

2008 Buick LaCrosse CX

2008 ENGINE Engine Mechanical - 3.6L - LaCrosse

2008 ENGINE**Engine Mechanical - 3.6L - LaCrosse****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS**

Application	Specification	
	Metric	English
A/C		
• Compressor Bolt	50 N.m	37 lb ft
• Compressor Hose Assembly Bolt	16 N.m	12 lb ft
Barometric (BARO) Sensor Bolt	10 N.m	89 lb in
Camshaft Position Actuator		
• Camshaft Bolt	58 N.m	43 lb ft
• Oil Control Valve Bolt	10 N.m	89 lb in
Camshaft Cap Bolt	10 N.m	89 lb in
Camshaft Cover Bolt	10 N.m	89 lb in
Camshaft Intermediate Drive Sprocket Bolt - Idler Sprocket	58 N.m	43 lb ft
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Catalytic Converter		
• Exhaust Manifold Nut	50 N.m	37 lb ft
Close Out Cover Bolt	10 N.m	89 lb in
Connecting Rod Bolt		
• First Pass	30 N.m	22 lb ft
• Second Pass - Counterclockwise	Back Off to Zero	
• Third Pass	25 N.m	18 lb ft
• Final Pass	110 Degrees	
Coolant Outlet Bolt	10 N.m	89 lb in
Crankshaft Balancer Bolt		

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• First Pass	100 N.m	74 lb ft
• Final Pass	150 Degrees	
Crankshaft Main Bearing Bolt		
Inner		
• First Pass	20 N.m	15 lb ft
• Final Pass	80 degrees	
Outer		
• First Pass	15 N.m	10 lb ft
• Final Pass	110 Degrees	
Side		
• First Pass	30 N.m	22 lb ft
• Final Pass	60 Degrees	
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Crankshaft Position Sensor/Right Exhaust Manifold Lower Heat Shield		
• M6 - Bolt	10 N.m	89 lb in
• M10 - Bolt	50 N.m	37 lb ft
Crankshaft Rear Oil Seal Housing Bolt	10 N.m	89 lb in
Cylinder Head Bolt - M8		
• First Pass	15 N.m	10 lb ft
• Final Pass	60 Degrees	
Cylinder Head Bolt - M11		
• First Pass	45 N.m	33 lb ft
• Final Pass	120 degrees	
Cylinder Head Core Hole Plug	31 N.m	23 lb ft
Drive Belt		
• Idler Pulley Bolt	50 N.m	37 lb ft
• Tensioner Bracket Bolt	23 N.m	17 lb ft
Engine Control Module (ECM)		

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• Bolt	10 N.m	89 lb in
• Bracket Bolt - Front	23 N.m	17 lb ft
• Bracket Bolt - Side	10 N.m	89 lb in
• Grounding Bolt	4.5 N.m	40 lb in
Engine Coolant Temperature (ECT) Sensor	22 N.m	16 lb ft
Engine Flywheel Bolt		
• First Pass	30 N.m	22 lb ft
• Final Pass	45 Degrees	
Engine Front Cover Bolt	23 N.m	17 lb ft
Engine Mount		
• Nut to Engine Mount Bracket	80 N.m	59 lb ft
• Nut to Frame	80 N.m	59 lb ft
• Bracket Bolt to Engine Block - M8	38 N.m	28 lb ft
• Bracket Bolt to Engine Block - M10	60 N.m	45 lb ft
Engine Mount Bracket Bolt	58 N.m	43 lb ft
Engine Mount Lower Nut	47 N.m	35 lb ft
Engine Mount Strut Bracket Bolts - to Engine	50 N.m	37 lb ft
Engine Mount Strut Bracket Bolts - to Radiator Support	26 N.m	19 lb ft
Engine Mount Strut Nut	48 N.m	35 lb ft
Engine Mount Upper Nut	53 N.m	39 lb ft
Engine Wiring Harness Bracket		
• Bolt - Cylinder Head Rear	10 N.m	89 lb in
• Bolt - ECM Bracket Side	23 N.m	17 lb ft
• Bolt - ECM Bracket Top	10 N.m	89 lb in
• Bolt - Left Side Oil Pan	10 N.m	89 lb in
• Bolt - Left Side Oil Filter Adapter	10 N.m	89 lb in
• Bolt - Near Crankshaft Position Sensor	50 N.m	37 lb ft

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• Bolt - Right Side Block Front	23 N.m	17 lb ft
• Bolt - Right Side Head Front	10 N.m	89 lb in
Engine Wiring Harness Ground		
• Bolt - ECM Bracket Top	10 N.m	89 lb in
• Bolt - Left Cylinder Head Side	10 N.m	89 lb in
• Bolt - Right Cylinder Head Rear	10 N.m	89 lb in
Evaporative (EVAP) Purge Valve Bolt/Ball Stud	10 N.m	89 lb in
Exhaust Crossover Pipe Nuts	34 N.m	25 lb ft
Exhaust Manifold		
• Bolt	20 N.m	15 lb ft
• Heat Shield Bolt	10 N.m	89 lb in
• Studs	6 N.m	53 lb in
Fuel Rail Bolt	10 N.m	89 lb in
Fuel Rail Support Bracket	10 N.m	89 lb in
Generator		
• Bolt	50 N.m	37 lb ft
• Cable Nut	10 N.m	89 lb in
Ground Cable Bolt	50 N.m	37 lb ft
Heater Inlet/Outlet Pipe Assembly Bolt	10 N.m	89 lb in
Ignition Coil Bolt	10 N.m	89 lb in
Intake Manifold		
• Upper-to-Cylinder Head Bolt - Long	23 N.m	17 lb ft
• Upper-to-Cylinder Head Bolt - Short	23 N.m	17 lb ft
• Upper-to-Lower Intake Manifold Bolt	23 N.m	17 lb ft
• Tuning Valve Bolt	10 N.m	89 lb in
Knock Sensor Bolt	23 N.m	17 lb ft
Oil Drain Plug	25 N.m	18 lb ft
Oil Filter	25 N.m	18 lb ft

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Oil Filter Housing Adapter Bolt	23 N.m	17 lb ft
Oil Gallery Plug	31 N.m	23 lb ft
Oil Level Indicator Tube Bolt	10 N.m	89 lb in
Oil Pan		
• Bolt - Block M8	23 N.m	17 lb ft
• Bolt - Crankshaft Rear Oil Seal Housing M6	10 N.m	89 lb in
• Windage Tray Bolt	10 N.m	89 lb in
Oil Pressure Sender	20 N.m	15 lb ft
Oil Pump		
• Bolt	23 N.m	17 lb ft
• Cover Bolt	13 N.m	115 lb in
Oxygen Sensor		
• Pump Converter Pipe	40 N.m	30 lb ft
PCV Tube Bracket Bolt/Ball Stud	10 N.m	89 lb in
Piston Oil Cooling Nozzle Bolt	10 N.m	89 lb in
Power Steering Pump		
• Bracket to Engine Bolt	50 N.m	37 lb ft
• Reservoir Stud	25 N.m	18 lb ft
Primary Camshaft Drive Chain		
• Left Lower Guide Bolt - Oil Pump - Second Design	23 N.m	17 lb ft
• Tensioner Bolt	23 N.m	17 lb ft
• Upper Guide Bolt	23 N.m	17 lb ft
Radiator Inlet Support Bracket Bolt	50 N.m	37 lb ft
Radiator Outlet Pipe Assembly Bolt	10 N.m	89 lb in
Secondary Camshaft Drive Chain		
• Guide Bolt	23 N.m	17 lb ft
• Shoe Bolt	23 N.m	17 lb ft

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• Tensioner Bolt	23 N.m	17 lb ft
Spark Plug	18 N.m	13 lb ft
Starter Motor		
• Bolt	50 N.m	37 lb ft
• Cable Nut	10 N.m	89 lb in
Suction Tube Bolt	10 N.m	89 lb in
Suction Screen Bolt	10 N.m	89 lb in
Thermostat Housing Bolt	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Torque Converter Bolt	60 N.m	44 lb ft
Transmission		
• Mount Bolt to Transmission - RPO	60 N.m	45 lb ft
• To Engine Bolt	50 N.m	37 lb ft
• Range Selector Lever Nut	9.5 N.m	84 lb in
Water Pump		
• Bolt	10 N.m	89 lb in
• Pulley Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.6 Liter	217 cu in
• RPO	LY7	
• VIN	7	
• Bore	94 mm	3.7008 in
• Stroke	85.6 mm	3.37 in
	10.2:1	

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• Compression Ratio		
• Cranking RPM - at 40° C (104°F)	80 RPM	
• Idle Speed	600 A/C Off - 700 A/C On	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	1.1 mm	0.0433 in
Block		
• Crankshaft Main Bearing Bore Diameter	72.867-72.881 mm	2.8688-2.8693 in
• Cylinder Bore Diameter	93.992-94.008 mm	3.7005-3.7011 in
• Cylinder Bore Out-of-Round - Production Max.	0.013 mm	0.0005 in
Camshaft		
• Camshaft Bearing Inside Diameter - Front Number 1	35.000-35.020 mm	1.3779-1.3787 in
• Camshaft Bearing Inside Diameter - Middle and Rear Number 2-4	27.000-27.020 mm	1.0630-1.0638 in
• Camshaft End Play	0.045-0.215 mm	0.0018-0.0085 in
• Camshaft Journal Diameter - Front Number 1	34.936-34.960 mm	1.3754-1.3764 in
• Camshaft Journal Diameter - Middle and Rear Number 2-4	26.936-26.960 mm	1.0605-1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040-0.084 mm	0.0016-0.0033 in
• Camshaft Lobe Duration - Exhaust @ 0.150 mm (0.0059 in) Lift	238 degrees	
• Camshaft Lobe Duration - Intake @ 0.150 mm (0.0059 in) Lift	237 degrees	

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• Camshaft Lobe Lift - Exhaust	42.425-42.725 mm	1.6703-1.6821 in
• Camshaft Lobe Lift - Intake	42.385-42.685 mm	1.6687-1.6805 in
• Camshaft Lobe Overlap @ 0.150 mm (0.0059 in) Lift	0 degrees	
• Camshaft Runout - Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout - Middle 2 and 3	0.050 mm	0.0020 in
• Camshaft Timing @ 0.15 mm (0.0059 in) Lift		
• Valve Opens - Exhaust	-229 degrees BTDC	
• Valve Opens - Intake	14 degrees BTDC	
• Centerline - Exhaust	111 degrees BTDC	
• Centerline - Intake	132 degrees ATDC	
• Valve Closes - Exhaust	9 degrees ATDC	
• Valve Closes - Intake	251 degrees ATDC	
• Valve Lift - Exhaust	10.8 mm	0.4252 in
• Valve Lift - Intake	10.8 mm	0.4252 in
Cooling System		
• Thermostat Full Open Temperature	95°C	203°F
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010-0.070 mm	0.0004-0.0028 in
• Connecting Rod Bore Diameter - Bearing End	59.620-59.636 mm	2.3472-2.3479 in
• Connecting Rod Bore Diameter - Pin End	24.007-24.021 mm	0.9452-0.9457 in
• Connecting Rod Length - Center to Center	150.400 mm	5.9212 in

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• Connecting Rod Side Clearance	0.095-0.355 mm	0.0374-0.0140 in
• Connecting Rod Width - Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
• Connecting Rod Width - Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725-21.825 mm	0.8553-0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	55.992-56.008 mm	2.2044-2.2050 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		
• Production	22.000 mm	0.8661 in
• Service	21.920-22.080 mm	0.8630-0.8693 in
• Crankshaft End Play	0.100-0.330 mm	0.0039-0.0130 in
• Crankshaft Main Bearing Clearance	0.010-0.060 mm	0.0004-0.0024 in
• Crankshaft Main Journal Diameter	67.992-68.008 mm	2.6768-2.6775 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000-0.040 mm	0.0000-0.0016 in

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• Square	0.000-0.010 mm	0.0000-0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	24.000 mm	0.9449 in
• Service	23.900-24.100 mm	0.9409-0.9488 in
• Crankshaft Main Journal Width, #3		
• Production	24.400 mm	0.9606 in
• Service	24.360-24.440 mm	0.9591-0.9622 in
• Crankshaft Pilot Bearing Bore Diameter	20.965-20.995 mm	0.8254-0.8266 in
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout - Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076-0.305 mm	0.0030-0.0120 in
• Crankshaft Thrust Surface - Height Diameter	95.000 mm	3.7401 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Combustion Chamber Volume	53.407 cc	3.259 cu in
• Valve Guide Bore - Exhaust	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Bore - Intake	6.000-6.020 mm	0.2362-0.2370 in
• Valve Guide Installed Height	14.050-14.550 mm	0.5531-0.5728 in
• Valve Lifter Bore Diameter	12.008-12.030 mm	0.4728-0.4736 in

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Lubrication System

• Oil Capacity - with New Dry Oil Filter	5.2 Liters	5.5 Quarts
• Oil Capacity - without Oil Filter Change	4.8 Liters	5.2 Quarts
• Oil Pressure - Minimum @ Idle	69 kPa	10 psi
• Oil Pressure - Minimum @ 2,000 RPM	138 kPa	20 psi
• Piston Cooling Jet Valve Opening Pressure	1.7-2.3 bar	25-33 psi

Oil Pump

• Gear Diameter - Outer	87.095-87.175 mm	3.4289-3.4321 in
• Gear Pocket - Depth	15.565-15.600 mm	0.6128-0.6142 in
• Gear Pocket - Diameter	87.275-87.325 mm	3.4360-3.4380 in
• Gear Thickness - Drive/Driven	15.511-15.536 mm	0.6107-0.6117 in
• Gear-to-Cover Clearance - Drive/Driven	0.030-0.085 mm	0.0012-0.0033 in
• Gear-to-Housing Clearance - Drive/Driven	0.100-0.230 mm	0.0039-0.0091 in
• Inner Gear Tip Clearance	0.075-0.180 mm	0.0030-0.0071 in
• Crankshaft Clearance to Housing	0.040-0.130 mm	0.0016-0.0051 in
• Inner Gerotor Hub Diameter	53.310-53.335 mm	2.0988-2.0998 in
• Housing Hub Diameter	53.380-53.420 mm	2.1016-2.1031 in
• Inner Gerotor Hub Clearance to Housing	0.045-0.110 mm	0.0018-0.0043 in

Piston Rings

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• Piston Ring End Gap		
• First Compression Ring	0.150-0.300 mm	0.0059-0.0118 in
• Second Compression Ring	0.280-0.480 mm	0.0110-0.0189 in
• Oil Control Ring	0.150-0.600 mm	0.0059-0.0236 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.030-0.065 mm	0.0012-0.0026 in
• Second Compression Ring	0.015-0.060 mm	0.0006-0.0024 in
• Oil Control Ring	0.030-0.170 mm	0.0012-0.0067 in
• Piston Ring Thickness		
• First Compression Ring	1.175-1.190 mm	0.0463-0.0469 in
• Second Compression Ring	1.470-1.495 mm	0.0579-0.0589 in
• Oil Control Ring	2.360-2.480 mm	0.0929-0.0976 in
Pistons and Pins		
• Piston		
• Piston Diameter	93.956-93.974 mm	3.6990-3.6998 in
• Piston Pin Bore Diameter	24.004-24.009 mm	0.9450-0.9452 in
• Piston Ring Groove Width - First Compression Ring	1.220-1.240 mm	0.0480-0.0488 in
• Piston Ring Groove Width - Second Compression Ring	1.510-1.530 mm	0.0595-0.0602 in
• Piston Ring Groove Width - Oil Control	2.510-2.530	0.0988-0.0996

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Ring	mm	in
• Piston to Bore Clearance	0.026-0.052 mm	0.0010-0.0021 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore	0.007-0.024 mm	0.0003-0.0010 in
• Piston Pin Clearance to Piston Pin Bore	0.004-0.012 mm	0.0002-0.0005 in
• Piston Pin Diameter	23.997-24.000 mm	0.9448-0.9449 in
• Piston Pin Length	60.600-61.100 mm	2.3858-2.4055 in
Valve System		
• Valves		
• Valve Face Angle	44.25 degrees	
• Valve Face Runout	0.038 mm	0.0015 in
• Valve Face Width - Exhaust	2.750 mm	0.1083 in
• Valve Face Width - Intake	2.180 mm	0.0858 in
• Valve Head Diameter - Exhaust	30.470-30.730 mm	1.1996-1.2098 in
• Valve Head Diameter - Intake	36.830-37.090 mm	1.4500-1.4602 in
• Valve Installed Height	35.23-36.69 mm	1.3870-1.4445 in
• Valve Length - Exhaust	97.110 mm	3.8232 in
• Valve Length - Intake	101.230 mm	3.9854 in
• Valve Seat Angle - Seating Surface	45 degrees	
• Valve Seat Angle - Relief Surface	30 degrees	
• Valve Seat Angle - Undercut Surface	60 degrees	
• Valve Seat Runout - Maximum	0.050 mm	0.0020 in

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• Valve Seat Width - Exhaust Seating Surface	1.400-1.800 mm	0.0551-0.0709 in
• Valve Seat Width - Exhaust Relief Surface	0.700-0.900 mm	0.0276-0.0354 in
• Valve Seat Width - Intake Seating Surface	1.000-1.400 mm	0.0394-0.0551 in
• Valve Seat Width - Intake Relief Surface	0.500-0.700 mm	0.0197-0.0276 in
• Valve Stem Diameter - Exhaust	5.945-5.965 mm	0.2341-0.2348 in
• Valve Stem Diameter - Intake	5.955-5.975 mm	0.2344-0.2352 in
• Valve Stem-to-Guide Clearance - Exhaust	0.035-0.075 mm	0.0014-0.0030 in
• Valve Stem-to-Guide Clearance - Intake	0.025-0.065 mm	0.0010-0.0026 in
• Valve Lifters		
• Valve Lifter Diameter	11.489-12.000 mm	0.4523-0.4724 in
• Valve Lifter-to-Bore Clearance	0.037-0.041 mm	0.0015-0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.750-17.800 mm	0.6988-0.7008 in
• Valve Springs		
• Valve Spring Coil Thickness	3.250 x 3.900 mm	0.1280 x 0.1535 in
• Valve Spring Diameter - Inside Top	12.090-12.590 mm	0.4760-0.4957 in
• Valve Spring Diameter - Outside Top	20.140 mm	0.7929 in

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• Valve Spring Diameter - Inside Bottom	17.950-18.450 mm	0.7067-0.7264 in
• Valve Spring Diameter - Outside Bottom	26.000 mm	1.0236 in
• Valve Spring Free Length	42.050-44.850 mm	1.6555-1.7657 in
• Valve Spring Installed Height - Closed	35.000 mm	1.3779 in
• Valve Spring Installed Height - Open	24.000 mm	0.9449 in
• Valve Spring Load - Closed	247-273 N	56-61 lb
• Valve Spring Load - Open	598-662 N	134-149 lb
• Valve Spring Total Number of Coils	7.1	

SEALERS, ADHESIVES, AND LUBRICANTS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Prelube	Lubricant	89021329	993362
Coolant and Oil Plug Threads	Sealant	12346004	10953480
Crankshaft Prelube	Lubricant	1052367	992869
Engine Oil	5W-30 Oil	12345610	993193
Oil Pan, Engine Front Cover, Crankshaft Rear Oil Seal Housing, Expansion Plugs	Sealant	12378521	88901148

THREAD REPAIR SPECIFICATIONS

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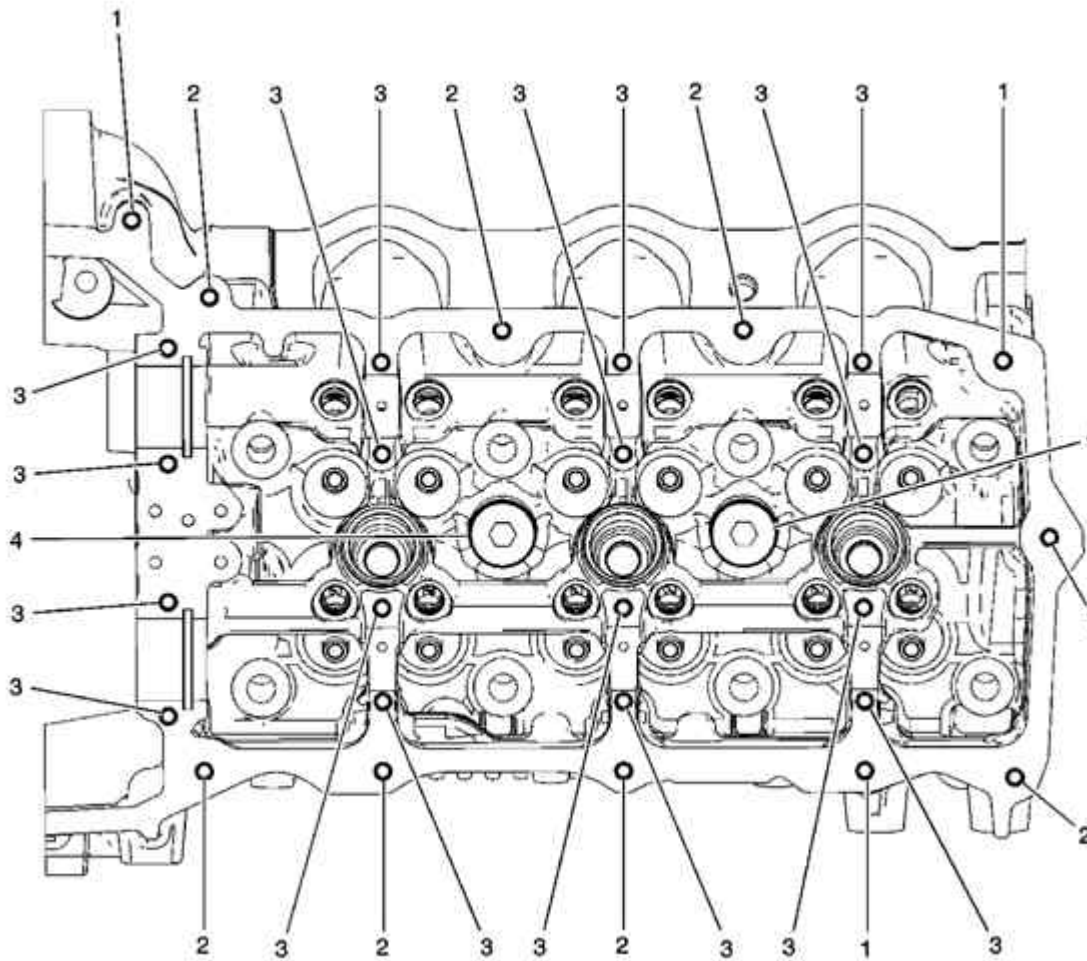


Fig. 1: View Of Left Cylinder Head Camshaft Cover Face
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Camshaft Cover Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
2	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
3	M6 x	701	N/A	N/A	203	204	205	28.5	1.1220	24.0	0.9449

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	1.0										
4	M20 x 1.5	715	716	N/A	717	718	719	25.0	0.9842	17.0	0.6693

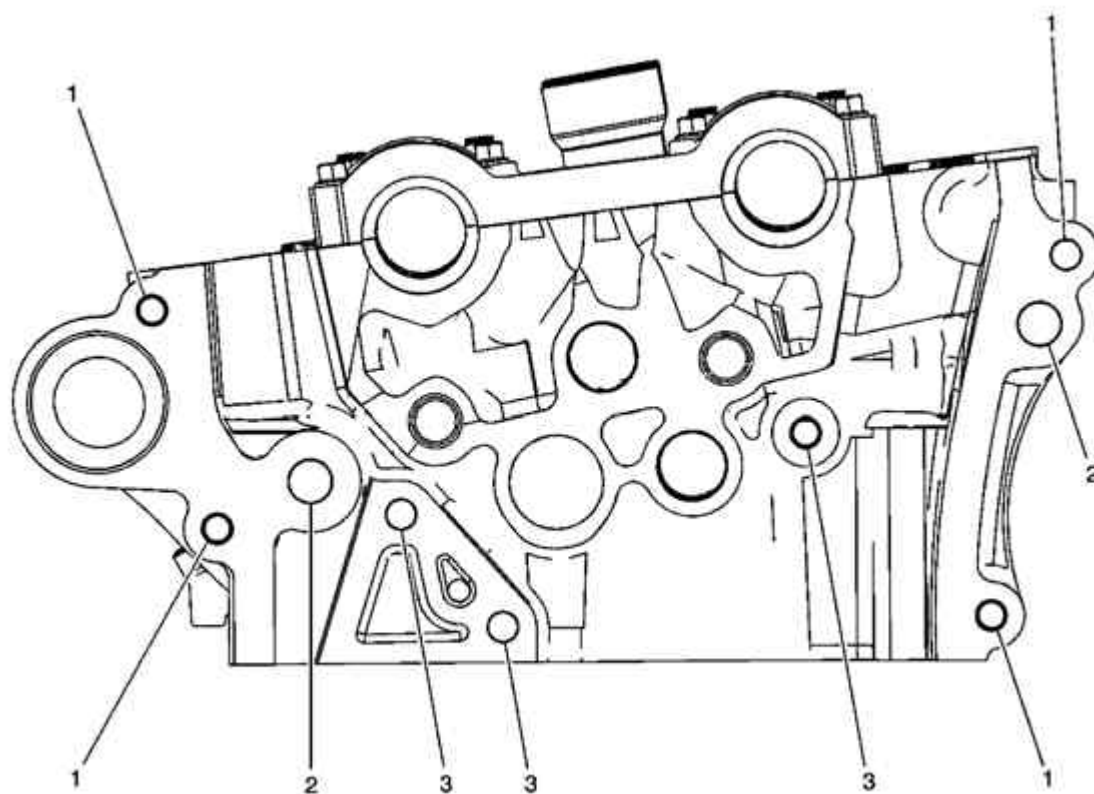


Fig. 2: Identifying Left Cylinder Head Front Face
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Front Face

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3	1.25	206	207	N/A	208	209	210	18.0	0.7087	22.5	0.8858
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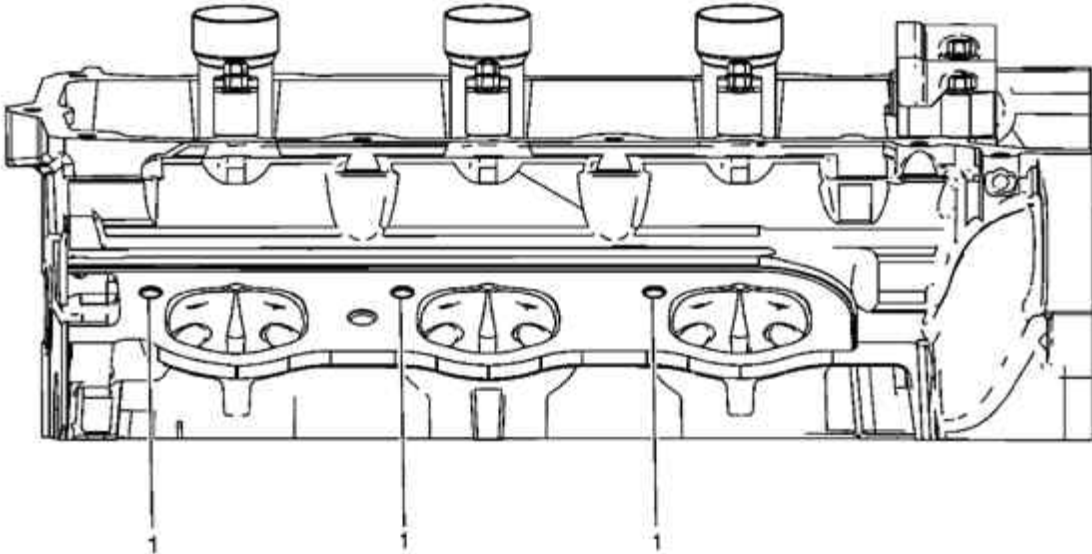


Fig. 3: View Of Left Cylinder Head Intake Face
 Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

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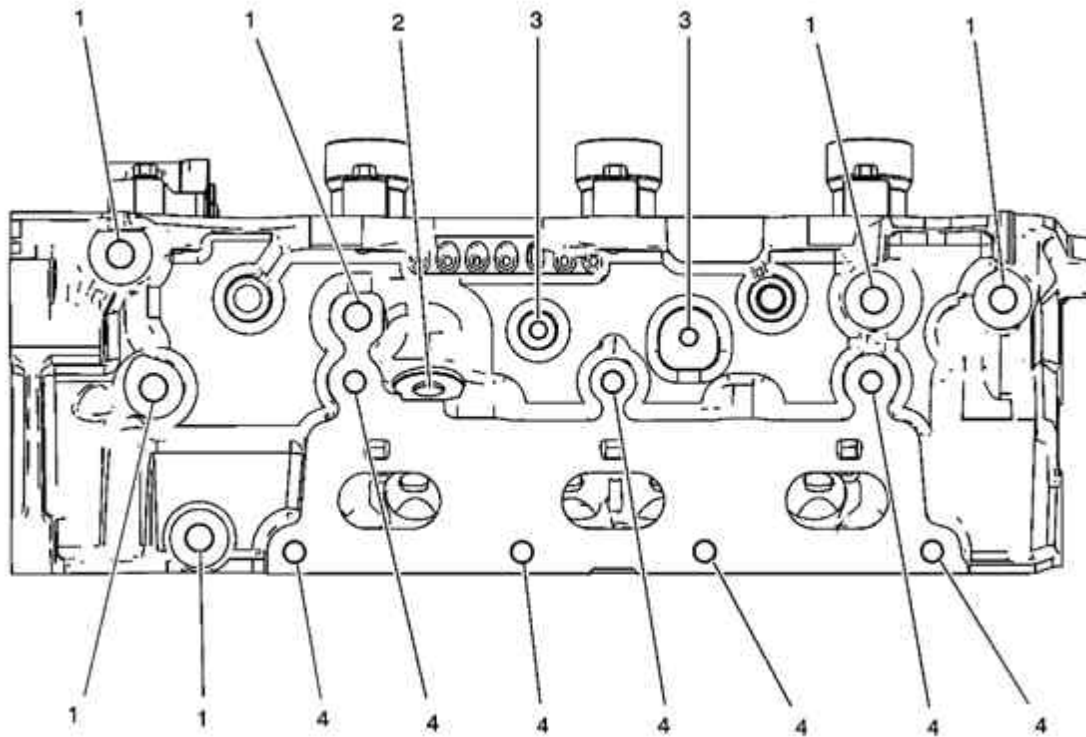


Fig. 4: View Of Left Cylinder Head Exhaust Face
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
2	M12 x 1.5	705	706	N/A	707	708	709	27.5	1.0827	13.0	0.5118
3	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.0000
4	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

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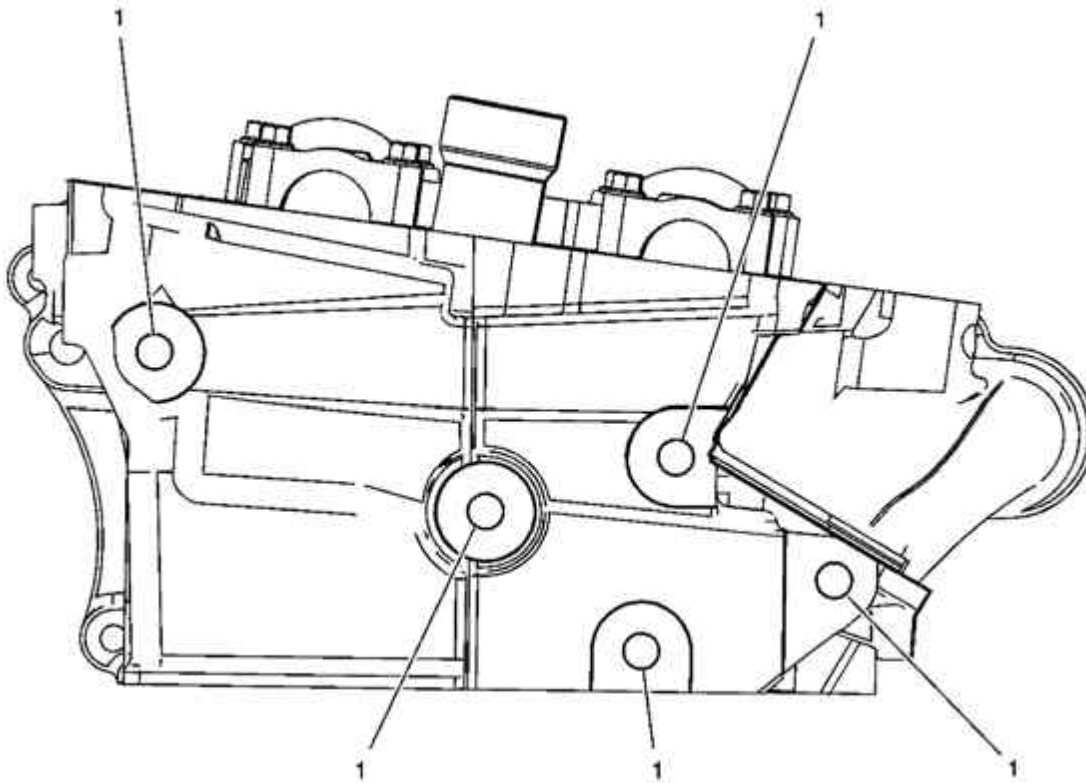
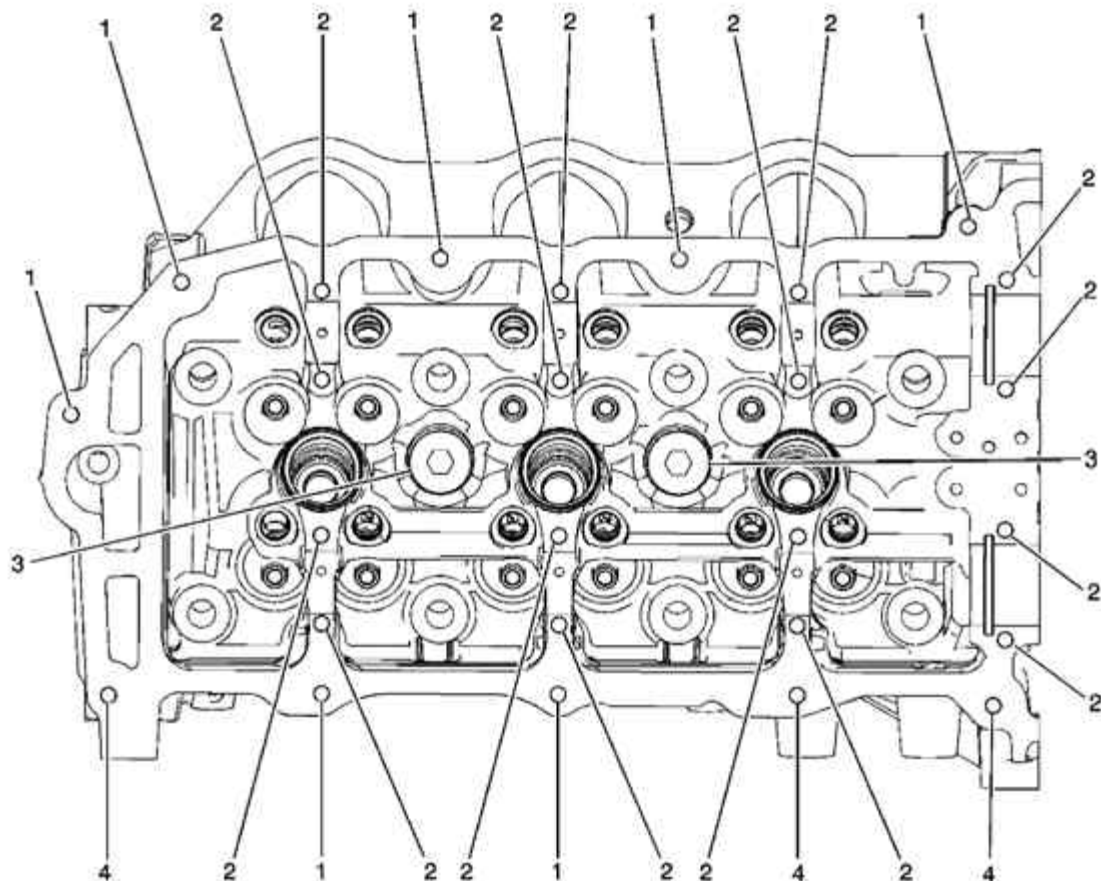


Fig. 5: Identifying Left Cylinder Head Rear Face
Courtesy of GENERAL MOTORS CORP.

Left Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630

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Right Cylinder Head Camshaft Cover Face

[illegible]

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4	1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
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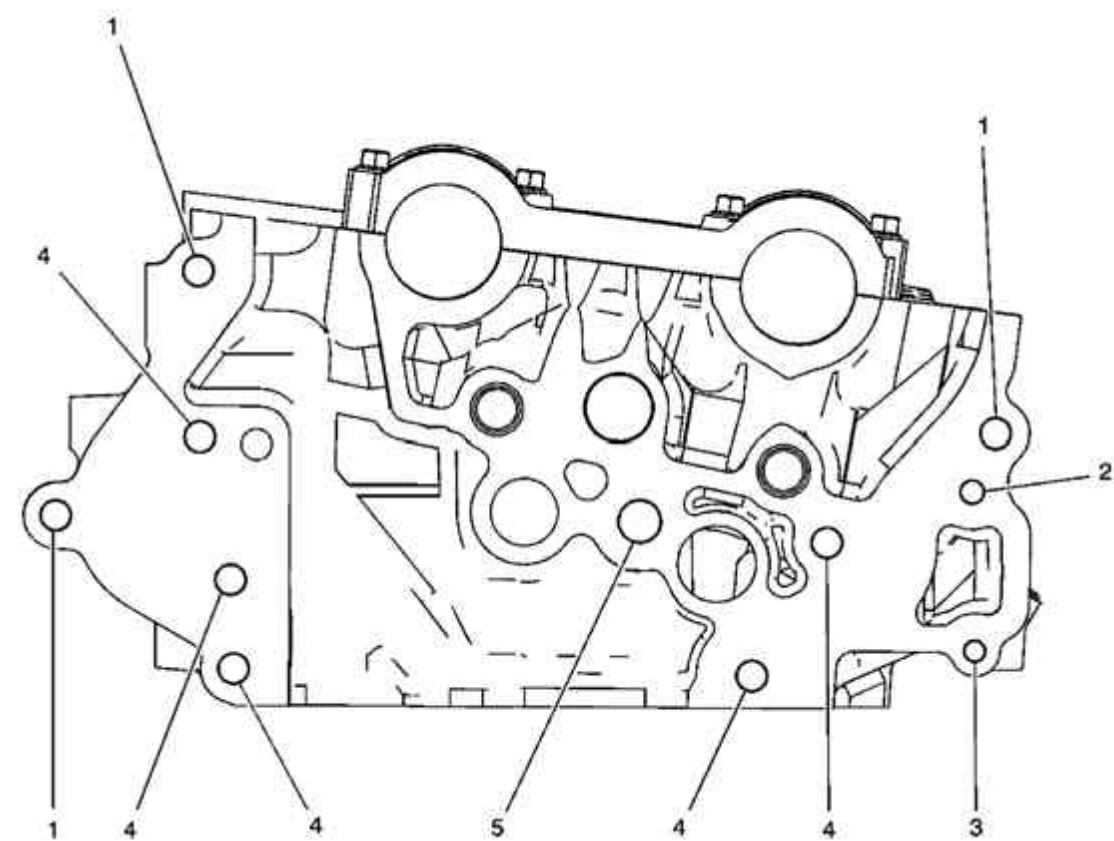


Fig. 7: View Of Right Cylinder Head Front Face
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
								MM	(IN)	MM	(IN)
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
2	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8880	18.0	0.7087
3	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

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4	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
5	M12 x 1.75	856	857	N/A	858	859	416	40.0	1.5748	32.5	1.2795

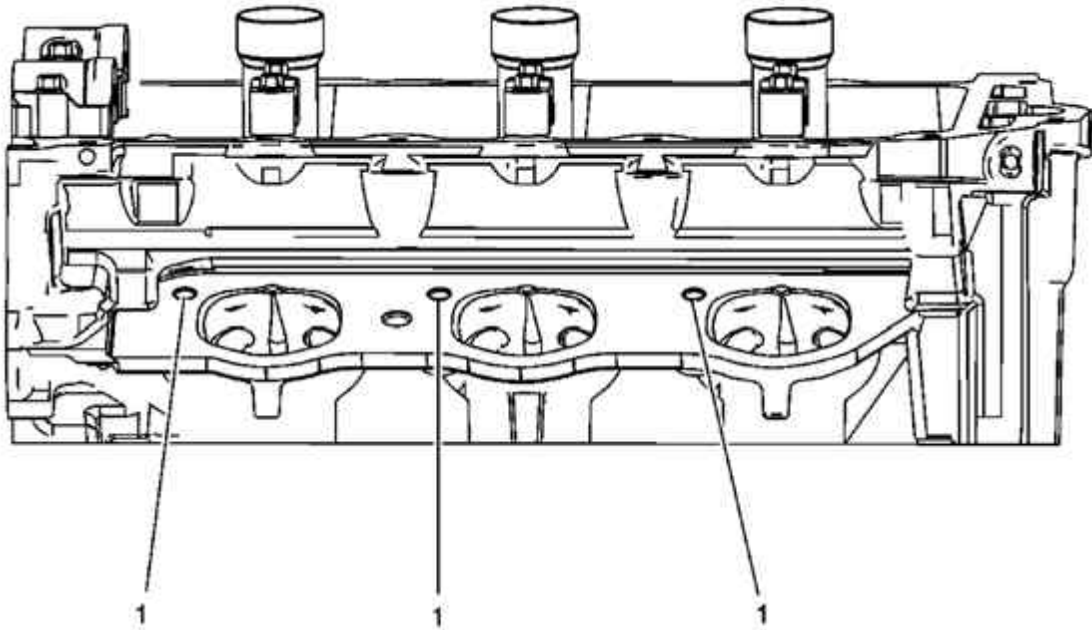


Fig. 8: Identifying Right Cylinder Head Intake Face
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

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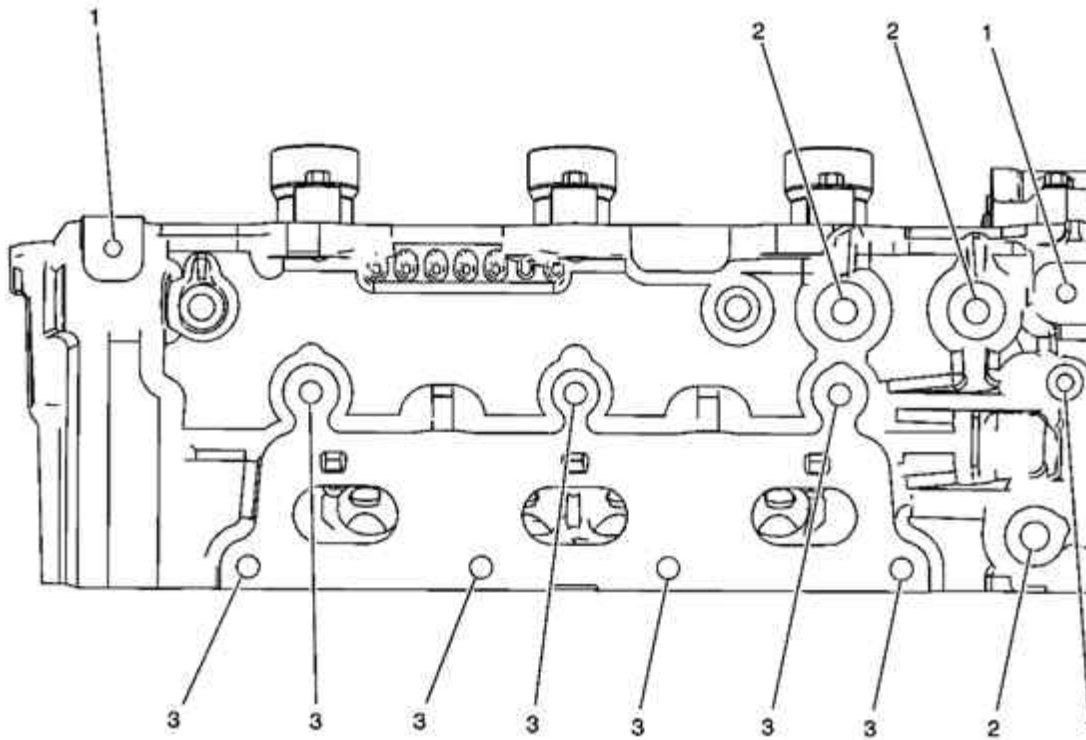


Fig. 9: Identifying Right Cylinder Head Exhaust Face
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.0000
2	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
3	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

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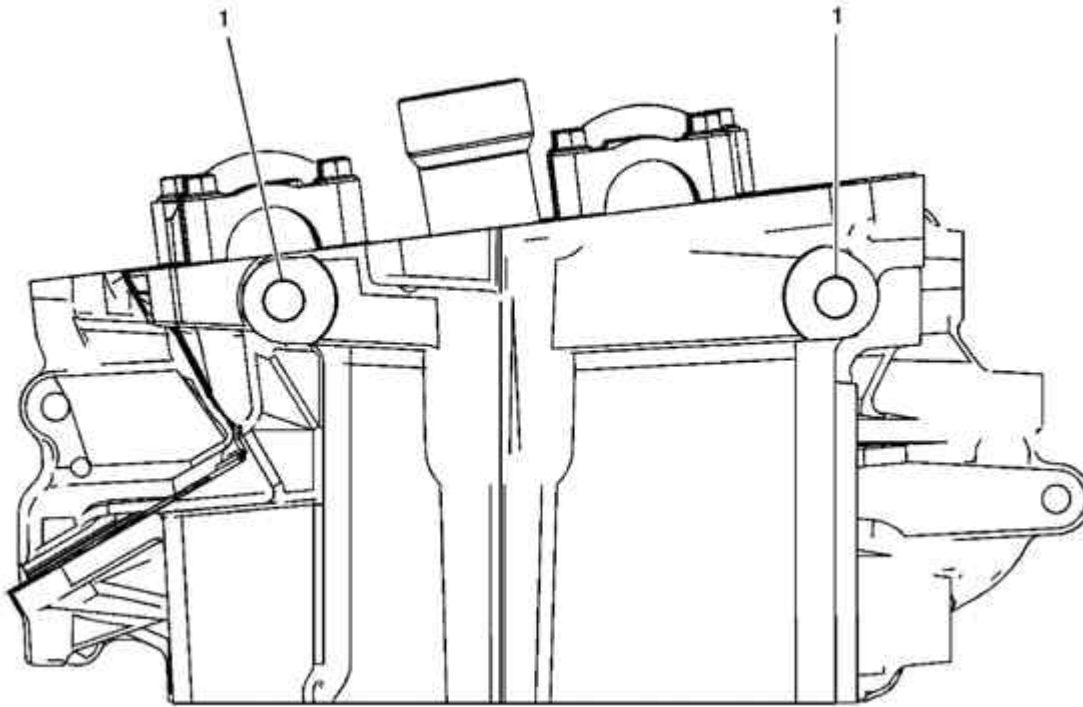
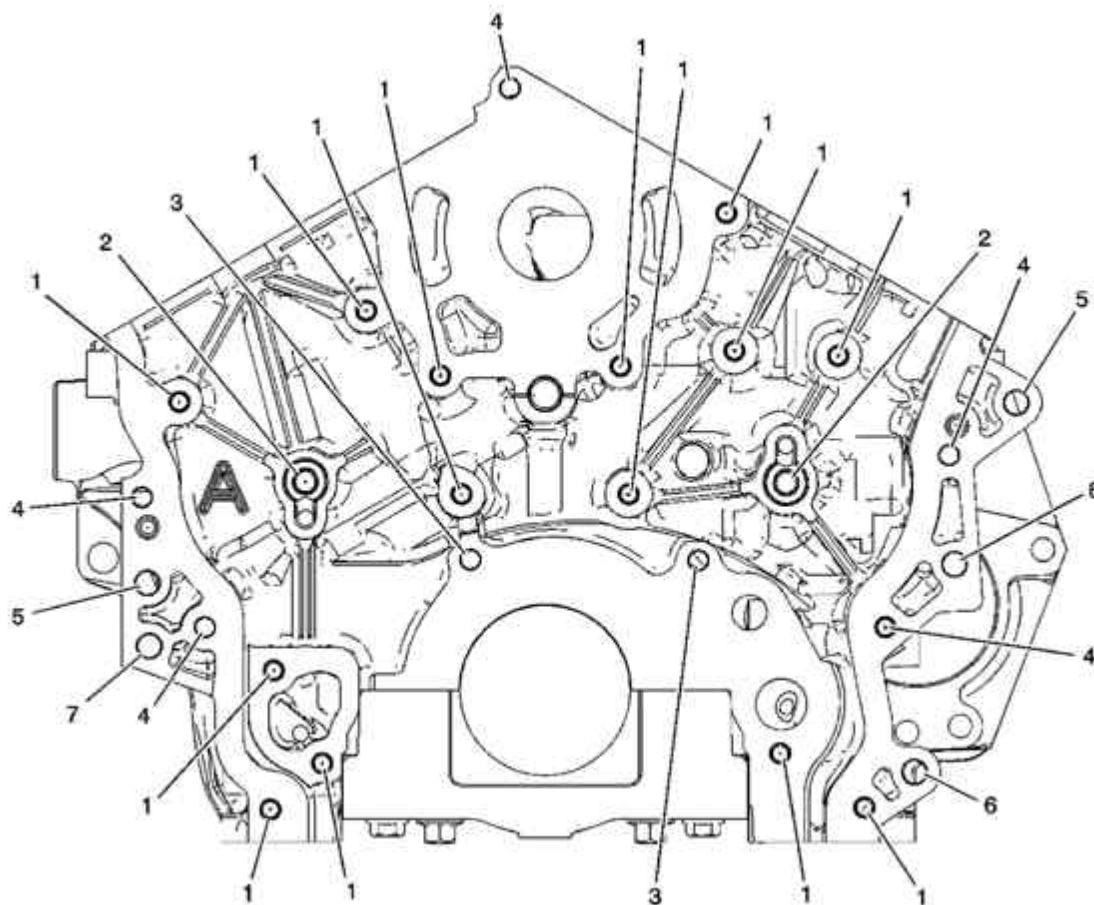


Fig. 10: View Of Right Cylinder Head Rear Face
Courtesy of GENERAL MOTORS CORP.

Right Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630

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Engine Block Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
3	M8 x 1.25	206	207	N/A	208	209	210	THRU		23.0	0.9055

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4	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
5	M10 x 1.5	211	212	N/A	213	214	215	28.0	1.1024	28.0	1.1024
6	M10 x 1.5	211	212	N/A	213	214	215	THRU		20.0	0.7874
7	M10 x 1.5	211	212	N/A	213	214	215	THRU		28.0	1.1024

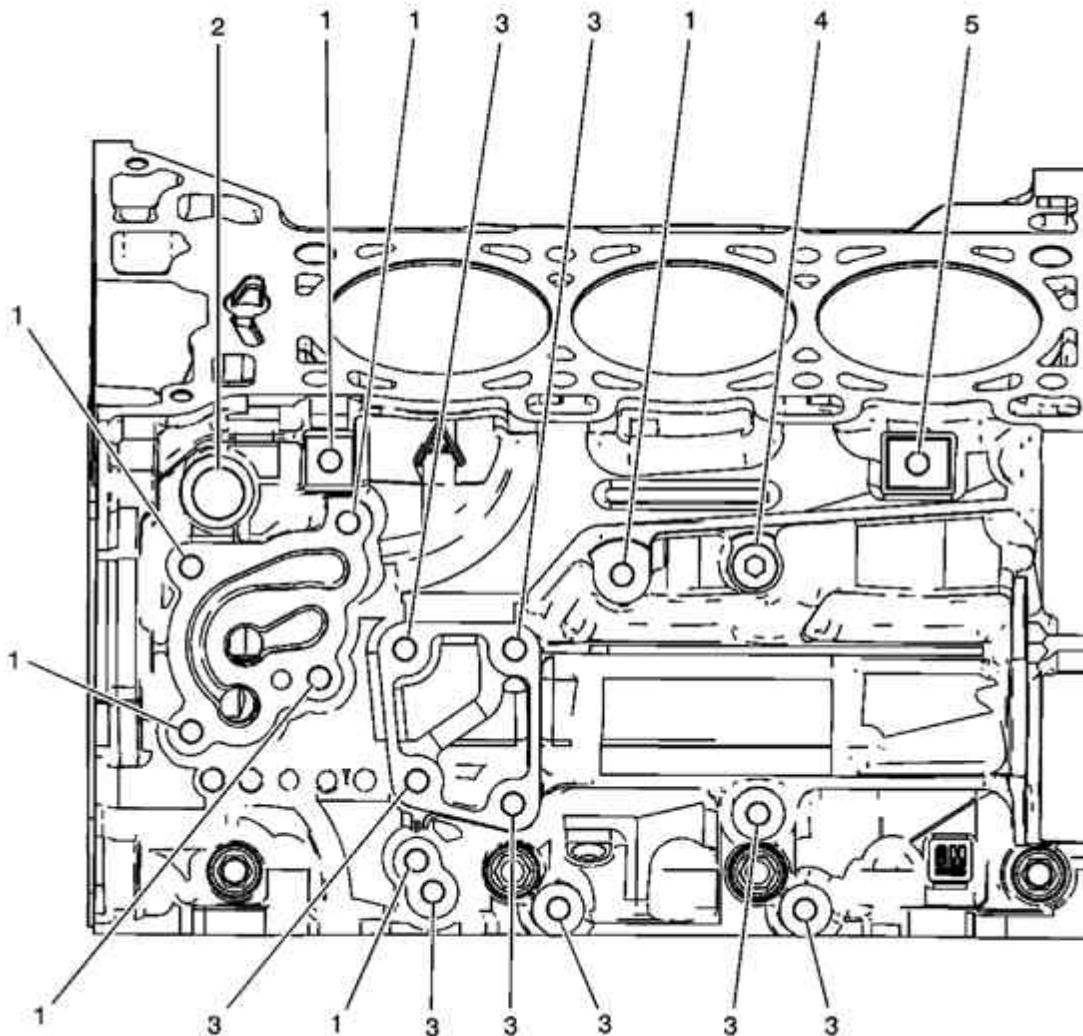


Fig. 12: View Of Engine Block Left Side
Courtesy of GENERAL MOTORS CORP.

Engine Block Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M20 x 1.5	715	716	N/A	717	718	719	30.0	1.1810	20.0	0.7874
3	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3190	27.0	1.0630
4	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
5	M8 x 1.25	206	207	N/A	208	209	415	16.5	0.6496	11.0	0.4331

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Fig. 13: View Of Engine Block Right Side
Courtesy of GENERAL MOTORS CORP.

Engine Block Right Side

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3	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
4	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3190	27.0	1.0630

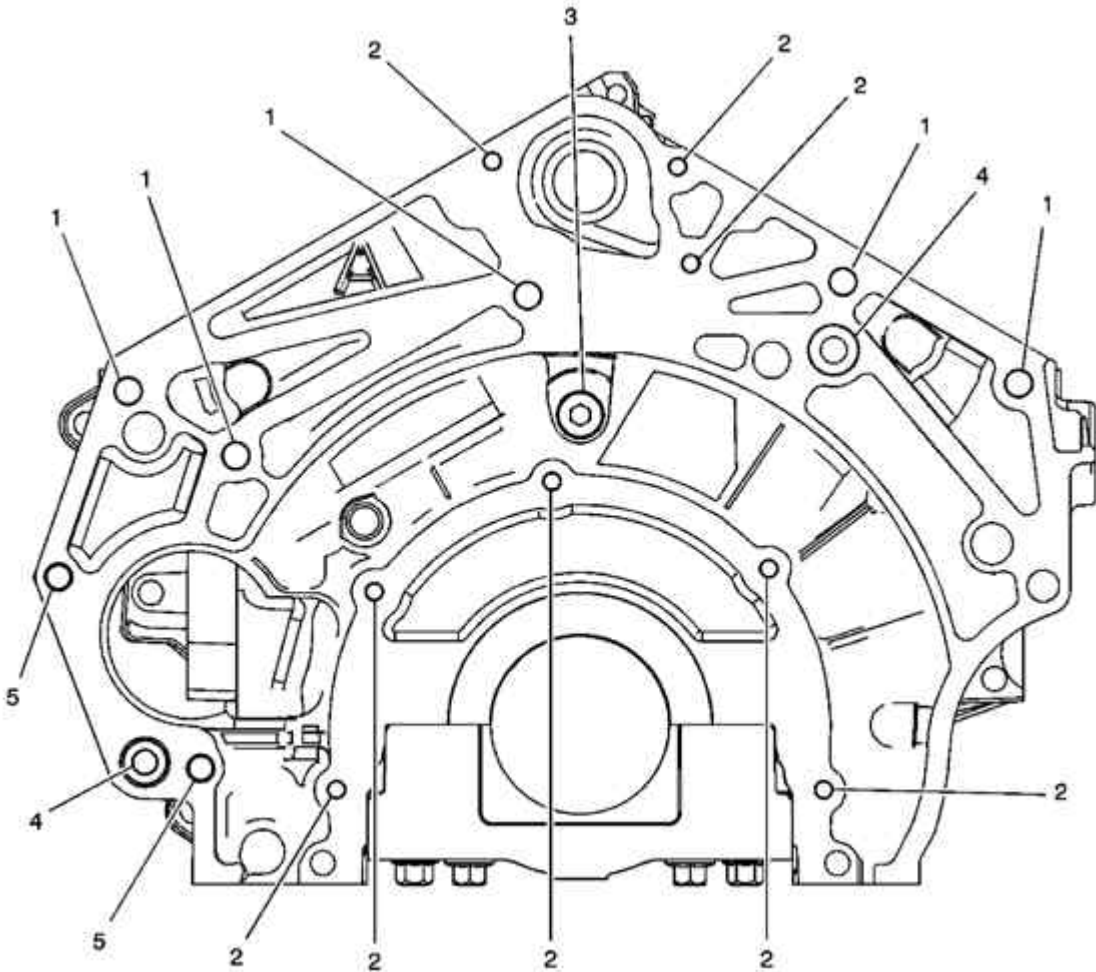


Fig. 14: Engine Block Rear Component View
Courtesy of GENERAL MOTORS CORP.

Engine Block Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)

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1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3190	27.0	1.0630
2	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
3	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
4	M10 x 1.5	211	212	N/A	213	214	216	39.5	1.5551	33.0	1.2992
5	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	

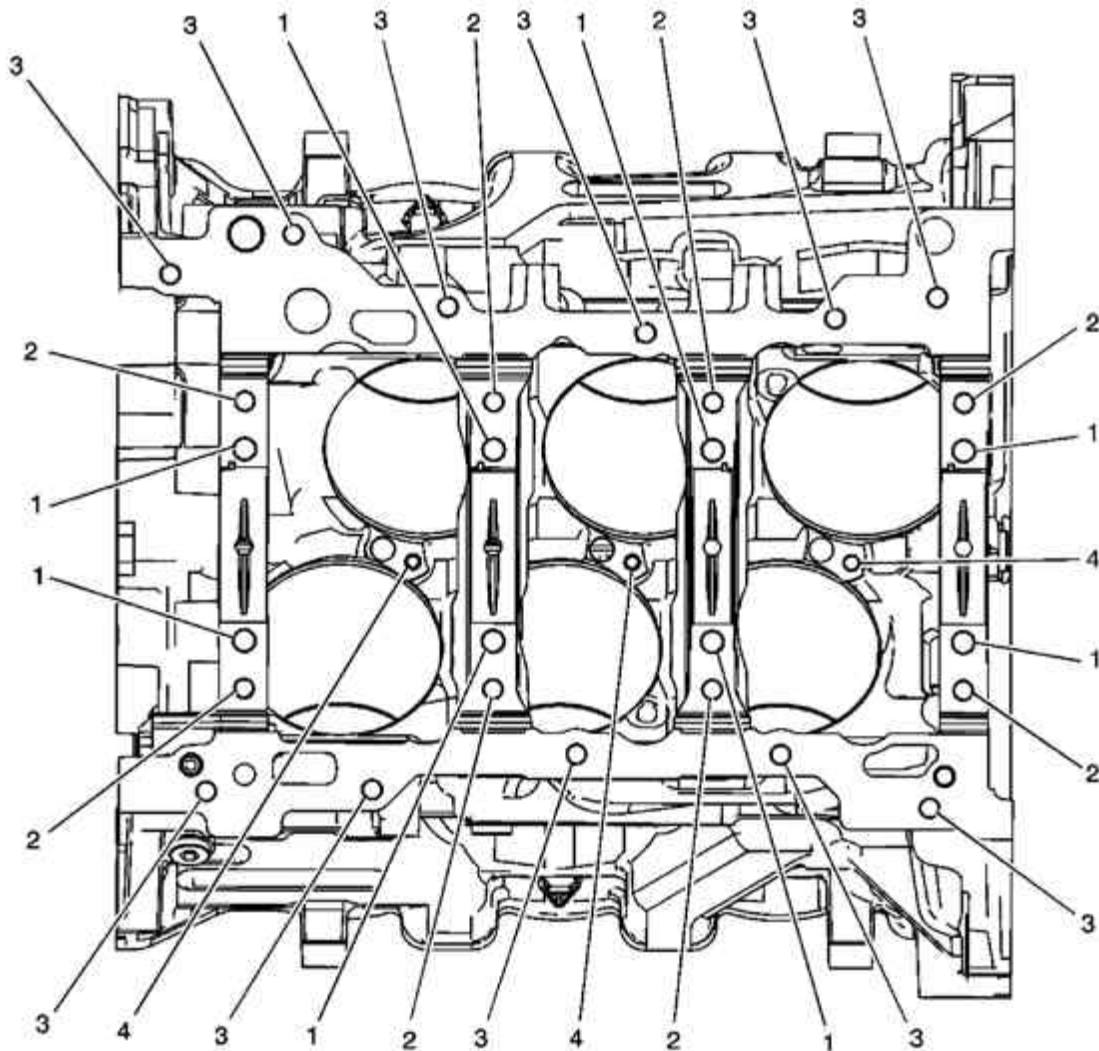


Fig. 15: View Of Engine Block Bottom
Courtesy of GENERAL MOTORS CORP.

Engine Block Bottom

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 2.0	720	N/A	N/A	721	722	104	56.0	2.2047	49.0	1.9291
2	M8 x 1.25	702	N/A	N/A	703	704	620	46.0	1.8110	40.5	1.5945
3	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
4	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

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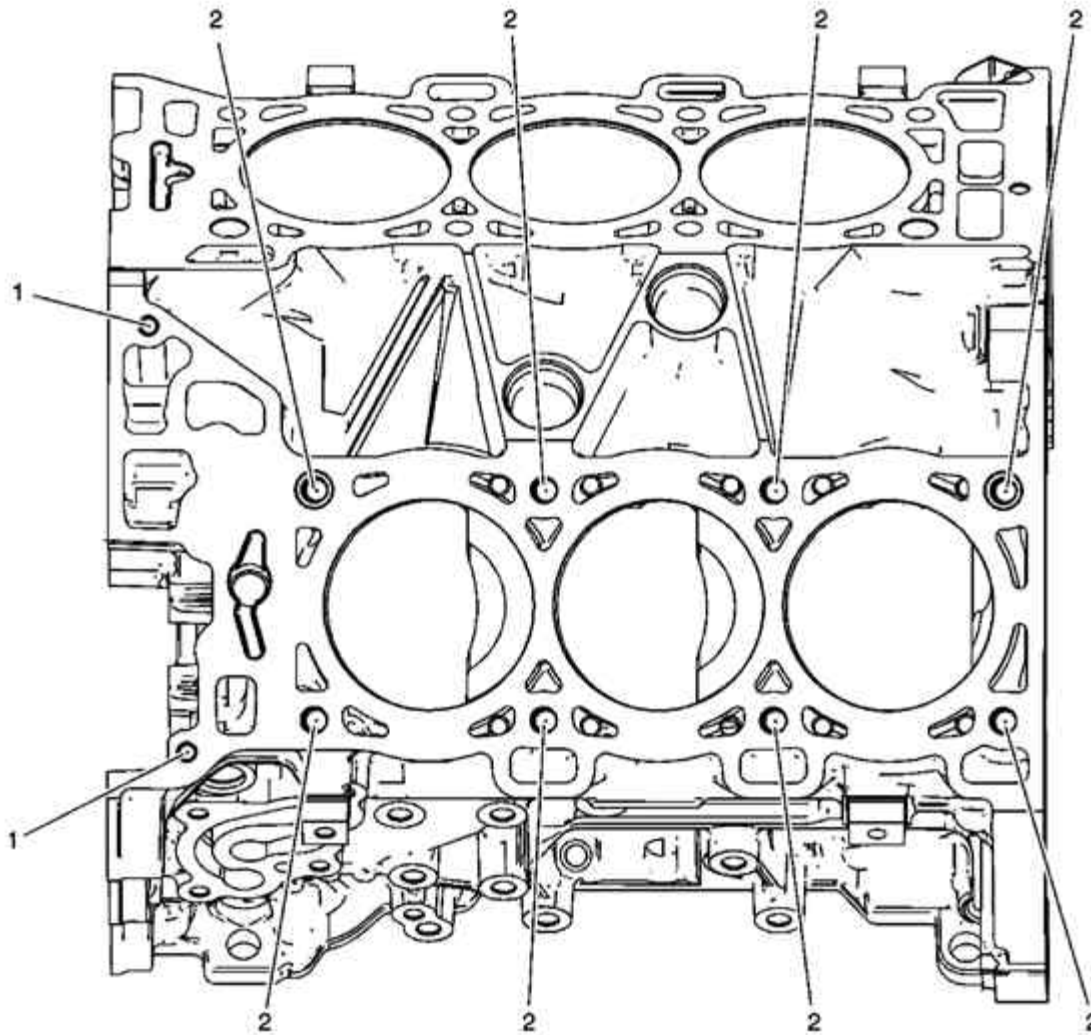


Fig. 16: Engine Block Left Deck Face Component View
Courtesy of GENERAL MOTORS CORP.

Engine Block Left Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M11 x 2.0	723	N/A	N/A	724	725	108	102.5	4.0354	94.0	3.7008

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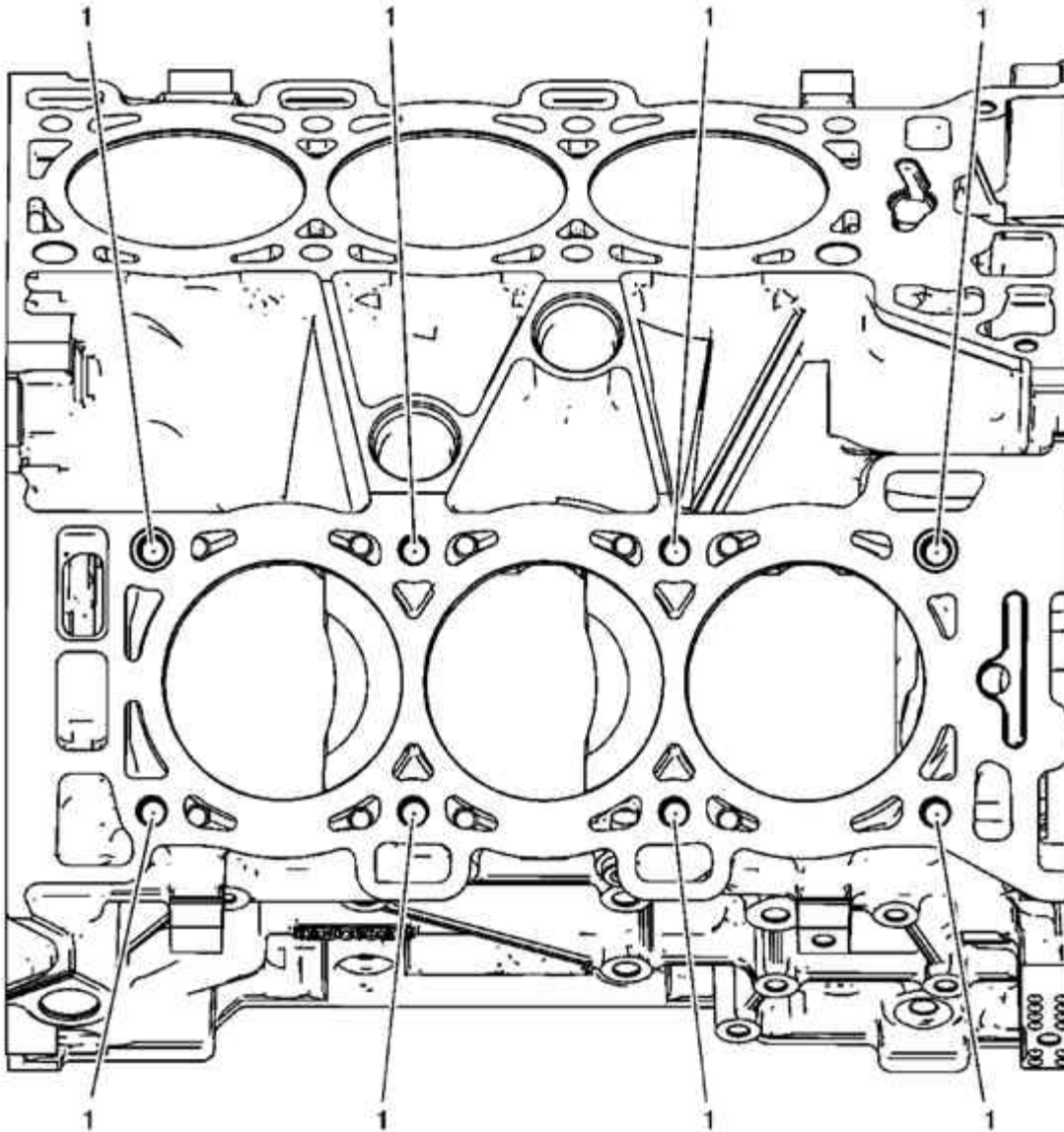


Fig. 17: View Of Engine Block Right Deck Face
Courtesy of GENERAL MOTORS CORP.

Engine Block Right Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M11 x	723	N/A	N/A	724	725	108	102.5	4.0354	94.0	3.7008

	2.0									
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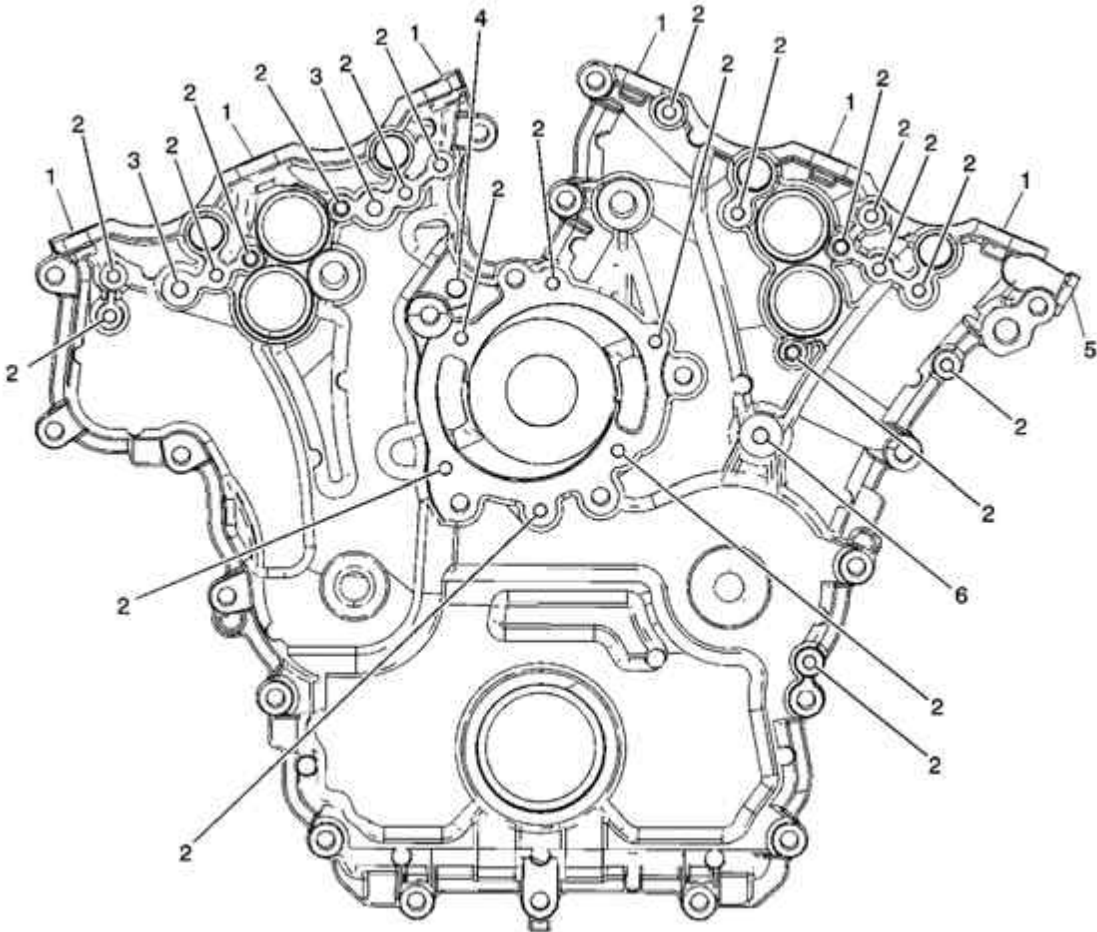


Fig. 18: Identifying Engine Front Cover
 Courtesy of GENERAL MOTORS CORP.

Engine Front Cover

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M6 x 1.0	201	202	N/A	203	204	205	21.5	0.8465	18.0	0.7087

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3	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
4	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	
5	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630
6	M8 x 1.25	206	207	N/A	208	209	210	27.5	1.0827	23.0	0.9055

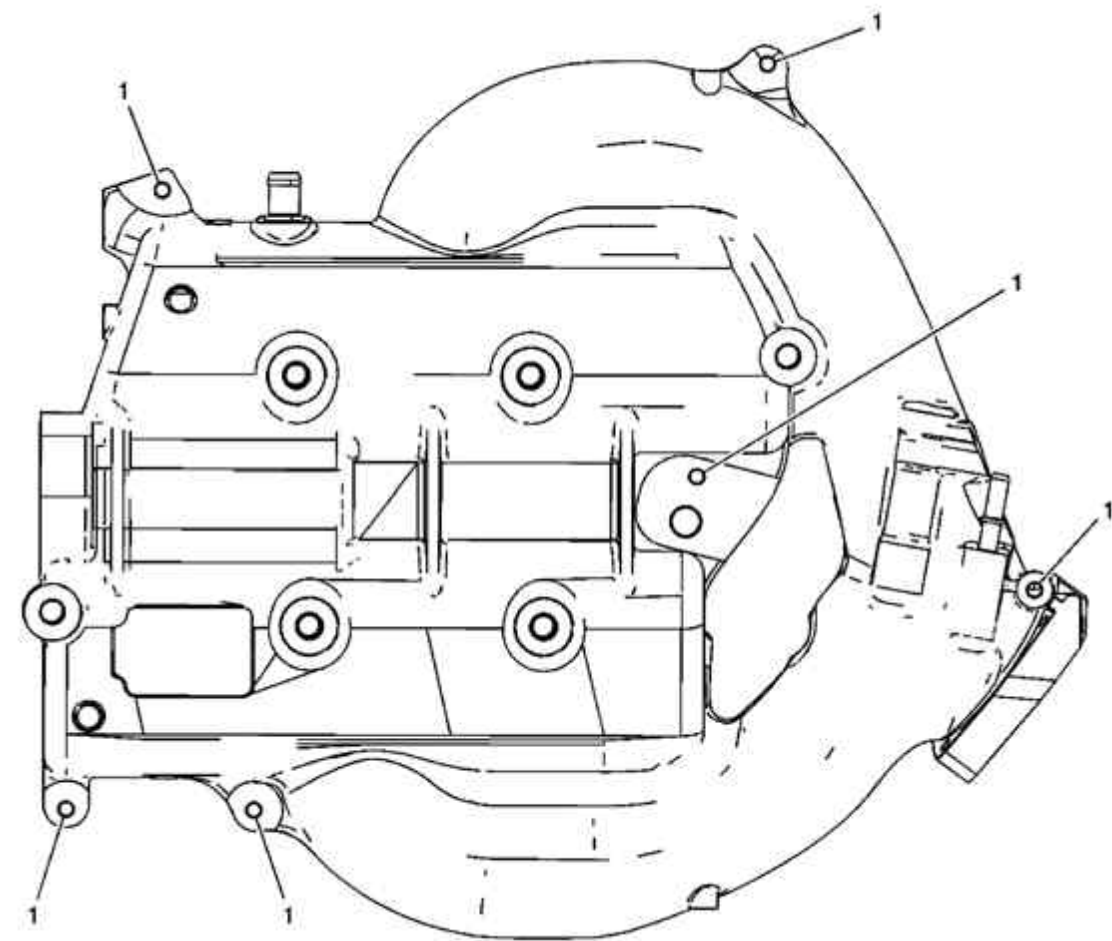


Fig. 19: Upper Intake Manifold - Top View
Courtesy of GENERAL MOTORS CORP.

Upper Intake Manifold - Top

			Counter								
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Hole Location	Thread Size	Drill	Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

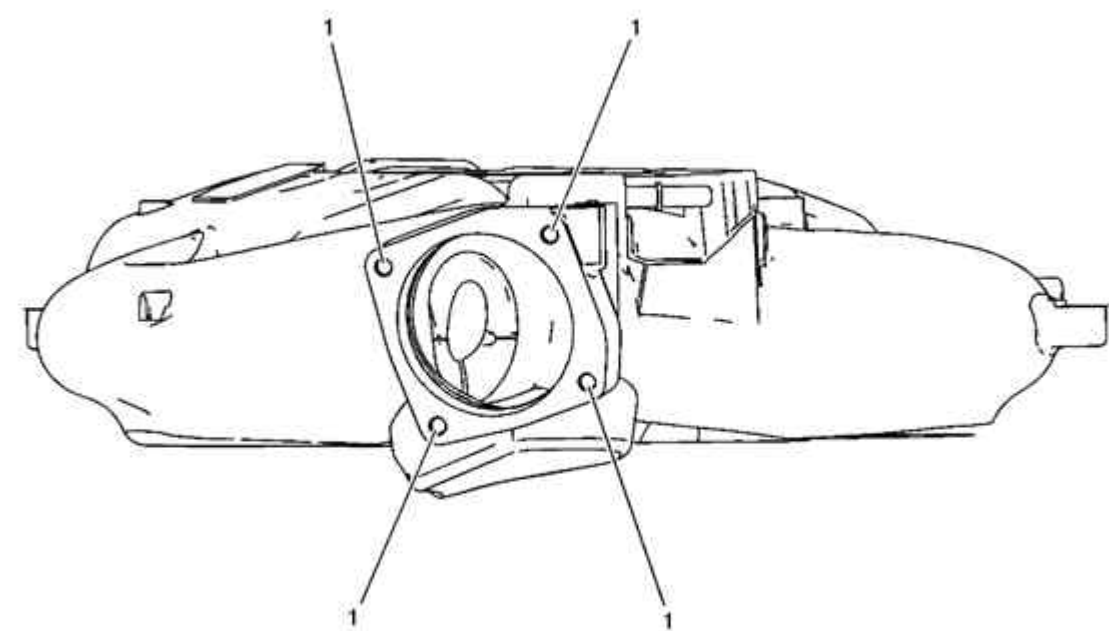


Fig. 20: Upper Intake Manifold - Front View
 Courtesy of GENERAL MOTORS CORP.

Upper Intake Manifold - Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

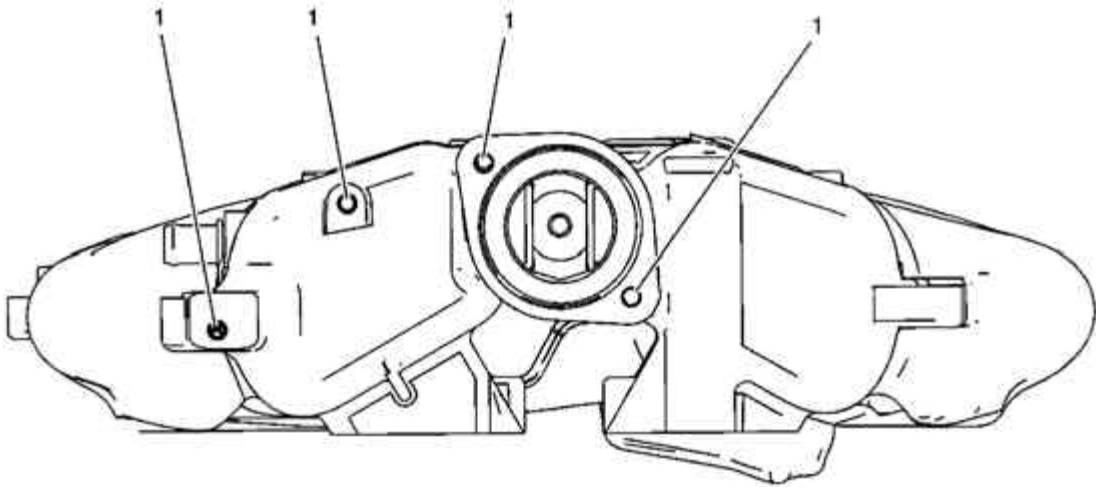


Fig. 21: Upper Intake Manifold - Rear View
Courtesy of GENERAL MOTORS CORP.

Upper Intake Manifold - Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

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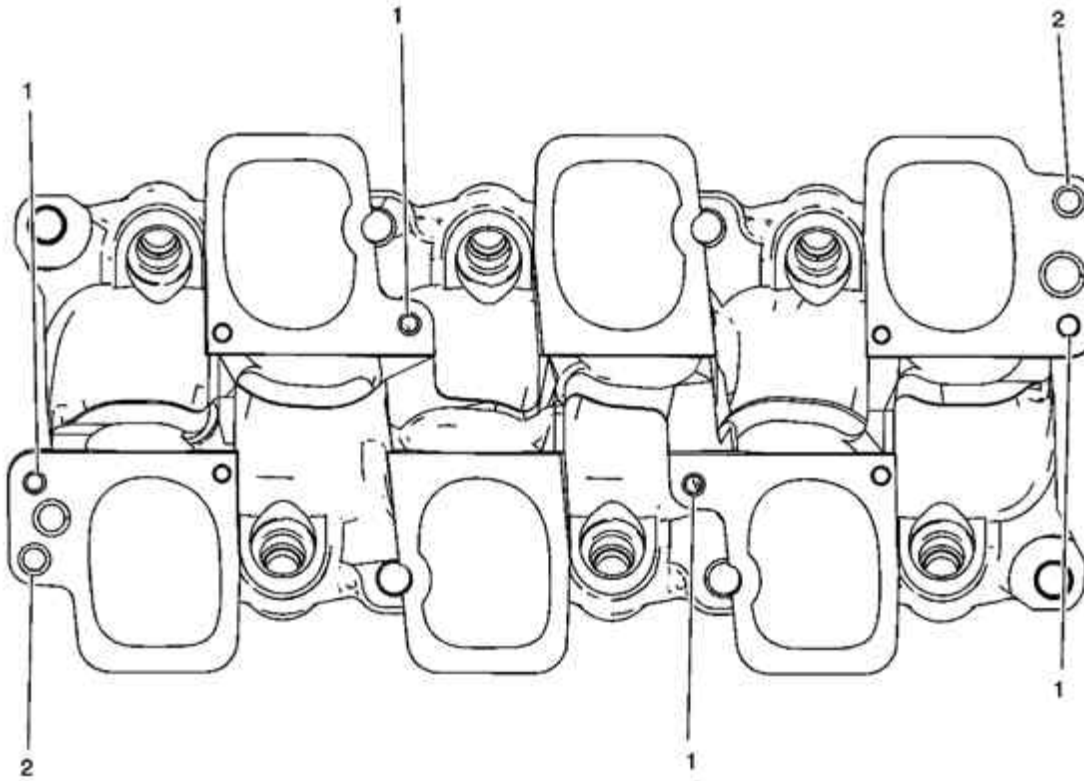


Fig. 22: Lower Intake Manifold - Top View
 Courtesy of GENERAL MOTORS CORP.

Lower Intake Manifold - Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)	Tap Depth (Minimum)
-	-	J 42385-						MM (IN)	MM (IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU	THRU
2	M8 x 1.25	206	207	N/A	208	209	210	THRU	THRU

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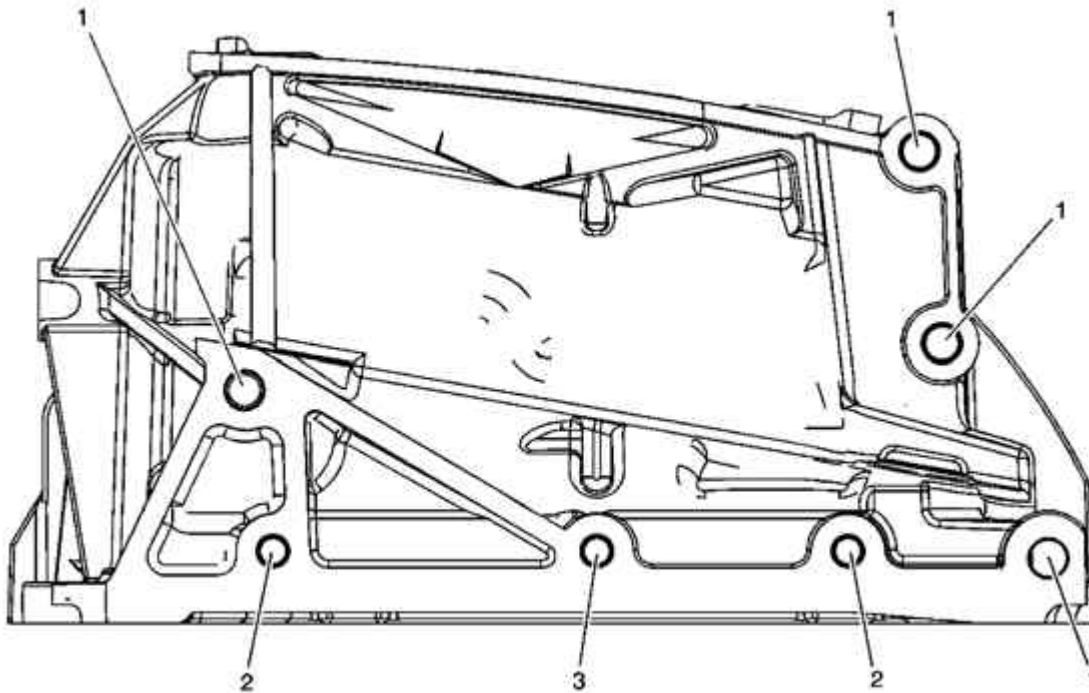


Fig. 23: Oil Pan Front View
Courtesy of GENERAL MOTORS CORP.

Oil Pan Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
								MM	(IN)	MM	(IN)
-	-	J 42385-									
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630
2	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
3	M8 x 1.25	610	N/A	N/A	208	209	620	37.5	1.4764	32.0	1.2598

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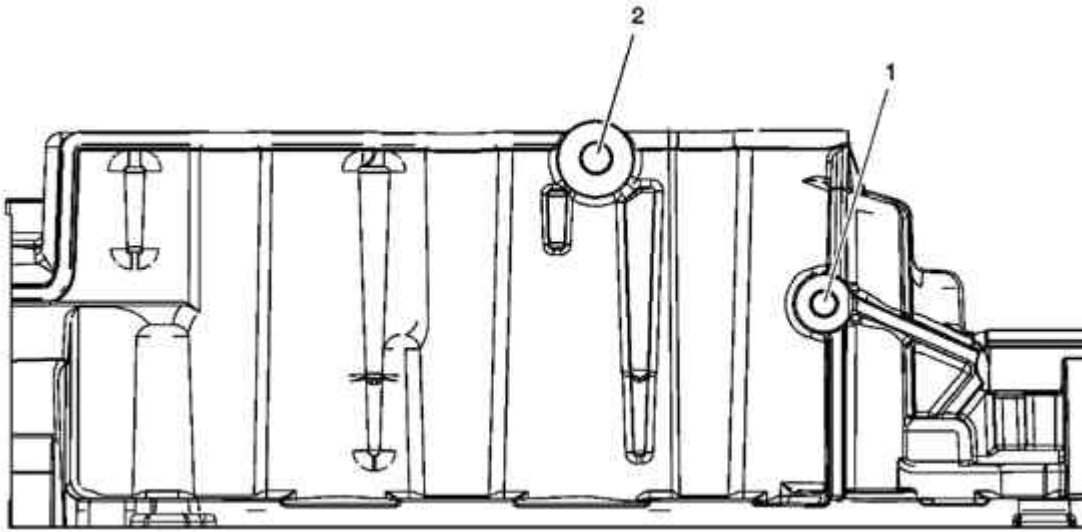


Fig. 24: View Of Oil Pan Left Side
Courtesy of GENERAL MOTORS CORP.

Oil Pan Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
								MM	(IN)	MM	(IN)
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630
2	M12 x 1.75	856	857	N/A	858	859	416	Thru		Thru	

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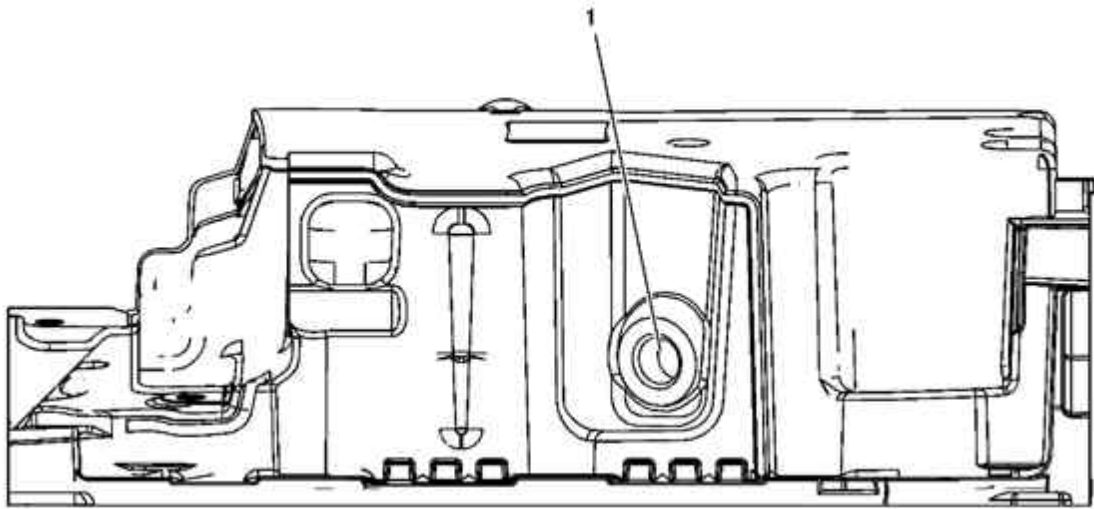


Fig. 25: View Of Oil Pan Right Side
Courtesy of GENERAL MOTORS CORP.

Oil Pan Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	

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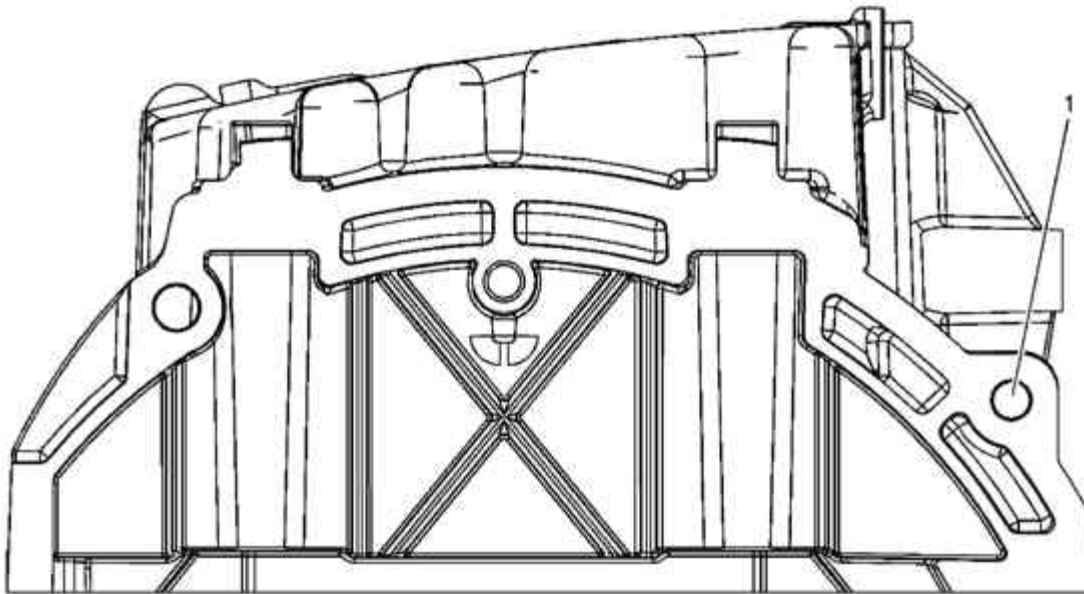


Fig. 26: View Of Oil Pan Rear
Courtesy of GENERAL MOTORS CORP.

Oil Pan Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630

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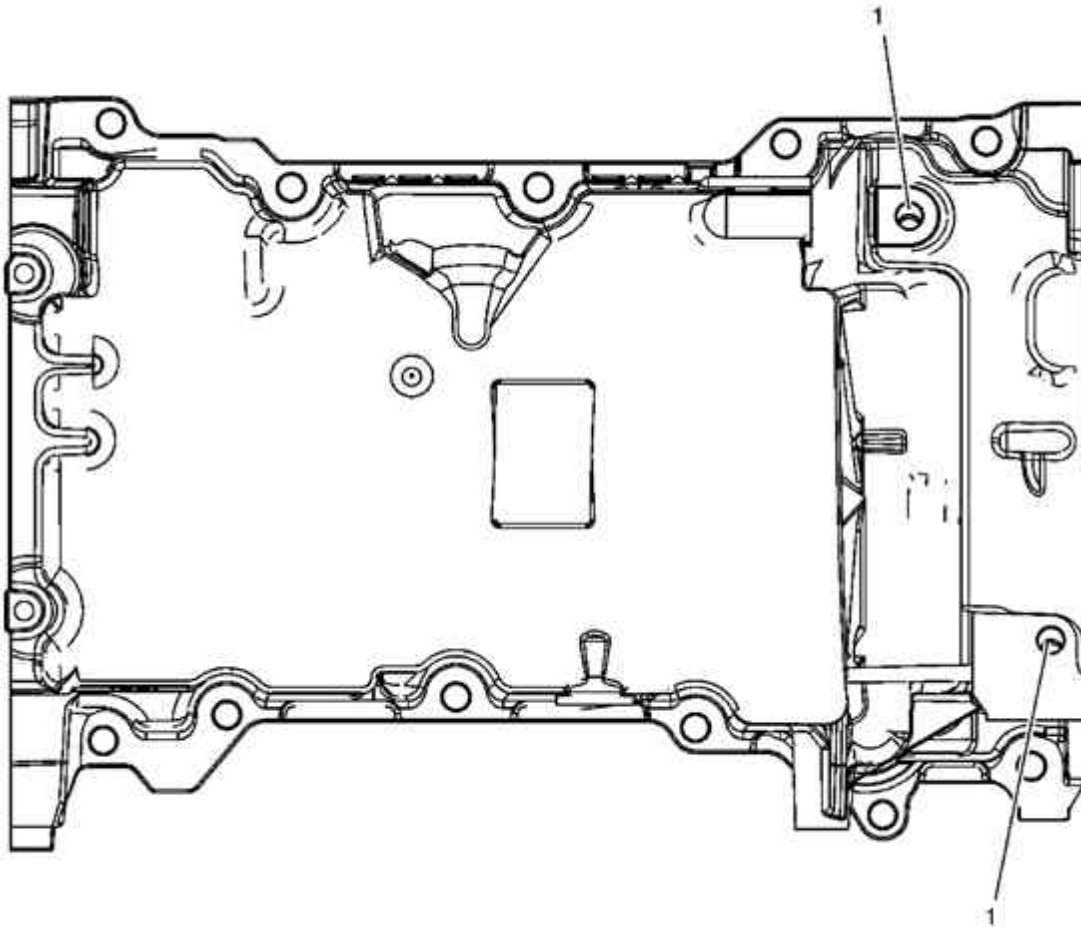


Fig. 27: View Of Oil Pan Bottom
Courtesy of GENERAL MOTORS CORP.

Oil Pan Bottom

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630

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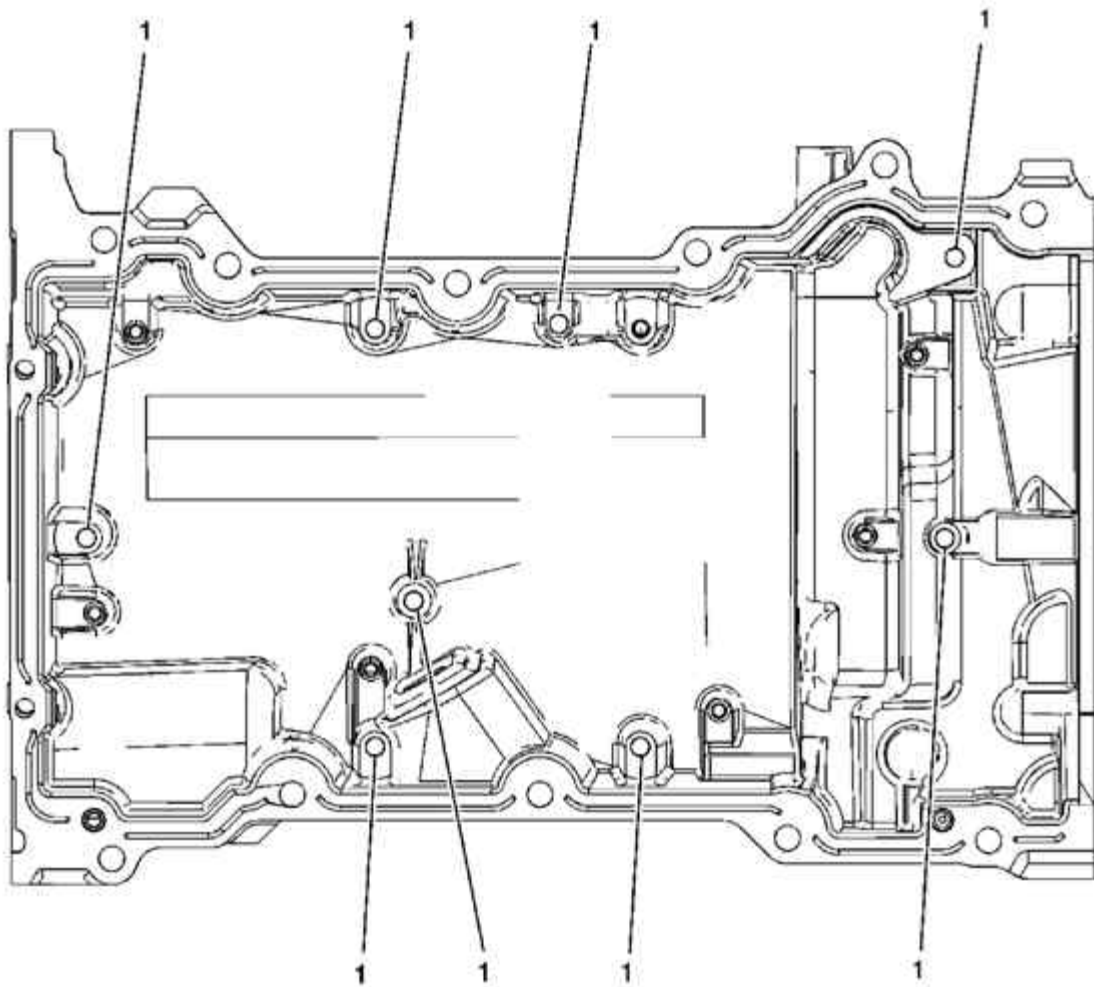


Fig. 28: View Of Oil Pan Top
Courtesy of GENERAL MOTORS CORP.

Oil Pan Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
-	-	J 42385-						MM	(IN)	MM	(IN)
1	M6 x 1.0	701	N/A	N/A	203	204	205	28.0	1.1024	23.5	0.9252

SCHEMATIC AND ROUTING DIAGRAMS

CAMSHAFT TIMING DRIVE CHAIN ALIGNMENT DIAGRAM (THIRD DESIGN)

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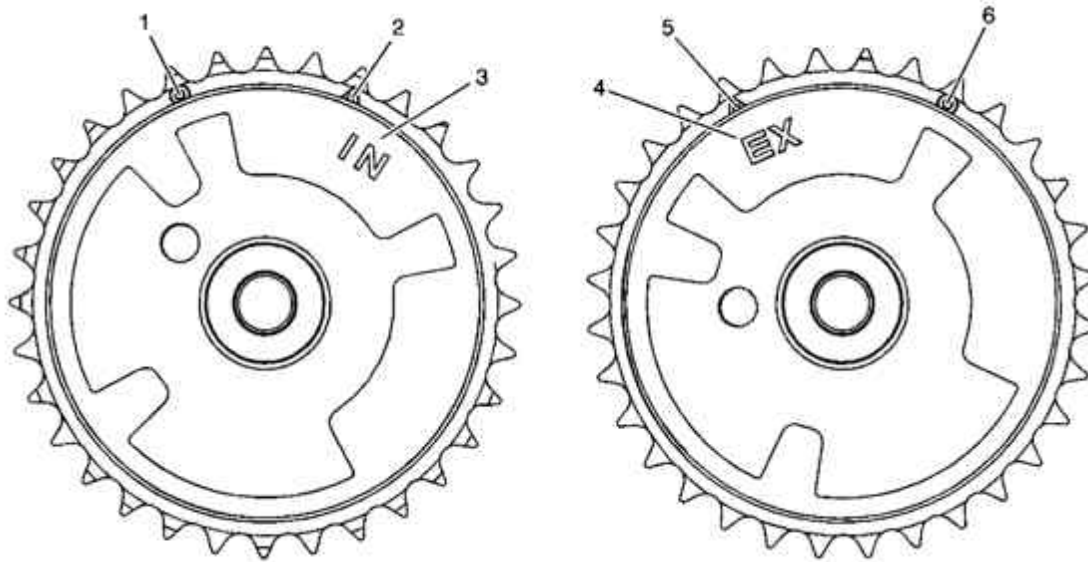


Fig. 29: Identifying Camshaft Position Actuator Timing Marks
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Intake Camshaft Position Actuator Left Side Timing Mark - Circle
2	Intake Camshaft Position Actuator Right Side Timing Mark - Triangle
3	Intake Camshaft Position Actuator Identifier
4	Exhaust Camshaft Position Actuator Identifier
5	Exhaust Camshaft Position Actuator Right Side Timing Mark - Triangle
6	Exhaust Camshaft Position Actuator Left Side Timing Mark - Circle

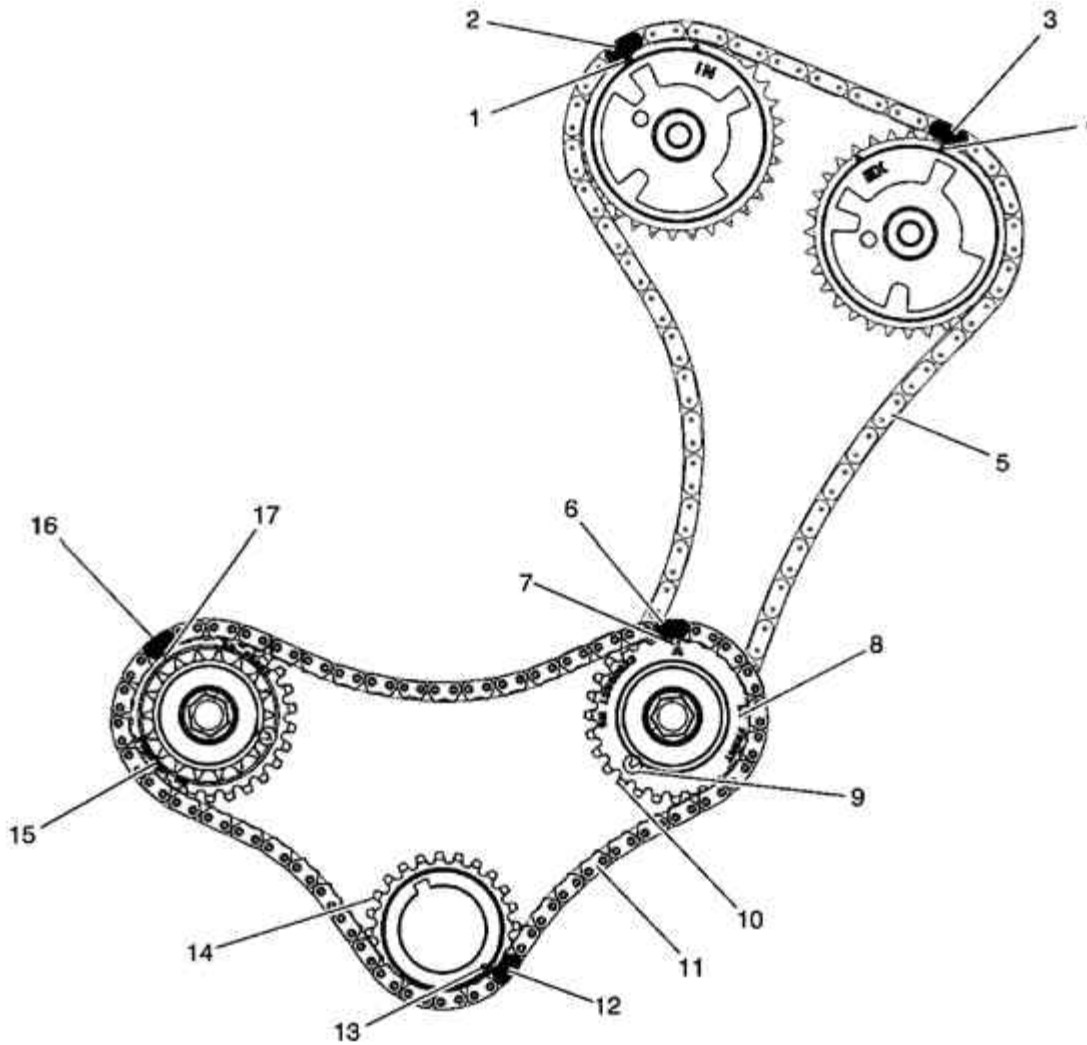


Fig. 30: Camshaft Timing Drive Chain Alignment Diagram (Stage One - Third Design)

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle
2	Left Intake Secondary Camshaft Timing Drive Chain Timing Link
3	Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link

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4	Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle
5	Left Secondary Camshaft Timing Drive Chain
6	Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
7	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
8	Left Primary Camshaft Intermediate Drive Chain Sprocket
9	Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
10	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window for the Left Secondary Camshaft Timing Drive Chain Timing Link
11	Primary Camshaft Drive Chain
12	Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
13	Crankshaft Sprocket Timing Mark
14	Crankshaft Sprocket
15	Right Primary Camshaft Intermediate Drive Chain Sprocket
16	Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
17	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark

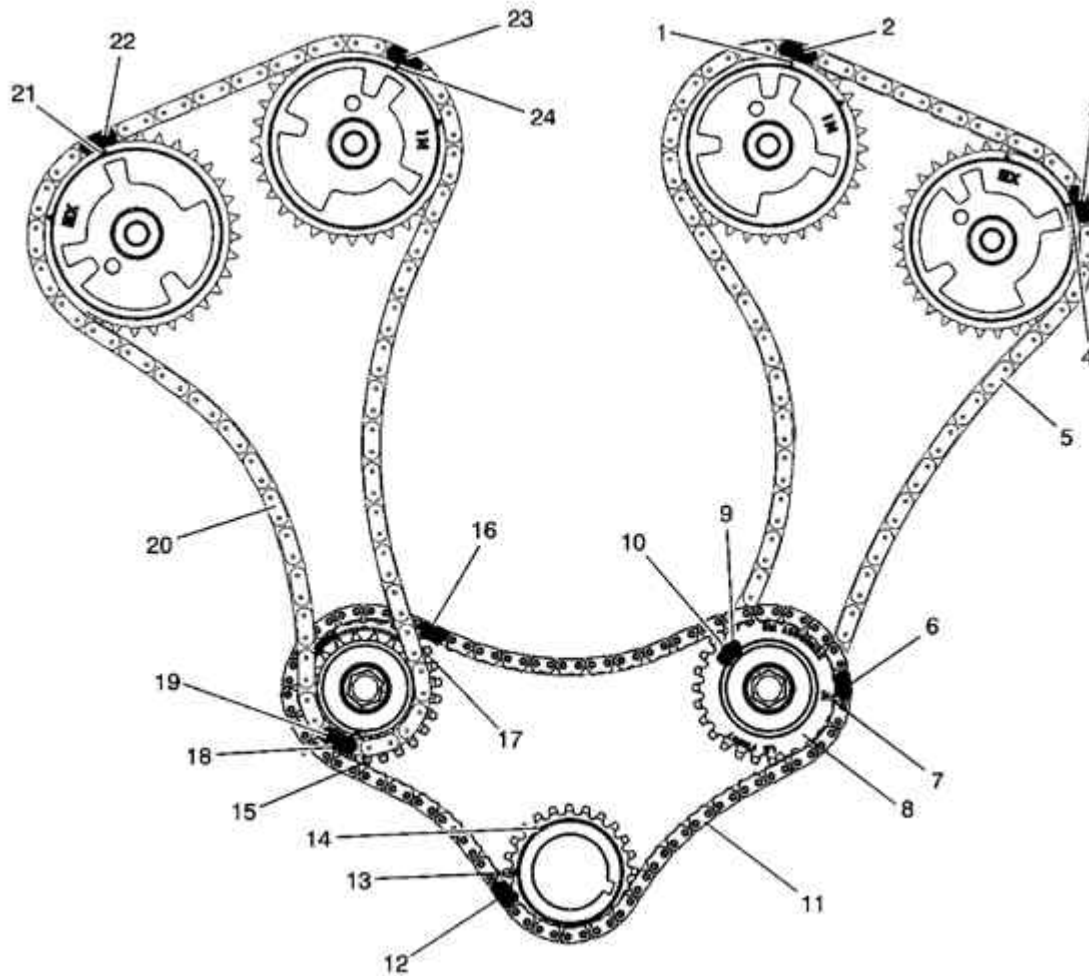


Fig. 31: Camshaft Timing Drive Chain Alignment Diagram (Stage Two - Third Design)

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle
2	Left Intake Secondary Camshaft Timing Drive Chain Timing Link
3	Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link
4	Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle

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5	Left Secondary Camshaft Timing Drive Chain
6	Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
7	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
8	Left Primary Camshaft Intermediate Drive Chain Sprocket
9	Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
10	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window
11	Primary Camshaft Drive Chain
12	Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
13	Crankshaft Sprocket Timing Mark
14	Crankshaft Sprocket
15	Right Primary Camshaft Intermediate Drive Chain Sprocket
16	Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
17	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
18	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark/Window for the Right Secondary Camshaft Timing Drive Chain
19	Right Secondary Camshaft Timing Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
20	Right Secondary Camshaft Timing Drive Chain
21	Right Exhaust Camshaft Position (CMP) Actuator Timing Mark - Triangle
22	Right Exhaust Secondary Camshaft Timing Drive Chain Timing Link
23	Right Intake Secondary Camshaft Timing Drive Chain Timing Link

24

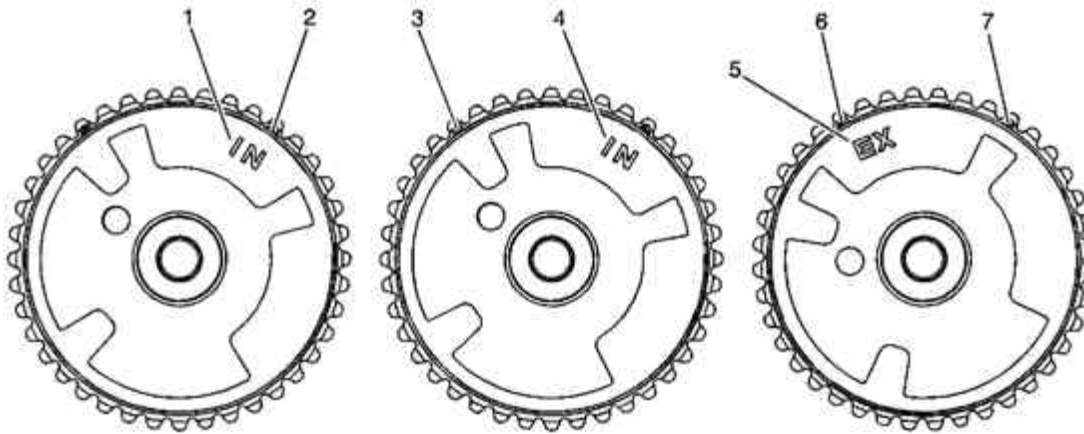
Right Intake Camshaft Position (CMP) Actuator Timing Mark
- Triangle**CAMSHAFT TIMING DRIVE CHAIN ALIGNMENT DIAGRAM (FOURTH DESIGN)**

Fig. 32: Camshaft Timing Drive Chain Component View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Right Intake Camshaft Position Actuator Identifier
2	Right Intake Camshaft Position Actuator Right Side Timing Mark - Triangle
3	Left Intake Camshaft Position Actuator Left Side Timing Mark - Circle
4	Left Intake Camshaft Position Actuator Identifier
5	Exhaust Camshaft Position Actuator Identifier
6	Exhaust Camshaft Position Actuator Right Side Timing Mark - Triangle
7	Exhaust Camshaft Position Actuator Left Side Timing Mark - Circle

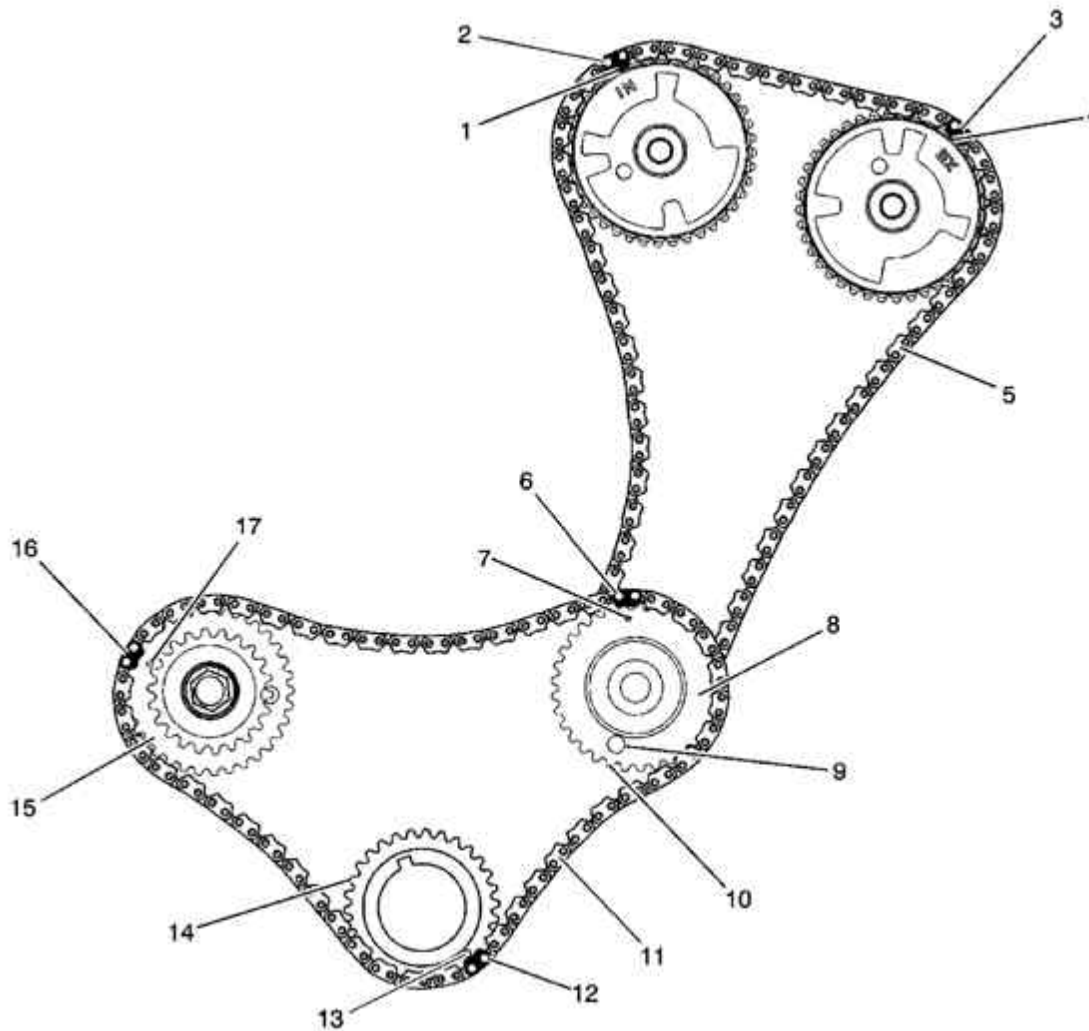


Fig. 33: Stage One Component View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle
2	Left Intake Secondary Camshaft Timing Drive Chain Timing Link
3	Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link
4	Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle

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5	Left Secondary Camshaft Timing Drive Chain
6	Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
7	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
8	Left Primary Camshaft Intermediate Drive Chain Sprocket
9	Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
10	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window for the Left Secondary Camshaft Timing Drive Chain Timing Link
11	Primary Camshaft Drive Chain
12	Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
13	Crankshaft Sprocket Timing Mark
14	Crankshaft Sprocket
15	Right Primary Camshaft Intermediate Drive Chain Sprocket
16	Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
17	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark

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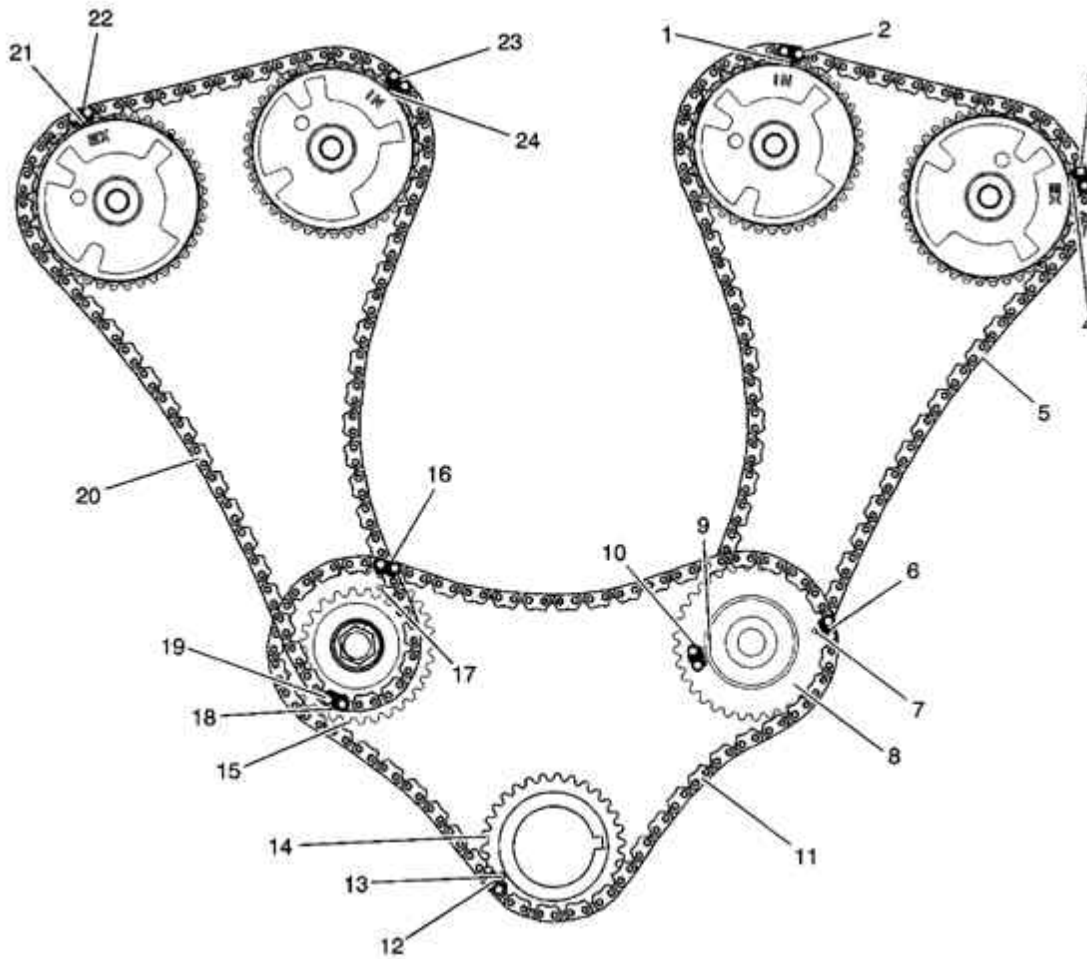


Fig. 34: Stage Two Component View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle
2	Left Intake Secondary Camshaft Timing Drive Chain Timing Link
3	Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link
4	Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle
5	Left Secondary Camshaft Timing Drive Chain

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6	Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
7	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
8	Left Primary Camshaft Intermediate Drive Chain Sprocket
9	Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
10	Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window
11	Primary Camshaft Drive Chain
12	Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
13	Crankshaft Sprocket Timing Mark
14	Crankshaft Sprocket
15	Right Primary Camshaft Intermediate Drive Chain Sprocket
16	Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
17	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
18	Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark/Window for the Right Secondary Camshaft Timing Drive Chain
19	Right Secondary Camshaft Timing Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
20	Right Secondary Camshaft Timing Drive Chain
21	Right Exhaust Camshaft Position (CMP) Actuator Timing Mark - Triangle
22	Right Exhaust Secondary Camshaft Timing Drive Chain Timing Link
23	Right Intake Secondary Camshaft Timing Drive Chain Timing Link
24	Right Intake Camshaft Position (CMP) Actuator Timing Mark

- Triangle

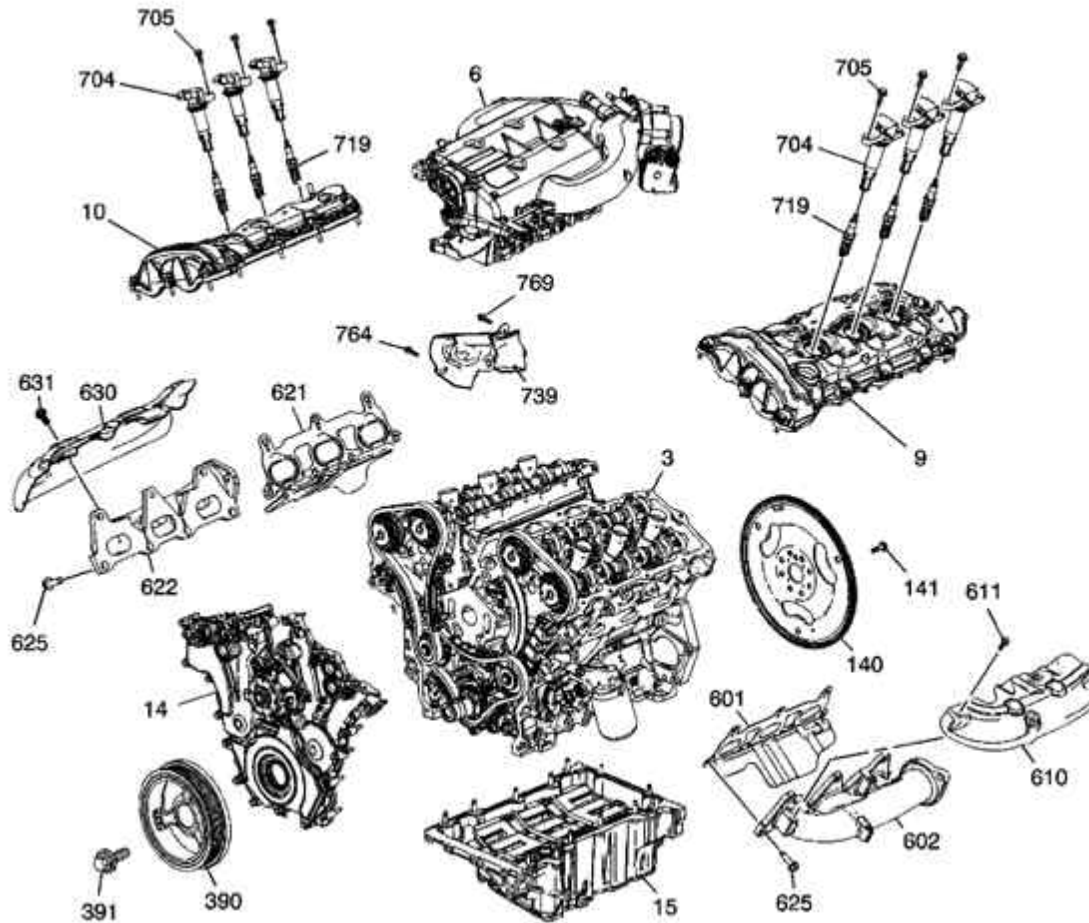
COMPONENT LOCATOR**DISASSEMBLED VIEWS**

Fig. 35: View Of Engine Covers & Component Assemblies (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
3	Engine Assembly
6	Intake Manifold Assembly
9	Left Camshaft Cover Assembly
10	Right Camshaft Cover Assembly

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14	Engine Front Cover Assembly
15	Oil Pan Assembly
140	Engine Flywheel
141	Engine Flywheel Bolt
390	Crankshaft Balancer
391	Crankshaft Balancer Bolt
601	Left Exhaust Manifold Gasket
602	Left Exhaust Manifold
610	Left Exhaust Manifold Heat Shield
611	Left Exhaust Manifold Heat Shield Bolt
621	Right Exhaust Manifold Gasket
622	Right Exhaust Manifold
625	Cylinder Head Exhaust Manifold Bolt
625	Cylinder Head Exhaust Manifold Bolt
630	Right Exhaust Manifold Heat Shield
631	Right Exhaust Manifold Heat Shield Bolt
704	Ignition Coil
704	Ignition Coil
705	Ignition Coil Bolt
705	Ignition Coil Bolt
719	Spark Plug
719	Spark Plug
739	Crankshaft Position Sensor Heat Shield
764	Crankshaft Position Sensor Heat Shield Bolt - Large
769	Crankshaft Position Sensor Heat Shield Bolt - Small

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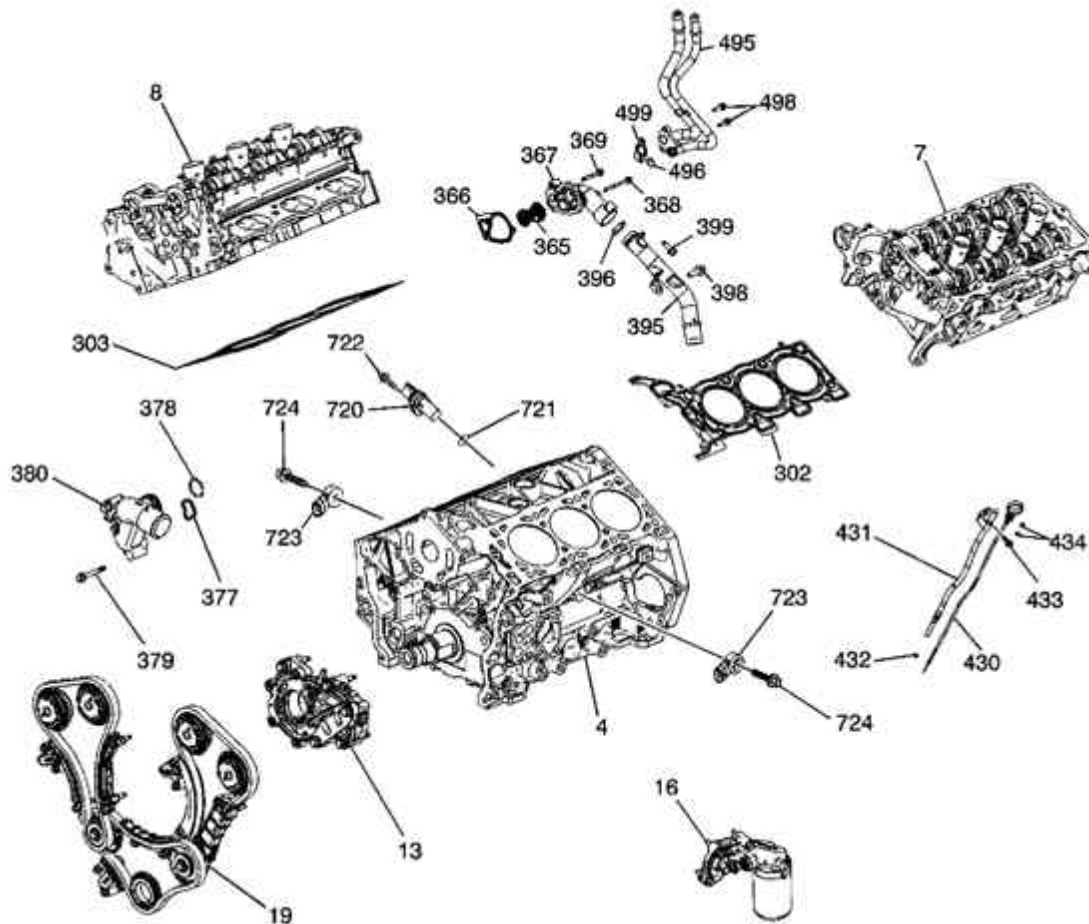


Fig. 36: View Of Engine Covers & Component Assemblies (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
4	Engine Short Block Assembly
7	Left Cylinder Head Assembly
8	Right Cylinder Head Assembly
13	Oil Pump Assembly
16	Oil Filter Adapter Assembly
19	Timing Drive Assembly
302	Left Cylinder Head Gasket
303	Right Cylinder Head Gasket
365	Engine Cooling Thermostat

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366	Engine Cooling Thermostat Gasket
367	Engine Cooling Thermostat Housing
368	Engine Cooling Thermostat Housing Bolt
369	Engine Cooling Thermostat Bolt - Short
377	Water Outlet Seal
378	Water Outlet O-ring
379	Water Outlet Bolt
380	Water Outlet
395	Coolant Pipe
396	Coolant Pipe O-ring
398	Coolant Pipe Bracket Bolt - Large
399	Coolant Pipe Bracket Bolt - Small
430	Oil Level Indicator
431	Oil Level Indicator Tube
432	Oil Level Indicator Tube O-ring
433	Oil Level Indicator Tube Bolt
434	Oil Level Indicator Handle O-ring
495	Water Inlet/Outlet Pipe
496	Water Inlet/Outlet Pipe O-ring
498	Water Inlet/Outlet Pipe Bolts
499	Water Inlet/Outlet Pipe Gaskets
720	Crankshaft Position Sensor
721	Crankshaft Position Sensor O-ring
722	Crankshaft Position Sensor Bolt
723	Knock Sensor
723	Knock Sensor
724	Knock Sensor Bolt
724	Knock Sensor Bolt

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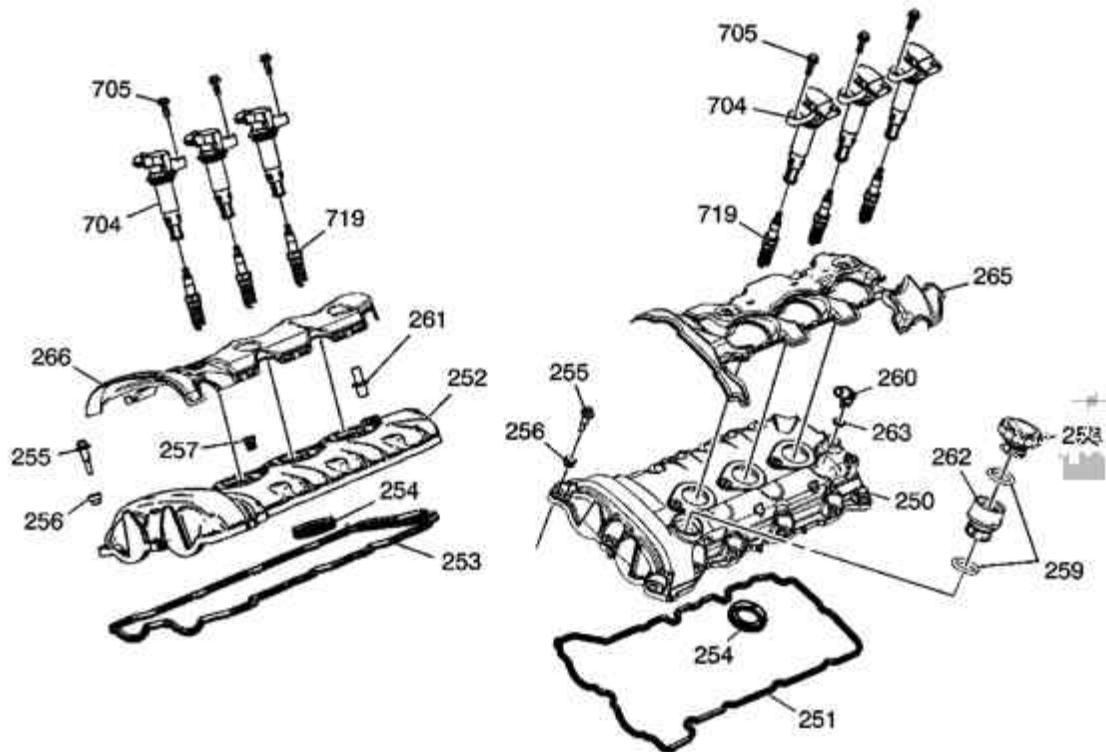


Fig. 37: View Of Camshaft Cover Assemblies
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
250	Left Camshaft Cover
251	Left Camshaft Cover Gasket
252	Right Camshaft Cover
253	Right Camshaft Cover Gasket
254	Camshaft Cover Spark Plug Port Seal
254	Camshaft Cover Spark Plug Port Seal
255	Camshaft Cover Bolt
255	Camshaft Cover Bolt
256	Camshaft Cover Bolt Insulator
256	Camshaft Cover Bolt Insulator
257	Ignition Coil Bolt Thread Insert
258	Oil Fill Cap

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259	Oil Fill O-ring
260	Left Camshaft Cover PCV Fitting
261	Right Camshaft Cover PCV Fitting Orifice
262	Oil Fill Tube
263	Left Camshaft Cover PCV Fitting O-ring
265	Left Camshaft Housing Cover Insulator
266	Right Camshaft Housing Cover Insulator
704	Ignition Coil
704	Ignition Coil
705	Ignition Coil Bolt
705	Ignition Coil Bolt
719	Spark Plug
719	Spark Plug

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Fig. 38: Identifying Camshaft Timing Components - Third Design
Courtesy of GENERAL MOTORS CORP.

[illegible]

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154	Lower Primary Timing Chain Guide Bolt
155	Primary Timing Chain
156	Upper Primary Timing Chain Guide
161	Camshaft Intermediate Drive Shaft Sprocket Bolt
161	Camshaft Intermediate Drive Shaft Sprocket Bolt
164	Primary Timing Chain Tensioner Gasket
165	Left Camshaft Intermediate Drive Shaft Sprocket
166	Right Camshaft Intermediate Drive Shaft Sprocket
170	Secondary Timing Chain
170	Secondary Timing Chain
171	Left Secondary Timing Chain Guide
173	Left Secondary Timing Chain Shoe
174	Left Secondary Timing Chain Shoe Bolt
174	Left Secondary Timing Chain Shoe Bolt
175	Left Secondary Timing Chain Tensioner
177	Left Secondary Timing Chain Tensioner Gasket
181	Right Secondary Timing Chain Guide
183	Right Secondary Timing Chain Shoe
185	Right Secondary Timing Chain Tensioner
187	Right Secondary Timing Chain Tensioner Gasket
190	Exhaust Camshaft Position Actuator
190	Exhaust Camshaft Position Actuator
191	Intake Camshaft Position Actuator
191	Intake Camshaft Position Actuator
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt

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Fig. 39: View Of Camshaft Timing Components - Fourth Design
Courtesy of GENERAL MOTORS CORP.

[illegible]

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154	Lower Primary Timing Chain Guide Bolt
155	Primary Timing Chain
156	Upper Primary Timing Chain Guide
161	Camshaft Intermediate Drive Shaft Sprocket Bolt
161	Camshaft Intermediate Drive Shaft Sprocket Bolt
164	Primary Timing Chain Tensioner Gasket
165	Left Camshaft Intermediate Drive Shaft Sprocket
166	Right Camshaft Intermediate Drive Shaft Sprocket
170	Secondary Timing Chain
170	Secondary Timing Chain
171	Left Secondary Timing Chain Guide
173	Left Secondary Timing Chain Shoe
174	Left Secondary Timing Chain Shoe Bolt
174	Left Secondary Timing Chain Shoe Bolt
175	Left Secondary Timing Chain Tensioner
177	Left Secondary Timing Chain Tensioner Gasket
181	Right Secondary Timing Chain Guide
183	Right Secondary Timing Chain Shoe
185	Right Secondary Timing Chain Tensioner
187	Right Secondary Timing Chain Tensioner Gasket
190	Exhaust Camshaft Position Actuator
190	Exhaust Camshaft Position Actuator
191	Intake Camshaft Position Actuator
191	Intake Camshaft Position Actuator
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt
192	Camshaft Position Actuator Bolt

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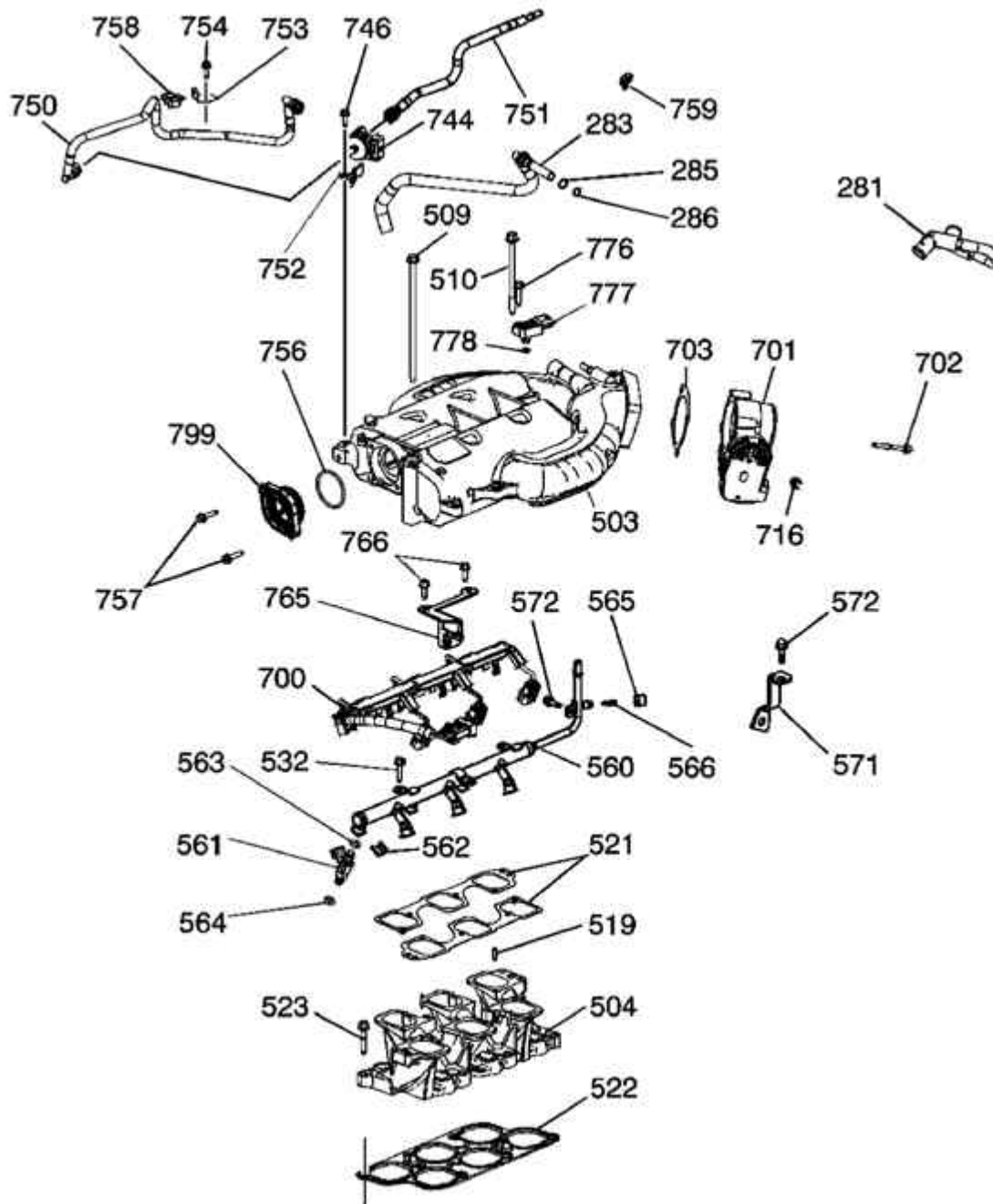


Fig. 40: Identifying Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
281	Clean PCV Hose
283	Dirty PCV Hose

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285	PCV Hose O-ring Outer/Larger
286	PCV Hose O-ring Inner/Smaller
503	Upper Intake Manifold
504	Lower Intake Manifold
509	Upper Intake Manifold Bolt - Long
510	Upper Intake Manifold Bolt - Short
519	Lower Intake Manifold to Upper Intake Manifold Dowel Pin
521	Upper Intake Manifold Gasket
522	Lower Intake Manifold Gasket
523	Lower Intake Manifold Bolt
532	Fuel Rail Bolt
560	Fuel Rail
561	Fuel Injector
562	Fuel Injector Retainer
563	Fuel Injector Upper Seal
564	Fuel Injector Lower Seal
565	Fuel Pressure Service Valve Cap
566	Fuel Pressure Service Valve
571	Fuel Rail Support Bracket
572	Fuel Rail Support Bracket Bolt
572	Fuel Rail Support Bracket Bolt
700	Fuel Injector Wiring Harness
701	Throttle Body
702	Throttle Body Bolt
703	Throttle Body Gasket
716	Throttle Body Engine Wiring Harness Clip
744	EVAP Purge Solenoid
746	EVAP Purge Solenoid Bolt
750	EVAP Purge Solenoid Tube - Intake Manifold to EVAP Solenoid
751	EVAP Purge Solenoid Tube - EVAP Solenoid to Chassis
752	EVAP Purge Solenoid Bracket

753	EVAP Purge Solenoid Tube Bracket
754	EVAP Purge Solenoid Tube Bracket Bolt
756	Intake Manifold Tuning Valve O-ring
757	Intake Manifold Tuning Valve Bolt
758	EVAP Purge Solenoid Tube Clip
759	EVAP Purge Solenoid Tube Clip
765	Fuel Injector Wiring Harness Bracket
766	Fuel Injector Wiring Harness Bracket Bolt
776	BARO Sensor Bolt
777	BARO Sensor
778	BARO Sensor O-ring
799	Intake Manifold Opening Cover

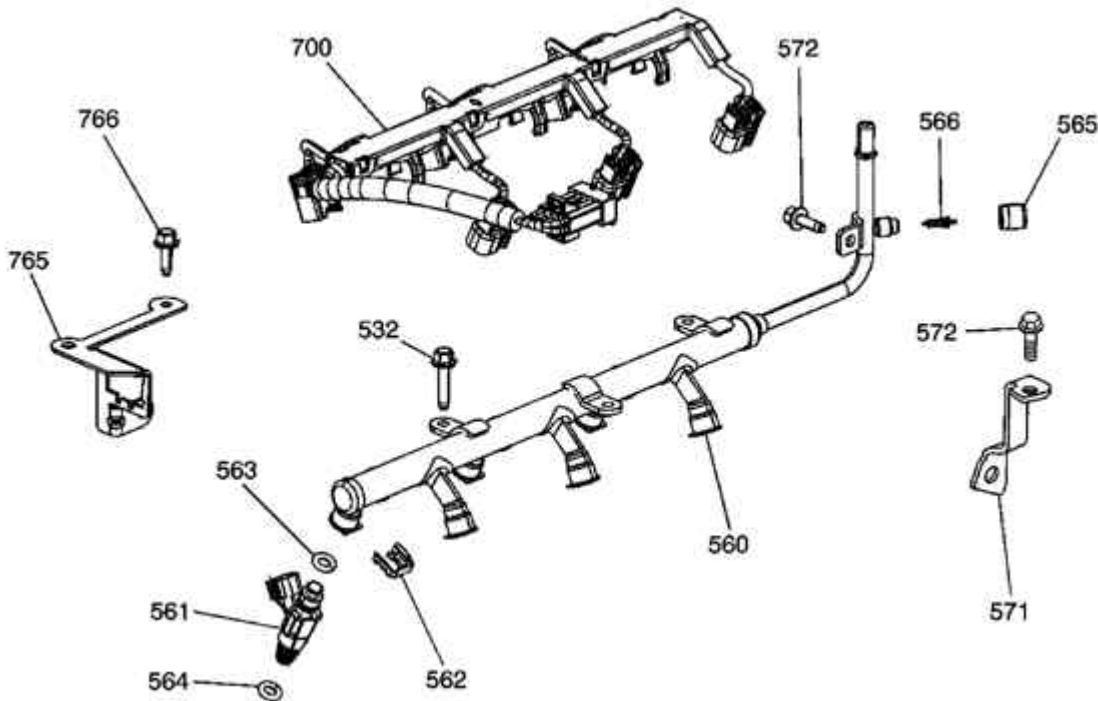


Fig. 41: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name

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532	Fuel Rail Bolt
560	Fuel Rail
561	Fuel Injector
562	Fuel Injector Retainer
563	Fuel Injector Upper Seal
564	Fuel Injector Lower Seal
565	Fuel Pressure Service Valve Cap
566	Fuel Pressure Service Valve
571	Fuel Rail Bracket
572	Fuel Rail Bracket Bolt
572	Fuel Rail Bracket Bolt
700	Fuel Injector Wiring Harness
765	Fuel Injector Wiring Harness Bracket
766	Fuel Injector Wiring Harness Bracket Bolt

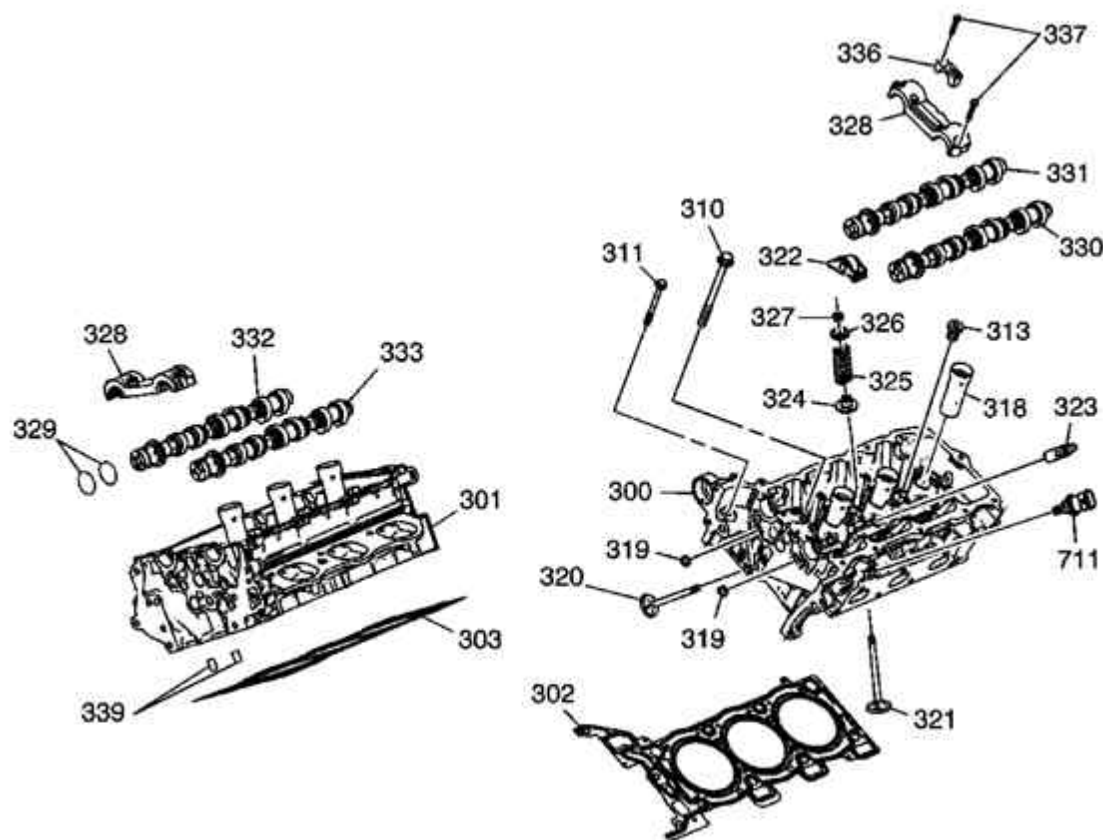


Fig. 42: View Of Cylinder Head Assemblies
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
300	Left Cylinder Head
301	Right Cylinder Head
302	Left Cylinder Head Gasket
303	Right Cylinder Head Gasket
310	Cylinder Head Bolt
311	Cylinder Head Front Bolt
313	Cylinder Head Coolant Hole Threaded Plug
318	Spark Plug Sleeve
319	Cylinder Head Oil Gallery Expansion Plug - 14 mm
319	Cylinder Head Oil Gallery Expansion Plug - 14 mm
320	Exhaust Valve
321	Intake Valve
322	Valve Rocker Arm Assembly
323	Hydraulic Valve Lash Adjuster Assembly
324	Valve Stem Oil Seal
325	Valve Spring
326	Valve Spring Cap
327	Valve Stem Key
328	Cylinder Head Camshaft Front Thrust Bearing Cap
328	Cylinder Head Camshaft Front Thrust Bearing Cap
329	Camshaft Oil Seal Ring
330	Left Exhaust Camshaft
331	Left Intake Camshaft
332	Right Intake Camshaft
333	Right Exhaust Camshaft
336	Cylinder Head Camshaft Cap - Intermediate
337	Cylinder Head Camshaft Cap Bolt
339	Cylinder Head Oil Gallery Check Valve

711

Engine Coolant Temperature Sensor

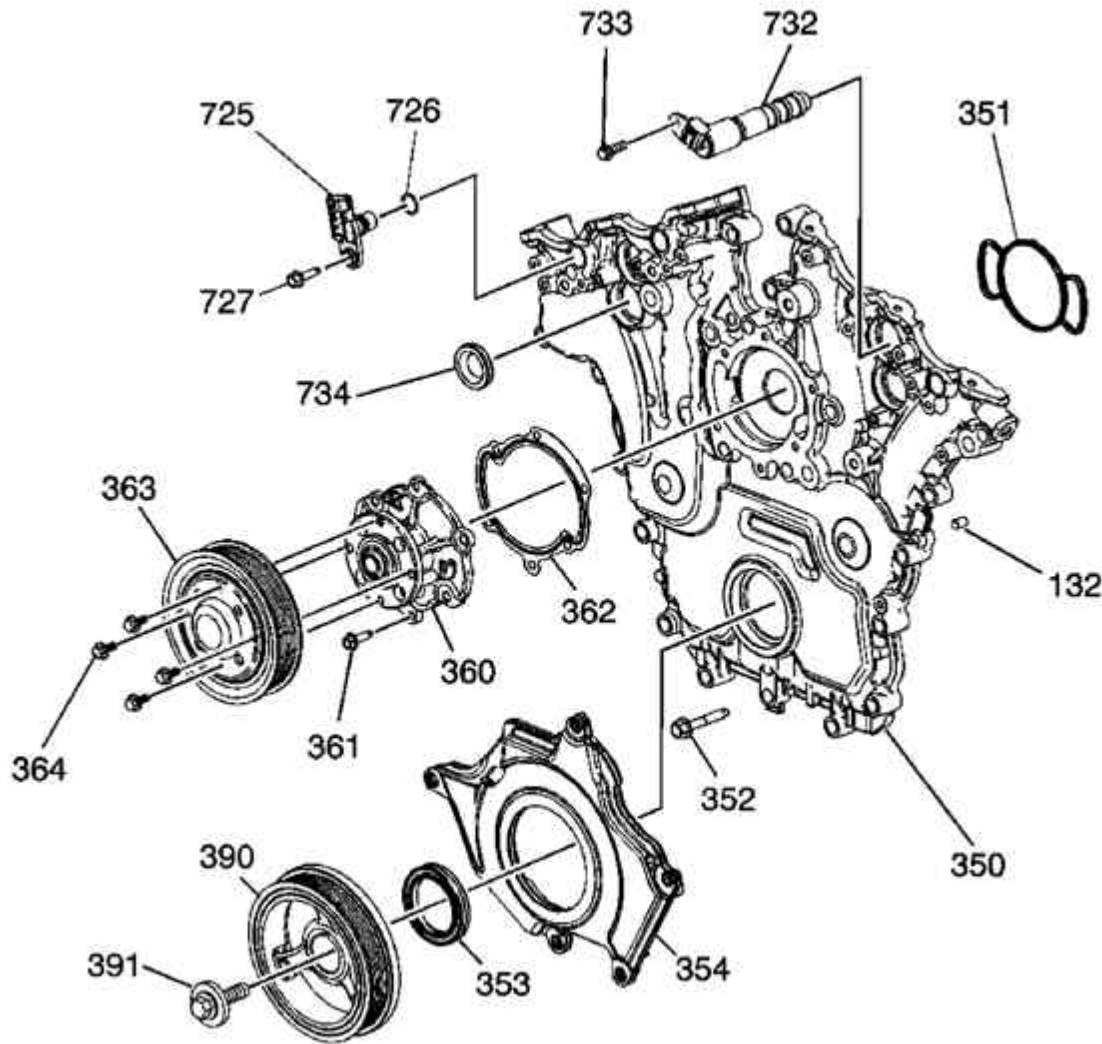


Fig. 43: Identifying Engine Front Cover & Related Components
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
132	Engine Front Cover Locating Pin
350	Engine Front Cover
351	Engine Front Cover Gasket
352	Engine Front Cover Bolt
353	Engine Front Cover Seal

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354	Engine Front Cover Deadener
360	Water Pump Assembly
361	Water Pump Bolt
362	Water Pump Gasket
363	Water Pump Pulley
364	Water Pump Pulley Bolt
390	Crankshaft Balancer
391	Crankshaft Balancer Bolt
725	Camshaft Position Sensor
726	Camshaft Position Sensor O-ring
727	Camshaft Position Sensor Bolt
732	Camshaft Position Actuator Solenoid Valve
733	Camshaft Position Actuator Solenoid Valve Bolt
734	Camshaft Position Actuator Solenoid Valve Seal

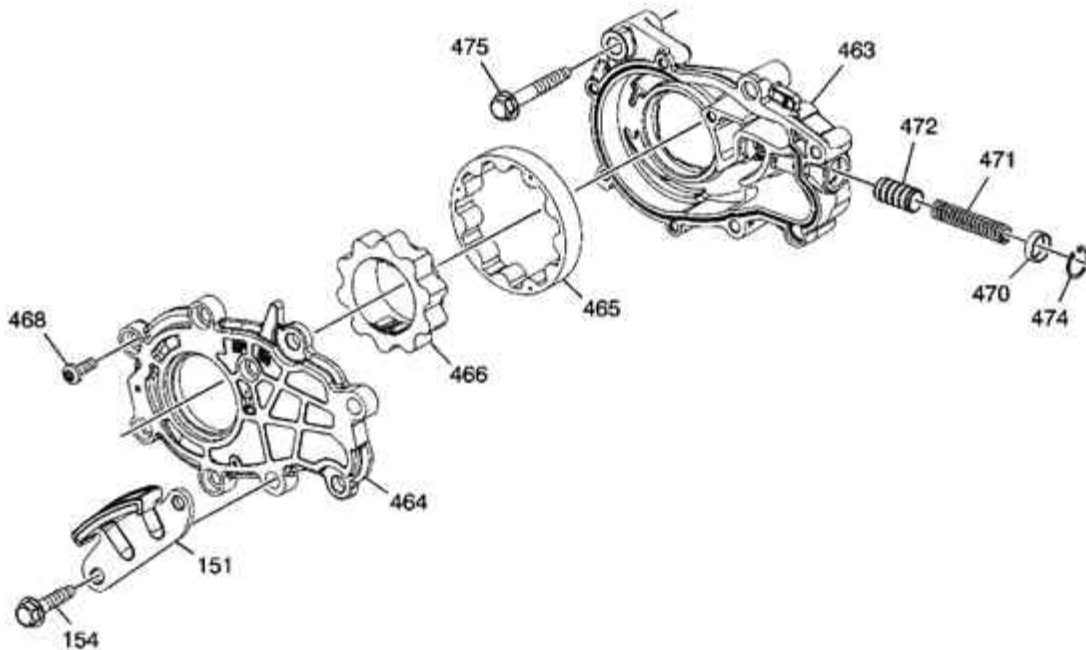


Fig. 44: View Of Oil Pump Components - Second Design
Courtesy of GENERAL MOTORS CORP.

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Callout	Component Name
151	Lower Primary Timing Chain Guide
154	Lower Primary Timing Chain Guide Bolt
463	Oil Pump Housing
464	Oil Pump Cover
465	Oil Pump Driven Gear
466	Oil Pump Drive Gear
468	Oil Pump Cover Bolt
470	Oil Pressure Relief Valve Bore Plug
471	Oil Pressure Relief Valve Spring
472	Oil Pressure Relief Valve
474	Oil Pressure Relief Valve Bore Plug Retainer Clip
475	Oil Pump Bolt

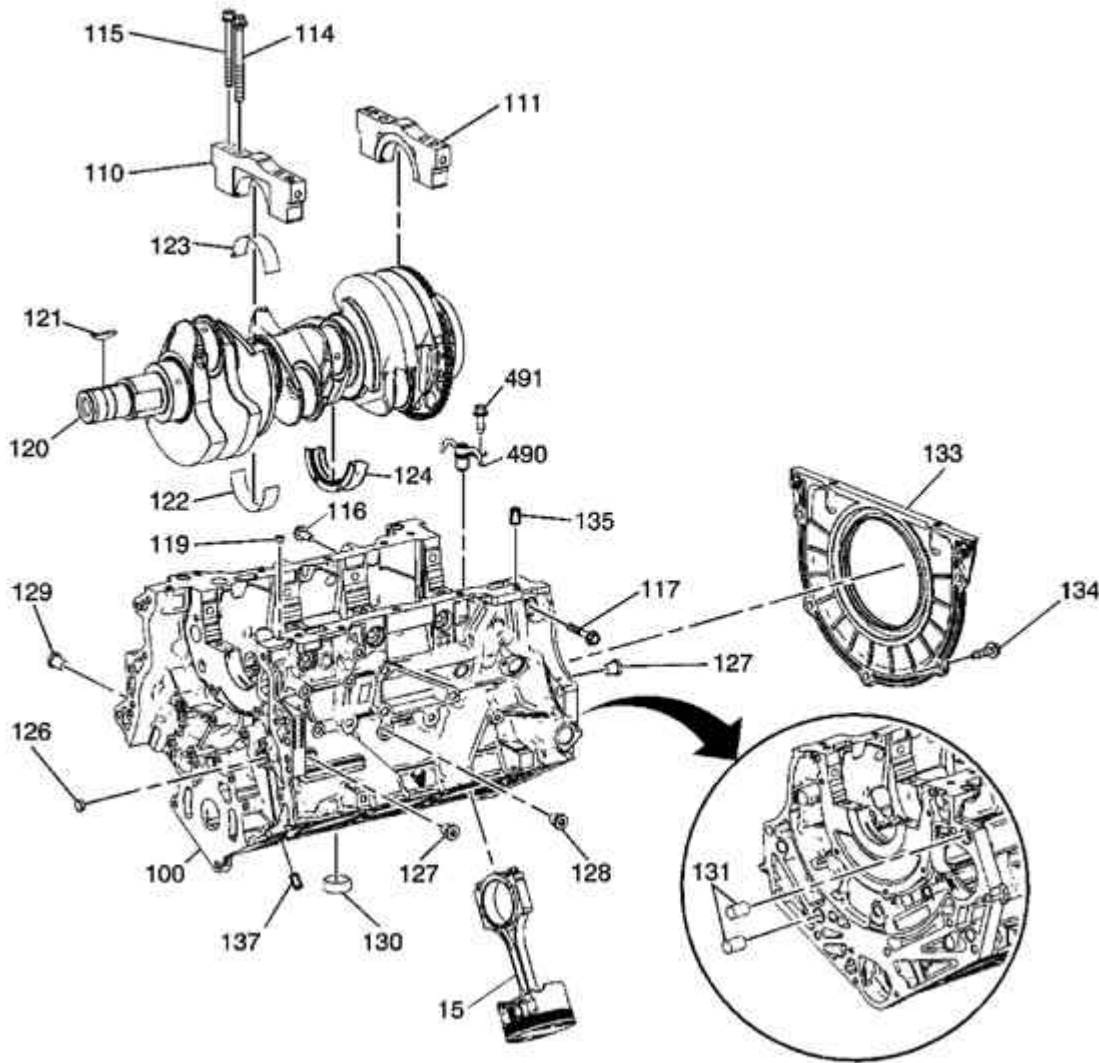


Fig. 45: Disassembled View Of Engine Block Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
15	Piston and Connecting Rod Assembly
100	Engine Block
110	Crankshaft Bearing Cap
111	Crankshaft Bearing Thrust Cap
114	Crankshaft Bearing Cap Inboard Bolt
115	Crankshaft Bearing Cap Outboard Bolt
116	Crankshaft Bearing Cap Side Bolt - Short

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117	Crankshaft Bearing Cap Side Bolt - Long
119	Engine Block Oil Gallery Expansion Plug - 10 mm
120	Crankshaft
121	Crankshaft Key
122	Crankshaft Upper Bearing
123	Crankshaft Lower Bearing
124	Crankshaft Upper Thrust Bearing #3
126	Engine Block Oil Gallery Expansion Plug - 14 mm
127	Engine Block Oil Gallery Threaded Plug - 14 mm
127	Engine Block Oil Gallery Threaded Plug - 14 mm
128	Engine Block Coolant Drain Threaded Plug - 14 mm
129	Engine Block Oil Gallery Threaded Plug - 20 mm
130	Engine Block Core Coolant Expansion Plug - 34.3 mm
131	Transaxle Locating Pin
133	Crankshaft Rear Oil Seal Housing Assembly
134	Crankshaft Rear Oil Seal Housing Assembly Bolt
135	Oil Pan Locating Pin
137	Cylinder Head Locating Pin
490	Piston Oil Nozzle
491	Piston Oil Nozzle Bolt

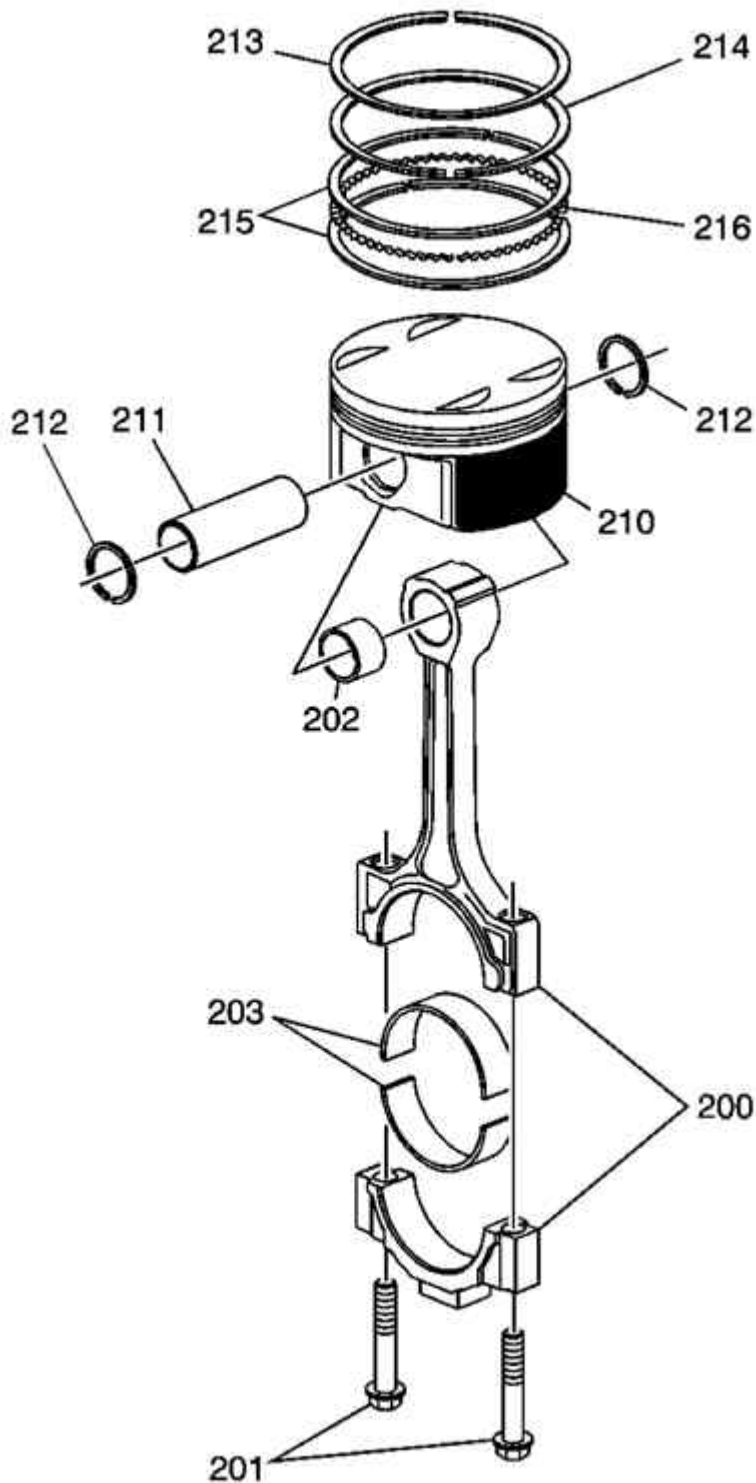


Fig. 46: Piston, Rings, Bearing and Connecting Rod Disassembled View
Courtesy of GENERAL MOTORS CORP.

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Callout	Component Name
200	Connecting Rod
201	Connecting Rod Bolt
202	Connecting Rod Bushing
203	Connecting Rod Bearing
210	Piston
211	Piston Pin
212	Piston Pin Retainer
212	Piston Pin Retainer
213	Piston Upper Compression Ring
214	Piston Lower Compression Ring
215	Piston Oil Control Rail Ring
216	Piston Oil Control Ring Spacer

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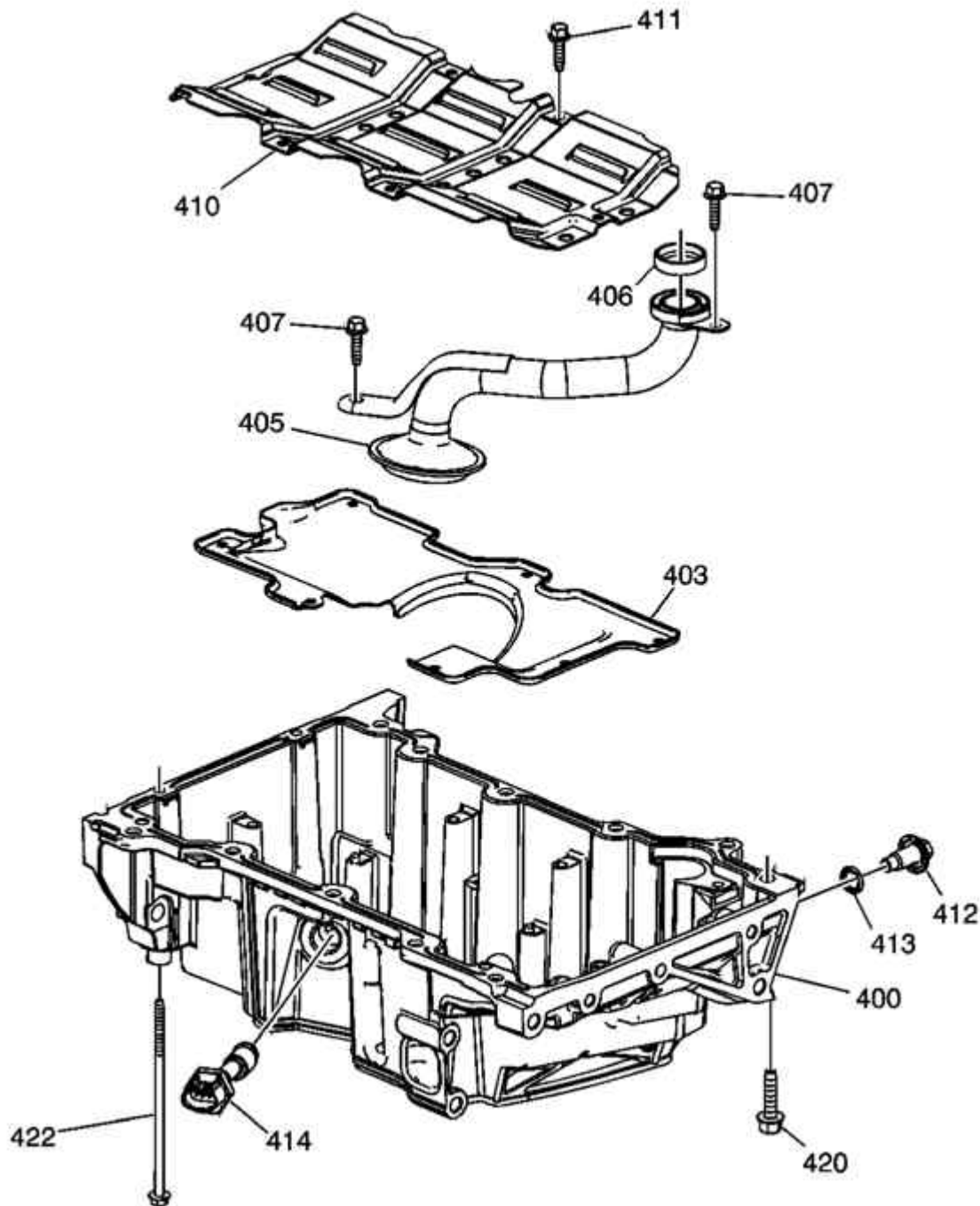


Fig. 47: View Of Oil Pan Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
400	Oil Pan

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403	Oil Pan Baffle
405	Oil Pump Suction Pipe
406	Oil Pump Suction Pipe Gasket
407	Oil Pump Suction Pipe Bolt
407	Oil Pump Suction Pipe Bolt
410	Oil Pan Baffle Scraper
411	Oil Pan Baffle Scraper Bolt
412	Oil Pan Drain Plug
413	Oil Pan Drain Plug O-ring
414	Oil Level Sensor
420	Oil Pan Bolt
422	Oil Pan Bolt - Long

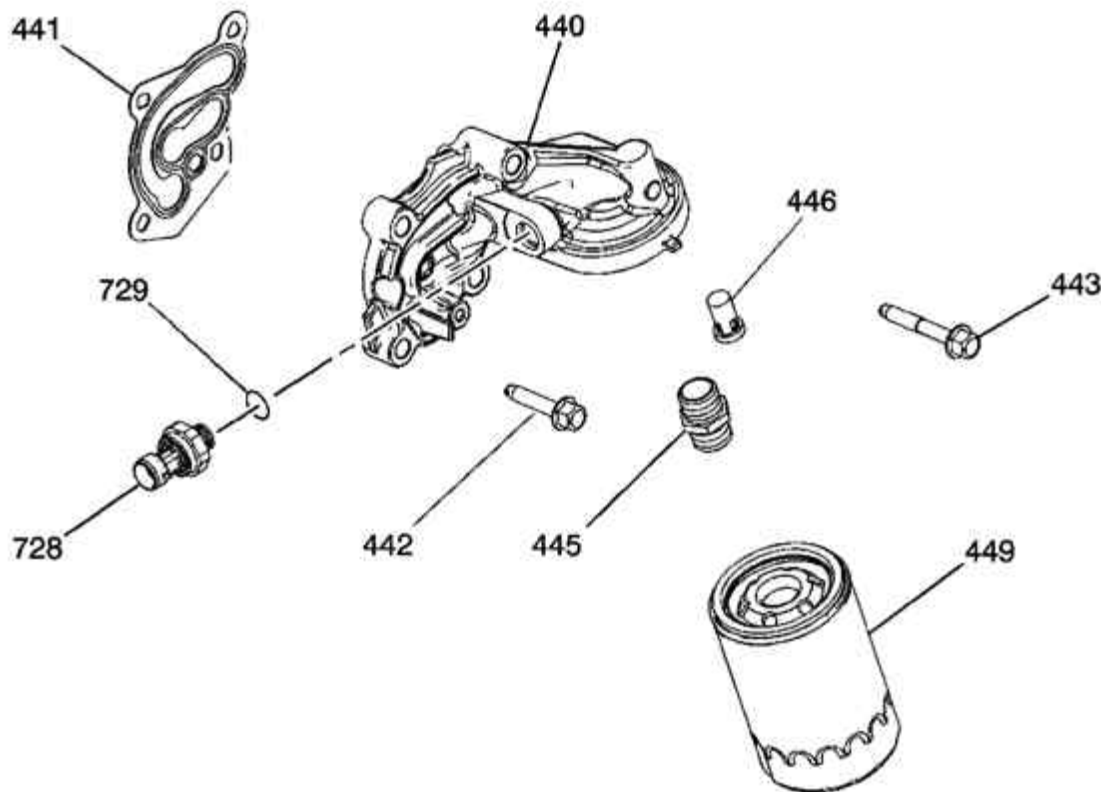


Fig. 48: Oil Filter Adapter Disassembled View
Courtesy of GENERAL MOTORS CORP.

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Callout	Component Name
440	Oil Filter Adapter
441	Oil Filter Adapter Gasket
442	Oil Filter Adapter Bolt
443	Oil Filter Adapter Bolt - Long
445	Oil Filter Fitting
446	Oil Filter Bypass Valve
449	Oil Filter
728	Engine Oil Pressure Sensor
729	Engine Oil Pressure Sensor O-ring.

ENGINE IDENTIFICATION

Vehicle Identification Number

The Vehicle Identification Number (VIN) Derivative is located in two places on the engine and is a nine digit number stamped or laser etched onto the block at the vehicle assembly plant. If reading the identification number the following information can be obtained:

- The first digit identifies the vehicle division.
- The second digit is the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

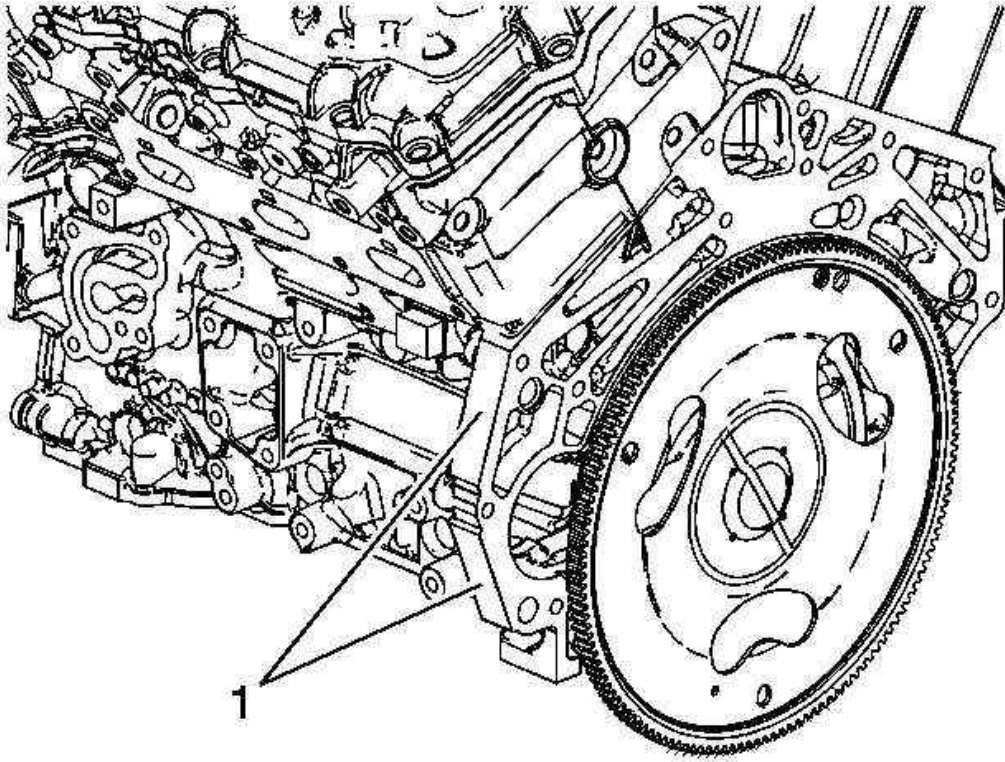


Fig. 49: Locating Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The engine block is marked with the VIN on a pad area on the left rear side (1).

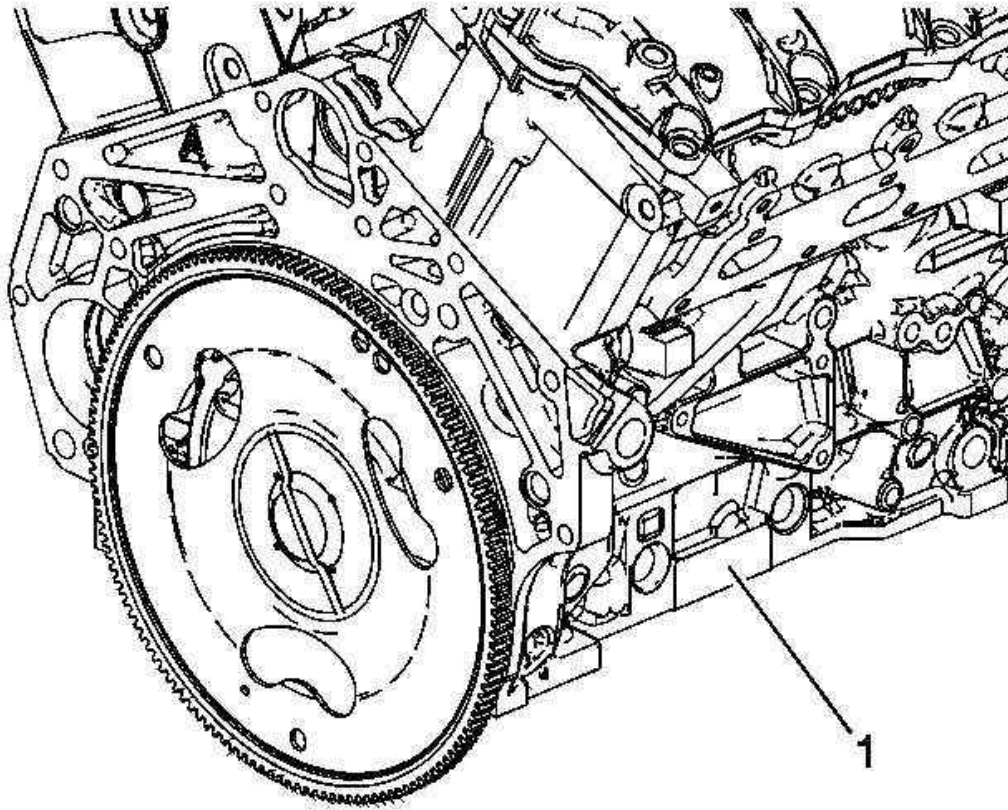


Fig. 50: Identifying Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The engine block is marked with the VIN on a pad area on the center lower right side (1).

Engine Traceability Label

The engine traceability label is located in two places on the engine and consists of the broadcast code, bar code and sequence number.

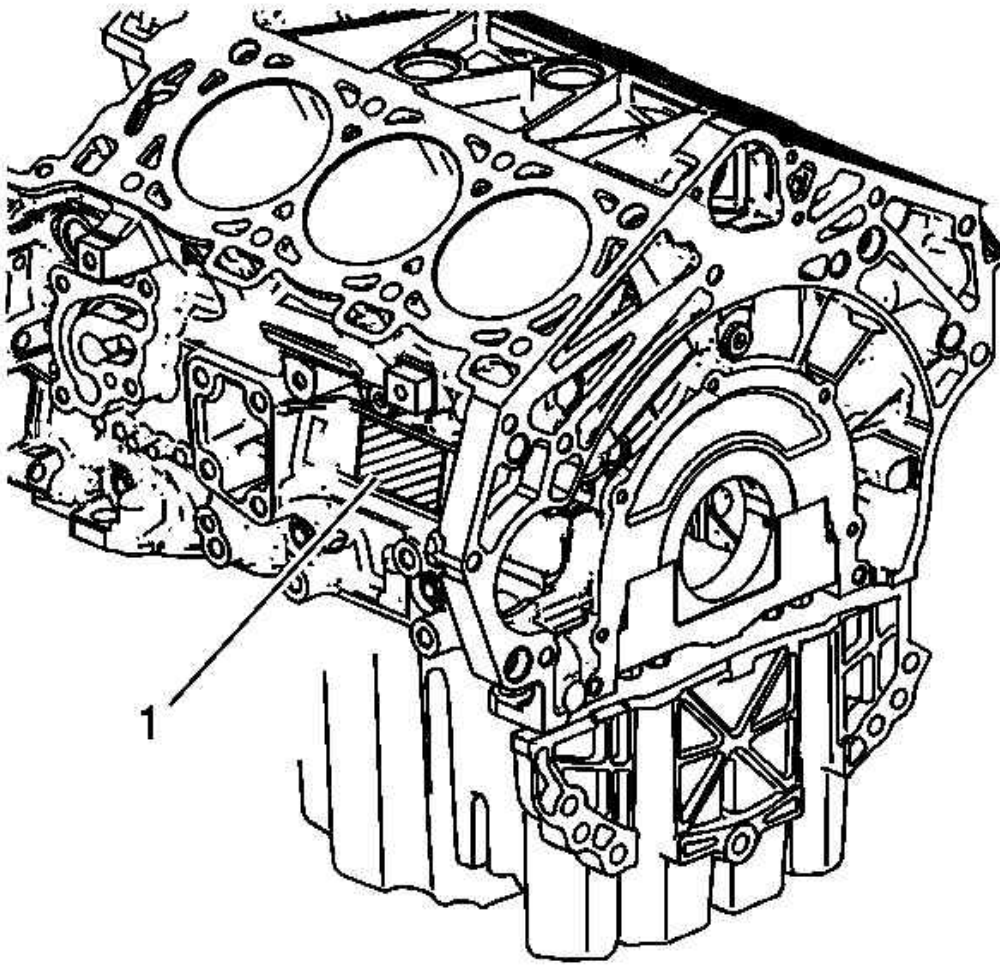


Fig. 51: Locating Left Rear Engine Traceability Label
Courtesy of GENERAL MOTORS CORP.

One engine traceability label (1) is located on the left rear side of the engine block.

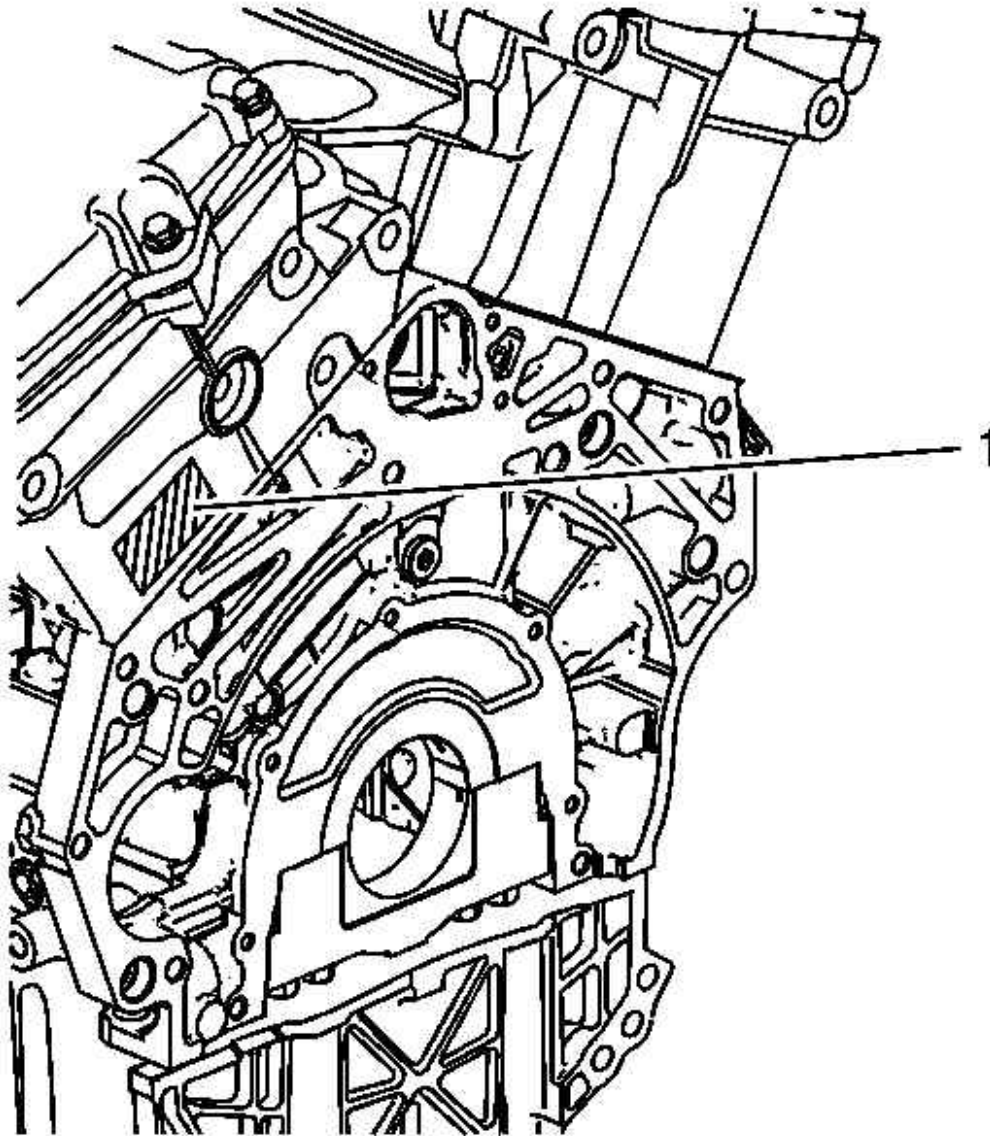


Fig. 52: View Of Engine Traceability Label On Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

Another engine traceability label (1) is located on the rear of the left cylinder head.

The engine verification label is located in two places on the engine and consists of the broadcast code and bar code.

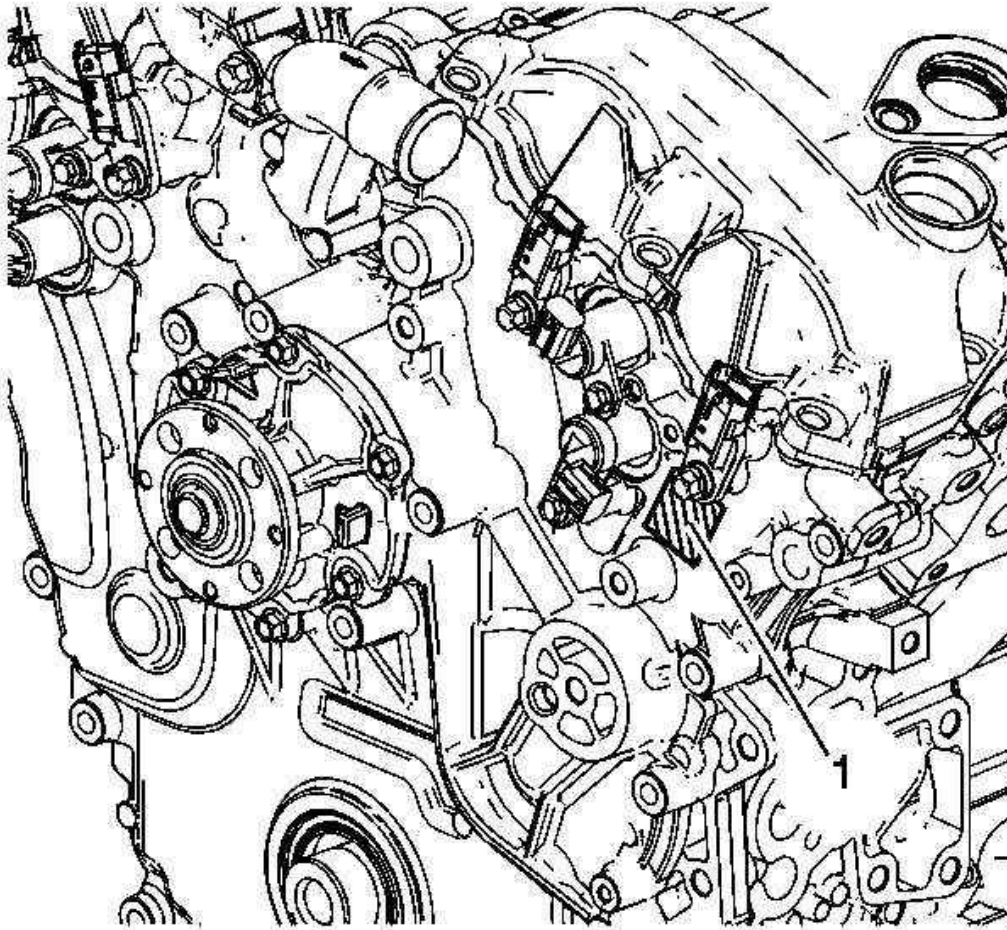


Fig. 53: Locating Left Engine Verification Label
Courtesy of GENERAL MOTORS CORP.

One engine verification label (1) is located on the left side of the engine front cover below the exhaust camshaft position sensor.

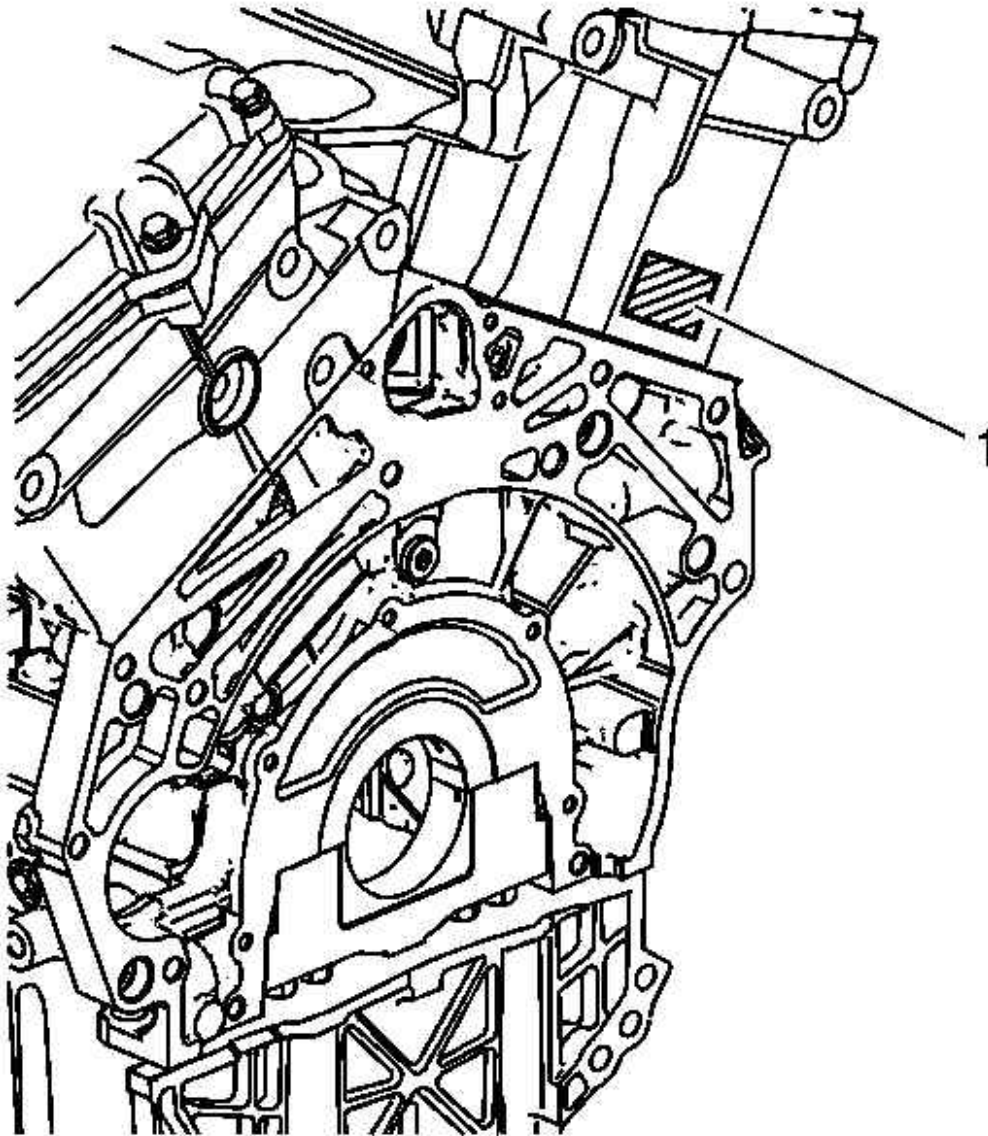


Fig. 54: Identifying Engine Verification Label On Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

Another engine verification label (1) is located on the rear of the right cylinder head.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note

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factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.

- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Engine Compression Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas, in the	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> .

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accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout and may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads, intake manifold and plenum duct, plenum duct and water crossover, water crossover and throttle body and/or pressure relief valve and intake manifold.	Replace the intake manifold, plenum duct, gaskets, cylinder heads, throttle body and/or pressure relief valve as required.
Improperly installed or damaged MAP sensor and/or seal	Repair or replace the MAP sensor as required.

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The sealing grommet of the MAP sensor should not be torn or damaged.	
Improperly installed or damaged EVAP purge solenoid and/or O-ring seal	Repair or replace the EVAP purge solenoid as required.
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs, valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to <u>Diagnostic Starting Point - Engine Cooling</u> . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> for the 3.6L engine. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> for the 3.6L engine. • Inspect the cylinders for a loss of

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compression. Refer to **Engine Compression Test**.

- Perform cylinder leak down and compression testing to identify the cause.
- Repair or replace as required.

A damaged crankshaft reluctor wheel
A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.

- Systems with SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.
- Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.

Replace the crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> .

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misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the engine flywheel and/or crankshaft balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .
Worn or Broken Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> for the 3.6L engine. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn Crankshaft Thrust Bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller	Replace the followers, valve rocker arms, as required.

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bearing should be intact and in the proper position.	
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs, valve lifters.
Sticking SHLAs, lifters	Replace the SHLAs as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to <u>Diagnostic Starting Point - Engine Cooling</u> . Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> . • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> . 2. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> .

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2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**.
3. Perform cylinder leak down and compression testing to determine the cause.
4. Repair or replace as required.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	Drain the engine oil and replace with the correct viscosity oil.
High stationary hydraulic lash adjuster (SHLA), valve lifter, leak down rate	Replace the SHLAs, valve lifters, as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Repair or replace as required.
Loose and/or worn follower, valve rocker arm	1. Inspect the follower, valve rocker arm.

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	2. Repair or replace as required.
Improper lubrication to the followers, valve rocker arms	Inspect the following components, and repair or replace as required: • The follower, valve rocker arm • The SHLA, valve lifter • The oil filter bypass valve • The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty stationary hydraulic lash adjusters (SHLAs), valve lifters	Replace the SHLAs, valve lifters.
Stretched or broken timing chain or chains and/or damaged sprocket teeth	Replace the timing chain or chains and sprockets.
Worn timing chain tensioner or tensioners	Replace the timing chain tensioner or tensioners as required.
Worn timing chain shoe or shoes	Replace the timing chain shoe or shoes as required.
Worn timing chain guide or guides	Replace the timing chain guide or guides as required.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft or camshafts and SHLAs, valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
• Stuck valves • Carbon on the valve stem or valve	Inspect the following components, and repair as required:

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seat may cause the valve to stay open

- The valves
- The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u> . • Repair or replace damaged components as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the Knock Sensor System. Refer to <u>Electronic Ignition (EI) System Diagnosis</u> .
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen • Repair or replace as required.
Oil pump screen loose, damaged or	• Inspect the oil pump screen.

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restricted	• Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u> .

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	• Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the Knock Sensor System. Refer to <u>Electronic Ignition (EI) System Diagnosis</u> .
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel, automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belt or belts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location.

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	3. Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and check for fluid. 2. Inspect for broken head gasket or gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace as required.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair as required.
Seized or broken camshaft	1. Inspect the camshaft or camshafts. 2. Inspect the cylinder head camshaft journals for damage.

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	3. Repair as required.
Seized or broken balance shaft	1. Inspect the balance shaft. 2. Inspect the block for damaged balance shaft bearings. 3. Repair as required.
Seized or broken camshaft timing components	1. Inspect the following sprockets: • The crankshaft sprocket • The exhaust sprockets • The intake sprockets 2. Inspect the following chains: • The primary camshaft drive chain • The secondary camshaft drive chains 3. Inspect the following guides: • The lower primary camshaft drive chain guide • The upper primary camshaft drive chain guides 4. Inspect the secondary camshaft drive chain shoe. 5. Inspect the following tensioners: • The primary camshaft drive chain tensioner • The secondary camshaft drive chain tensioners 6. Repair as required.
Seized or broken valve train components	1. Inspect the followers, rocker arms. 2. Inspect the lifters. 3. Inspect the valves.

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4. Inspect the valve springs.
5. Repair as required.

COOLANT IN COMBUSTION CHAMBER

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

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	Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

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

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	Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

ENGINE COMPRESSION TEST

Tools Required

J 39313 Spark Plug Port Adapter. See **Special Tools**.

A compression pressure test of the engine cylinders determines the condition of the rings, the valves and the head gasket.

Testing Procedure

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge.
2. Turn the engine OFF.

IMPORTANT: Remove the powertrain control module (PCM) and the ignition fuse from the instrument panel (I/P) fuse block.

3. Disable the ignition.
4. Disable the fuel systems.
5. Remove the spark plugs from all cylinders.
6. Remove the air duct from the throttle body.
7. Block the throttle plate in open position.
8. Measure the engine compression, using the following procedure:
 1. Thread the **J 39313** into the spark plug hole. See **Special Tools**.
 2. Thread the compression gage into the **J 39313** . See **Special Tools**.
 3. Have an assistant crank the engine through, at least 4 compression strokes, in the testing cylinder.

4. Check and record the readings on the gage at each stroke.
5. Remove the compression gage from the **J 39313** . See **Special Tools**.
6. Remove the **J 39313** from the spark plug hole. See **Special Tools**.
7. Repeat the compression test for each cylinder.
9. Record the compression readings from all of the cylinders.
 - The lowest reading should not be less than 70 percent of the highest reading.
 - No cylinder reading should be less than 965 kPa (140 psi).
10. The following are examples of measurement problems:
 - When the compression measurement is normal, the compression builds up quickly and evenly to specified compression on each cylinder.
 - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil. Use approximately 3 squirts of oil from a plunger-type oiler.
 - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
 - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
11. Remove the block from the throttle plate.
12. Install the air duct to the throttle body.
13. Install the spark plugs.
14. Install the powertrain control module (PCM).
15. Install the ignition fuses to the I/P fuse block.

CYLINDER LEAKAGE TEST

Tools Required

- **J 35667-A** Cylinder Head Leakdown Tester. See **Special Tools**.
- **J 39313** Spark Plug Port Adapter. See **Special Tools**.

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

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

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Thread the **J 39313** into the spark plug hole. See Special Tools.
5. Install the **J 35667-A** or equivalent. See Special Tools.

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

6. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturers instructions. See Special Tools.
7. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:

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- Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring
- Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring
- Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head
- Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

8. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Checks	Causes
DEFINITION: Excessive oil consumption (not due to leaks) is the use of 0.946 L (1 qt) or more of engine oil within 3 200 km (2,000 mi). The causes of excessive oil consumption may include the following conditions:	
Preliminary	• External oil leaks - Refer to <u>Oil Leak Diagnosis</u>. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or

malfunctioning components

- Worn valve guides and/or valve stems
- Worn, missing or improperly installed valve stem oil seals
- Piston rings broken, worn, not seated properly

Allow adequate time for the rings to seat.

Replace worn piston rings as necessary.

- Piston and rings improperly installed or miss-fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **J 21867** Pressure Gage. See **Special Tools**.
- **J 42907** Oil Pressure Tester. See **Special Tools**.

1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2-3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
 - Oil diluted by water or glycol antifreeze
 - Foamy oil

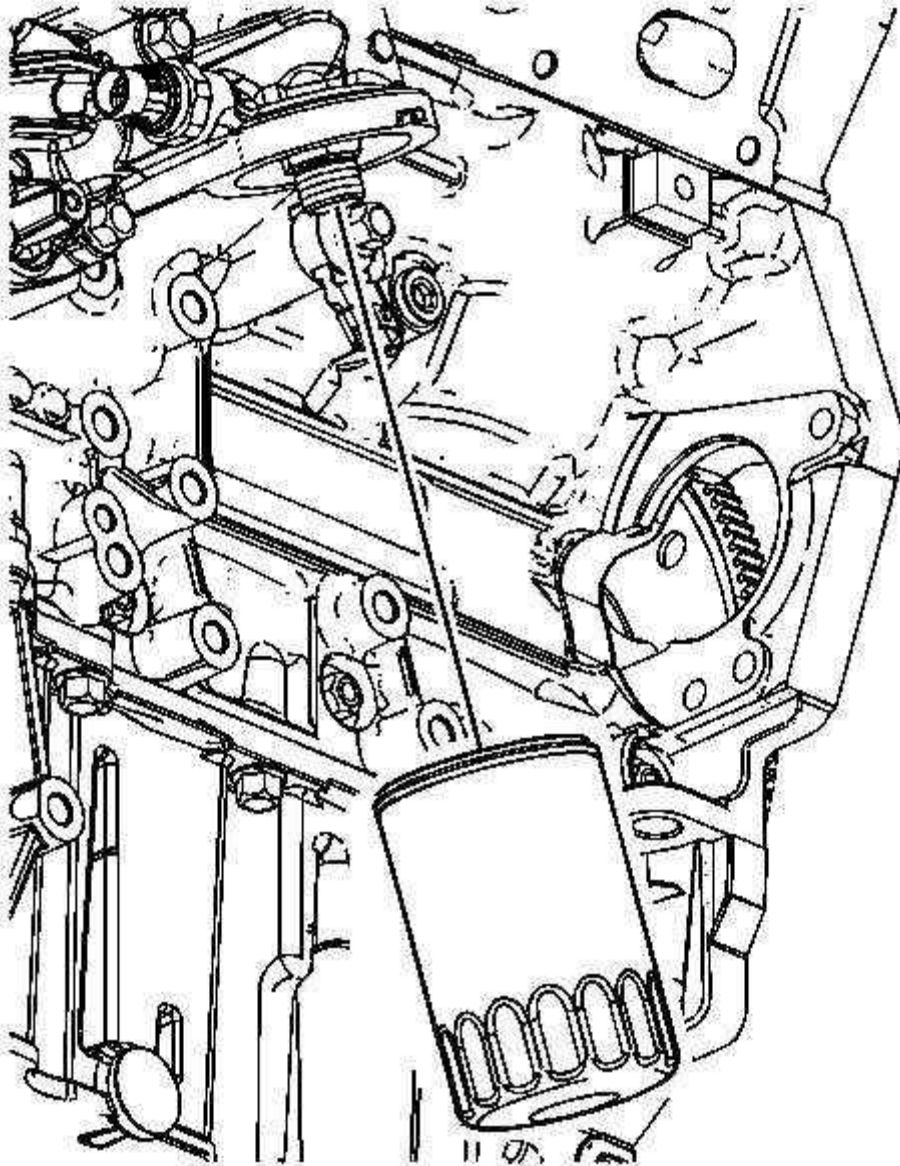


Fig. 55: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.

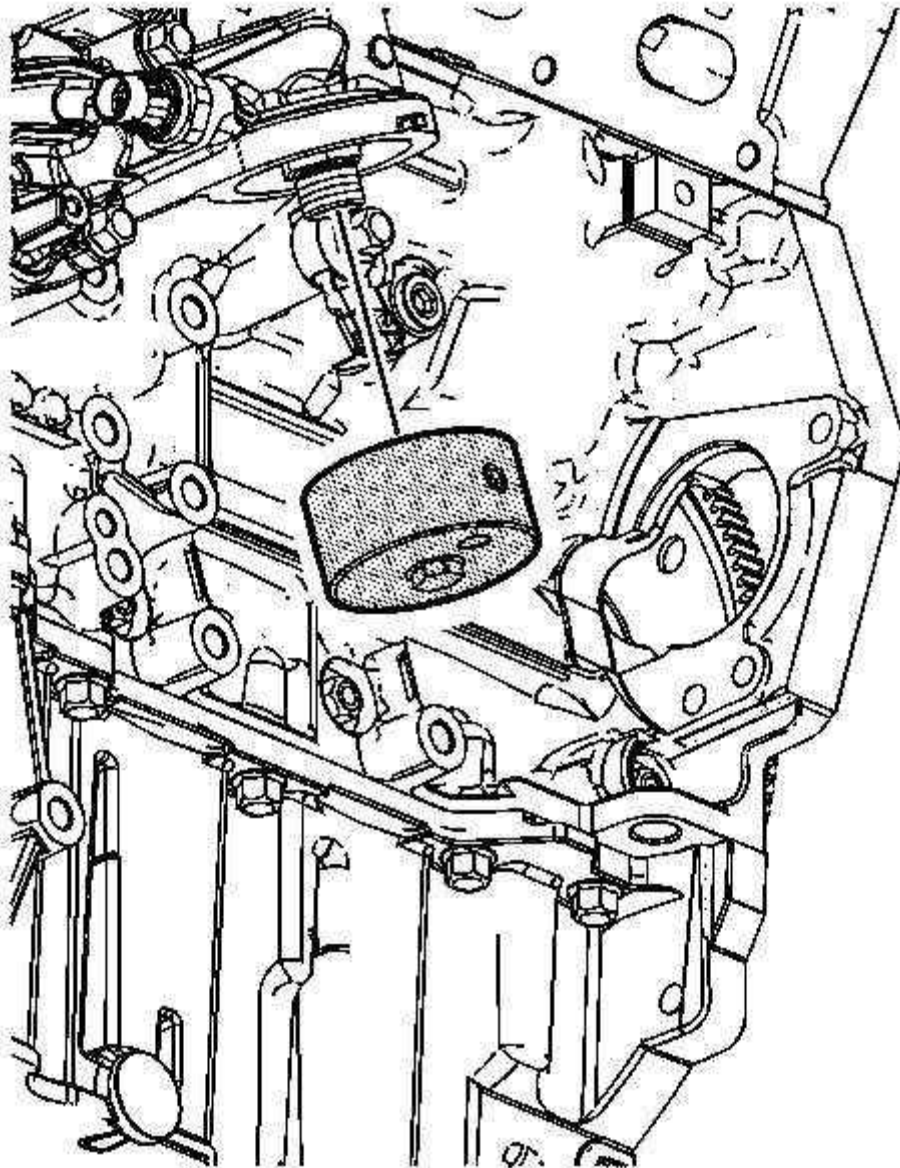


Fig. 56: View Of Engine Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 42907** onto the oil filter adapter. See **Special Tools**.

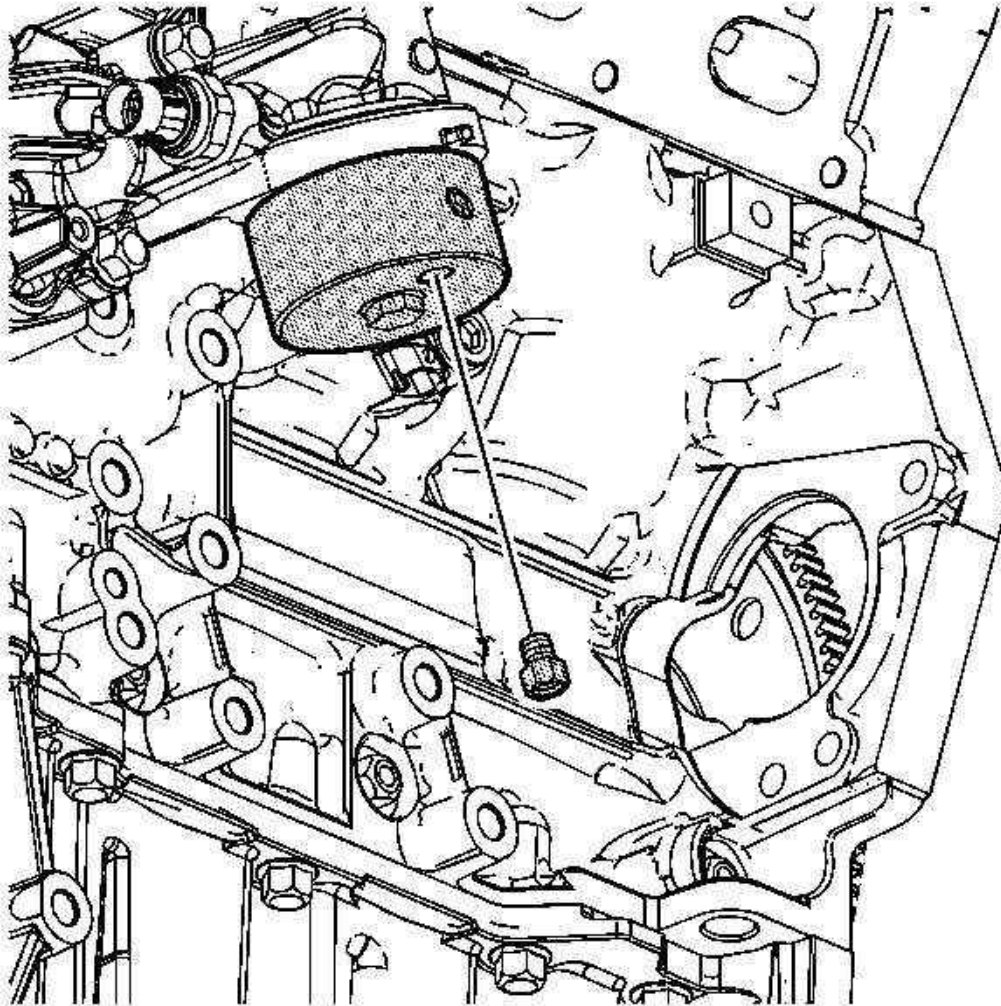


Fig. 57: View Of Engine Oil Filter Adapter & 1/8 NPT Fitting
Courtesy of GENERAL MOTORS CORP.

8. Install the 1/8 NPT fitting from the **J 21867** into the port on the **J 42907** . See **Special Tools**.

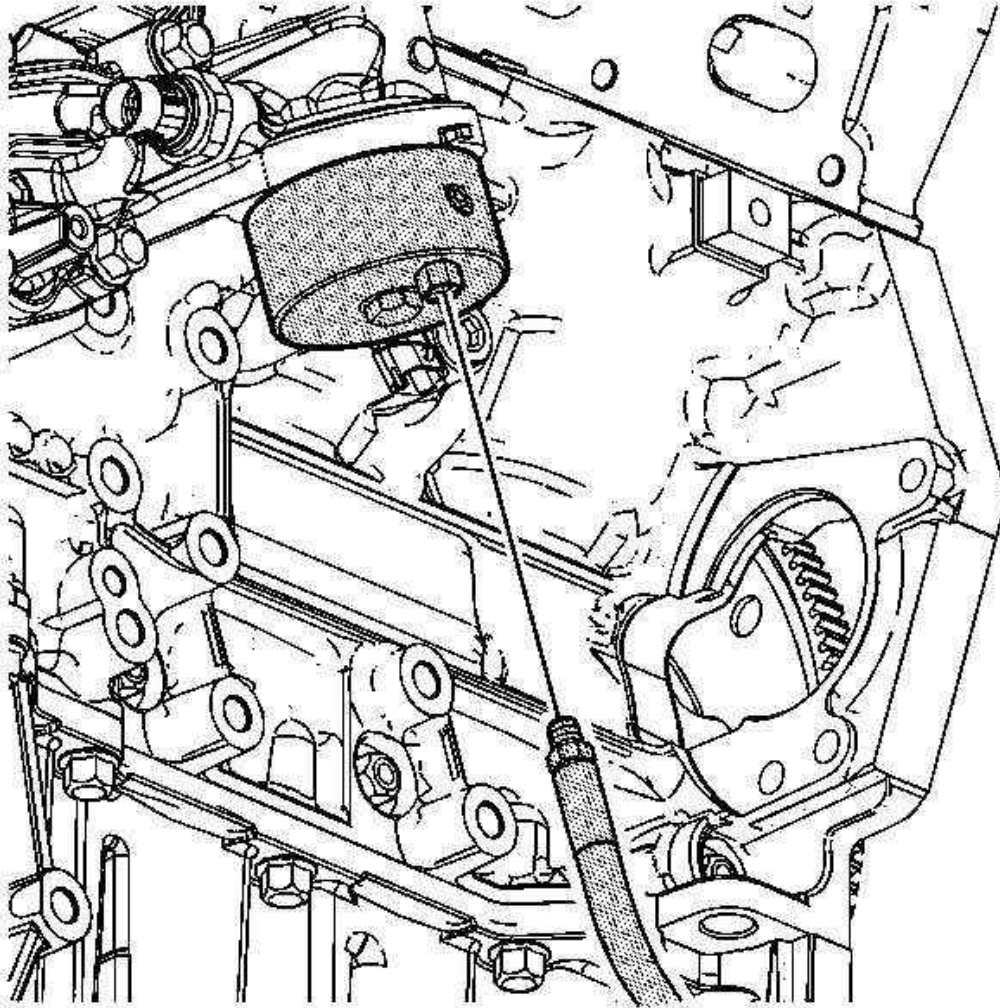


Fig. 58: View Of Engine Oil Filter Adapter & Flexible Hose
Courtesy of GENERAL MOTORS CORP.

9. Install the **J 21867** flexible hose to the **J 42907** . See **Special Tools**.
10. Run the engine and measure the engine oil pressure.
11. Compare the readings to **Engine Mechanical Specifications**.
12. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:

- Oil pump worn or dirty. Refer to **Oil Pump Replacement** , **Oil Pump Disassemble** and **Oil Pump Cleaning and Inspection** .
 - Oil pump-to-engine block bolts loose. Refer to **Oil Pump Replacement** .
 - Oil pump screen loose, plugged, or damaged. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement** .
 - Oil pump screen O-ring seal missing or damaged. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement** .
 - Oil pump pressure relief valve malfunction. Refer to **Oil Pump Replacement** .
 - Engine bearing clearance excessive. Refer to **Crankshaft and Bearing Cleaning and Inspection** , **Crankshaft and Bearing Installation** and **Piston, Connecting Rod, and Bearing Installation** .
 - Cracked, porous, or restricted oil galleries.
 - Oil gallery plugs missing or incorrectly installed. Refer to **Engine Block Assemble** and **Cylinder Head Assemble** .
 - Valve lifters broken. Repair, as necessary. Refer to **Valve Lifter Replacement - Left Side** and/or **Valve Lifter Replacement - Right Side** and **Valve Lifters Cleaning and Inspection** .
13. If the oil pressure reading on the **J 21867** , or equivalent, is within specifications, inspect for the following conditions:
- Plugged or incorrect oil filter and/or malfunctioning oil bypass valve. Refer to **Engine Oil and Oil Filter Replacement** .
 - Malfunctioning oil pressure gage or sensor. Repair, as necessary. Refer to **Engine Oil Pressure Sensor and/or Switch Replacement** .

OIL LEAK DIAGNOSIS

Checks	Action
NOTE: It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components. You can repair most fluid leaks by first visually locating the leak, repairing or	

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replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.

Locating and identifying the leak

To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid, or some other fluid, use the visual inspection method.

Visual Inspection Method

1. Bring the vehicle to normal operating temperature.
2. Park the vehicle over a large sheet of paper, or other clean surface.
3. Wait several minutes, then check for drippings.
4. Identify the type of fluid, and the approximate location of the leak.
5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components.
7. If you cannot locate the leak, do the following:
 1. Completely clean the entire engine and surrounding components.
 2. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
 3. Park the vehicle over a large sheet of paper, or other clean surface.
 4. Wait several minutes, then check for drippings.
 5. Identify the type of fluid, and the approximate location of the leak.
 6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.

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	7. See possible causes for leaks. 8. If you still cannot locate the leak, use the powder method or the black light and dye method.
Powder Method	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. See possible causes for leaks.
Black Light and Dye Method	1. A dye and light kit is available for finding leaks. Use the J 28428-E High-Intensity Black Light Kit or equivalent. See Special Tools. Refer to the manufacturer's instructions when using the tool. 2. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 3. See possible causes for leaks.
Possible Causes for Leaks	Check for the following conditions: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components

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- Improper sealants or gaskets where required
- Improper sealant or gasket installation
- Damaged or worn gaskets or seals
- Damaged or worn sealing surfaces

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

1. Disconnect the PCV hose.
2. Start the engine.
3. Check for vacuum at the hose. If there is no vacuum, check for a plugged hose or manifold port. Check for a hose that collapses when blocked (vacuum applied). Replace the plugged or the deteriorated hoses.
4. Allow the engine to idle at normal operating temperature.
5. Remove the engine oil dipstick and install a vacuum gage on the dipstick tube.
6. Block off the PCV system fresh air intake passage.
7. Run the engine at 1500 RPM for 30 seconds, then read vacuum gage while engine is running at 1500 RPM.
 - If vacuum is present, this indicates that the crankcase ventilation system is functioning properly.
 - If no vacuum is indicated, the engine may not be sealed and is drawing in outside air. Check the valve covers, the oil pan gasket or other sealing areas for leaks.
 - If the vacuum gage registers a pressure, or if a vacuum gage is pushed out of dipstick tube, check for a plugged PCV port, a plugged hose or an excessive engine blow-by.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the

probable solution.

- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.

3: The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

4: Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.

6: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

10: Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.

12: Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when

the back side of the belt is used to drive the pulley.

14: This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.

15: This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

16: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

17: This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

19: Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice . DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an			

air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.

DEFINITION: The following items are indications of drive belt whine:

- A high pitched continuous noise.
- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6

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5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	NOTE: Refer to Fastener Notice . 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids.	Go to Step 20	Go to Step 14
	Test the drive belt tensioner for proper		

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14	operation. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19
19	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS**Diagnostic Aids**

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

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

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive

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components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.

3: This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

4: Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plies of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

5: Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

9: Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.

11: This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.

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

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> .			
DEFINITION: The following items are indications of drive belt rumbling:			

- A low pitch tapping, knocking, or thumping noise heard at or just above idle.
- Heard once per revolution of the drive belt or a pulley.
- Rumbling may be caused from:
 - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
 - The separation of the drive belt
 - A damaged drive belt

DEFINITION: The following items are indications of drive belt vibration:

- The vibration is engine-speed related.
- The vibration may be sensitive to accessory load.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical or Go to Vibration Analysis - Engine	Go to Step 4

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4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to <u>Drive Belt Replacement</u> . Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	NOTE: Refer to <u>Fastener Notice</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	Go to Step 11
	Inspect for a bent water pump shaft. Refer to <u>Water Pump Replacement (LY7)</u> or <u>Water Pump Replacement</u>		

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11	(RPOs L26/L32) or Water Pump Replacement (LS4) . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: This inspection is to verify the condition of the drive belt. Damage may of

occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5: Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

6: Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

7: Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing. loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

13: The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

14: The installation of a drive belt that is two wide or two narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

15: This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
NOTE:			

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Refer to **Belt Dressing Notice** .

DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	NOTE: Refer to <u>Fastener Notice</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace improper or missing fasteners.		

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	Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to <u>Drive Belt Replacement</u> . Did you find this condition?	Go to Step 16	Go to Step 14
14	Inspect for the proper drive belt. Did you find this condition?	Go to Step 16	Go to Step 15
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the replacement?	Go to Step 17	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No

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1	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u> . 2. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 4	Go to Step 2
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 4
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . Is the repair complete?	System OK	-

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

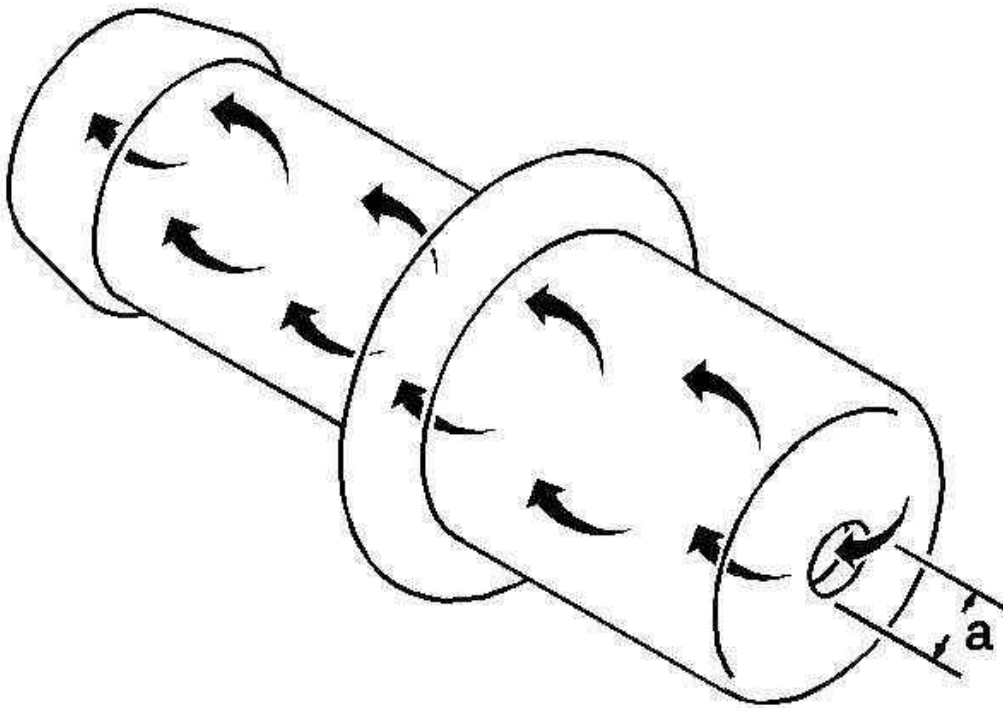


Fig. 59: Identifying PCV
Courtesy of GENERAL MOTORS CORP.

A crankcase ventilation system is used to consume crankcase vapors created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using a 3 mm (0.118 in) (a) orifice located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped
 - The engine cooling fan, if belt driven
 - The water pump, if belt driven
 - The vacuum pump, if equipped
 - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM, and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive

component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

The High Feature V6 VIN Code 7 RPO LY7 is a 3.6L engine incorporating two intake and two exhaust valves per cylinder. Individual intake and exhaust camshafts (DOHC) with camshaft position actuators are mounted on each cylinder head. The cylinder bore is 94 mm (3.7008 in) and the piston stroke is 85.6 mm (3.3701 in). The cylinders are arranged in two banks of three with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6. The engine firing order is 1-2-3-4-5-6.

Crankcase

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each copper-infiltrated sintered steel main bearing cap incorporates six bolts bolting the cap into the engine block. Along with two outer and two inner bolts, two side bolts are used in the deep skirt block. To prevent aeration, oil return from the valvetrain and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. A knock sensor is located on each side of the exterior of the engine block. The crankshaft position sensor is located on the right side of the exterior of the engine block.

Crankshaft

The crankshaft is a forged steel design with four main bearings. Crankshaft thrust is controlled by the number three main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. The crankshaft is internally balanced with an integral oil pump drive machined into the nose in front of the front main journal.

Connecting Rods and Pistons

The connecting rods are sinterforged steel and have full floating piston pins. The piston pins are a slip fit in the bronze bushed connecting rod. Round wire retainers are used to retain the piston pin into the piston. The cast aluminum pistons

incorporate a polymer-coated skirt to reduce friction. The piston uses two low tension compression rings and one multi-piece oil control ring. The top compression ring is plasma sprayed. The second compression ring is cast iron Napier. The oil control ring incorporates a steel expander and two chrome plated steel rails.

Camshaft Drive System

The camshaft drive system consists of one primary timing drive chain driven by the crankshaft sprocket. The primary timing drive chain drives two intermediate drive shaft sprockets. Each oil pressure fed intermediate drive shaft sprocket drives separate secondary timing drive chains. Each secondary timing drive chain drives the respective cylinder head's intake and exhaust camshaft position actuators.

The primary timing drive chain uses two stationary timing drive chain guides and an oil pressure hydraulically actuated tensioner with built-in shoe. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. The tensioner is equipped with an oiling jet to spray oil onto the timing components during engine operation. The secondary timing drive chains use a stationary timing drive chain guide and movable timing drive chain shoe. The secondary timing drive chain shoe is under tension from an oil pressure hydraulically actuated tensioner. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

From the initial production of the High Feature V6 there have been four timing drive systems. This application may have been built using the third or fourth design.

The third design uses an inverted tooth (IT) timing drive chain on the primary timing drive components and roller timing drive components on the secondary components. NOTE: The difference between the third design and the previous second design is a revised reluctor wheel on the camshaft position actuators. The reluctor wheels were revised due to revised camshaft position sensors.

The third design primary timing drive chain uses an IT timing drive chain and a

crankshaft sprocket with IT timing drive chain teeth. The primary timing drive chain connects the crankshaft sprocket with the left and right side intermediate drive shaft sprockets. The third design intermediate drive shaft sprockets incorporate IT primary timing drive chain sprocket teeth and roller timing drive chain secondary timing drive chain sprocket teeth. The third design actuators incorporate a new reluctor wheel and cannot be used on earlier designs.

The fourth design uses IT timing drive components on both the primary and secondary components. NOTE: The pitch of the IT chain has changed therefore third and fourth primary IT components are not interchangeable.

The two timing drive system's individual rotating components cannot be mixed. DO NOT mix third design timing drive chain rotating components with fourth design timing drive chain rotating components.

The following components are the ONLY components that are same between the third and fourth design:

- All timing drive tensioners
- Primary Guides
- Secondary Shoes - Pivoting guides

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes the inlet and exhaust valve timing within a range of 25 camshaft degrees as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and driveability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator,

rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains this position during start-up conditions. Under other engine operating conditions, the camshaft position actuator is controlled by the Engine Control Module (ECM) to deliver optimal intake and exhaust valve timing for performance, driveability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover to accurately determine the position of each camshaft. Each camshaft position actuator has a specific timing drive mark for right or left bank application, as the camshaft position actuators are common bank to bank. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

The camshaft front journal has several drilled oil holes to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. The center camshaft bolt hole is counterbored to allow oil to flow around the camshaft bolt and to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position. Radially outward from the center of the journal is a set of four drilled camshaft position actuator oil holes. Oil in this group of oil holes is used to move the camshaft from the default position to a specific set position as determined by the ECM. Seal rings are used at the front and rear of the front camshaft journal to prevent oil leakage from the camshaft position actuator hydraulic system. The seal is made from a plastic compound that resists wear and has a diagonal end gap to enhance sealing. The camshaft position actuator is mounted to the front end of the

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camshaft and the timing notch in the nose of the camshaft aligns with the dowel pin in the camshaft position actuator to ensure proper cam timing and camshaft position actuator oil hole alignment.

Cylinder Heads

The cylinder heads are semi permanent mold cast aluminum with powdered metal valve seat inserts and valve guides. Two 36.96 mm (1.4551 in) intake valves and two 30.60 mm (1.2047 in) exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). Separate exhaust and intake camshafts are supported by four bearings machined into the cylinder head. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The engine coolant temperature (ECT) sensor is threaded into the left cylinder head.

Induction System

The intake manifold consists of two cast aluminum components. Two short bolts in the lower intake manifold and four long bolts, that pass through both manifolds, mount the intake manifold assembly to the cylinder heads. Additionally two bolts mount the upper intake manifold to the lower intake manifold. The throttle body, Barometric Pressure (BARO) sensor, Evaporative Emissions (EVAP) solenoid and tubes, Positive Crankcase Ventilation (PCV) tubes, fuel rail support bracket, fuel injector wiring harness bracket, intake manifold opening cover, and brake booster hose are mounted to the upper intake manifold. The fuel injector wiring harness, fuel rail assembly, and fuel injectors are mounted to the lower intake manifold.

Right and Left Bank Designation

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear of the engine or from inside the vehicle.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important changes from the previous model year.

Changes may include one or more of the following items:

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- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

There are no changes to the fastener tightening specifications for 2007.

Changed Engine Specifications

There are no changes to the engine specifications for 2007.

New Sealants and/or Adhesives

There are no changes to the sealants and/or adhesives used for model year 2007.

Disassembly and Assembly Procedure Revisions

There are no changes to the engine disassembly or assembly procedures for 2007.

Engine Mechanical Diagnostic Procedure Revisions

There are no revisions to the engine mechanical diagnostic procedures for 2007.

New Special Tools Required

- The piston clip remover and installation tool **J 43654** has been replaced by **EN-46745** . See **Special Tools**.
- The oil pressure gage adapter **J 36648-A** has been replaced by **J-21867-6** .

A Component Comparison from the Previous Year

Two new designs of timing components are being used.

Third Design:

- The camshaft position actuator sensors are a new design.
- The camshaft position actuators incorporate new sensor wheels that correspond with the new design of camshaft position actuator sensors.

Fourth Design:

- New secondary timing drive chains, Inverted Tooth (IT) design.
- The camshaft position actuators incorporate new sprockets that correspond with the use of IT chains on the secondary timing drive system.
- The intake camshaft position actuators are different for the left and right sides.
- The left and right secondary timing drive guides are new due to the use of IT chains on the secondary timing drive system.
- The intermediate timing drive sprockets are new due to the use of IT chains on the secondary timing drive system.
- New intake camshafts.
- New second design IT primary timing drive chain.
- New second design IT crankshaft sprocket.

LUBRICATION DESCRIPTION

A structural diecast aluminum oil pan incorporates an oil suction tube, a baffle, a windage tray and an oil level sensor. The oil suction tube is bolted into the oil pan and seals to the bottom of the block with O-ring gasket. The baffle is mounted to the lower portion of the 6-quart capacity oil pan sump and ensures oil supply to the oil suction pickup. The windage tray is bolted to the upper portion of the oil pan and reduces friction losses at high speed. The oil level sensor is mounted through the bottom of the oil pan.

A crankshaft driven gerotor oil pump with internal pressure-relief valve is mounted to the front of the engine block and pulls oil from the oil suction tube through the lower passage in the engine block. The oil pump then directs the flow of pressurized oil back through the upper passage in the block to the left side of the engine block where the oil filter adapter is mounted.

An oil filter adapter is mounted with a gasket to the left side of the engine block.

The oil filter adapter incorporates a bottom-access, spin-on oil filter. The oil filter adapter housing incorporates a built-in oil bypass valve and a threaded oil pressure sending unit. Oil flows through the lower passage in the oil filter adapter to and through the oil filter. Filtered oil travels back through the upper passage of the oil filter adapter and back into the engine block.

Oil is directed up and across the engine block front through several drilled passages. These front passages feed oil to each cylinder head, oil to the passage for the main bearings and piston oil jets, oil to the right and left secondary idler sprockets and oil to the primary timing drive chain tensioner.

Each cylinder head passage directs oil into the cylinder head where it is directed to oiling circuits for the stationary hydraulic lifter assemblies (SHLAs) and the camshaft bearing journals. Oil is also directed through two passages each with a spring-loaded check-ball valve to the two chambers where the camshaft position actuator oil control solenoid valves are mounted. Each chamber contains a camshaft position actuator oil control solenoid valve with built-in oil filter screen. One camshaft position actuator oil control solenoid valve is used to control the exhaust camshaft position actuator and one camshaft position actuator oil control solenoid valve is used to control the intake camshaft position actuator. The engine control module (ECM) electrically controls each camshaft position actuator oil control solenoid valve. When energized by the ECM the camshaft position actuator oil control solenoid valve directs oil to pass up through the cylinder head front camshaft bearing cap. Oil passes through the camshaft bearing cap passage into oil holes drilled into the side of the front camshaft journal and onto the front of the camshaft mounting surface. Oil passes through to matching passages in the camshaft position actuator. Oil is directed by the camshaft position actuator oil control solenoid valve to the appropriate passage in the system to pressurize oil on the vanes on the inside of the of the camshaft position actuator. Oil acting on the vanes rotates the camshaft mounted to the inner camshaft position actuator rotor relative to the sprocket mounted to the outer camshaft position actuator housing. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains the camshaft position actuator in the home or default position during start-up conditions. Oil pressure directed by the camshaft position actuator oil control solenoid valve unlocks the pin and allows the camshaft position actuator to function. An additional passage in the cylinder head also directs oil to

the secondary timing drive chain tensioner mounted to each cylinder head.

The oil passage that supplies oil to the main bearings also supplies oil to pressure-actuated piston-cooling oil jets. Each oil jet is mounted between opposing cylinder bores and directs oil to the two bores to provide extra cooling and control piston temperatures.

Oil is directed from the front passages to the front of the block where the right and left secondary idler sprockets and the primary timing drive chain tensioner are mounted. Each camshaft timing drive chain tensioner relies on a gasket in order to maintain an oil reserve after the engine is turned OFF. All camshaft timing drive chain tensioners incorporate a small oil jet to supply an oil spray onto the camshaft timing drive chain components.

Oil returns to the oil pan sump either through the camshaft timing drive chain area or through the cast oil drain back passages on the outboard walls of the cylinder heads and engine block.

CLEANLINESS AND CARE

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

NOTE: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

CAUTION: Refer to BATTERY DISCONNECT CAUTION .

Disconnect the negative battery cables before you perform any major work on the engine.

SEPARATING PARTS

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. If possible, bump the components sideways rather than using prying tools in order to remove the components. This technique prevents damage when the bonding strength of the RTV sealant is stronger than the component itself. Perform bumping at the bends or at the reinforced areas in order to prevent part distortion.

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 an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

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:

- Anaerobic sealant room temperature vulcanizing (RTV)
- Anaerobic sealant, which include the following:
 - Gasket eliminator
 - Pipe
 - Threadlock

Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant

Anaerobic type room temperature vulcanizing (RTV) sealant cures in the absence of 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.

NOTE: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

- 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.

IMPORTANT: Do not wait for the RTV sealant to skin over.

- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

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.

NOTE: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- IMPORTANT:**
- Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.
 - Do not overtighten the fasteners.
 - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
 - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
 - 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.

Use the following information when using threadlock sealant:

- 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 5 minutes, may result in incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

NOTE: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

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 designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools 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 component cleaning tank
 - A compressed air supply
 - Trays or storage containers to keep components and fasteners organized
 - An adequate set of hand tools
 - Approved engine repair stand
 - An approved engine lifting device that adequately supports the weight of the components

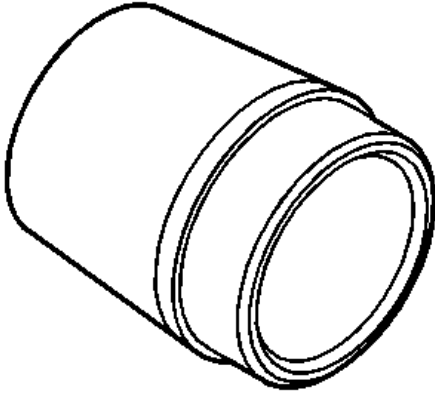
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

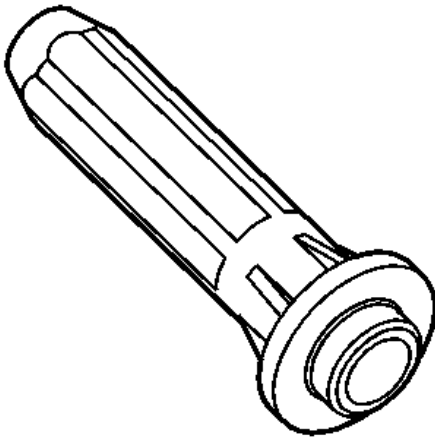
Illustration	Tool Number/Description

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EN 46101
Spark Plug Tube Seal Guide

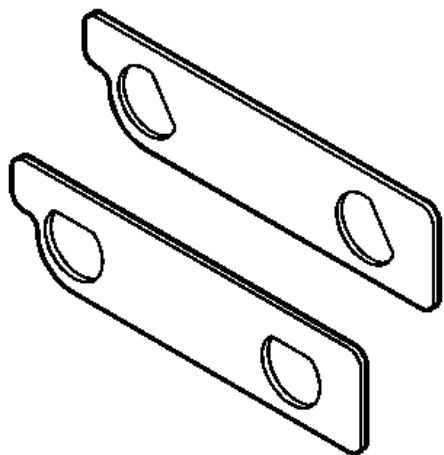
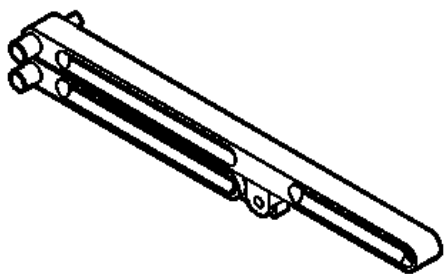


EN 46103
Camshaft Actuator Valve Seal
Remover/Installer

EN 46104
Water Pump Pulley Holding Tool

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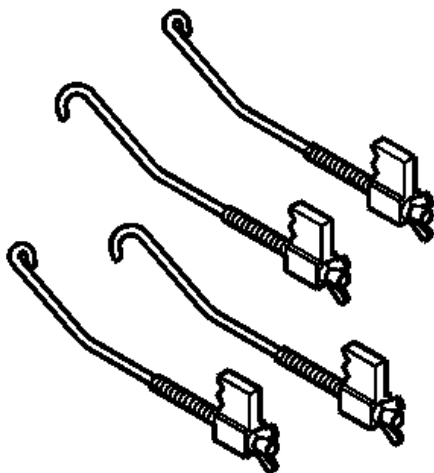
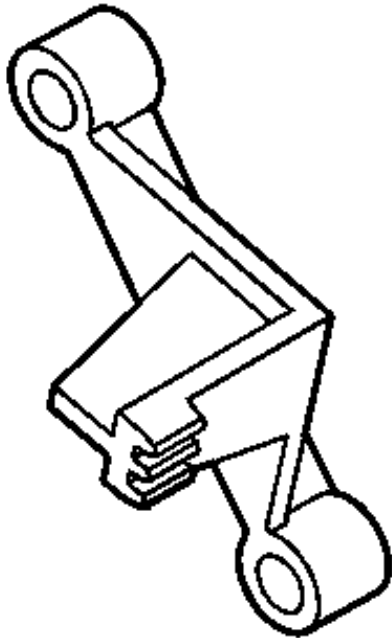


EN 46105
Camshaft Locking Tool

EN 46106
Flywheel Holding Tool

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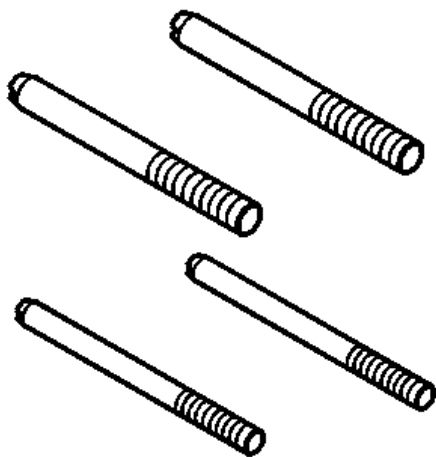
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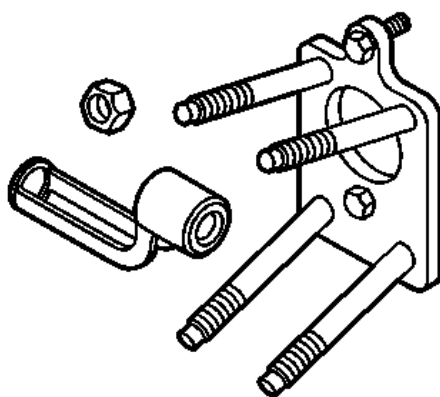
EN 46108
Timing Chain Retention Tool

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EN 46109
Engine Front Cover Installation Guide
Pins

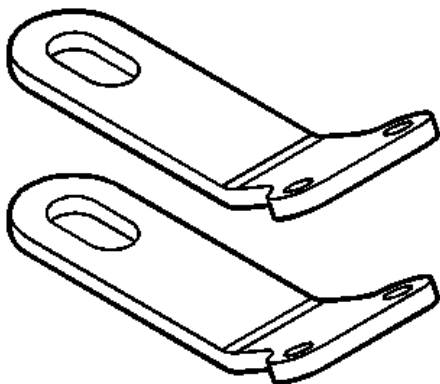
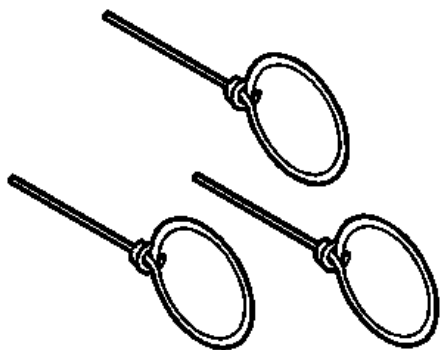


EN 46110
On-Vehicle Valve Spring Compressor

EN 46112
Tensioner Retraction Pins

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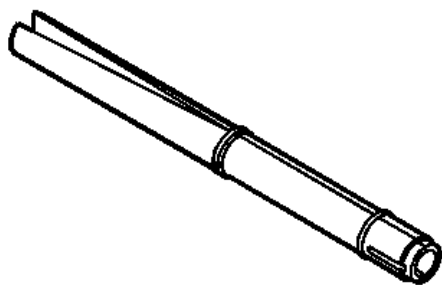
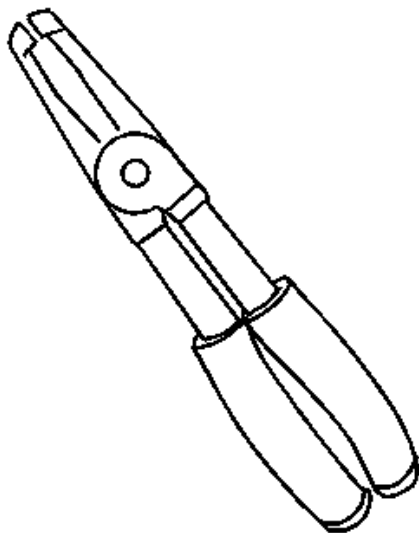


EN 46114
Engine Lift Brackets

EN 46116
Valve Stem Seal Remover/Installer

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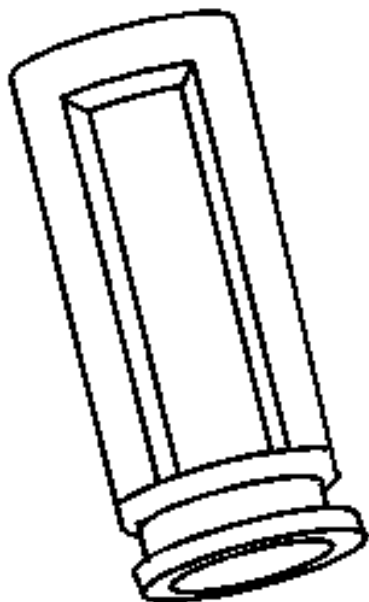
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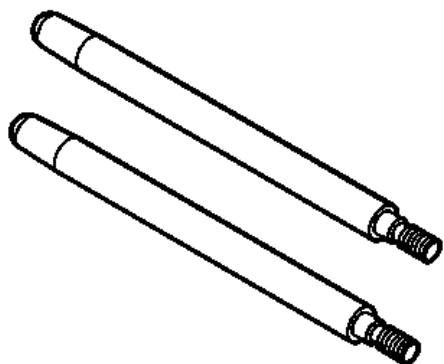
EN 46117
Valve Stem Key Remover/Installer

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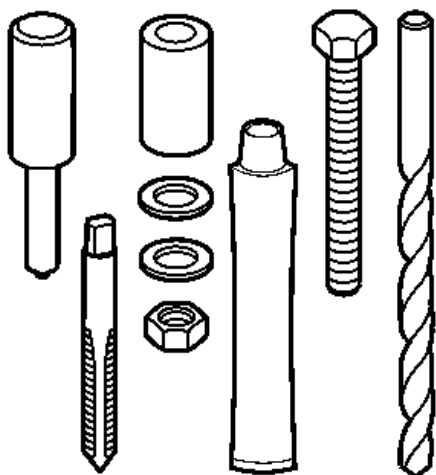
EN 46119
Off-Vehicle Valve Spring Compressor
Adapter



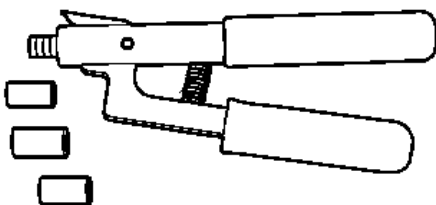
EN 46121
Connecting Rod Guide Pin Set

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EN 46122
Camshaft Position Actuator Check-
Ball Valve Remover/Installer

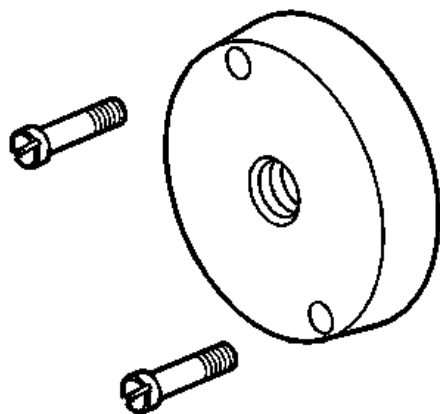


EN 46745
Piston Pin Clip Remover/Installer

EN 47839
Crankshaft Rear Oil Seal Installation
Tool

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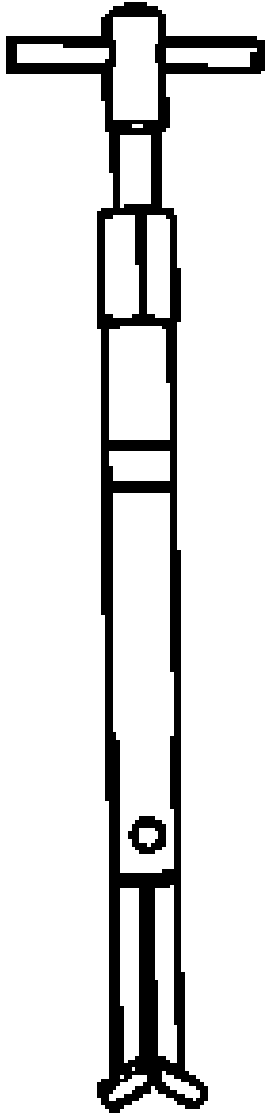
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EN 48313
Timing Chain Retention Tool

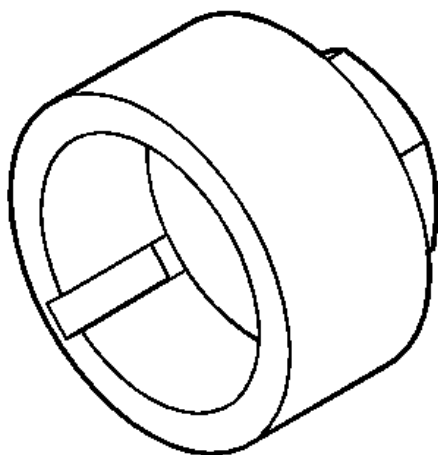
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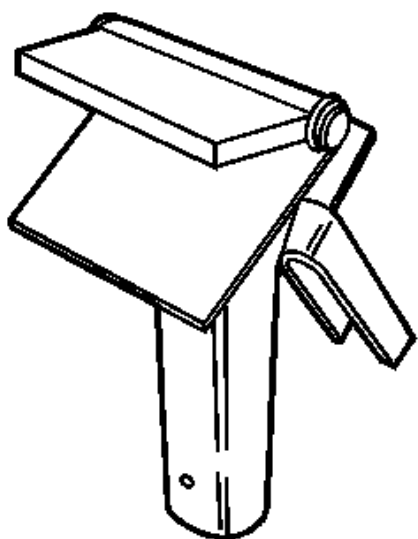


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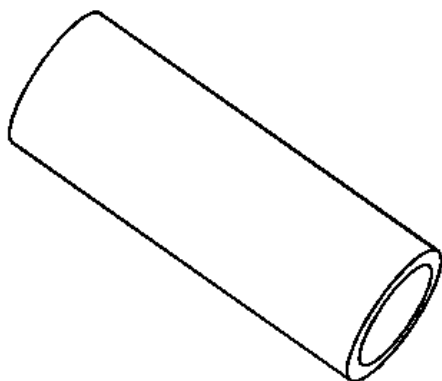
EN 48589
Crankshaft Rotation Socket



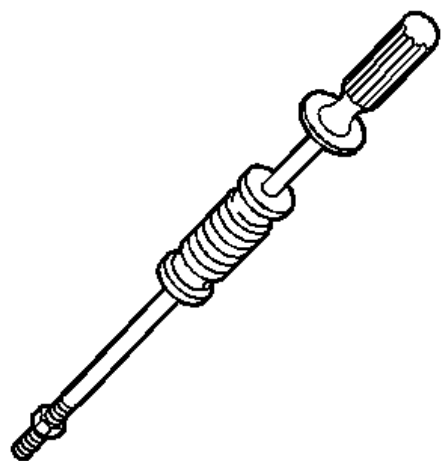
GE 48326
Sealant Dispenser

2008 Buick LaCrosse CX

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J 5590
Bearing and Seal Driver

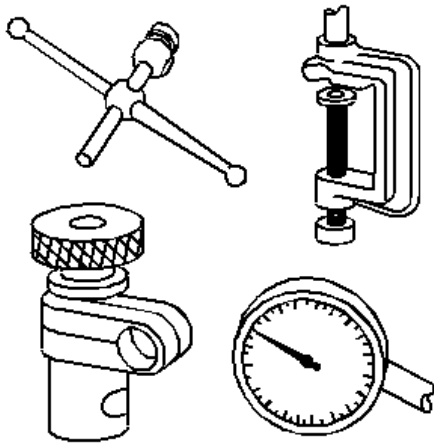
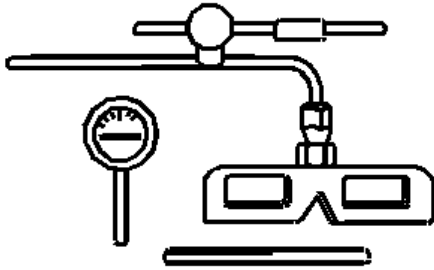


J 6125-1B
Slide Hammer Adapter

J 7872
Magnetic Base Dial Indicator

2008 Buick LaCrosse CX

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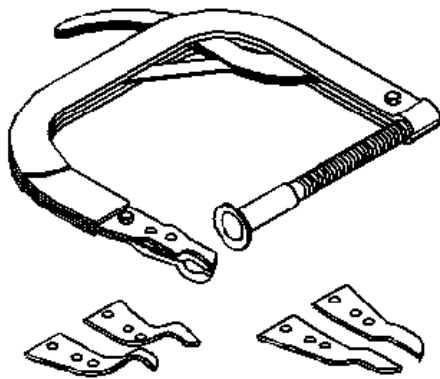
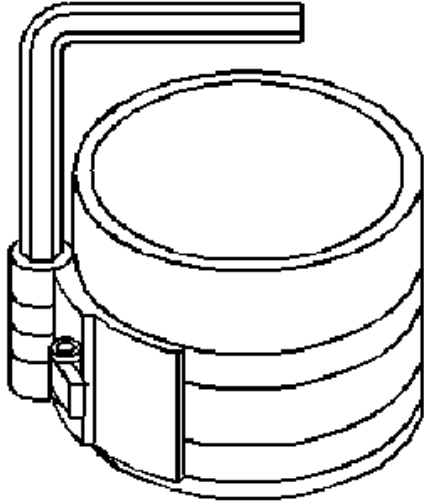


J 8001
Dial Indicator Set

J 8037
Ring Compressor

2008 Buick LaCrosse CX

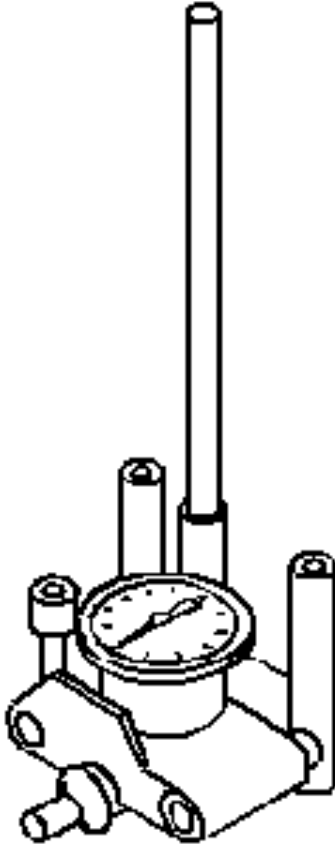
2008 ENGINE Engine Mechanical - 3.6L - LaCrosse



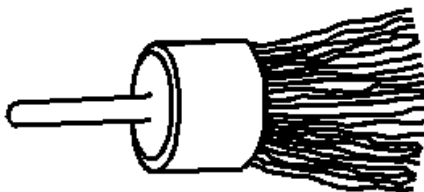
J 8062
Valve Spring Compressor - Head Off

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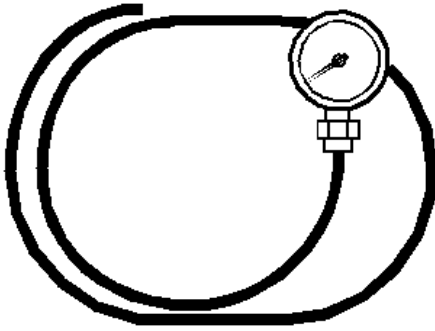
J 8087
Cylinder Bore Gage



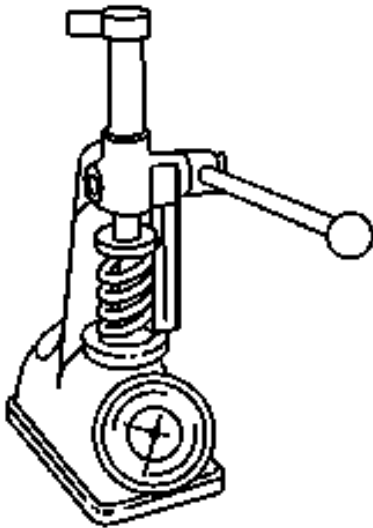
J 8358
Carbon Removal Brush

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J 21867
Pressure Gage

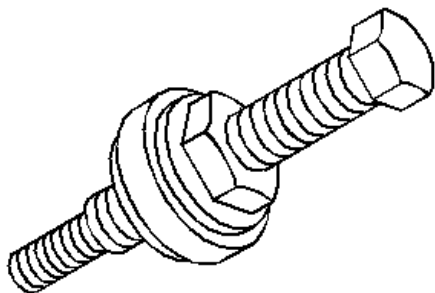


J 22738-B
Valve Spring Tester

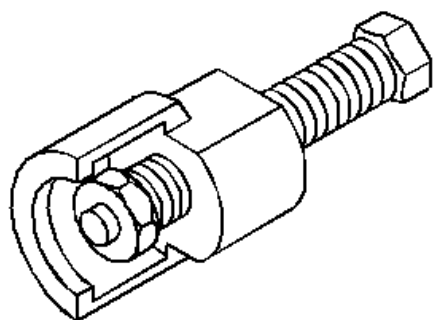
J 25033-C

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Pulley Installer

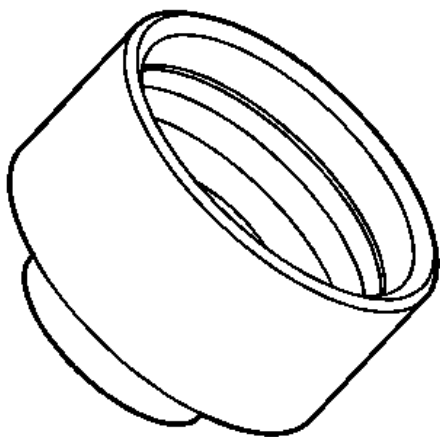


J 25034-C
Pulley Remover

J 25254-A
Oil Seal Installer

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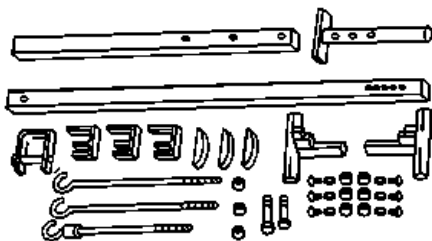
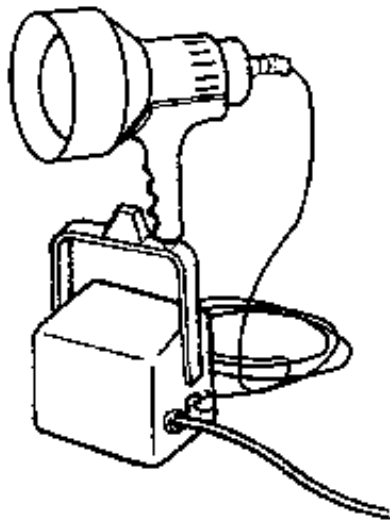


J 28410
Gasket Remover

J 28428-E
High Intensity Black Light Kit

2008 Buick LaCrosse CX

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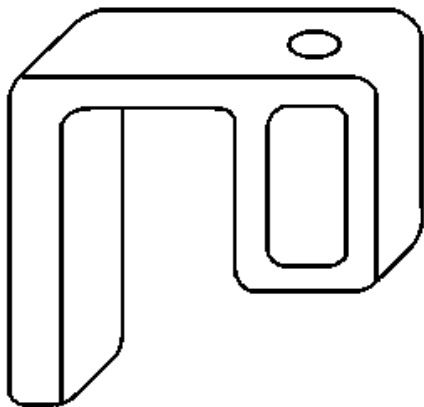


J 28467-B
Universal Engine Support Fixture

J 28467-6A
Bracket Assembly

2008 Buick LaCrosse CX

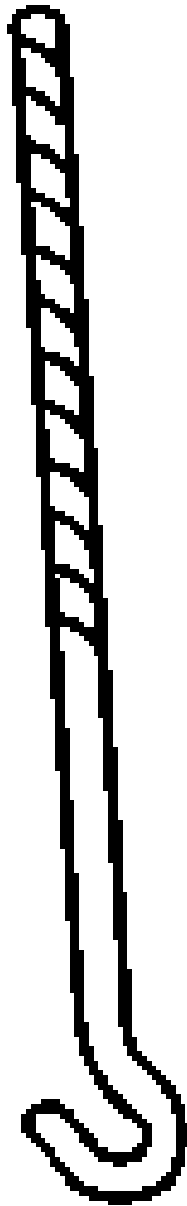
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J 28467-7A
Bolt Hook

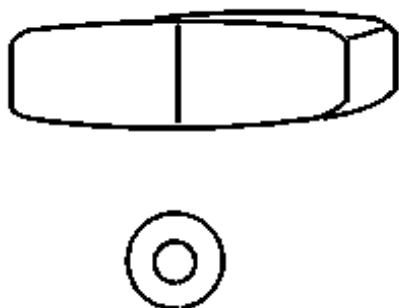
2008 Buick LaCrosse CX

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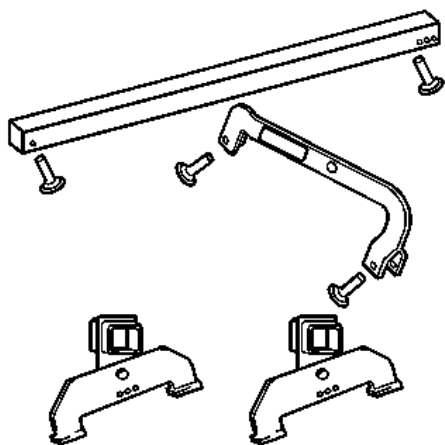


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J 28467-34
Lift Hook Wing Nut and Washer

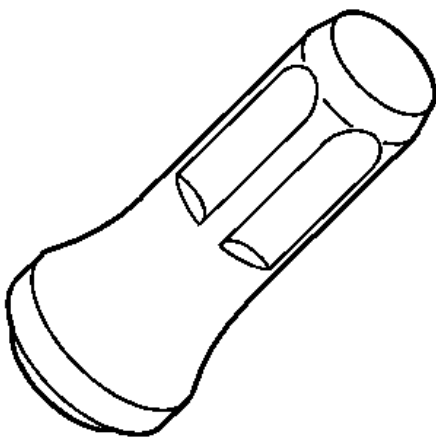
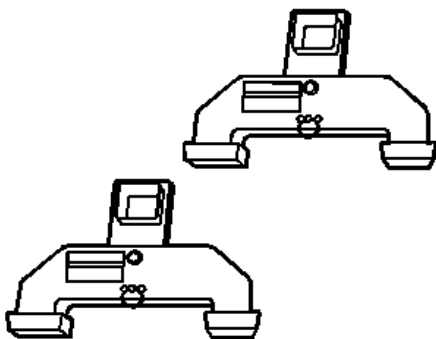


J 28467-500
Engine Support Fixture

J 28467-501
Engine Support Fixture Adapters

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J 29184
Oil Seal Installer

J 35667-A

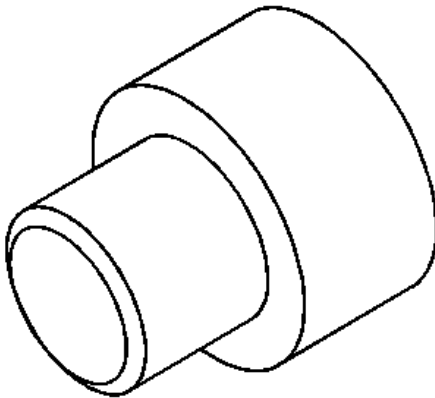
2008 Buick LaCrosse CX

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Cylinder Head Leakdown Tester

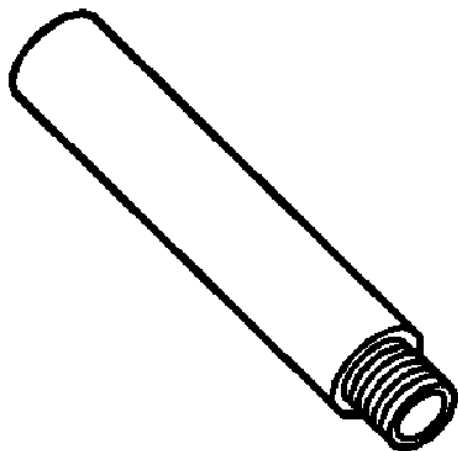


J 38416-2 Crankshaft Button

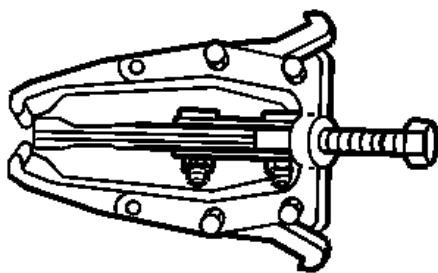


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J 39313
Spark Plug Port Adapter

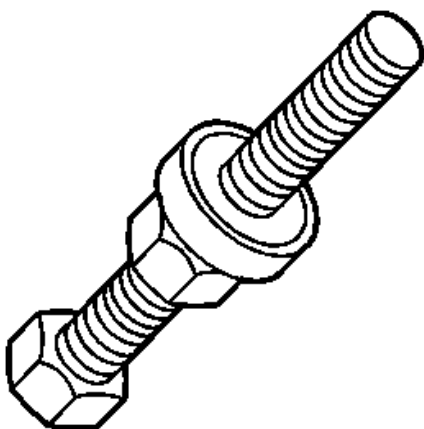
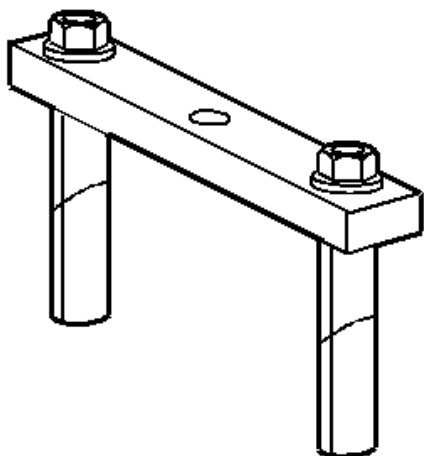


J 41816-A
Crankshaft Balancer Remover

J 41818
Crankshaft Bearing Cap Remover

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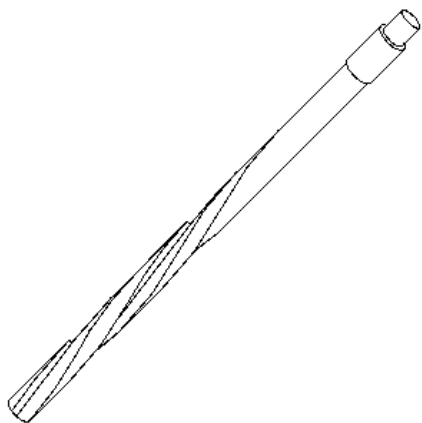
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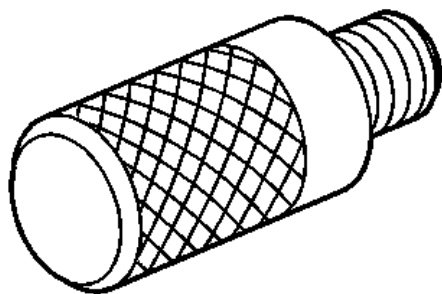
J 41998-B
Crankshaft Balancer Installer

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J 42096
Valve Guide Reamer

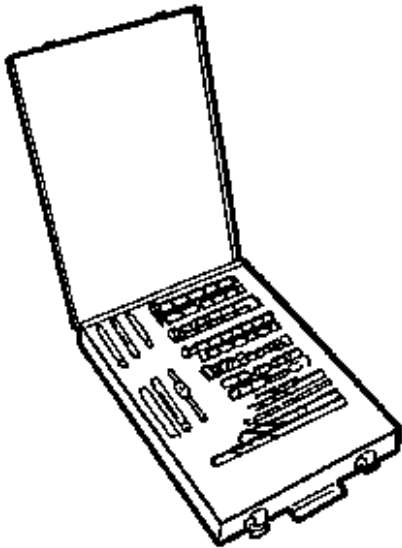
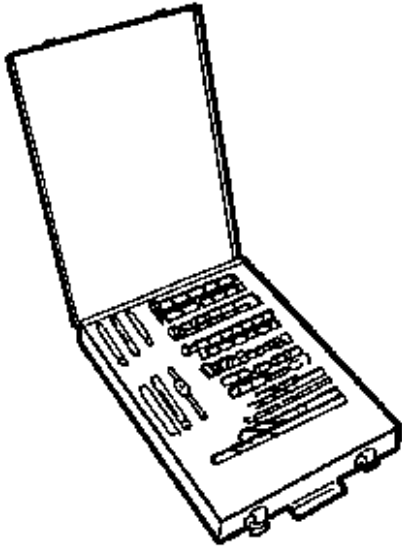


J 42183
Handle

J 42385-700
High Feature Thread Repair Kit

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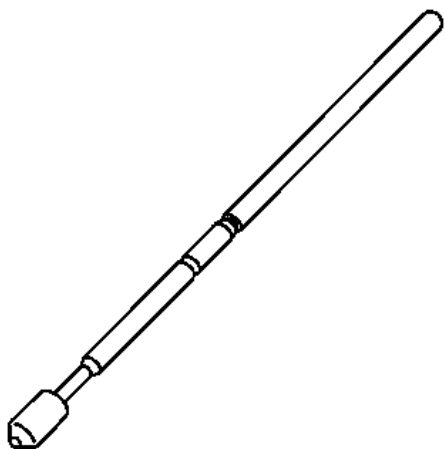
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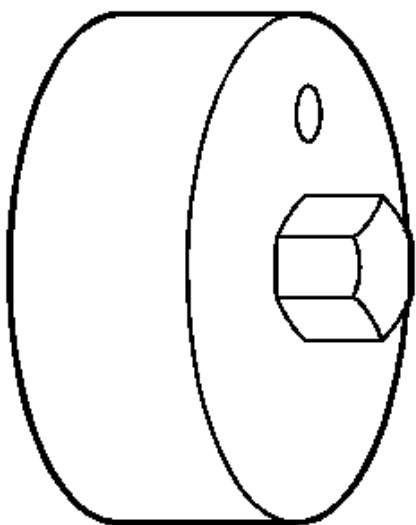
J 42385-2000
Thread Insert Kit

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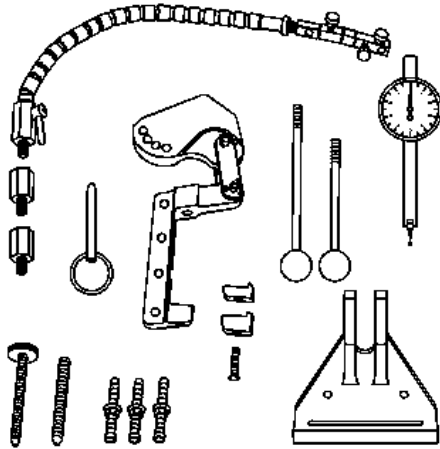
J 42640
Steering Column Anti-rotation Pin



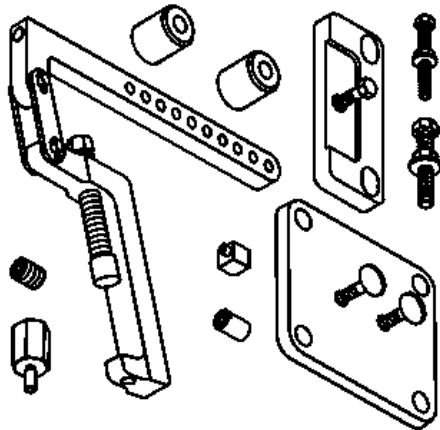
J 42907
Oil Pressure Tester

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J 43690
Rod Bearing Clearance Checking Tool

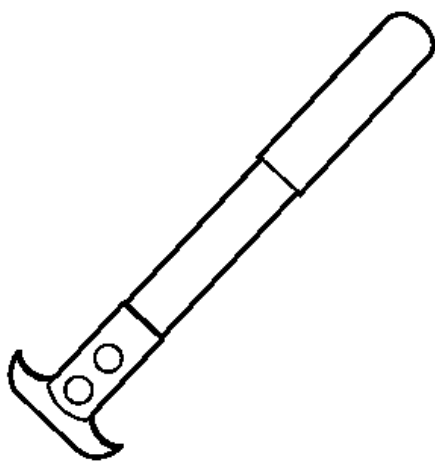
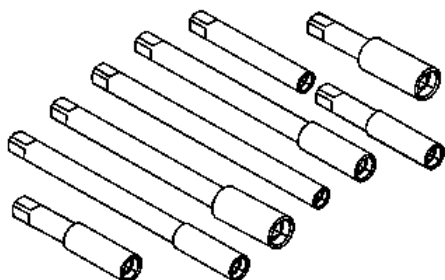


J 43690-100
Rod Bearing Clearance Checking Tool
- Adapter Kit

J 43965
Thread Repair Extension Kit

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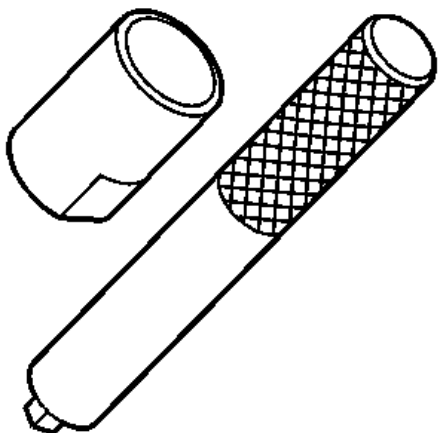


J 45000
Seal Remover

J 45027
Tensioner Tool

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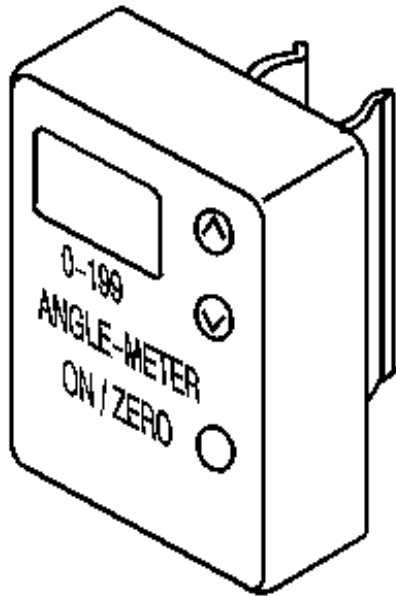


J 45057-2
Lower Support Bar

J 45059
Angle Meter

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J 45299
Engine Preluber

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