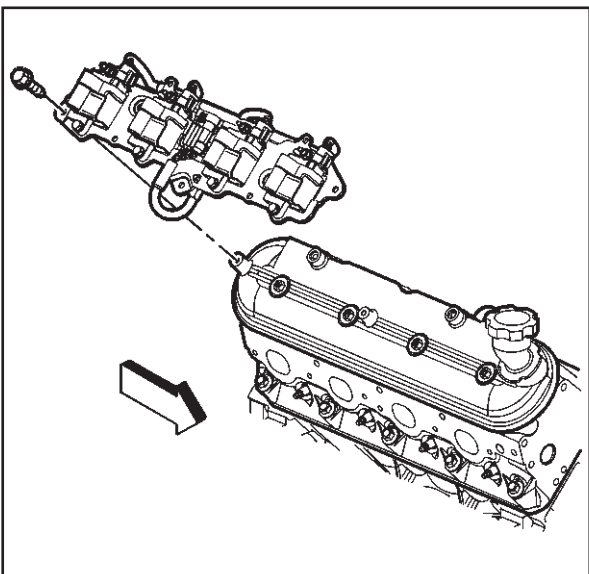
260085

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)

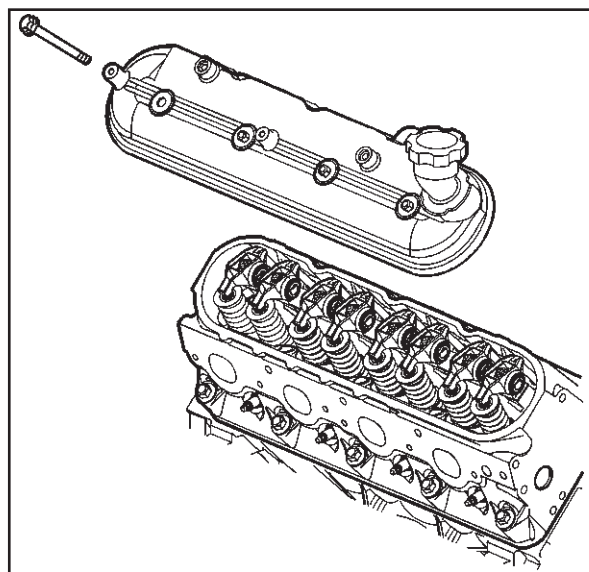
Important: Do not remove the ignition coils from the valve rocker arm cover unless required.

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.

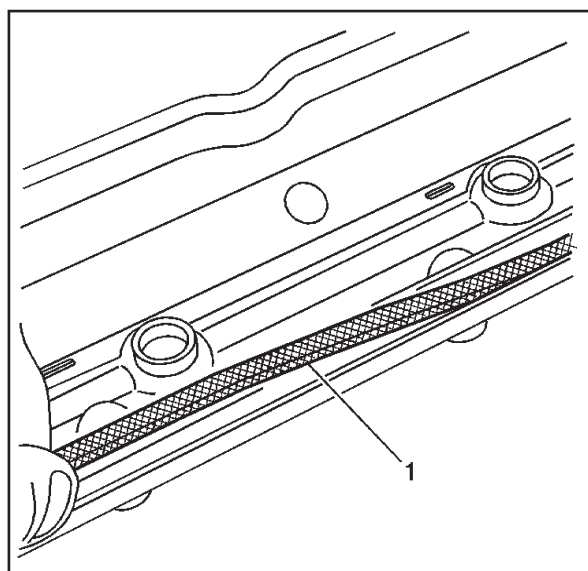
1. Remove the ignition coil bracket bolts from the valve rocker arm cover (if required).
2. Remove the ignition coil and bracket assembly and bolts.

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



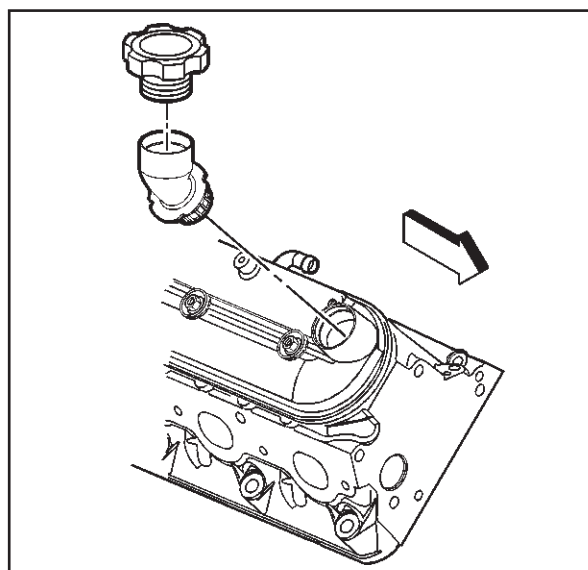
260084

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

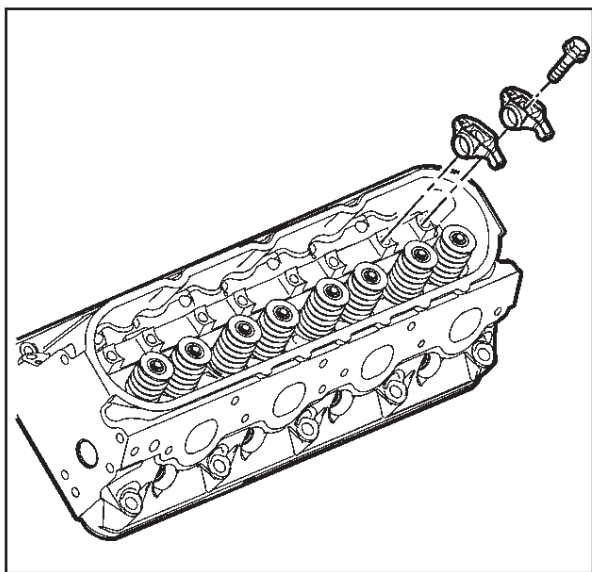


490696

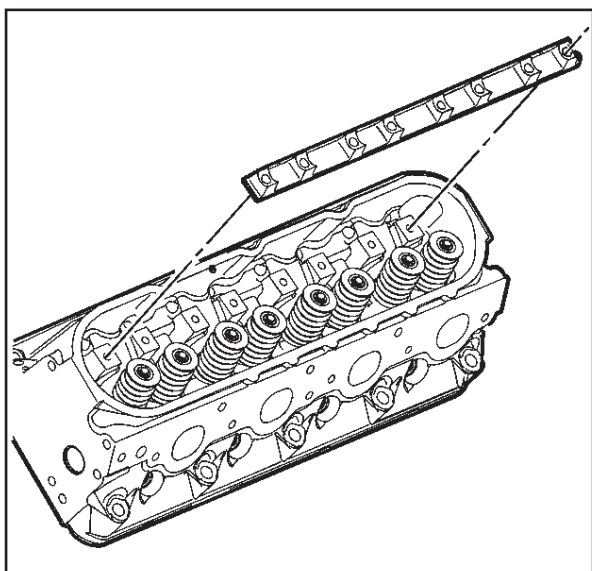
7. Remove the oil fill cap from the oil fill tube.
8. Remove the oil fill tube, if required.
9. Discard the oil fill tube.



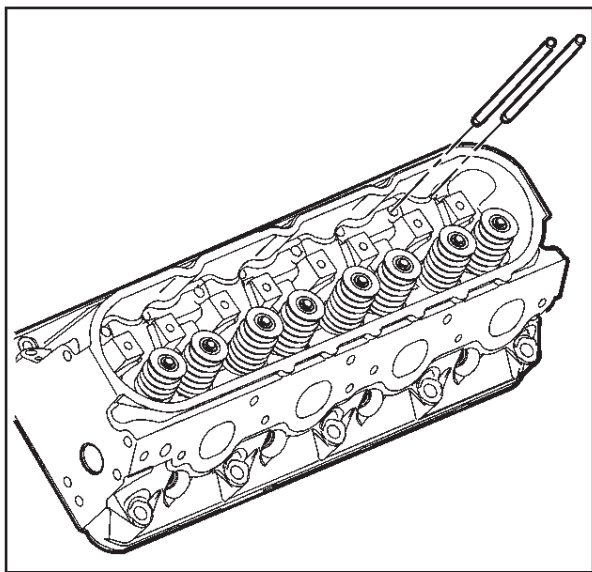
260110



260140



260141



260142

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.
3. Remove the valve rocker arm pivot support.
4. Remove the pushrods.

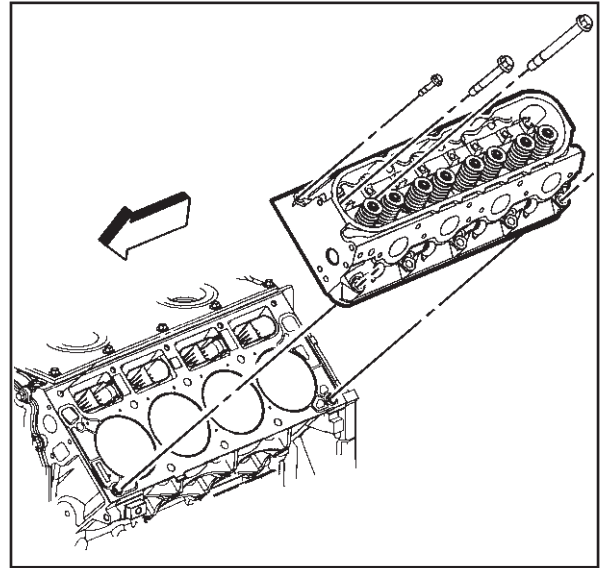
Cylinder Head Removal - Left Side

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.

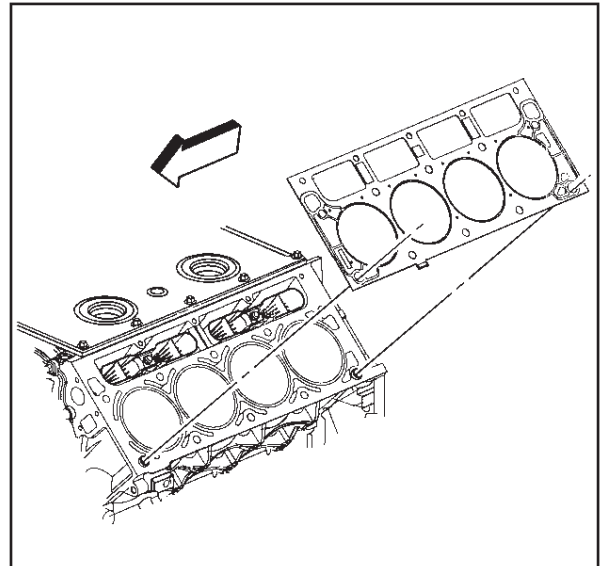
2. Remove the cylinder head bolts.

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



260146

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



63169

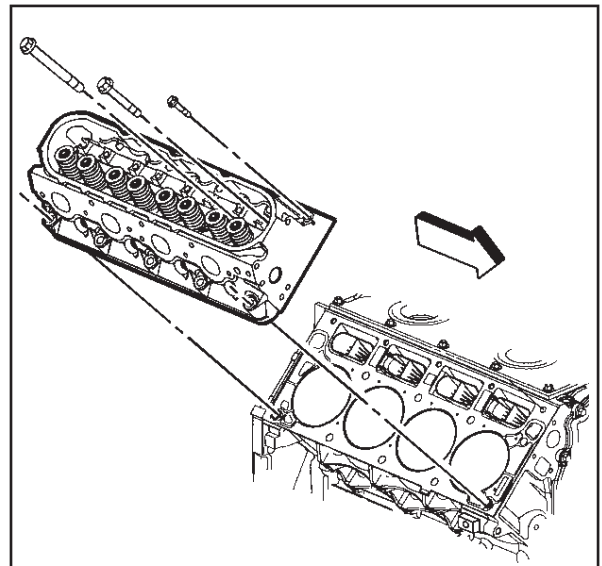
Cylinder Head Removal - Right Side

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

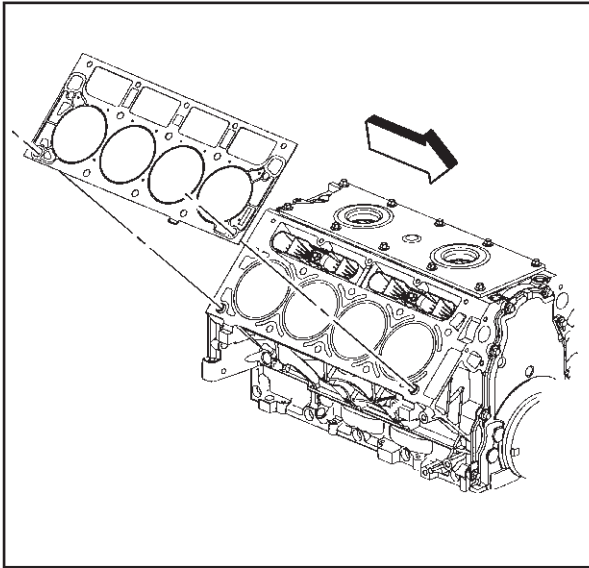
Important: The M11 cylinder head bolts are NOT reusable. Install NEW M11 cylinder head bolts during assembly.

2. Remove the cylinder head bolts.

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

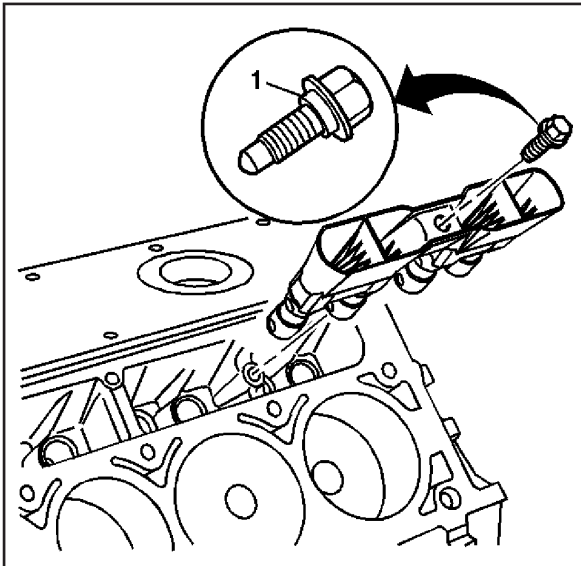


260149



63170

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



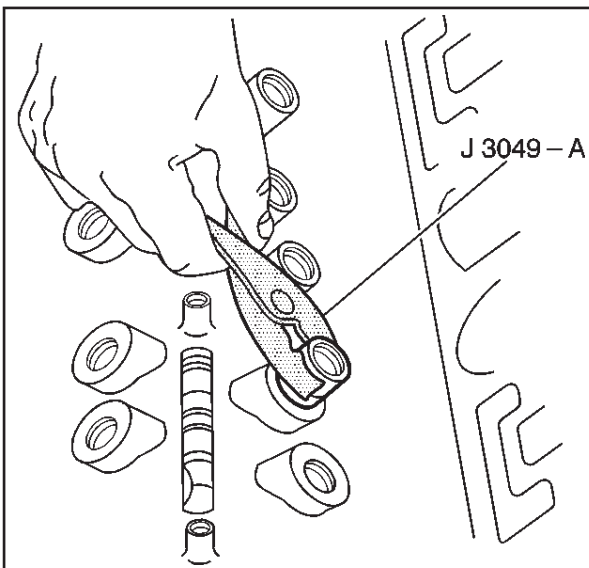
63230

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.

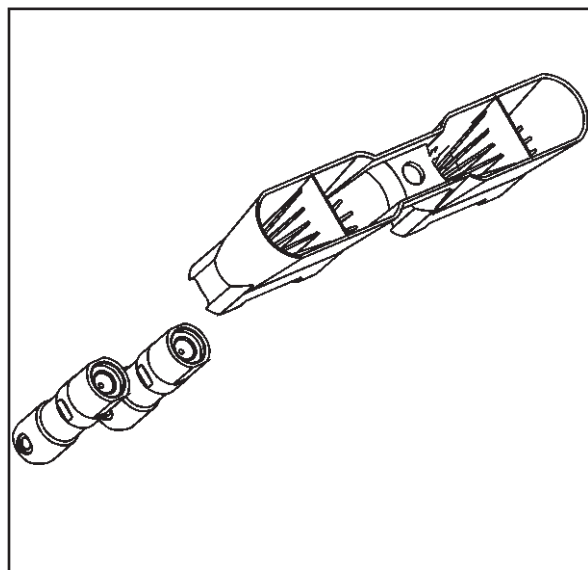


31350

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.

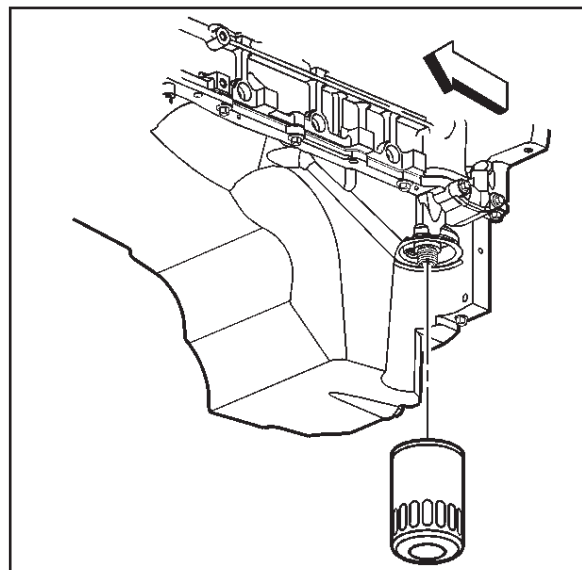
4. Remove the valve lifters from the guide.
5. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to *Separating Parts*.



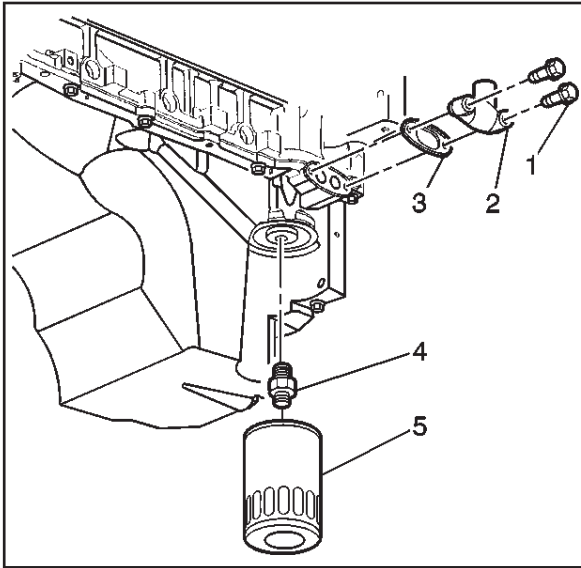
63233

Oil Filter, Adapter and Pan Cover Removal

1. Remove the oil filter.

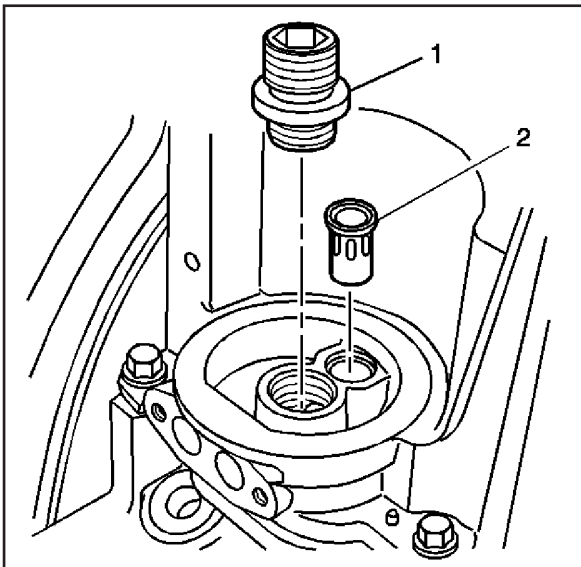


260117



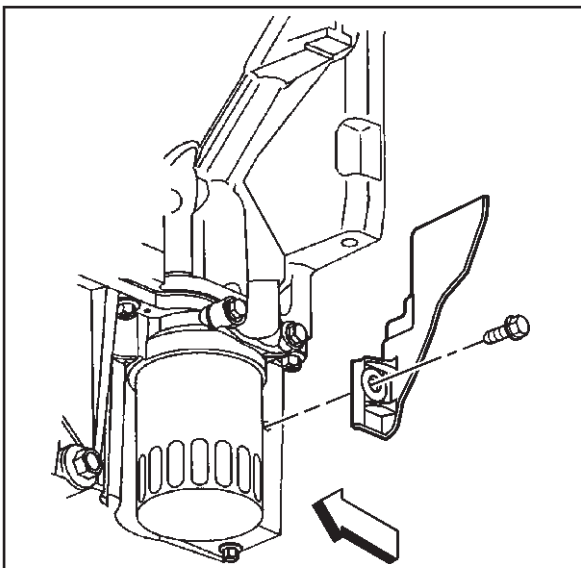
260125

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

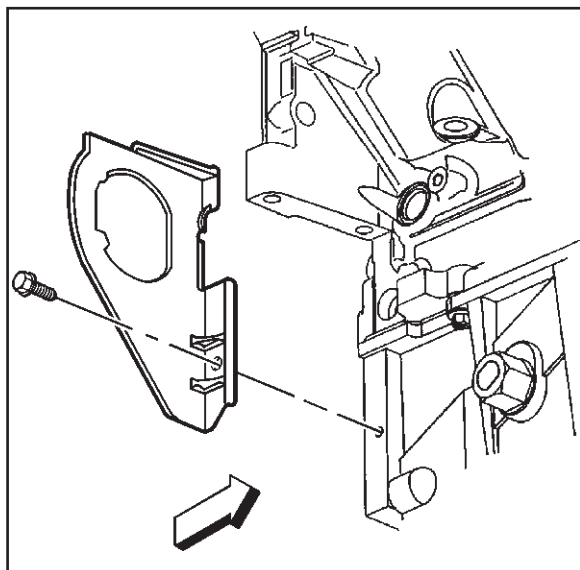
Oil Pan Removal

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.

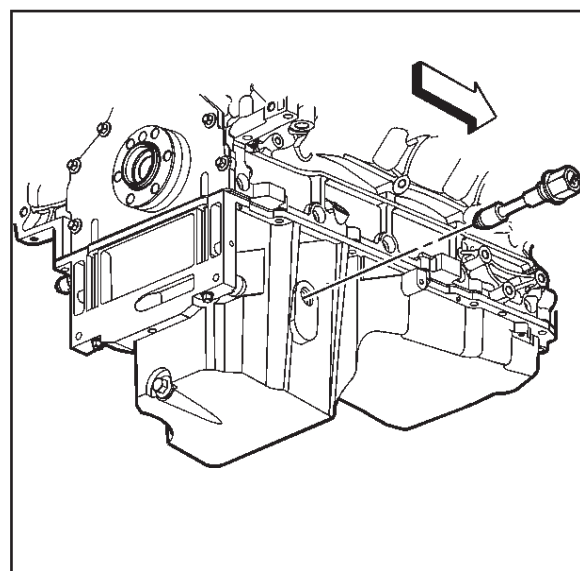
It is not necessary to remove the oil level sensor prior to oil pan removal. Remove the oil level sensor if service is required.

2. Remove the right closeout cover and bolt.



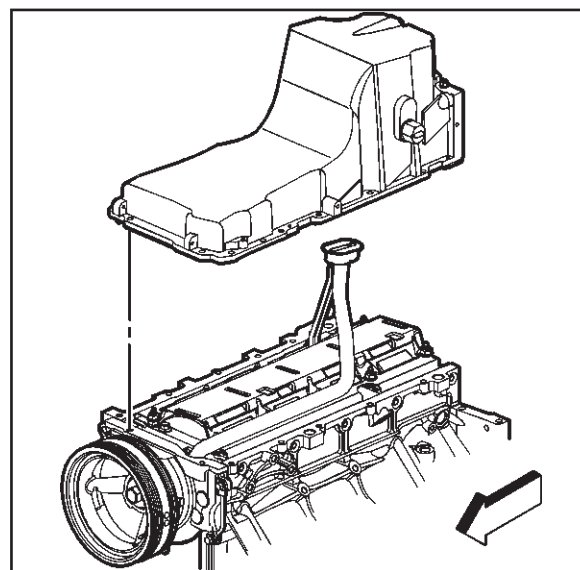
178480

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

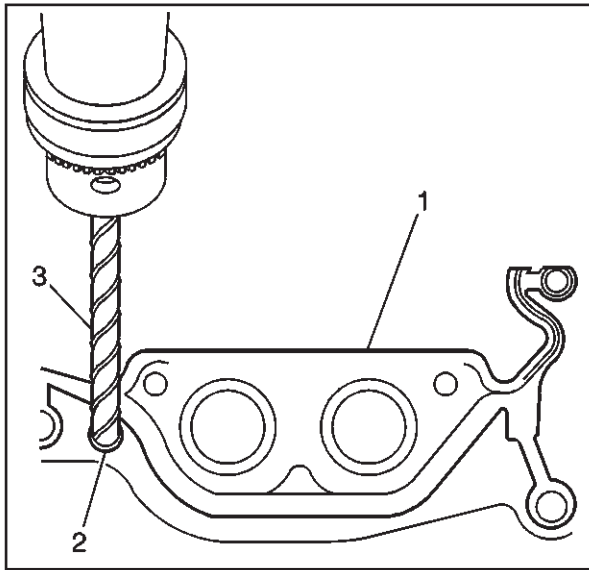


260123

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



260108

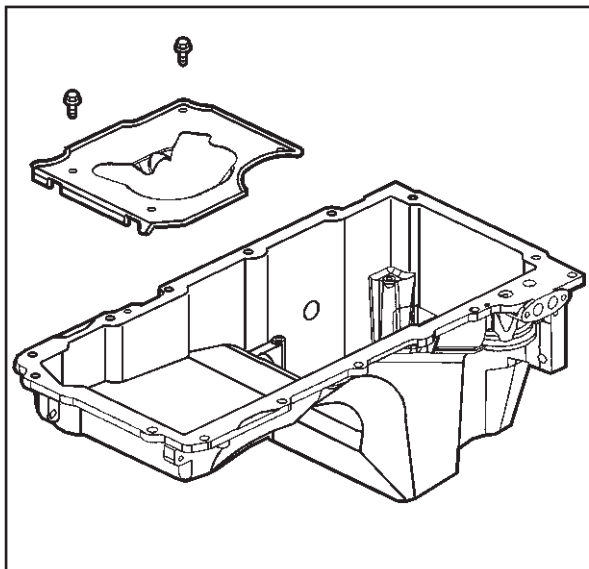


384699

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

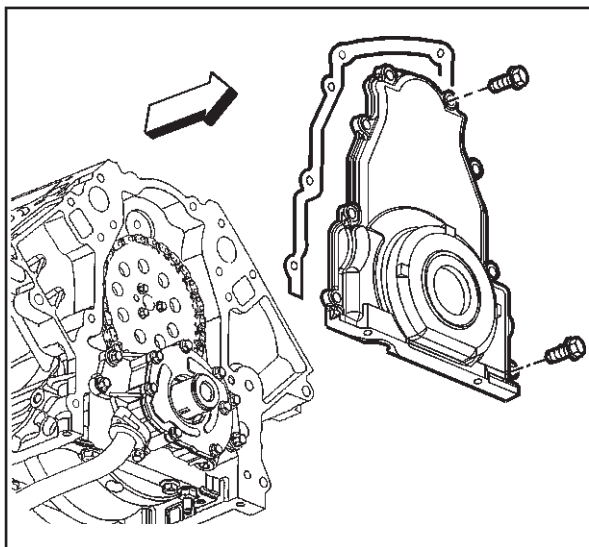
Use care not to gouge, score or damage the oil pan sealing service.

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

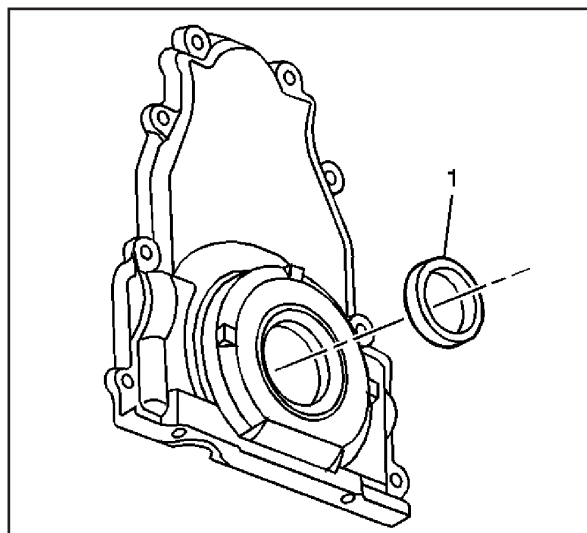


64278

Engine Front Cover Removal

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

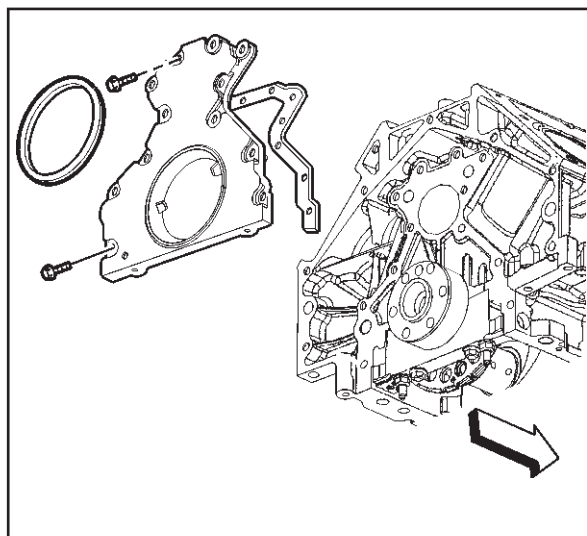
4. Remove the crankshaft front oil seal (1) from the



490689

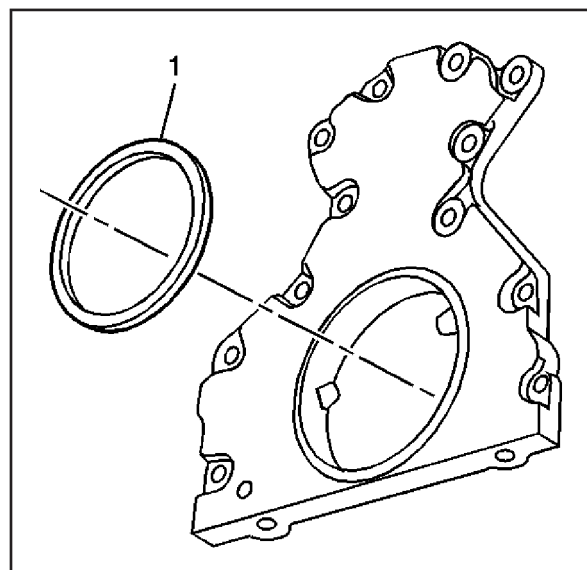
Engine Rear Cover Removal

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

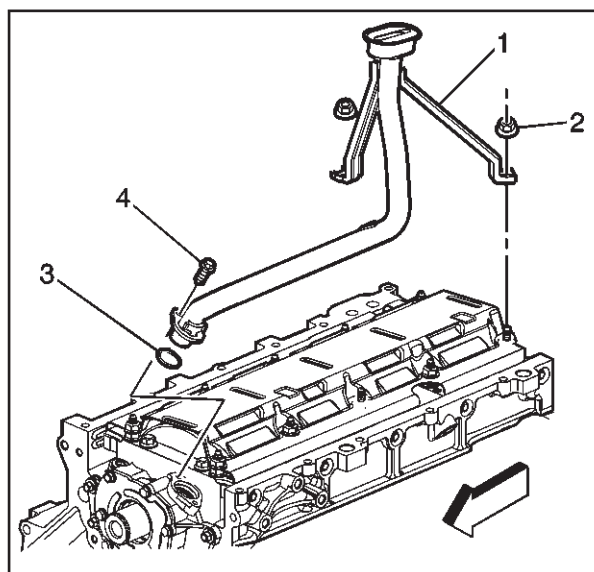


64282

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



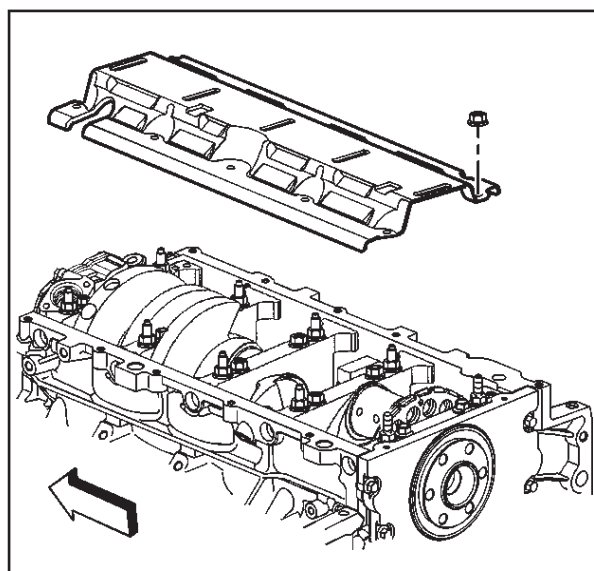
490692



260109

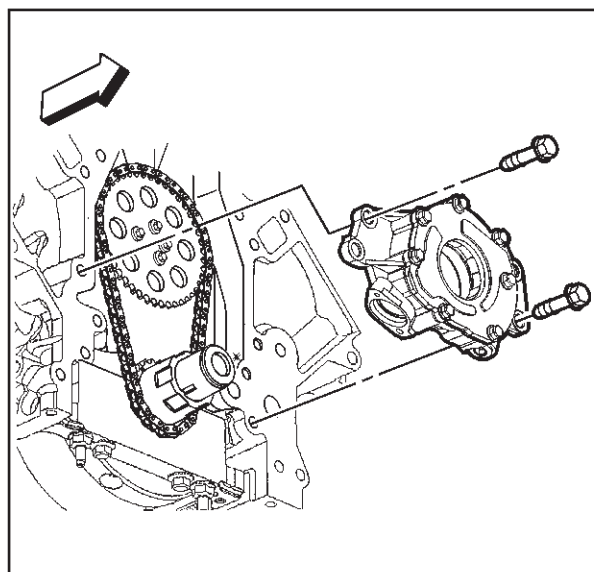
Oil Pump, Pump Screen and Deflector Removal

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

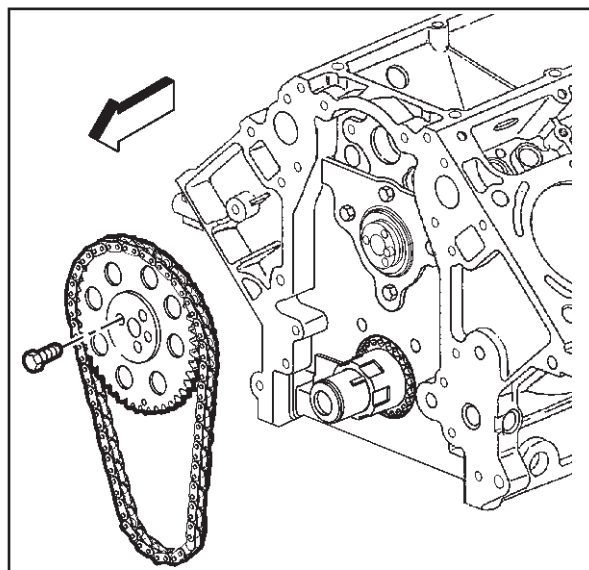
J 8433-1 Puller Bar

J 41816-2 Crankshaft Pilot

J 41558 Crankshaft Sprocket Remover

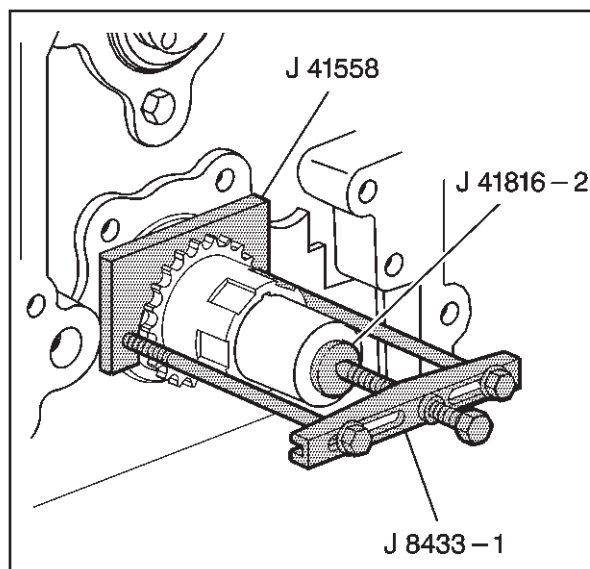
Notice: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

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



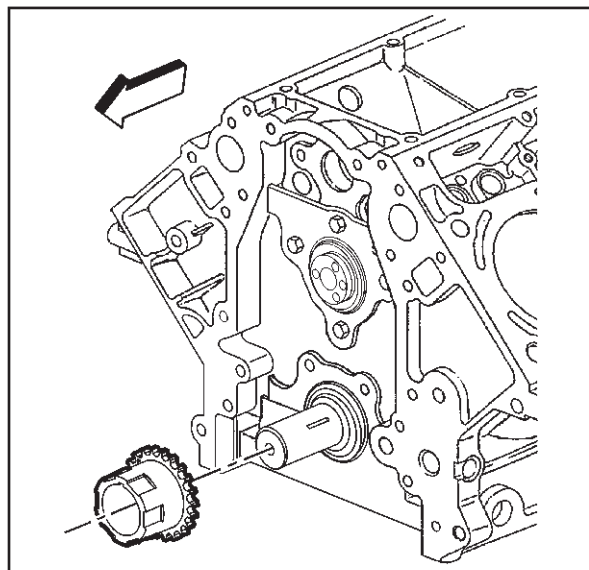
63263

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

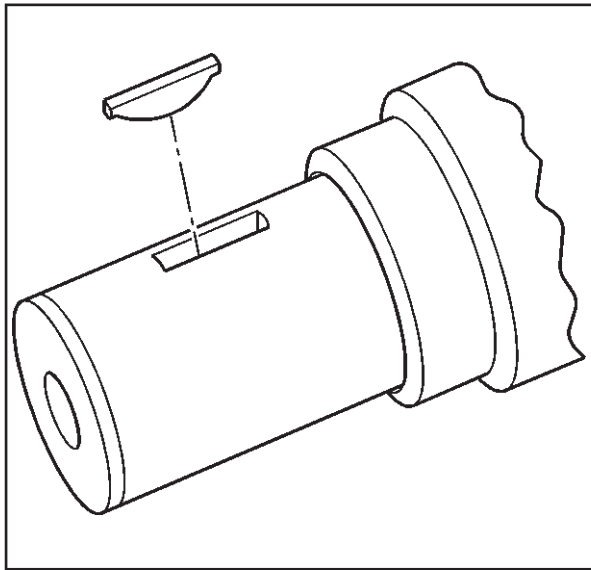


63189

4. Remove the crankshaft sprocket.

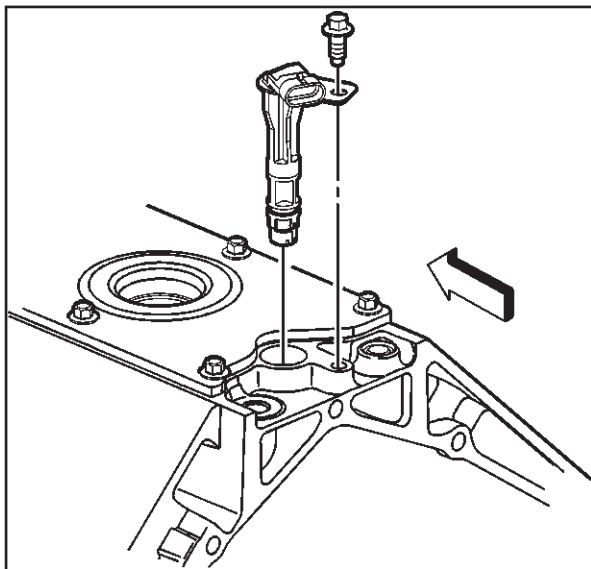


156150



156149

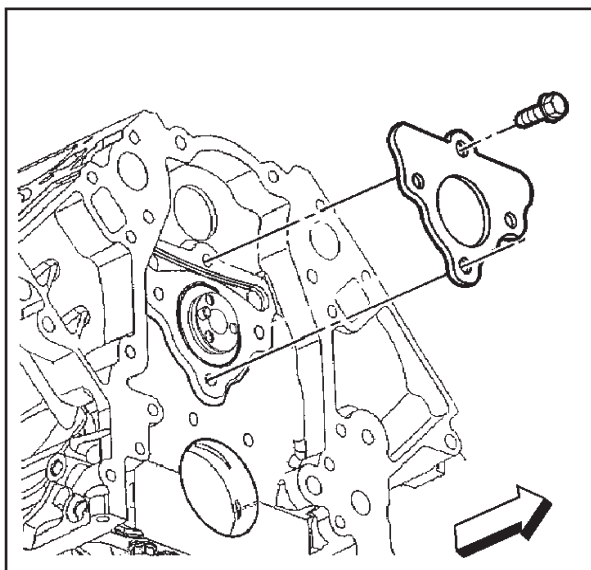
5. Remove the crankshaft sprocket key, if required.



260128

Camshaft Removal

1. Remove the camshaft sensor bolt and the sensor.

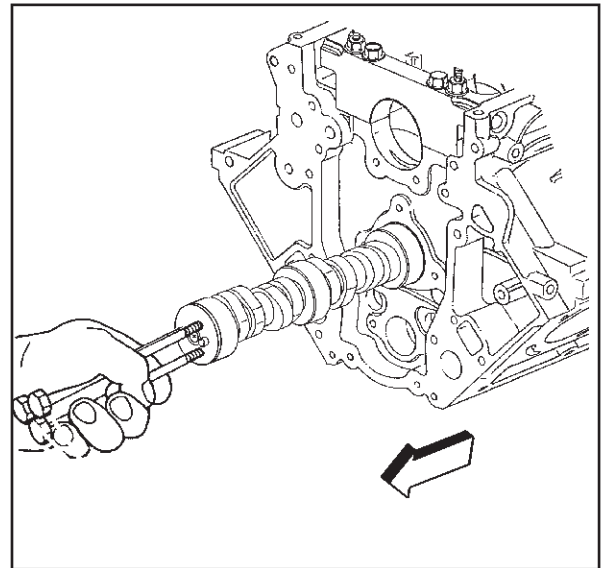


63211

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



63212

Piston, Connecting Rod and Bearing Removal

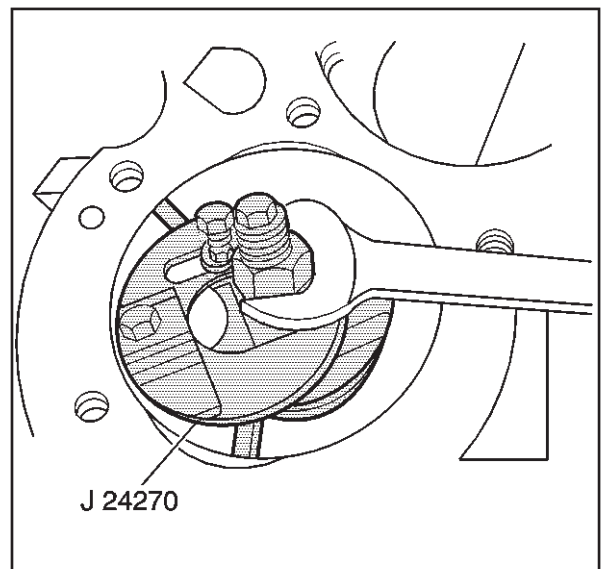
Tool Required

J 41556 Connecting Rod Guide

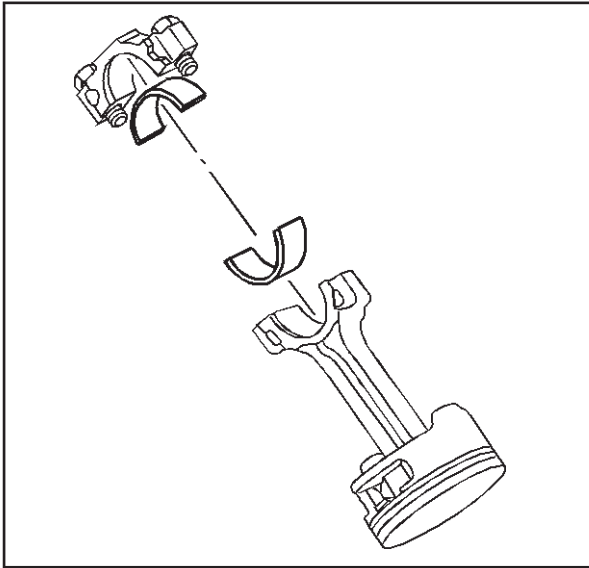
J 24270 Cylinder Bore Ridge Reamer

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.

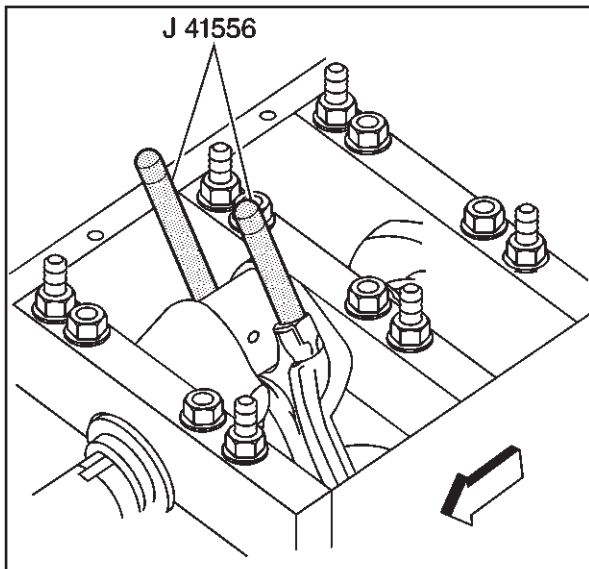
A stamping mark on the side of the connecting rod at the crank journal may effect component geometry.

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

2. Remove the connecting rod bolts.

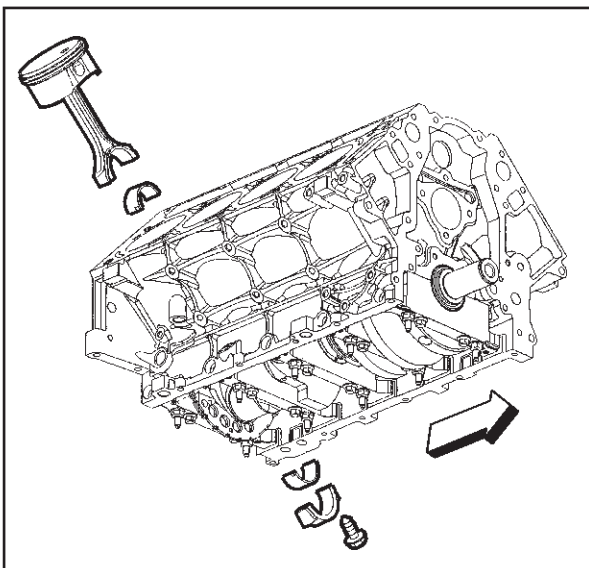
Important: Mark, sort or organize the connecting rod bearings so they may be installed to their original position and location.

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



63186

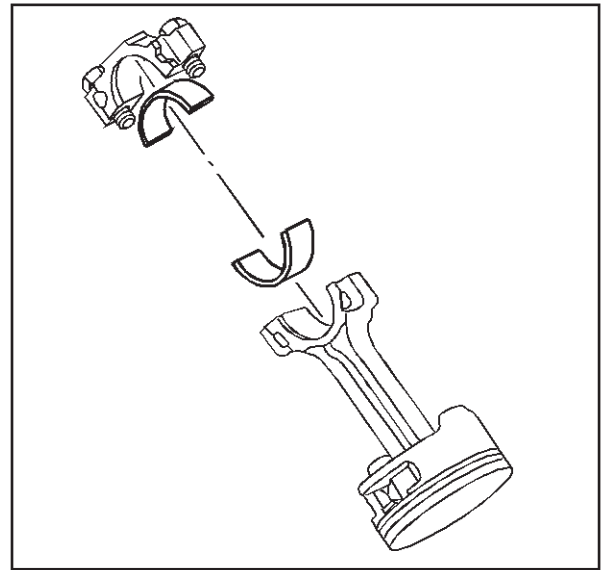
4. Install the *J 41556* to the connecting rod.



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

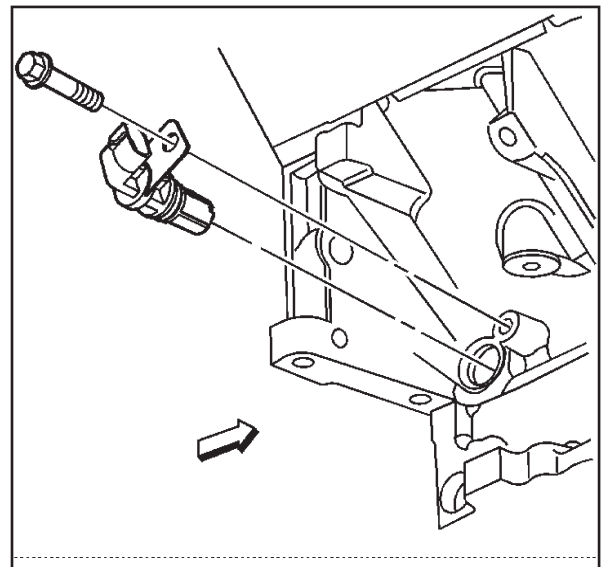
J 6125-1B Slide Hammer

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.

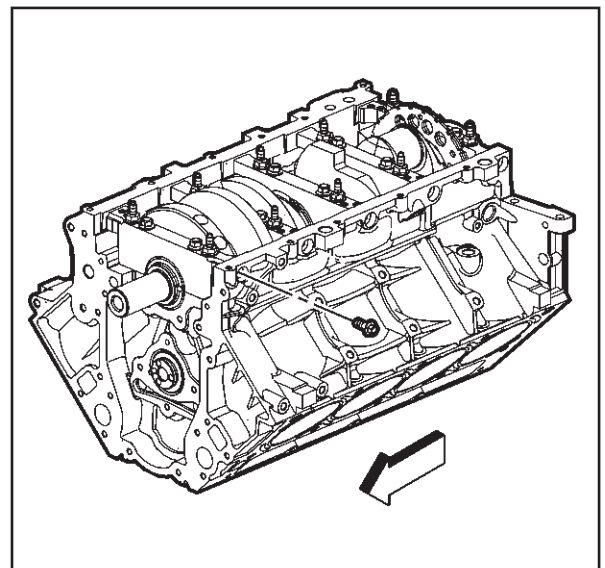
Remove the bearing cap M8 side bolts prior to cap removal.

1. Remove the crankshaft position sensor bolt.

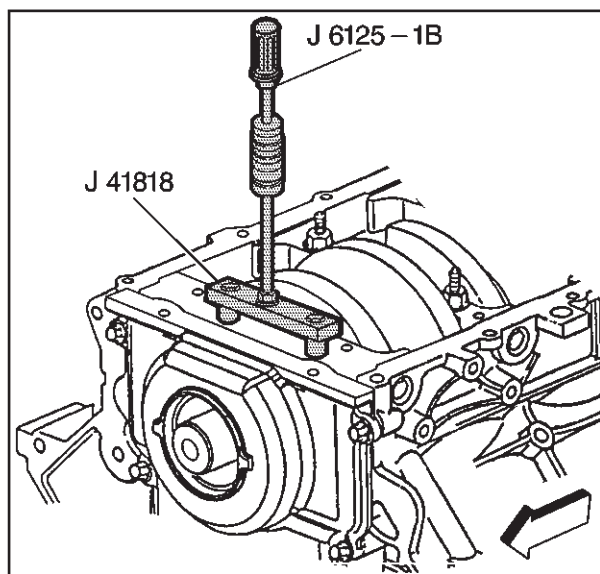


55322

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

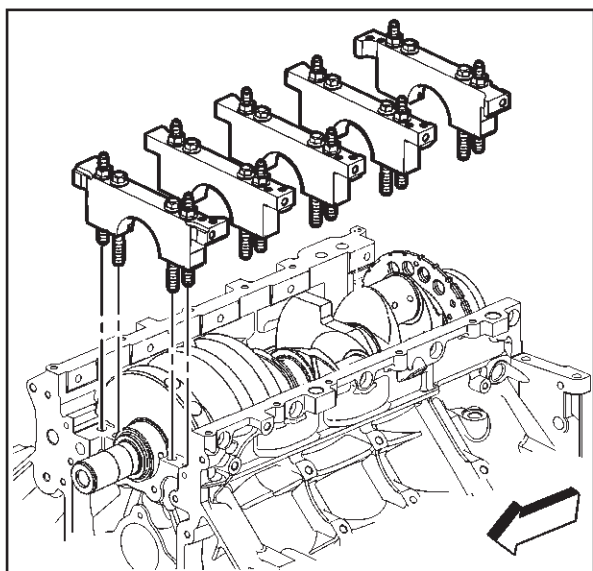
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the *J 41818*.

Tighten

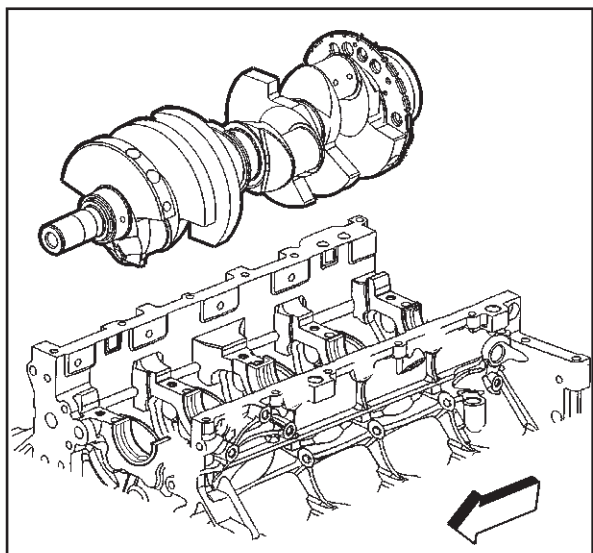
Tighten the *J 41818* bolts to 11 N·m (100 lb in).

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



156152

7. Remove the bearing caps.

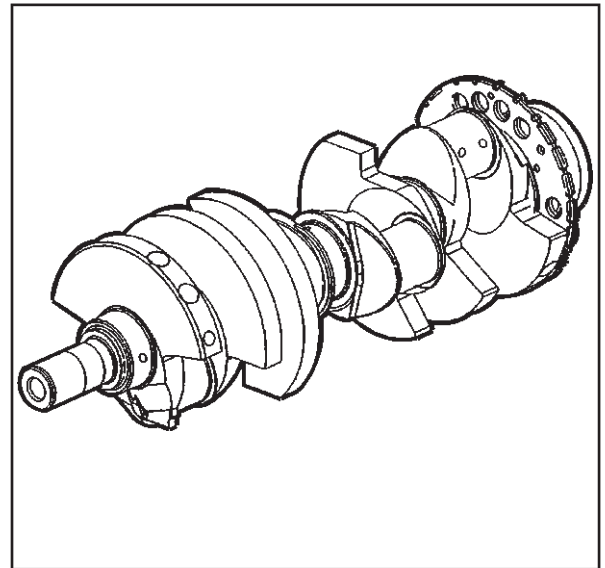


156151

8. Remove the crankshaft.

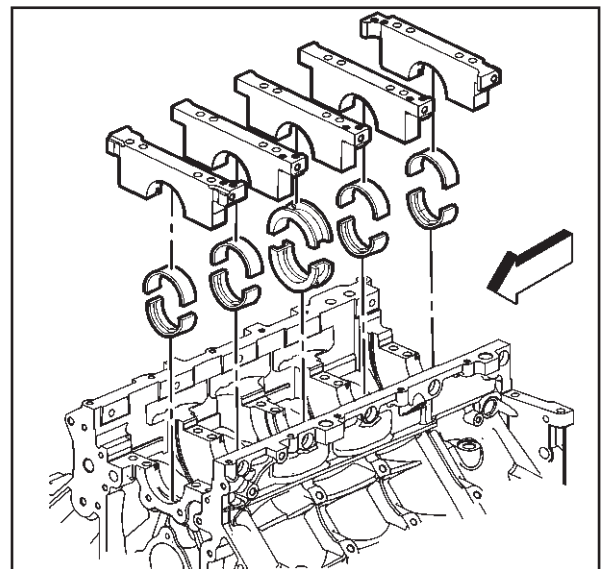
Important: Use care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may effect On-Board Diagnostics (OBD) system performance.

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

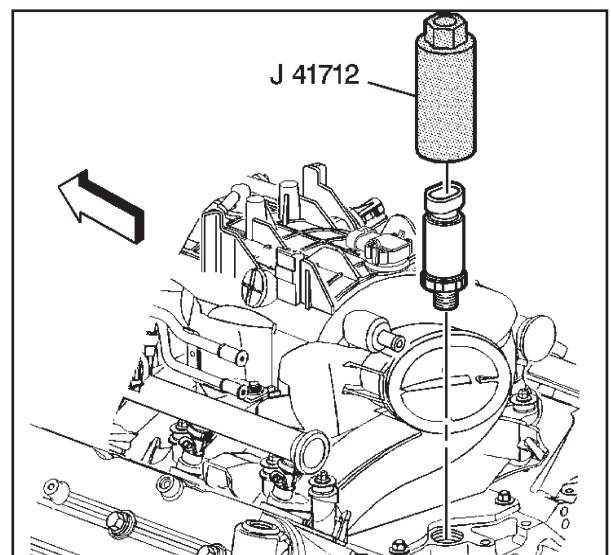
Tools Required

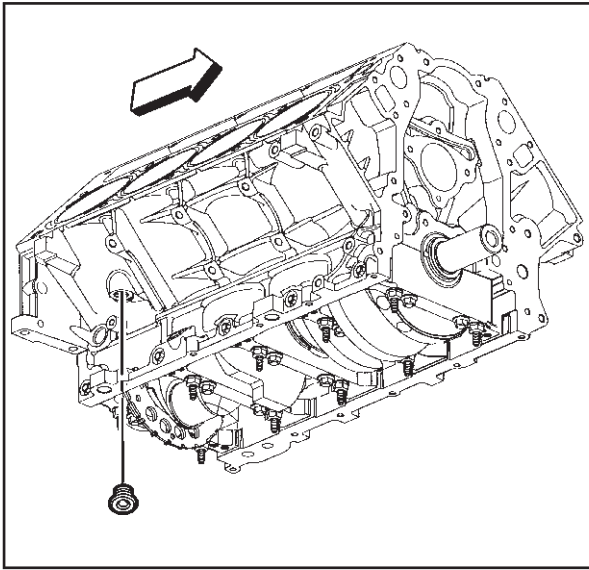
J 41712 Oil Pressure Sensor Socket

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.

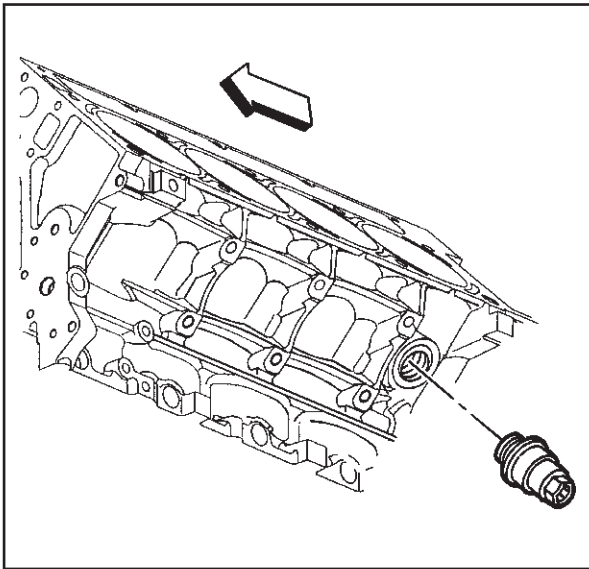
1. Remove the oil pressure sensor, if not previously removed, using the *J 41712* or equivalent.





63164

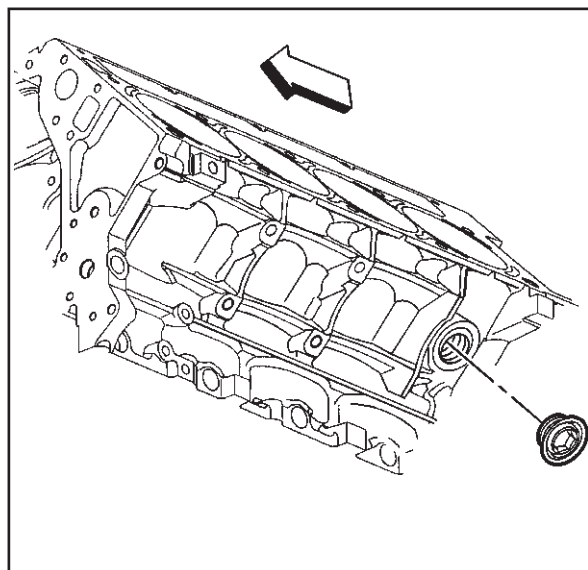
2. Remove the engine block right rear coolant plug.



260137

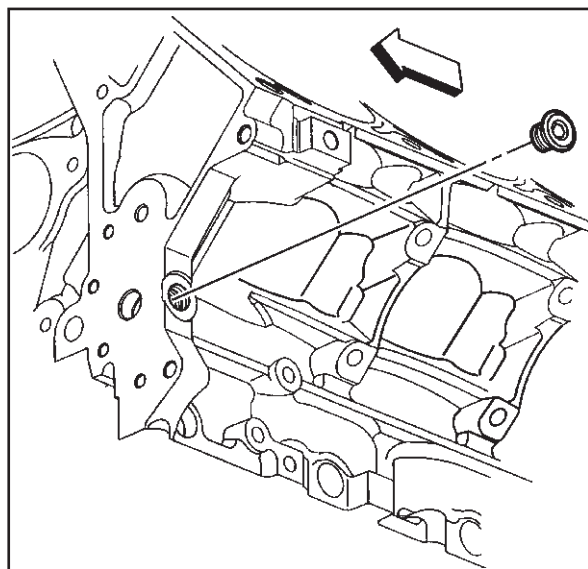
3. Remove the engine block coolant heater, if

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



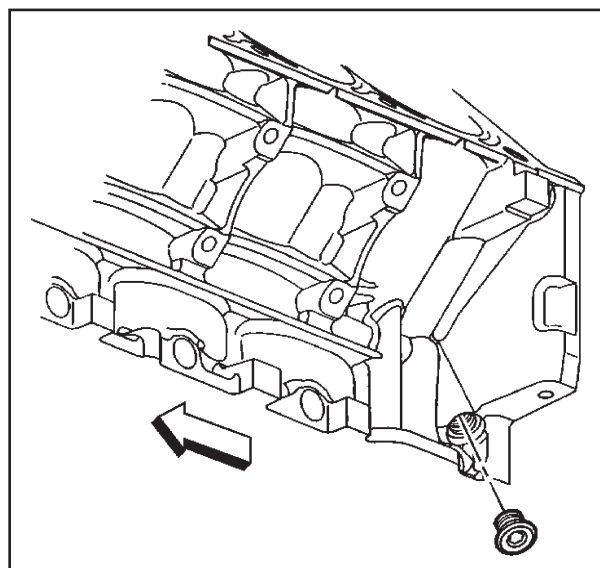
260138

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

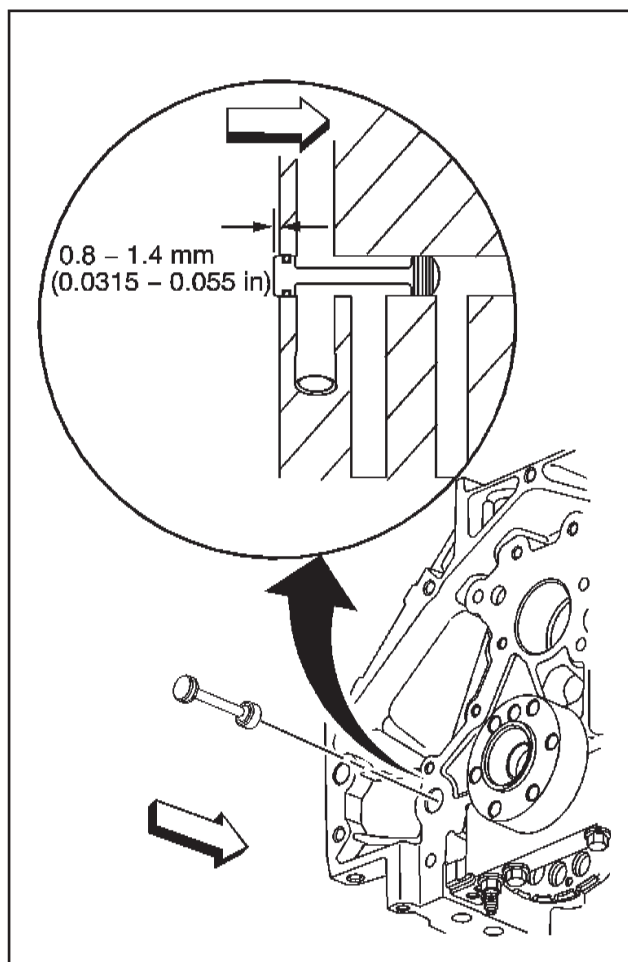


260139

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.

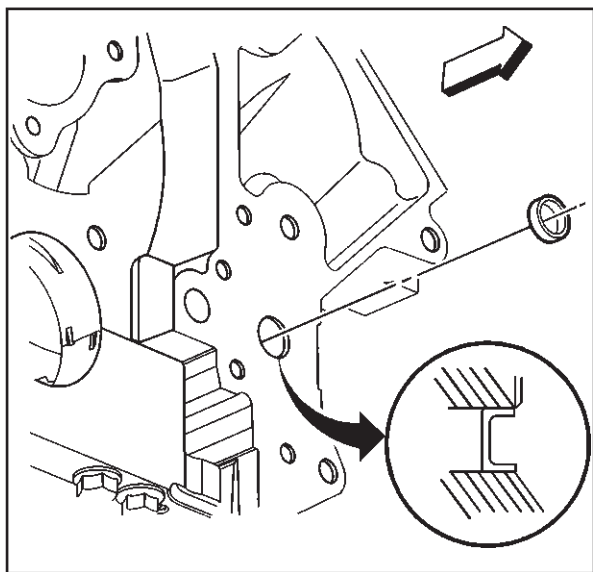


64923



63228

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.



64295

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*.

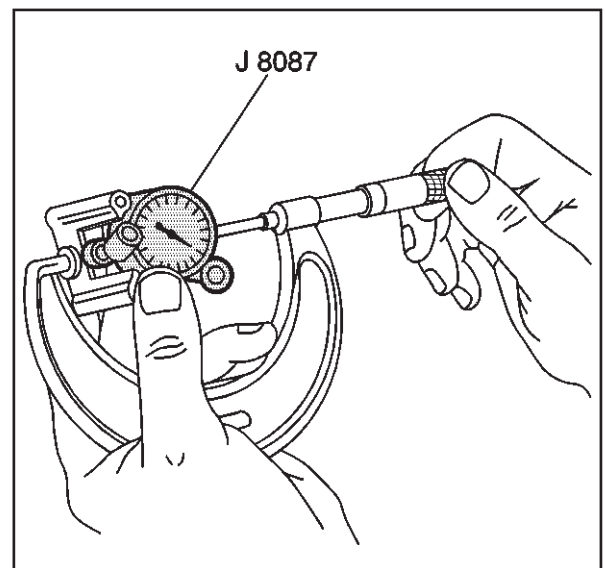
- The oil galleries for restrictions
- All threaded bolt holes for damage

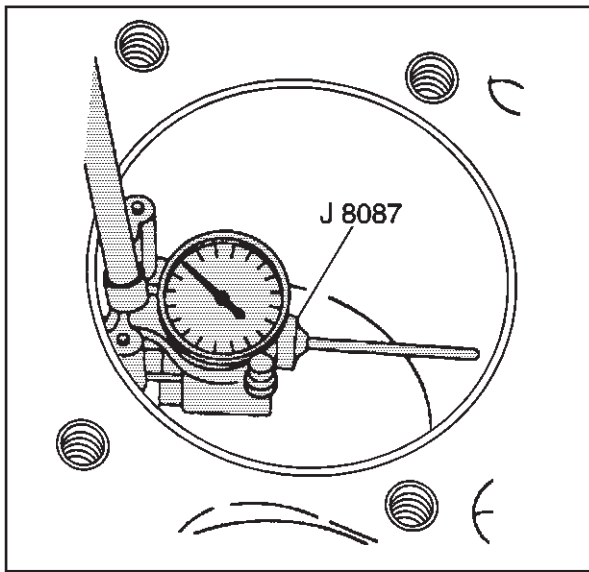
3. Measure the following areas:

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

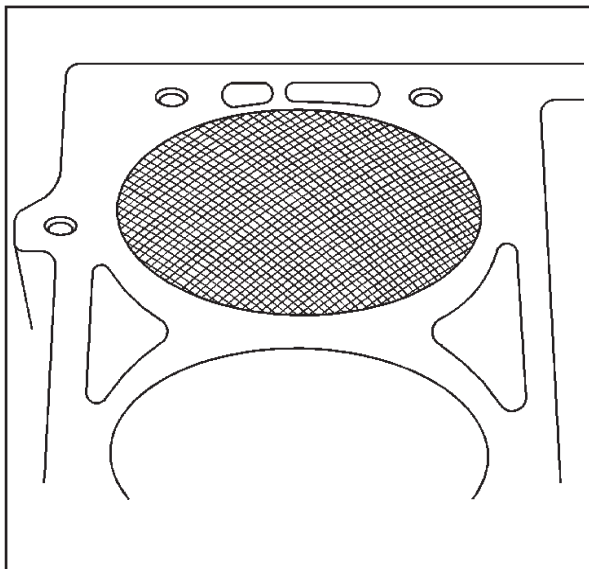
Measuring Cylinder Taper, Out-of-Round and Oversize

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

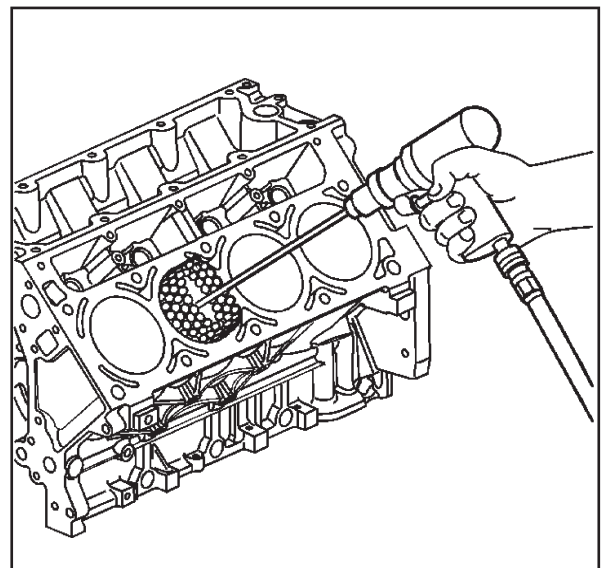
All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

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.

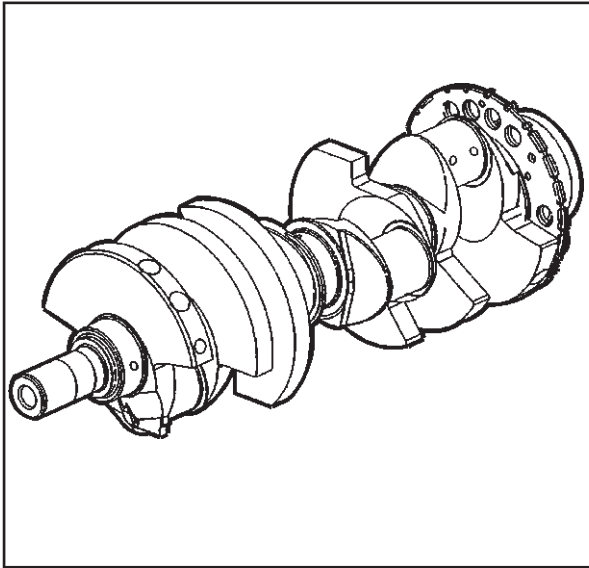
Deglazing Procedure

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.*

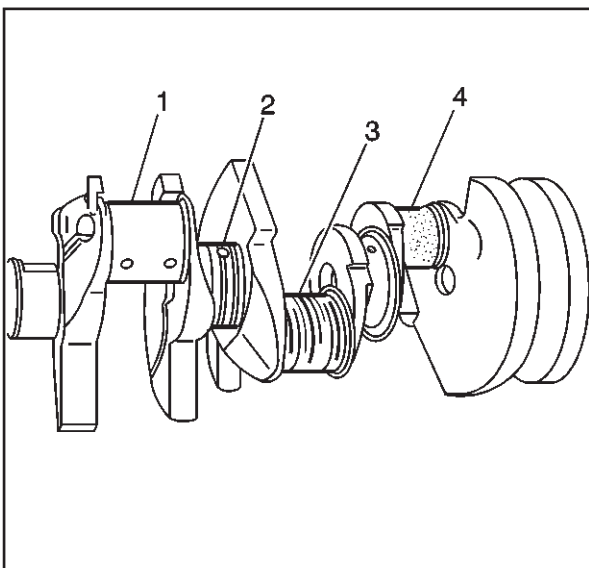
3. Dry the crankshaft with compressed air.

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.

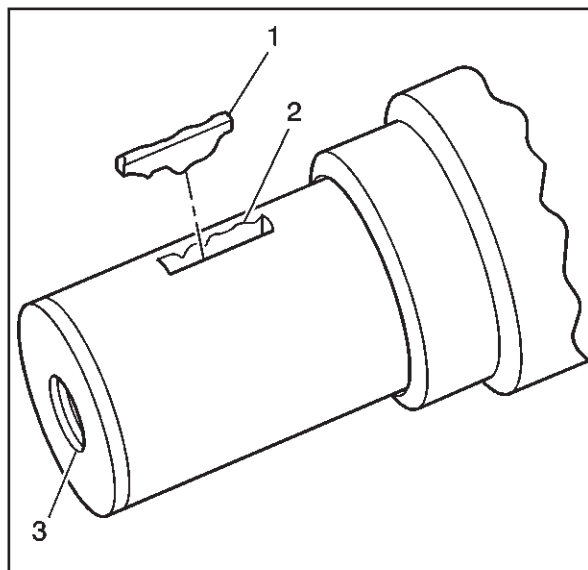
1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the crankshaft position reluctor ring lobes for damage.



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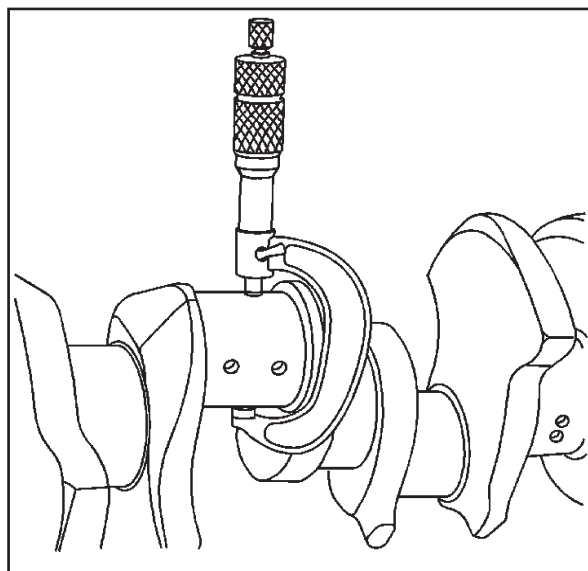
3. Inspect the crankshaft journals for wear (1).
Journals should be smooth with no signs of scoring, wear or damage.
4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded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

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



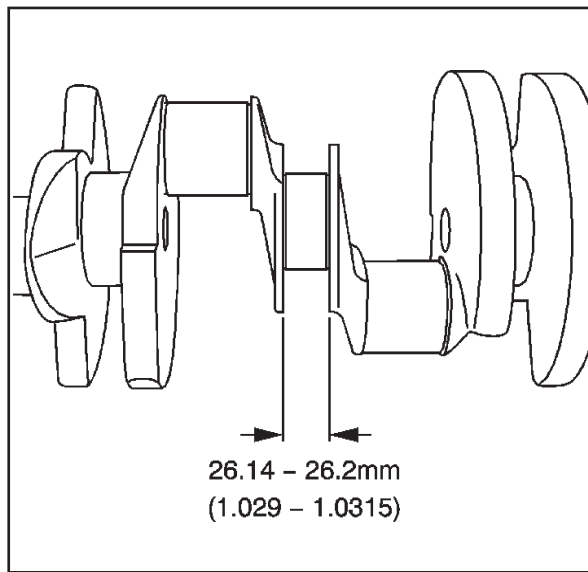
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8. Measure the crankpins for the out-of-round.
9. Measure the crankpins for taper.

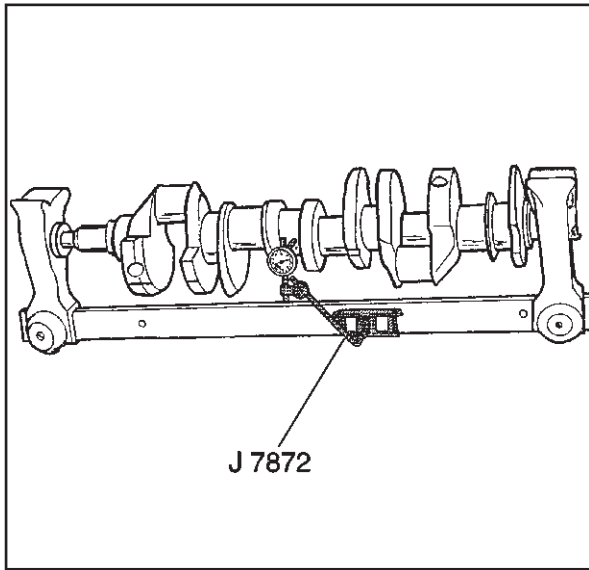


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10. Measure the crankshaft thrust wall width.
A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.

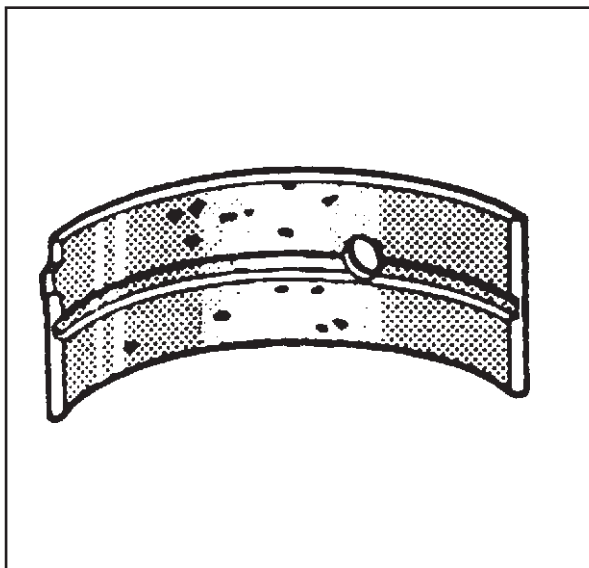


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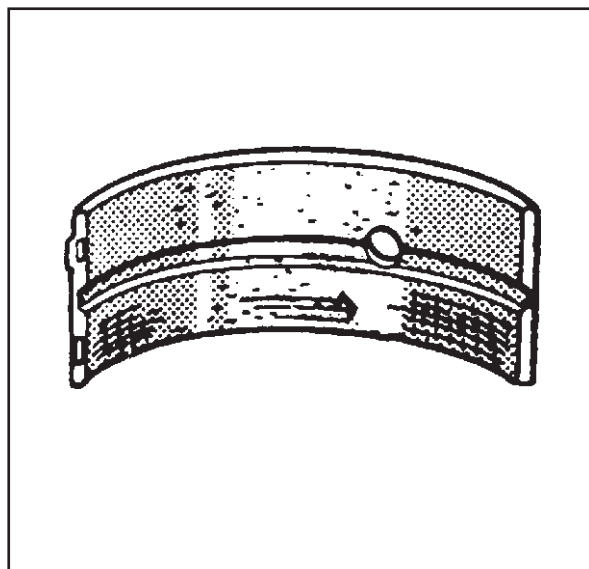
11. Measure the crankshaft runout.
Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.
12. Use the *J 7872* in order to measure the crankshaft runout at the front and rear intermediate journals.
13. Use the *J 7872* in order to measure the runout of the crankshaft 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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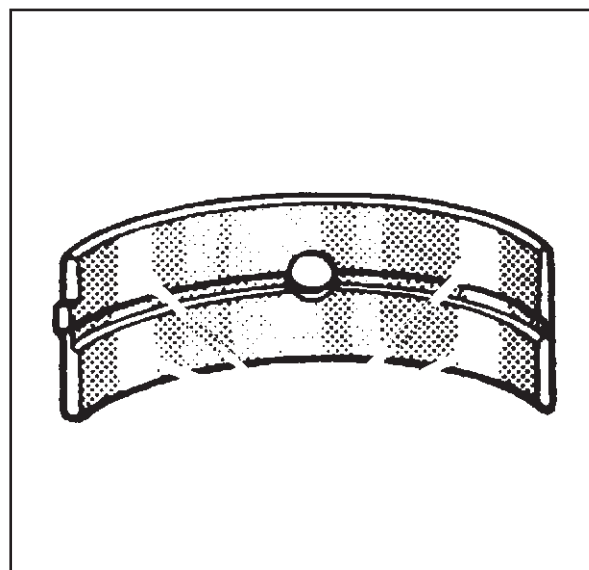
15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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

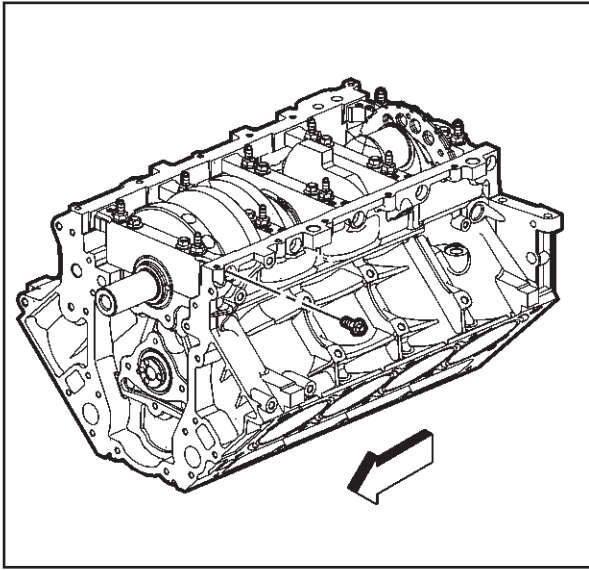


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18. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing. If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced. Generally, if the lower half is suitable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



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Measuring Main Bearing Clearance

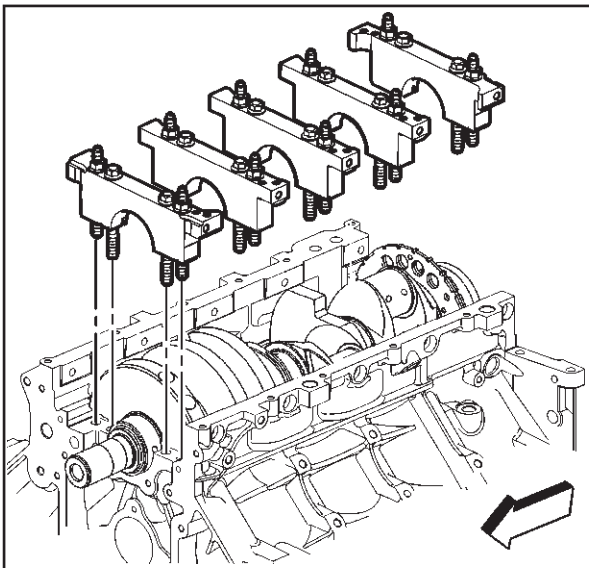
Important: The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may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

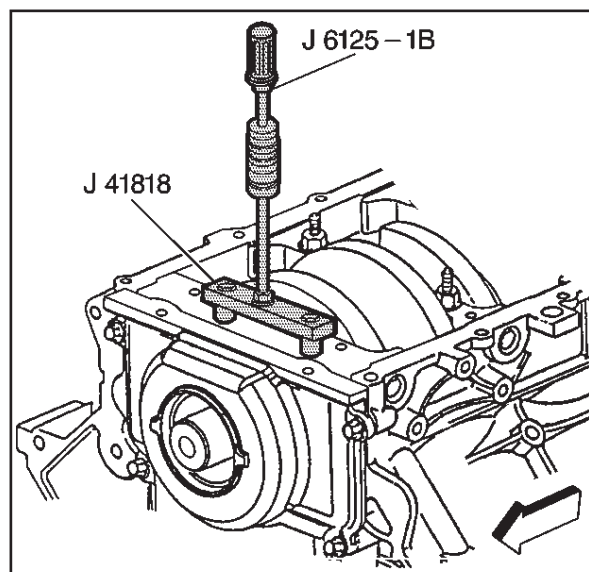
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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

Tighten

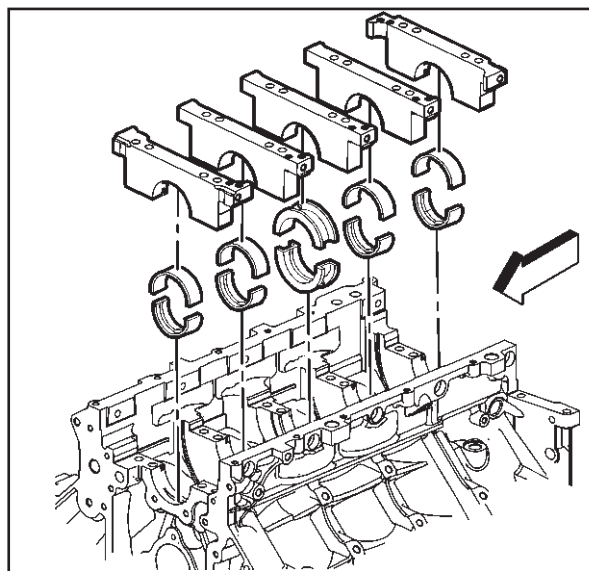
Tighten the *J 41818* bolts to 11 N·m (100 lb in).

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



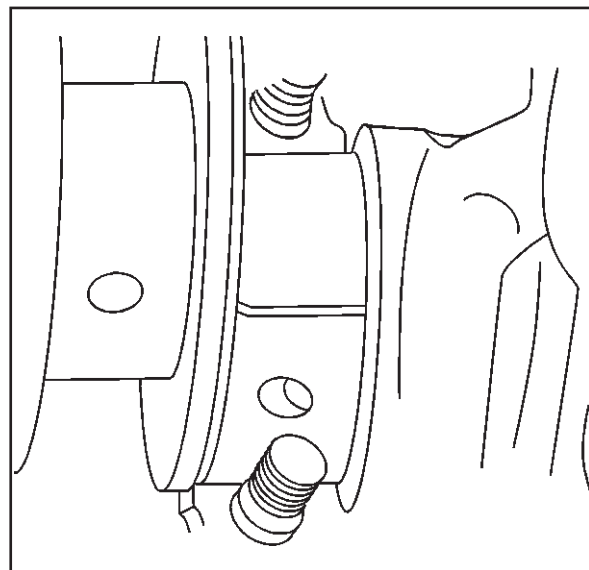
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5. Remove the bearing cap and lower bearing.

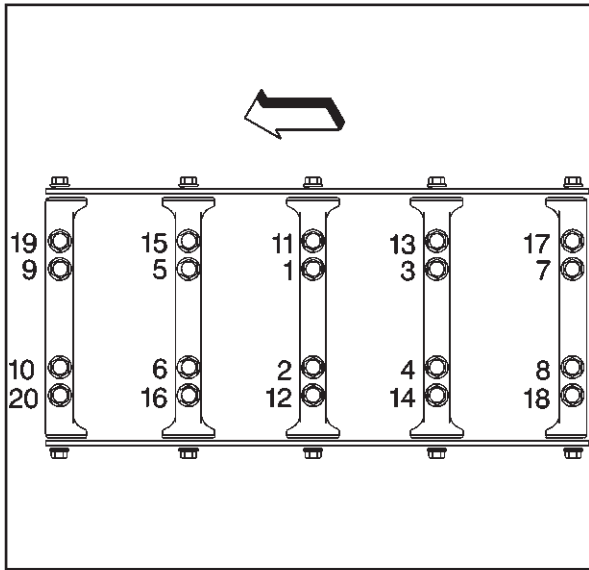


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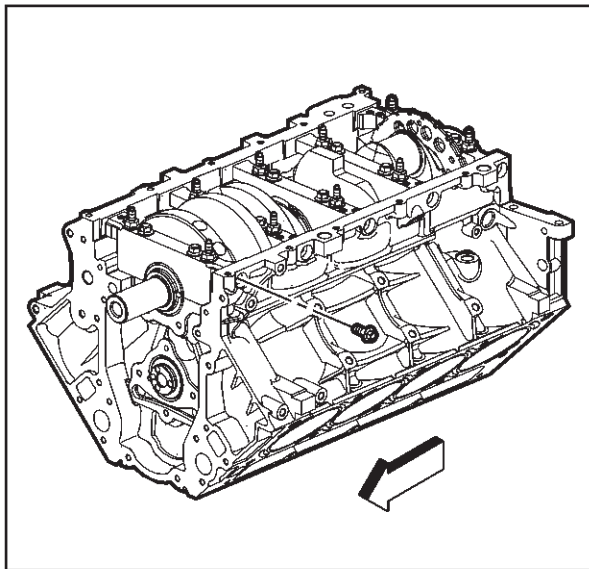
6. Install gauging plastic onto the crankshaft journal.
Install the gauging plastic the full width of the crankshaft bearing journal.



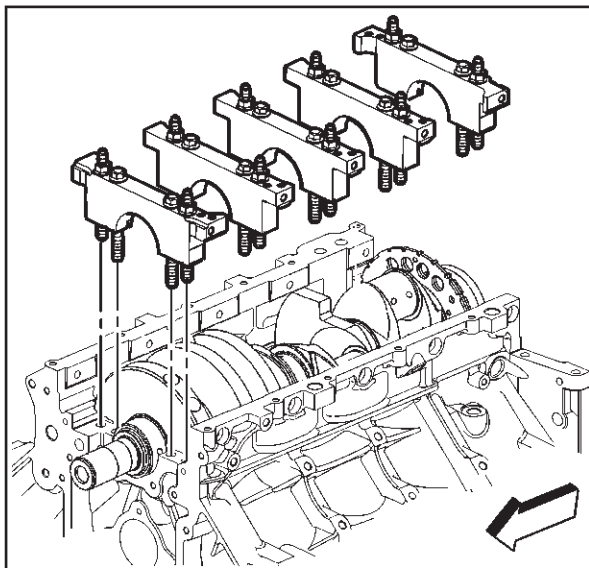
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7. Install the bearing, bearing cap, bolts and bolt/studs.

Tighten

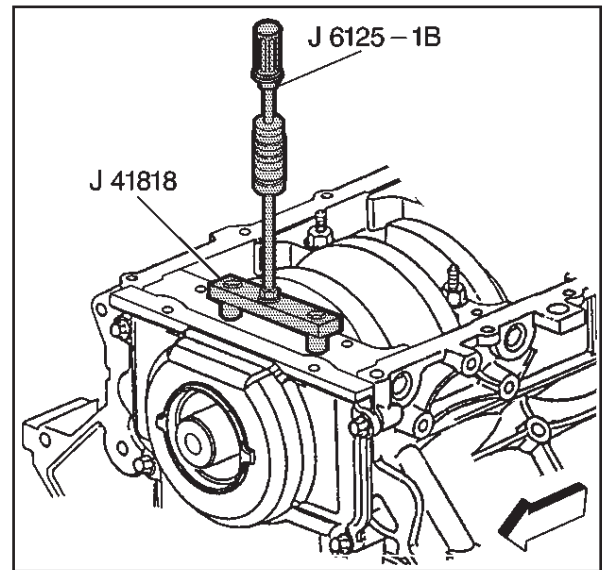
- 7.1. Tighten the inner bolts (1-10) a first pass in sequence to 20 N·m (15 lb ft).
- 7.2. Tighten the inner bolts (1-10) a final pass in sequence to 80 degrees using the *J 36660-A*.
- 7.3. Tighten the outer bolt/studs (11-20) a first pass in sequence to 20 N·m (15 lb ft).
- 7.4. Tighten the outer 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

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

8. Remove the bearing cap M8 side bolts.

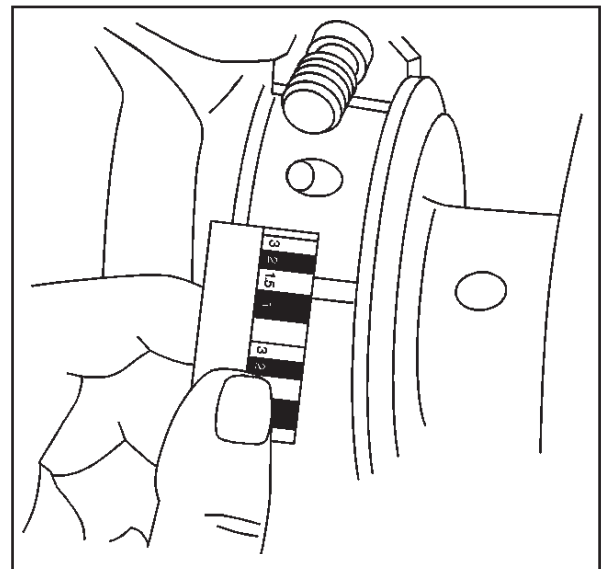
9. Remove the bearing cap bolts and bolt/studs.

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



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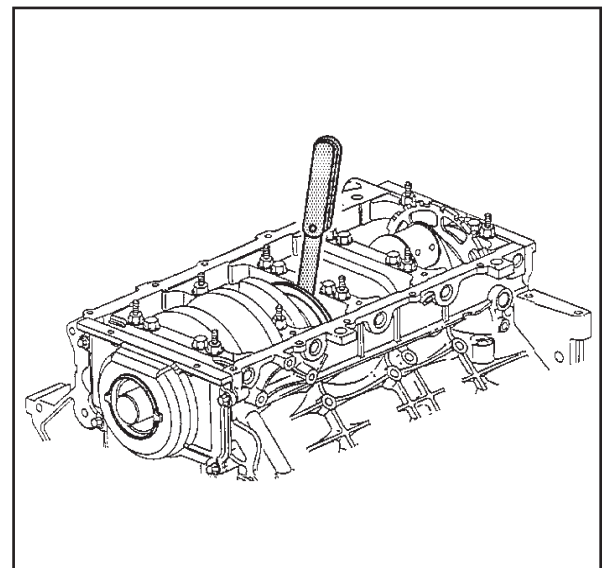
11. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
 - If the gauging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
 - If the bearing clearance is greater 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



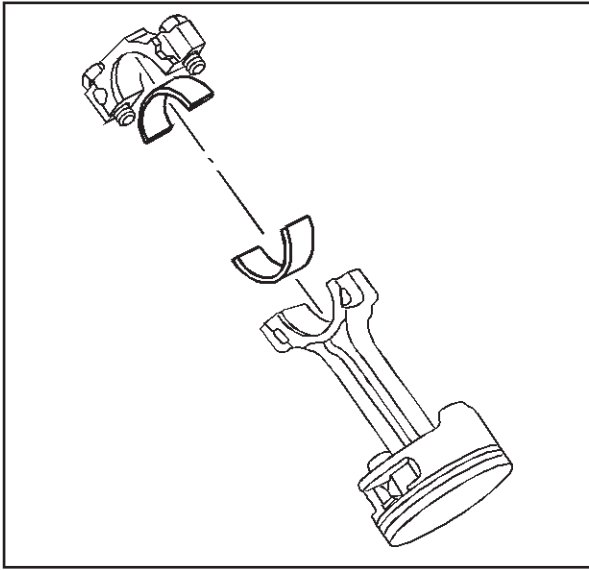
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12. Measure the crankshaft end play.
 - 12.1. Thrust the crankshaft forward or rearward.
 - 12.2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

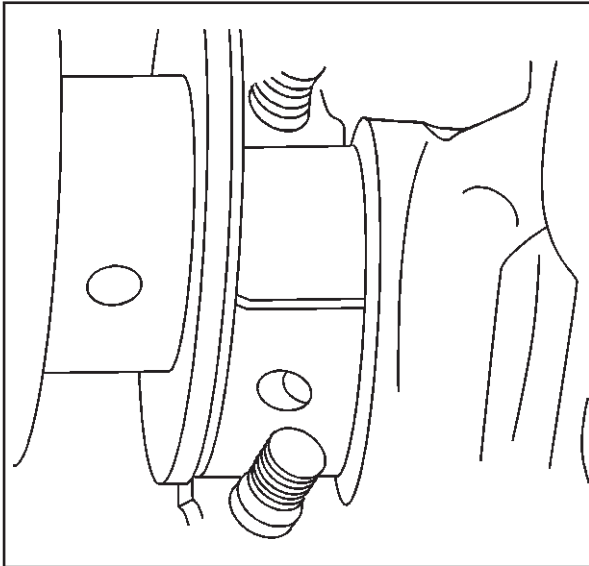
The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).
 - 12.3. If the bearing clearance is not within specifications:
 - Inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.
 - Replace the thrust bearings and measure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



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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.

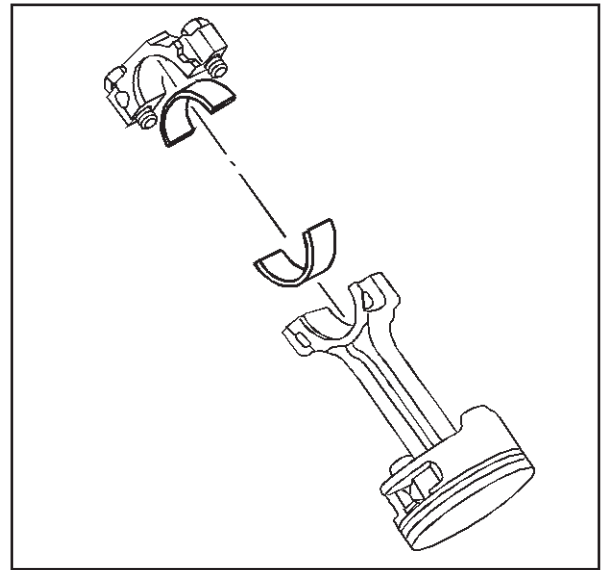
2. Install the gauging plastic onto the connecting rod bearing journal. Install the gauging plastic the full width of the journal.

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

3. Install the bearing cap, bearing and bolts.

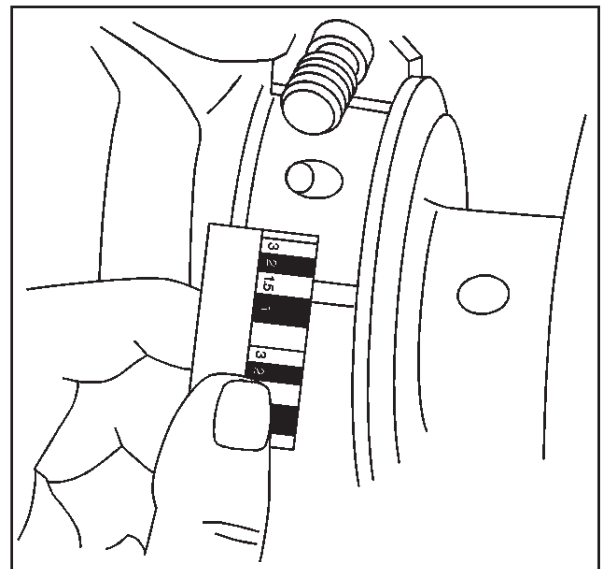
Tighten

- 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*



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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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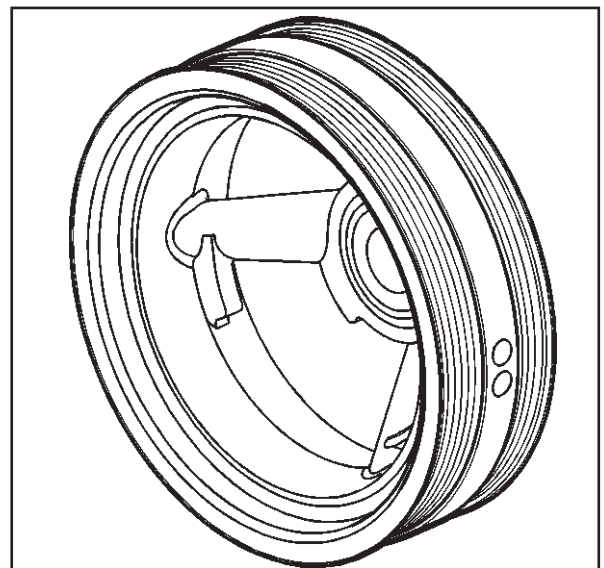
Crankshaft Balancer Clean and Inspect

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.

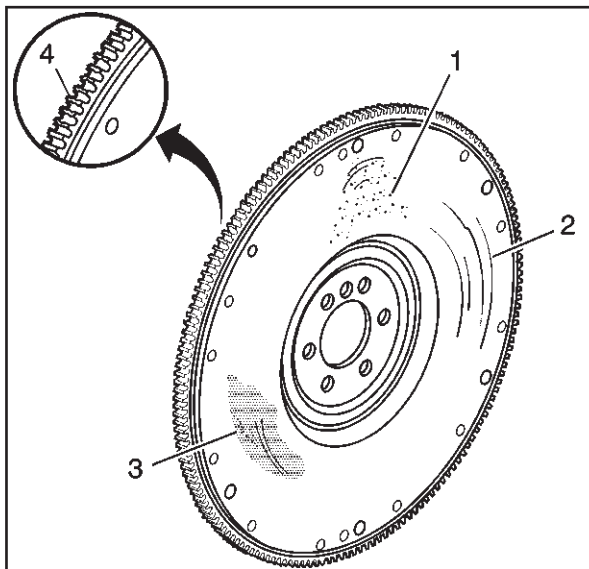


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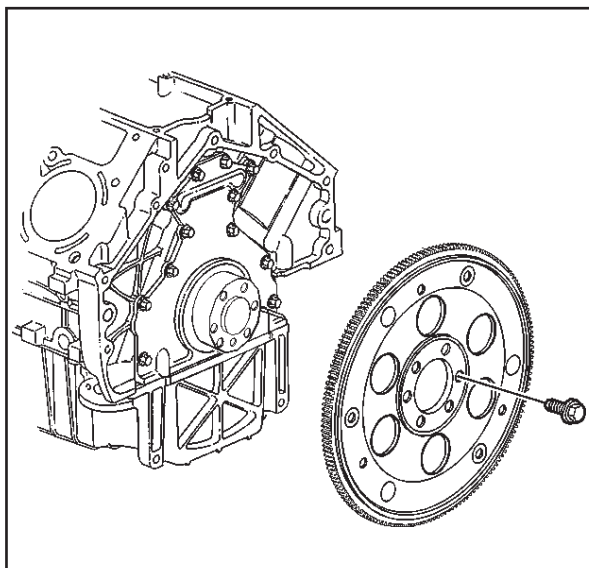
The balancer belt grooves should be free of any nicks, gouges or other damage that may not allow the belt to track properly.

Minor imperfections may be removed with a fine file.

- Worn, chunking or deteriorated rubber between the



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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

Piston and Connecting Rod Disassemble

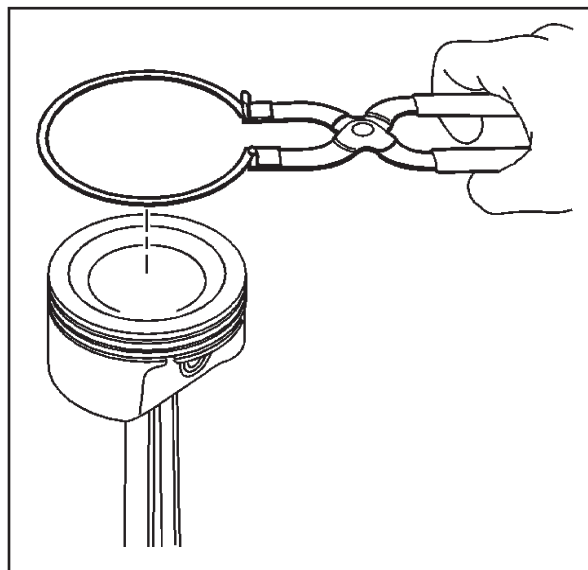
Important: Certain LQ9 engines will use a full-floating piston and pin design. In those applications, the pin is retained in the piston by retaining clips.

Press Fit Piston Pin

Tools Required

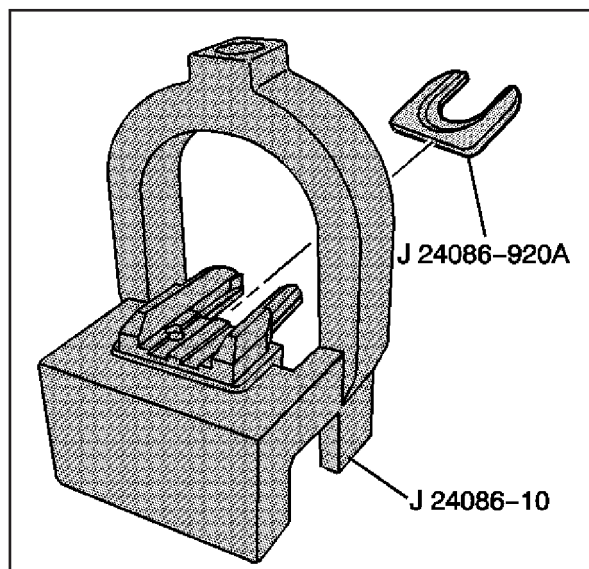
J 24086-C Piston and Pin Remover/Installer

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

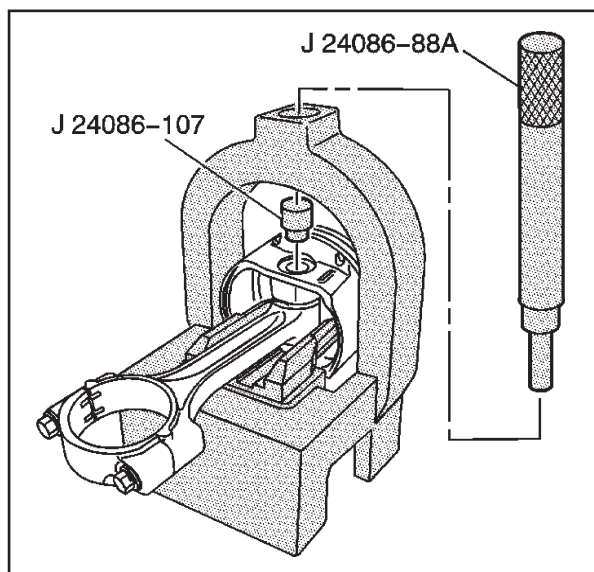


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2. Install fork insert *J 24086-920A* into fixture *J 24086-*

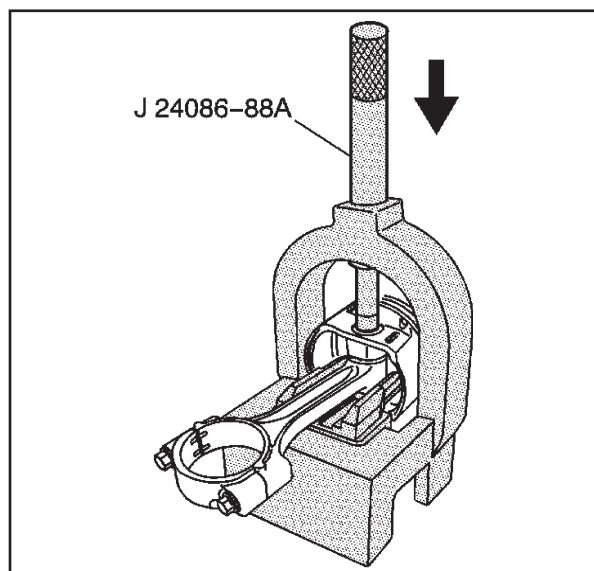


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3. Install the piston and connecting rod assembly onto *J 24086-10*.
4. Install *J 24086-107* into the piston pin and *J 24086-88A* through the fixture and into *J 24086-107*.



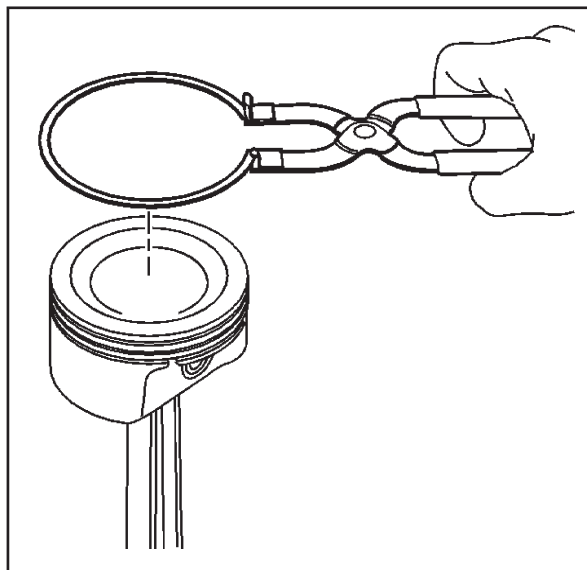
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Notice: After the installer hub bottoms on the support assembly, do not exceed 35,000 kPa (5,000 psi) pressure, this could cause damage to the tool.

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

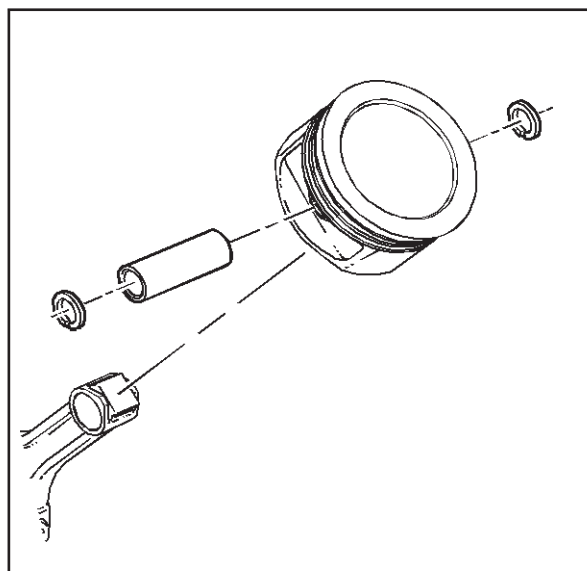
Full-Floating Piston Pin

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

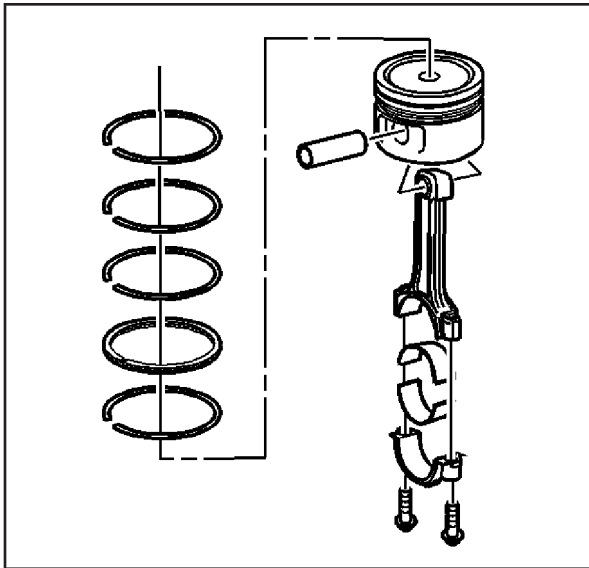


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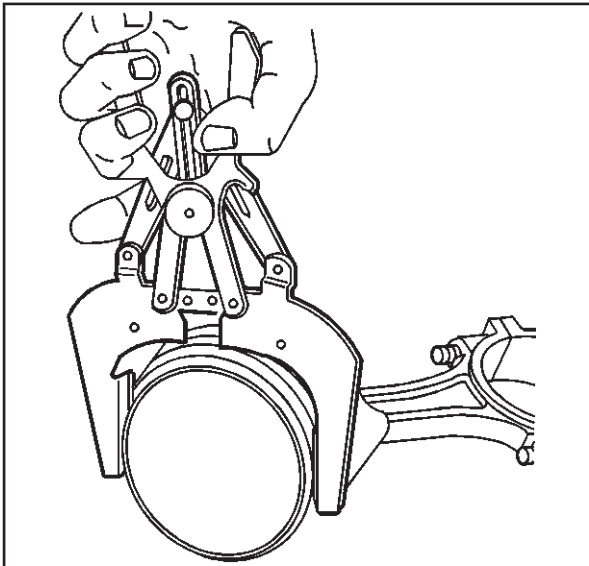
2. Remove the piston pin retaining clips.
3. Remove the pin from the piston and connecting rod.
4. The piston and pin are a matched set and are not to be serviced separately. Mark, sort or organize the piston and the matching piston pin. Refer to



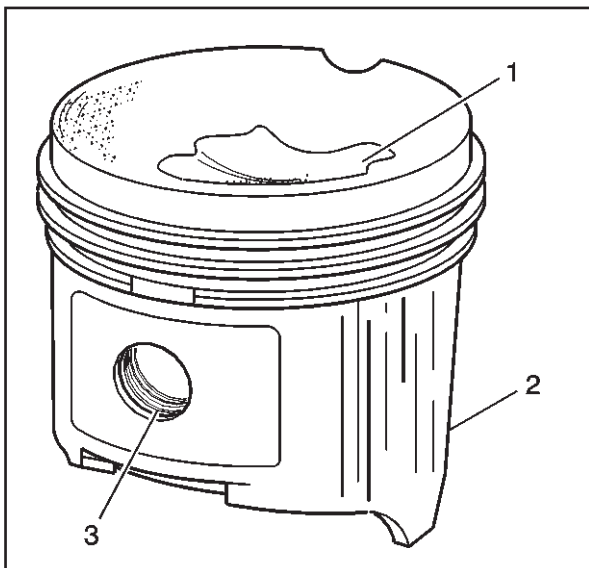
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Piston, Connecting Rod and Bearings Clean and Inspect

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.*

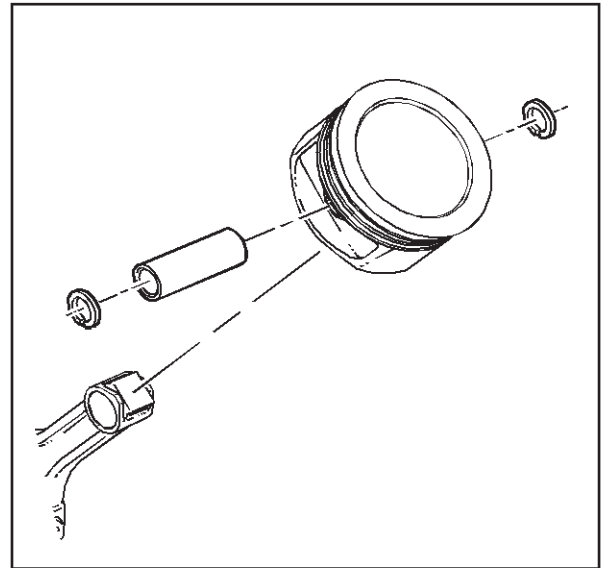
2. Dry the piston and the pin with compressed air.

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

5. Inspect the piston 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

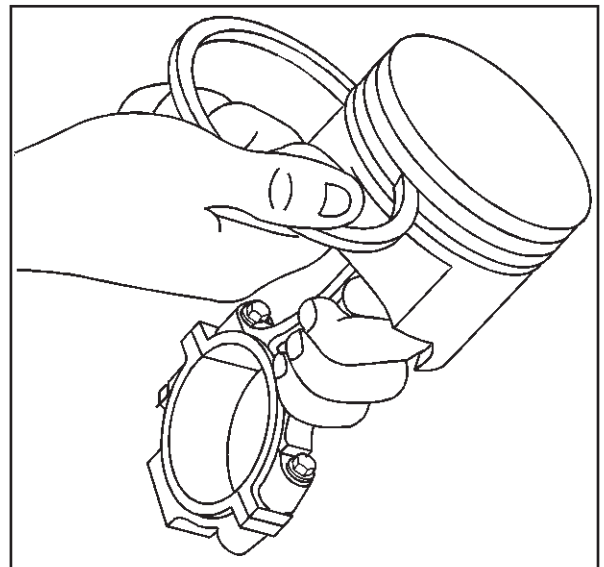
6. For certain applications, inspect for bent pin retaining clips or damage to the clip groove of the piston.



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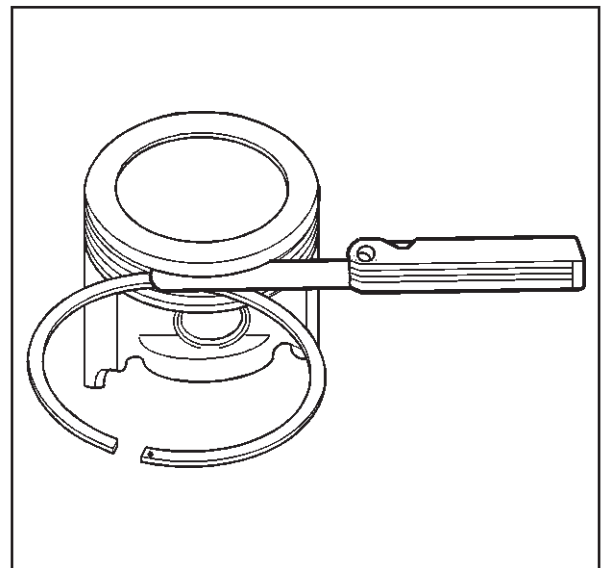
Important: Measurements of components should be taken with the components at normal room temperature.

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,

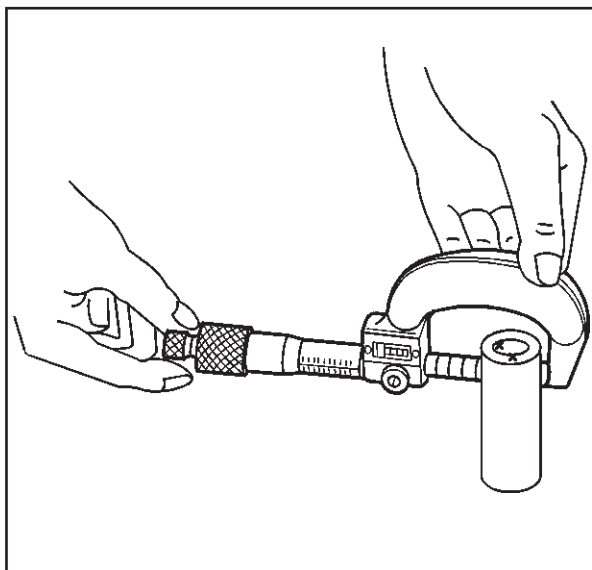


4969

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.

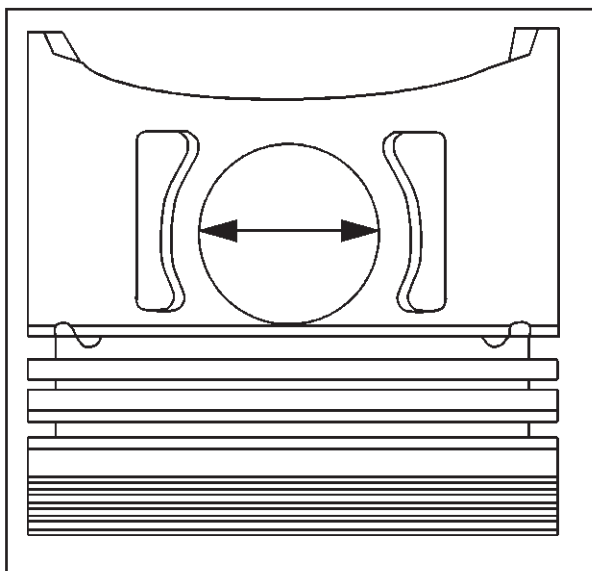


22934



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*

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.

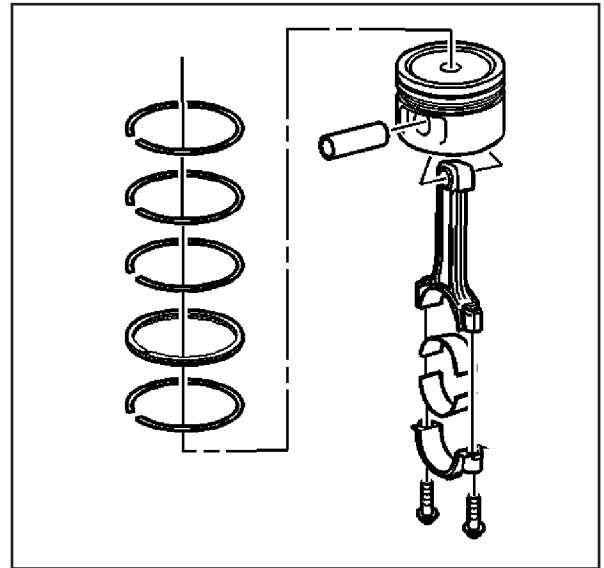
2. Clean the connecting rod threaded bolt holes.

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

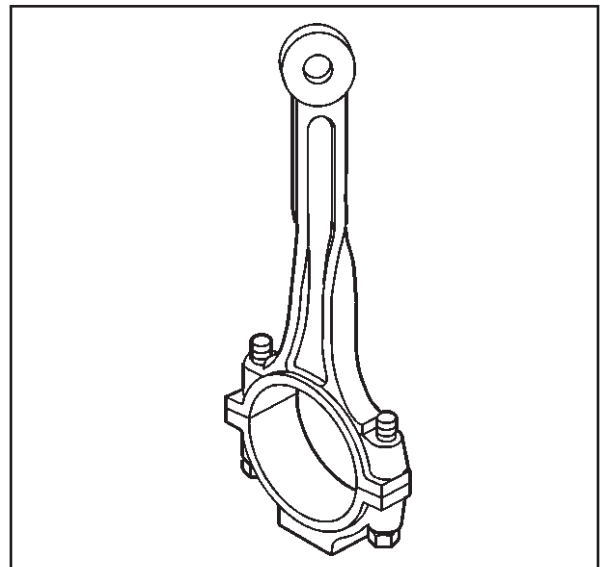
3. Dry the connecting rod with compressed air.

4. Inspect the connecting rod for the following:

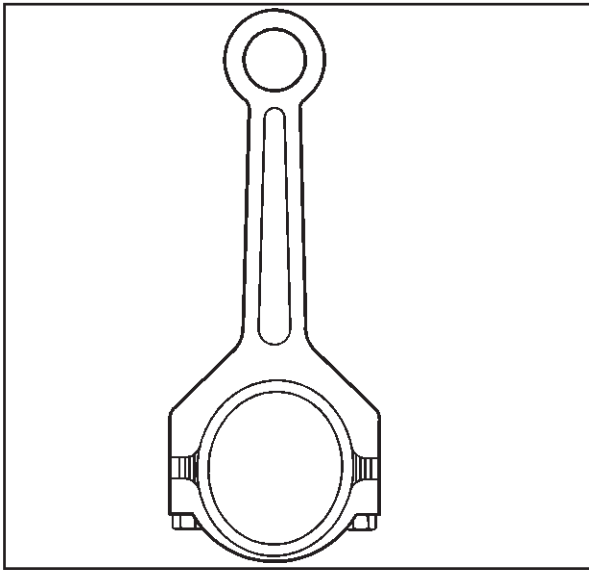
- Twisting
- Nicks or gouging in the bearing bore
- Damage to the bearing locating slots in the bearing bore
- Proper fit of the connecting rod and the cap mating surfaces



64180



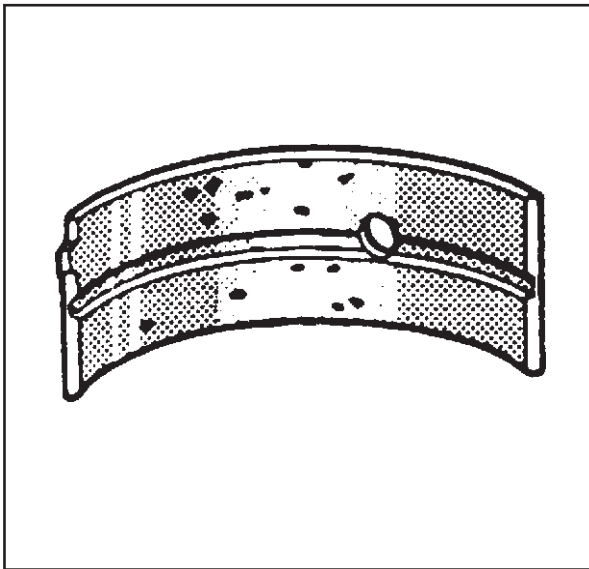
156169



156167

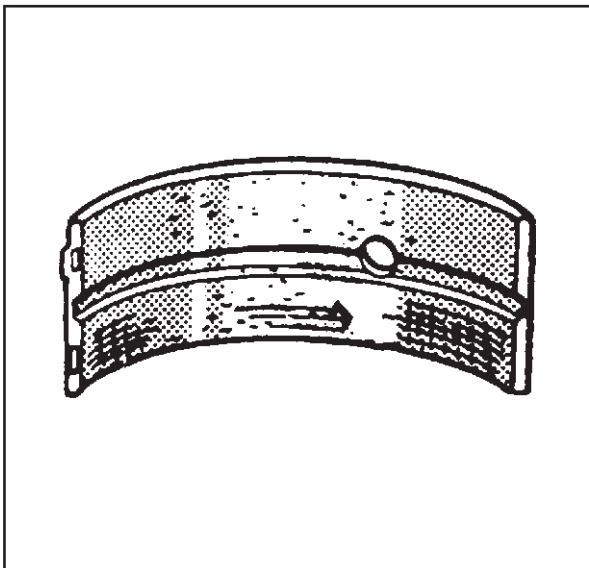
5. Measure the connecting rod bearing bore for out-of-round.

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



52051

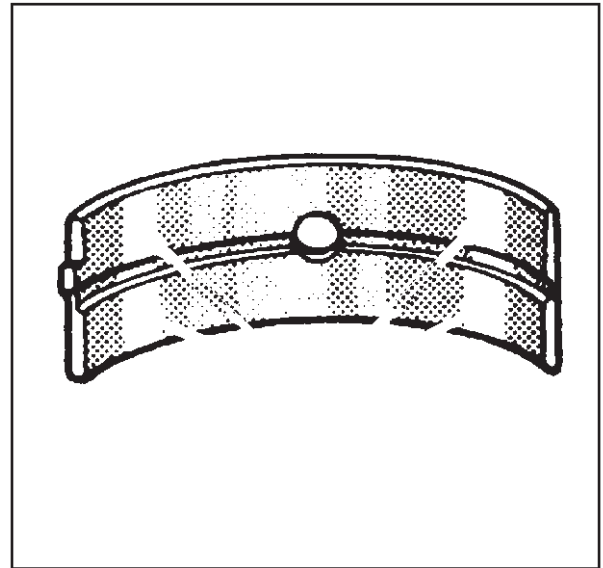
6. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



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.



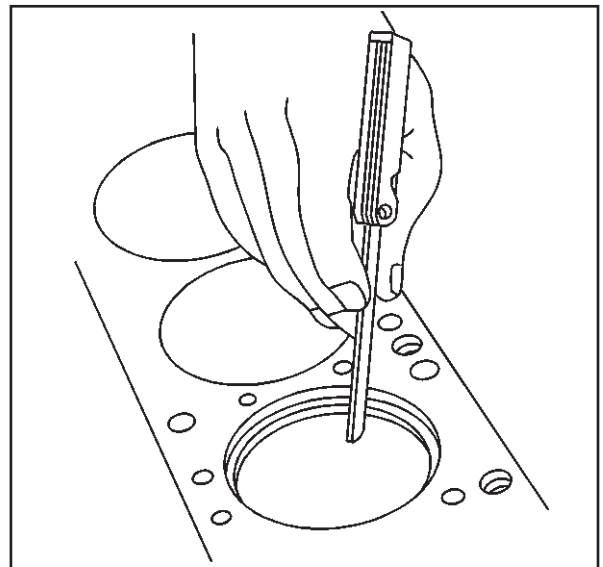
52056

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

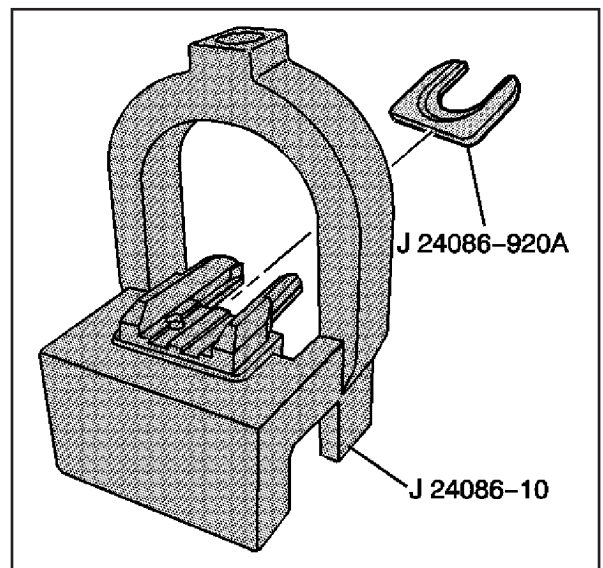
Tools Required

J 24086-C Piston Pin Remover/Installer Set

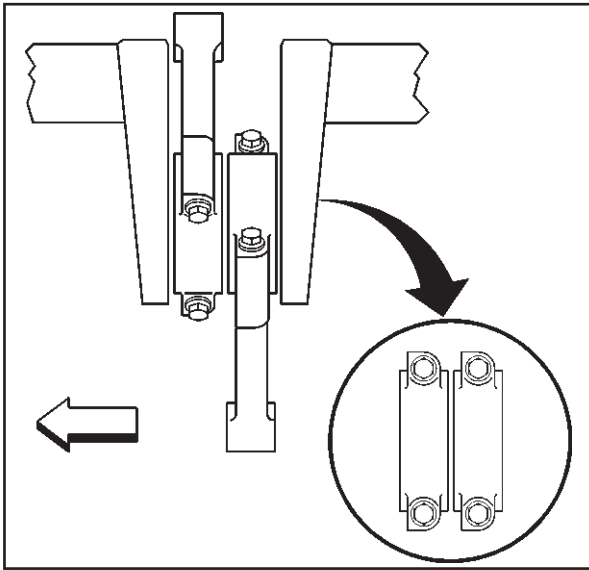
J 24086-10 Piston Pin Remover/Installer Base

J 24086-9 Adjustable Installer

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



533477



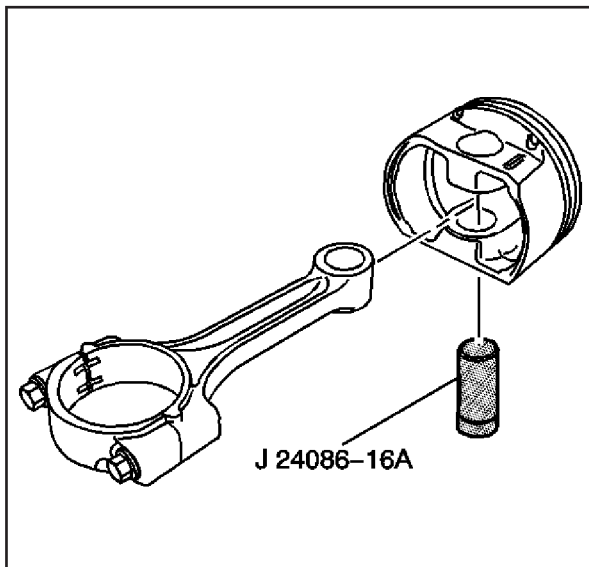
63227

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.

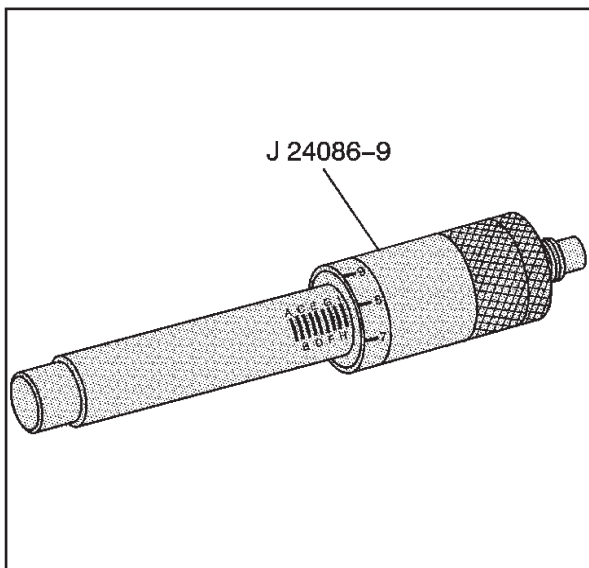
2. Use a torch and apply MILD heat to the pin end of the connecting rod.
Mild heating of the connecting rod will ease in piston and pin assembly.

3. With the piston and connecting rod properly assembled, both the flat flange area of the



533488

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

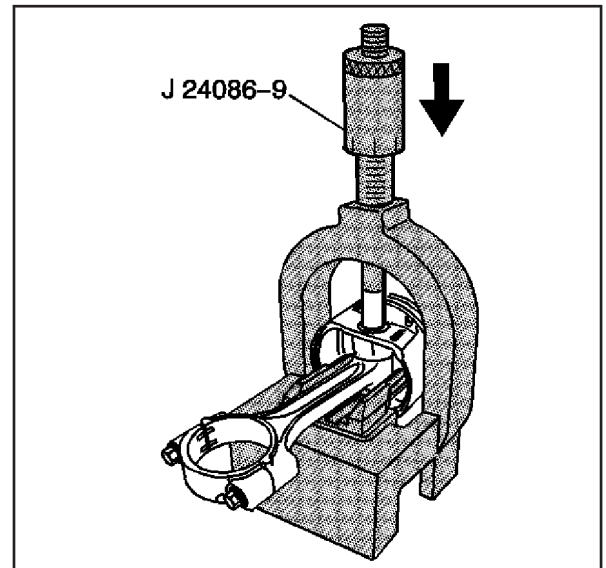


533486

5. Adjust installation pin J 24086-9 to 1-8.

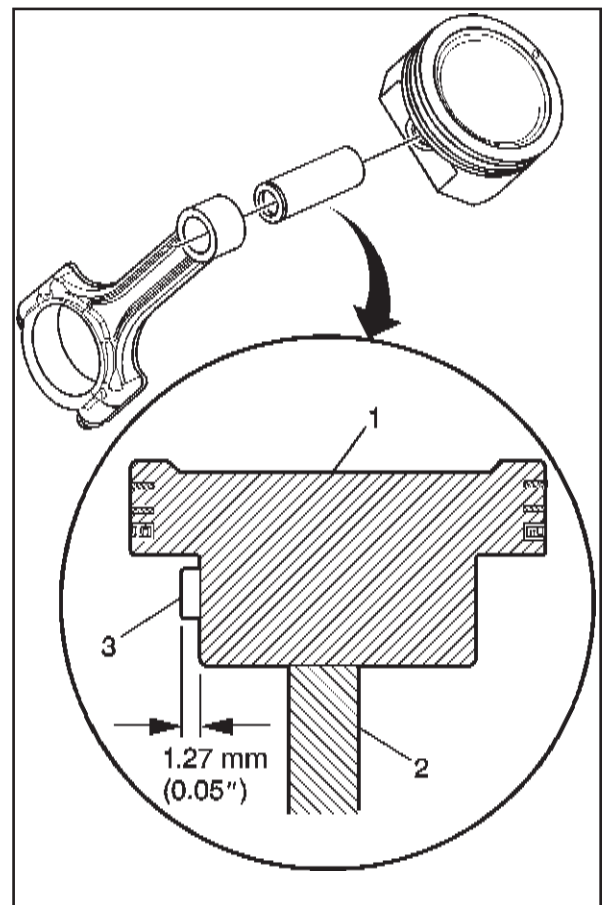
Notice: After the installer hub bottoms on the support assembly, do not exceed 35,000 kPa (5,000 psi) pressure, this could cause damage to the tool.

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*.

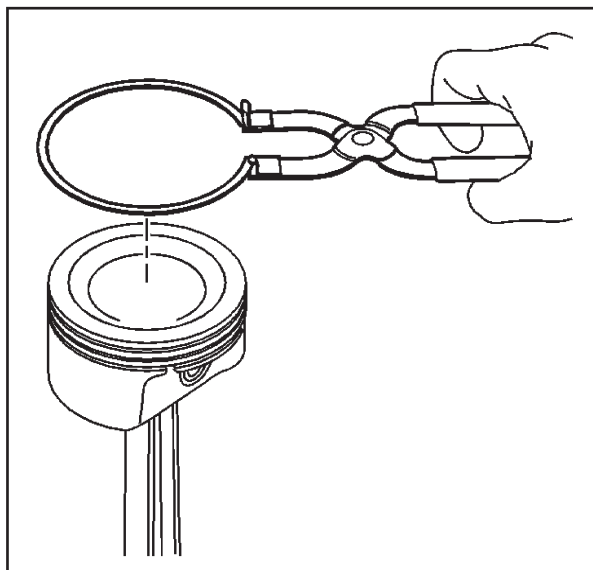


533483

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.

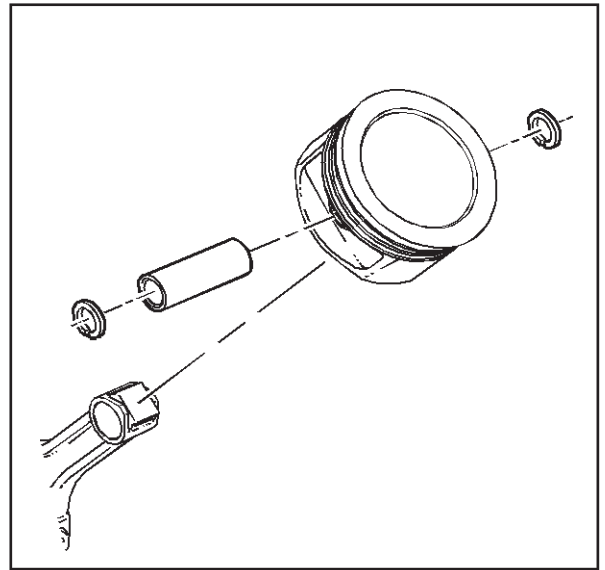
The upper compression ring does not have a dimple or orientation mark and may be installed in either direction.

- 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.

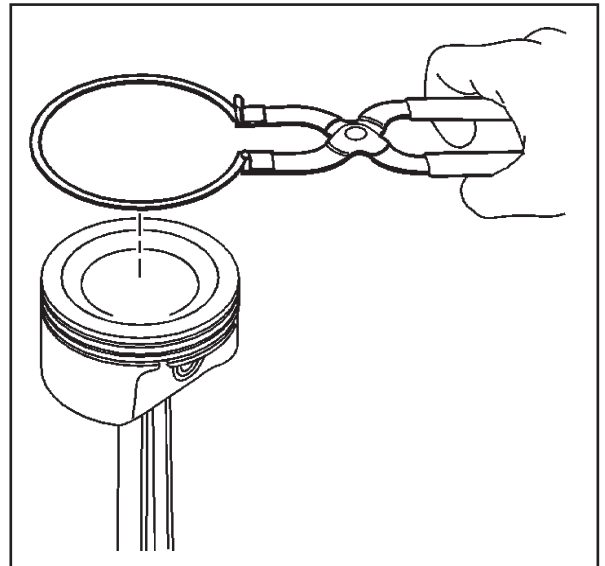
- 3.5. Using piston ring pliers, install the lower compression ring.

The lower compression ring has a dimple or orientation mark and must face the top of the piston.

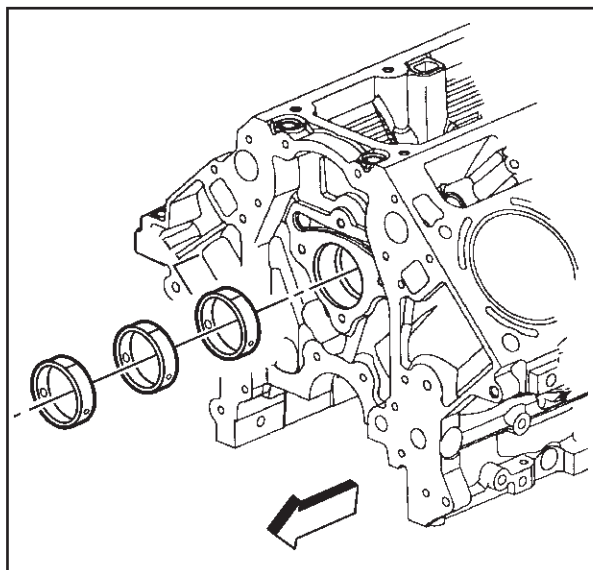
- 3.6. Using piston ring pliers, install the upper compression ring.

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).



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63163

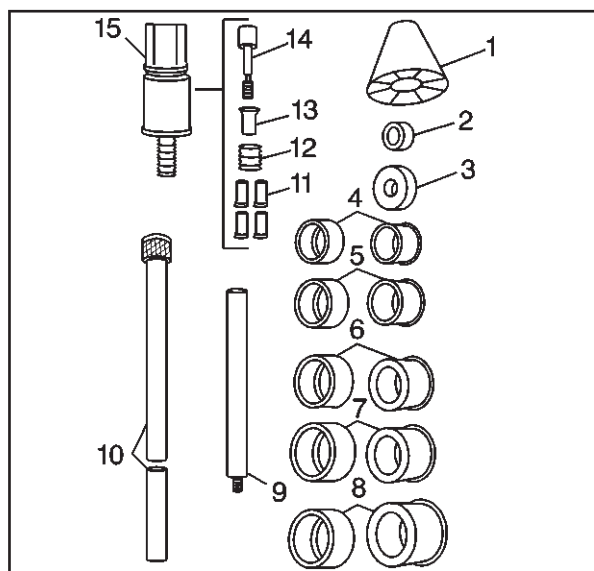
Camshaft Bearing Removal

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.



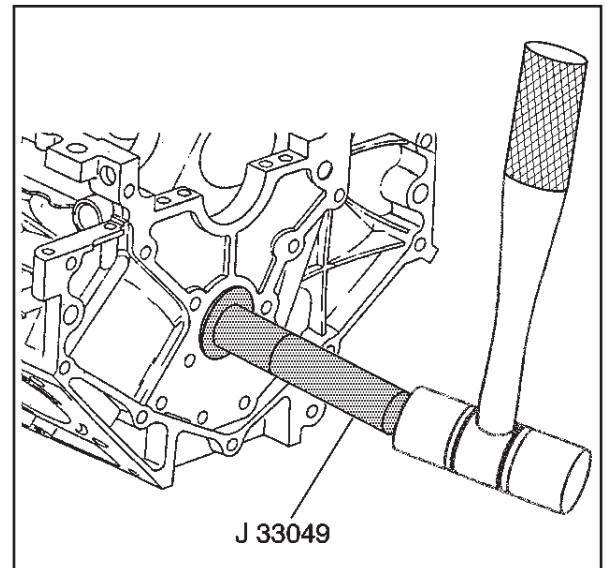
66100

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.

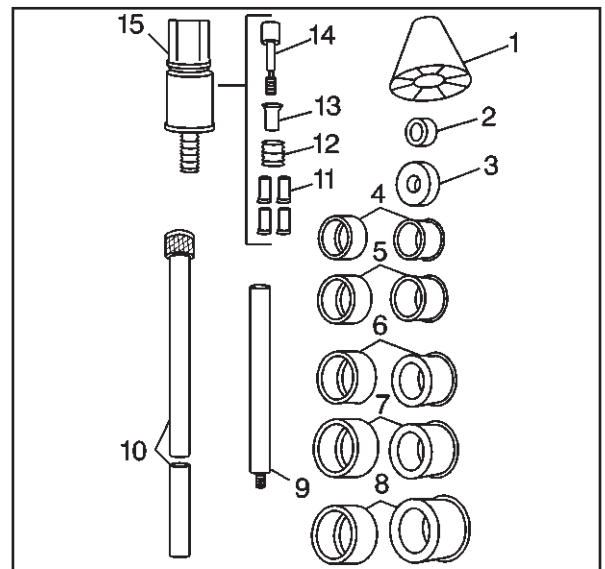


63219

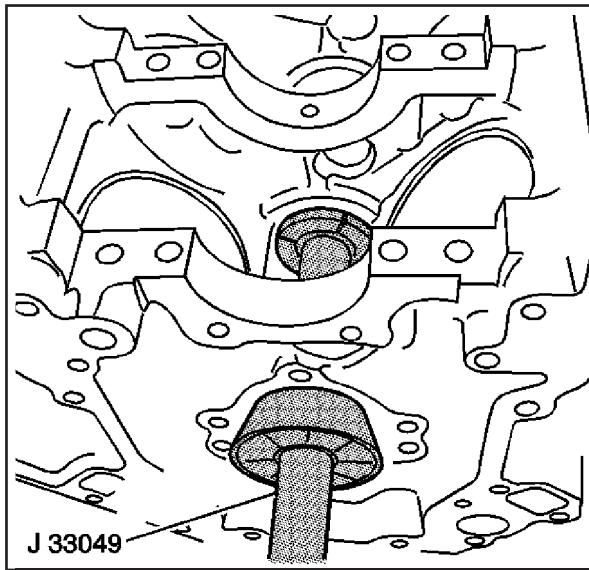
Tool Usage Information

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



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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.

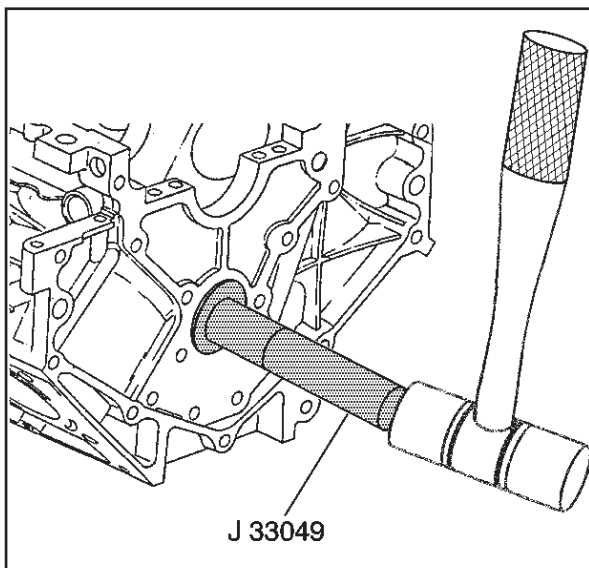
It may be necessary to install the driver bar extension for removal of the inner bearings.

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

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

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

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



63219

Camshaft and Bearings Clean and Inspect

Tools Required

J 7872 Magnetic Base Dial Indicator Set

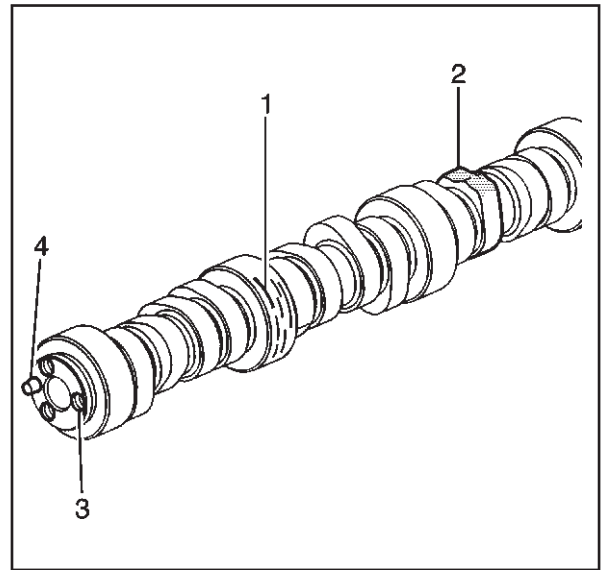
J 8520 Camshaft Lobe Lift Indicator

1. Clean the components in solvent.

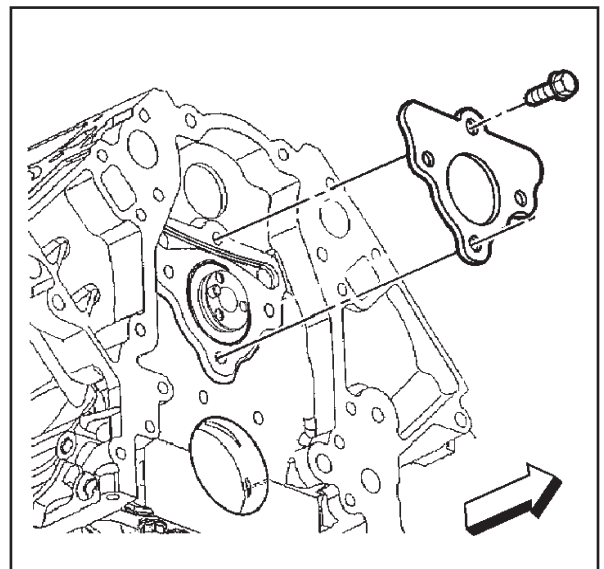
Caution: Wear safety glasses in order to avoid eye damage.

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.



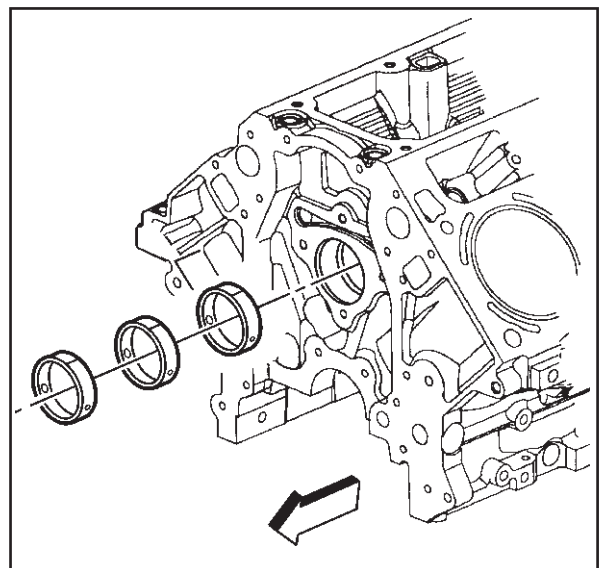
188095



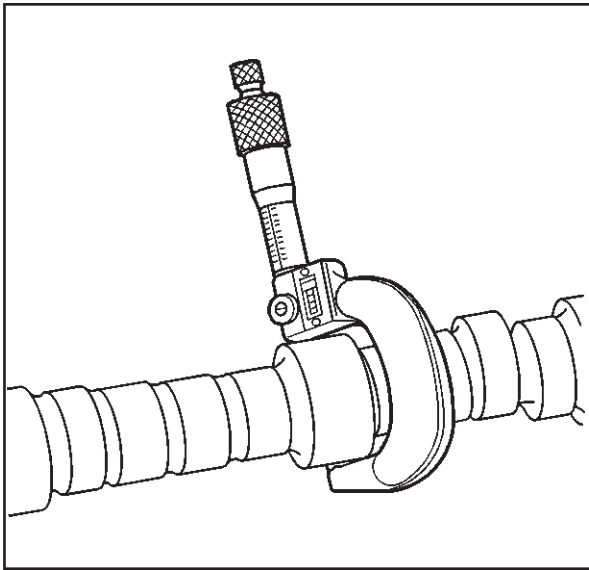
63211

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.



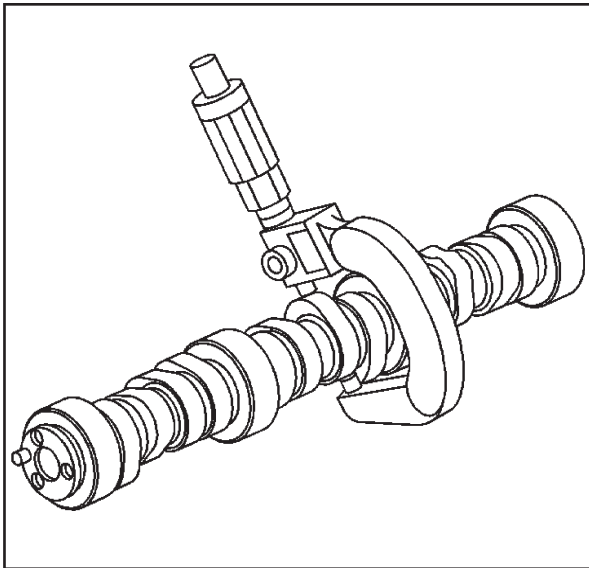
63163



35212

11. Measure the camshaft journals for wear and out-of-round with a micrometer.

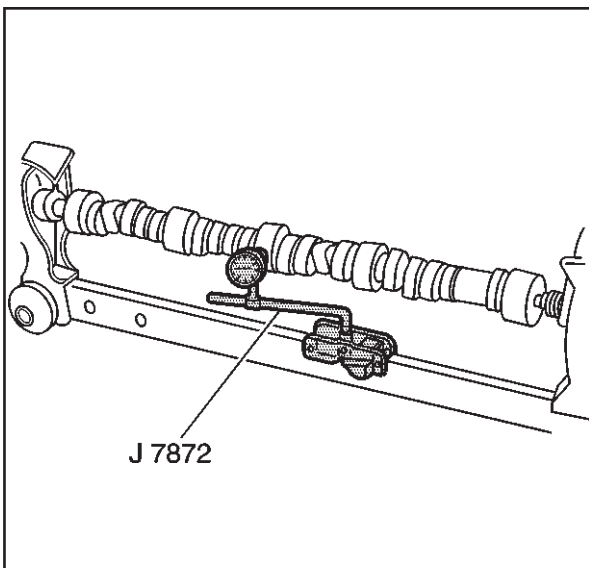
- If the camshaft bearing journals are more than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
- If the camshaft bearing journal diameter is less



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



64297

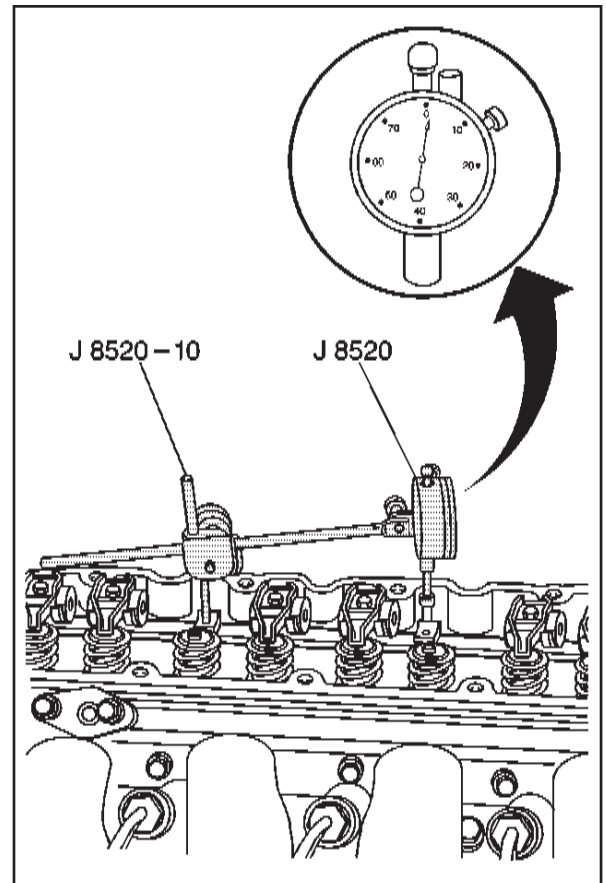
13. Measure the camshaft runout.

- 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

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



64967

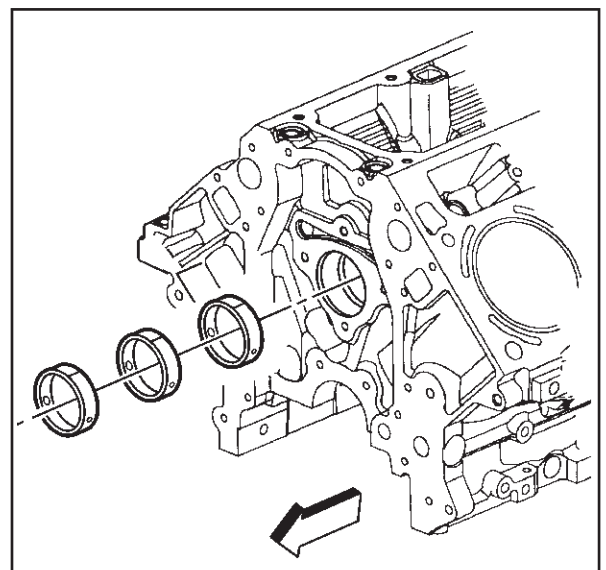
Camshaft Bearing Installation

Tools Required

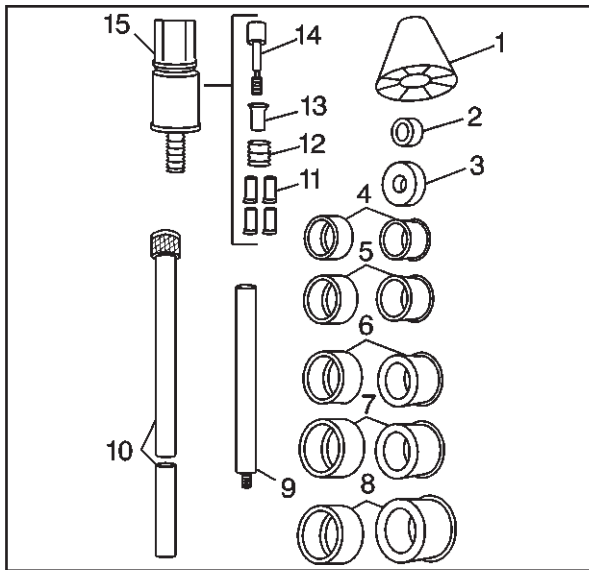
J 33049 Camshaft Bearing Remover/Installer

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

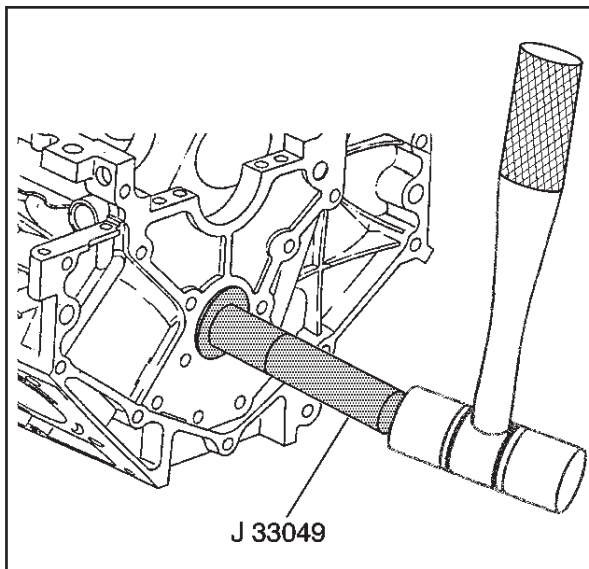
1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing



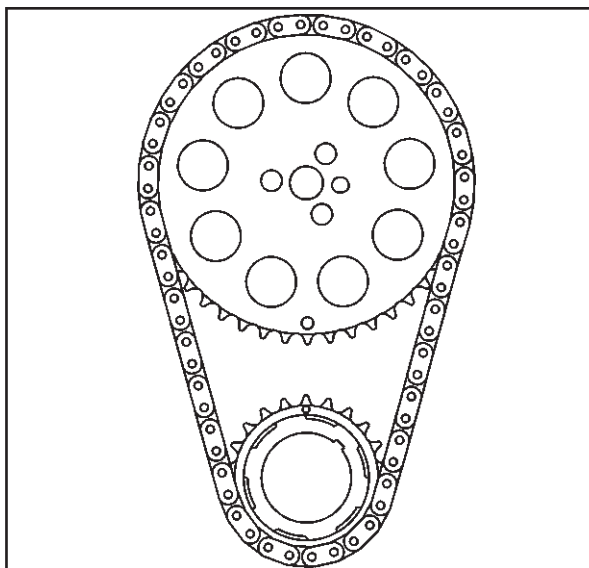
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3. Select the expanding driver (4-6) and washer (2 or 3) from the tool usage information.
Refer to *Camshaft Bearing Removal*.
4. Assemble the tool.

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.

Timing Chain and Sprockets Clean and Inspect

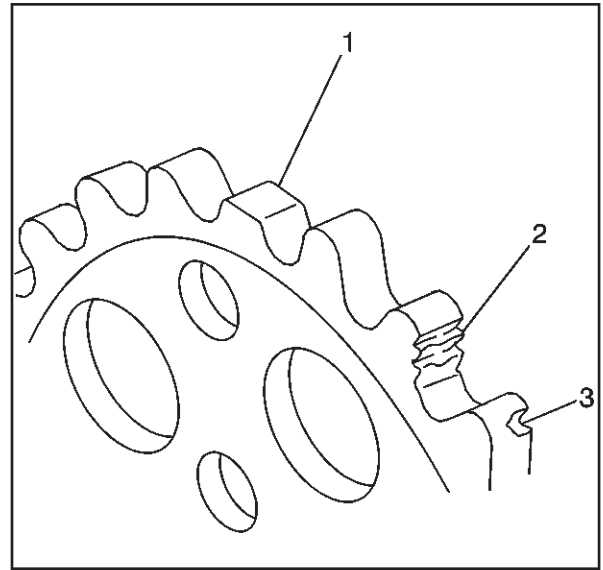
1. Clean the components in solvent.

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.

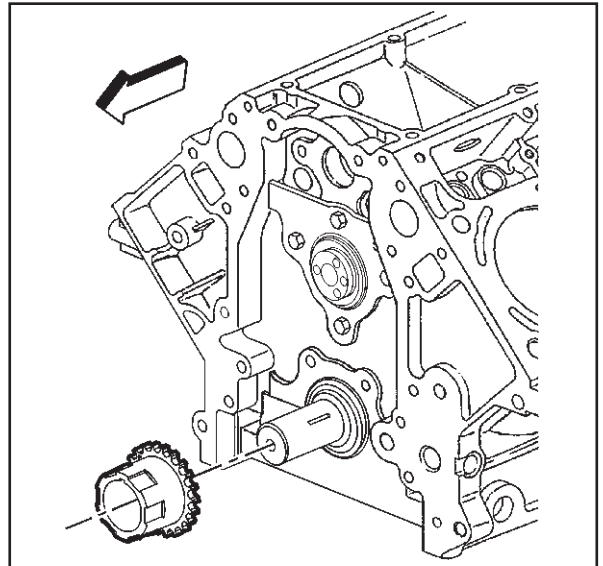
4. Inspect the camshaft and crankshaft sprockets for the following:

- 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

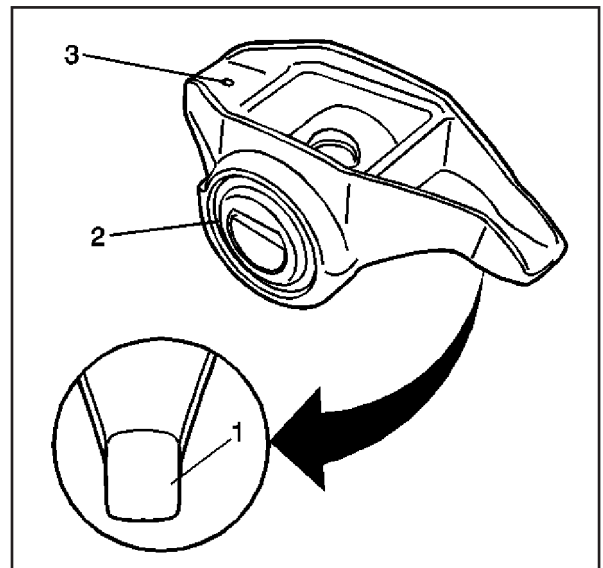
Valve Rocker Arm and Push Rods Clean and Inspect

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

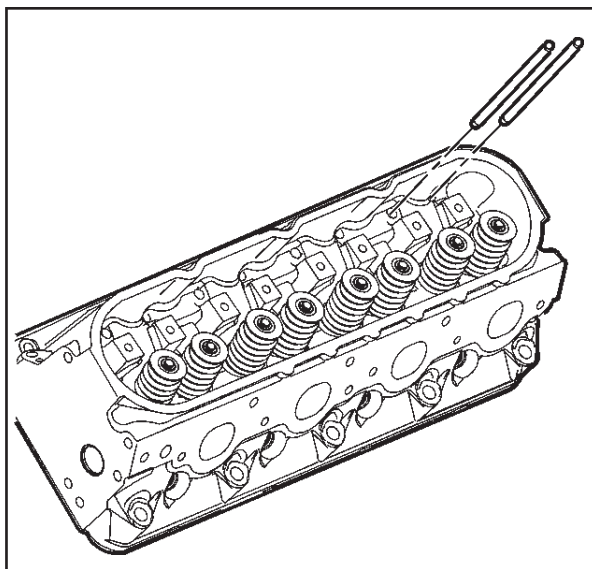
1. Mark, sort or organize the components for assembly.
2. Clean the components with cleaning solvent.

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

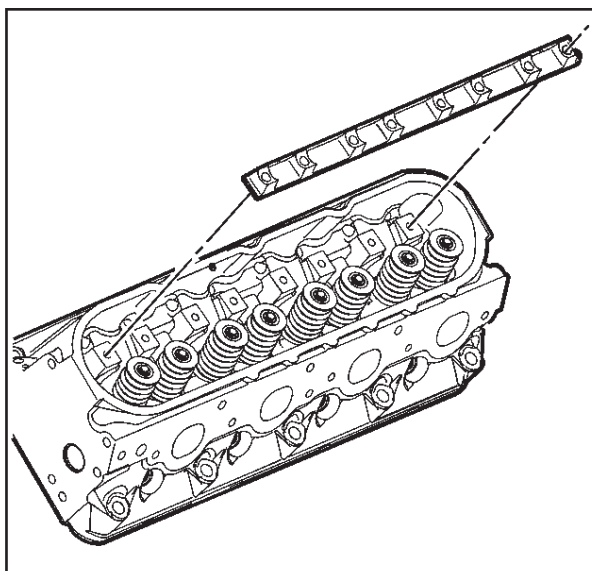


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6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod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



260141

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

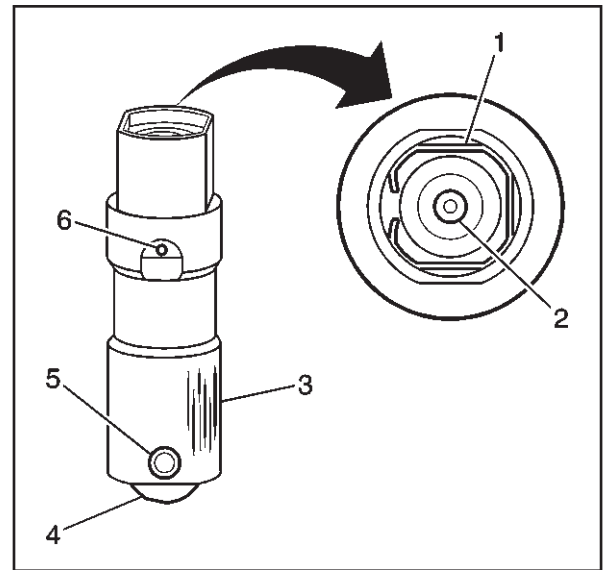
Valve Lifters and Guides Clean and Inspect

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.

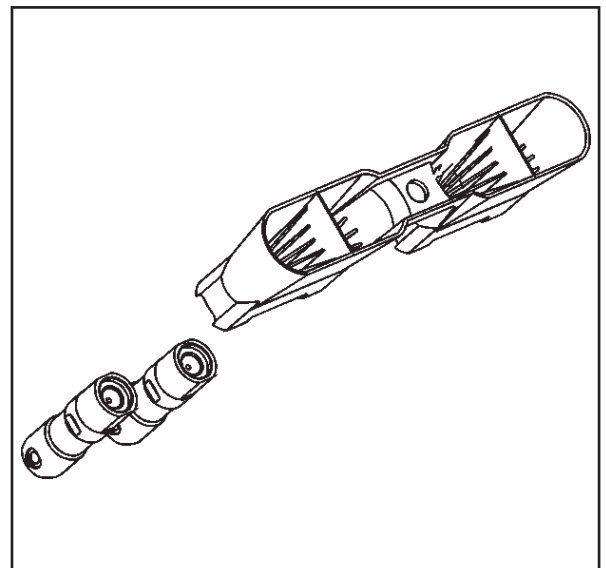
Caution: *Wear safety glasses in order to avoid eye damage.*

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 bearingThe roller should rotate freely with no binding or roughness.

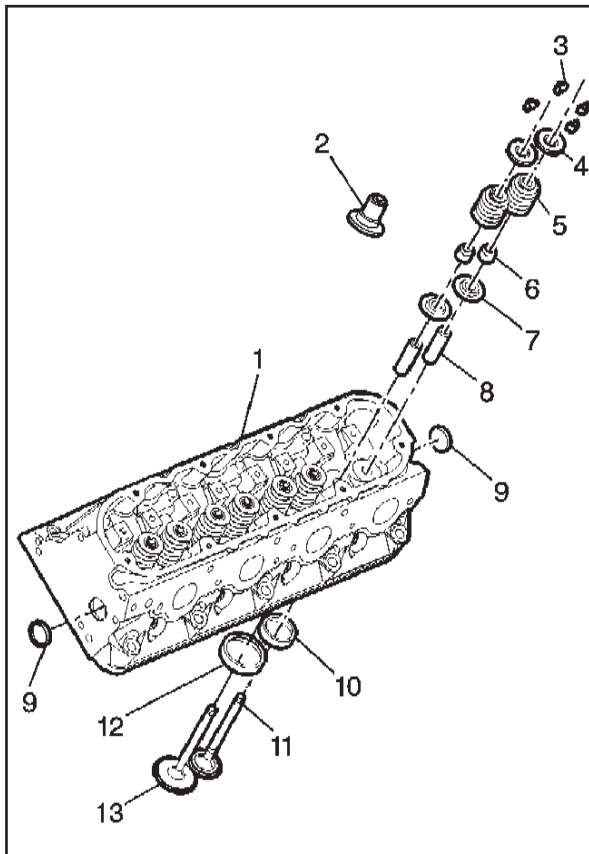


178485

5. Inspect the valve lifter guides for the following:
 - For cracks or damage
 - Excessive wear in the lifter mounting bores.



63233



721939

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.

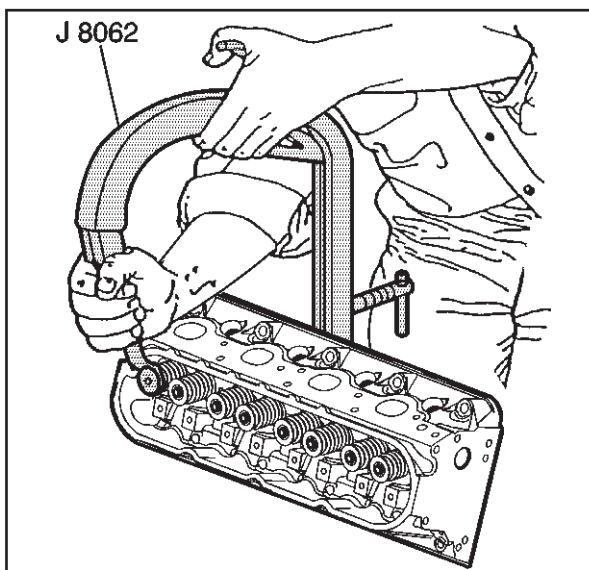
Do not remove the cylinder head expansion plugs (9) (aluminum heads only) unless service is required.

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.

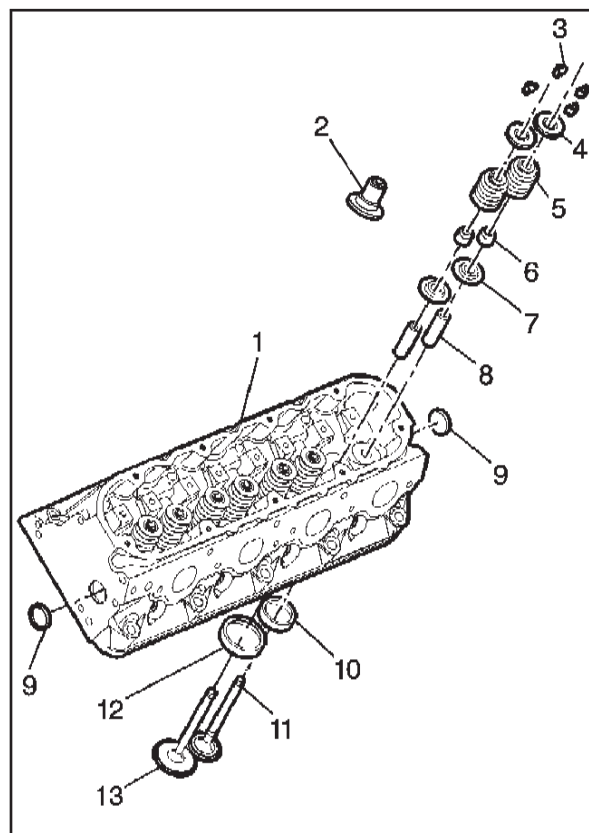
1. Remove the spark plugs from the cylinder heads.



260151

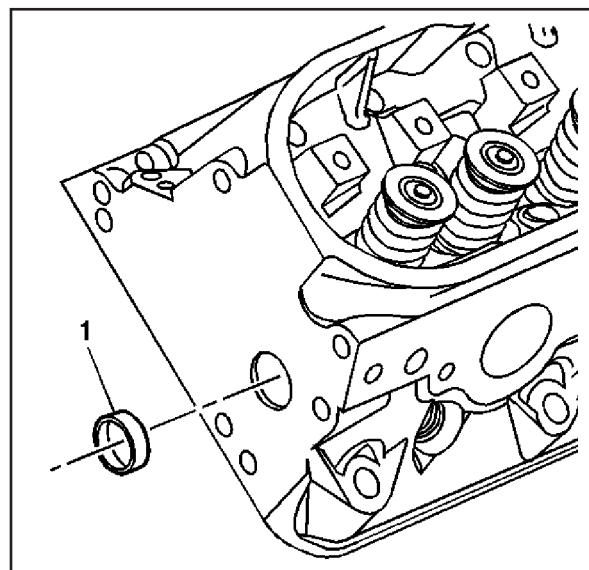
2. Use the *J 8062* in order to compress the valve

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 (second design). Refer to *Separating Parts*.

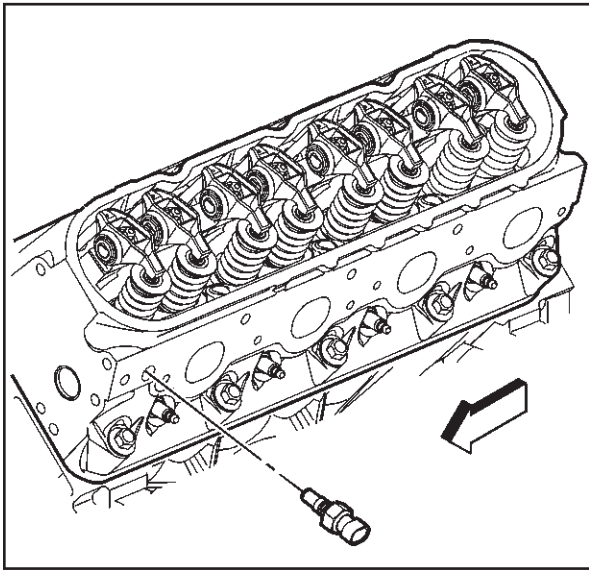


721939

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

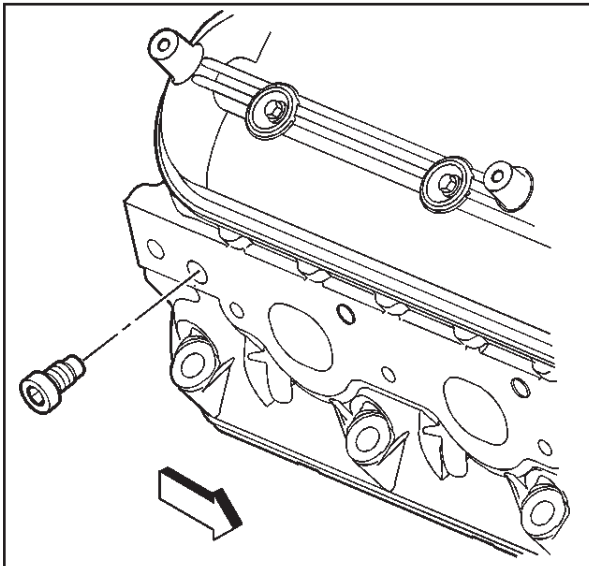


490662



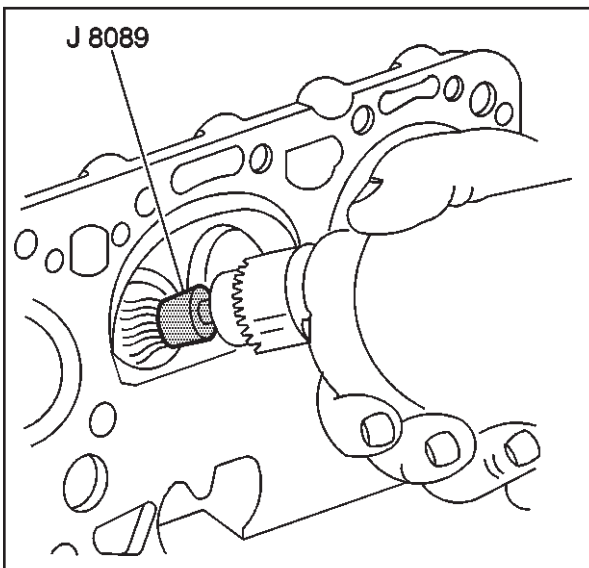
260086

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:

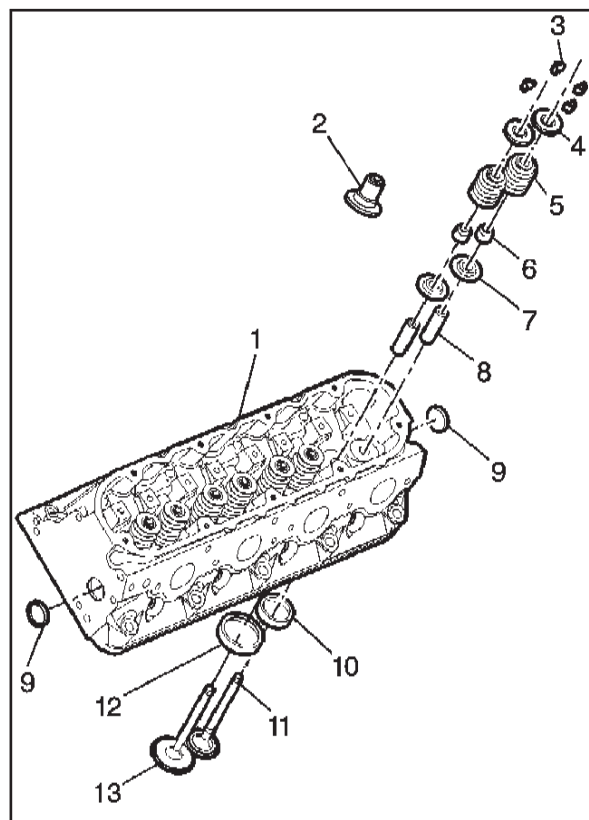
Caution: *Wear safety glasses in order to avoid eye damage.*

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.

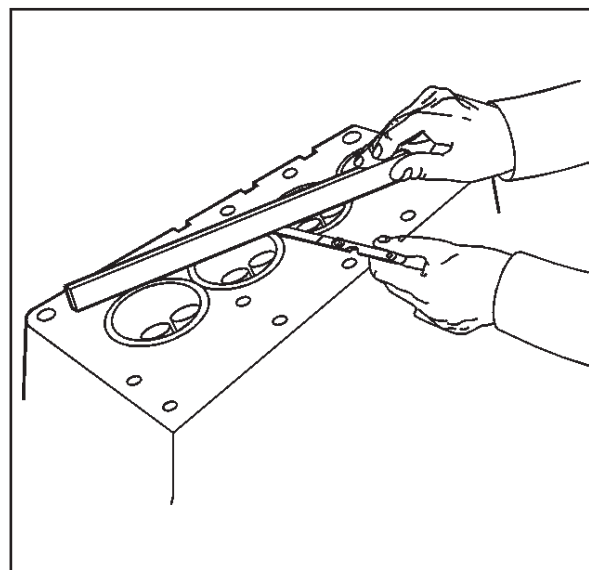
2. Inspect the following:

- 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*

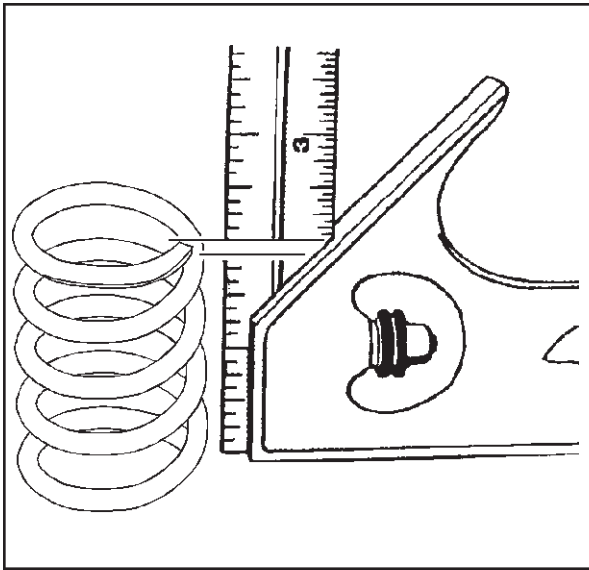


721939

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

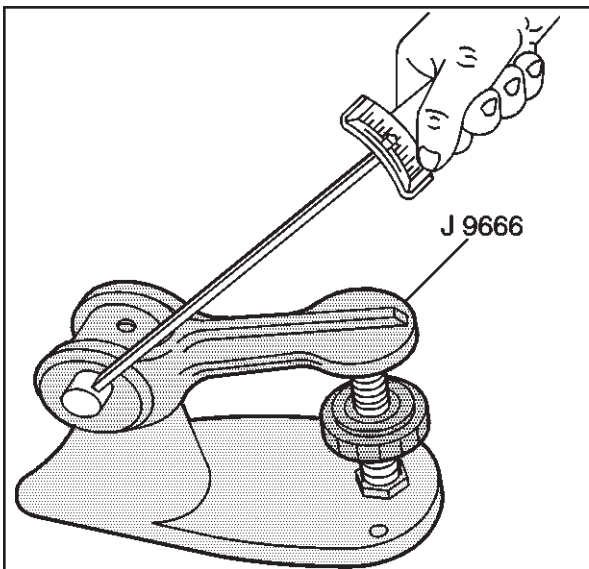


64318



40075

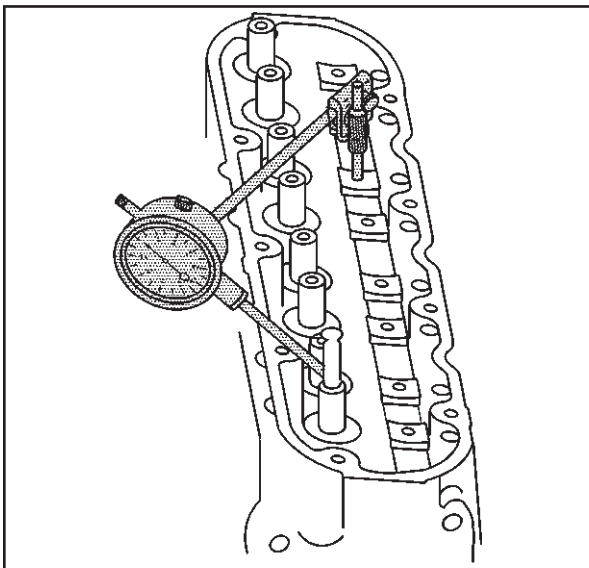
4. Inspect the valve springs for squareness.



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.

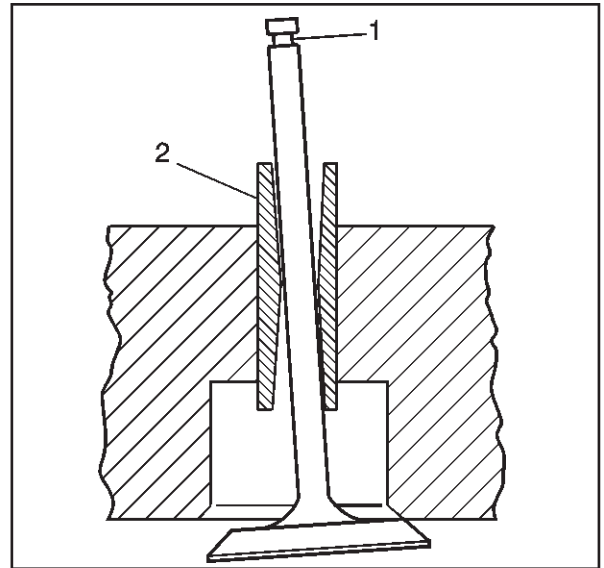
Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

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

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

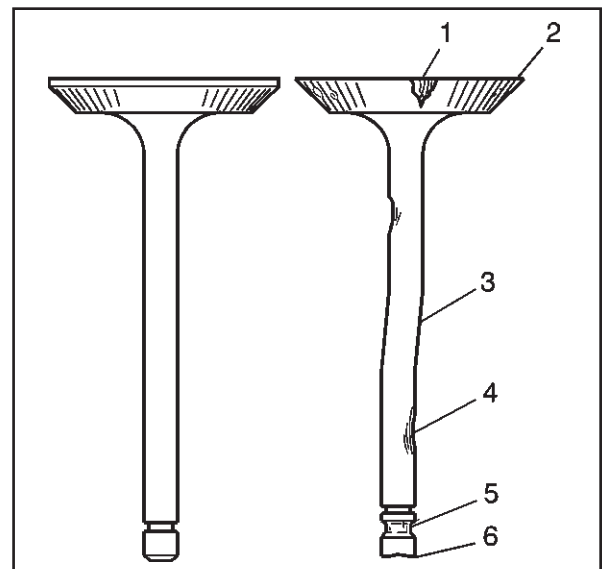
Refer to *Engine Mechanical Specifications*.



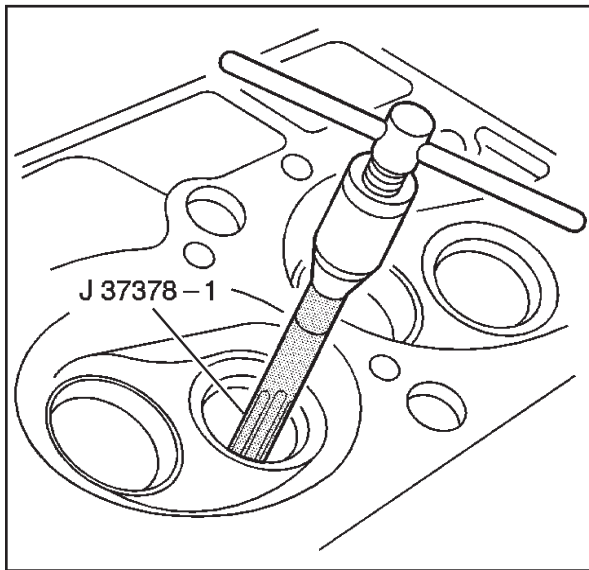
156172

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.

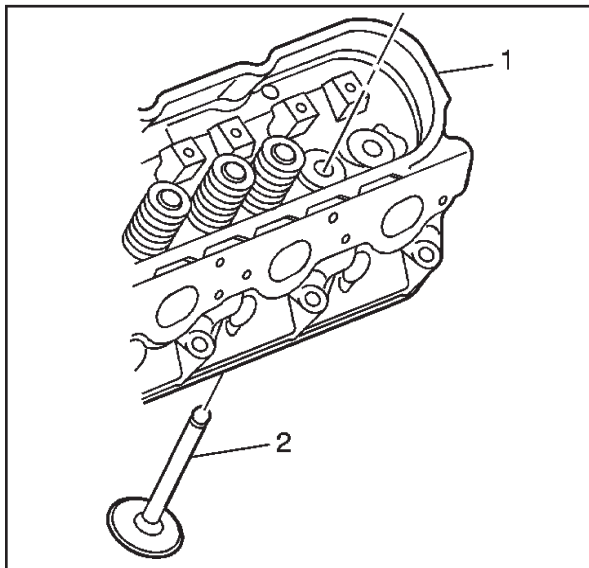


156174



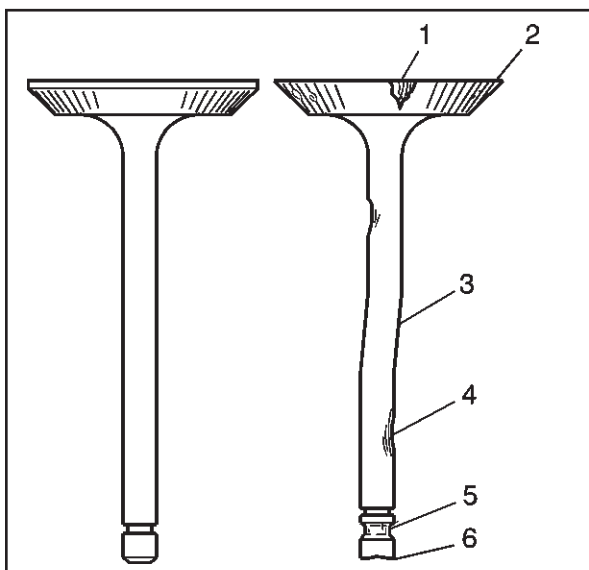
572270

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



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.



156174

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.

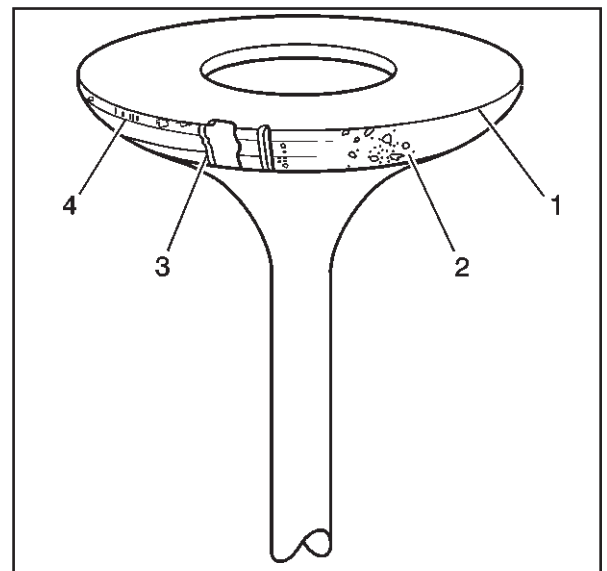
- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that 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:

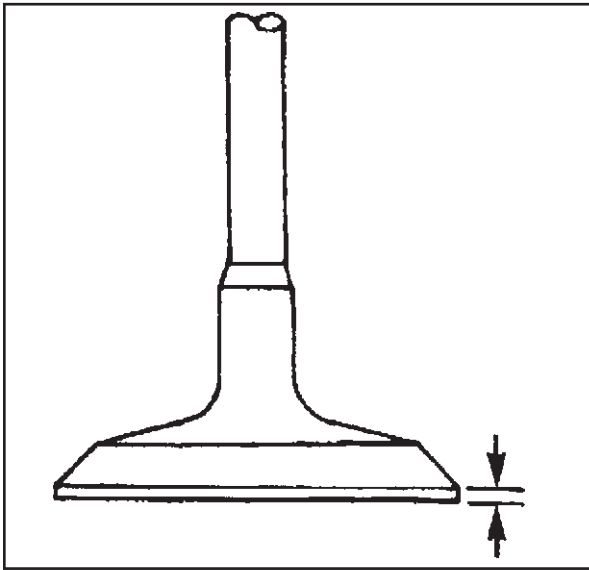
- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)

2. Inspect the valve face for the following:

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

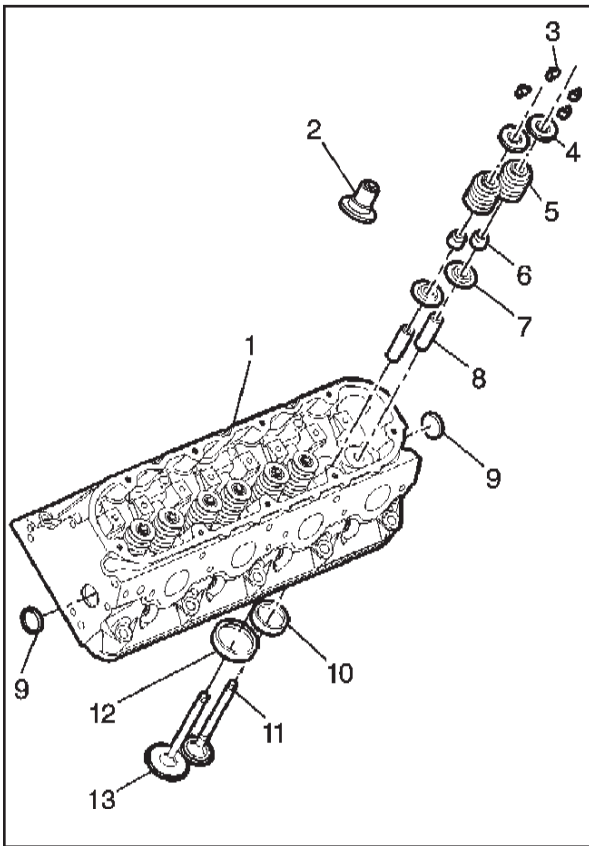


156173



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*



721939

7. Inspect for a loose valve seat (9 or 11) in the cylinder head (1). The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide (7) 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

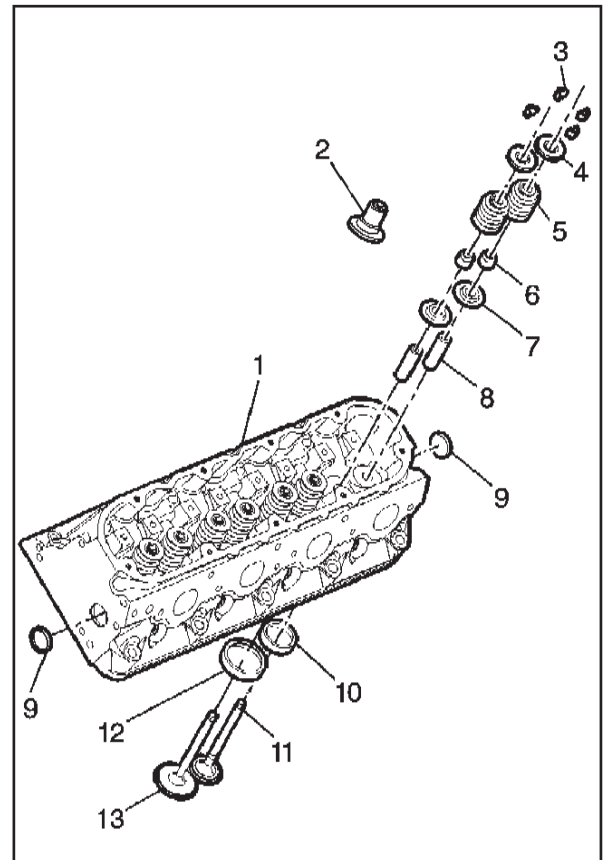
J 42078 Valve Stem Oil Seal Installer

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.



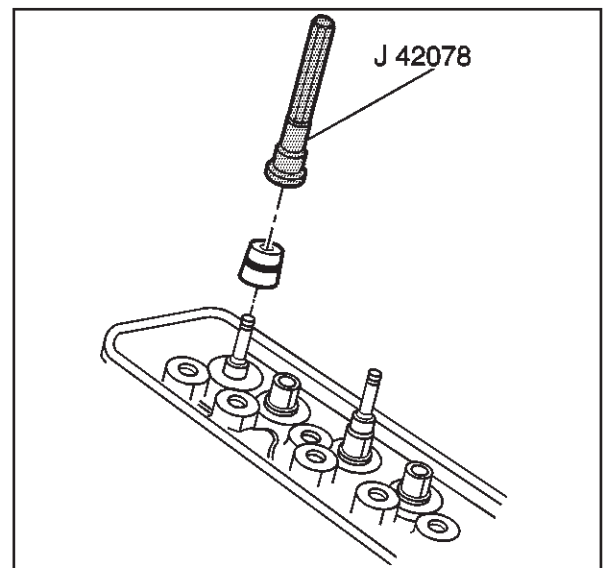
721939

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

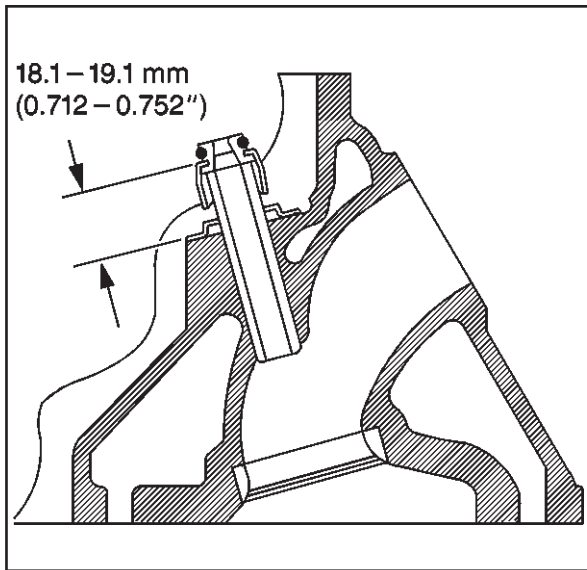
An improperly installed valve stem oil seal may lead to excessive oil consumption, increased emissions or component damage.

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



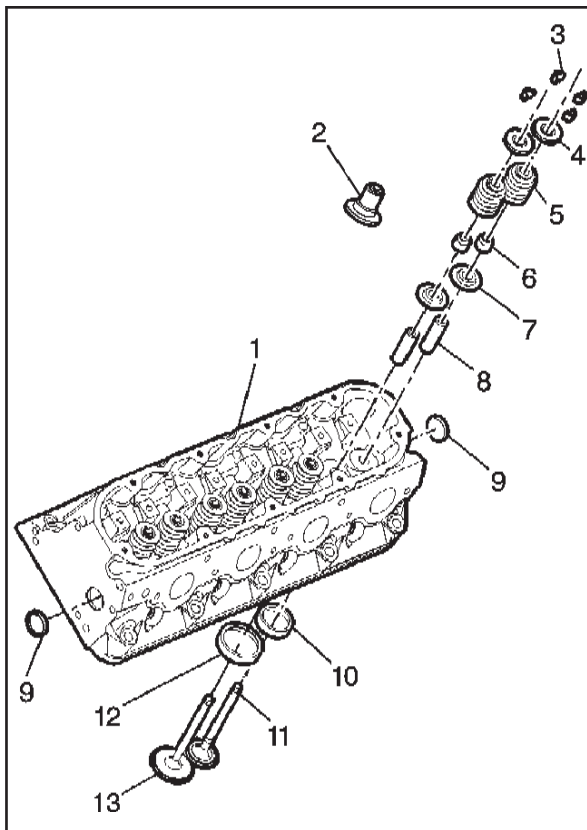
63193



63158

6. Measure the valve stem oil seals, first design, for the properly installed height.

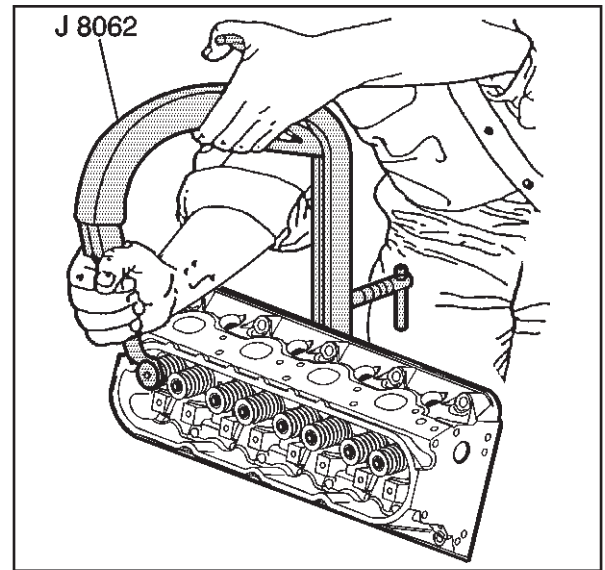
There should be a 18.1-19.1 mm (0.712-0.752 in) gap between the top edge of the oil seal body and the valve spring seat surface.



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).



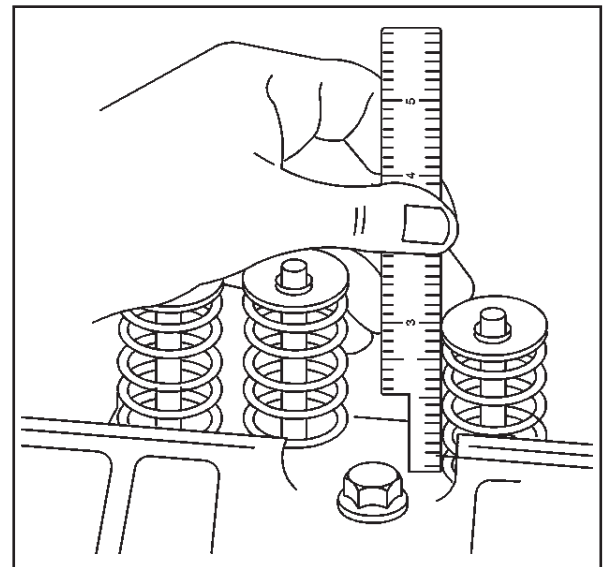
260151

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

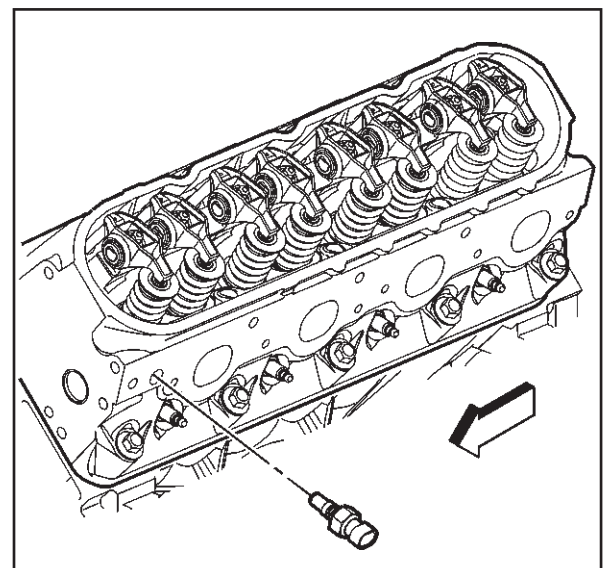
13. Install sealant GM P/N 12346004 or equivalent to the threads of the coolant sensor.

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

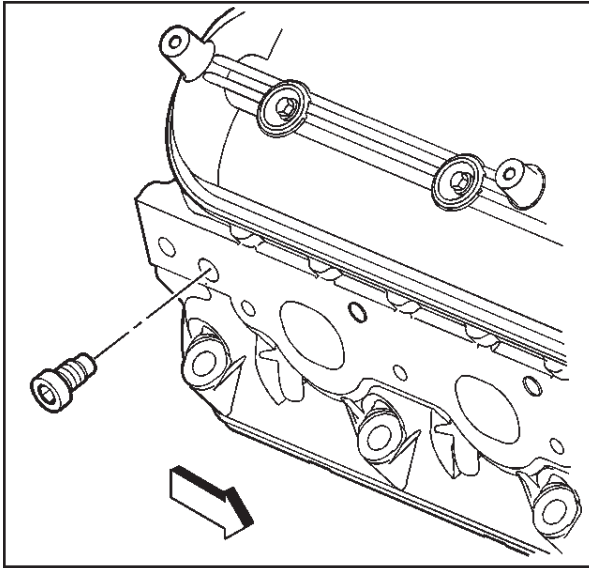
14. Install the coolant sensor into the left cylinder head.

Tighten

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



260086

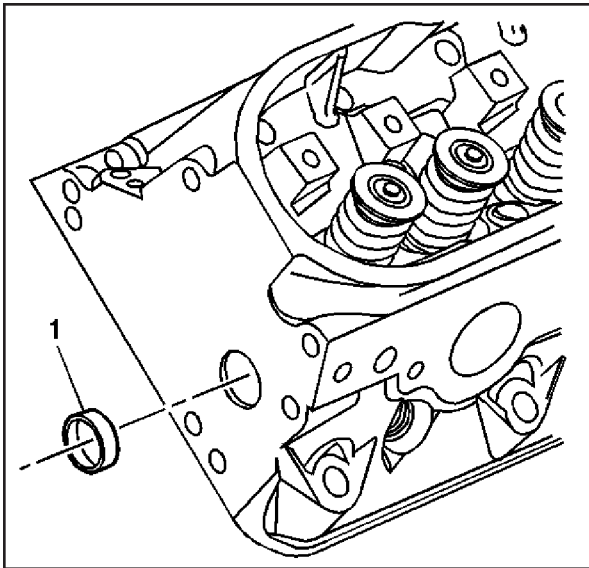


260157

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

Tighten

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

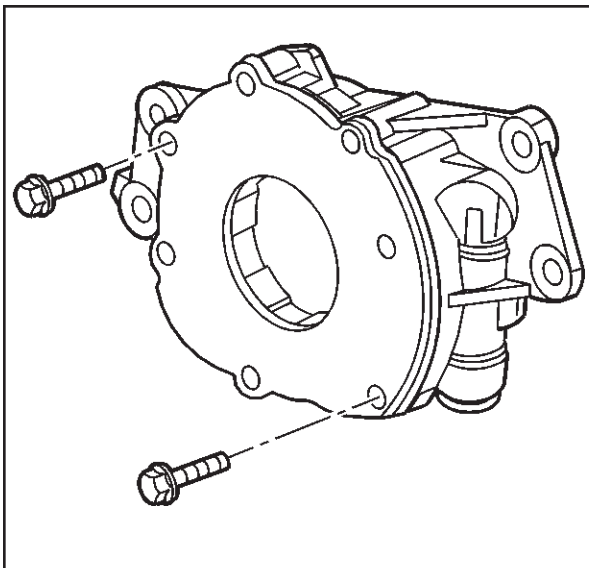


490662

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.



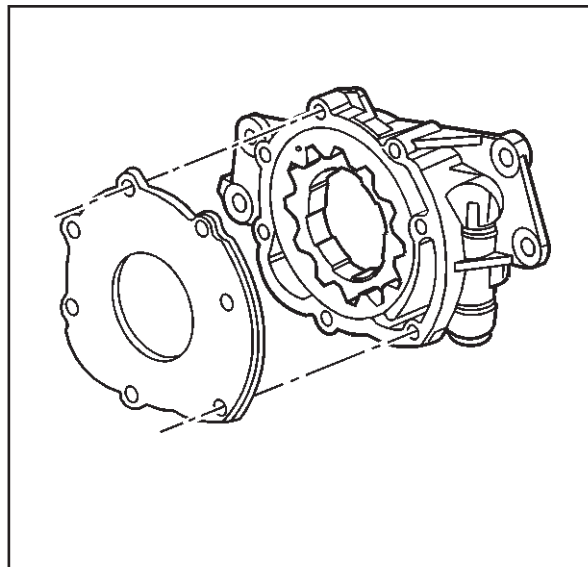
65055

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.

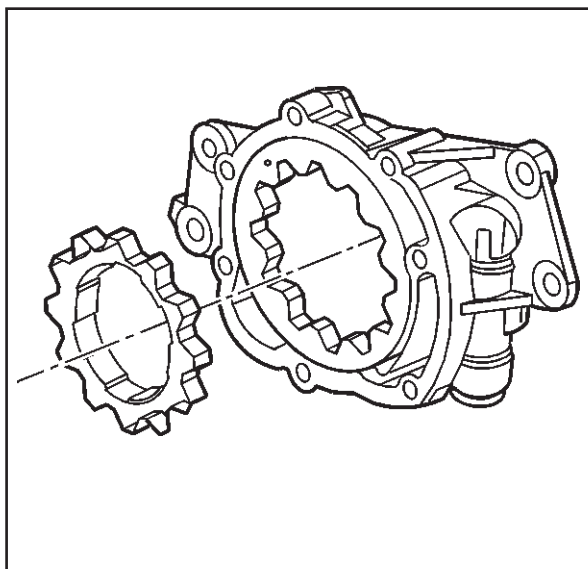
2. Remove the oil pump cover.



65057

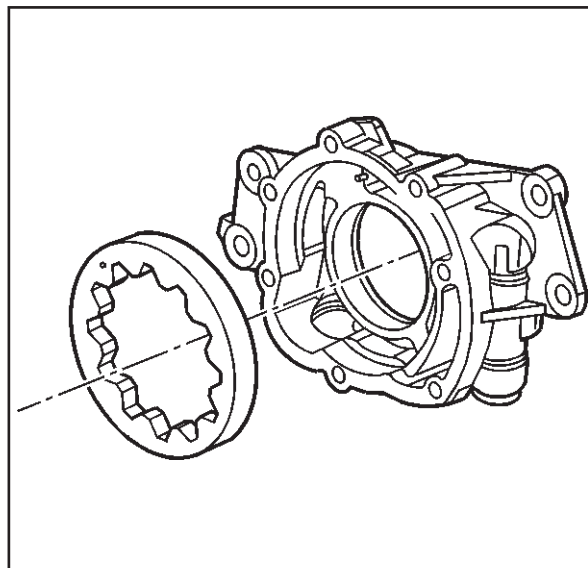
Important: Mark or identify the gears for assembly. Refer to *Separating Parts*.

3. Remove the drive gear.

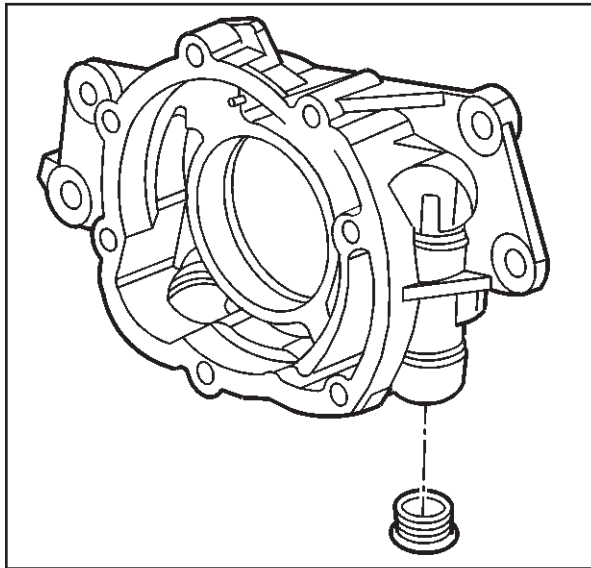


65058

4. Remove the driven gear.

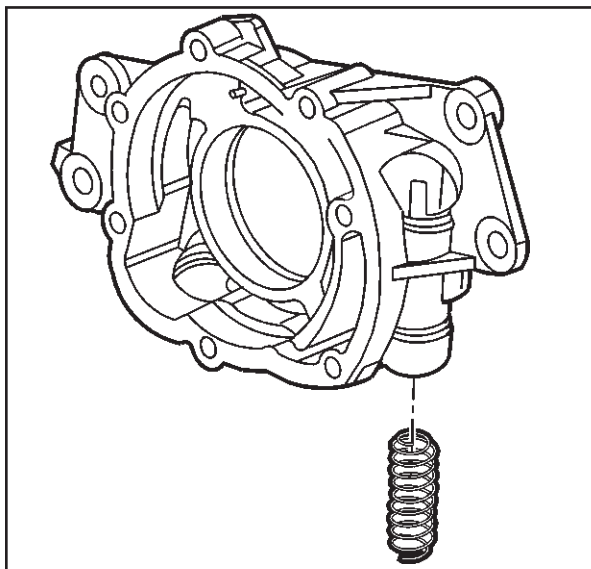


65060



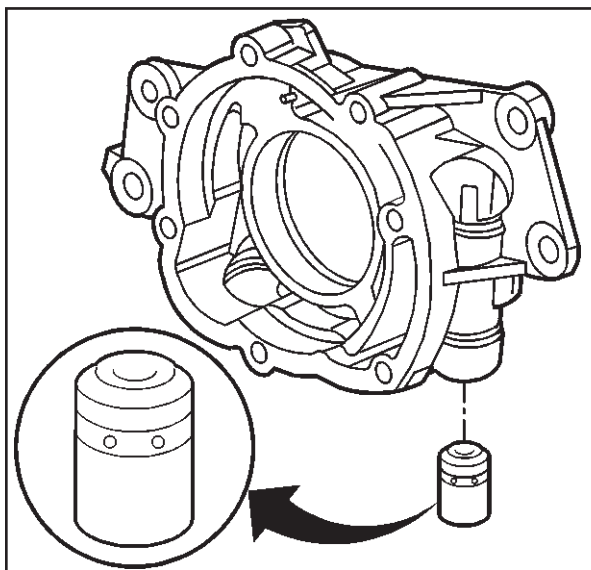
65064

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

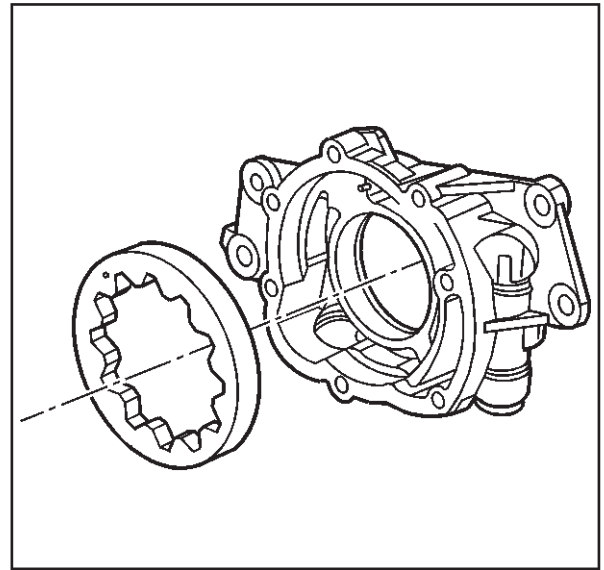
Important: The internal parts of the oil pump assembly are not serviced separately (excluding the spring). If the oil pump components are worn or damaged, replace the oil pump as an assembly.

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.

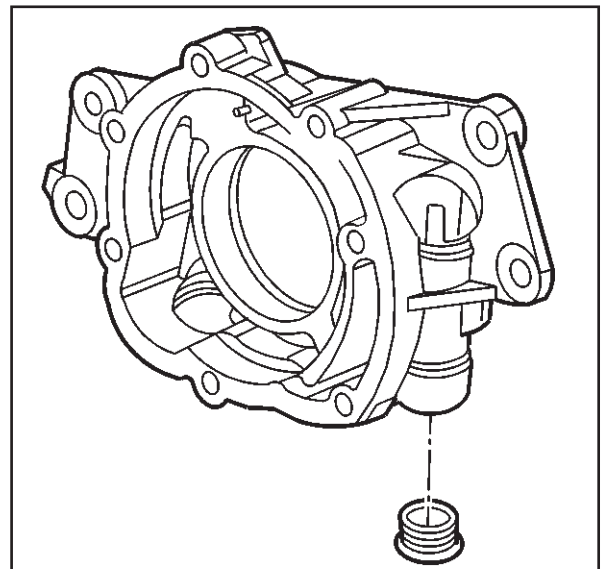
1. Clean the parts in solvent.

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

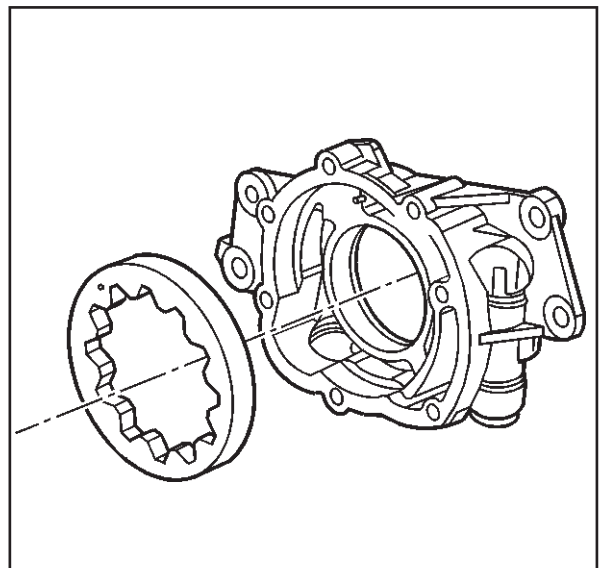
2. Dry the parts with compressed air.
3. Inspect the oil pump housing and the cover for cracks, excessive wear, scoring or casting
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
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.



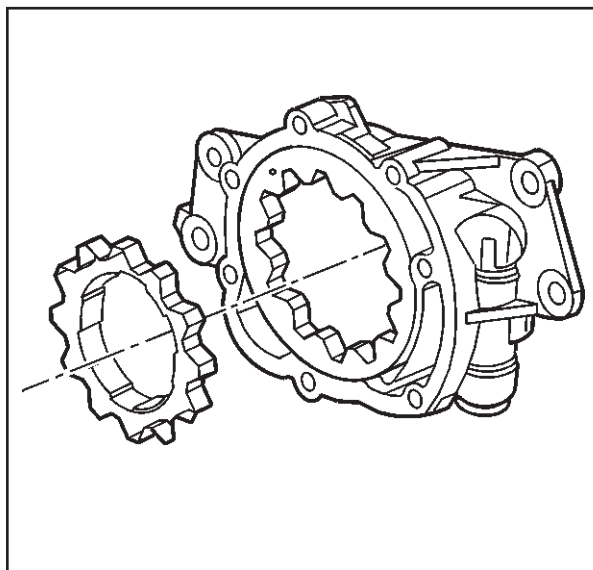
65060



65064

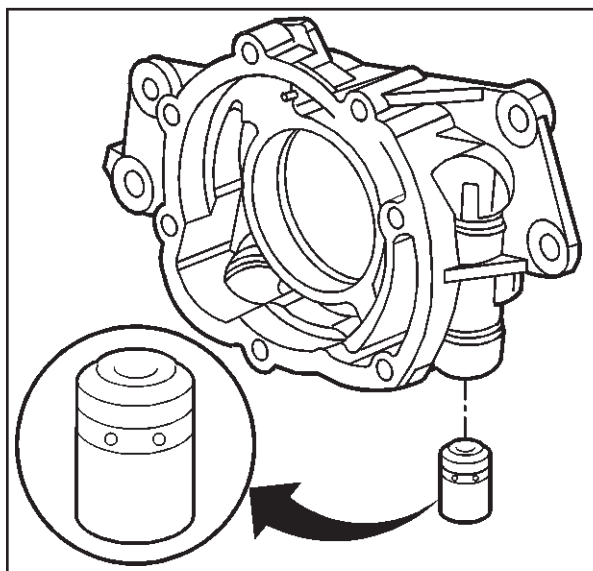


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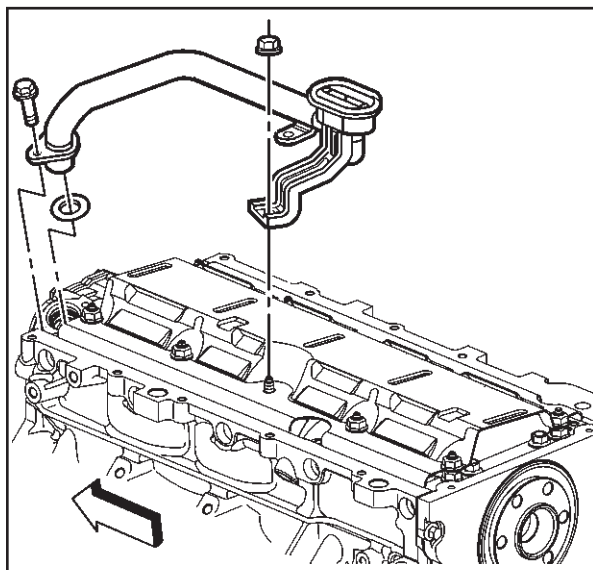
65058

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.



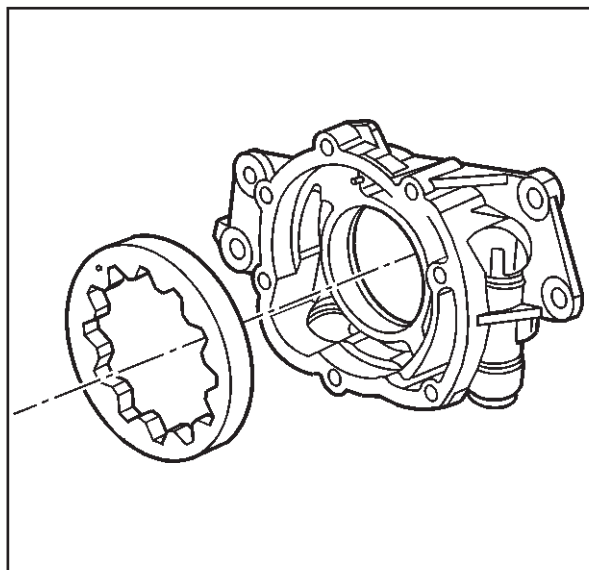
64268

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

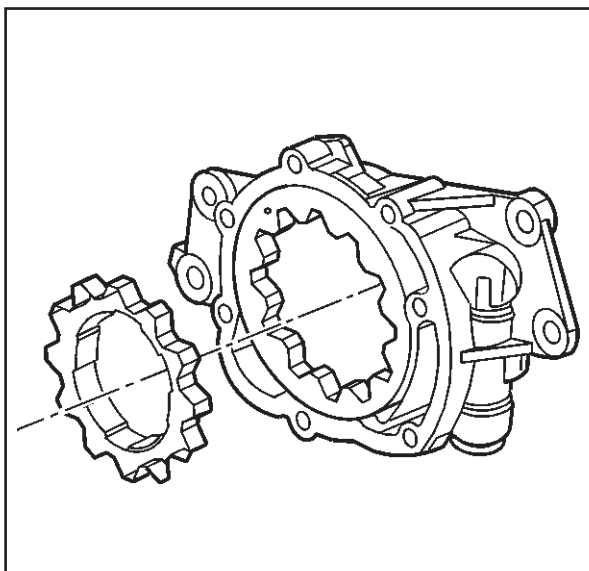
Important: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

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



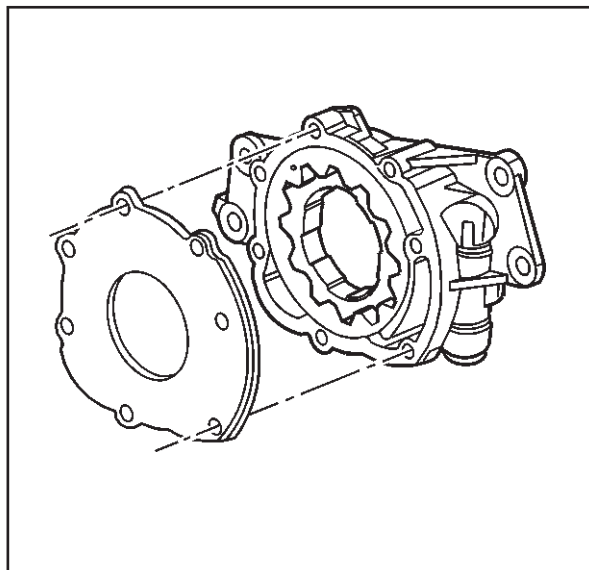
65060

2. Install the drive gear into the pump housing.

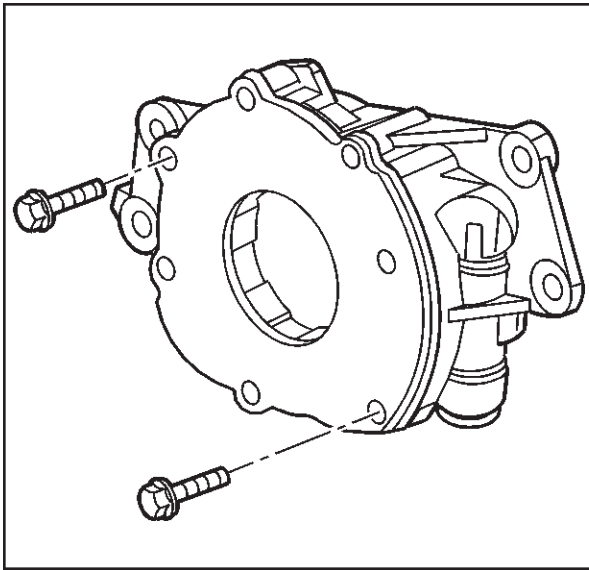


65058

3. Install the oil pump cover.



65057



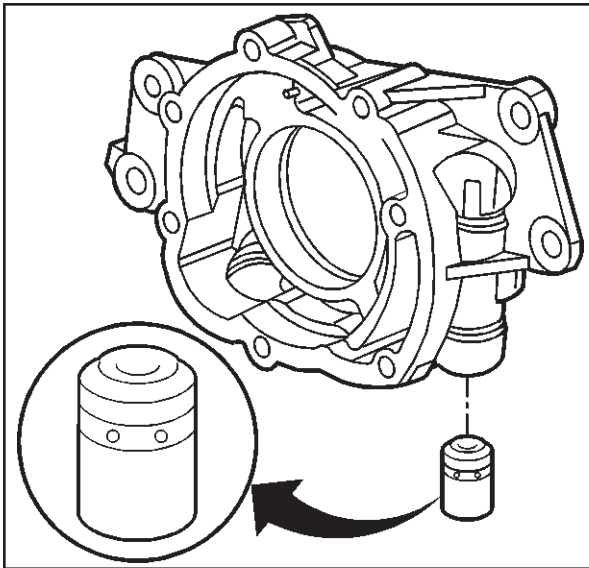
65055

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

4. Install the pump cover bolts.

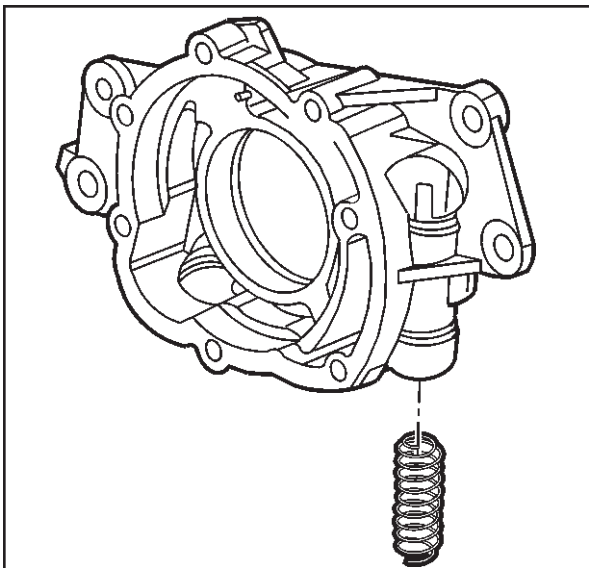
Tighten

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



65076

5. Install the regulator valve.



65068

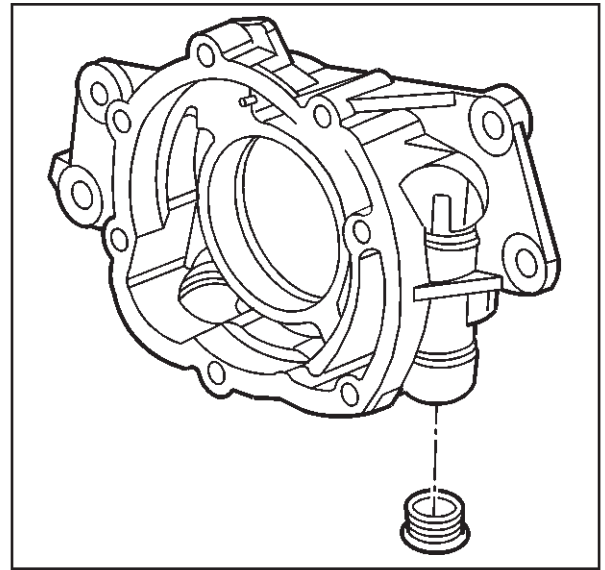
6. Install a NEW regulator valve spring.

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.

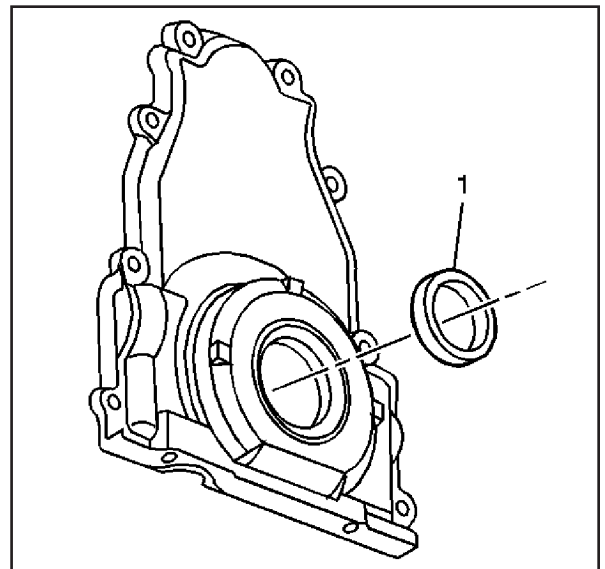
Do not reuse the front cover-to-engine block gasket. Install a NEW gasket during assembly.

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.

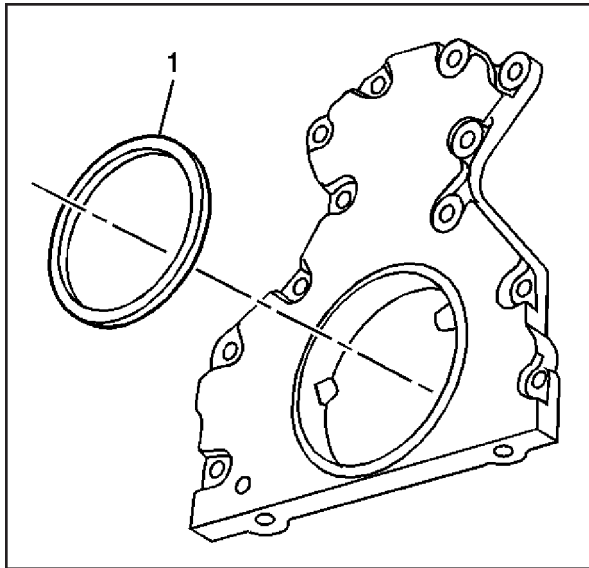
Refer to *Replacing Engine Gaskets*.

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



490689



490692

Engine Rear Cover Clean and Inspect

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

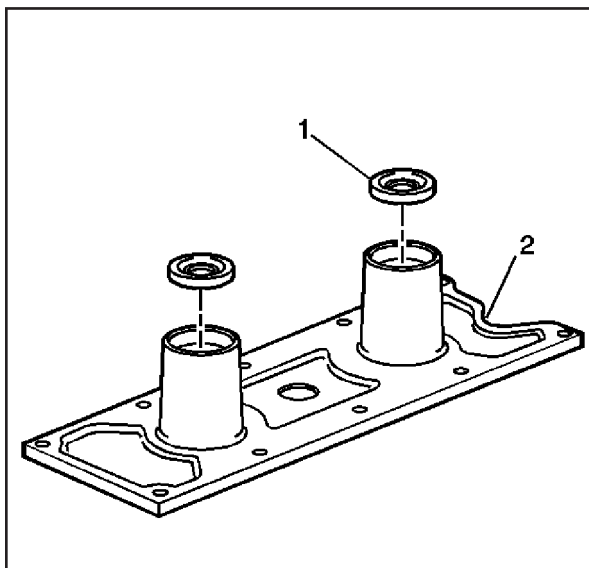
Do not reuse the rear cover-to-engine block gasket. Install a NEW gasket during assembly.

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



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

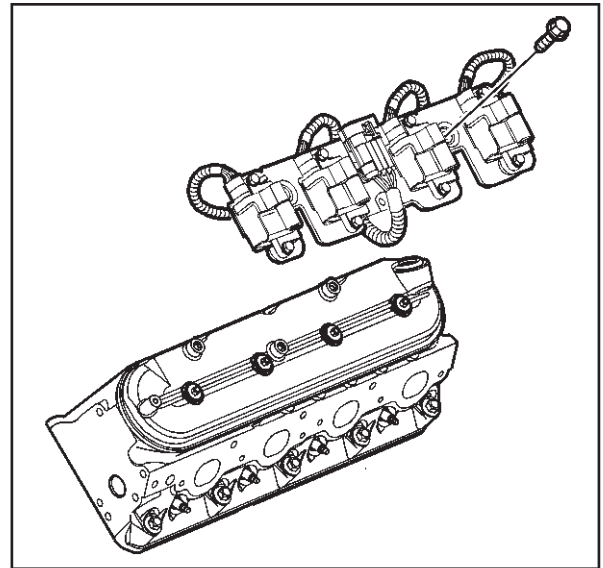
Important: Do not reuse the valve rocker arm cover gasket. Install a NEW gasket during assembly.

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.

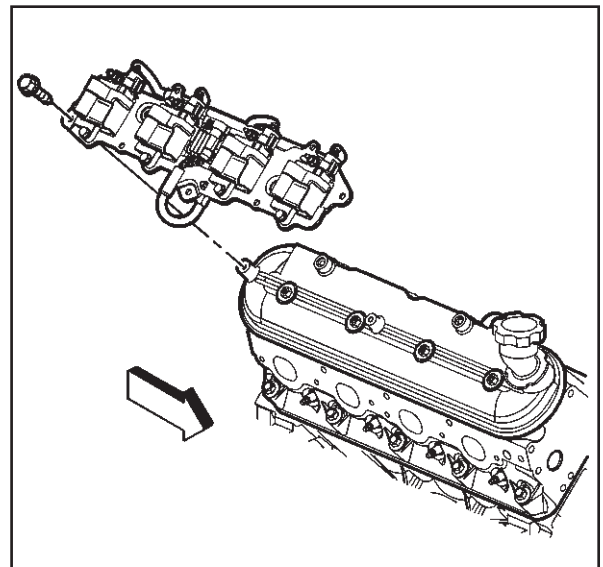
If the fill tube or crankcase vent valve grommet have been removed from the rocker arm covers, install a NEW tube or grommet during assembly.

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



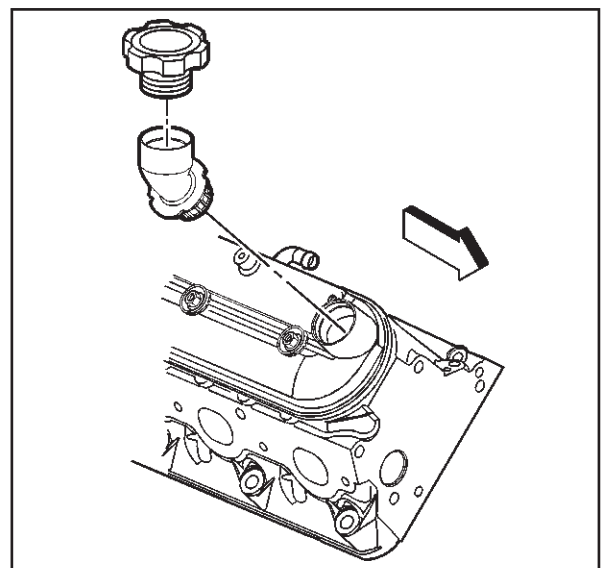
260083

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

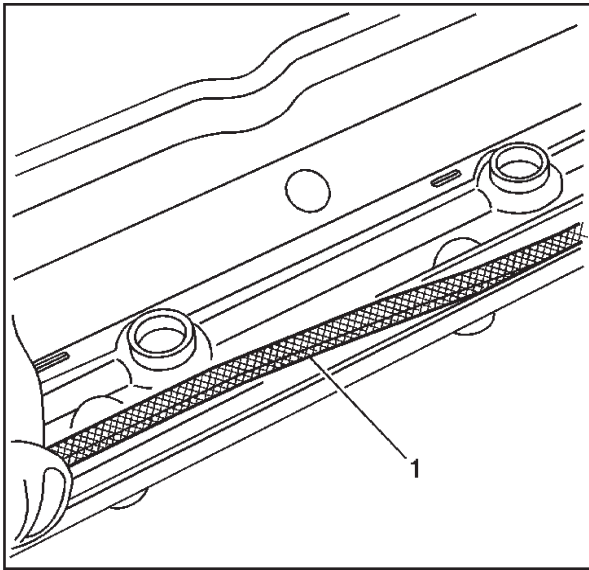


260090

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

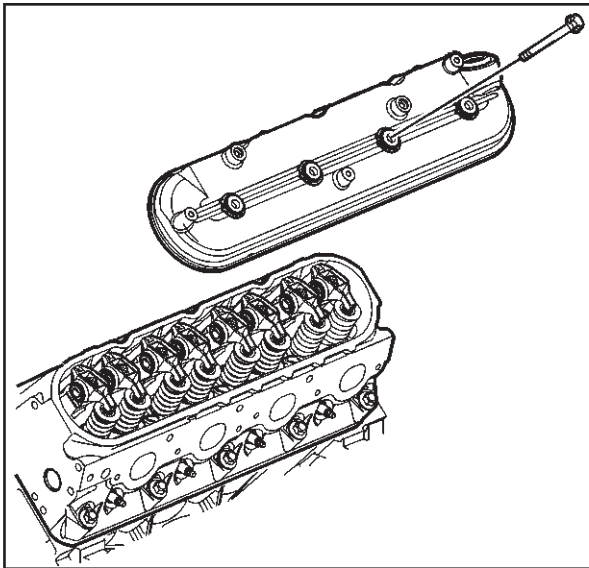


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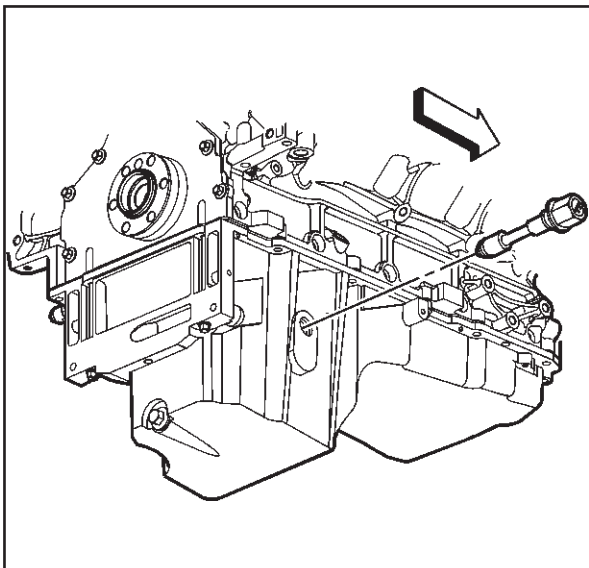
5. Remove the gaskets (1) from the covers.
6. Remove the cover mounting bolts (with grommets).
Cover mounting bolts and grommets that are not damaged may be reused during assembly.
7. Clean the covers in solvent.



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

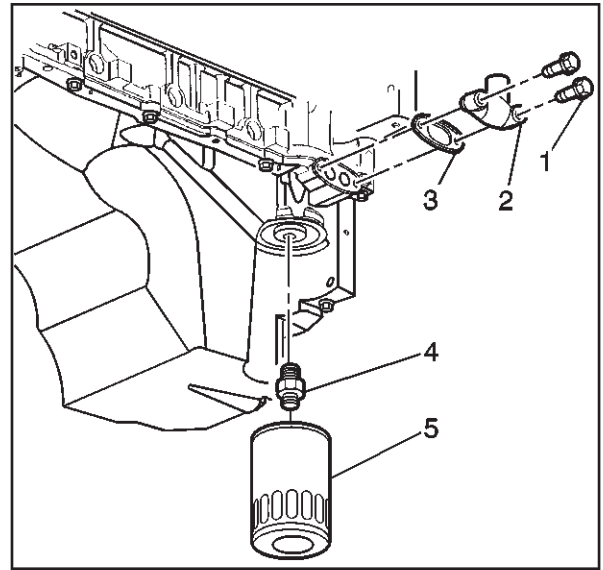
Important: Do not reuse the oil pan cover gasket. Install a NEW cover gasket during assembly.

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.

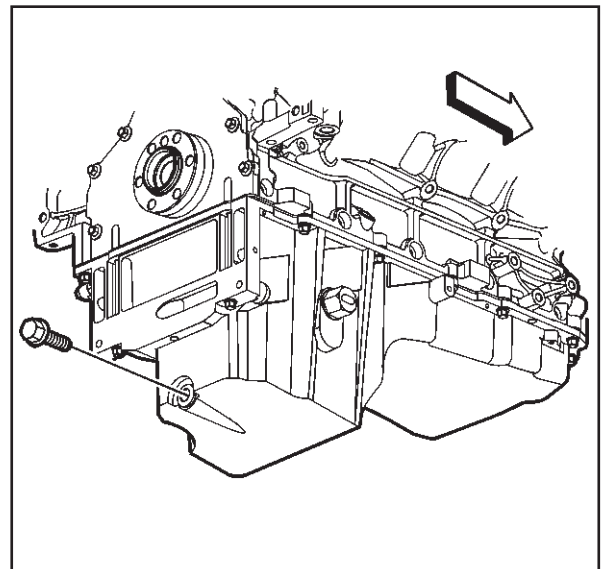
1. Remove the oil level sensor from the pan (if

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



260125

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

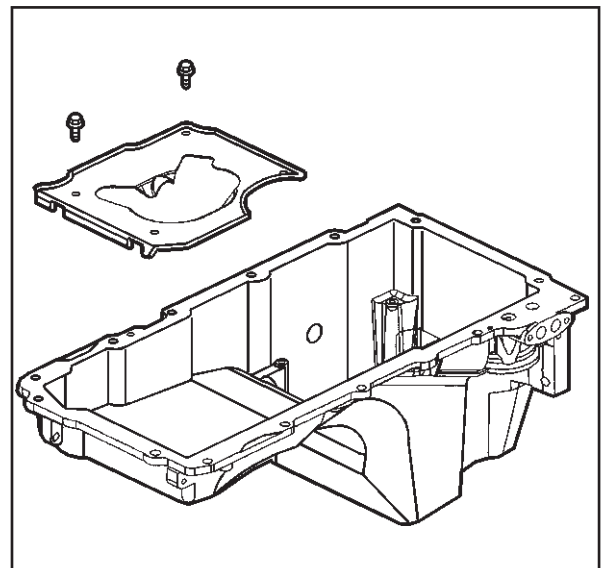


260111

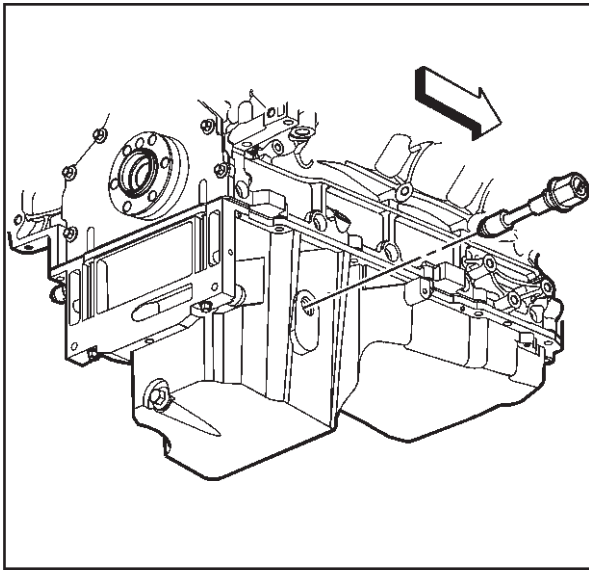
4. Remove the oil pan baffle and bolts.
5. Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.
6. Clean the oil pan gasket surfaces. Refer to *Replacing Engine Gaskets*.

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

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

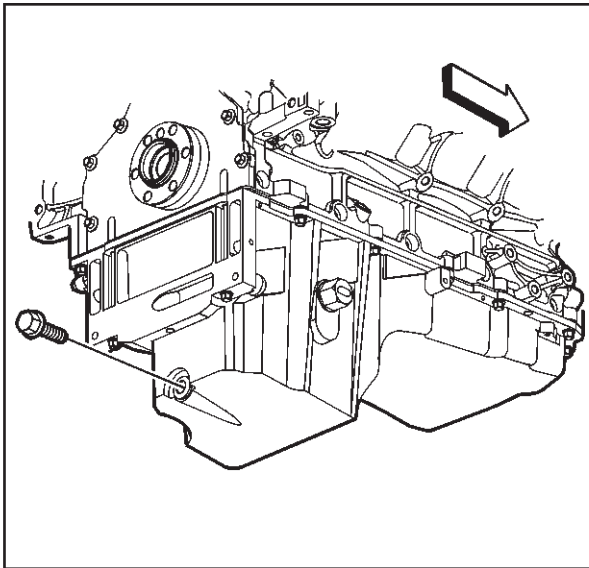


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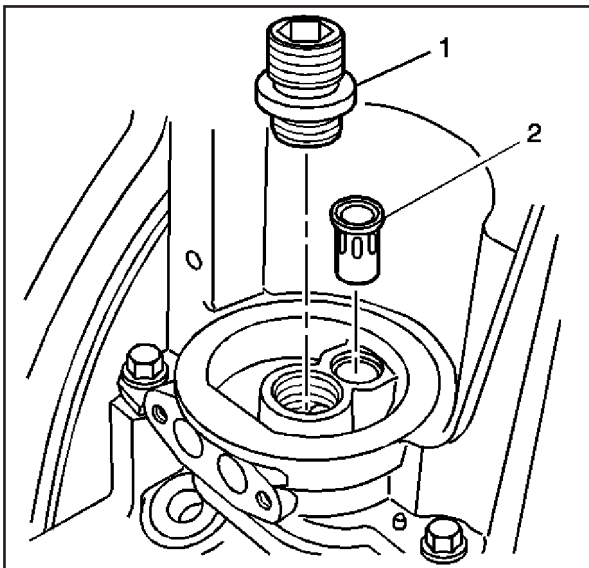
260123

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.



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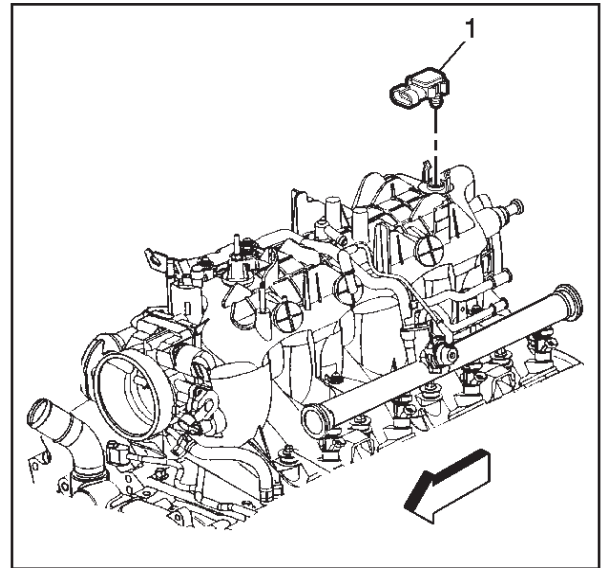
11. Inspect the oil filter sealing surface for scratches or gouging.
12. Inspect the oil filter fitting (1) for a loose fit or damaged threads.
13. Inspect the oil passages for restrictions.
14. Inspect the oil filter bypass valve (2) for proper operation.
Lightly push the bypass valve into the bore. The valve spring should reseal the valve to the proper position.

Intake Manifold Clean and Inspect

Cleaning Procedure

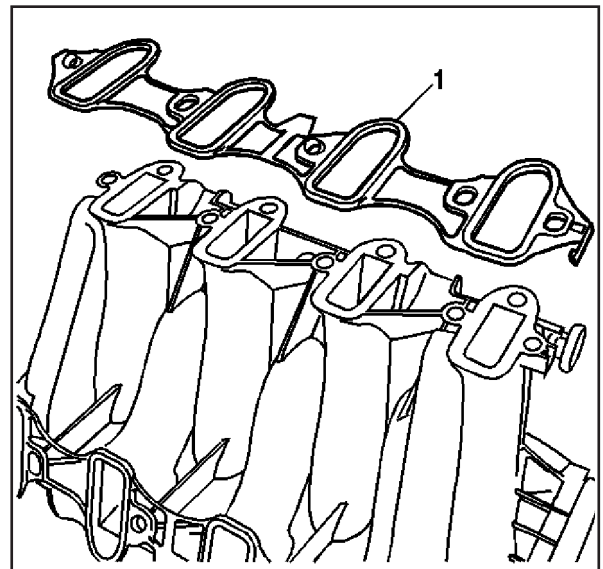
Important: Do not reuse the intake manifold-to-cylinder head sealing gaskets.

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.



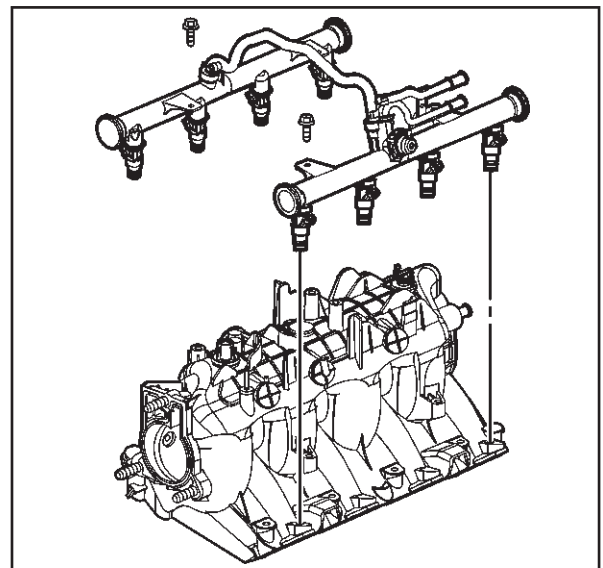
260159

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

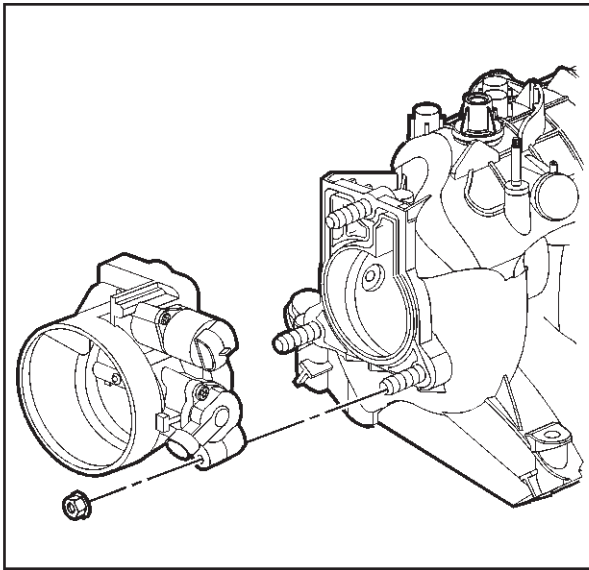


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4. Remove the fuel rail with injectors. Refer to *Fuel Rail and Injectors Removal*.

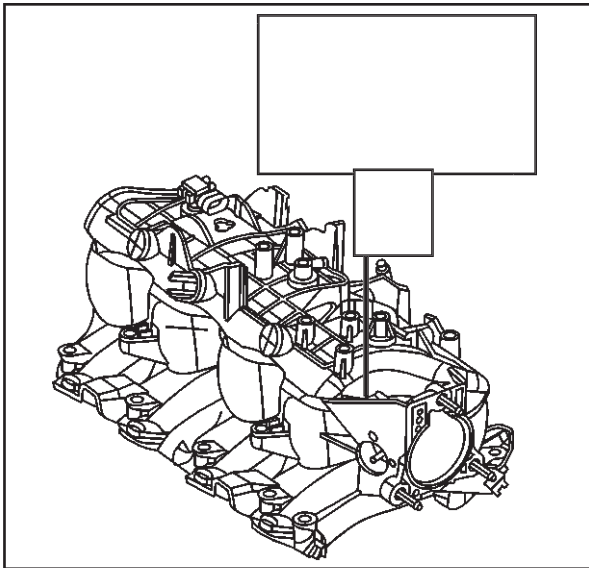


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5. Remove the throttle body and gasket. Refer to *Throttle Body Removal*.

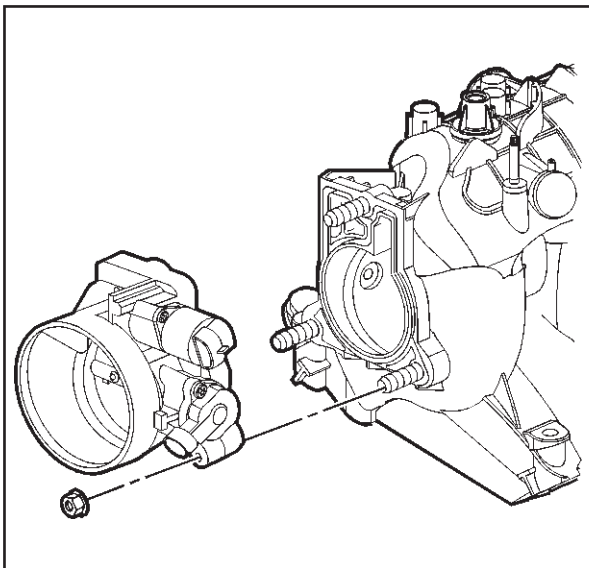


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6. Clean the intake manifold in solvent.
 - Clean the intake manifold gasket surfaces.
 - Clean the intake manifold internal passages.

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

7. Dry the intake manifold with compressed air.

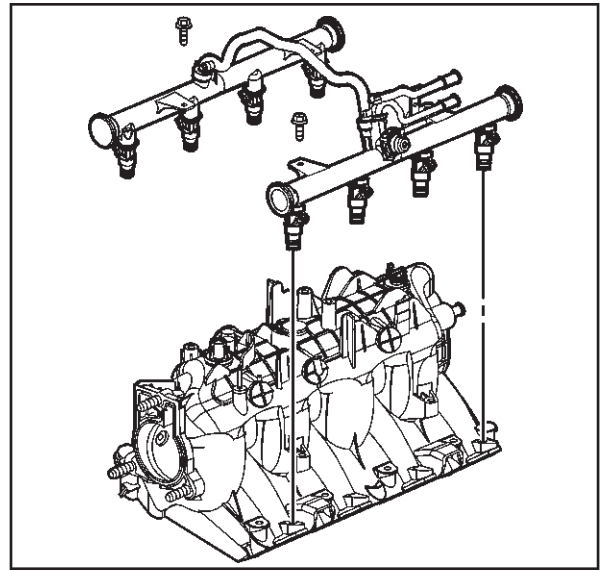


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Inspection Procedure

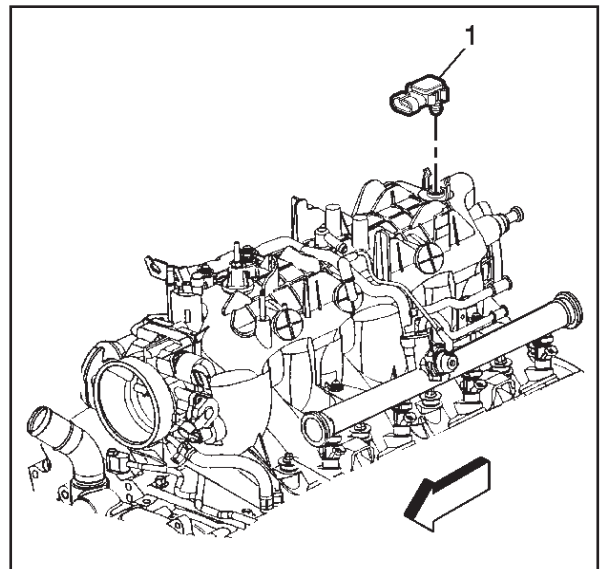
1. Inspect the throttle body studs and stud inserts for looseness or damaged threads.
2. Inspect the wire harness stud and stud insert for looseness or damaged threads.

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



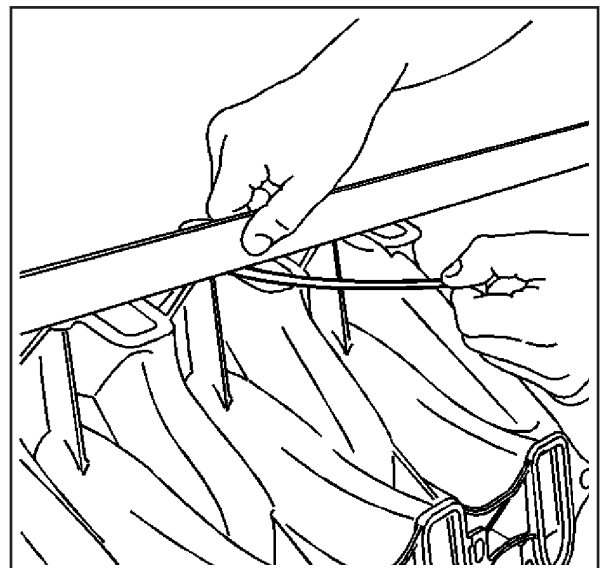
260176

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.

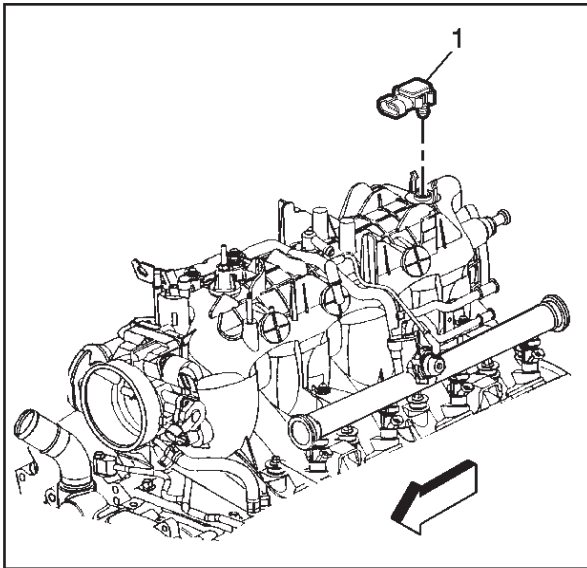


260159

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

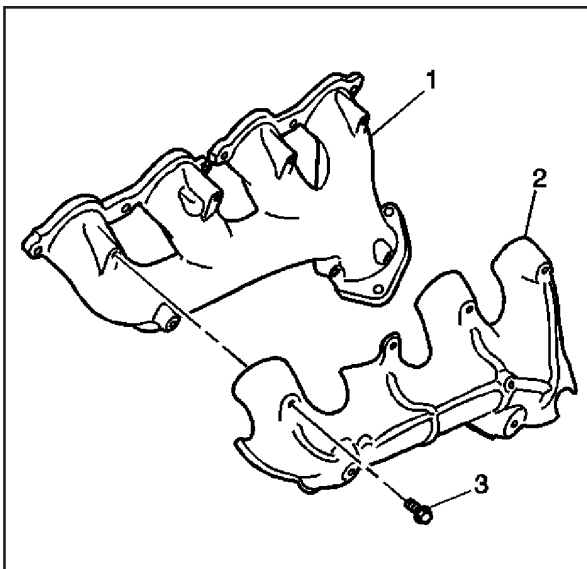


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10. Install the MAP sensor (1).



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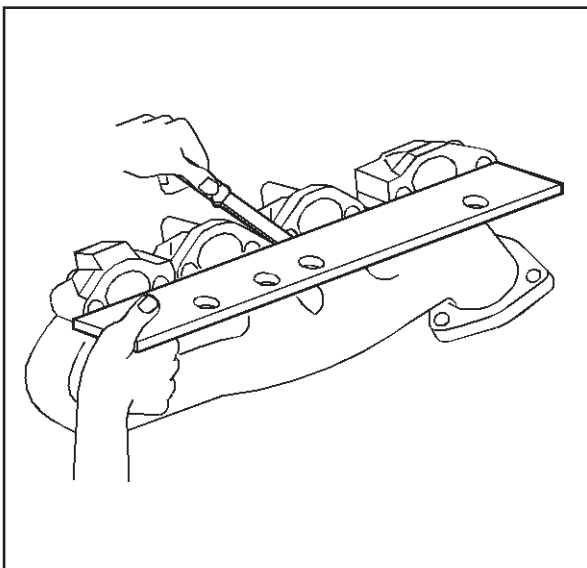
Exhaust Manifold Clean and Inspect

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.



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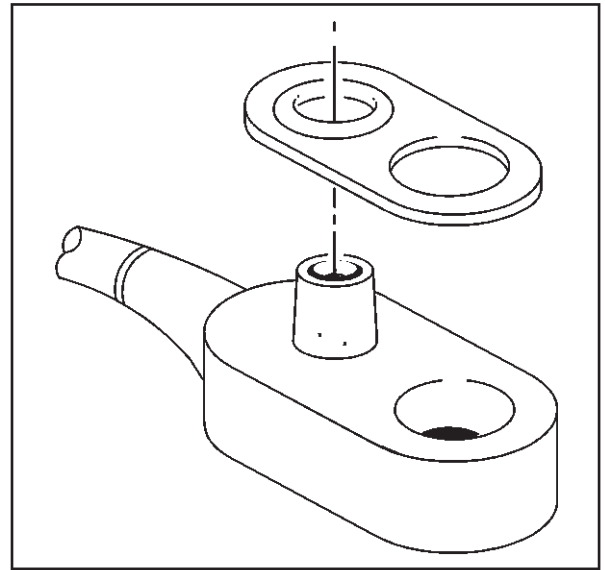
6. Use a straight edge and a feeler gauge and measure the exhaust manifold cylinder head deck for warpage.

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.

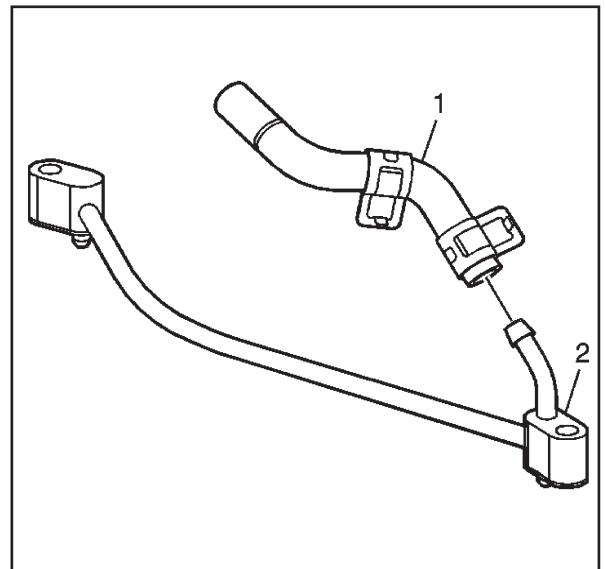


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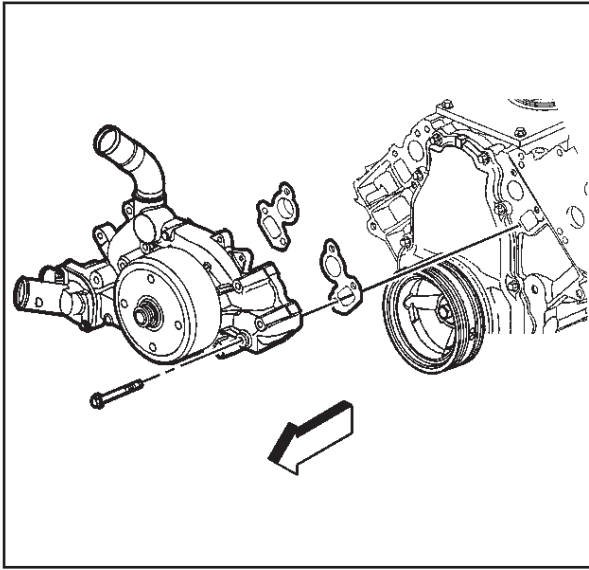
3. Clean the pipe (2), hose (1) and covers in solvent.

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

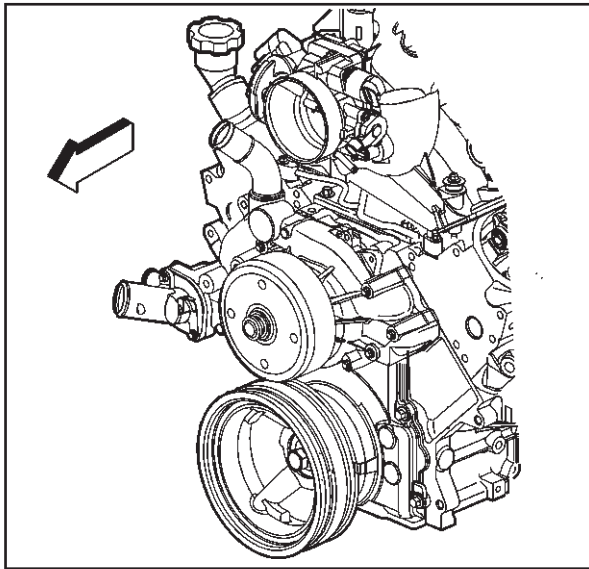
4. Dry the pipe and covers with compressed air.
5. Inspect the pipe and covers for damage or restrictions.
6. Inspect the gasket and hose sealing surfaces for damage.
7. Inspect the hose (1) for restrictions, cracking or wear.



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

Thread Repair

Tools Required

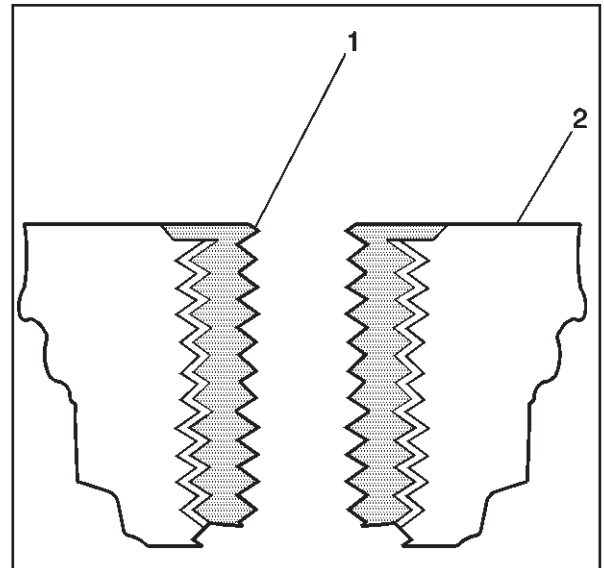
J 42385-100 Head/Main Bolt Thread Repair Kit

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



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

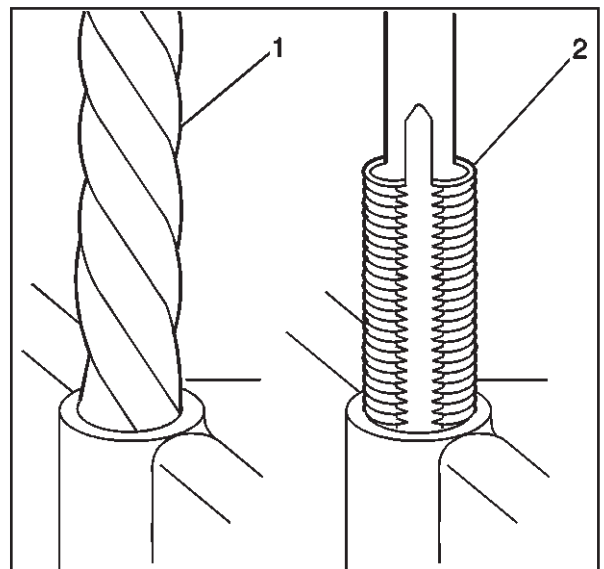
Important: The use of a cutting type fluid GM P/N 1052864, WD-40, or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

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.

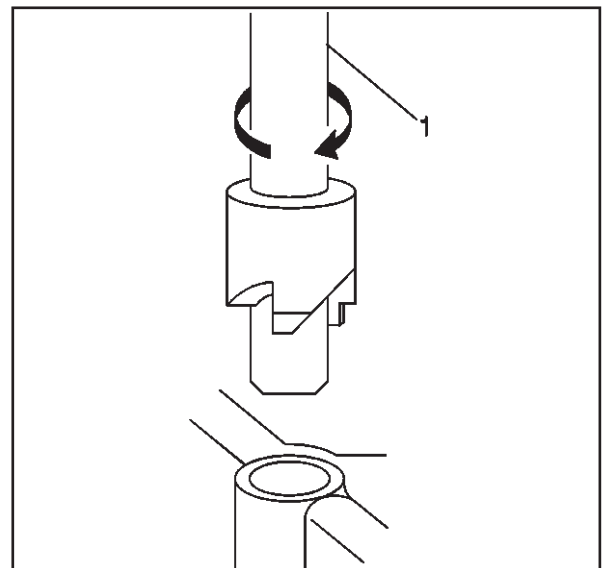
1. Drill out the threads of the damaged hole (1).

- 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).

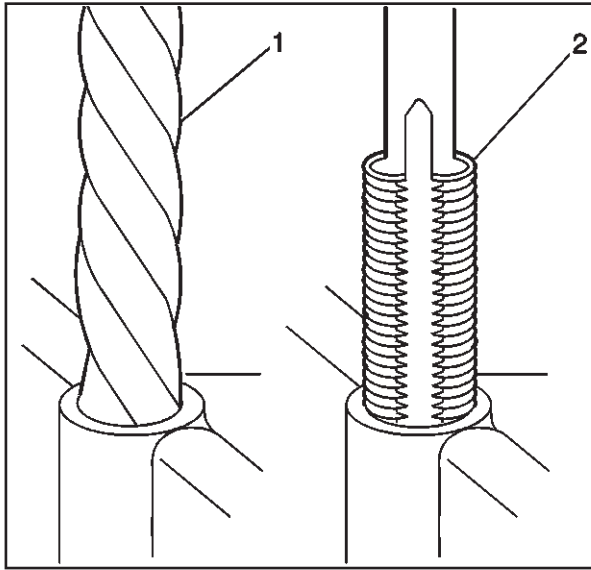


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3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.



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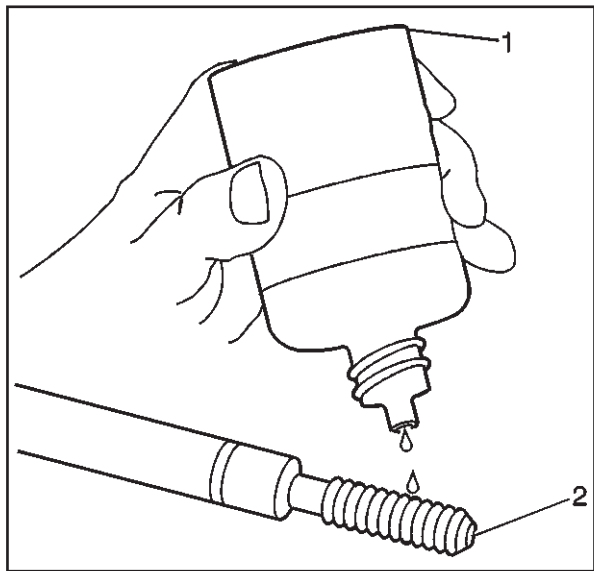


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5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require minimum tap depth of 23.5 mm (0.93 in).

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

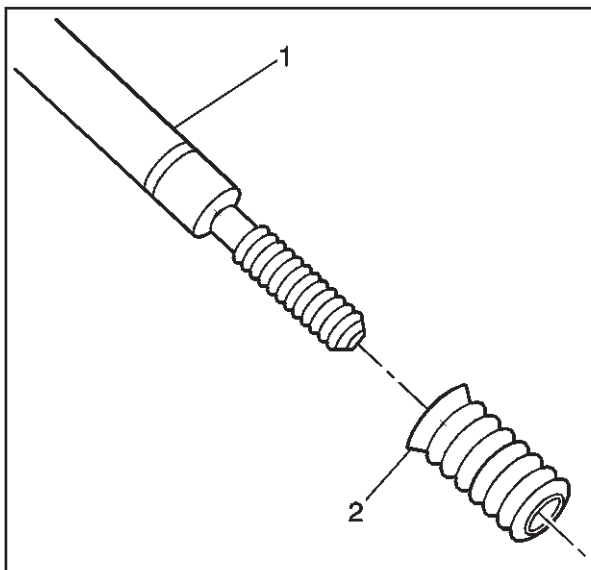
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, P/N 12377981, or equivalent into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.



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

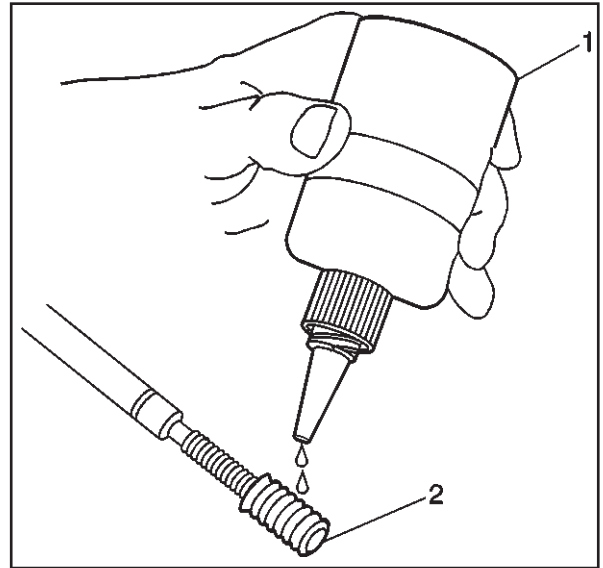
9. Lubricate the threads of the installer tool (2) with the driver oil (1).



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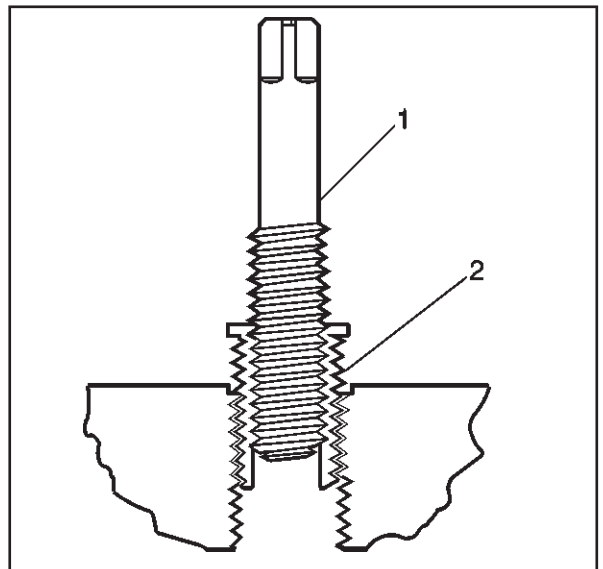
10. Install the insert (2) onto the driver tool (1).

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



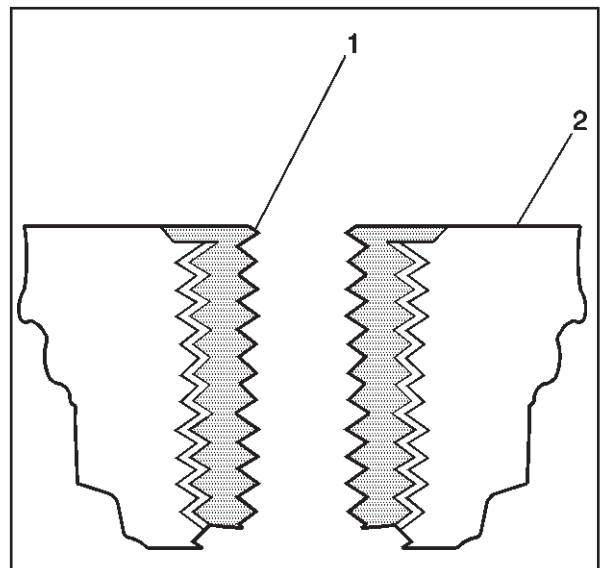
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12. Install the insert (2) into the hole.
Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.
The installer tool will tighten up before screwing completely 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.

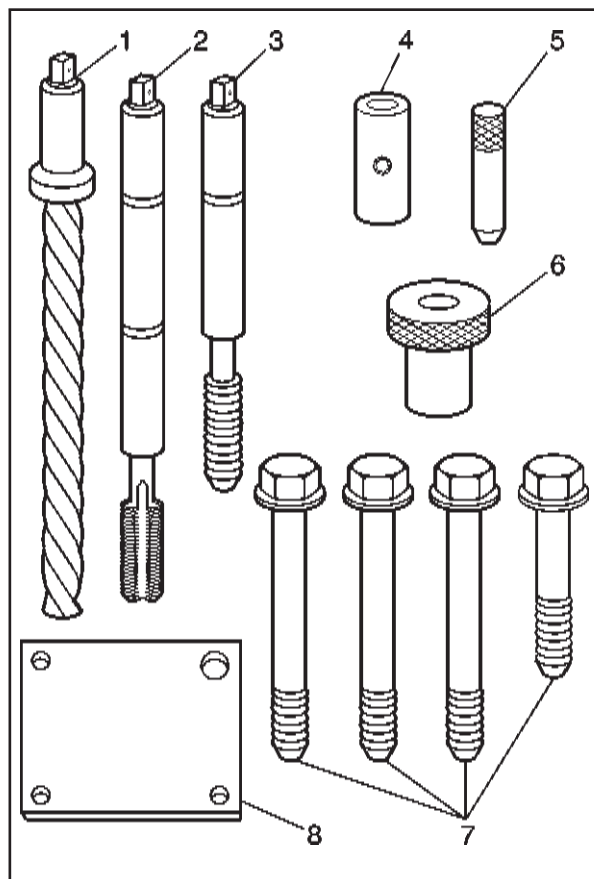


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13. Inspect the insert for proper installation into the hole.
A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).



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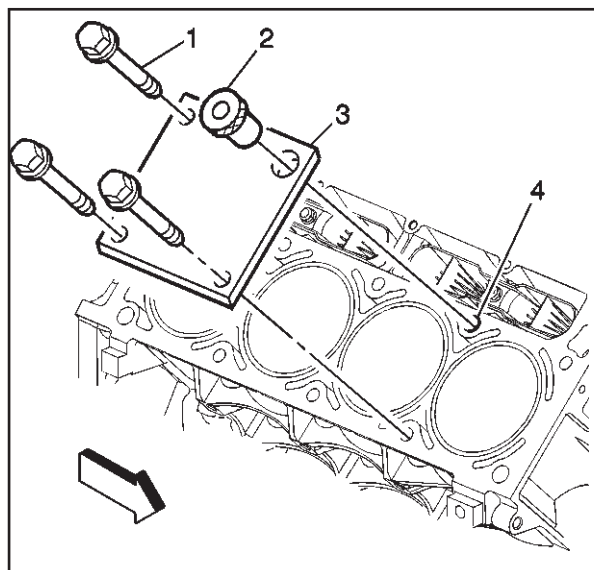


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Cylinder Head Bolt Hole Thread Repair

1. The cylinder head bolt hole thread repair kit consists of the following items:

- The Drill (1)
- The Tap (2)
- The Installer (3)
- The Sleeve (4)
- The Alignment Pin (5)
- The Bushing (6)
- The Bolts (7)
- The Fixture Plate (8)



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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.

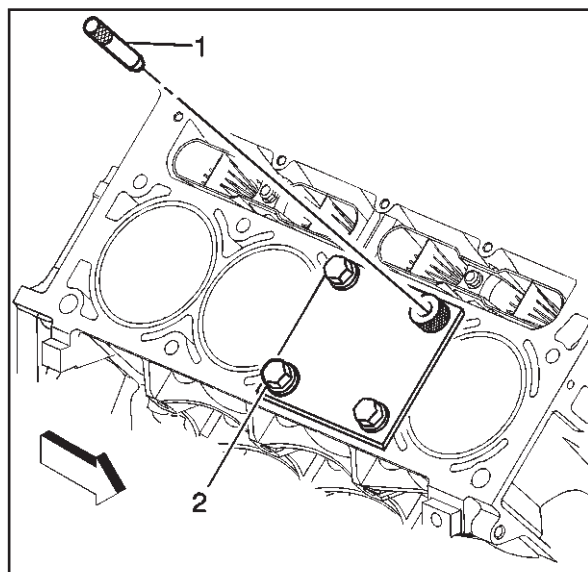
Driver oil **MUST** be used on the installer driver tool.

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

2. Install the fixture plate (3), bolts (1) and bushing (2) onto the engine block deck.

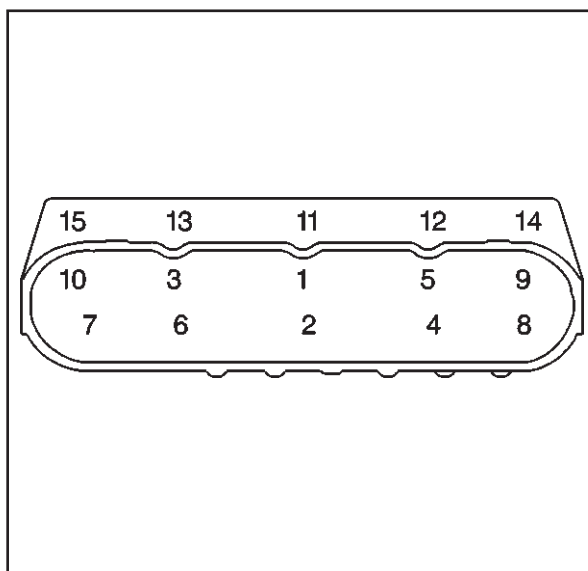
Position the fixture plate and bushing over the hole that is to be repaired (4).

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



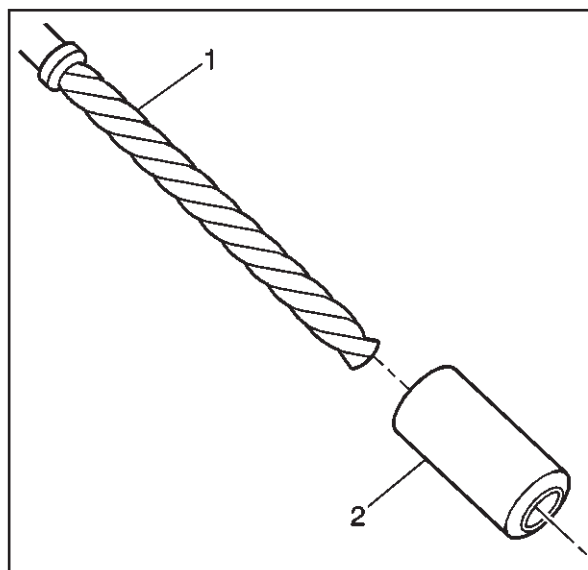
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6. Cylinder head bolt holes 1-8 are the deep holes and will be drilled without the drill sleeve.
Cylinder head bolt holes 9 and 10 are the shallower holes, drilling MUST be done with the drill sleeve in place.

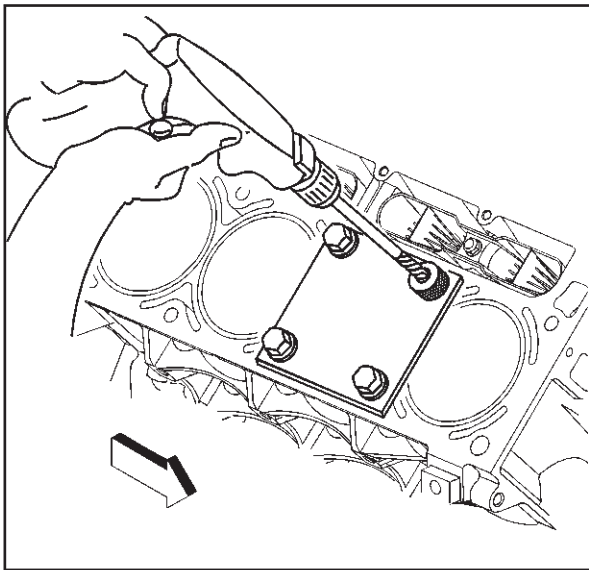


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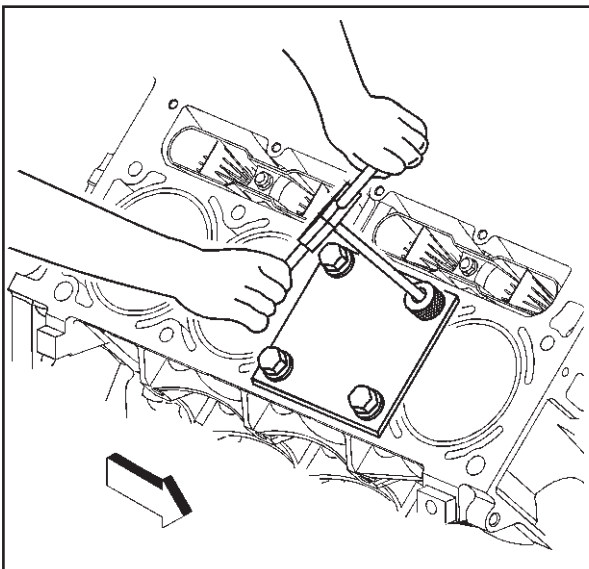
7. Install the sleeve (2) onto the drill (1), if required.



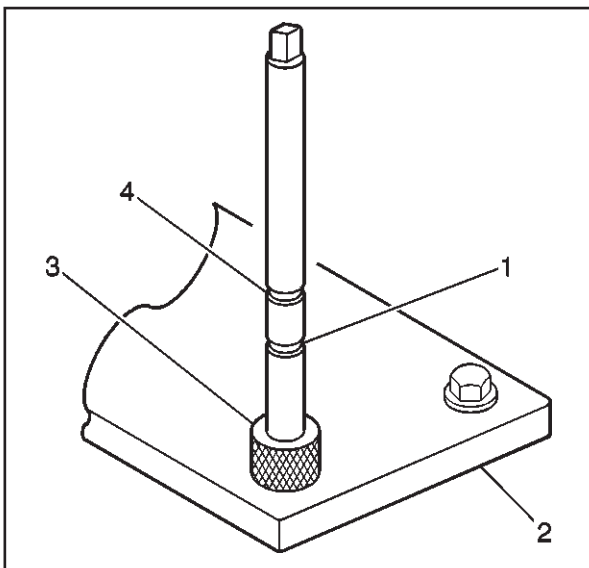
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Important: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

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.

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

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).

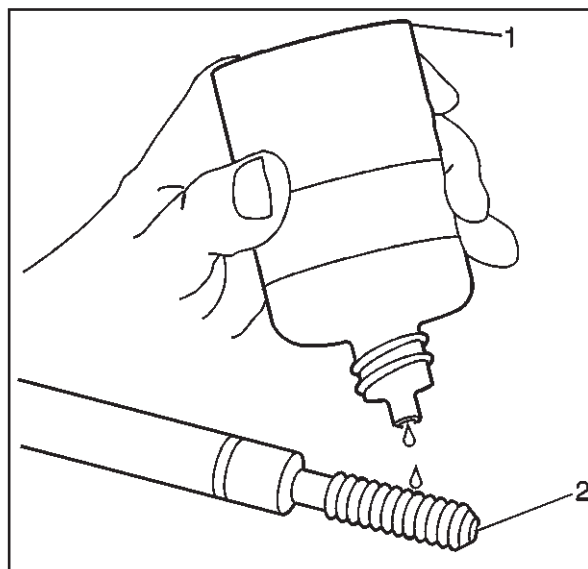
For the deeper cylinder head bolt holes (1-8), rotate the tap until the upper mark on the tap (4) aligns with the top of the drill bushing.

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.

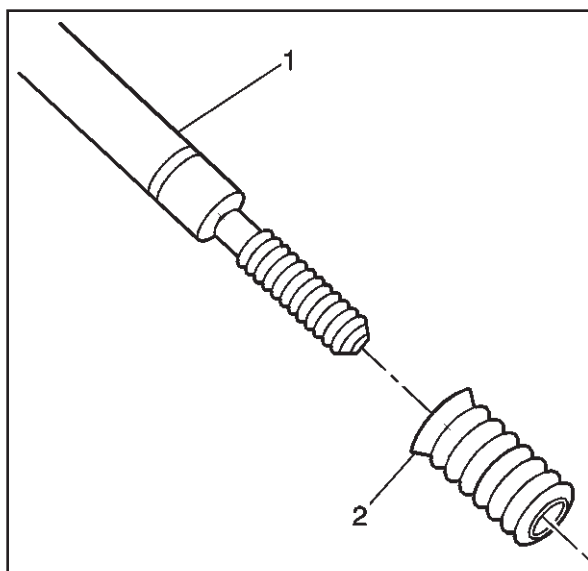
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



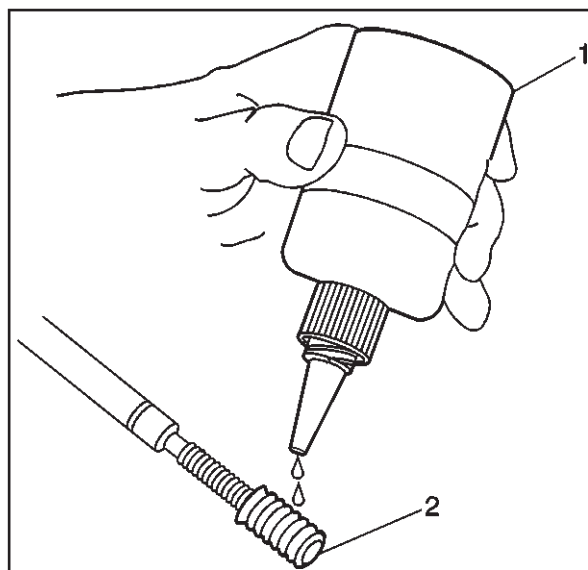
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17. Install the insert (2) onto the driver tool (1).

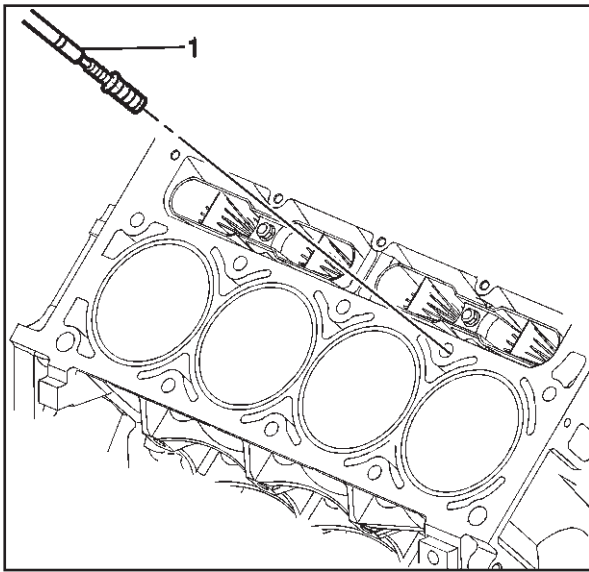


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18. Apply threadlock Loctite 277, J 42385-109 (1), or equivalent to the insert OD threads (2).



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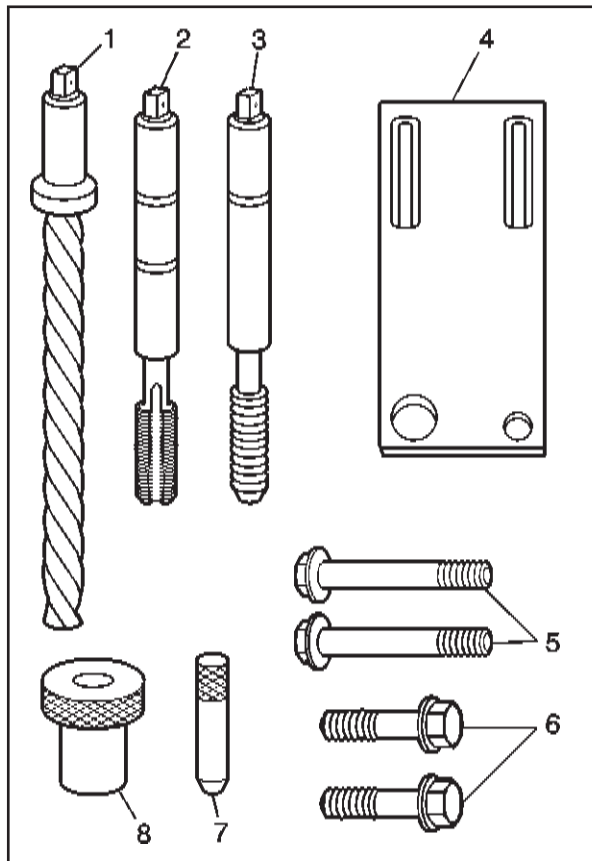


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19. Install the insert and driver (1) into the hole.

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.



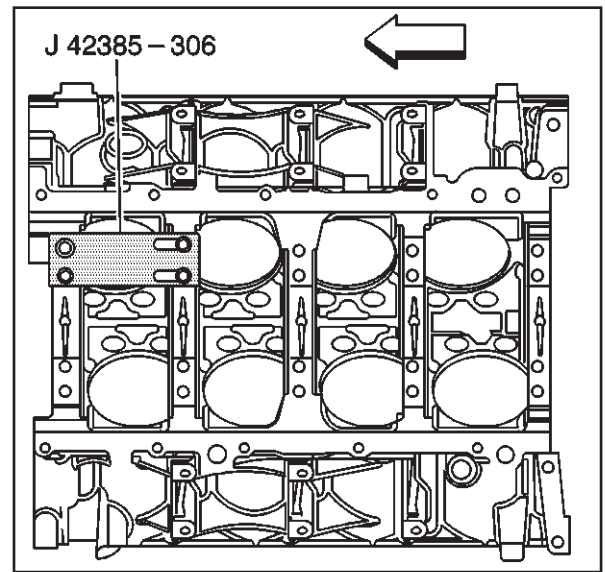
313556

Main Cap Bolt Hole Thread Repair

1. The main cap bolt hole thread repair kit consists of the following items:

- The Drill (1)
- The Tap (2)
- The Installer (3)
- The Fixture Plate (4)
- The Long Bolts (5)
- The Short Bolts (6)
- The Alignment Pin (7)
- The Bushing (8)

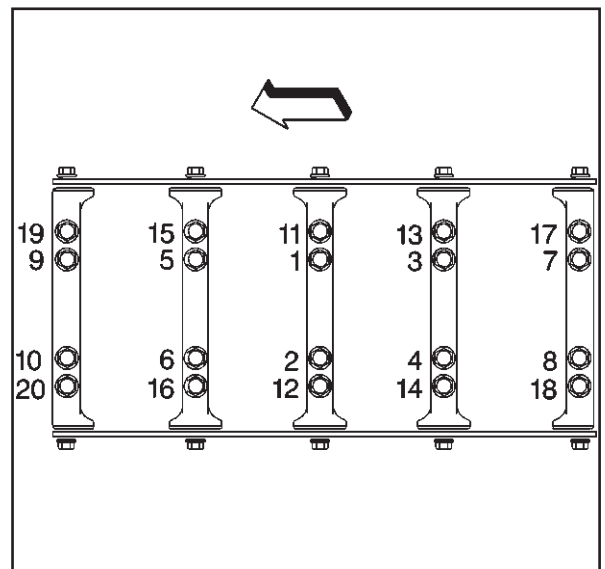
2. Install the fixture plate, bolt and bushing onto the engine block.
Position the fixture plate and bushing over the hole that is to be repaired.
3. Position the alignment pin in the desired hole and tighten the fixture plate retaining bolts.



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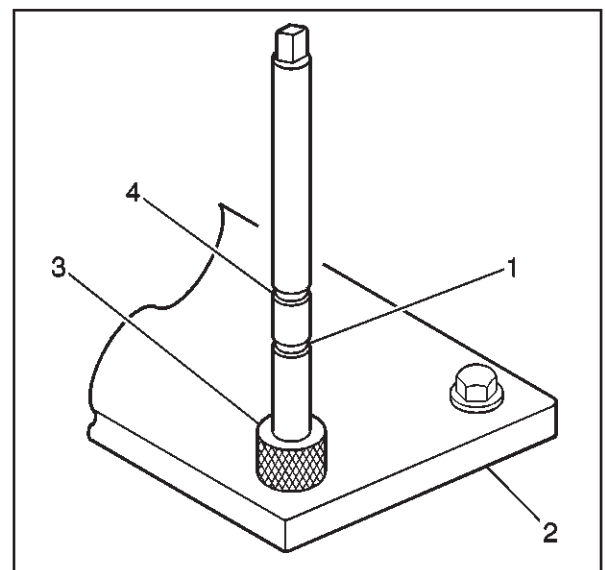
4. Drill out the damaged hole.
The outer bolt hole locations (11-20) have the shallower counterbores. Use sleeve J 42385-316 with the drill.
Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

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

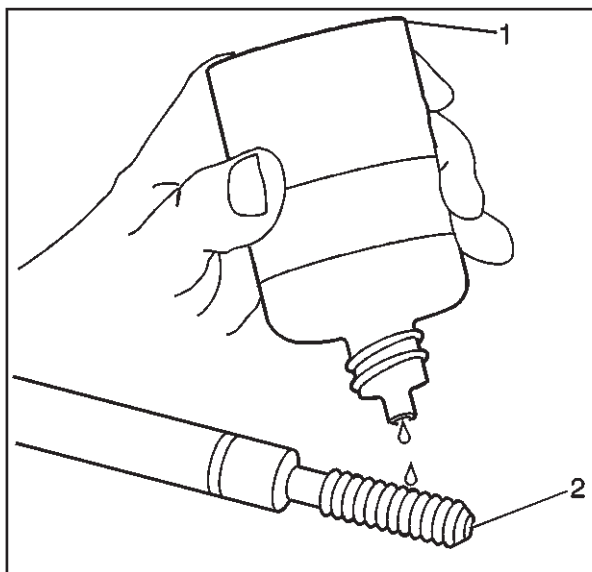


63214

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



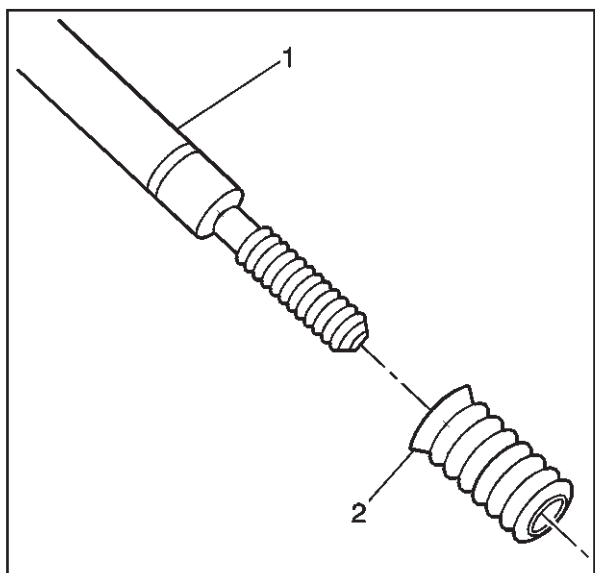
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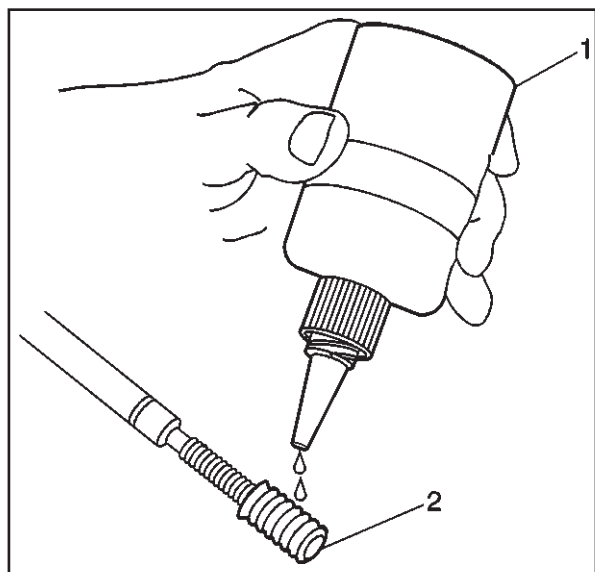
Important: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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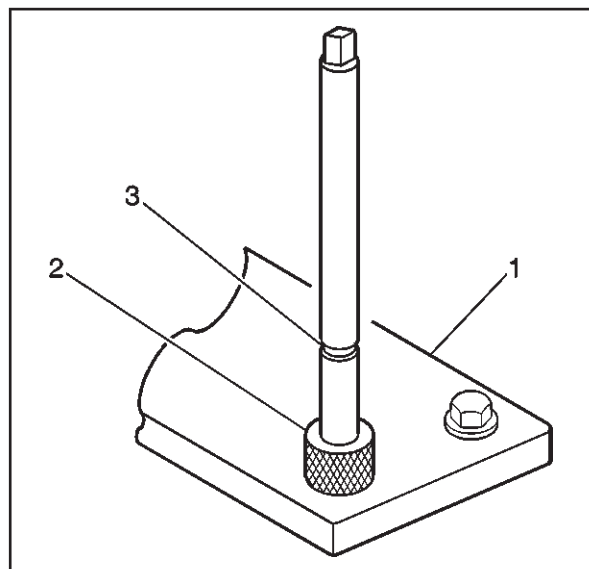
12. Apply threadlock Loctite 277, *J 42385-109* (1), or equivalent to the insert OD threads (2).

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

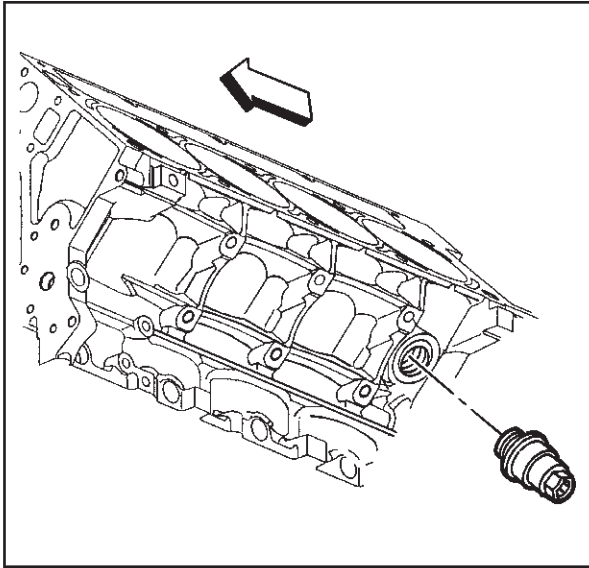


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Service Prior to Assembly

- 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

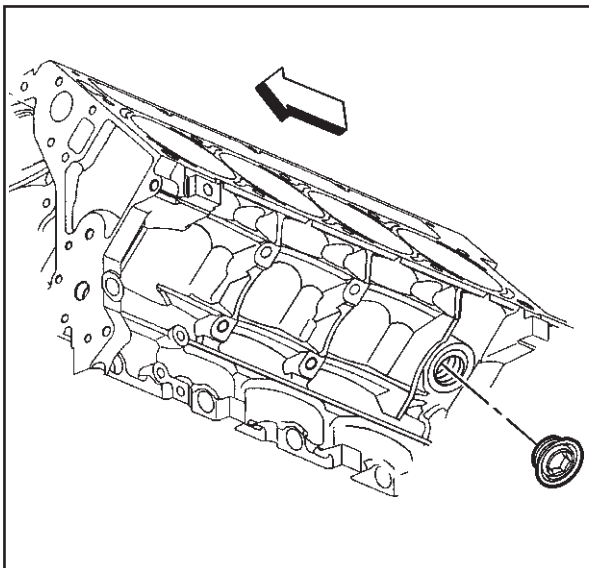
J 41712 Oil Pressure Sensor Socket or equivalent.

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).

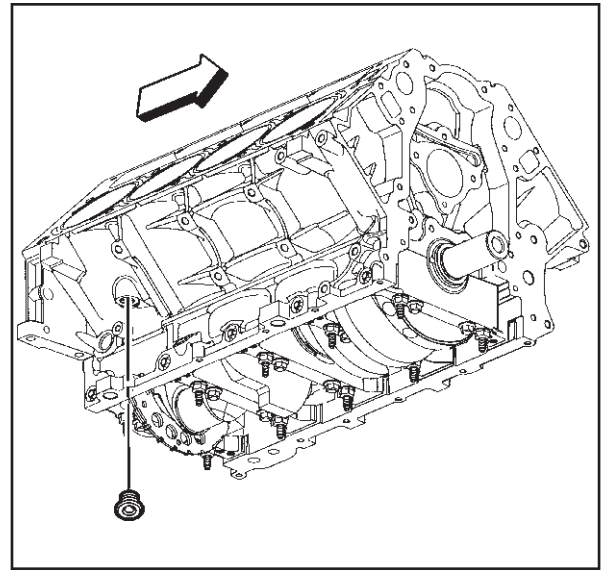
Tighten

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).

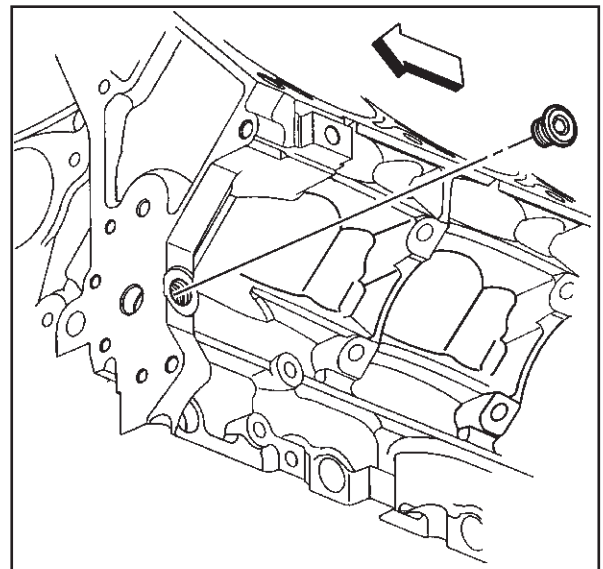


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7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block left front oil gallery plug sealing washer.
8. Install the engine block left front oil gallery plug.

Tighten

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

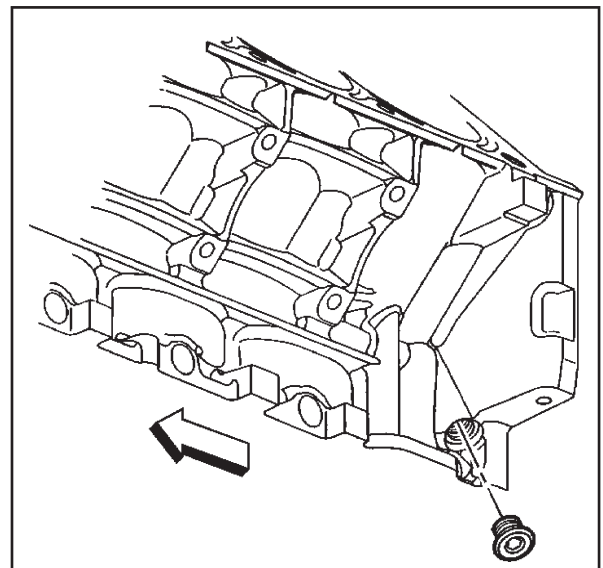


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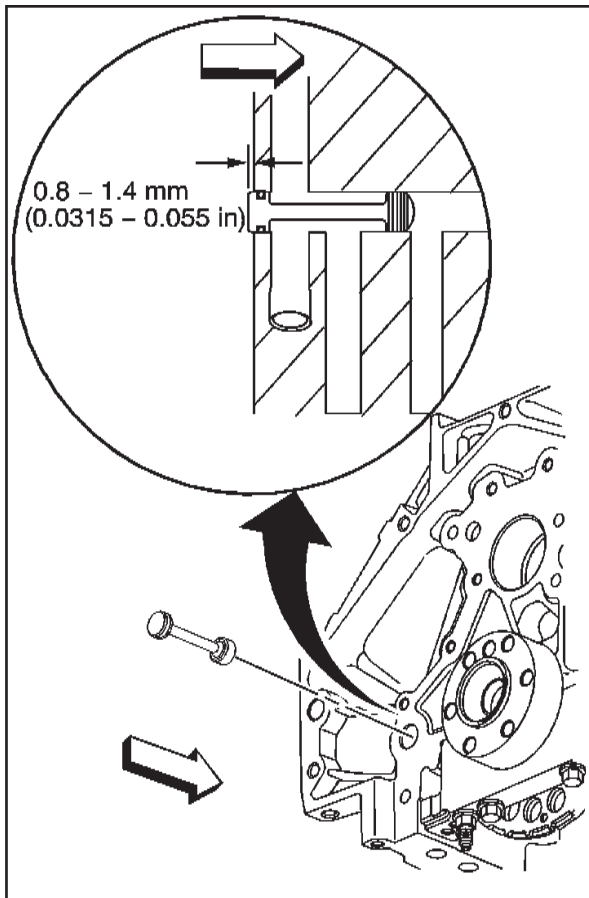
9. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 or equivalent to the engine block left rear oil gallery plug sealing washer.
10. Install the engine block left rear oil gallery plug.

Tighten

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

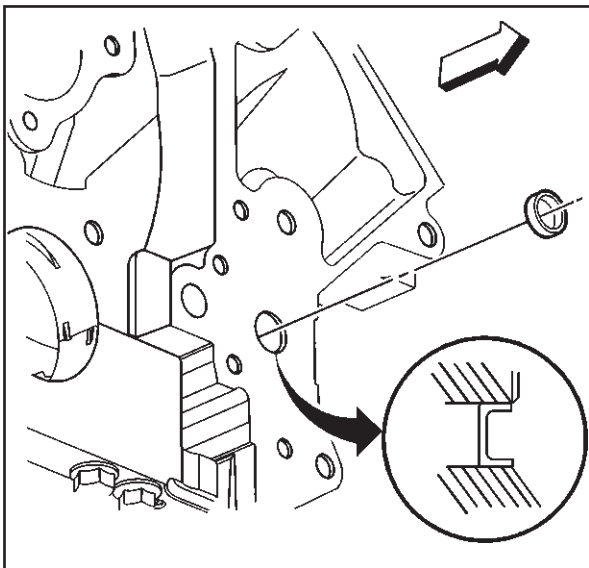


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11. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be reused.
12. Lubricate the O-ring seal with clean engine oil.
13. Install the block rear oil gallery 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



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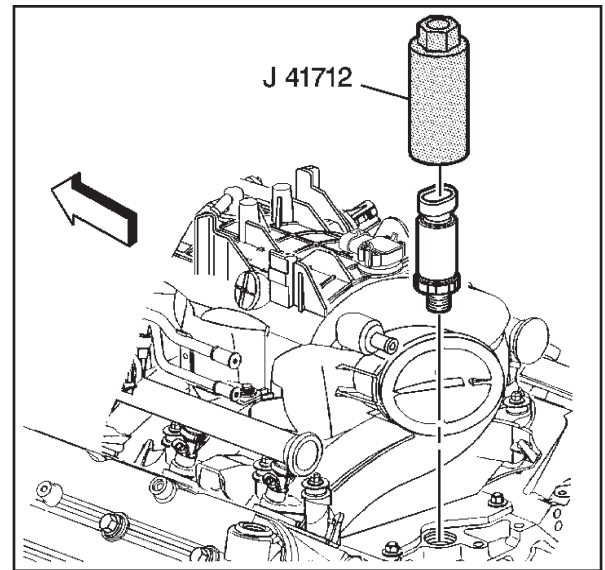
Important: The engine block front oil gallery plug should not be removed unless service is required.

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

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).



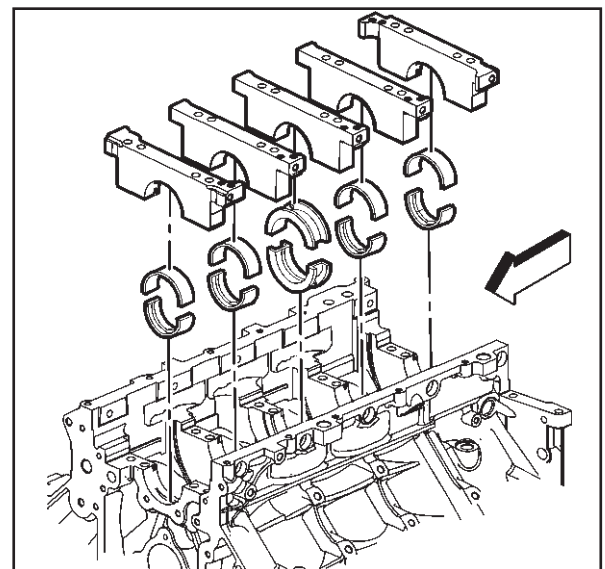
260089

Crankshaft and Bearings Installation**Tools Required**

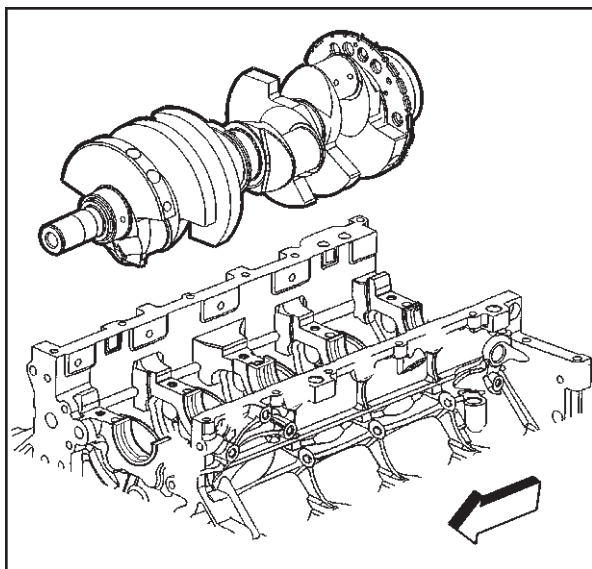
J 36660 Torque Angle Meter

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.



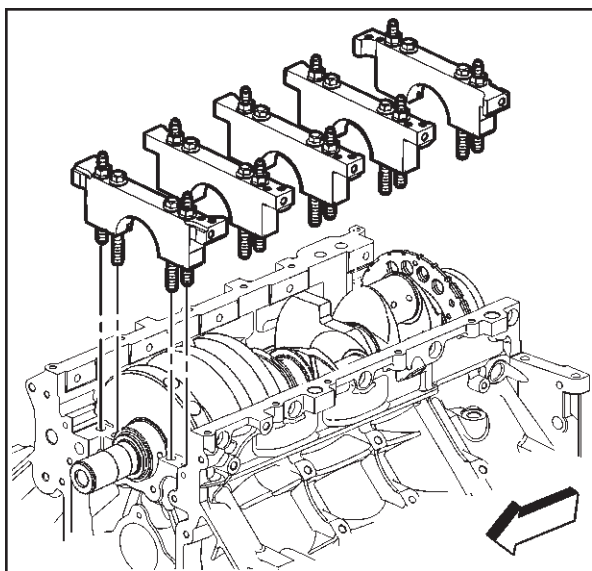
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Notice: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

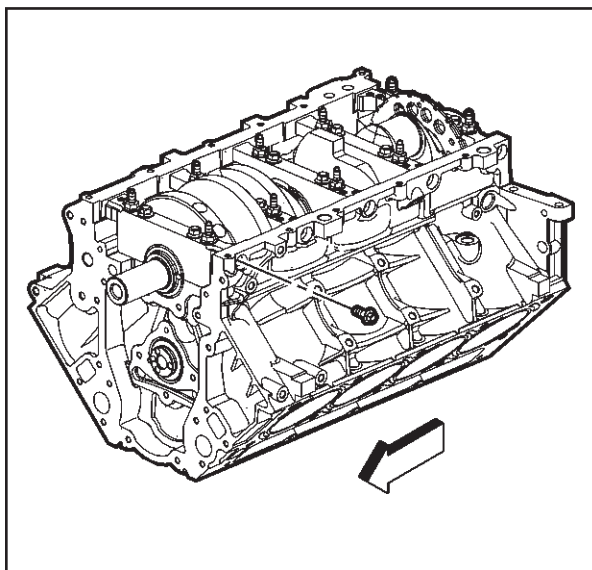
4. Install the crankshaft.



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).

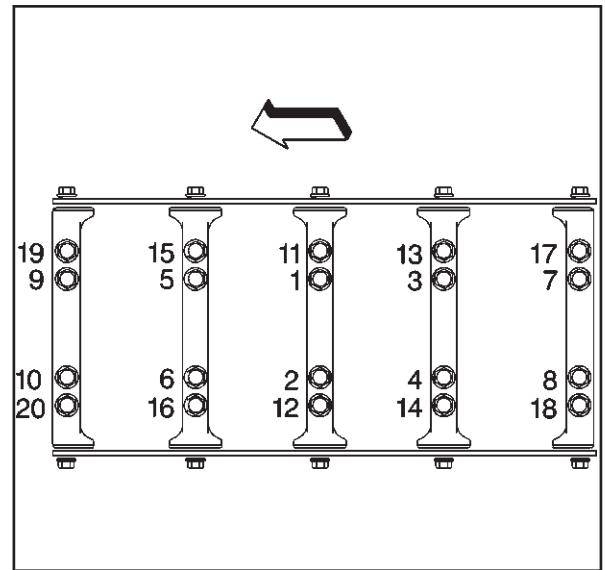
Important: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft **MUST** be in the forward direction.

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

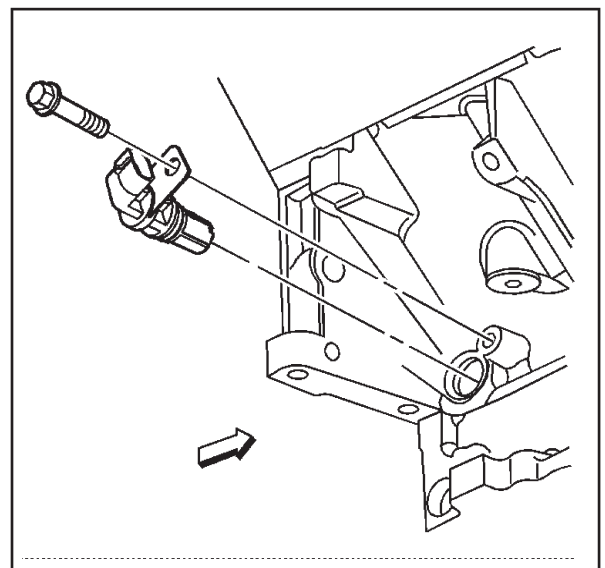


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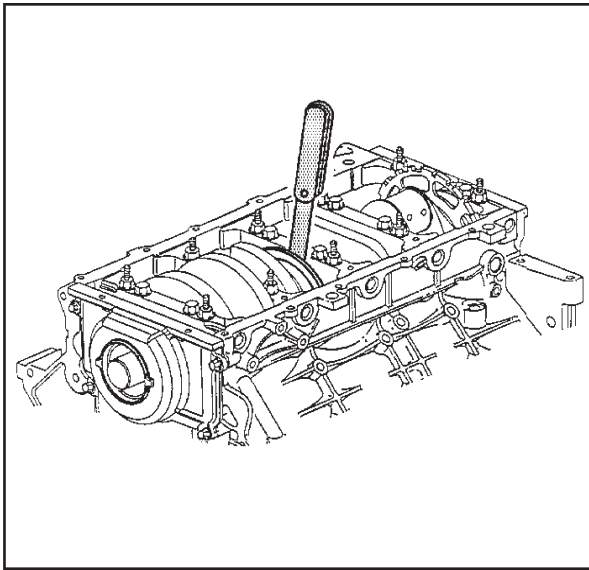
11. Install the crankshaft position sensor.
 - 11.1. Inspect the crankshaft position sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used.
 - 11.2. Coat the O-ring seal with clean engine oil.
 - 11.3. Install the sensor. Align the notch in the sensor retaining bracket with the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

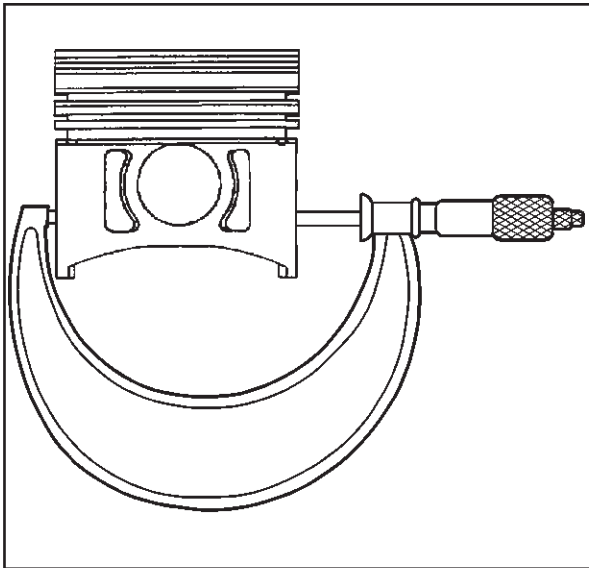


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12. Measure the crankshaft end play.
 - 12.1. Thrust the crankshaft forward or rearward.
 - 12.2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.
The proper crankshaft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



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

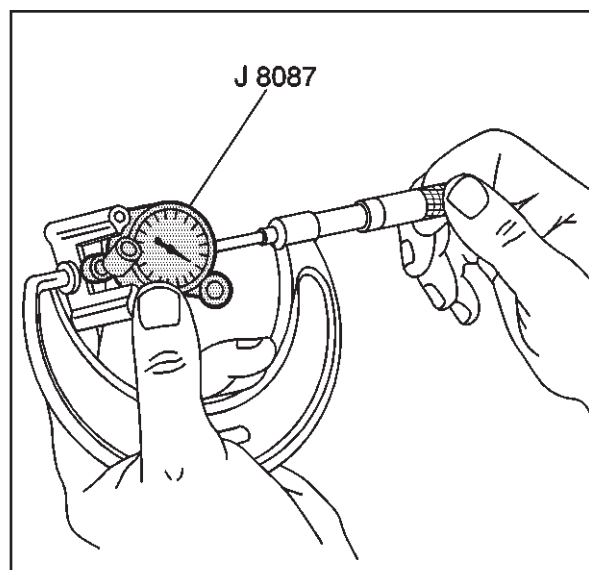
Important: Measurements of all components should be taken with the components at normal room temperature.

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.

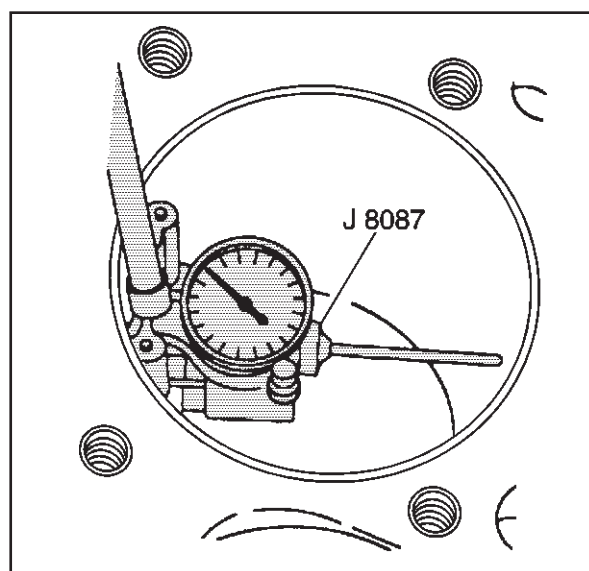
1. Inspect the engine block cylinder bore for scoring or other damage.
2. Inspect the piston and the piston pin. Refer to *Piston, Connecting Rod and Bearings Clean and Inspect*.
3. With the micrometer at a right angle to the piston, measure the piston. Refer to *Piston, Connecting Rod and Bearings Clean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

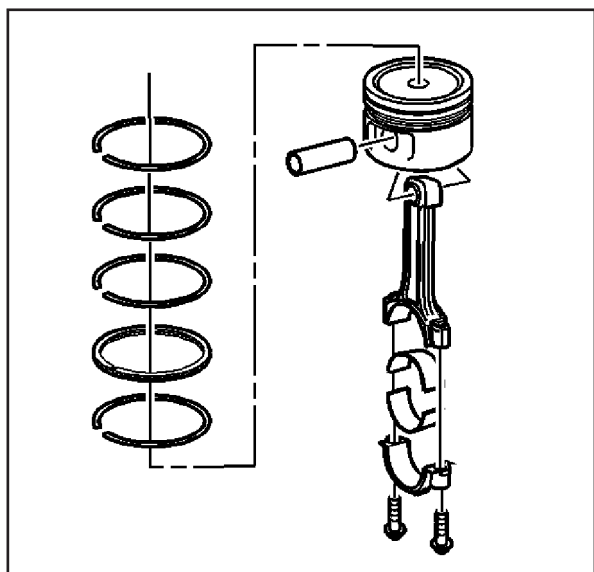


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7. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.
8. Record the cylinder bore diameter.
9. Subtract the piston diameter from the cylinder bore diameter in order to determine 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



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Installation Procedure

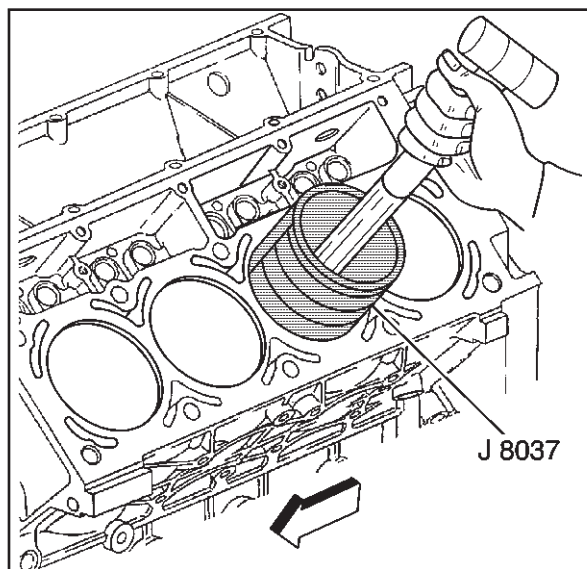
Important: The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore.

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.

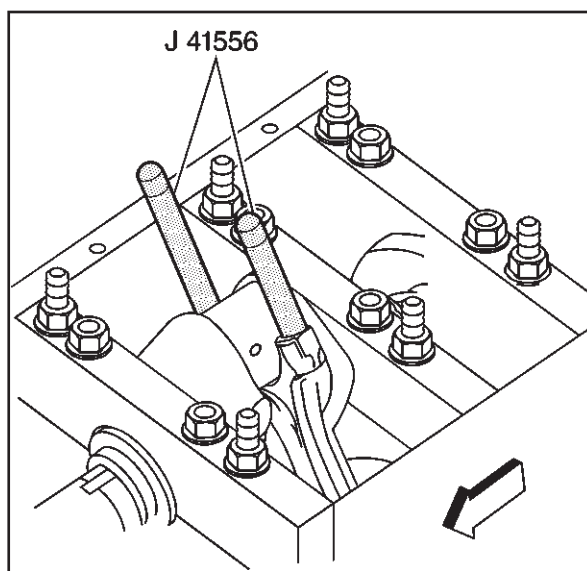
Important: The piston alignment mark **MUST** face the front of the engine block.

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

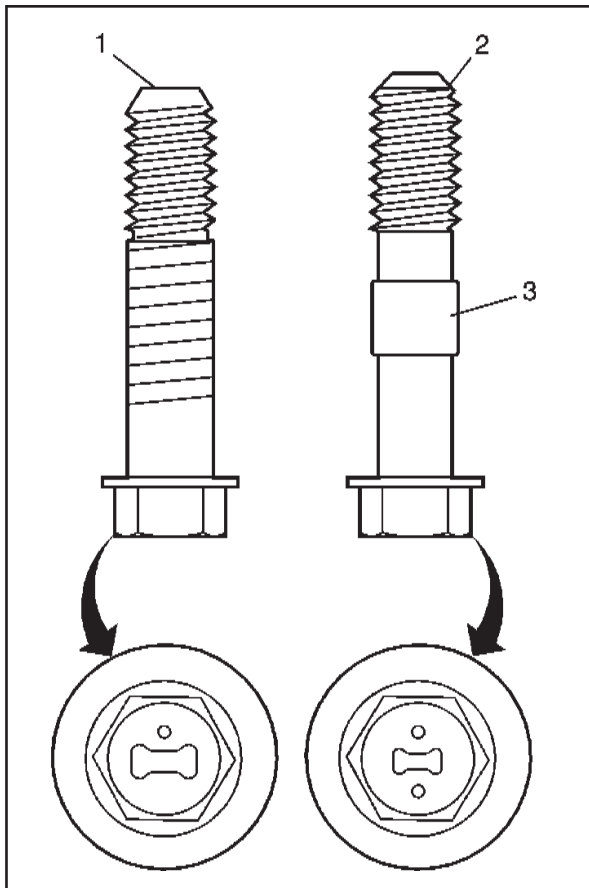


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7. Remove the *J 41556*.



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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

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.

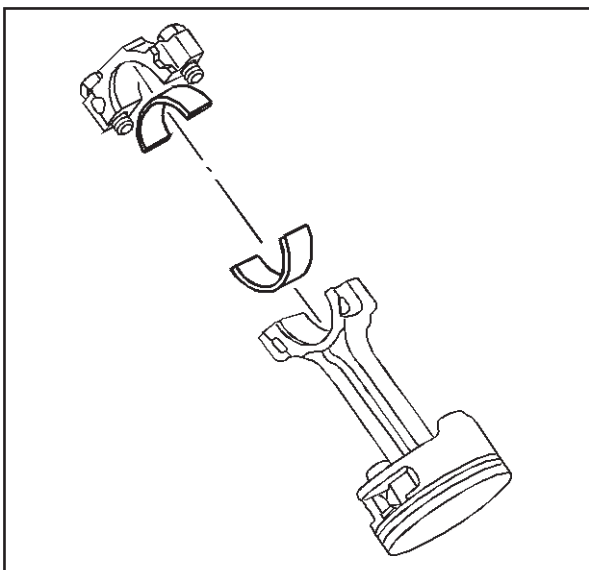
- Position the connecting rod cap onto the connecting rod properly.

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

9. Install the bearing, cap and bolts.

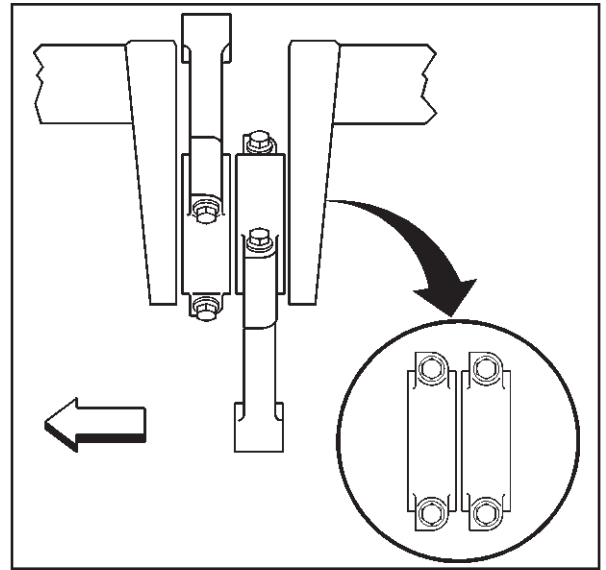
Tighten

- 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).



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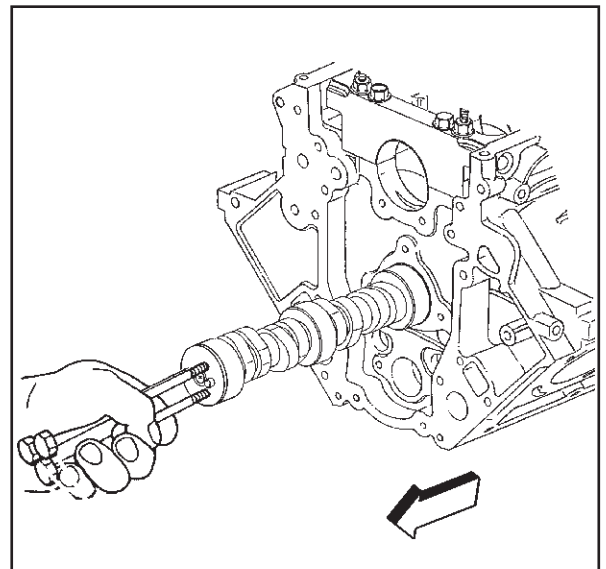
Camshaft Installation

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



63212

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

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

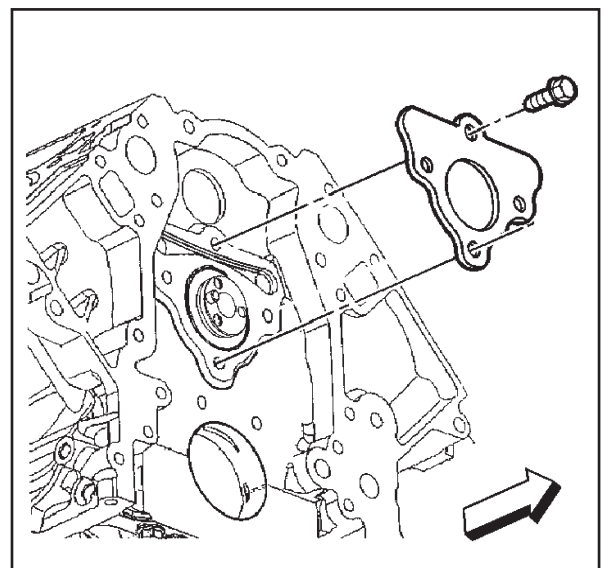
The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer and the bolts.

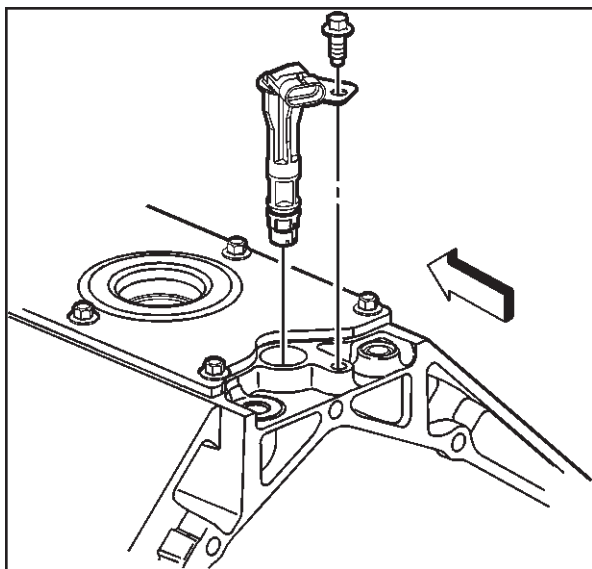
Tighten

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.



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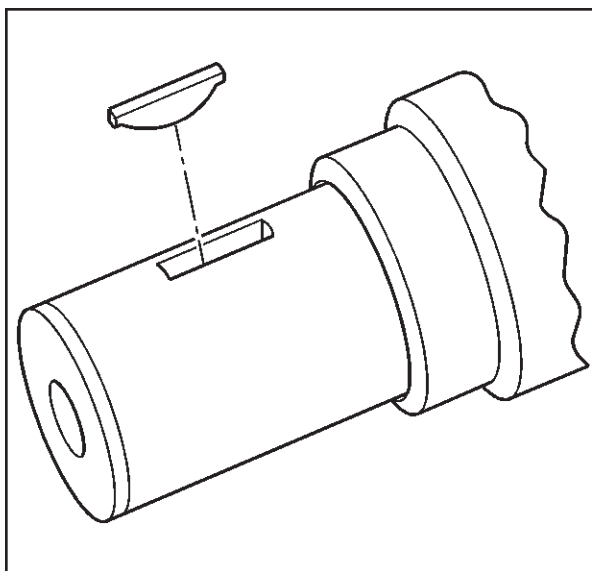


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8. Install the camshaft sensor and bolt.

Tighten

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

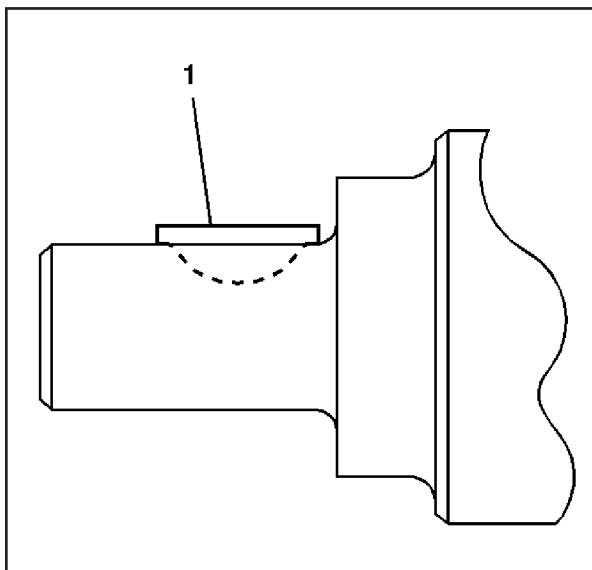


156149

Timing Chain and Sprockets Installation**Tools Required**

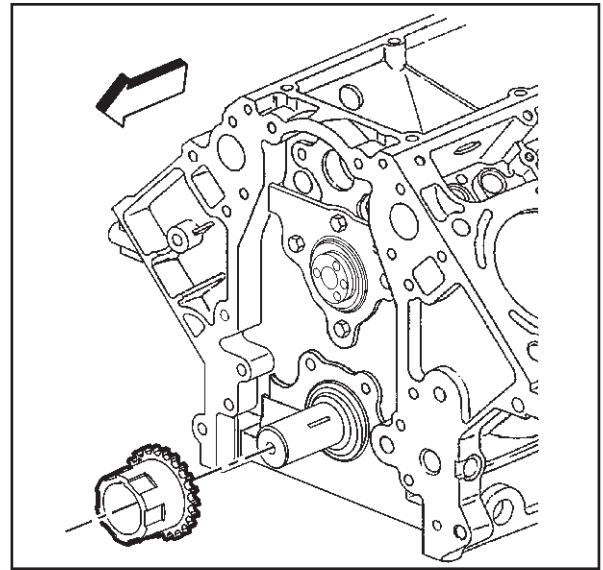
J 41665 Crankshaft Balancer and Sprocket Installer

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



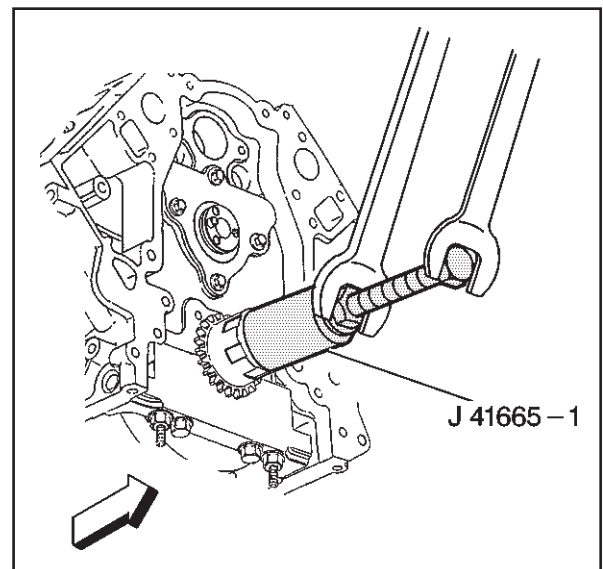
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3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.



156150

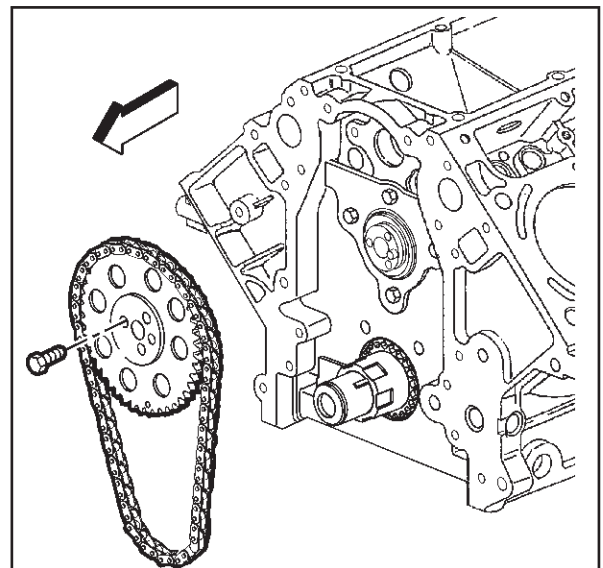
4. Use the *J 41665* in order to install the crankshaft sprocket.
Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.



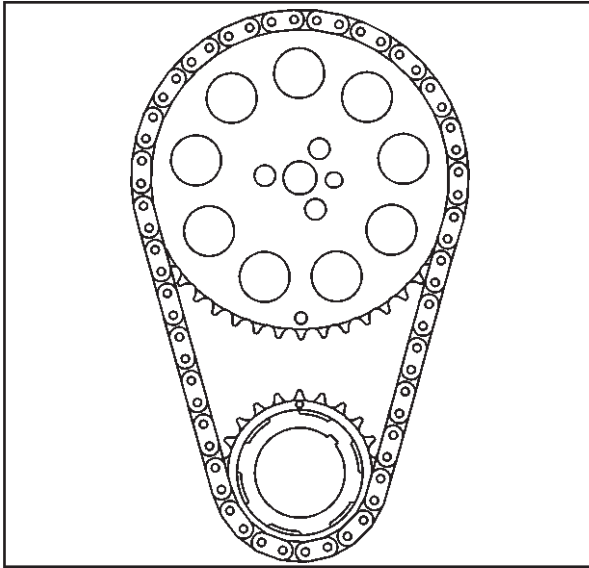
63199

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.



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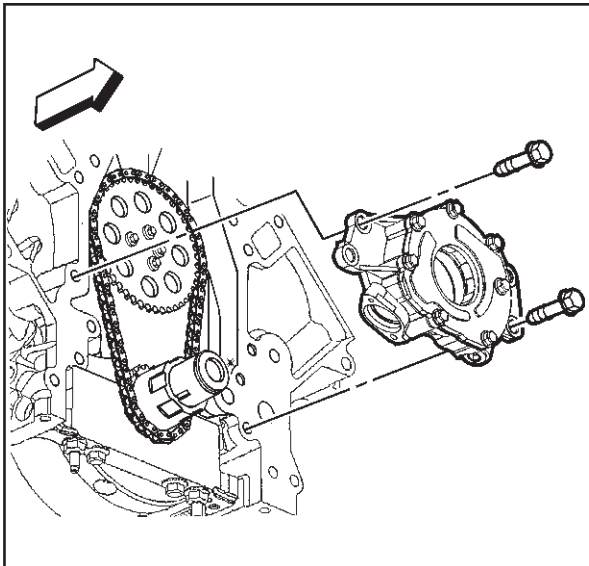
7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

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

8. Install the camshaft sprocket bolts.

Tighten

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



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.

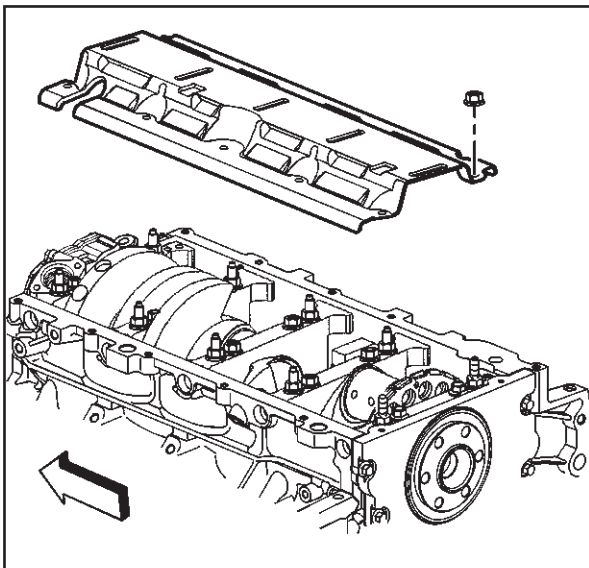
1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

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

3. Install the oil pump bolts.

Tighten

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



260099

4. 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.

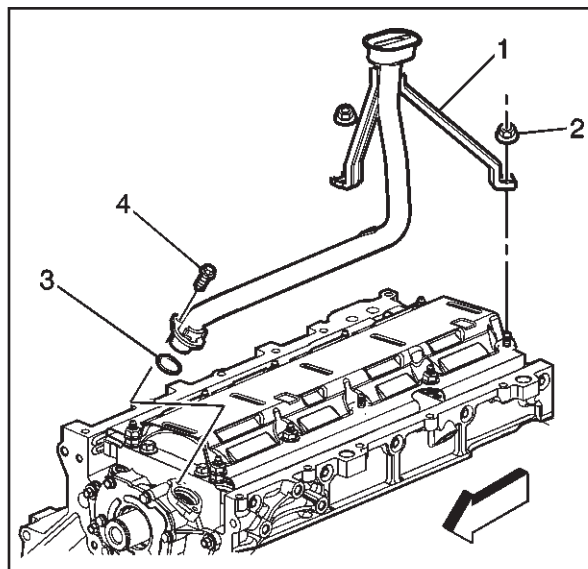
Important: Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.

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

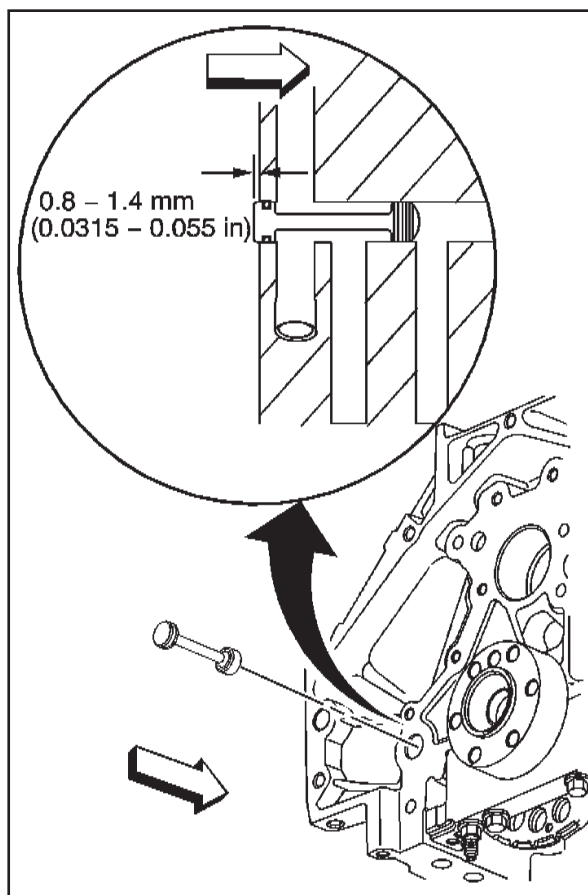
Tools Required

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

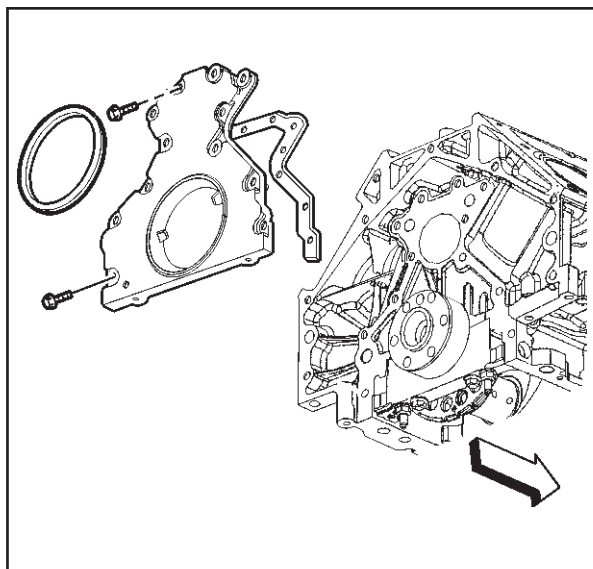
J 41476 Front/Rear Cover Alignment (Crankshaft Oil Seal Area)

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

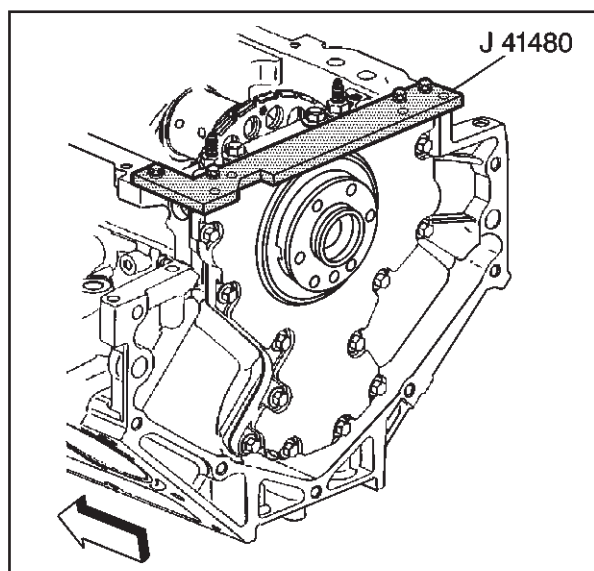


63228



64282

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



64204

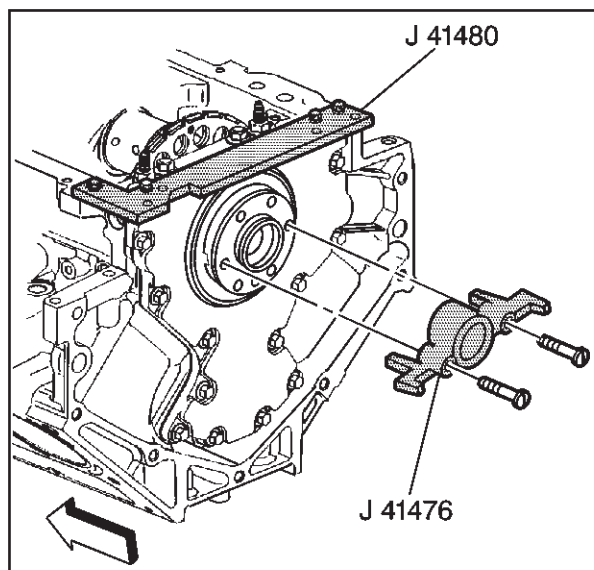
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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.

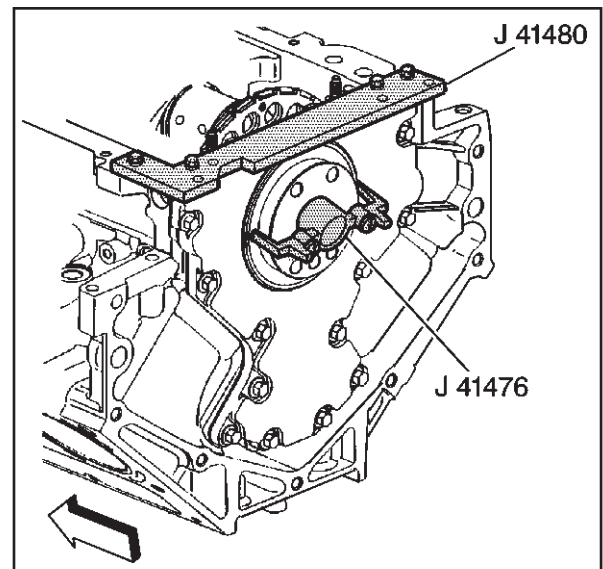
5. Rotate the crankshaft until two opposing flywheel bolt holes are parallel to the oil pan surface.

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

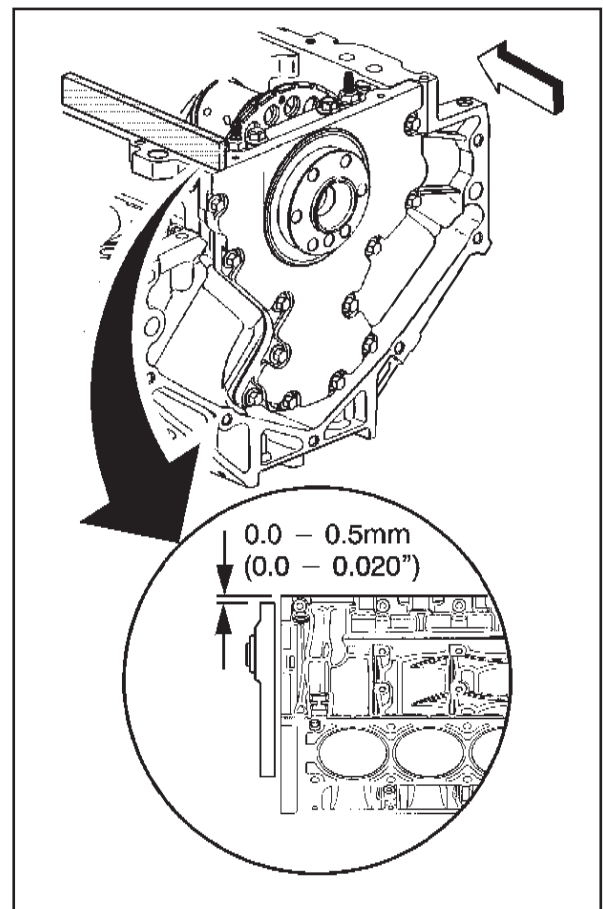
- 6.1. Tighten the tool mounting bolts until snug. Do not overtighten.
- 6.2. Tighten the *J 41480* tool-to-rear cover bolts evenly to 12 N·m (106 lb in).
- 6.3. Tighten the rear cover bolts to 25 N·m (18 lb ft).
7. Remove the tools.



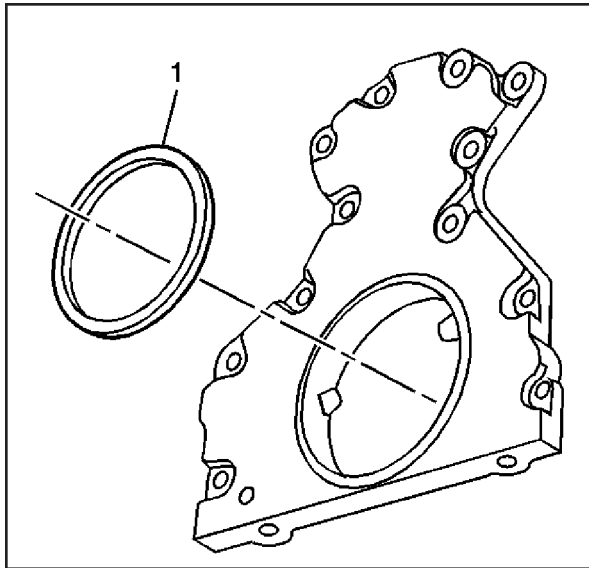
65286

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.

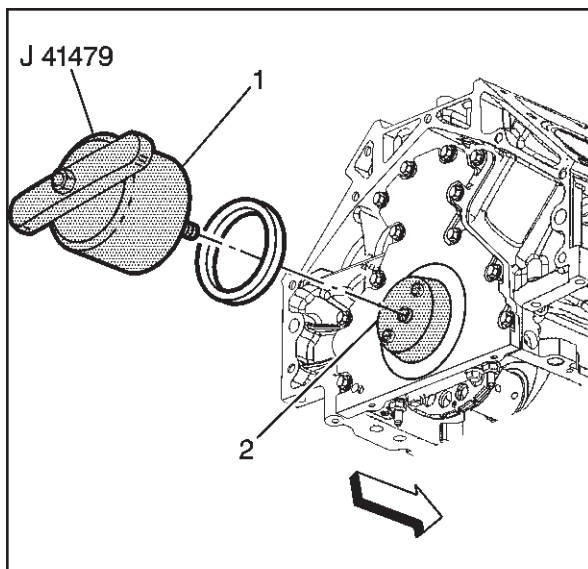
Avoid contact with the portion of the gasket that protrudes into the oil pan surface.
 - 8.2. Insert a feeler gauge between the rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear cover-to-engine block oil pan surface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



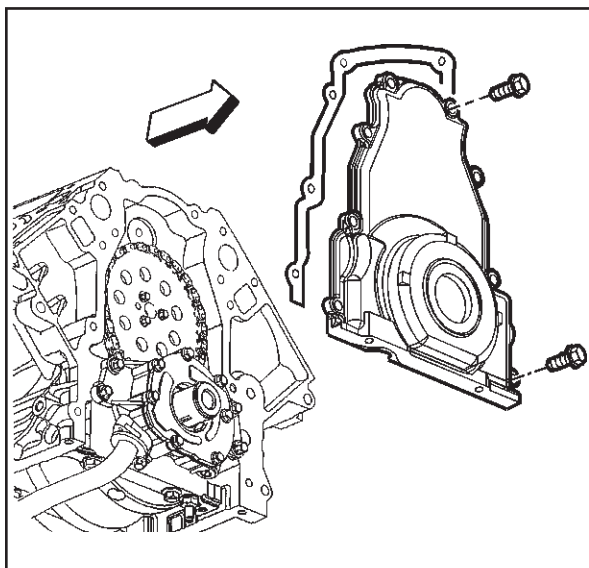
63240



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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 or other lubricants to contact the crankshaft surface.

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

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

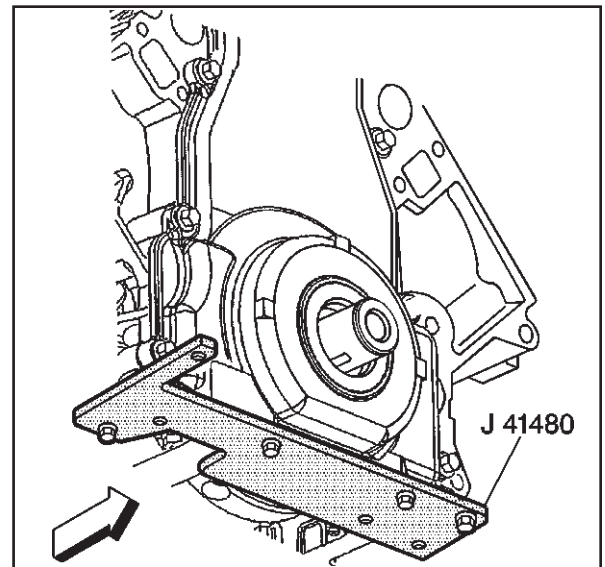
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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

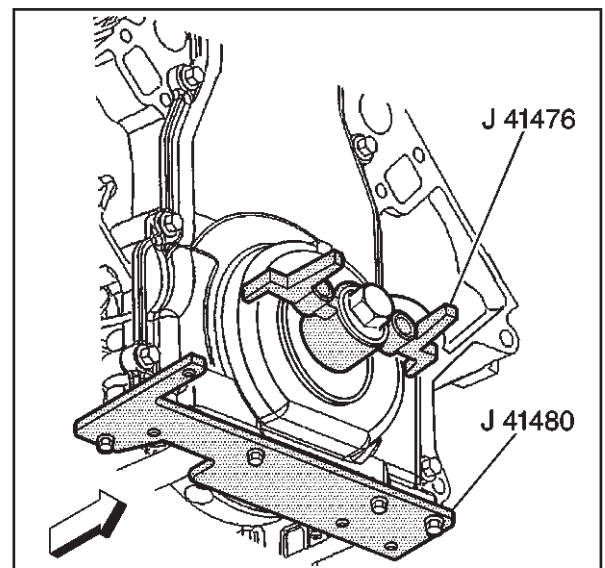
Important: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

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

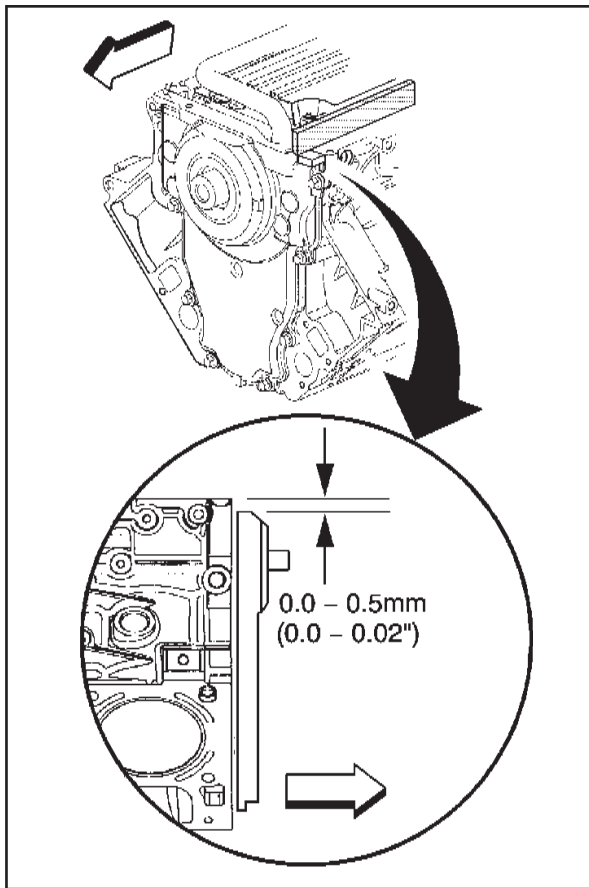
Tighten

- 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

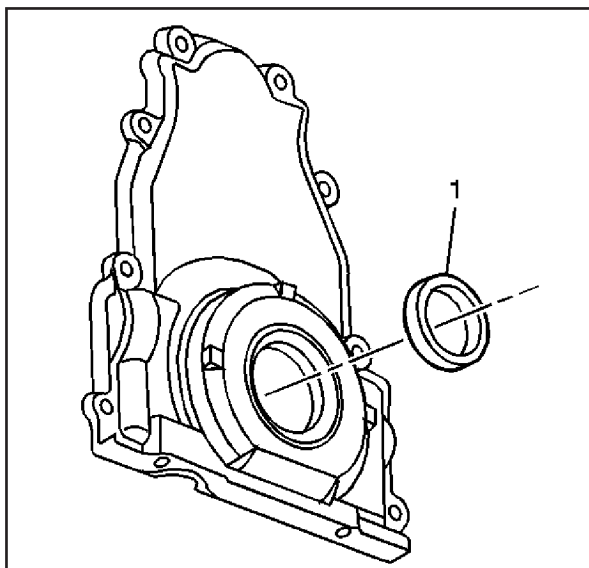
7. Measure the oil pan surface flatness (front cover-to-engine block).

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



490689

Crankshaft Front Cover Oil Seal Installation

Tools Required

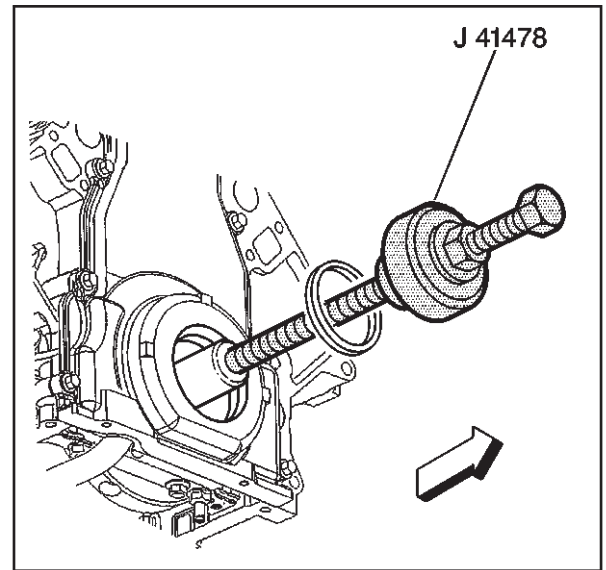
J 41478 Crankshaft Front Oil Seal Installer

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



63177

Oil Pan Installation

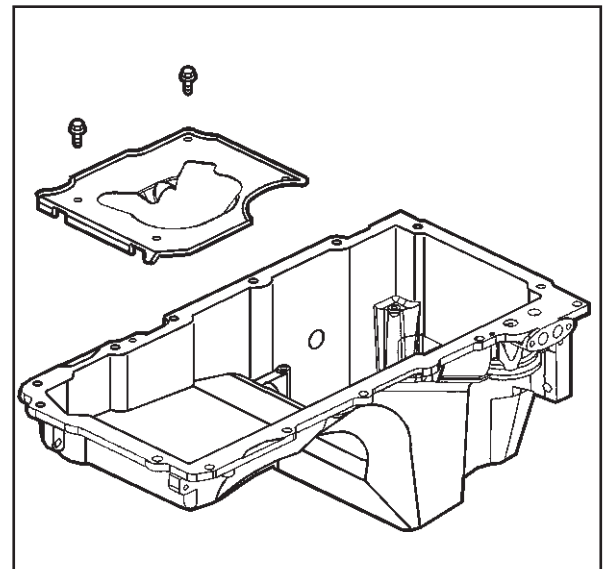
Important:

- 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.

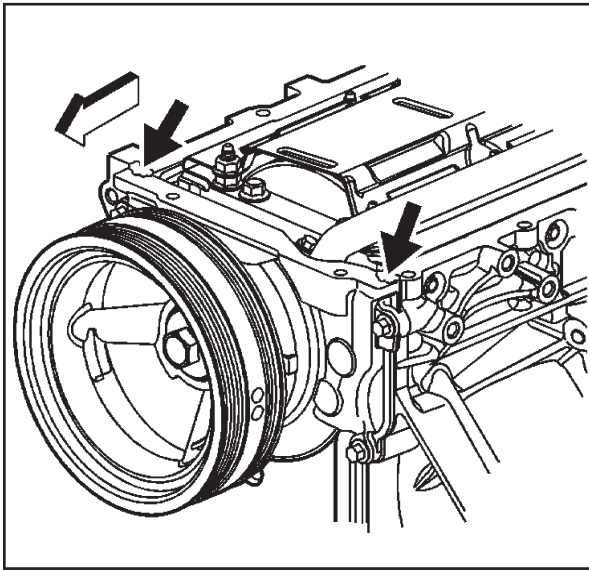
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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

Tighten

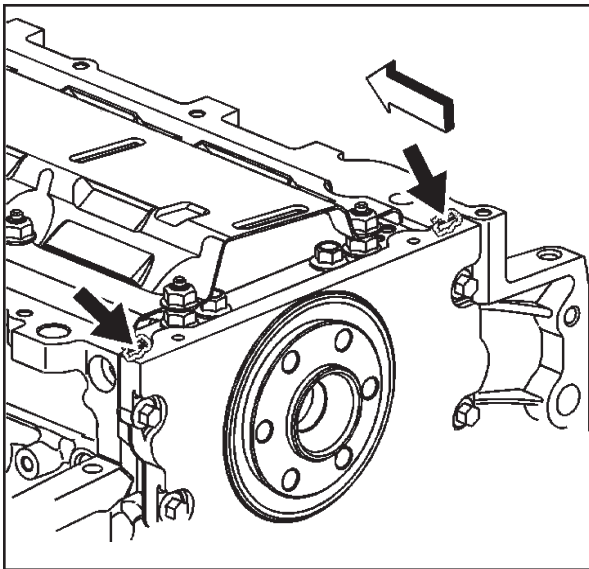


260180



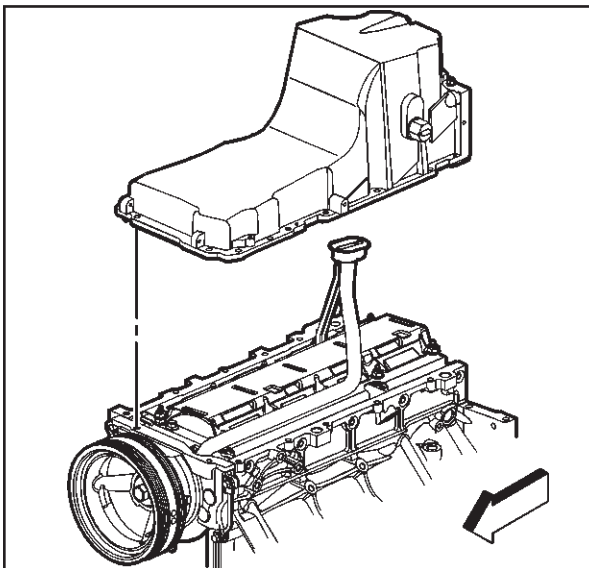
260107

2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) lint 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) lint 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

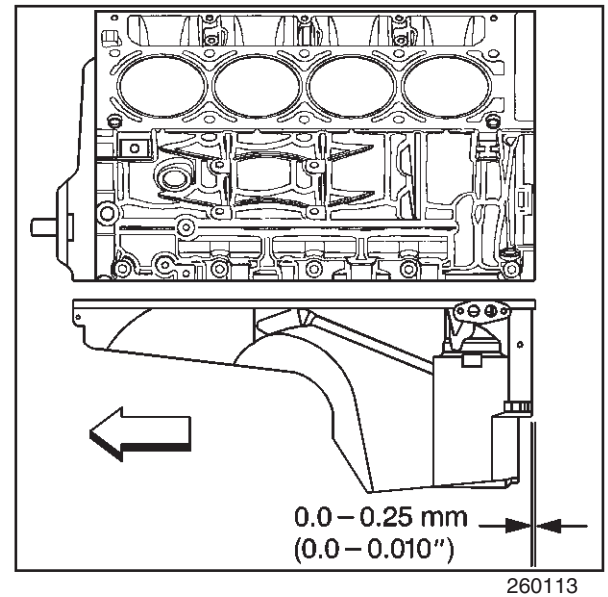
8. Align the oil pan until the rear of the engine block and rear of the oil pan are flush or even.

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.

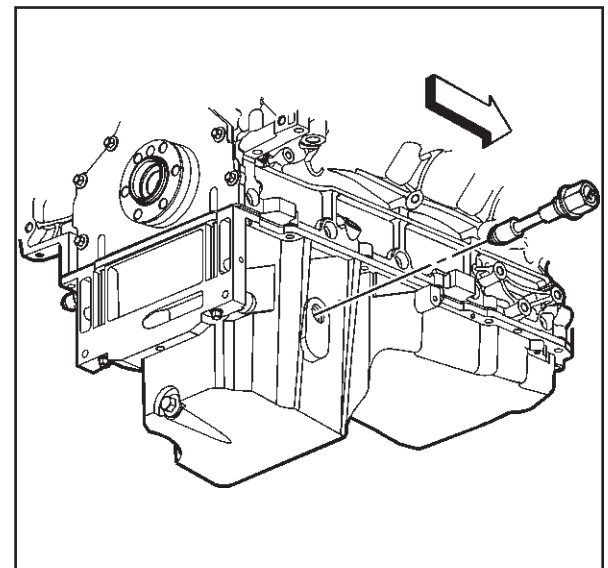
- 9.2. Insert a feeler gauge between the straight edge and the oil pan transmission housing mounting surface and check to make sure that there is no more than a 0.25 mm (0.01 in) gap between the pan and straight edge.
- 9.3. If the oil pan alignment is not within

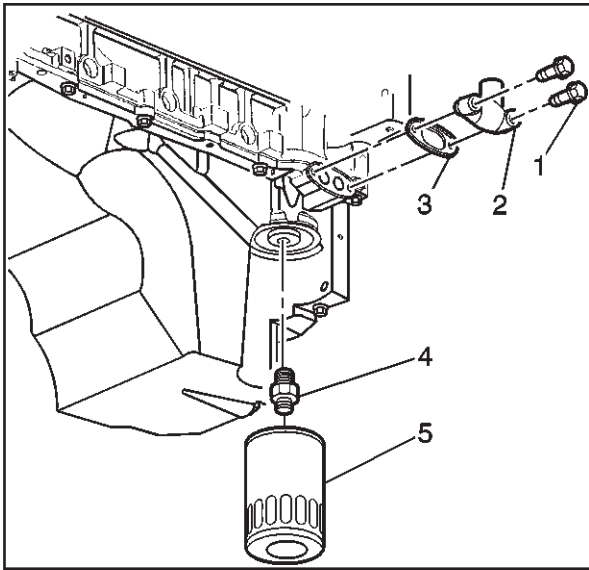


10. Install the oil level sensor (if applicable).

Tighten

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





260125

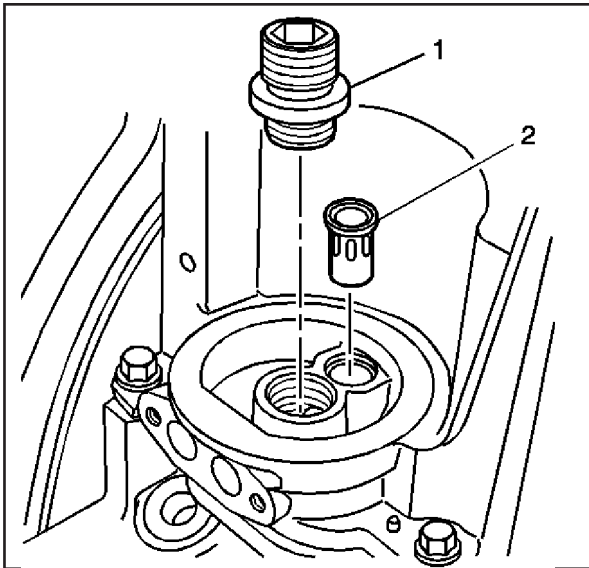
Oil Filter, Adapter and Pan Cover Installation

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).

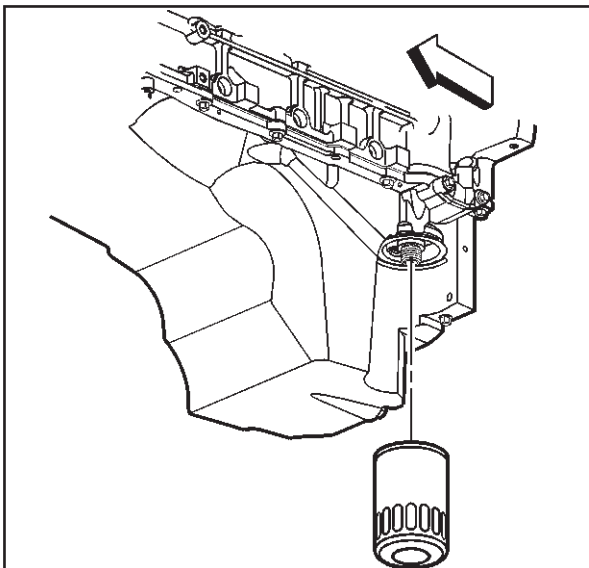


490699

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.

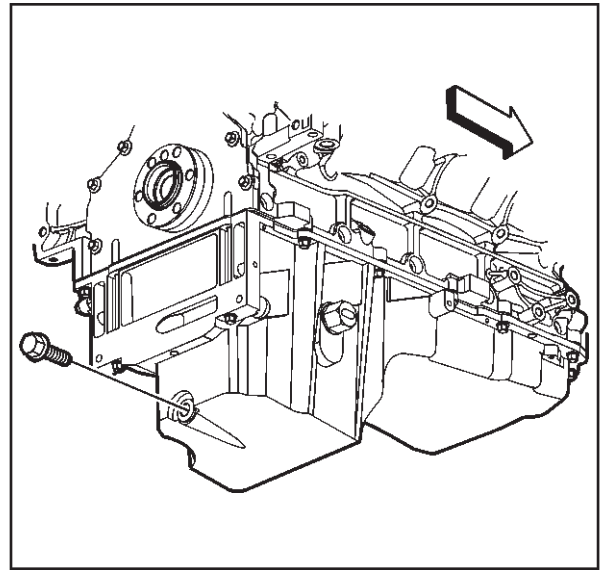
Tighten

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).



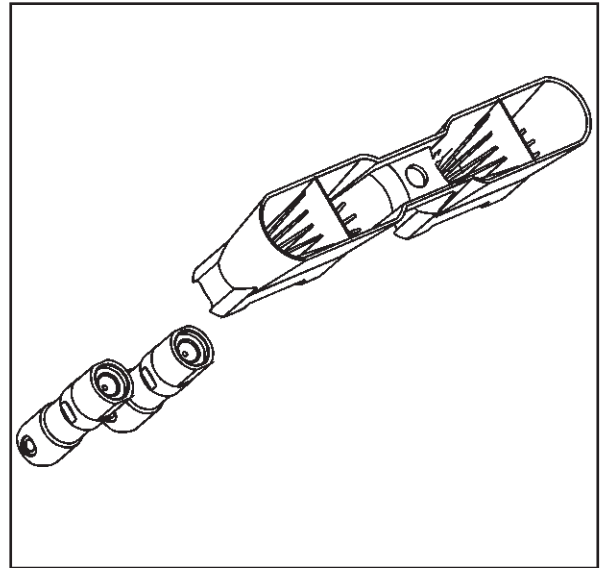
260111

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

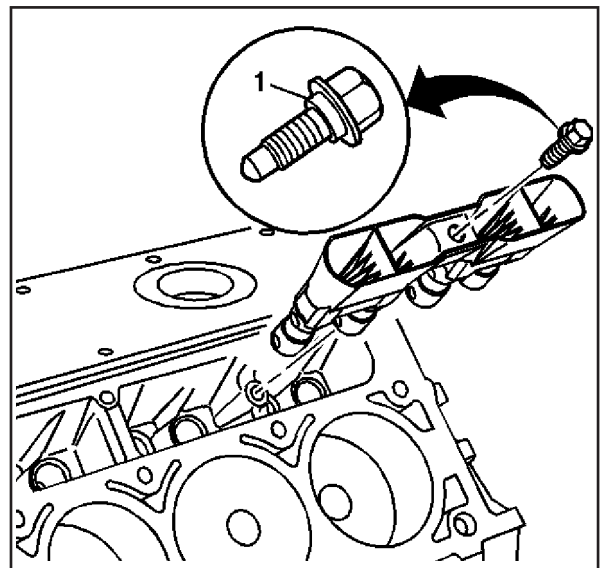
3. Install the valve lifters and guide assembly to the engine block.

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

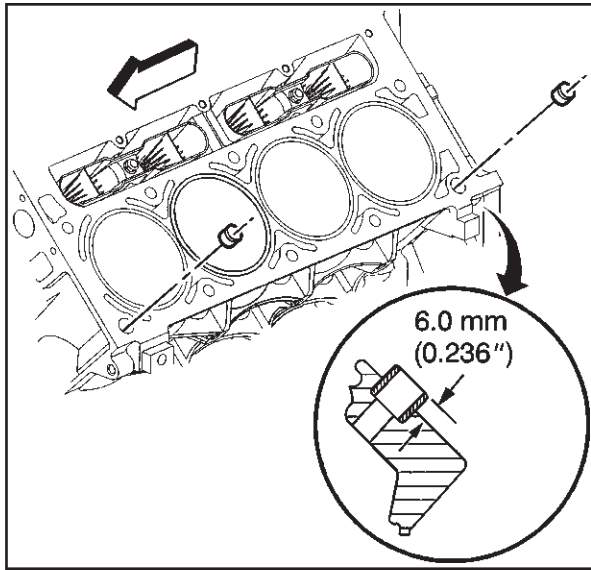
4. Install the valve lifter guide bolt (1).

Tighten

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



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.

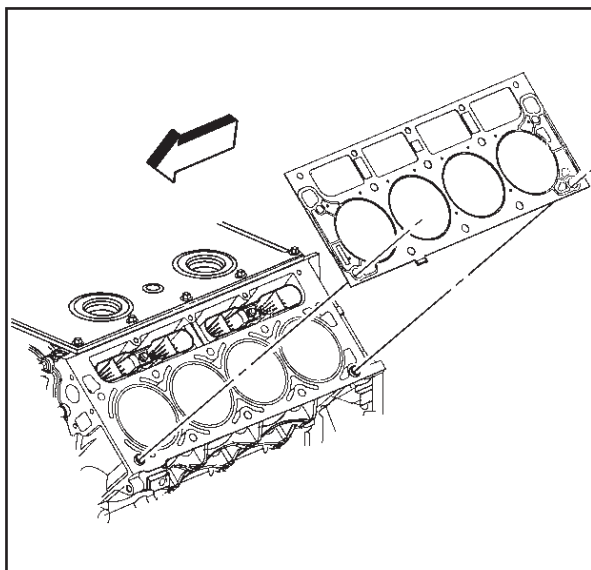
Important:

- 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

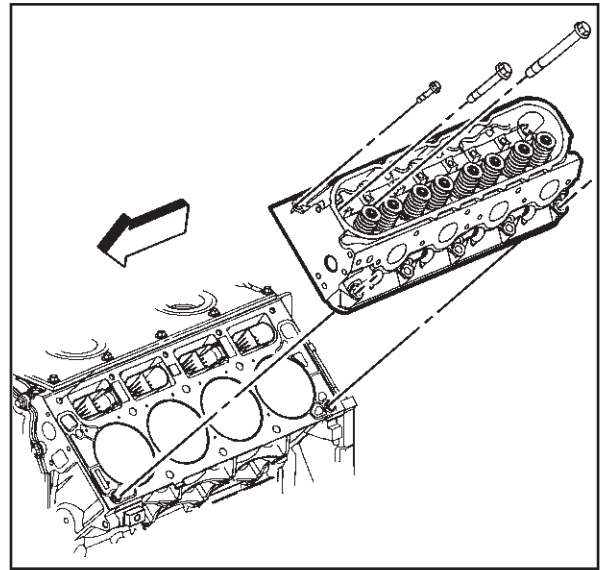


63169

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.



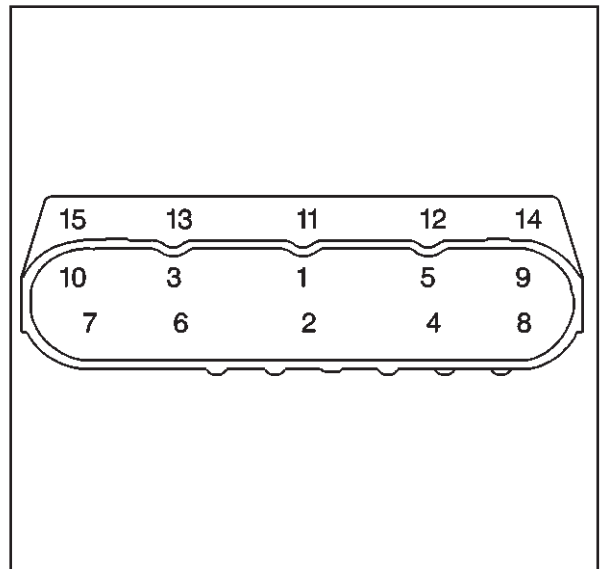
260146

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

10. Tighten the cylinder head bolts.

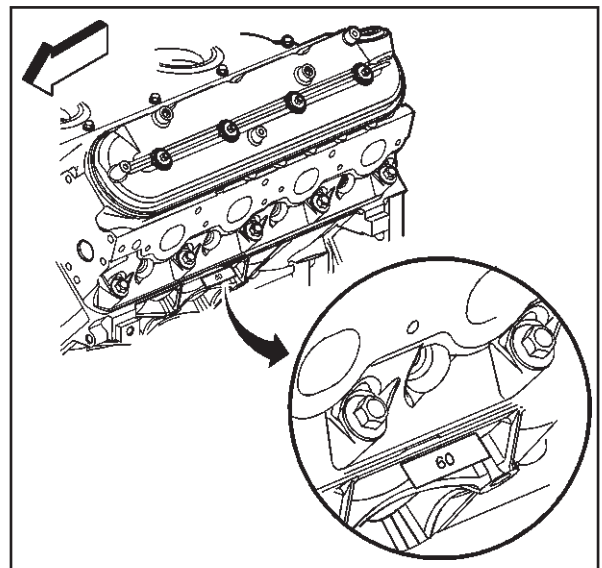
Tighten

- 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

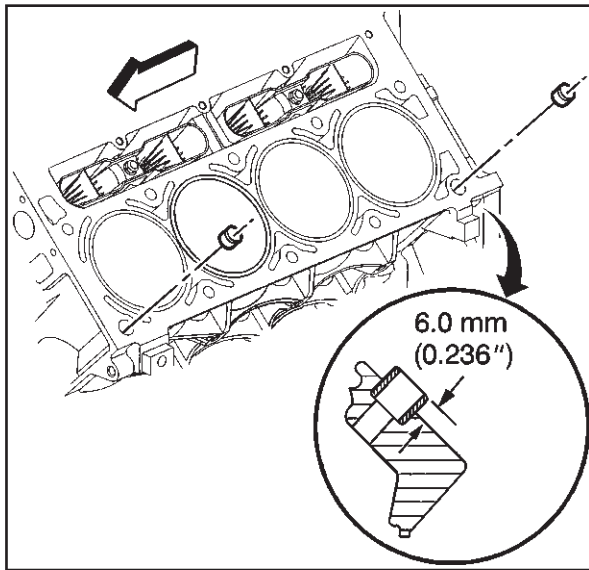


260150

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.

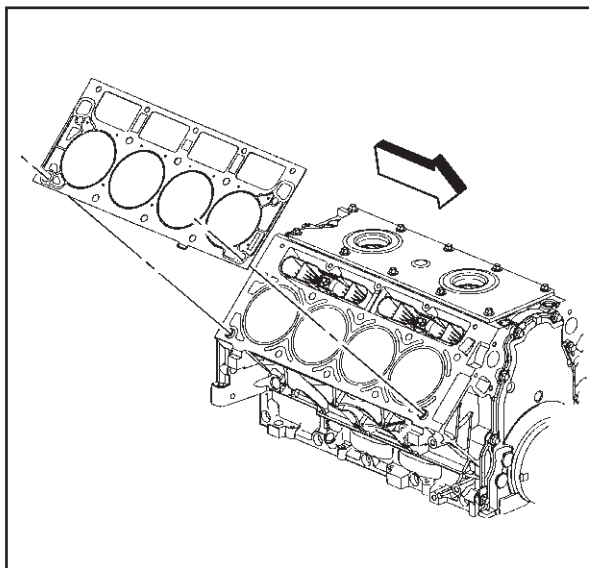
Important:

- 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

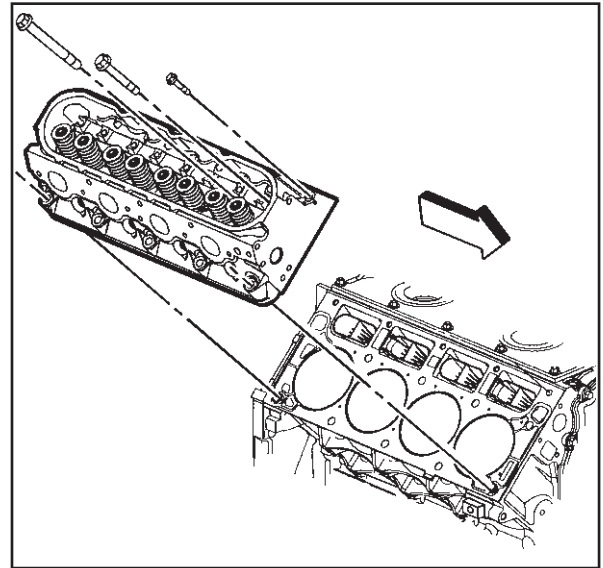


63170

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.



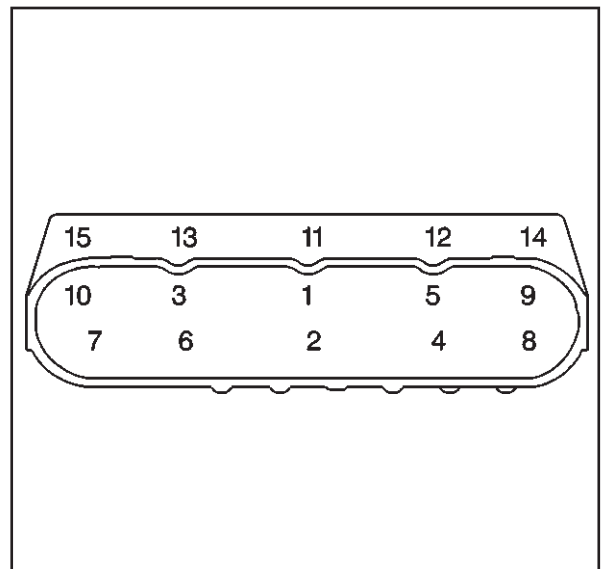
260149

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

10. Tighten the cylinder head bolts.

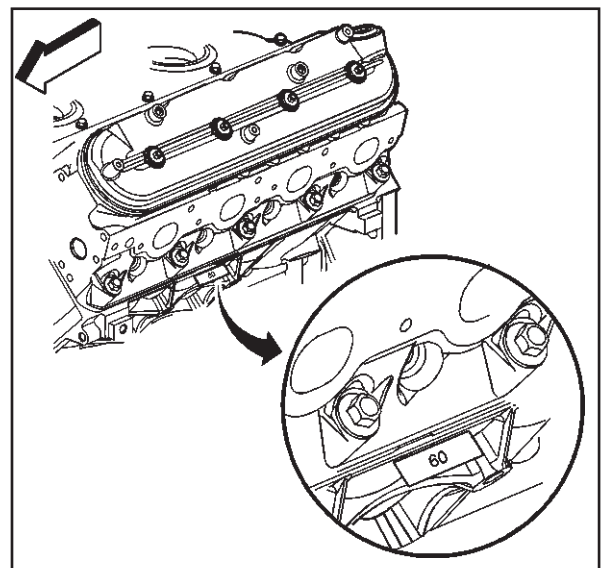
Tighten

- 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

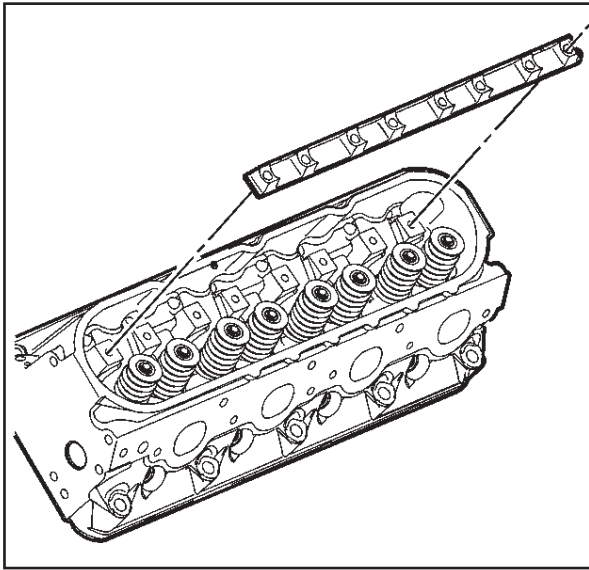


260150

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.



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260141

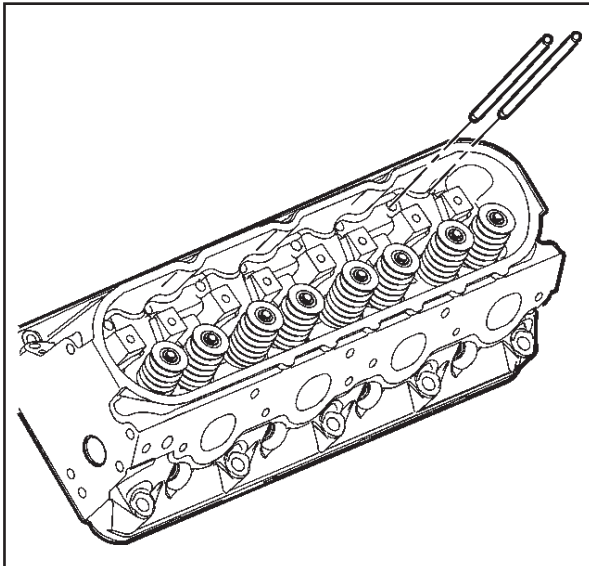
Valve Rocker Arm and Push Rod Installation

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.

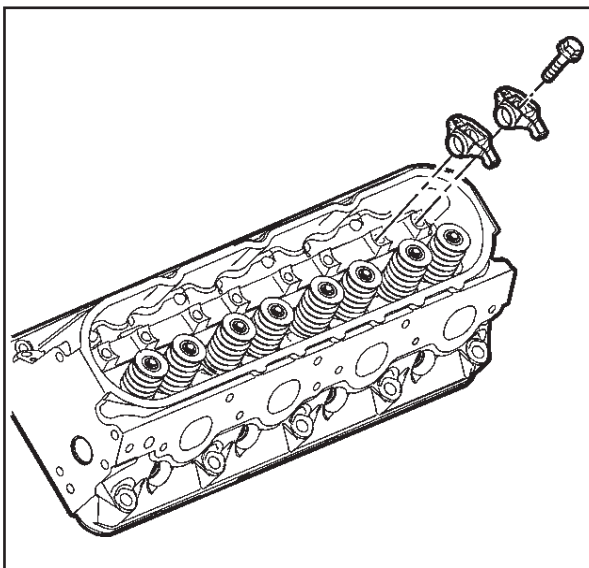
Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.



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.

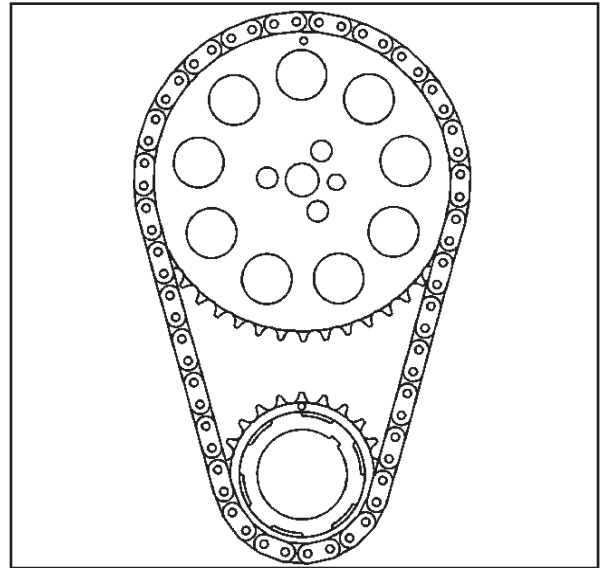
7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

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).

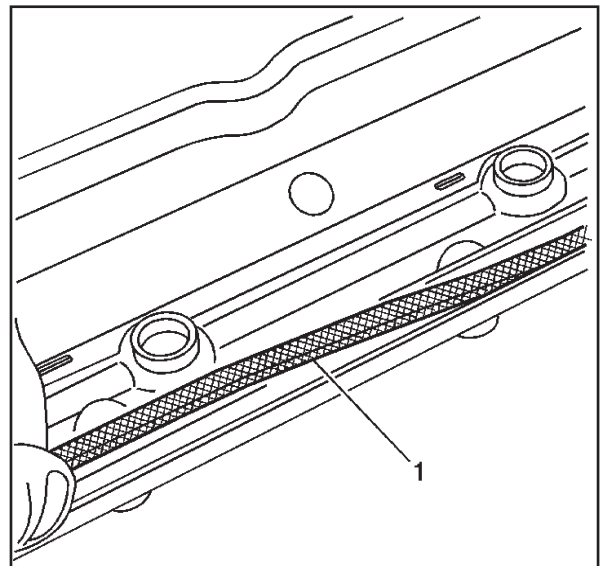


661566

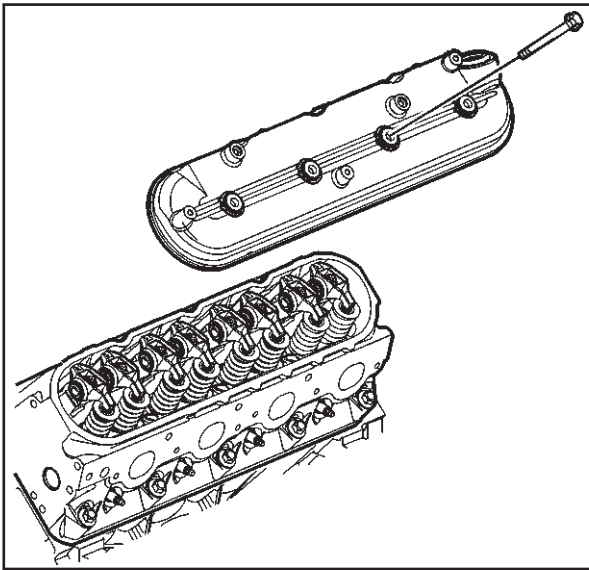
Valve Rocker Arm Cover Installation - Left

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.



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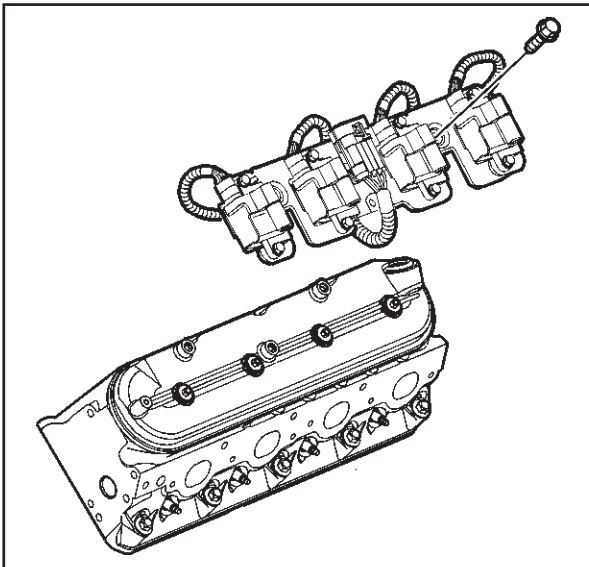
2. Install the valve rocker arm cover onto the cylinder head.

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).

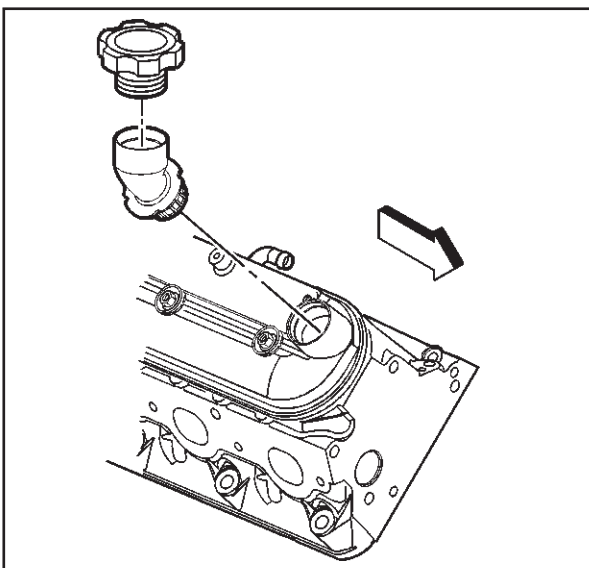


260083

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).



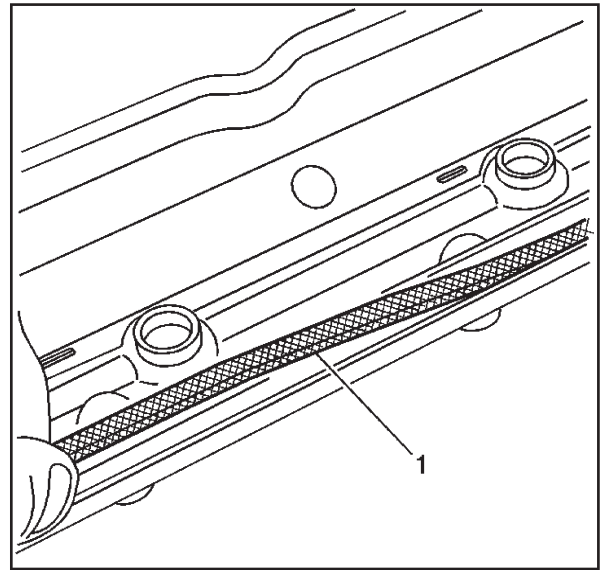
260110

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

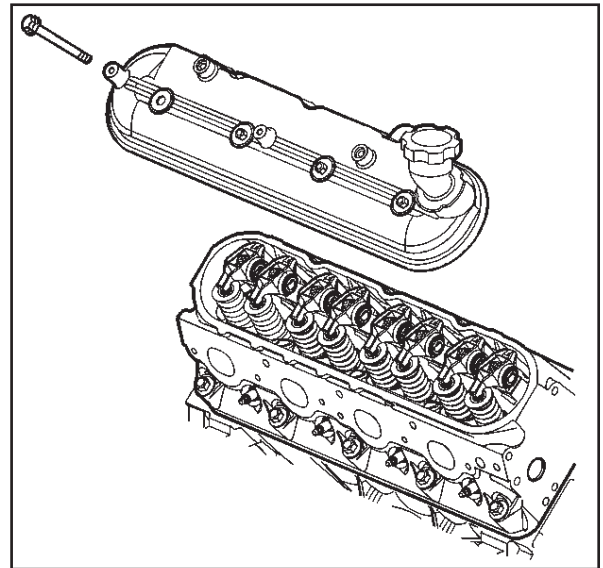
5. Install the valve rocker arm cover onto the cylinder head.

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).

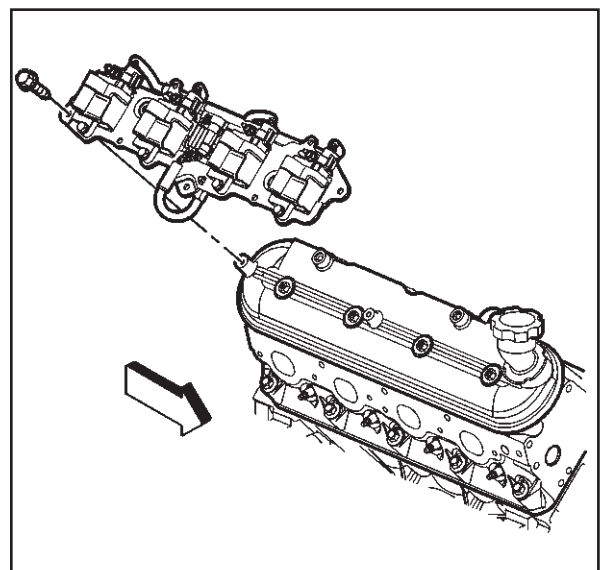


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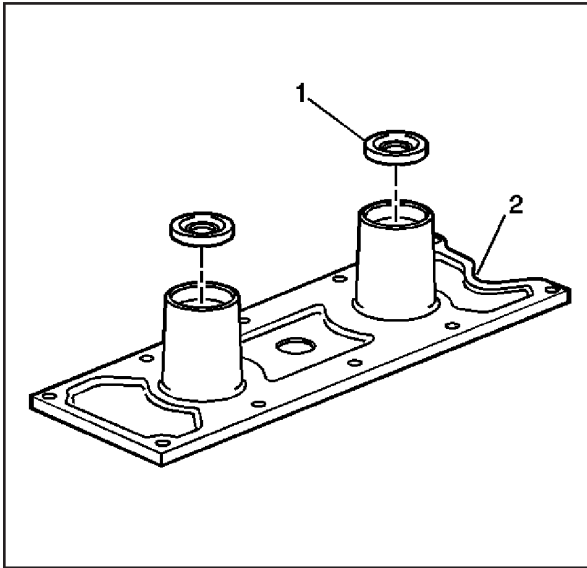
7. Apply threadlock GM P/N 12345382 or equivalent to the threads of the bracket bolts.
8. Install the ignition coil and bracket assembly and bolts.

Tighten

Tighten the ignition coil and bracket assembly bolts



260090



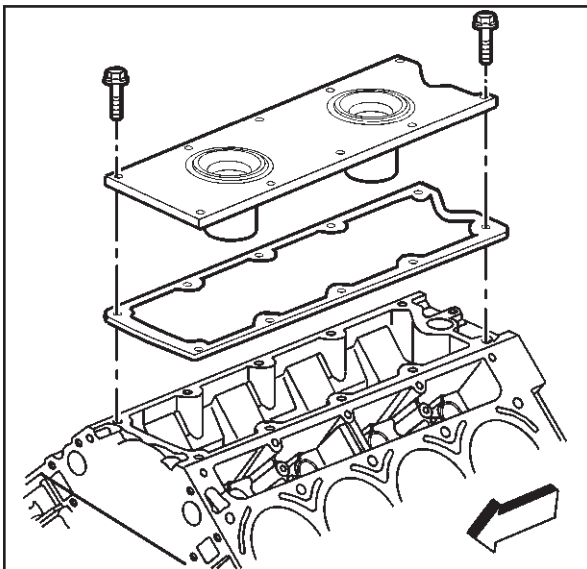
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Engine Valley Cover Installation

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

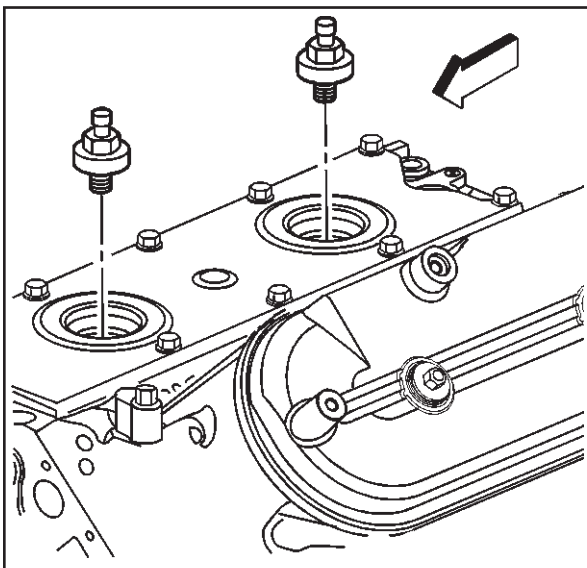
2. Install the valley cover and NEW gasket.

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).



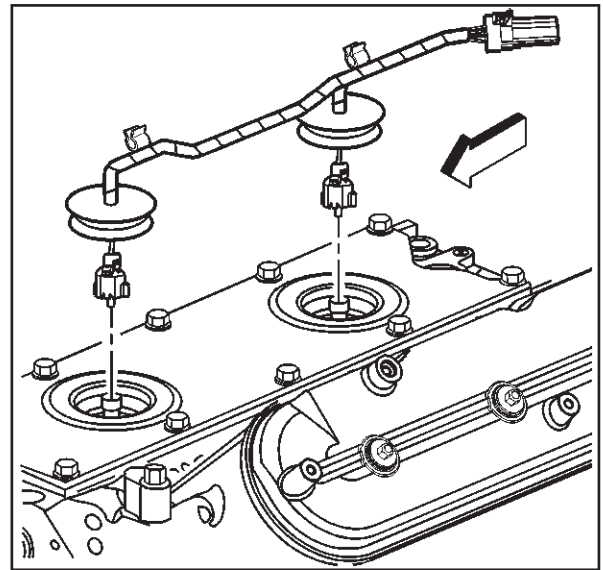
309864

4. Install the knock sensors.

Tighten

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

5. Install the knock sensor wire harness.



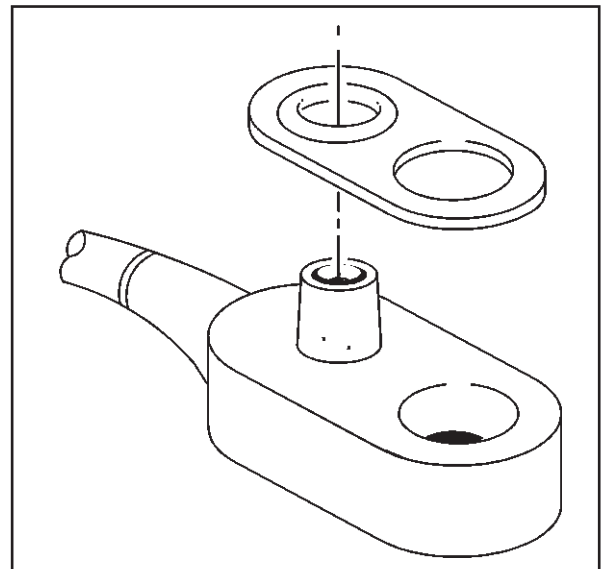
309859

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.



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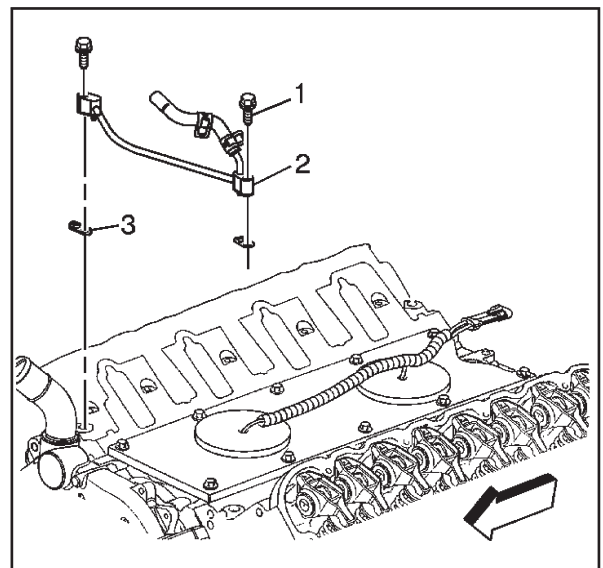
2. Install the pipe (2) and gaskets (3) onto the cylinder heads.

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

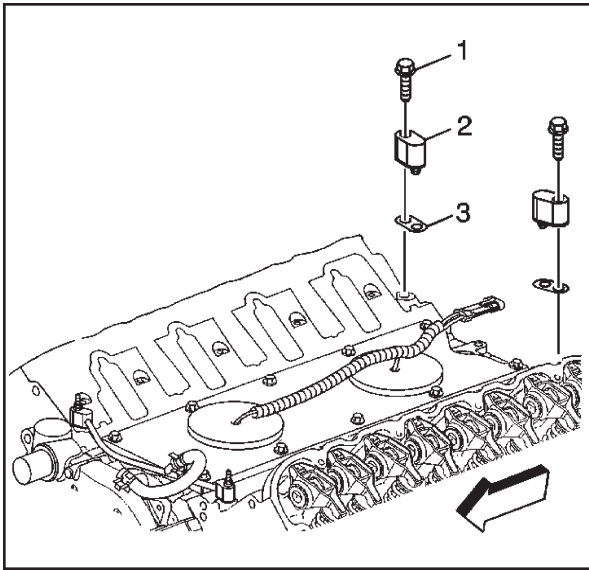
3. Install the pipe bolts (1).
Install the two pipe studs to the front of the engine.

Tighten

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



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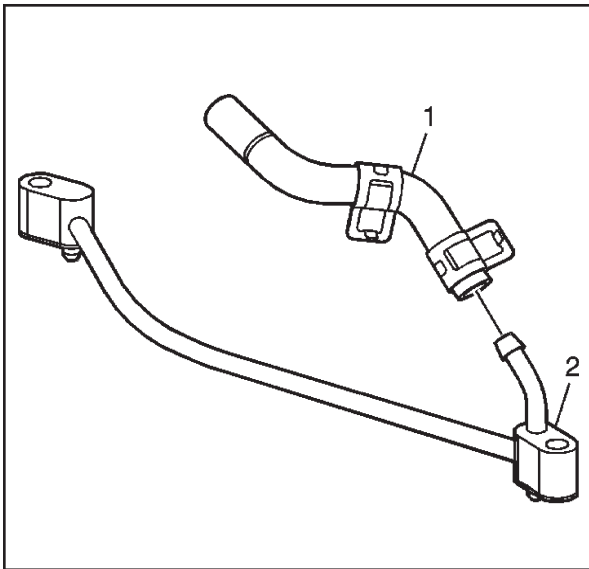


639609

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).



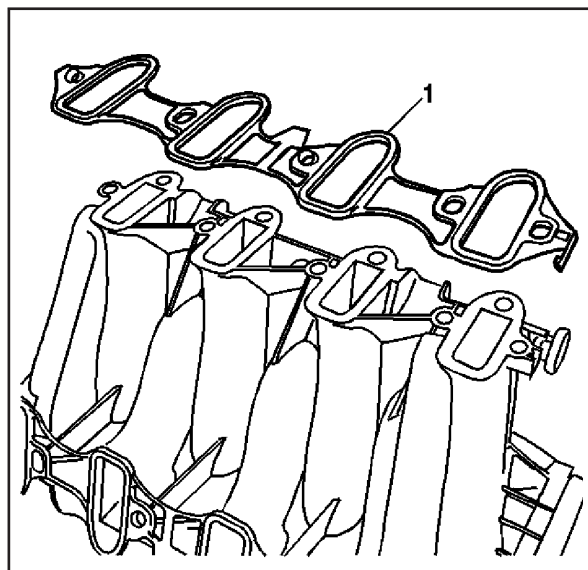
790766

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

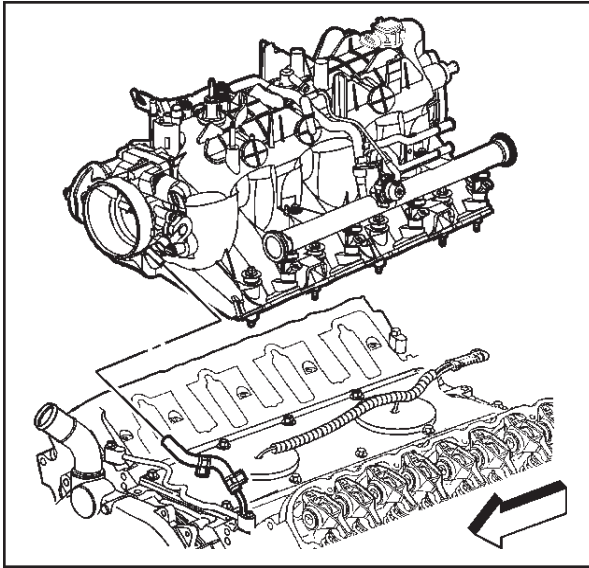
Intake Manifold Installation

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).

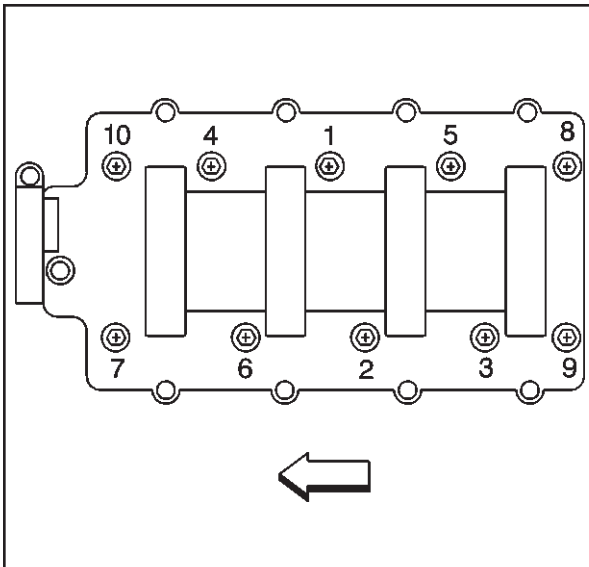


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2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the intake manifold bolts. Refer to *Sealers, Adhesives and Lubricants*.



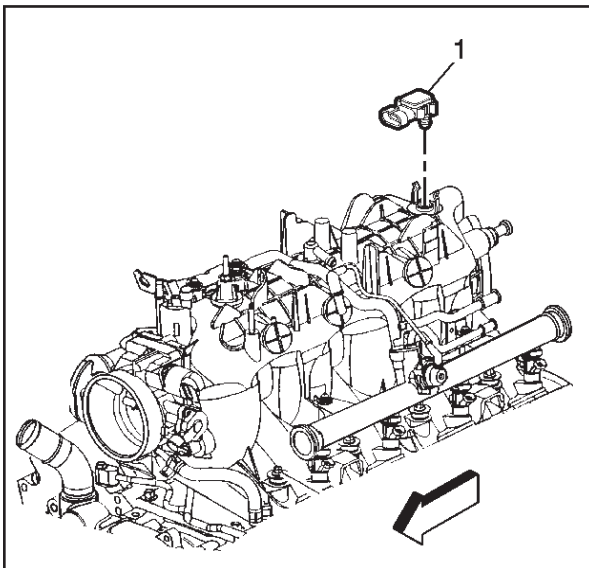
63222

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

4. Install the intake manifold.

Tighten

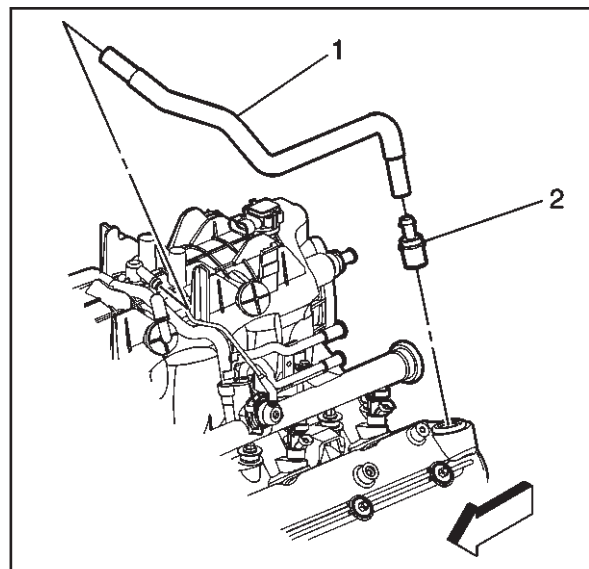
- Tighten the intake manifold bolts first pass in sequence to 5 N·m (44 lb in).
- Tighten the intake manifold bolts final pass in sequence to 10 N·m (89 lb in).



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.

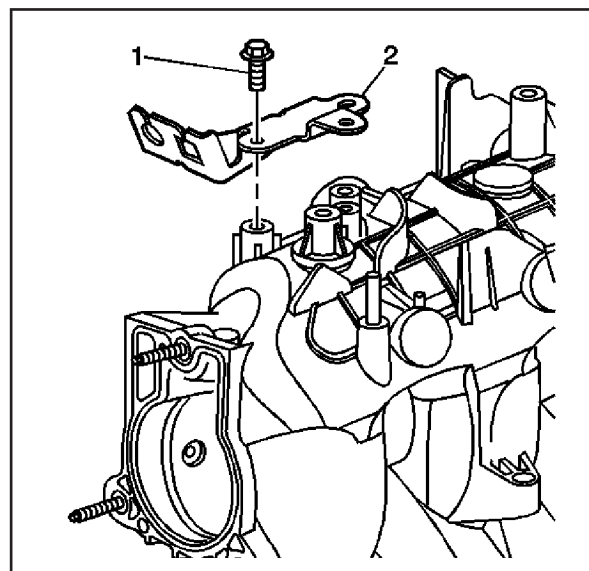


260078

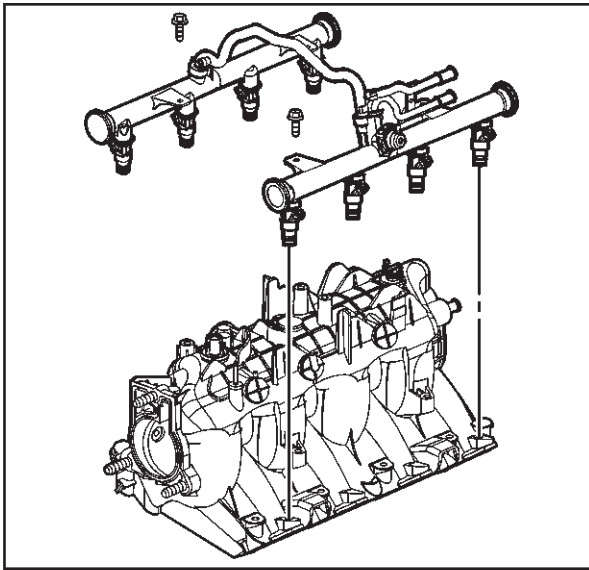
8. Install the accelerator control cable bracket (2) and bolts (1), if applicable.

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.

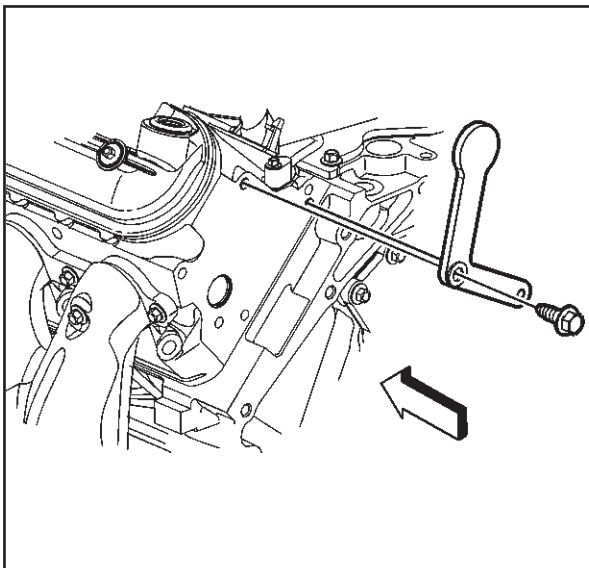
6. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 or equivalent to the threads of the fuel rail bolts. Refer to *Sealers, Adhesives and Lubricants*.

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.

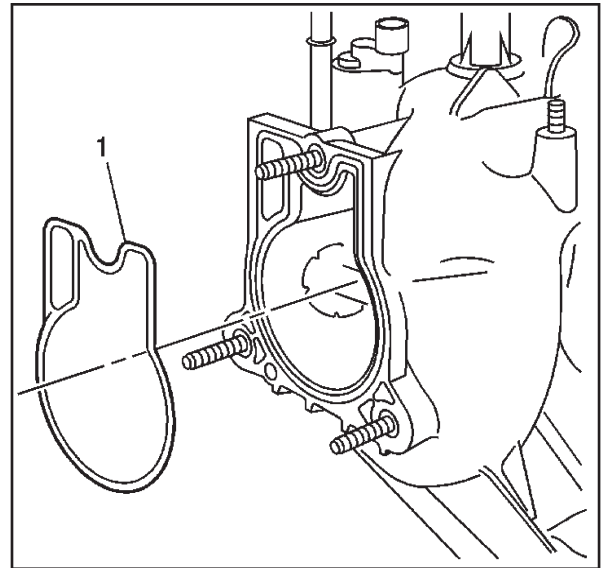
1. Install the throttle body studs, if required.

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.



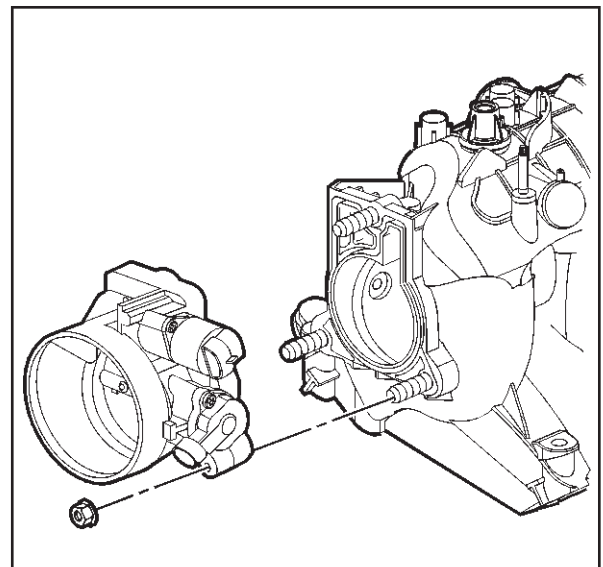
492774

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.

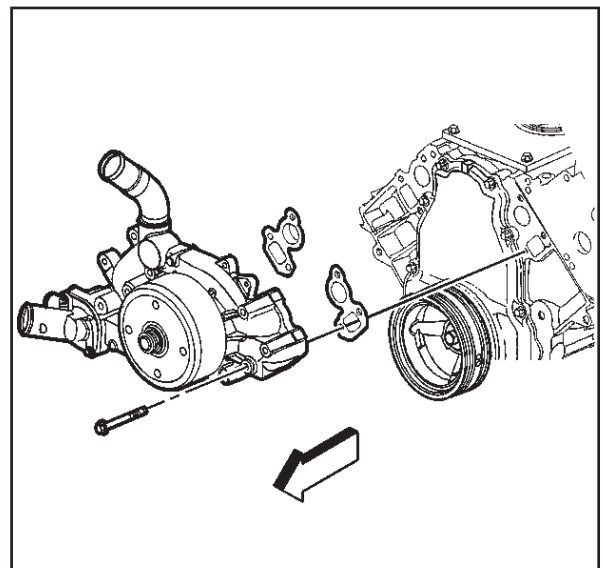
1. Install the water pump and NEW gaskets.

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

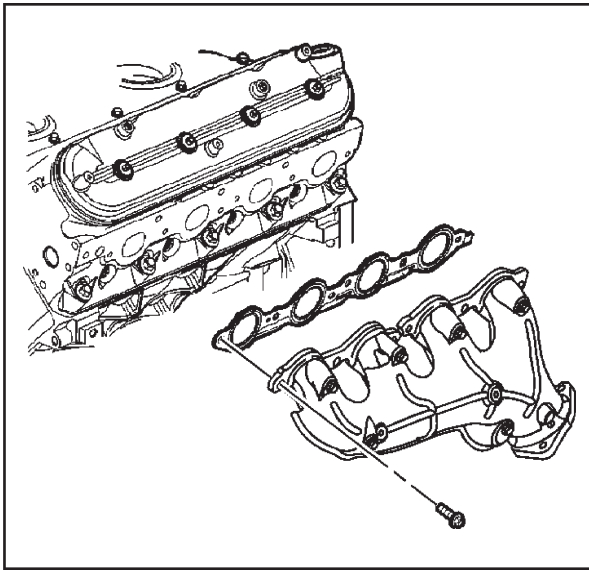
2. Install the water pump bolts.

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).



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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.

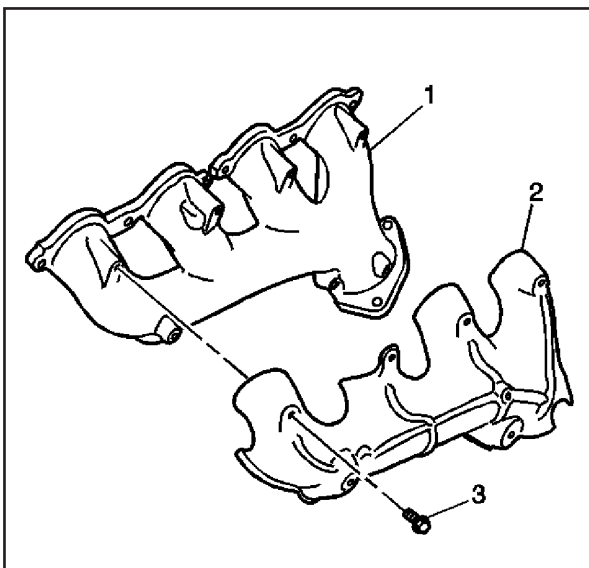
1. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts. Refer to *Sealers, Adhesives and Lubricants*.
2. Install the exhaust manifold and NEW exhaust manifold gasket.

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



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.

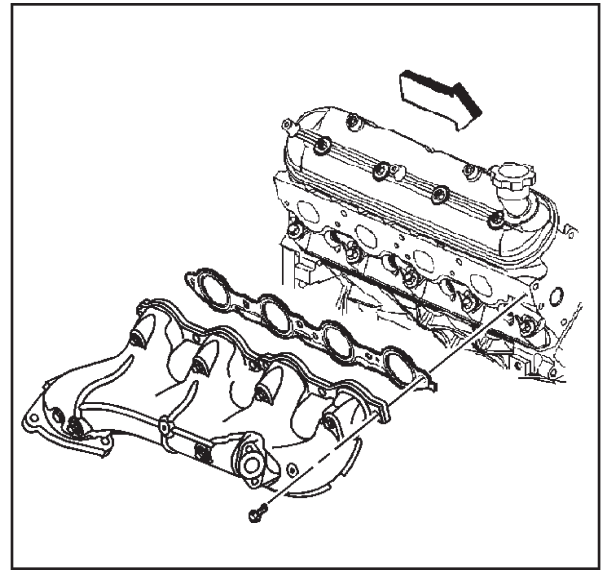
3. Install the exhaust manifold bolts.

Tighten

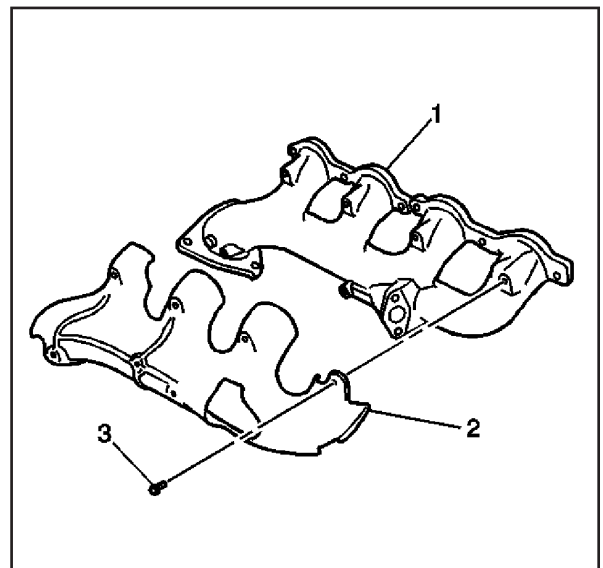
- Tighten the exhaust manifold bolts a first pass to 15 N·m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
 - Tighten the exhaust manifold bolts a final pass to 25 N·m (18 lb ft). Tighten the exhaust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

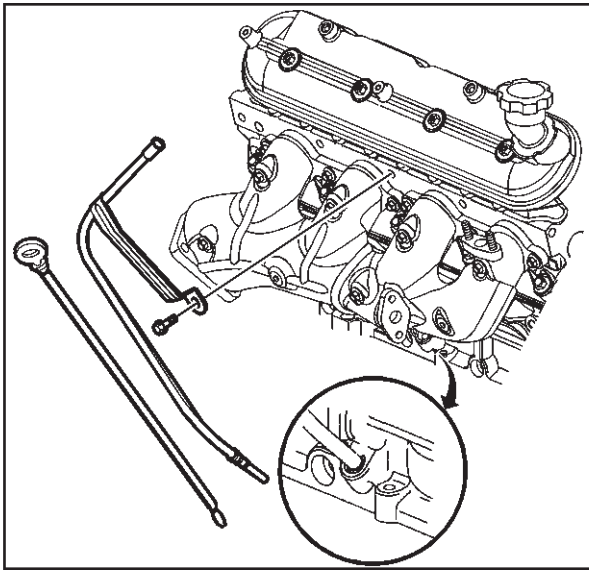
Tighten the heat shield bolts to 9 N·m (80 lb in).



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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.

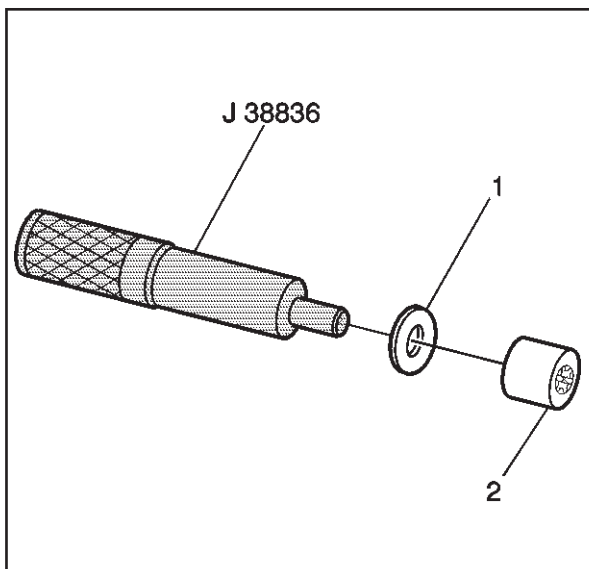
Notice: All gasket surfaces should be free of oil or other foreign material during assembly.

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.



260131

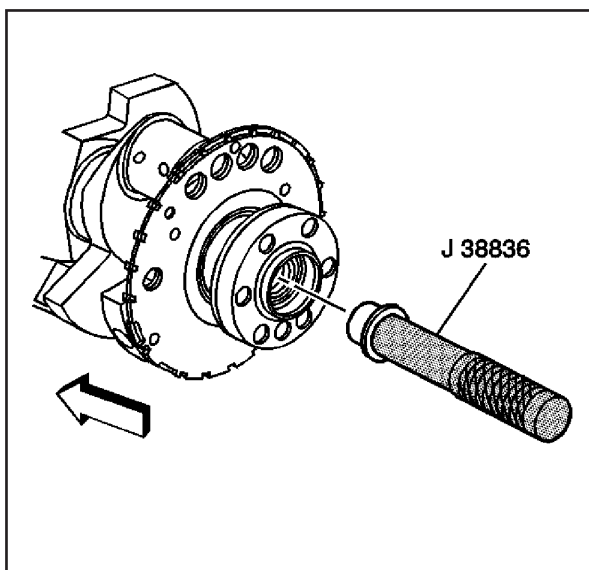
Clutch Pilot Bearing Installation

Tools Required

J 38836 Pilot Bushing Installer/Clutch

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

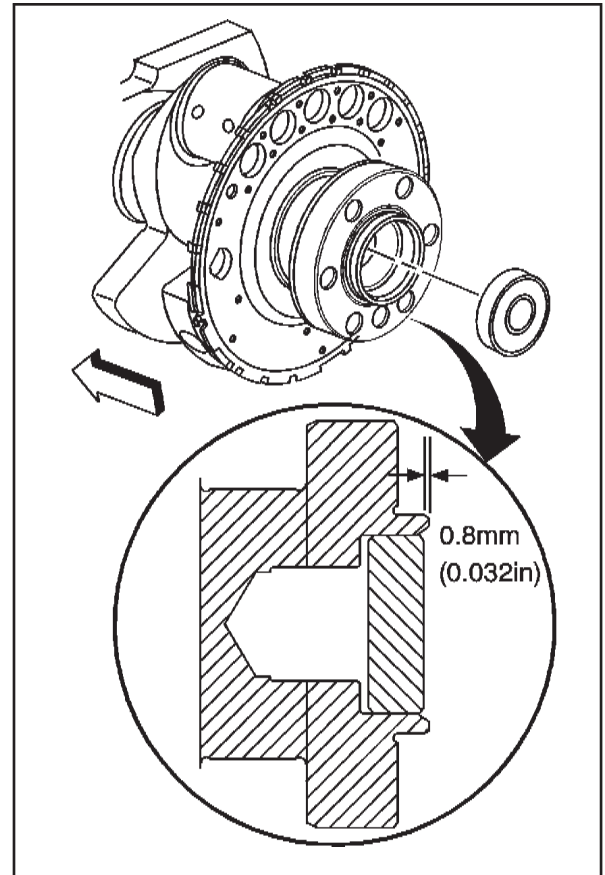
1. Install a 5/8 washer (1) onto the *J 38836* or equivalent.



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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.



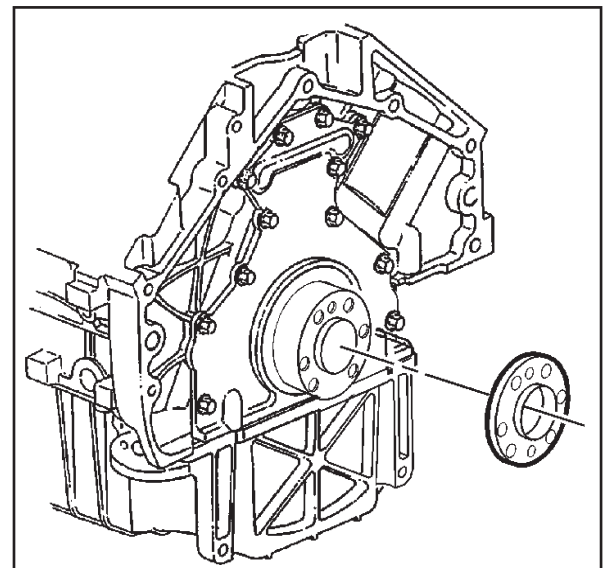
642288

Engine Flywheel Installation

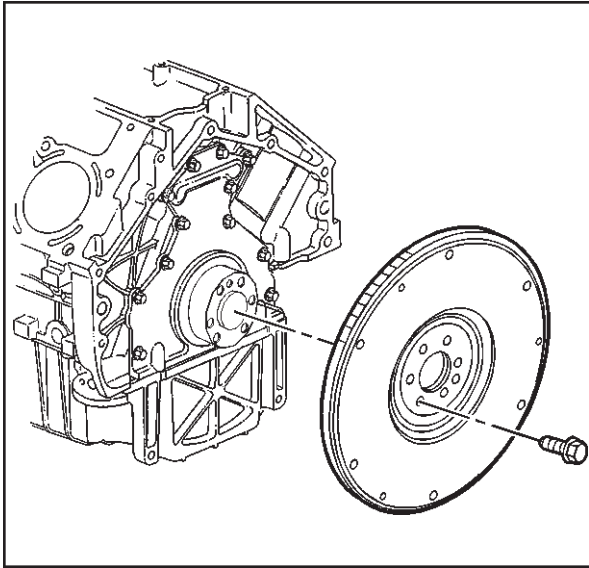
Important:

- 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

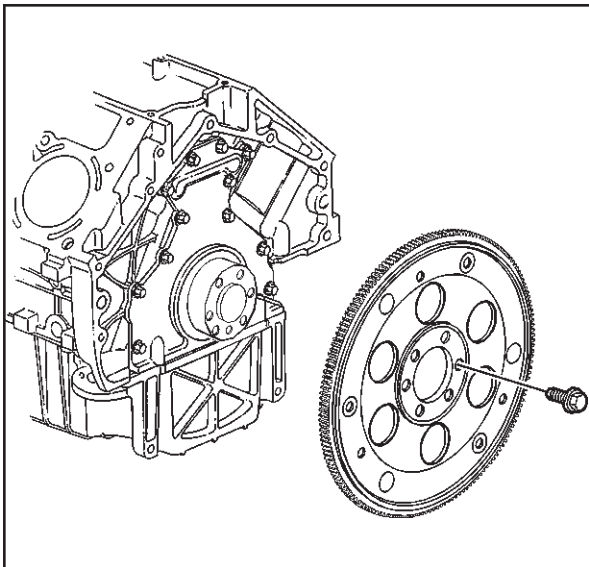


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2. Install the manual transmission engine flywheel to the crankshaft (if applicable).

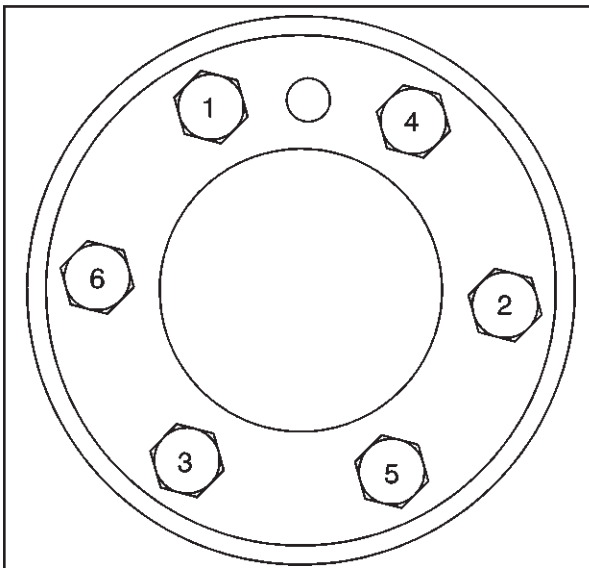


178458

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.



63174

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:

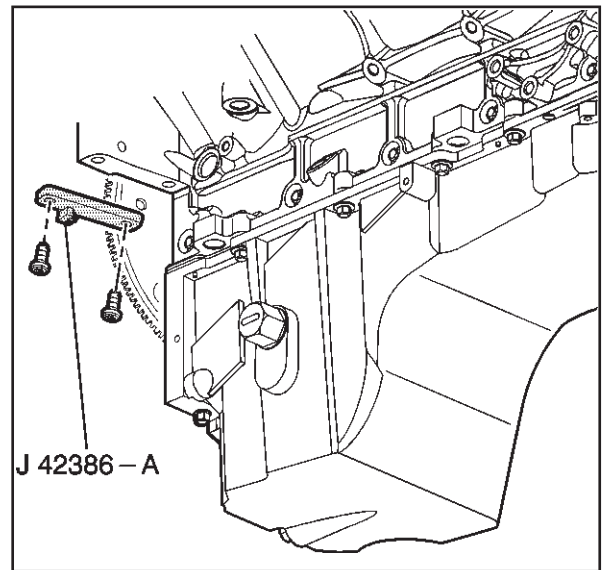
- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. 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.

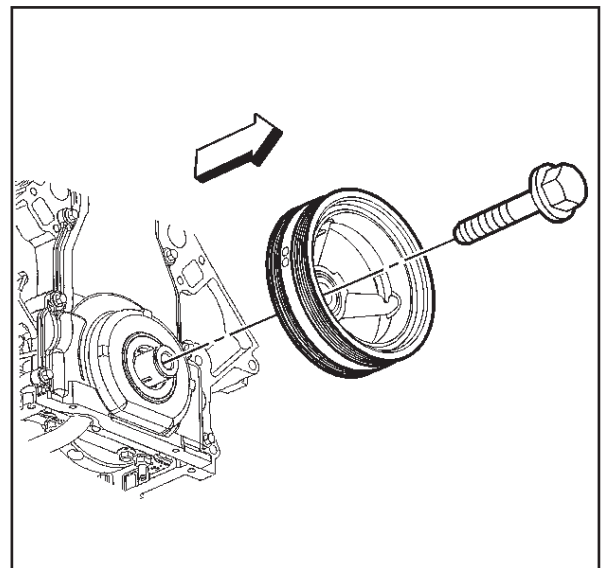
1. Install the J 42386-A and bolts.

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

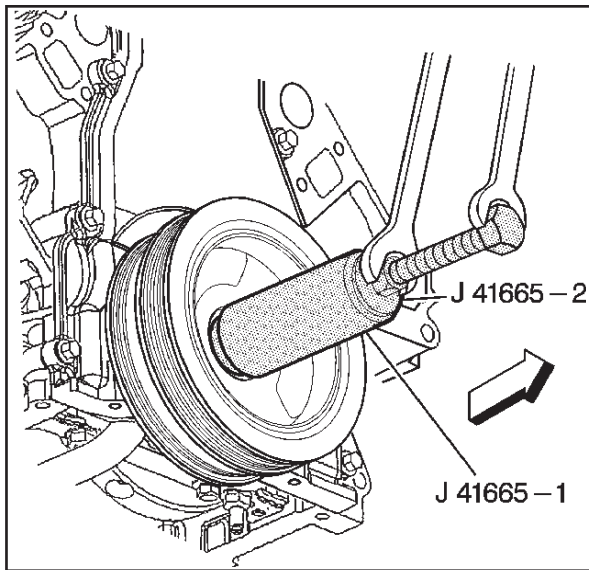
Important: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.



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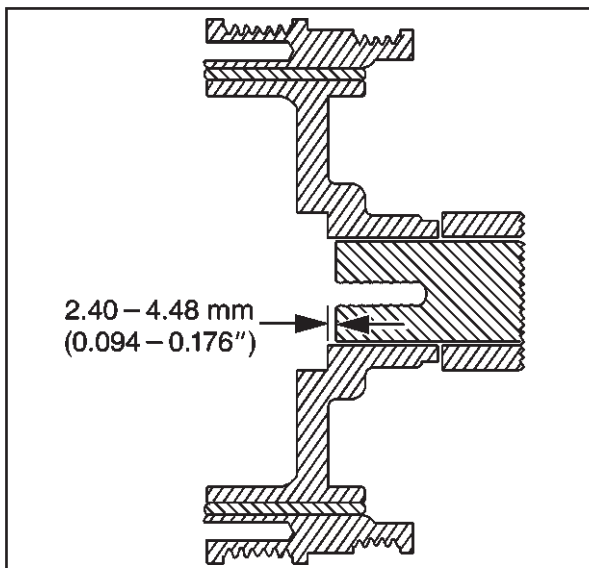


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3. Use the J 41665 in order to install the balancer.
 - 3.1. Assemble the threaded rod, nut, washer and installer.
Insert the smaller end of the installer into the front of the balancer.
 - 3.2. Use a wrench and hold the hex end of the threaded rod.
 - 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.



63245

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.

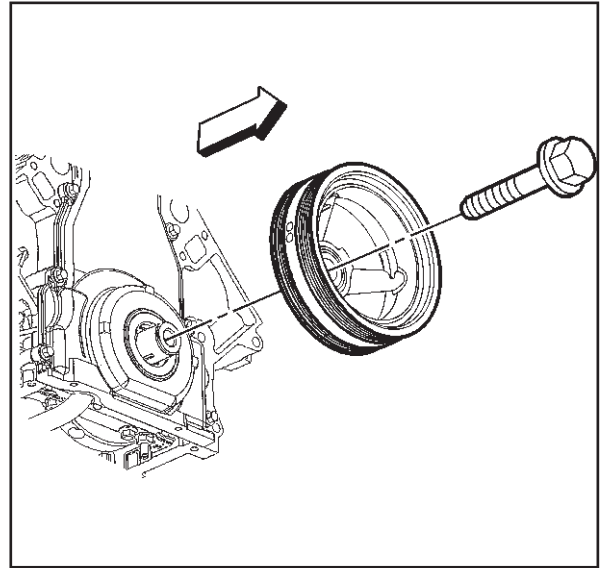
6. Measure for a correctly installed balancer.

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.

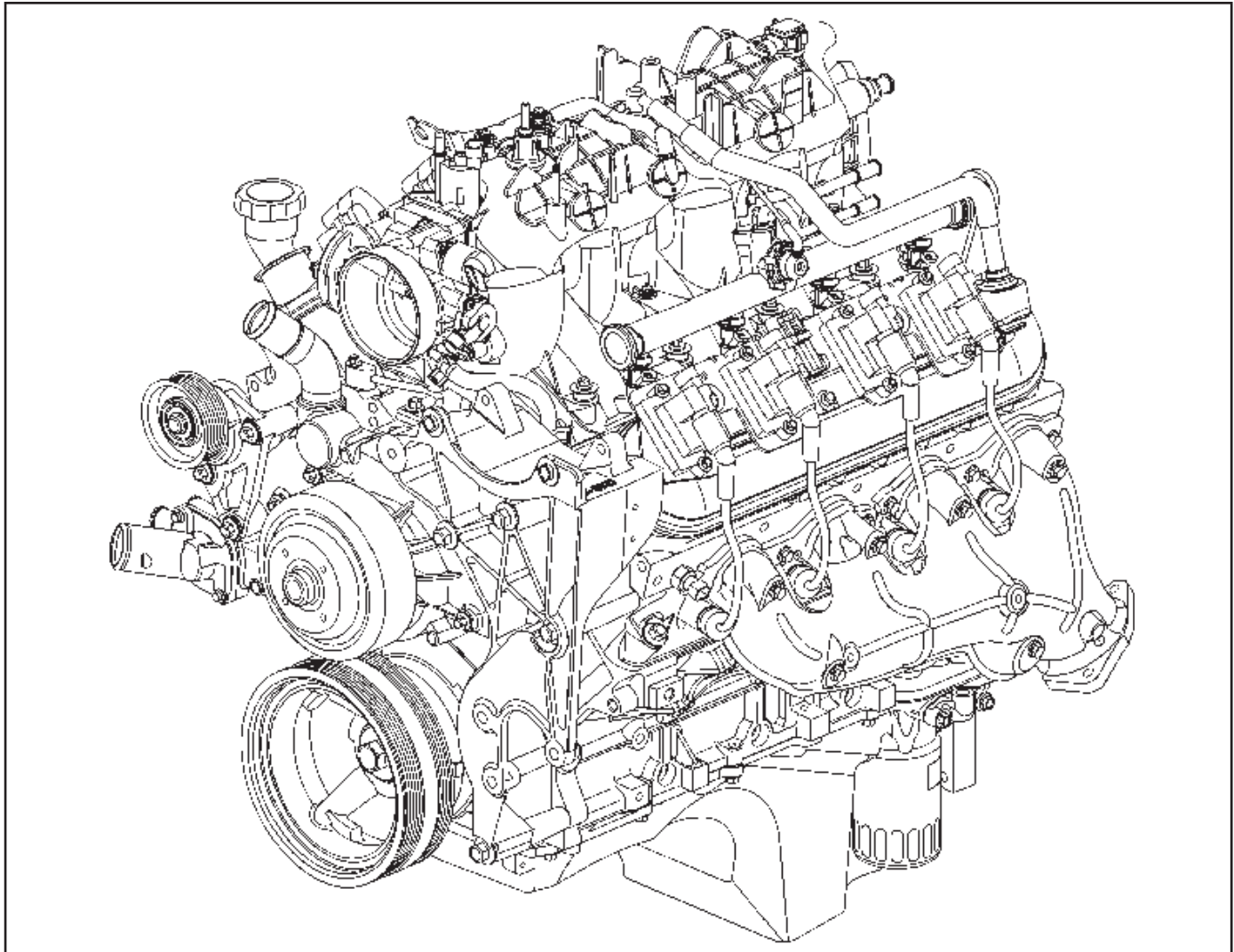


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Description and Operation

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

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

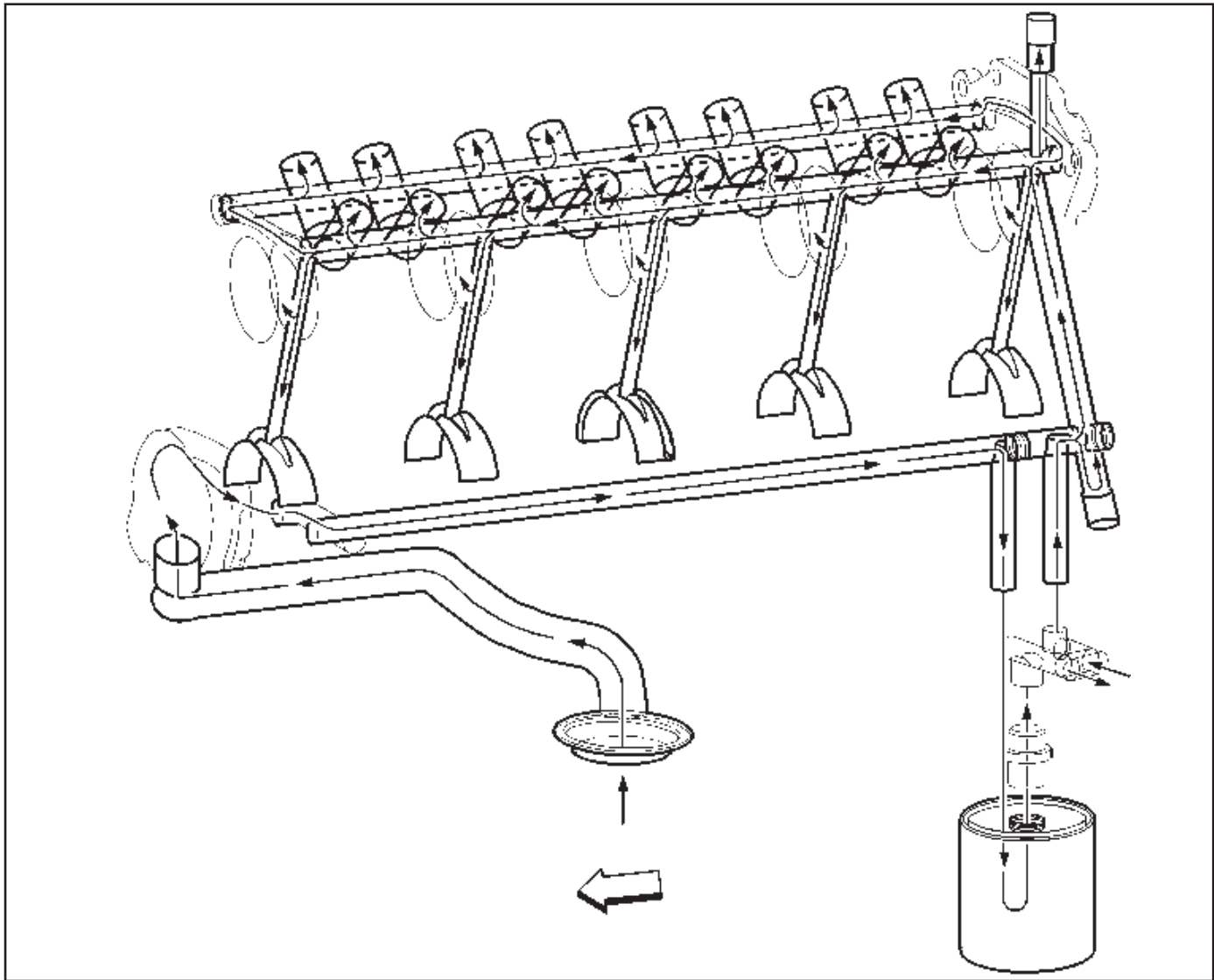
For certain applications, a spacer plate has been added between the flywheel and rear of the crankshaft. It is necessary to remove the spacer plate prior to removal and installation of the crankshaft rear oil seal and clutch pilot bearing.

Engine Mechanical Diagnostic Procedure Revisions

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for

Lubrication Description

Lubrication Flow Schematic



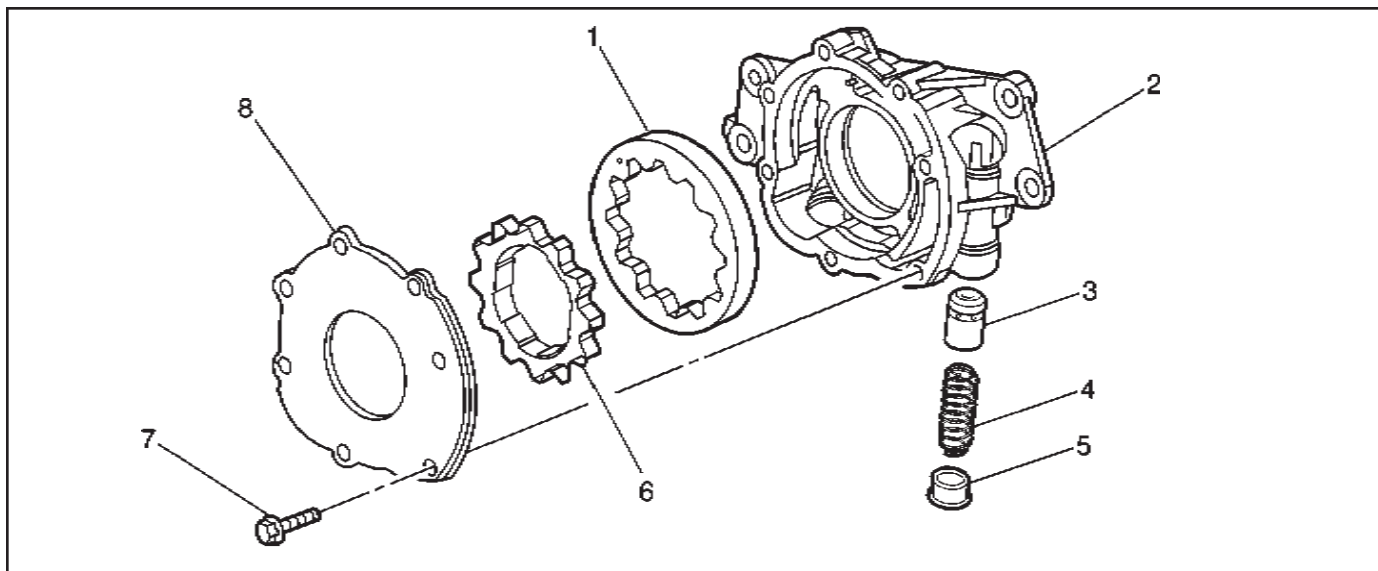
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Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen 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 | (6) Drive Gear |
| (2) Oil Pump Housing | (7) Cover Bolt |
| (3) Pressure Relief Valve | (8) Cover |
| (4) Pressure Relief Valve Spring | |
| (5) Plug | |

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 of 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

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

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

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

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

Special Tools

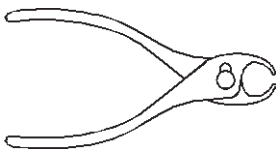
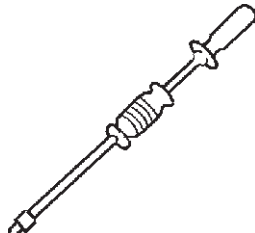
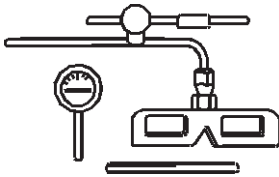
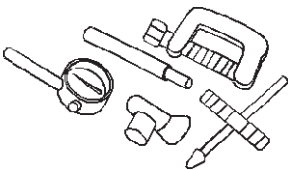
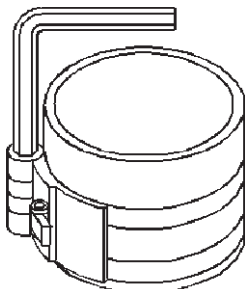
Illustration	Tool Number/Description
	J 3049-A Valve Lifter Remover
	J 6125-1B Slide Hammer
	J 7872 Magnetic Base Dial Indicator Set
	J 8001 Dial Indicator Set
	J 8037 Piston Ring Compressor

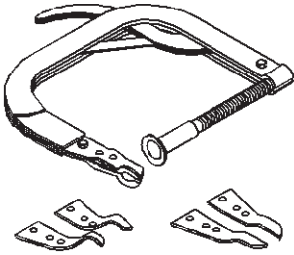
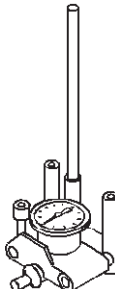
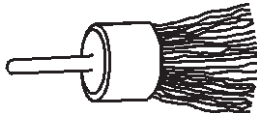
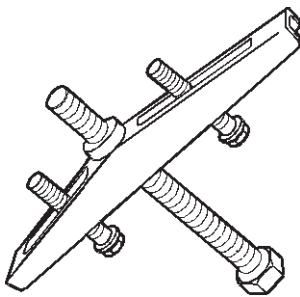
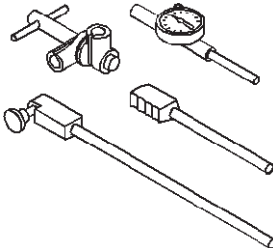
Illustration	Tool Number/Description
	J 8062 Valve Spring Compressor (head off vehicle)
	J 8087 Cylinder Bore Checking Gauge
	J 8089 Carbon Removal Brush
	J 8433-1 Pulley Puller
	J 8520 Camshaft Lobe Lift Dial Indicator Set

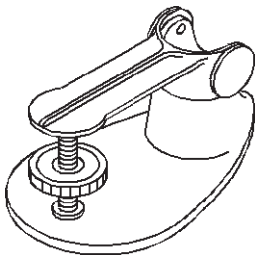

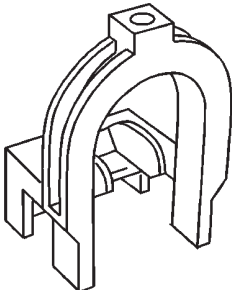
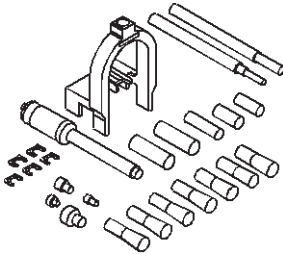
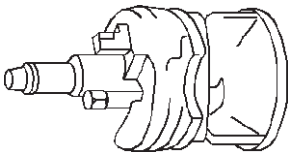
Illustration	Tool Number/Description
	J 9666 Valve Spring Tester
	J 24086-9 Adjustable Installer
	J 24086-10 Piston Pin Remover Installer Base
	J 24086-C Piston Pin Remover/ Installer
	J 24270 Cylinder Ridge Remover

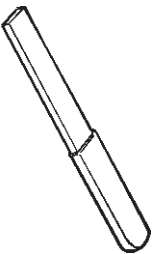
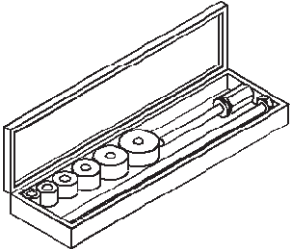
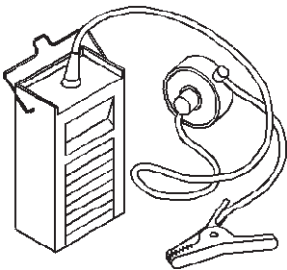
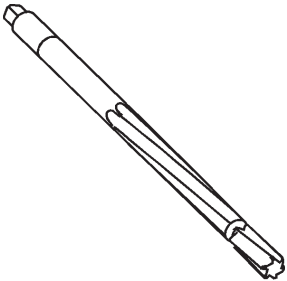
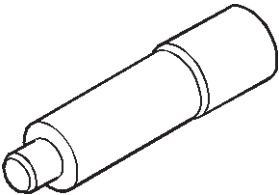
Illustration	Tool Number/Description
	J 28410 Gasket Remover
	J 33049 Camshaft Bearing Remover/Installer
	J 36660-A Torque Angle Meter
	J 37378-1 Valve Guide Reamer
	J 38836 Pilot Bushing Installer/ Clutch

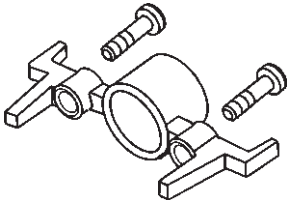
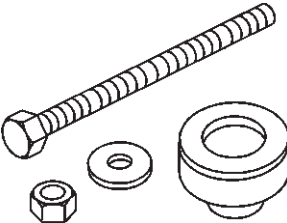
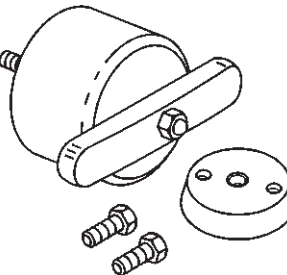
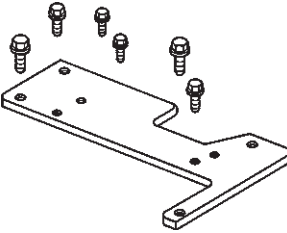
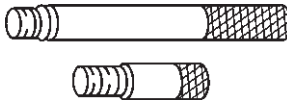
Illustration	Tool Number/Description
	J 41476 Front and Rear Cover Alignment (at crankshaft seal area)
	J 41478 Crankshaft Front Oil Seal Installer
	J 41479 Crankshaft Rear Oil Seal Installer
	J 41480 Front and Rear Cover Alignment (at the oil pan surface)
	J 41556 Connecting Rod Guide

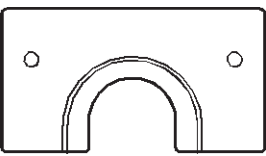
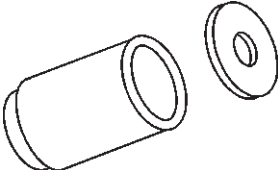
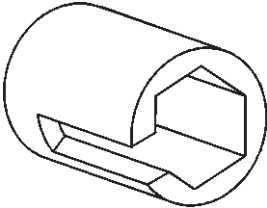
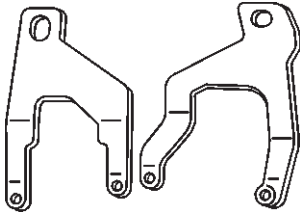
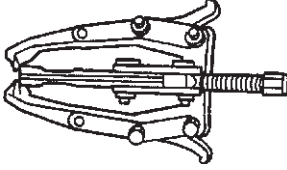
Illustration	Tool Number/Description
	J 41558 Crankshaft Sprocket Remover
	J 41665 Crankshaft Balancer and Sprocket Installer
	J 41712 Oil Pressure Sensor Socket
	J 41798 Engine Lifting Brackets
	J 41816 Crankshaft Balancer Remover

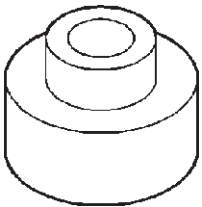
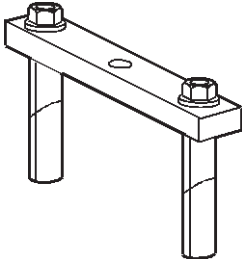
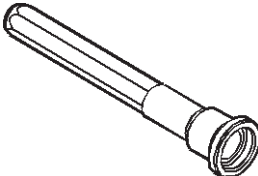
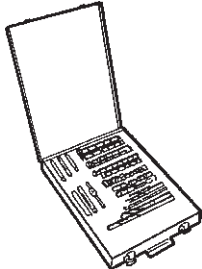
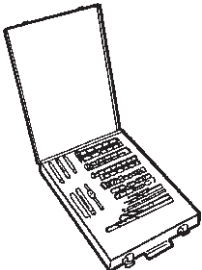
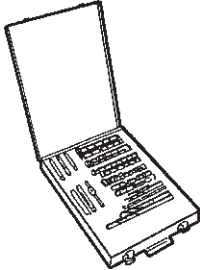

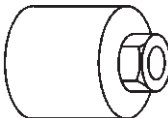
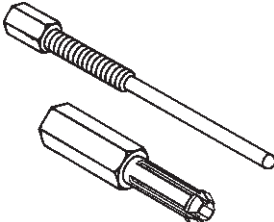
Illustration	Tool Number/Description
	J 41816-2 Crankshaft End Protector
	J 41818 Crankshaft Bearing Cap Remover
	J 42078 Valve Stem Oil Seal Installer
	J 42385-100 Thread Repair Kit (Cylinder)
	J 42385-200 Thread Repair Kit (General Threads)

Illustration	Tool Number/Description
	J 42385-300 Thread Repair Kit (Fixtures)
	J 42386-A Flywheel Holding Tool
	J 42907 Oil Pressure Testing Tool
	J 43276 Clutch Pilot Bearing Remover