2008 ENGINE

Engine Mechanical - 4.2L - Ascender, Envoy & Trailblazer

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specifications	
	Metric	English
A/C Line Bracket Nut at Oil Level Indicator Tube	7 N.m	61 lb in
A/C Line Bracket Bolt at Engine Lift Bracket	10 N.m	89 lb in
A/C Compressor Bolts	50 N.m	37 lb ft
A.I.R. Cover Stud	25 N.m	18 lb ft
Camshaft Cap Bolt	12 N.m	106 lb in
Camshaft Cover Bolt	10 N.m	89 lb in
Camshaft Position Actuator Valve Bolt	10 N.m	89 lb in
Connecting Rod Cap Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	110 degrees	
Coolant Temperature Sensor	20 N.m	15 lb ft
Cooling Fan Hub Nut	56 N.m	41 lb ft
Crankshaft Balancer Bolt		
• First Pass	150 N.m	110.6 lb ft
• Final Pass	180 degrees	
Crankshaft Main Bearing Cap Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	180 degrees	
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Crankshaft Rear Housing Bolt	10 N.m	89 lb in
Cylinder Head Access Hole Plug - Plastic	5 N.m	44 lb in
Cylinder Head Bolt - 14		
• First Pass	30 N.m	22 lb ft
• Final Pass	155 degrees	
Cylinder Head End Bolts - 2 Short		
• First Pass	7 N.m	62 lb in
• Final Pass	60 degrees	
Cylinder Head End Bolts - 1 Long		

• First Pass	7 N.m	62 lb in
• Final Pass	120 degrees	
Cylinder Head Oil Gallery Plug	38 N.m	28 lb ft
Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Oil Gallery Plug - Front and Rear	80 N.m	60 lb ft
Engine Block Oil Gallery Plug - Side	35 N.m	26 lb ft
Engine Flywheel Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	50 degrees	
Engine Front Cover Bolt	10 N.m	89 lb in
Engine Front Cover Spacer Bolt	10 N.m	89 lb in
Engine Front Lift Bracket Bolt	50 N.m	37 lb ft
Engine Harness Bracket Bolt	10 N.m	89 lb in
Engine Mount Bracket Bolt - Engine	50 N.m	37 lb ft
Engine Mount Bracket Bolt - Frame	110 N.m	81 lb ft
Engine Mount Nuts - Upper and Lower	70 N.m	52 lb ft
Engine Protection Shield Bolts	25 N.m	18 lb ft
EVAP Purge Solenoid Valve Bolt	10 N.m	89 lb in
Exhaust Camshaft Actuator Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	135 degrees	
Exhaust Camshaft Position Sensor Bolt	10 N.m	89 lb in
Exhaust Manifold Bolt		
• First Pass	20 N.m	15 lb ft
• Second Pass	20 N.m	15 lb ft
• Final Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Nut	10 N.m	89 lb in
Exhaust Manifold Heat Shield Stud	10 N.m	89 lb in
Exhaust Pipe Bolt	50 N.m	37 lb ft
Front Differential Bolt	85 N.m	63 lb ft
Fuel Injector Rail Bolt	10 N.m	89 lb in
Generator Battery Lead Nut	9 N.m	80 lb in
Heater Inlet Pipe Bolt	10 N.m	89 lb in
Heater Outlet Fitting	45 N.m	33 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Intake Camshaft Sprocket Bolt		
• First Pass	20 N.m	15 lb ft

• Final Pass	100 degrees	
Intake Manifold Bolt	10 N.m	89 lb in
Knock Sensor	25 N.m	18 lb ft
Oil Filter - PF 58	30 N.m	23 lb ft
Oil Filter Adapter	50 N.m	37 lb ft
Oil Filter Bypass Hole Plug	14 N.m	124 lb in
Oil Level Indicator Tube Stud	10 N.m	89 lb in
Oil Level Sensor Bolt	10 N.m	89 lb in
Oil Pan Bolt - Ends	10 N.m	89 lb in
Oil Pan Bolt - Sides	25 N.m	18 lb ft
Oil Pan Drain Plug	26 N.m	19 lb ft
Oil Pan Nut	25 N.m	18 lb ft
Oil Pan Stud	11 N.m	97 lb in
Oil Pressure Sensor	20 N.m	15 lb ft
Oil Pump Cover Bolt	10 N.m	89 lb in
Oil Pump Pickup Tube	10 N.m	89 lb in
Oil Pump Pressure Relief Valve	14 N.m	124 lb in
Power Steering Pump Bolt	25 N.m	18 lb ft
Power Steering Pump Bracket Bolt	50 N.m	37 lb ft
Spark Plug	18 N.m	13 lb ft
Starter Motor Bolt	50 N.m	37 lb ft
Starter Motor Nut	50 N.m	37 lb ft
Starter Motor Stud	16 N.m	12 lb ft
Thermostat Housing bolt	10 N.m	89 lb in
Throttle Control Module Bolt	10 N.m	89 lb in
Timing Chain Tensioner Bolt	25 N.m	18 lb ft
Timing Chain Tensioner Guide Bolt	12 N.m	107 lb in
Timing Chain Tensioner Shoe Bolt	25 N.m	18 lb ft
Torque Converter Bolts	60 N.m	44 lb ft
Transmission Bell Housing Bolts	50 N.m	37 lb ft
Transmission Fluid Tube to Air Adapter Nut	10 N.m	89 lb in
Water Outlet Bolt	10 N.m	89 lb in
Water Pump Bolt	10 N.m	89 lb in
Water Pump Pulley Bolt	25 N.m	18 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		

• Engine Type	In-Line-6	
• Displacement	4.2L	256 cu in
• RPO	LL8	
• VIN	"S"	
• Bore	93 mm	3.66 in
• Stroke	102 mm	4.02 in
• Compression Ratio	10.3:1	
• Engine Compression Test	1482 KPa	215 psi
• Firing Order	1-5-3-6-2-4	
• Spark Plug Gap	1.07 mm	0.042 in
Block		
• Crankshaft Main Bearing Bore Diameter	78.070-78.088 mm	3.0760-3.0766 in
• Cylinder Bore Diameter	92.990-93.006 mm	3.6638-3.6644 in
• Cylinder Bore Out-of-Round	0.013 mm	0.0005 in
• Cylinder Head Deck Surface Flatness	0.08 mm	0.003 in
• Cylinder Liner Recession	0.015 mm	0.0006 in
Camshaft		
• Camshaft End Play - Exhaust	0.045-0.215 mm	0.0017-0.0084 in
• Camshaft End Play - Intake	0.051-0.201 mm	0.0020-0.0079 in
• Camshaft Journal Diameter - All Intake and Exhaust #2-#7	26.936-26.960 mm	1.0612-1.0622 in
• Camshaft Journal Diameter - Exhaust #1	29.936-29.960 mm	1.1794-1.1804 in
• Camshaft Journal to Bore Clearance	0.040-0.085 mm	0.0015-0.0033 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.021-0.065 mm	0.0008-0.0025 in
• Connecting Rod Bore Diameter - Bearing End	60.322-60.338 mm	2.3749-2.3755 in
• Connecting Rod Bore Out-of-Round - Bearing End	0.005 mm	0.0002 in
Connecting Rod Side Clearance	0.05-0.35 mm	0.0019-0.0137 in
Crankshaft		
• Crankshaft End Play	0.112-0.388 mm	0.0044-0.0153 in
• Crankshaft Main Bearing Clearance	0.012-0.064 mm	0.0004-0.0025 in
• Crankshaft Main Journal Diameter	69.968-69.984 mm	2.7567-2.7574 in
• Crankshaft Rod Journal Diameter	56.7 mm	2.234 in

• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
Cylinder Head		
• Surface Flatness - Block Deck	0.08 mm	0.003 in
• Surface Flatness - Exhaust Manifold Deck	0.08 mm	0.003 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.003 in
Exhaust Manifold		
• Surface Flatness	0.08 mm	0.003 in
Lubrication System		
• Oil Capacity - with Filter	6.6 L	7.0 qts
• Oil Capacity - without Filter	6.1 L	6.5 qts
• Oil Pressure - Minimum	85 KPa	12 psi @ 1200 RPM
Oil Pump		
• Gear Diameter - Drive	73.415-73.370 mm	2.893-2.891 in
• Gear Diameter - Driven	87-86.975 mm	3.428-3.426 in
• Gear Pocket - Depth	15.609-15.584 mm	0.615-0.614 in
• Gear Pocket - Diameter	87.065-87.040 mm	3.430-3.429 in
• Gear Thickness - Drive	15.546-15.521 mm	0.613-0.611 in
• Gear Thickness - Driven	15.360-15.511 mm	0.605-0.611 in
• Lobe Inner Diameter - Maximum	11.9 mm	0.469 in
• Relief Valve-to-Bore Clearance	2.57-1.63 mm	0.101-0.064 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.15-0.3 mm	0.0059-0.0118 in
• Piston Ring End Gap - Second Compression Ring	0.36-0.51 mm	0.0142-0.0201 in
• Piston Ring End Gap - Oil Control Ring	0.250-0.760 mm	0.0098-0.0299 in
• Piston Ring to Groove Clearance - First Compression Ring	0.043-0.093 mm	0.0017-0.0037 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.043-0.093 mm	0.0017-0.0037 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.059-0.215 mm	0.0023-0.0085 in
Pistons and Pins		
• Piston - Piston Diameter	92.971-93.005 mm	3.6603-3.6616 in

• Piston - Piston Pin Bore Diameter	23.502-23.508 mm	0.9259-0.9262 in
• Piston - Piston to Bore Clearance	-0.015-0.035 mm	-0.0006-0.0014 in
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.001-0.018 mm	0.0004-0.0007 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.003-0.012 mm	0.00012-0.0005 in
• Pin - Piston Pin Diameter	23.496-23.499 mm	0.9257-0.9258 in
Valve System		
• Valves - Valve Face Runout	0.038 mm	0.0015 in
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Stem-to-Guide Clearance - Exhaust	0.0375-0.0775 mm	0.0015-0.0030 in
• Valves - Valve Stem-to-Guide Clearance - Intake	0.030-0.065 mm	0.0011-0.0025 in
• Valve Springs - Valve Spring Load - Closed	211.4-233.4 N @ 35 mm	47.5-52.5 lb @ 1.701 in
• Valve Springs - Valve Spring Load - Open	579-631 N @ 24.5 mm	130-142 lb @ 1.260 in

SEALERS, ADHESIVES & LUBRICANTS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Position Actuator Bolt	Sealant	89021297	10953488
Camshaft Position Sensor Bolt	Sealant	12378521	88901148
Coolant Sensor Threads	Sealant	12378521	88901148
Crankshaft Position Sensor Bolt	Sealant	12378521	88901148
Cylinder Head Core Hole Plugs	Sealant	12378521	88901148
Cylinder Head Expansion Plugs (Aluminum)	Sealant	12378521	88901148
Engine Block Front Oil Gallery Plug	Sealant	12378521	88901148
Engine Block Plug	Sealant	12378521	88901148
Engine Front Cover Surface	Sealant	12378521	88901148
EVAP Purge Solenoid Valve Bolt	Sealant	12378521	88901148
Exhaust Manifold Bolt Threads	Threadlock	89021297	10953488
Exhaust Manifold Heat Shield Nuts	Anti-Sieze	12371386	993128
Oil Level Indicator Tube Stud	Sealant	12378521	88901148
Oil Pan Surface	Sealant	12378521	88901148
Oil Pressure Sensor Threads	Sealant	12378521	88901148
Oil Pump Pipe Bolt	Sealant	12378521	88901148
PVC Hose	Lubricant	12345884	5728223
Rear Oil Seal Housing Surface	Sealant	12378521	88901148
Throttle Control Module Bolt	Sealant	12345382	10953489

Timing Chain Guide Bolt	Threadlock	89021297	10953488

THREAD REPAIR SPECIFICATIONS

Engine Block - Top View

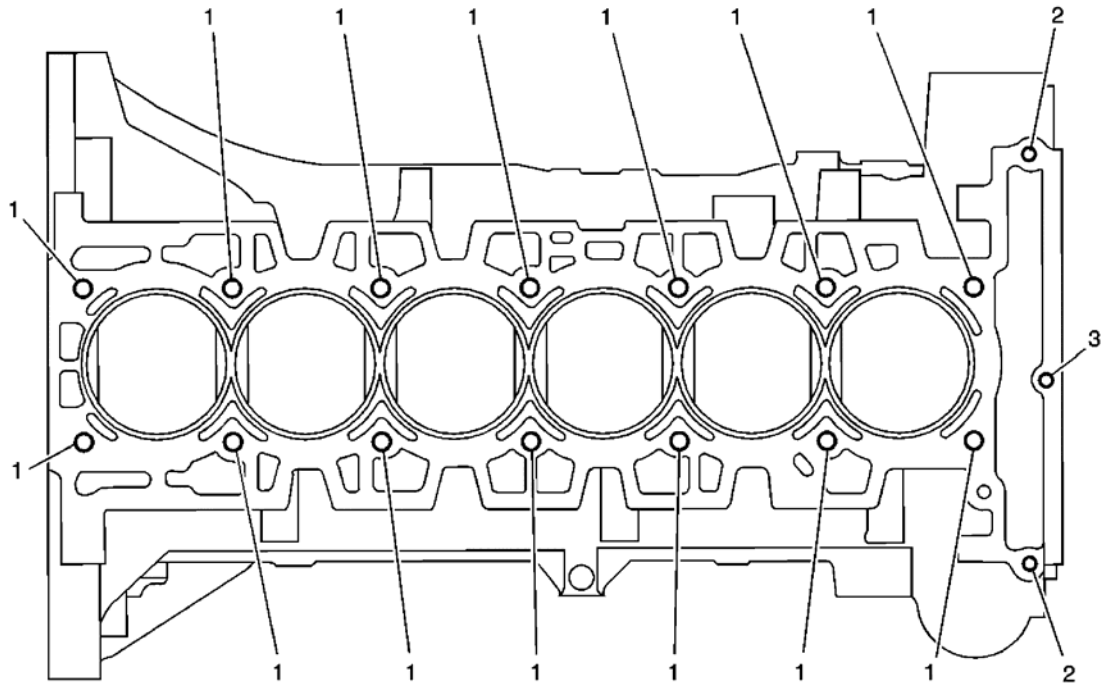


Fig. 1: Engine Block Thread Repair - Top View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 11 x 2	402	n/a	n/a	403	404	108	59	2.324	51	2.009
2	M 6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709
3	M 6 x 1	201	202	n/a	203	204	205	30	1.182	26	1.024

Engine Block - Bottom View

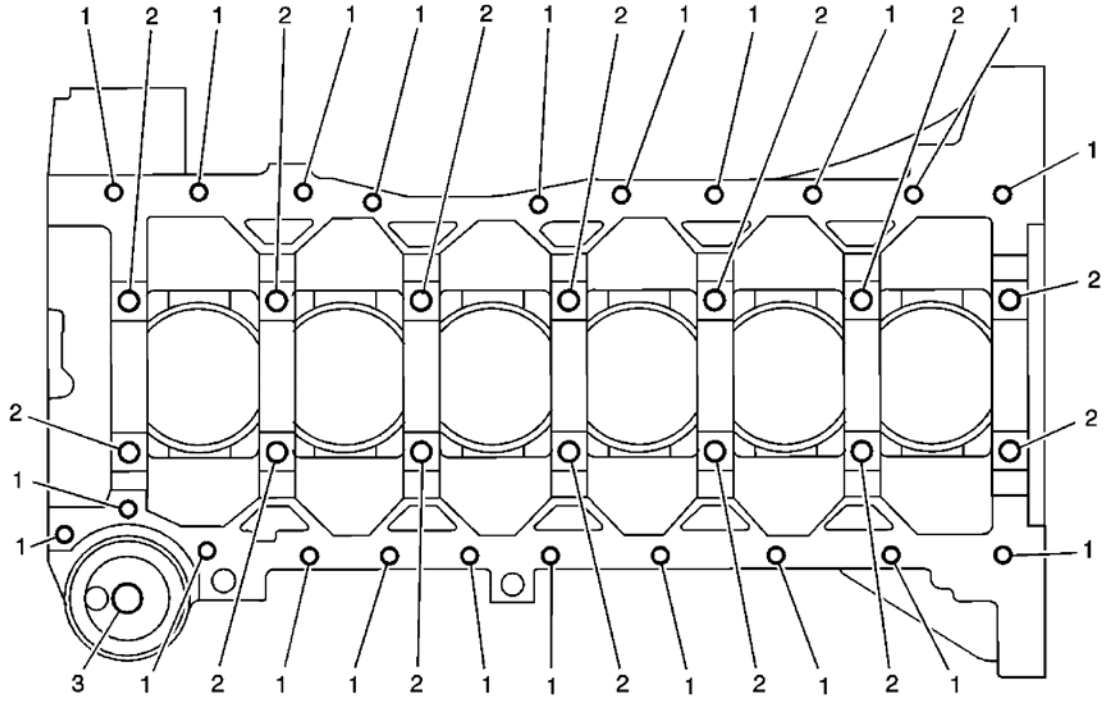


Fig. 2: Engine Block Thread Repair - Bottom View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Bottom View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	8 x 1.25	206	207	n/a	208	209	210	30	1.182	25	0.985
2	10 x 1.5	417	n/a	n/a	418	419	420	53	2.088	45	1.773
3	20 x 16	n/a	n/a	n/a	n/a	n/a	n/a	33	1.300	23	0.906

Engine Block - Left Side View

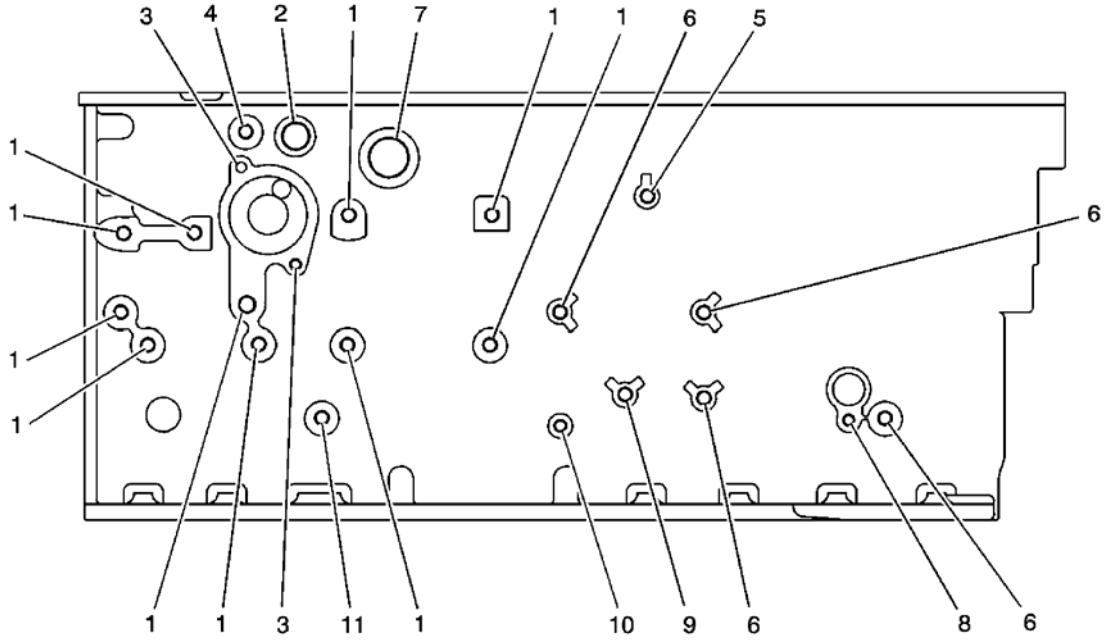


Fig. 3: Engine Block Thread Repair - Left Side View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
			J 42385-400					mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	420	33	1.3	27	1.063
2	M 24 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	30	1.182	20	0.788
3	M 6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709
4	M 12 x 1.75	856	857	n/a	858	859	416	33	1.3	17	0.669
5	M 6 x 1	201	202	n/a	203	204	205	25	0.985	20	0.788
6	M 8 x 1.25	206	207	n/a	208	209	210	25	0.985	20	0.788
7	M 28 x 1.25	n/a	n/a	n/a	n/a	n/a	n/a	25	0.985	17	0.669
8	M 6 x 1	201	202	n/a	203	204	205	19	0.748	15	0.591
9	M 10 x 1.5	211	212	n/a	213	214	420	25	0.985	20	0.788
10	M 8 x 1.25	206	207	n/a	208	209	210	19	0.748	15	0.591

11	M 8 x 1.25	206	207	n/a	208	209	210	33	1.3	27	1.063

Engine Block - Right Side View

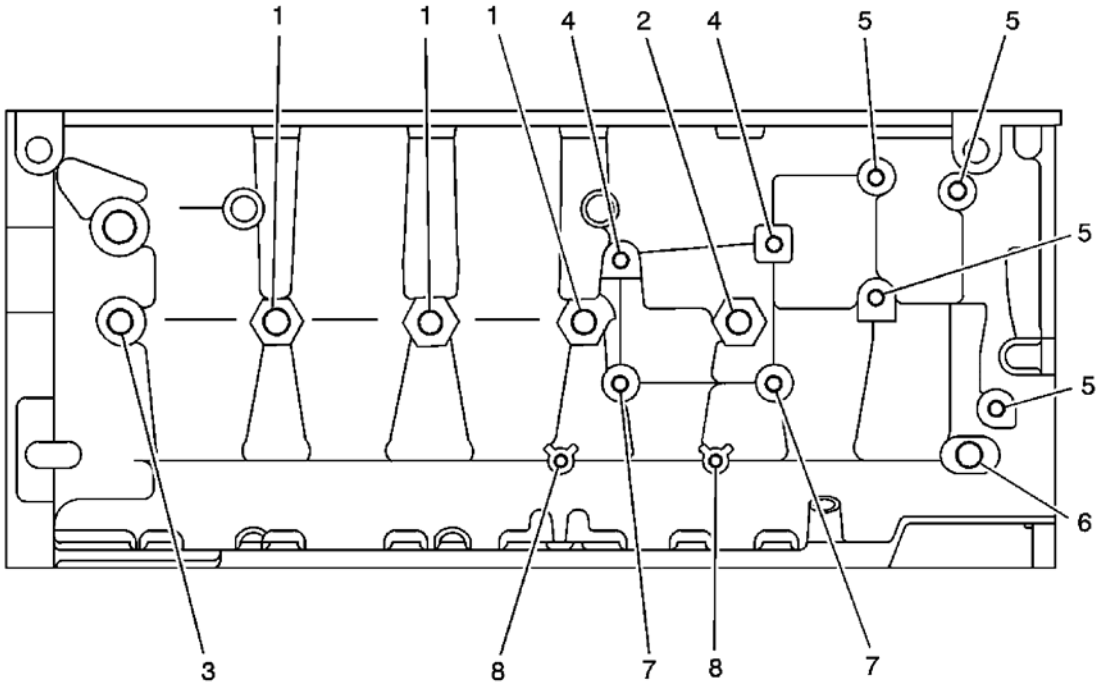


Fig. 4: Engine Block Thread Repair - Right Side View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Right Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
			J 42385-400					mm	(in)	mm	(in)
1	16 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	32	1.260	23	0.906
2	16 x 1.5	211	212	n/a	213	214	420	32	1.260	23	0.906
3	16 x 1.5	206	207	n/a	208	209	210	32	1.260	23	0.906
4	10 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	33	1.300	27	1.063
5	10 x 1.5	211	212	n/a	213	214	420	33	1.300	27	1.063
6	16 x 2	211	212	n/a	213	214	420	24	0.945	16	0.630
7	10 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	29	1.142	26	1.024
8	8 x 1.25	211	212	n/a	213	214	420	23	0.906	18	0.709

Engine Block - Front View

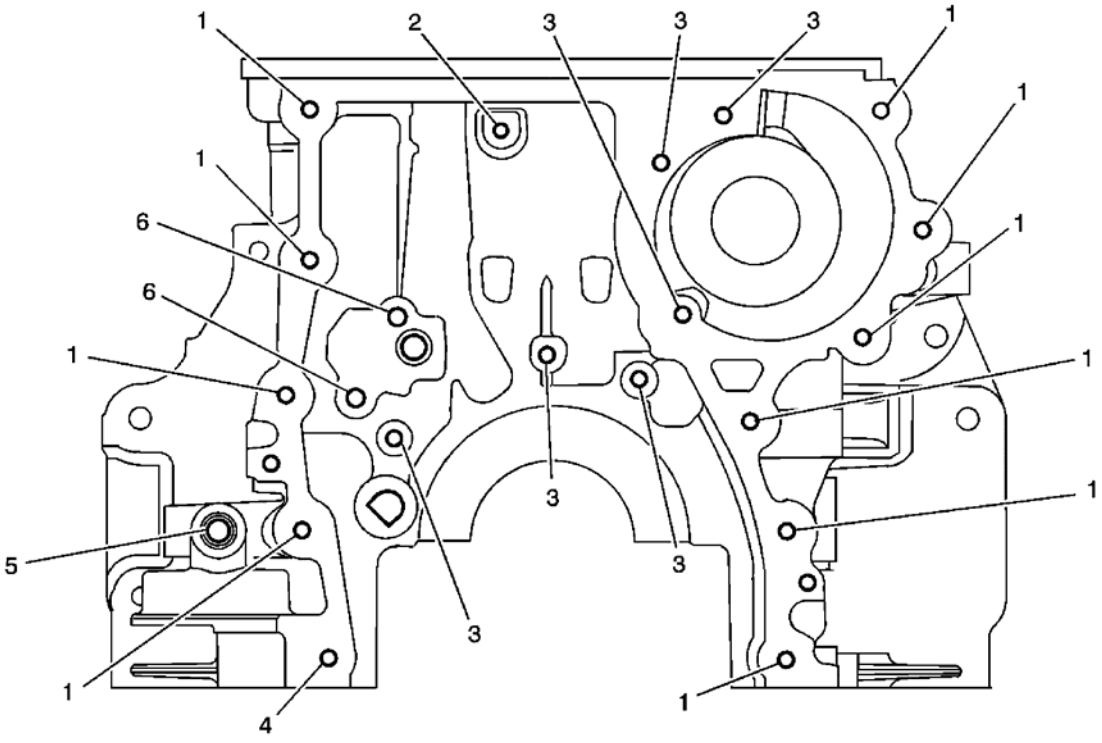


Fig. 5: Engine Block Thread Repair - Front View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	6 x 1	405	n/a	407	203	204	205	30	1.182	26	1.024
2	6 x 1	201	202	n/a	203	204	205	18	0.709	14	0.551
3	6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709
4	6 x 1	201	202	n/a	203	204	205	30	1.182	26	1.024
5	16 x 1.5	405	n/a	407	203	204	205	24	0.945	16	0.630
6	8 x 1.25	206	207	n/a	208	209	210	30	1.182	25	0.985

Engine Block - Rear View

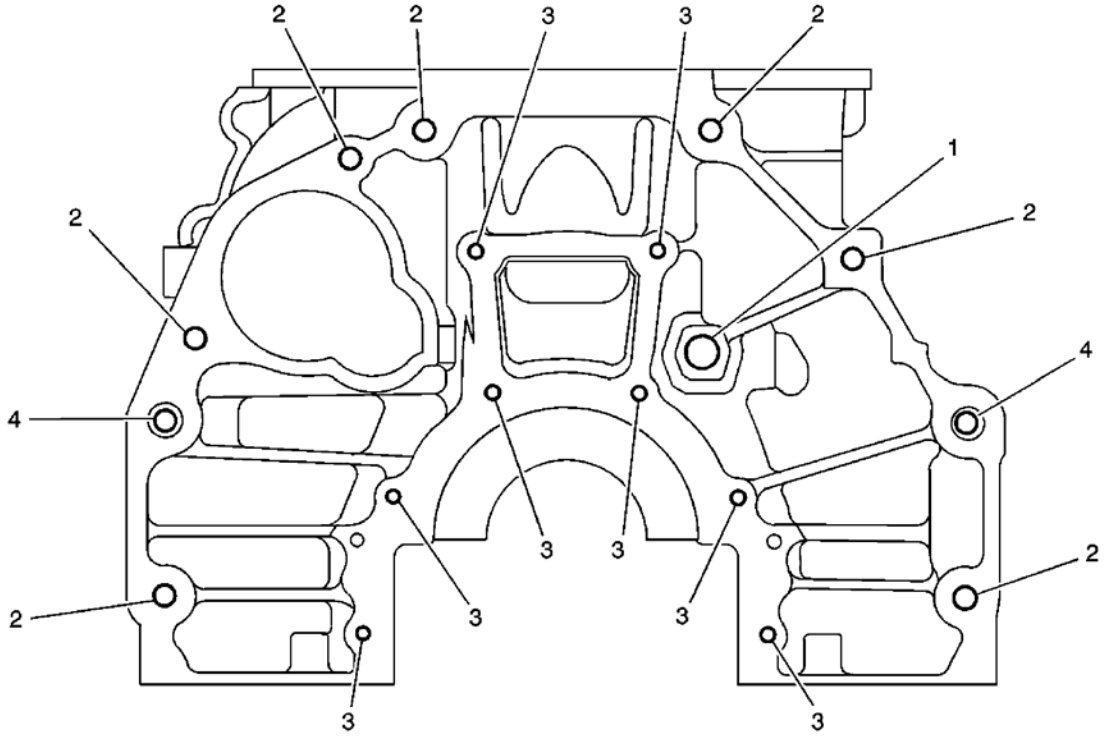


Fig. 6: Engine Block Thread Repair - Rear View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	16 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	24	0.945	16	0.630
2	10 x 1.5	211	212	n/a	213	214	420	39	1.536	33	1.300
3	6 x 1	201	202	n/a	203	204	205	20	0.788	16	0.630
4	10 x 1.5	211	212	n/a	213	214	215	57	2.245	54	2.127

Cylinder Head - Top View

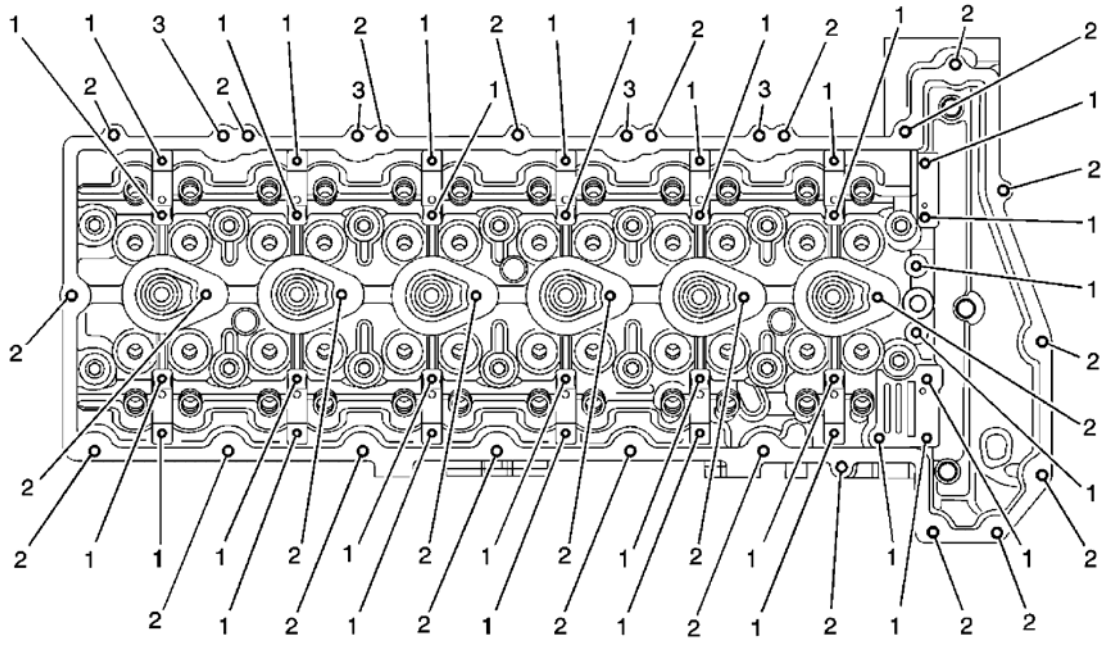


Fig. 7: Cylinder Head Thread Repair - Top View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
			J 42385-400					mm	(in)	mm	(in)
1	M 6 x 1	405	n/a	406	203	204	205	28	1.103	24	0.945
2	M 6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709
3	M 6 x 1	405	n/a	407	203	204	205	THRU		THRU	

Cylinder Head - End View (Front)

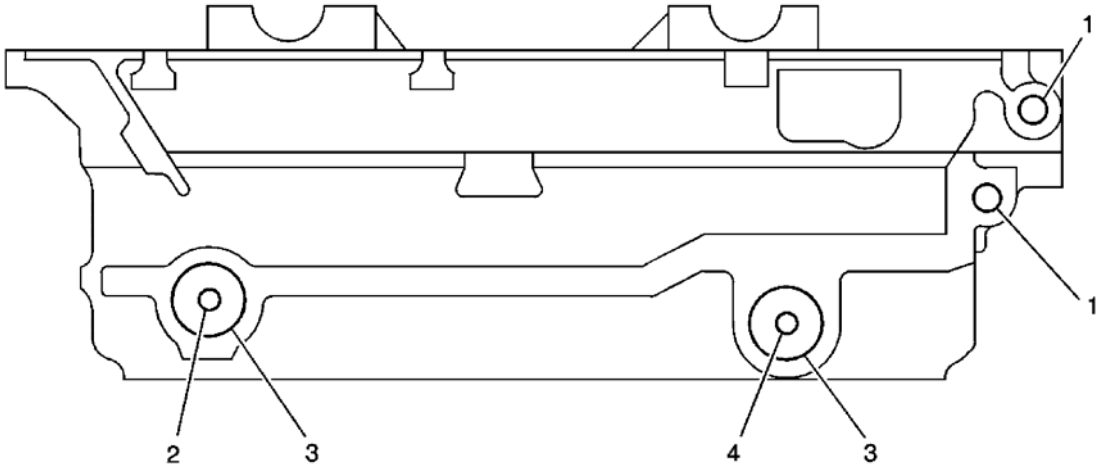


Fig. 8: Cylinder Head Thread Repair - End View (Front)
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - End View (Front)

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	215	28	1.103	22	0.866
2	M 8 x 1.25	206	207	n/a	208	209	210	28	1.103	23	0.906
3	M 24 x 1.5	n/a	n/a	n/a	n/a	n/a	n/a	THRU		THRU	
4	M 6 x 1	201	202	n/a	203	204	205	28	1.103	23	0.906

Cylinder Head - End View (Rear)

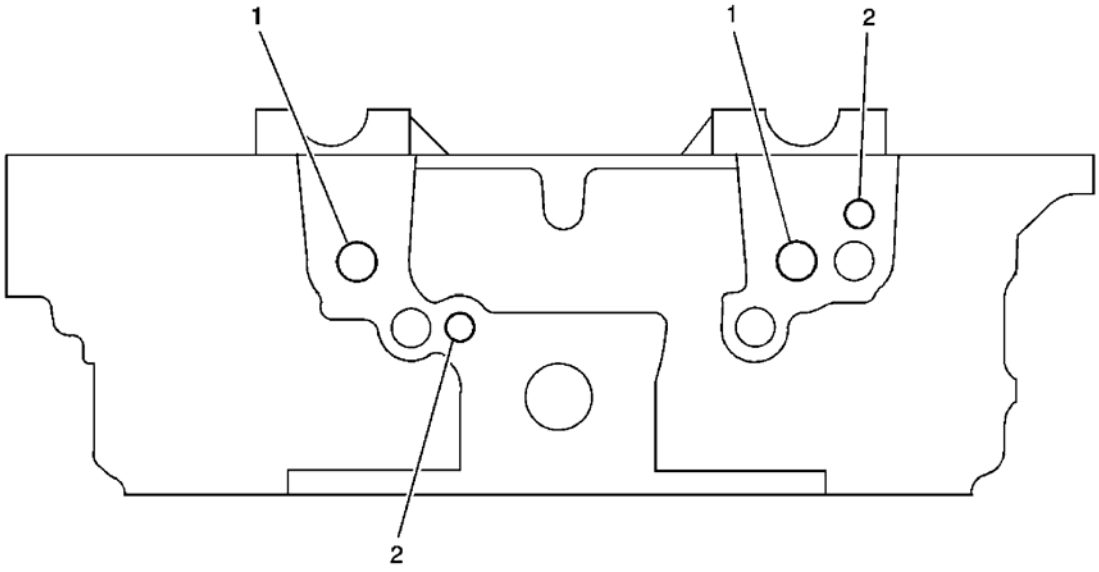


Fig. 9: Cylinder Head Thread Repair - End View (Rear)
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - End View (Rear)

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 14 x 1.5	409	410	n/a	411	412	413	36	1.418	28	1.103
2	M 10 x 1.5	211	212	n/a	213	214	215	28	1.103	22	0.866

Cylinder Head - Intake Manifold Deck View

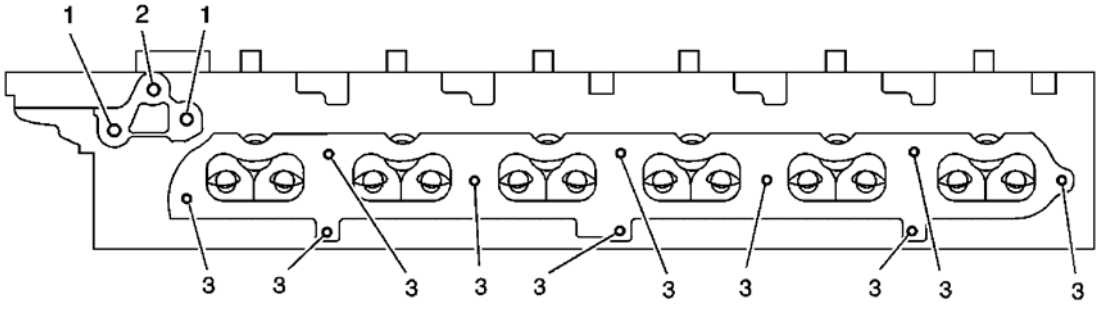


Fig. 10: Cylinder Head Thread Repair - Intake Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake Manifold Deck View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	420	33	1.3	27	1.063
2	M 10 x 1.5	211	212	n/a	213	214	215	28	1.103	22	0.866
3	M 6 x 1	201	202	n/a	203	204	205	23	0.906	18	0.709

Cylinder Head - Exhaust Manifold Deck View

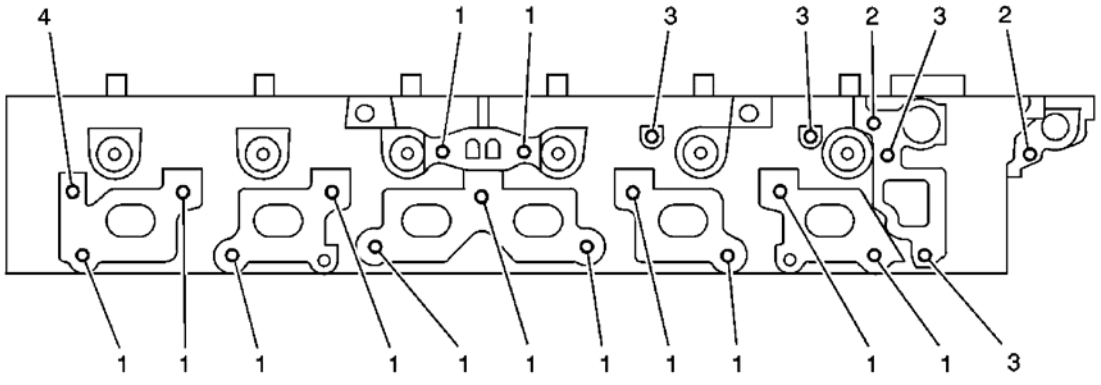


Fig. 11:
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Exhaust Manifold Deck View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	8 x 1.25	206	207	n/a	208	209	210	28	1.103	23	0.906
2	6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709
3	6 x 1	405	n/a	406	203	204	205	28	1.103	23	0.906
4	10 x 1.5	417	n/a	n/a	418	419	420	53	2.088	45	1.773

Oil Pan - Top View

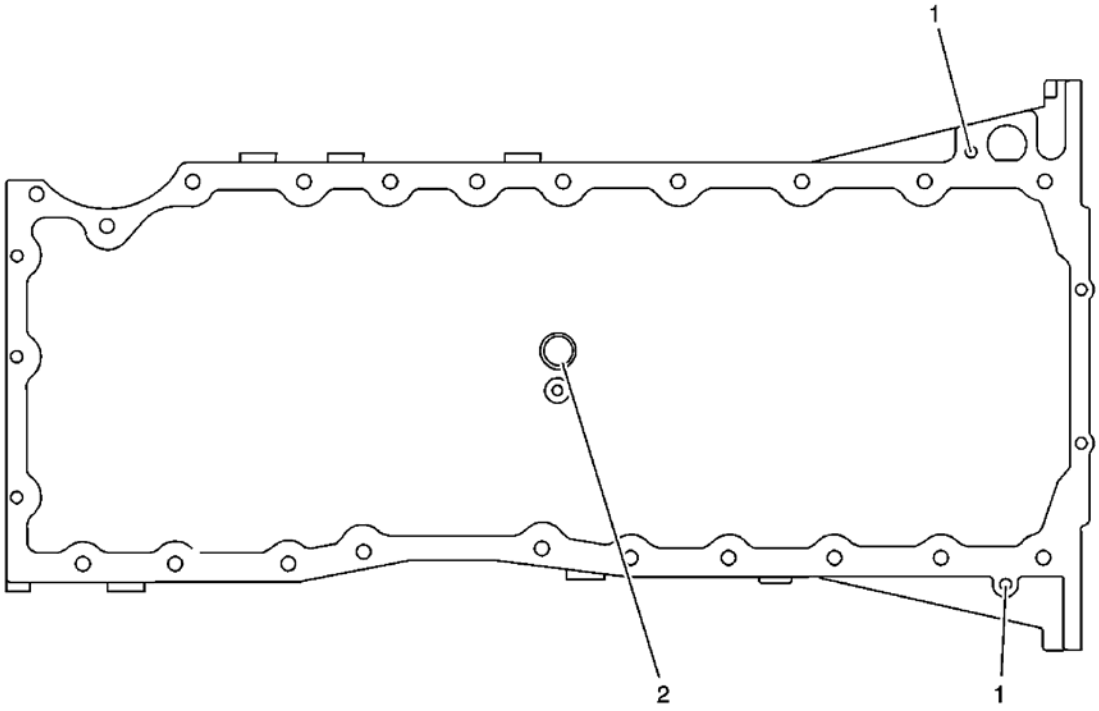


Fig. 12: Oil Pan Thread Repair - Top View
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Top View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 8 x 1.25	206	207	n/a	208	209	415	THRU		THRU	
2	M 12 x 1.75	856	857	n/a	858	859	416	THRU		THRU	

Oil Pan - Left Side View

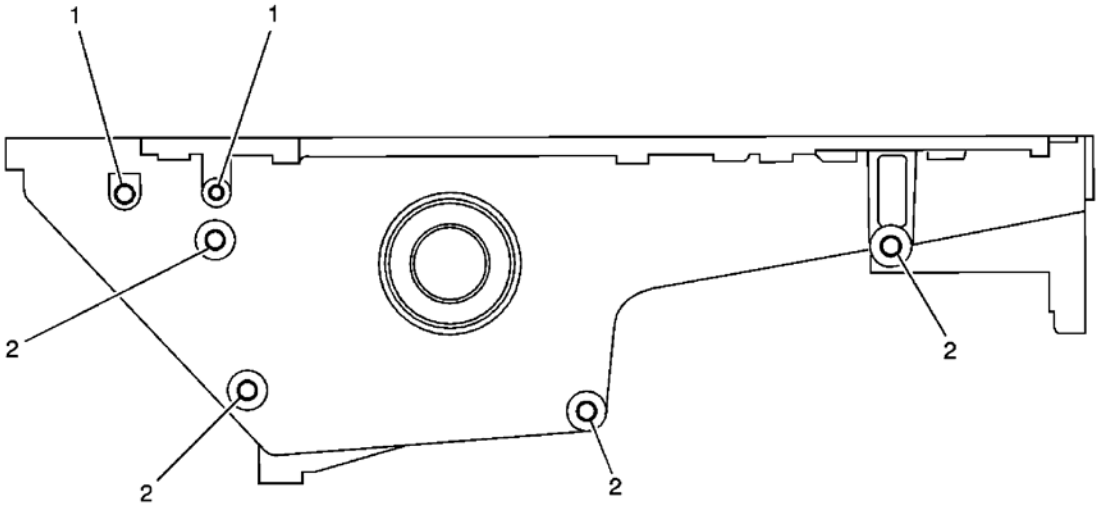


Fig. 13: Oil Pan Thread Repair - Left Side View
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Left Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	420	40	1.576	25	0.985
2	M 10 x 1.5	856	857	n/a	858	859	855	42	1.654	25	0.985

Oil Pan - Right Side View

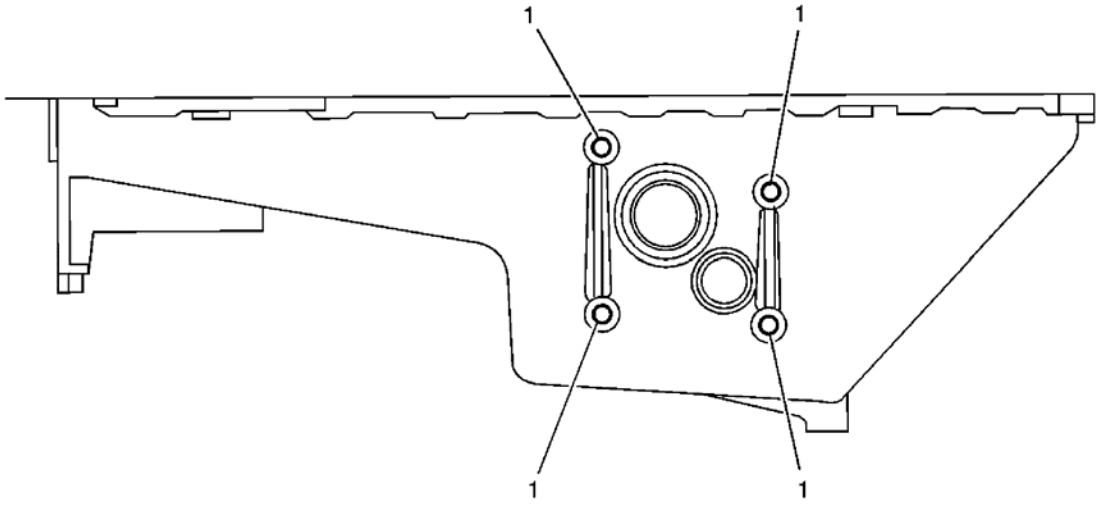


Fig. 14: Oil Pan Thread Repair - Right Side View
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Right Side View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
			J 42385-400					mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	420	42	1.654	25	0.985

Oil Pan - Rear View

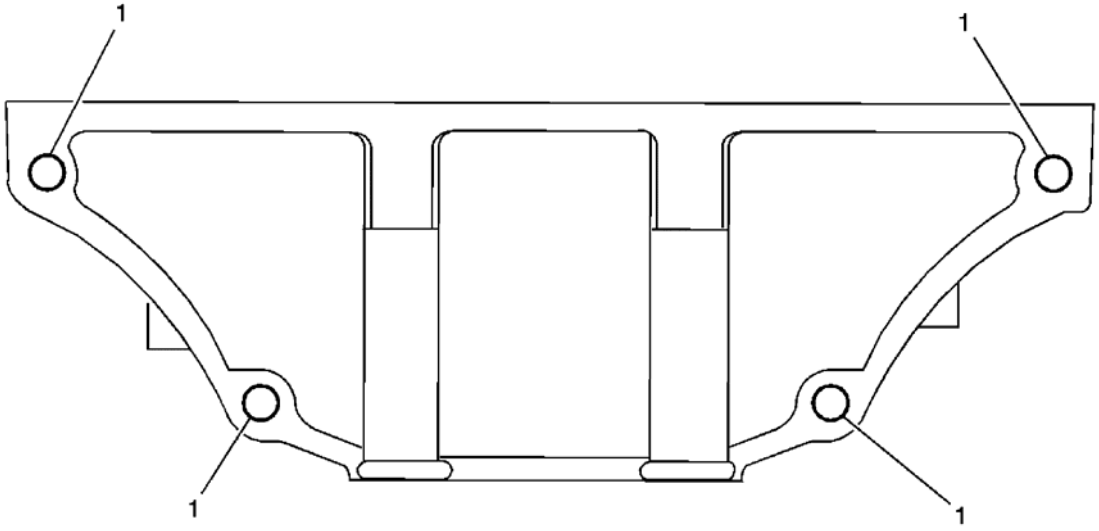


Fig. 15: Oil Pan Thread Repair - Rear View
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Rear View

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 10 x 1.5	211	212	n/a	213	214	215	THRU		THRU	

Engine Front Cover

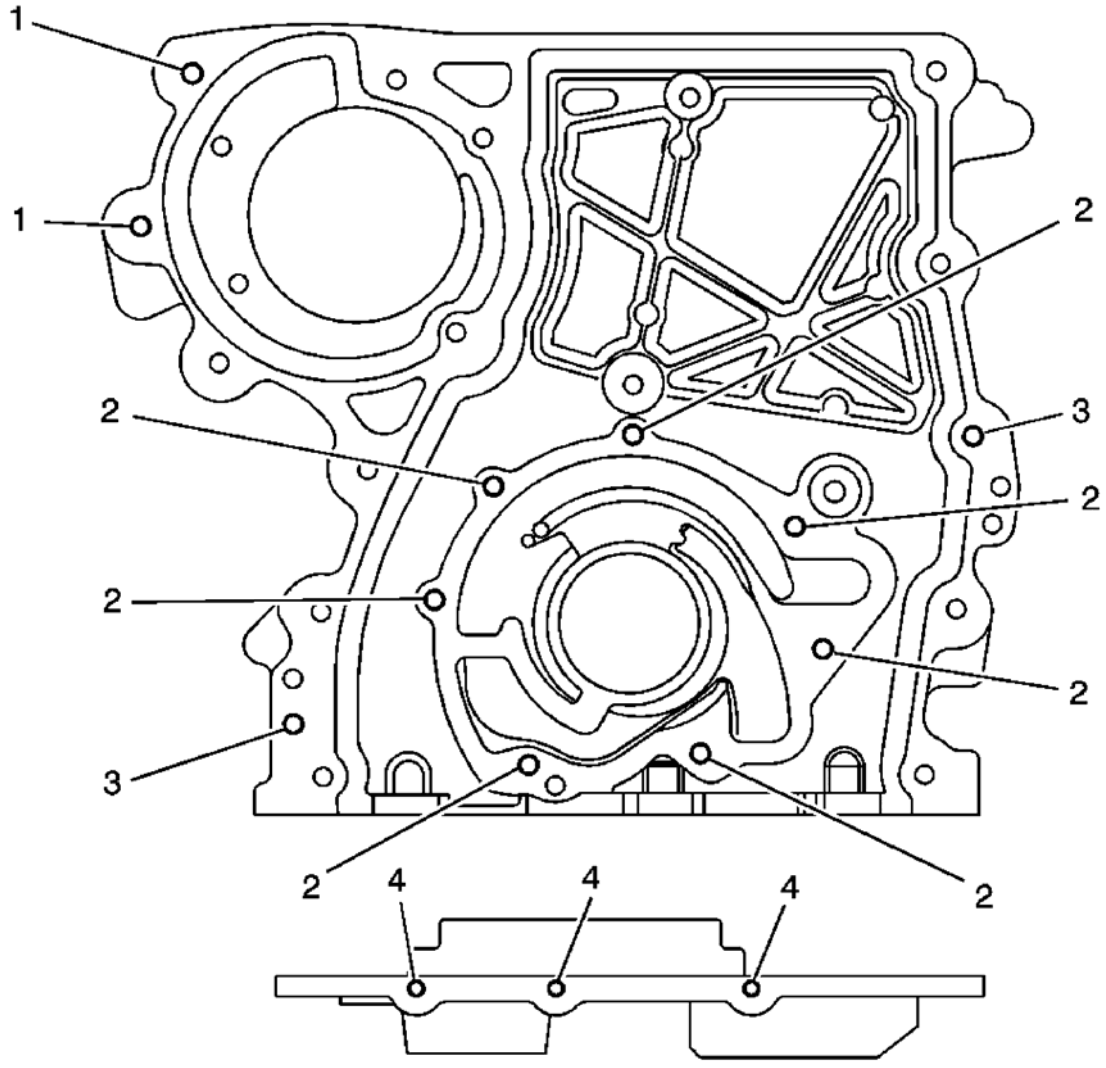


Fig. 16: Engine Front Cover Thread Repair
Courtesy of GENERAL MOTORS CORP.

Engine Front Cover

Service Hole Location	Thread Size	Drill	Counterbore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Max)		Tap Depth (Min)	
J 42385-400								mm	(in)	mm	(in)
1	M 6 x 1	n/a	n/a	n/a	n/a	n/a	n/a	30	1.182	26	1.024
2	M 6 x 1	201	202	n/a	203	204	205	16.5	0.65	13	0.512
3	M 6 x 1	201	202	n/a	203	204	205	THRU		THRU	
4	M 6 x 1	201	202	n/a	203	204	205	17	0.669	14	0.551

Crankshaft Rear Oil Seal Housing

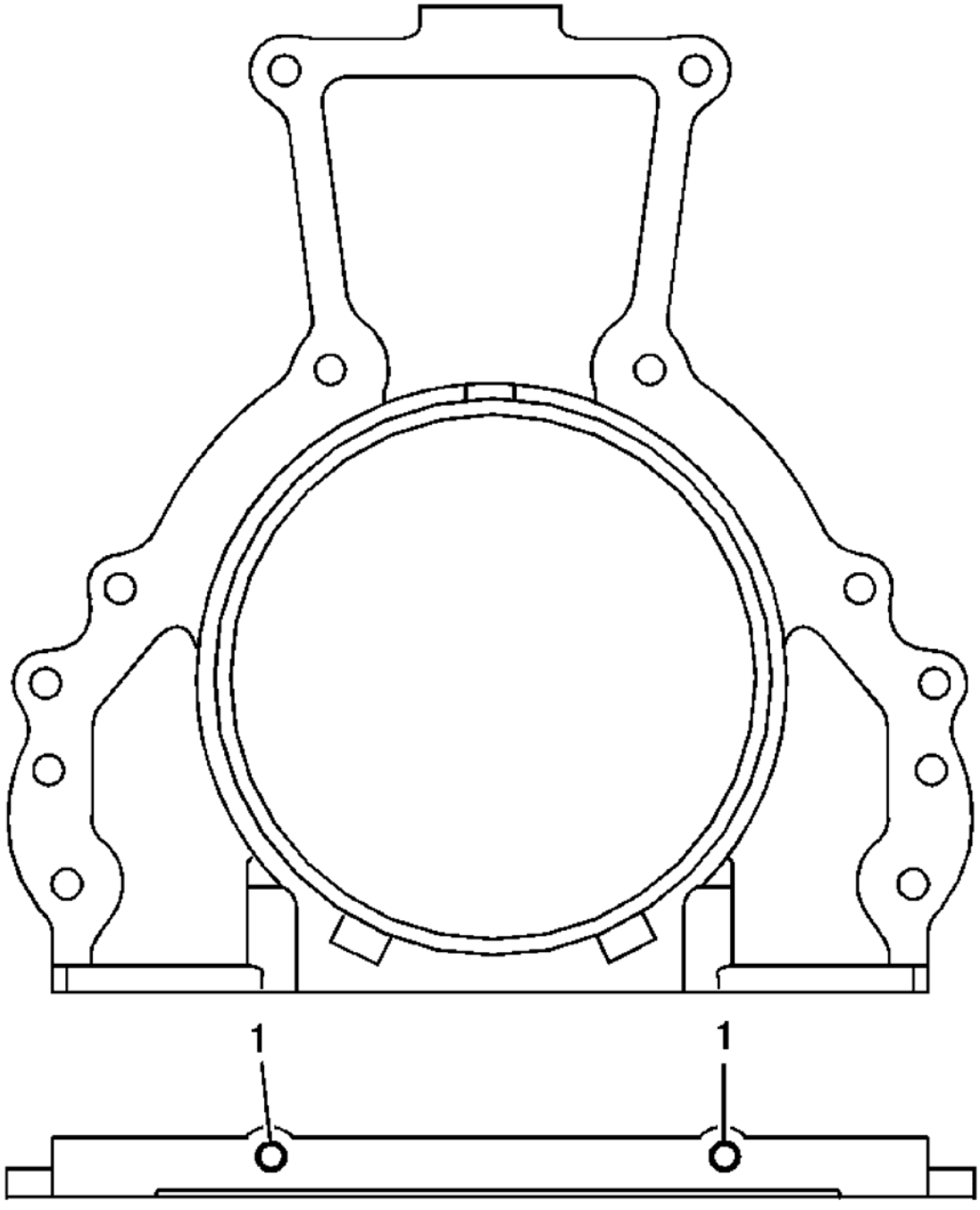


Fig. 17: Crankshaft Rear Oil Seal Housing Thread Repair
Courtesy of GENERAL MOTORS CORP.

Crankshaft Rear Oil Seal Housing

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

J 42385-400								mm	(in)	mm	(in)
1	M 6 x 1	201	202	n/a	203	204	205	22	0.866	18	0.709

SCHEMATIC & ROUTING DIAGRAMS

TIMING CHAIN ALIGNMENT DIAGRAM

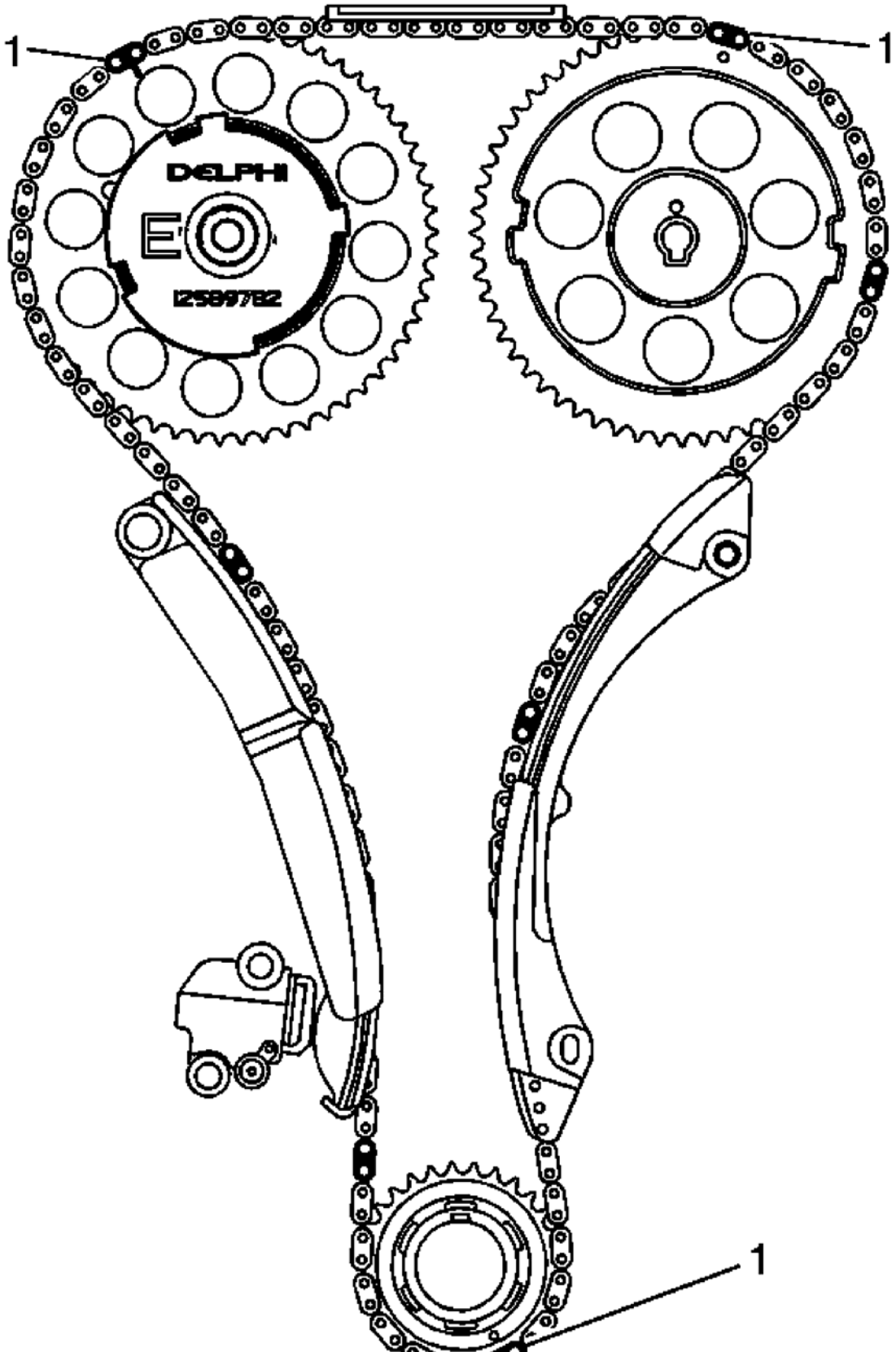

1
1
DELPHI
12589782
1

Fig. 18: Timing Chain Alignment Diagram
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Timing Marks
1	Timing Marks
1	Timing Marks

COMPONENT LOCATOR

DISASSEMBLED VIEWS

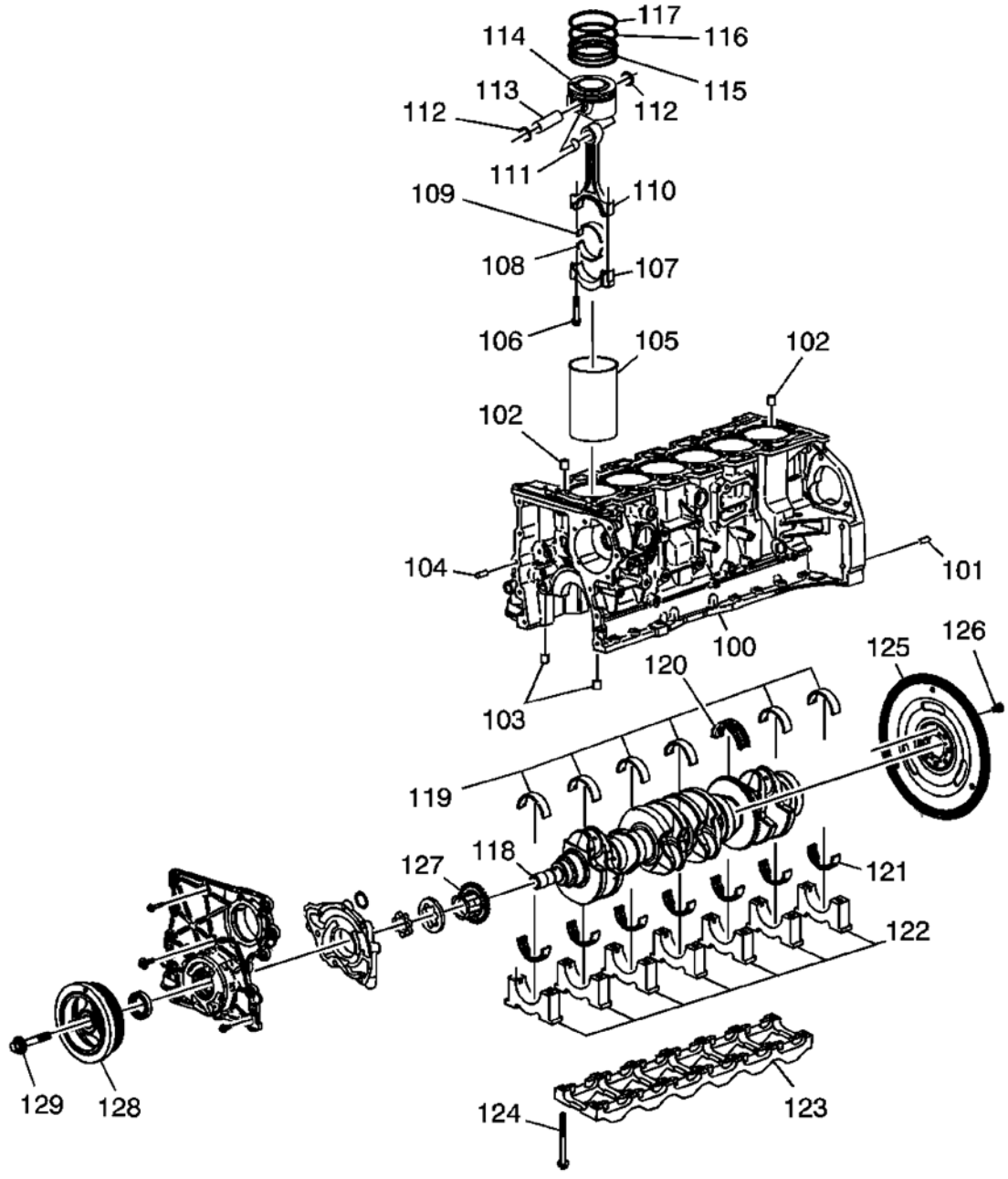


Fig. 19: Engine Block, Crankshaft & Pistons
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Transmission Locator Pin
102	Cylinder Head Locator Pin
102	Cylinder Head Locator Pin

103	Main Bearing Cap Locator Pin
104	Engine Front Cover Locator Pin
105	Cylinder Sleeve
106	Connecting Rod Bolt
107	Connecting Rod Cap
108	Connecting Rod Lower Bearing
109	Connecting Rod Upper Bearing
110	Connecting Rod
111	Connecting Rod Bushing
112	Piston Pin Retainer
112	Piston Pin Retainer
113	Piston Pin
114	Piston
115	Oil Control Ring Set
116	Lower Compression Ring
117	Upper Compression Ring
118	Crankshaft
119	Upper Main Bearings
120	Main Thrust Bearing
121	Lower Main Bearing
122	Main Bearing Cap
123	Main Bearing Cap Stiffener
124	Main Bearing Cap Bolt
125	Flywheel - Automatic Transmission
126	Flywheel Bolt
127	Crankshaft Sprocket
128	Crankshaft Balancer
129	Crankshaft Balancer Bolt

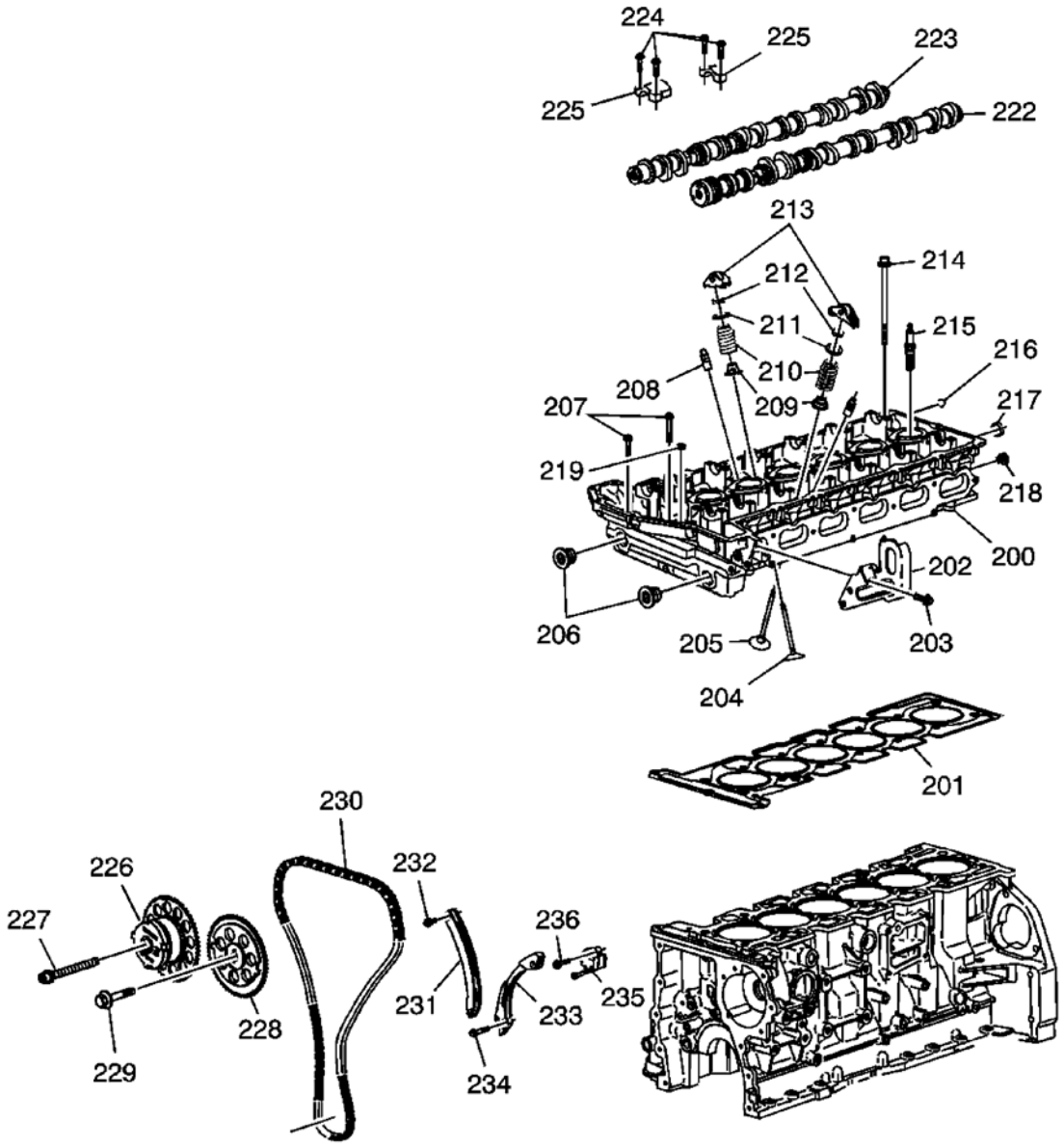


Fig. 20: Cylinder Head, Valves, Lifters, Timing Components, Camshaft
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Cylinder Head
201	Cylinder Head Gasket
202	Engine Lift Bracket
203	Engine Lift Bracket Bolts
204	Intake Valve
205	Exhaust Valve

206	Access Hole Plugs
207	Cylinder Head Bolt
208	Valve Lash Adjusters
209	Valve Seals
210	Valve Springs
211	Valve Spring Retainers
212	Valve Keys
213	Valve Rocker Arms
214	Cylinder Head Bolt
215	Spark Plug
216	A.I.R. Pipe Plug
217	Water Jacket Plug
218	Oil Gallery Plug
219	Oil Gallery Plug
222	Intake Camshaft
223	Exhaust Camshaft
224	Camshaft Cap Bolts
225	Camshaft Cap
225	Camshaft Cap
226	Exhaust Camshaft Actuator
227	Exhaust Camshaft Actuator Bolt
228	Intake Camshaft Sprocket
229	Intake Camshaft Sprocket Bolt
230	Timing Chain
231	Timing Chain Tensioner Shoe
232	Timing Chain Tensioner Shoe Bolt
233	Timing Chain Guide
234	Timing Chain Guide Bolt
235	Timing Chain Tensioner
236	Timing Chain Tensioner Bolt

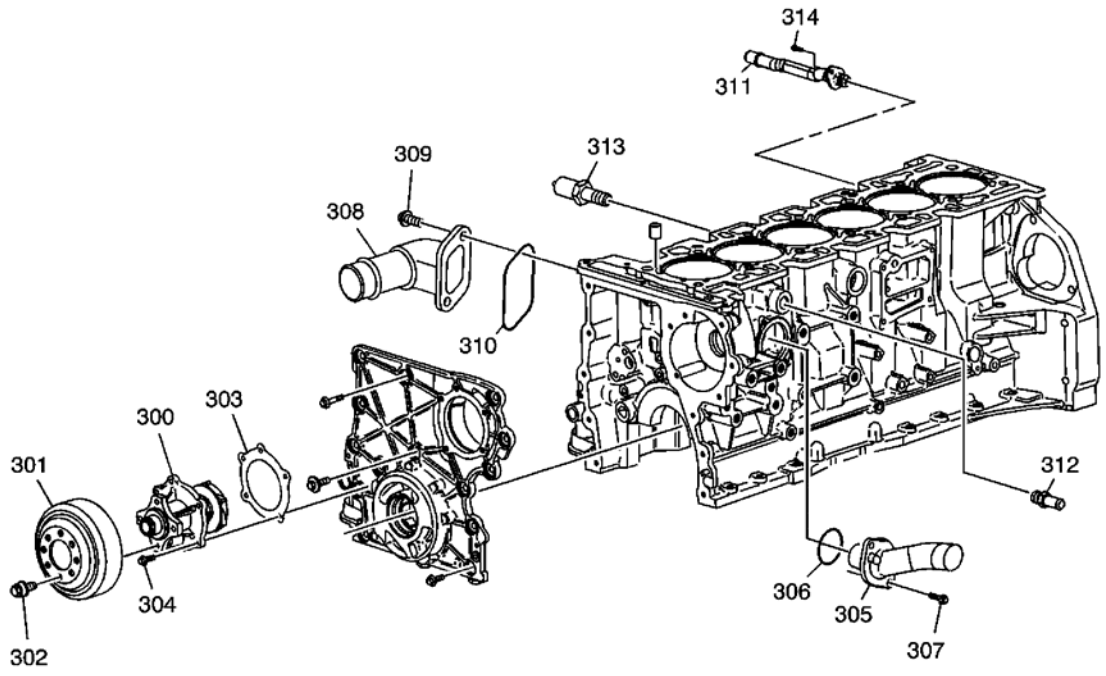


Fig. 21: Exploded View Of Cooling & Water Pump
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
300	Water Pump
301	Water Pump Pulley
302	Water Pump Pulley Bolt
303	Water Pump Gasket
304	Water Pump Bolt
305	Thermostat Housing
306	Thermostat Housing Seal
307	Thermostat Housing Bolt
308	Water Outlet
309	Water Outlet Bolt
310	Water Outlet Seal
311	Heater Inlet Pipe
312	Heater Outlet Hose Fitting
313	Coolant Temperature Sensor
314	Heater Inlet Pipe Bolt

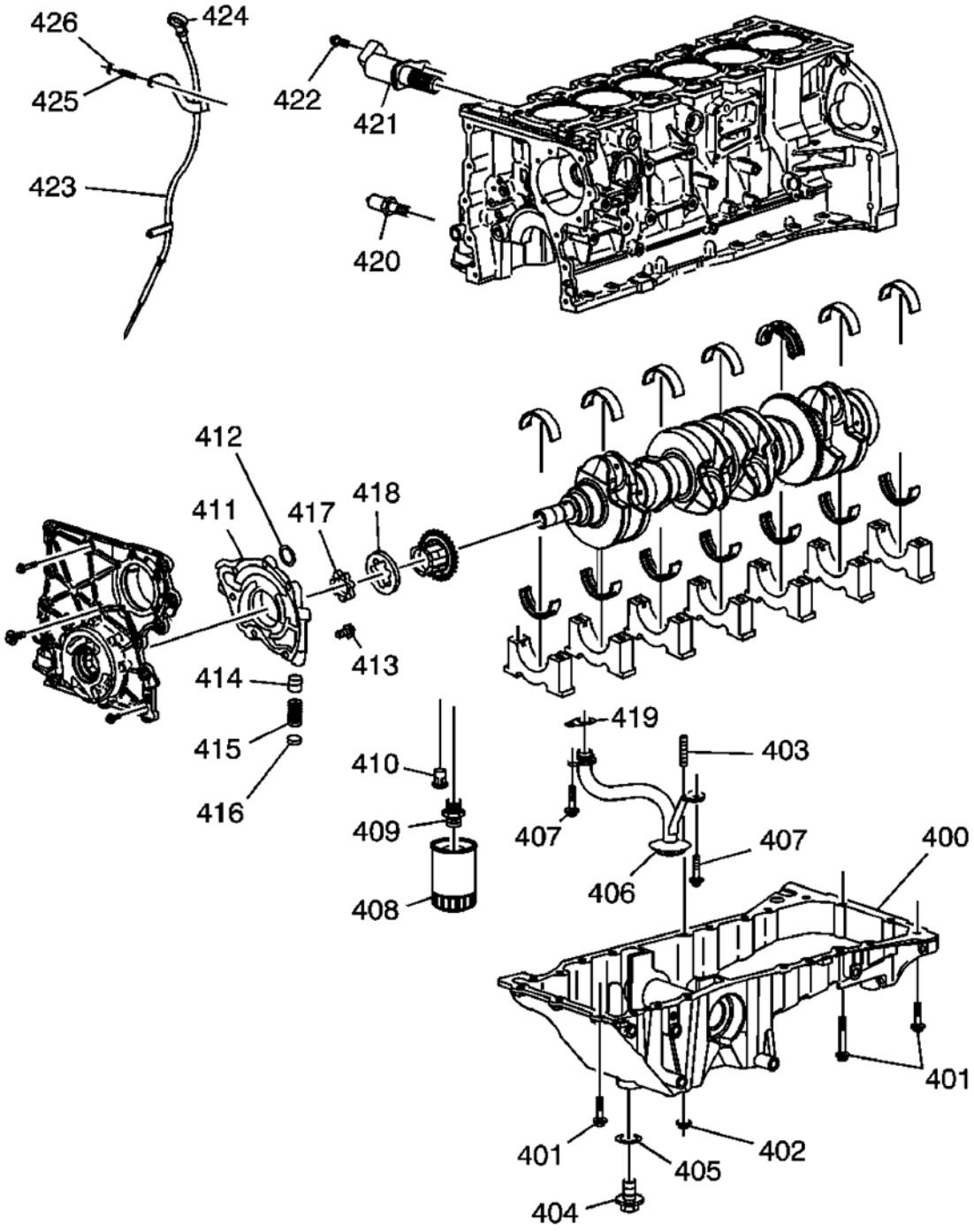


Fig. 22: Oil Pan, Pump, Filter, Tube
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
400	Oil Pan
401	Oil Pan Bolt

401	Oil Pan Bolt
402	Oil Pan Nut
403	Oil Pan Stud
404	Oil Drain Plug
405	Oil Drain Plug Gasket
406	Oil Pump Pickup Tube
407	Oil Pump Pickup Tube Bolt
407	Oil Pump Pickup Tube Bolt
408	Oil Filter
409	Oil Filter Adapter
410	Oil Filter Bypass Valve
411	Oil Pump
412	Oil Pump Seal
413	Oil Pump Bolt
414	Oil Pressure Relief Valve
415	Oil Pressure Relief Valve Spring
416	Oil Pressure Relief Valve Plug
417	Oil Pump Inner Gear
418	Oil Pump Outer Gear
419	Oil Pump Pickup Tube Gasket
420	Oil Pressure Switch
421	Camshaft Position Actuator Solenoid Valve
422	Camshaft Position Actuator Solenoid Valve Bolt
423	Oil Level Indicator Tube
424	Oil Level Indicator
425	Oil Level Indicator Tube Stud
426	Oil Level Indicator Tube Nut

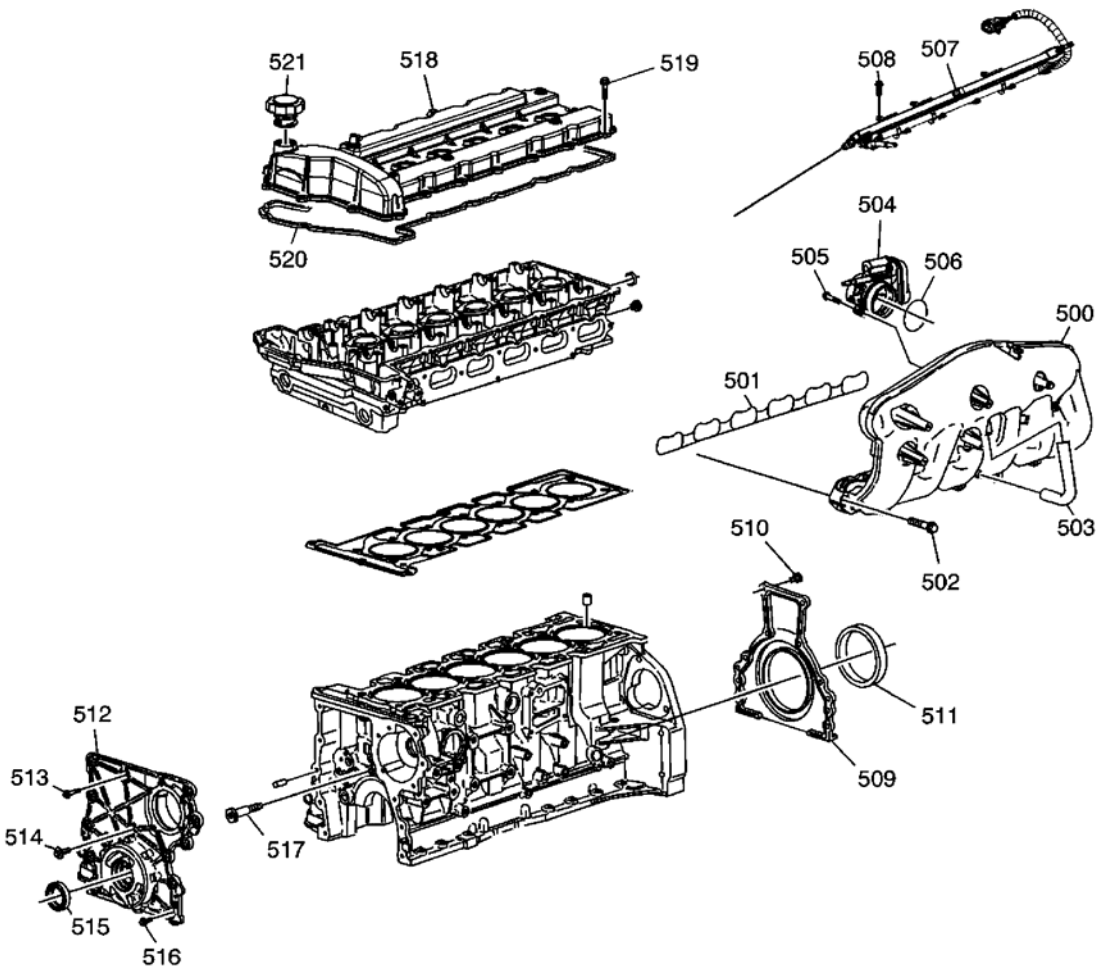


Fig. 23: Exploded View Of Intake Manifold, Rails & Covers
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
500	Intake Manifold
501	Intake Manifold Seal
502	Intake Manifold Bolt
503	Positive Crankcase Vent Hose
504	Throttle Control Module
505	Throttle Control Module Bolt
506	Throttle Control Module Seal
507	Fuel Injector Rail
508	Fuel Injector Rail Bolt
509	Crankshaft Rear Oil Seal Housing
510	Crankshaft Rear Oil Seal Housing Bolt
511	Crankshaft Rear Oil Seal

512	Engine Front Cover
513	Engine Front Cover Bolt
514	Engine Front Center Cover Bolt
515	Engine Front Oil Seal
516	Engine Front Cover Bolt
517	Engine Front Cover Bolt Spacer
518	Camshaft Cover
519	Camshaft Cover Bolt
520	Camshaft Cover Seal
521	Oil Fill Cap

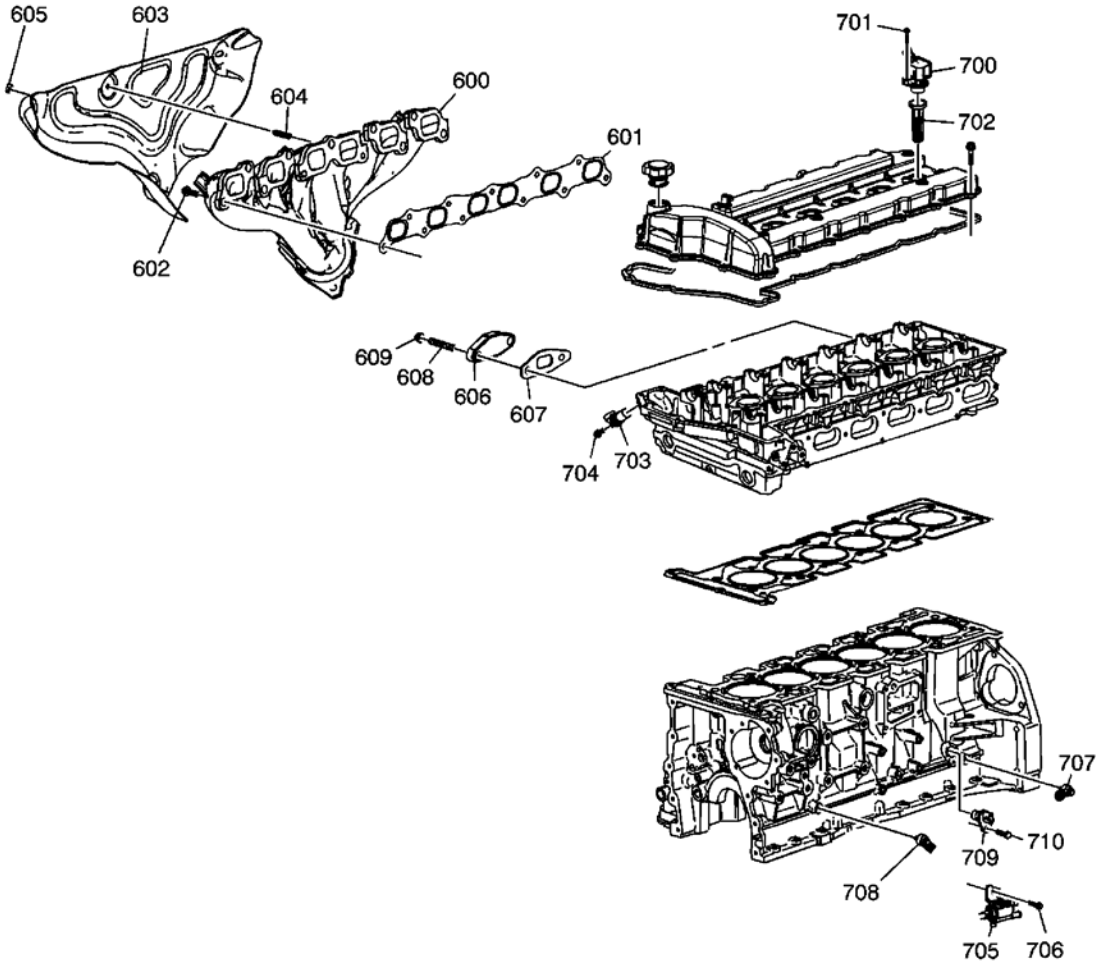


Fig. 24: Exhaust Manifold & Sensors
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
600	Exhaust Manifold

601	Exhaust Manifold Gasket
602	Exhaust Manifold Bolt
603	Exhaust Manifold Heat Shield
604	Exhaust Manifold Heat Shield Stud
605	Exhaust Manifold Heat Shield Nut
606	A.I.R. Cover
607	A.I.R. Cover Gasket
608	A.I.R. Cover Stud
609	A.I.R. Cover Nut
700	Ignition Control Module
701	Ignition Control Module Bolt
702	Ignition Control Module Boot
703	Exhaust Camshaft Position Sensor
704	Exhaust Camshaft Position Sensor Bolt
705	EVAP Emission Canister Purge Solenoid
706	EVAP Emission Canister Purge Solenoid Bolt
707	Knock Sensor
708	Knock Sensor
709	Crankshaft Position Sensor
710	Crankshaft position Sensor Bolt

ENGINE IDENTIFICATION

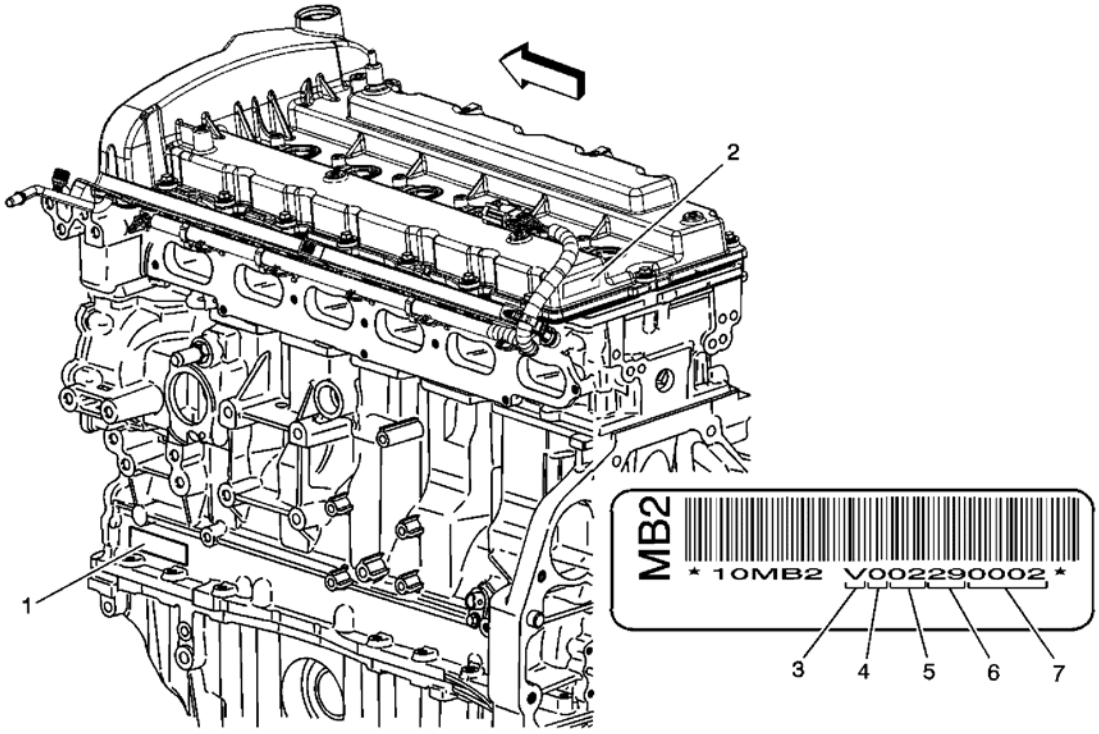


Fig. 25: Locating Engine VIN
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Engine ID Location
2	Engine ID Location
3	The first digit identifies the engine build location - All first digits will be a V, this engine is only being built at Flint Engine South
4	The second digit identifies the build year
5	The third and fourth digits identify the build month
6	The fifth and sixth digits identify the build date
7	The seventh through tenth digits identify the engine build sequence

DIAGNOSTIC INFORMATION & PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, and **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 in Engine Controls 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**, and **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.

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

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

- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Abnormalities (severe cracking, bumps, or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition).	Replace the drive belt.
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, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual misfire condition.)	Repair or replace the flywheel and/or balancer as required.
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 head or throttle body.	Replace the intake manifold, gaskets, cylinder head, and/or throttle body as required.
Improperly installed or damaged MAP sensor (The sealing grommet of the MAP sensor should not be torn or damaged.)	Repair or replace the MAP sensor as required.
Damage to the MAP sensor housing and/or O-ring seal	Replace the intake manifold.
Worn or loose valve rocker arms (The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position)	Replace the valve rocker arms as required.
Worn valve lash adjusters	Replace the valve lash adjusters.
Stuck valves	Repair or replace as required.

(Carbon buildup on the valve stem can cause the valve not to close properly.)	
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Excessive oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.
Faulty cylinder head gasket and/or cracking or other damage to the cylinder head and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder head, engine block, and/or head gasket. • 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. • Inspect the cylinders for a loss of 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 electronic communications (DIS or coil per cylinder) and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.) • Systems with electronic communication (DIS or coil per cylinder) and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set. • Systems with mechanical communications (high voltage switch) and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction

Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.)	Replace the drive belt.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout (A misfire code may be present without an actual misfire condition.)	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual misfire condition.)	Repair or replace the flywheel and/or balancer as required.
Worn Piston Rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • 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 valve rocker arms (The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.)	Replace the valve rocker arms as required.
Stuck valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft, valve lash adjusters, and rocker arms.
Sticking valve lash adjusters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gasket and/or cracking or other damage to the cylinder head and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. • Perform a cylinder leak down test. • Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. • 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. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
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	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.

Worn or damaged valve rocker arm	• Inspect the rocker arm for wear or missing needle bearings • Replace the valve rocker arms as required.
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • The valve lash adjusters • The oil filter bypass valve • The oil transfer tube • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty valve lash adjusters	Replace the valve lash adjusters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft, valve lash adjusters, and rocker arms as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck Valves (Carbon on the valve stem or valve seat may cause the valve to stay open)	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn accessory drive components (Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.)	• Inspect the accessory drive system. • Repair or replace as required.

Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Oil transfer tube loose, damaged or restricted	• Inspect the transfer tube. • 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 arrow or paint on the top of the piston facing the front of the engine. From the bottom, the squared pin boss must be toward the front of the engine.)	• 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 **Oil**

	Pressure Diagnosis and Testing. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Symptoms - Engine Controls** .
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. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flywheel bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Broken timing chain	• Inspect the timing chain and gears. • Repair or replace the components as required.
Seized timing chain or timing gears	• Inspect the timing chain and gears for foreign material or a seized chain.

	• Repair or replace the components as required.
Seized or broken camshaft	• Inspect the camshaft. • Repair or replace the components as required.
Bent valve in the cylinder head	• Inspect the valves and the cylinder head. • Repair or replace the components as required.
Seized oil pump	• Inspect the oil pump assembly. • Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in the cylinder • Oil in the cylinder • Fuel in the cylinder	1. Remove spark plugs and check for fluid in the cylinder. When rotating the engine with the spark plugs removed, the piston (on compression stroke) will push fluid from the combustion chamber. 2. Inspect for failed/broken head gasket. 3. Inspect for a cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace the components as required.
Material in the cylinder • Broken valve • Broken piston ring(s) • Piston material • Foreign material	• Inspect the cylinder for damaged components and/or foreign materials. • Repair or replace the components as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair or replace the components as required.
Bent or broken connecting rod	• Inspect the connecting rods. • Repair or replace the components as required.
Broken crankshaft	• Inspect the crankshaft. • Repair or replace the components as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. • A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer	

to **Engine Will Not Crank - Crankshaft Will Not Rotate**. • Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. • Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. • Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement**.
Warped cylinder head	Replace the cylinder head and gasket. Refer to **Cylinder Head Replacement**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder sleeve 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. • Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. • Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. • Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement**.
Warped cylinder head	Replace the cylinder head gasket. Refer to **Cylinder Head Replacement**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder sleeve or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.
Faulty sealing on engine front cover	Reseal or replace front cover.

ENGINE COMPRESSION TEST

Tools Required

J 38722 Compression Tester. See **Special Tools**.

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

Testing

IMPORTANT: The battery must be at or near full charge. Do not block the throttle open.

1. Remove the air duct from the throttle control module.
2. Remove the ignition control modules.
3. Disable the fuel system.
4. Remove the spark plugs.

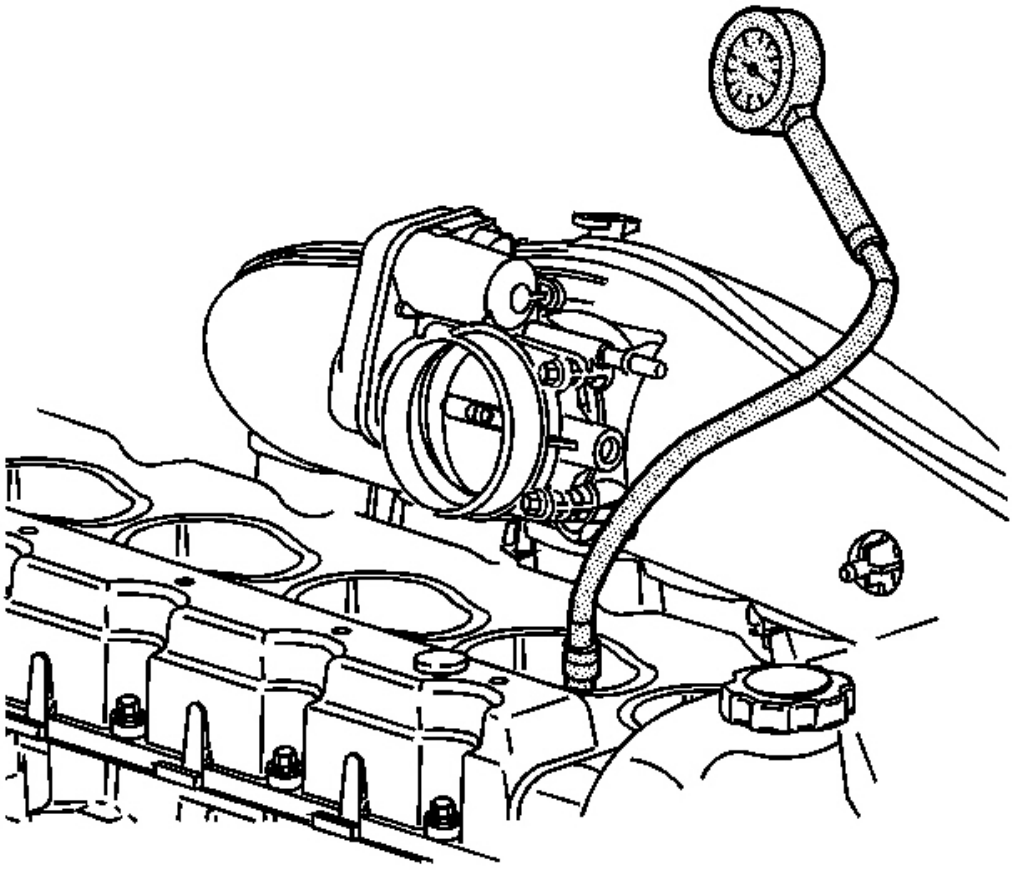


Fig. 26: Measuring Engine Compression
Courtesy of GENERAL MOTORS CORP.

5. Measure the engine compression, using the following procedure:
    1. Firmly install **J 38722** to the spark plug hole. See **Special Tools**.
    2. Have an assistant crank the engine through at least four compression strokes in the testing cylinder.
    3. Check and record the readings on **J 38722** at each stroke. See **Special Tools**.
    4. Disconnect **J 38722** . See **Special Tools**.
    5. Repeat the compression test for each cylinder.
6. Record the compression readings from all of the cylinders. A normal reading should be approximately 1482 kPa (215 psi).

    The lowest reading should not be less than 70 percent of the highest reading.

7. The following are examples of the possible measurements:
    - When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    - When the compression is low on the first stroke and tends to build up on the following strokes, but does not reach the normal compression, or if the compression improves considerably with the addition of three squirts of oil, the piston rings may be the cause.
    - When the compression is low on the first stroke and does not build up in the following strokes, or the addition of oil does not affect the compression, the valves may be the cause.
    - When the compression is low on two adjacent cylinders, or coolant is present in the crankcase, the head gasket may be the cause.
8. Install the air duct to the throttle body.
9. Install the spark plugs.
10. Enable the fuel system.
11. Install the ignition control modules.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester. See **Special Tools**.

Testing

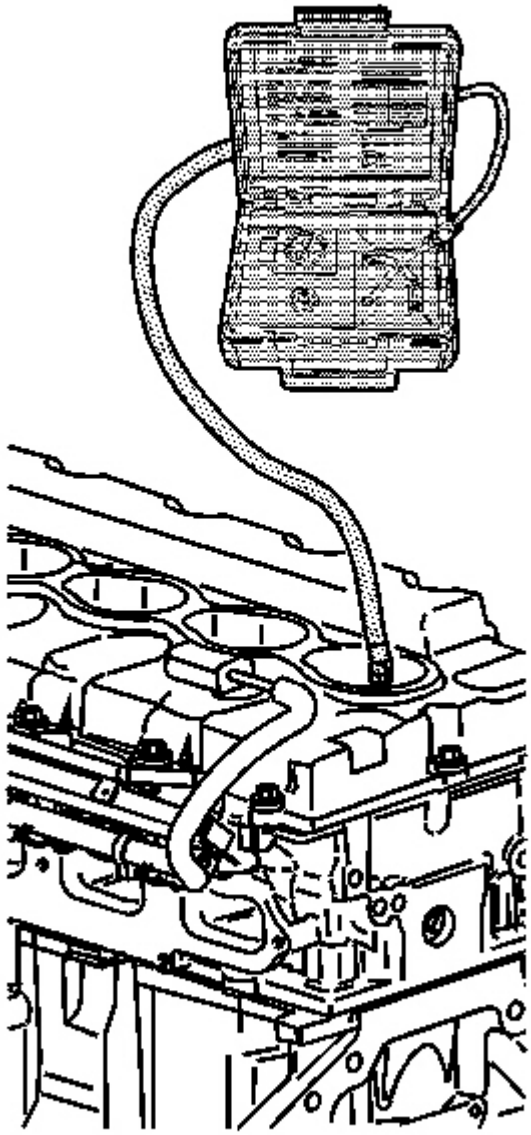


Fig. 27: Checking For Cylinder Leakage
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

IMPORTANT: A leakage test may be performed 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 lash adjuster**
- **Damaged piston**
- **Worn piston rings**
- **Worn or scored cylinder bore**
- **Damaged cylinder head gasket**
- **Cracked or damaged cylinder head**
- **Cracked or damaged engine block**

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. Install **J 35667-A** . See **Special Tools**.

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

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

OIL CONSUMPTION DIAGNOSIS

Checks	Causes

Excessive oil consumption (not due to leaks) is the use of 0.95 L (1.0 qts) or more of engine oil within 2,414 kilometers (1,500 miles).	
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, 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 & TESTING

Tools Required

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

Diagnosis & Testing

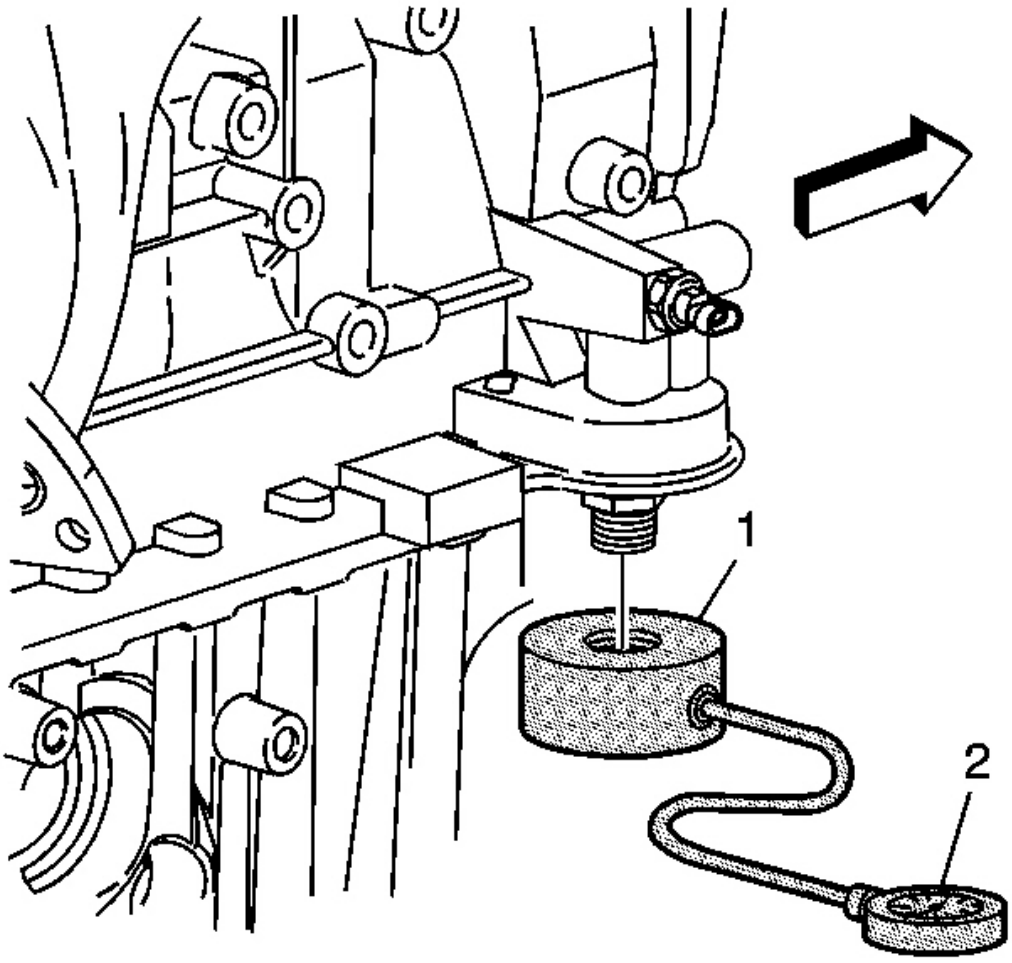


Fig. 28: Measuring Oil Pressure Using J 42907
Courtesy of GENERAL MOTORS CORP.

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 for a low 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:
    - Oil diluted by water or glycol (anti freeze)
    - Foamy oil

6. Remove the oil filter and install the **J 42907** (1). See **Special Tools**.
7. Install **J 21867** (2) or equivalent to the **J 42907** . See **Special Tools**.
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to **Engine Mechanical Specifications**.
10. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
    - Oil pump worn or dirty

      Refer to **Oil Pump Cleaning and Inspection** .

    - Oil pump screen loose, plugged, or damaged
    - Oil pump screen O-ring seal missing or damaged
    - Malfunctioning oil pump pressure regulator valve
    - Excessive bearing clearance
    - Cracked, porous, or restricted oil galleries
    - Oil gallery plugs missing or incorrectly installed

      Refer to **Engine Block Plug Installation** .

    - Broken valve lash adjusters

      Repair as necessary

11. If the reading on **J 21867** or equivalent is within specifications, inspect for the following:. See **Special Tools**.
    - Plugged or incorrect oil filter and/or malfunctioning oil bypass valve
    - Malfunctioning vehicle oil pressure gage or sensor

      Repair as necessary

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
IMPORTANT: **You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.**			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings.		

	Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 6**
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds.		

	4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use **J 28428-E** to identify the type of fluid, and the approximate location of the leak. See **Special Tools**. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components		

	• Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DESCRIPTION

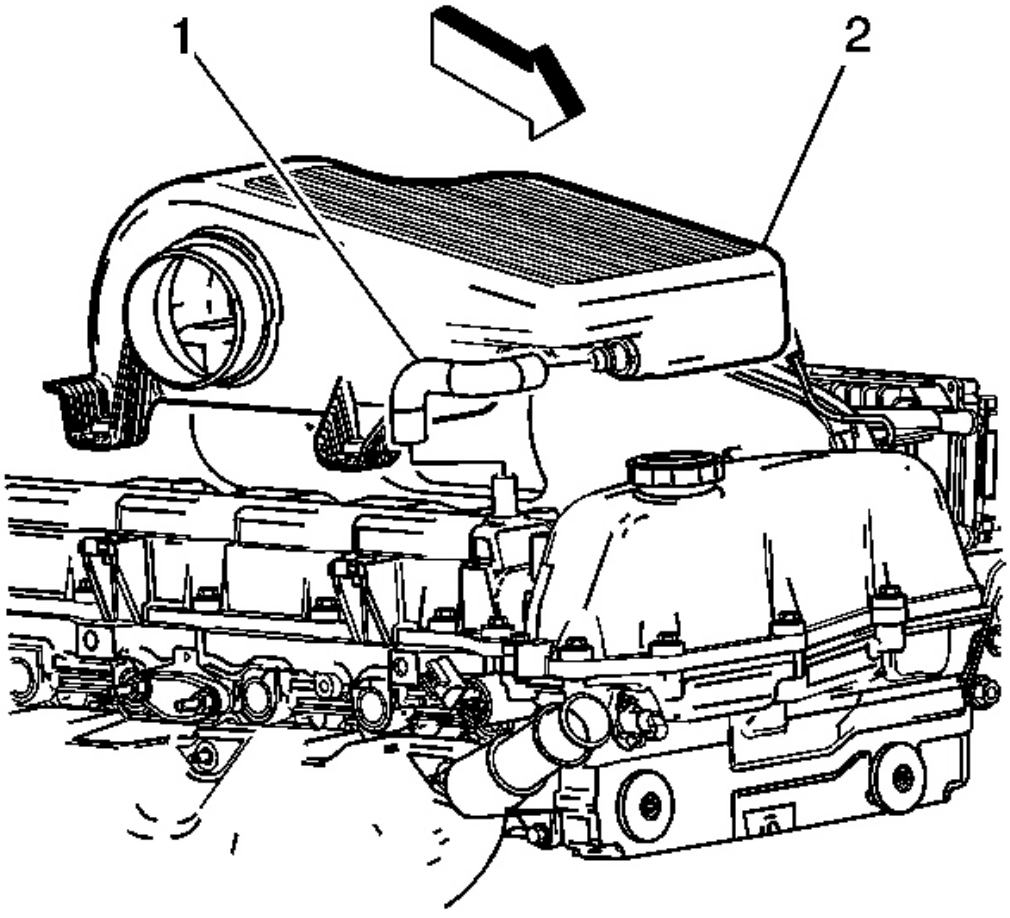


Fig. 29: View Of Crankcase Clean Air Hose & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

A crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. The air cleaner supplies fresh air (1) through a filter to the crankcase.

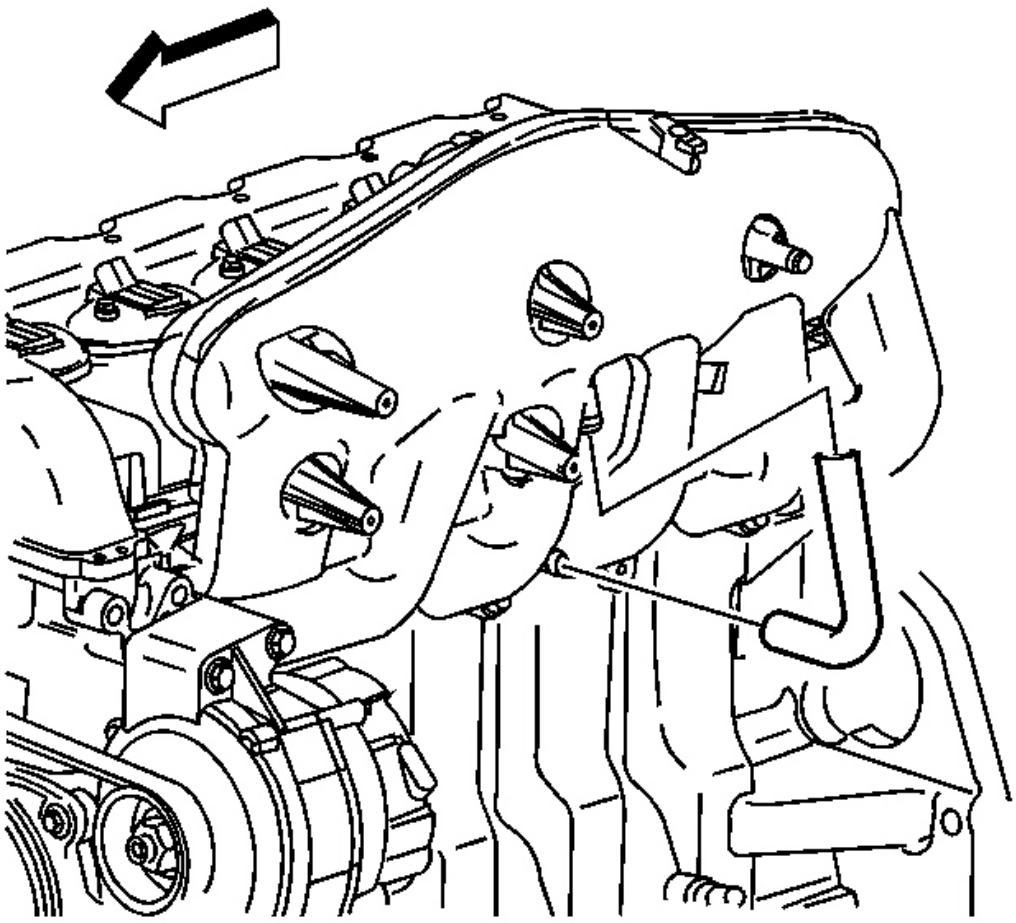


Fig. 30: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

The crankcase mixes the fresh air with blow-by gases. This mixture then passes through an orifice in the cylinder head gasket and to a pipe located in the intake manifold.

The crankcase ventilation system has no serviceable components so no maintenance of the system is required.

Symptom	Correction
External Oil Leak	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure

Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or Slow Idle Speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose
High Idle Speed	Inspect for a leaking (damaged) PCV hose
Sludge In the Engine	Inspect for restricted or kinked PCV hose or engine vent hose

DRIVE BELT CHIRPING, SQUEAL & 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.			
	Did you review the Drive Belt Symptom operation and		Go to **Symptoms -**

1	perform the necessary inspections?	Go to **Step 2**	**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**
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**
	Inspect for an accessory drive component seized		

13	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**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. 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 **Drive Belt Replacement**. 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 & 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 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 plys of the belt separating and may be seen at the edge of the belt our 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 Belt Dressing Notice .
	
	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**
	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below		

3	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**
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 **Drive Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement**. 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 Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement** . 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 & 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: **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 **Symptoms - Engine Mechanical**
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 **Drive Belt Replacement**. 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 Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. 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 **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**. 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 **Drive Belt Replacement**.		

	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 **Drive Belt Replacement**. 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

Inspection Procedure

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

1. Remove the drive belts. Refer to **Drive Belt Replacement**.
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the drive belt tensioner through it's full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
4. If any binding is observed, replace the tensioner. Refer to **Drive Belt Tensioner Replacement**.
5. Install the drive belt. Refer to **Drive Belt Replacement**.

CAMSHAFT POSITION ACTUATOR DIAGNOSIS

For overall description of the camshaft position actuator refer to **Exhaust Camshaft Position Actuator Description**.

The camshaft position actuator will only phase 25-cam degrees retard (counterclockwise). Full advance (clockwise) is 0 degrees.

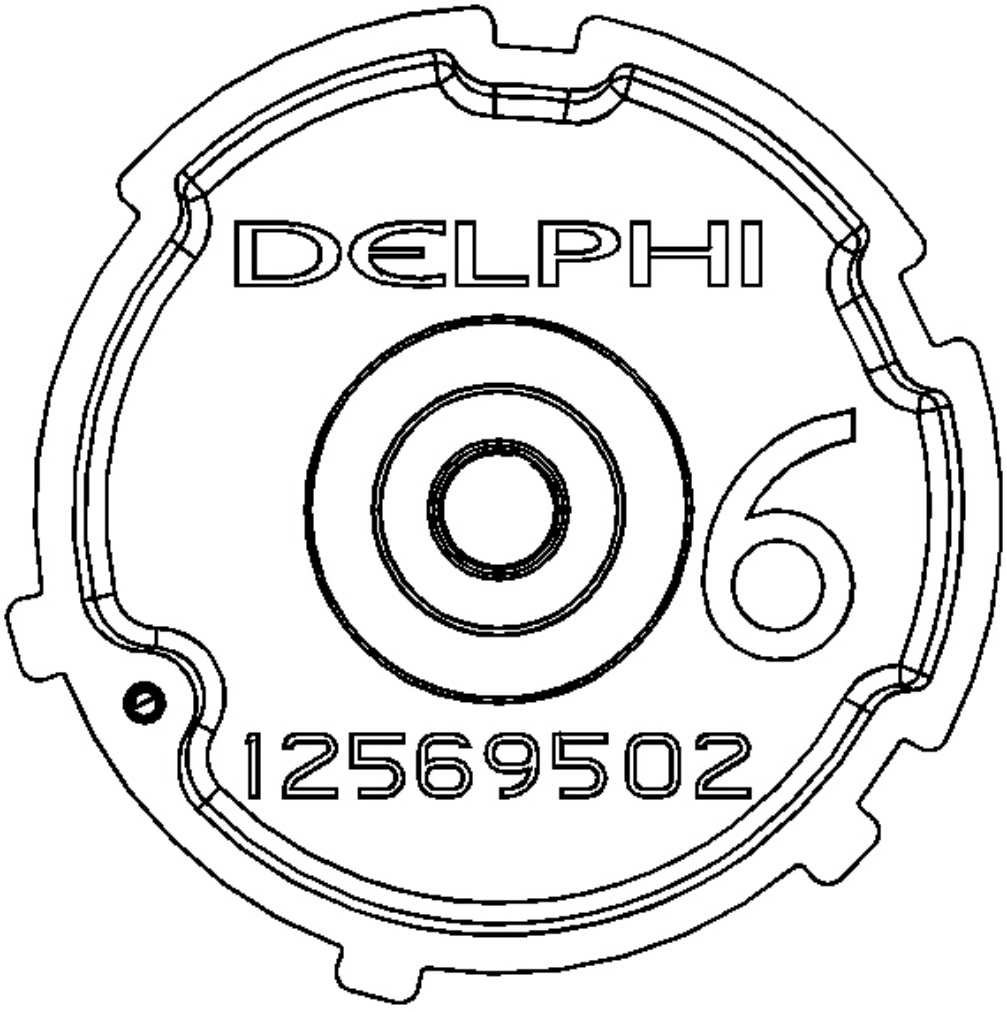


Fig. 31: View Of Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

The camshaft position actuator should always be serviced/replaced in the full advanced position (full clockwise or 0 degrees). New replacement (service) camshaft position actuators are shipped at full advance or 0 degrees. To be sure the camshaft position actuator is performing properly, perform the following to help in the diagnostics.

The camshaft position actuator must be removed from the engine to perform the proper diagnostic test.

1. Clamp the camshaft actuator in a vice. Use care not to damage the contact area of the sprocket.

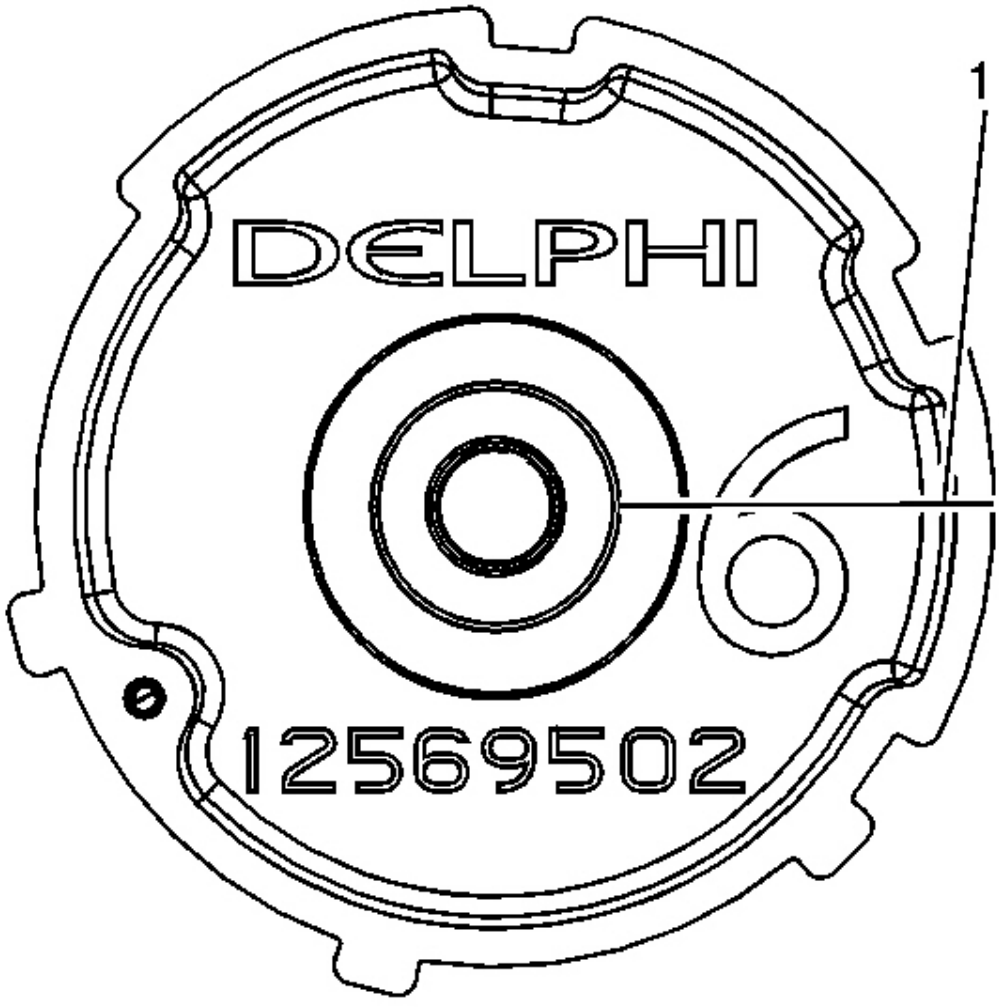


Fig. 32: Identifying Scribing Line On Camshaft Position (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Scribe or draw a line (1) on the camshaft position actuator outer ring face, in the full advanced position. With the engine at TDC on #1 cylinder, the wording should be level.
3. Apply compressed air pressure to the oil port (1) on the back side of the actuator to unlock the locking pin.

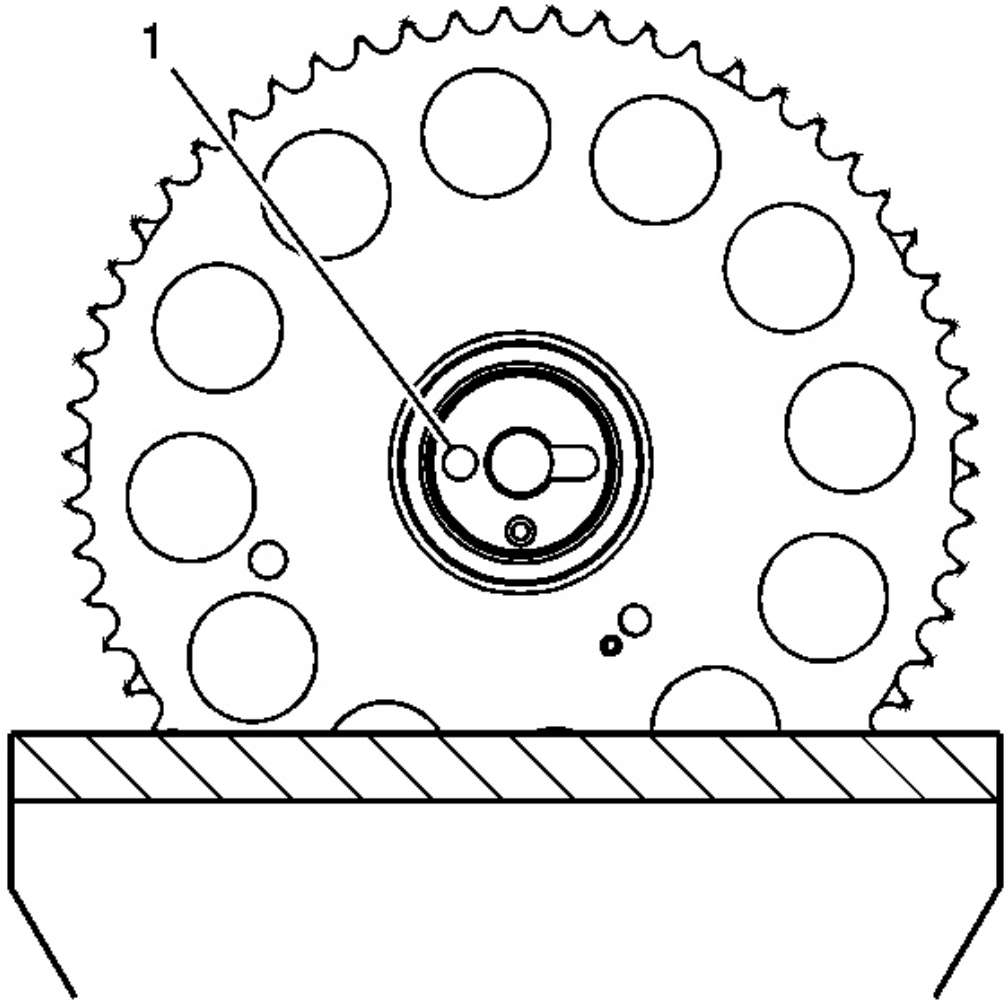


Fig. 33: Locating Oil Port On Back Side Of Actuator
Courtesy of GENERAL MOTORS CORP.

4. Turn the actuator, by hand, to the full counterclockwise position.

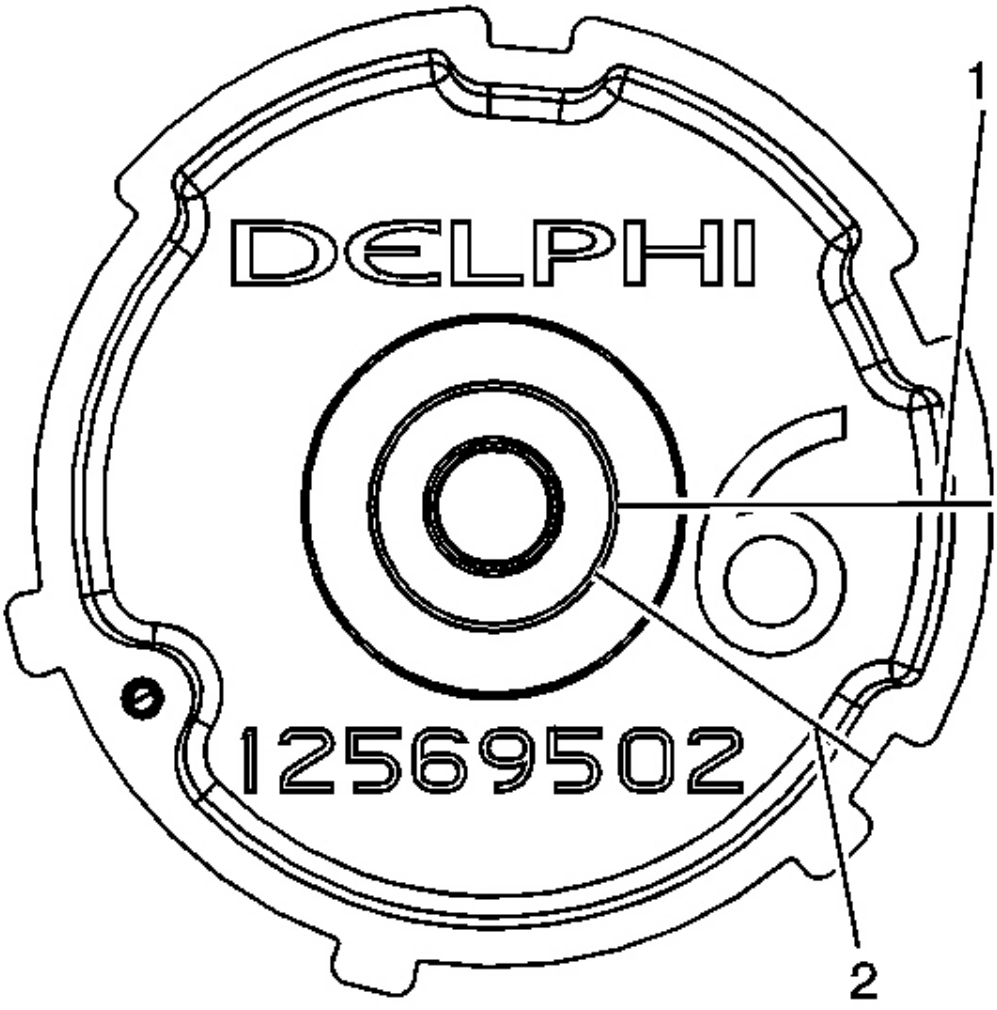


Fig. 34: Identifying Line On Camshaft Position (CMP) Sensor Actuator
Courtesy of GENERAL MOTORS CORP.

5. Scribe or draw a line (2) on the camshaft position actuator at that position.

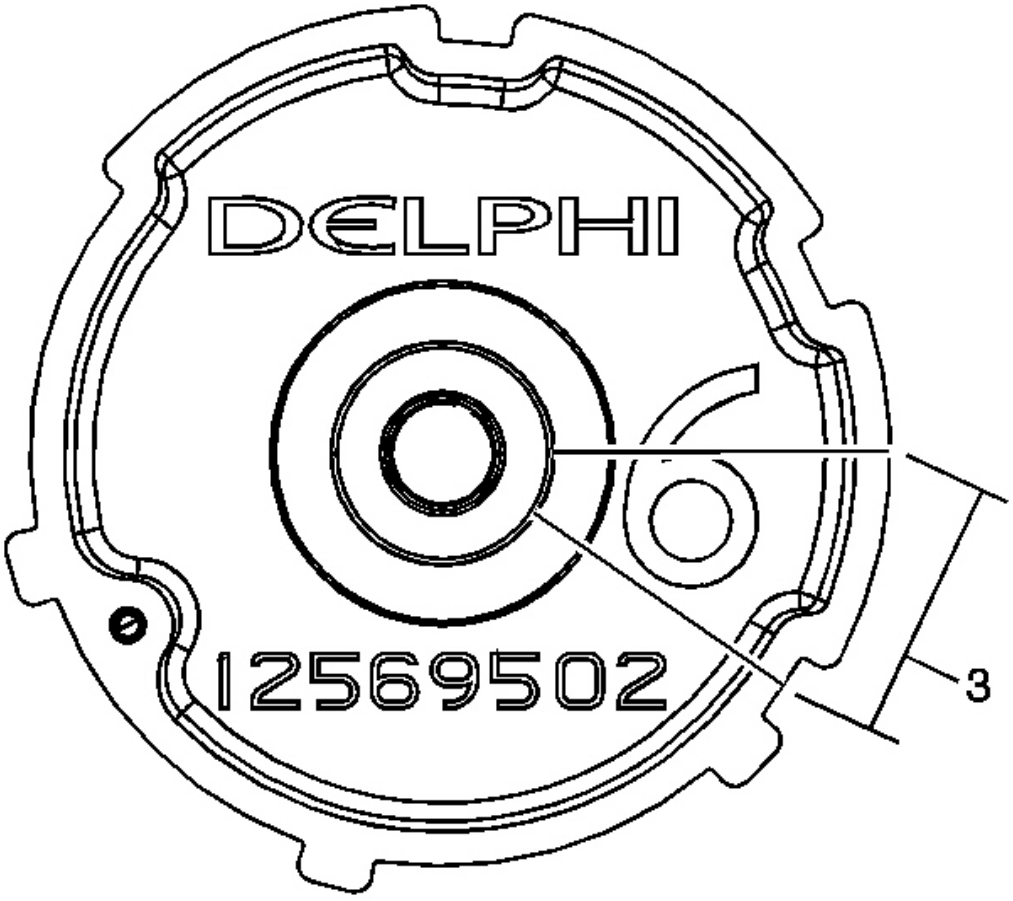


Fig. 35: Identifying Measurement Between Scribe Lines On Camshaft Position (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It is normal for oil and air to leak out of the camshaft actuator when compressed air is applied. It is also normal for oil bubbles to form on the camshaft sprocket surface due to porosity caused by the casting process. Do not replace the actuator due to this leakage.

6. Measure the distance between the two lines. The measurement (3) should be 14-15 mm (0.55-0.59 in).

   The camshaft position actuator must be replaced if it does not unlock when air pressure is applied, does not lock when air pressure is removed, or does not move within the 14-15 mm (0.55-0.59 in).

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT

Removal Procedure

1. Install 3/8 inch breaker bar on the drivebelt tensioner arm and turn the breaker bar clockwise enough to relieve the tension on the drivebelt.

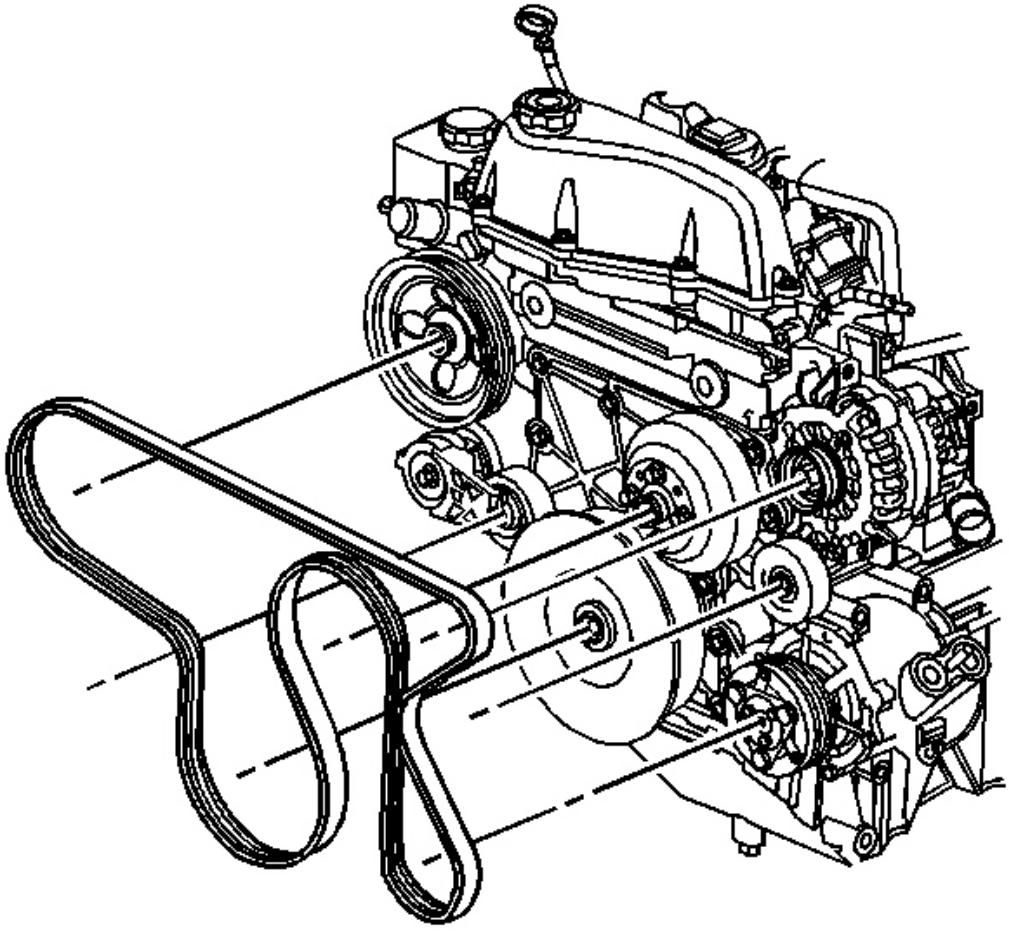


Fig. 36: View Of Drive Belt
Courtesy of GENERAL MOTORS CORP.

2. Remove the drivebelt.
3. Release the tension on the tensioner arm.

Installation Procedure

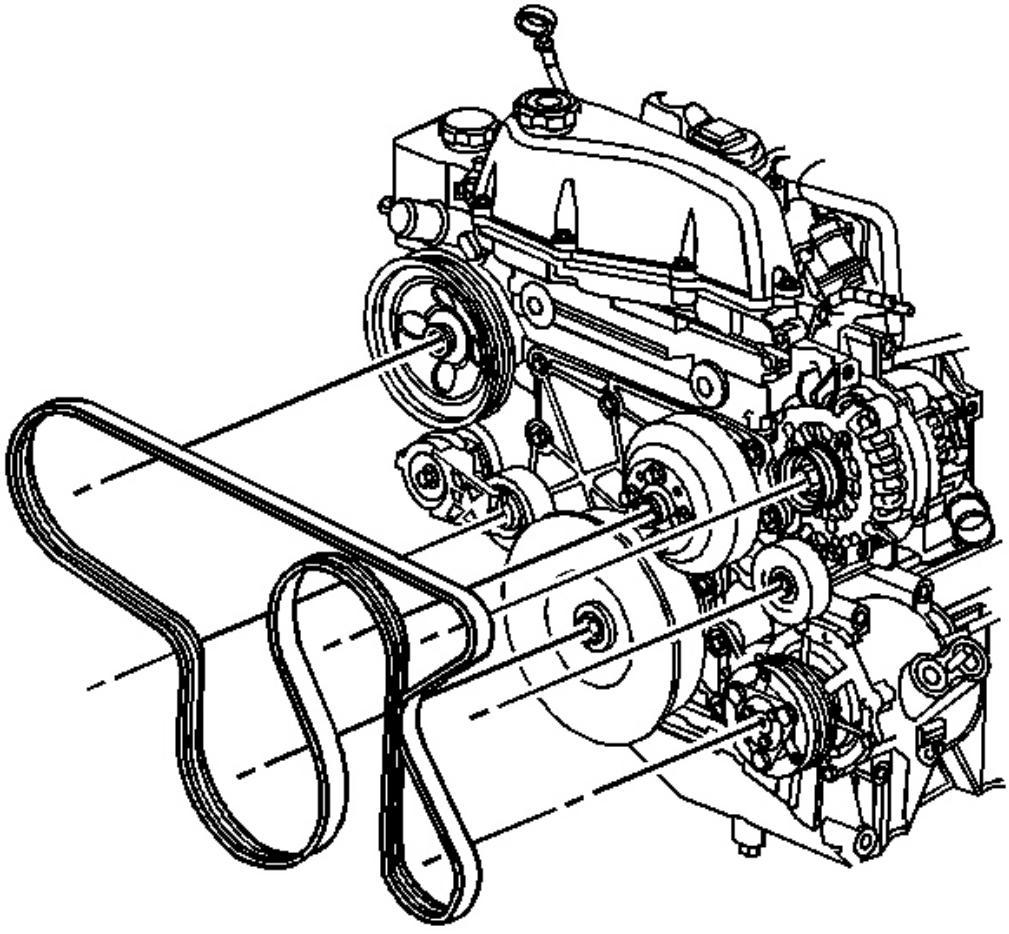


Fig. 37: View Of Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Route the drivebelt over all the pulleys except the drivebelt tensioner pulley.
2. Install the 3/8 inch breaker bar on the drivebelt tensioner arm and turn the breaker bar clockwise.
3. Install the drivebelt over the drivebelt tensioner pulley.
4. Slowly release the tension to the drivebelt tensioner arm.
5. Inspect for proper installation of the drivebelt on the pulleys.

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the drive belt tensioner bolt.

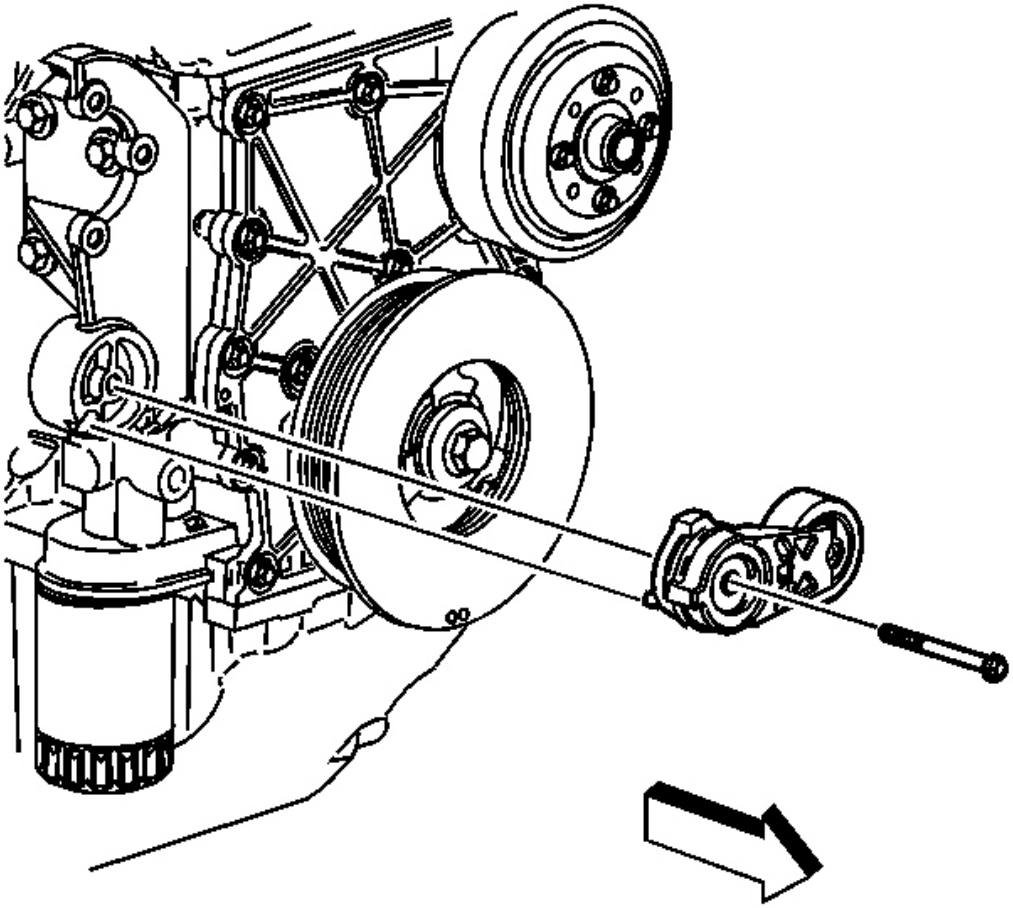


Fig. 38: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the drive belt tensioner.

Installation Procedure

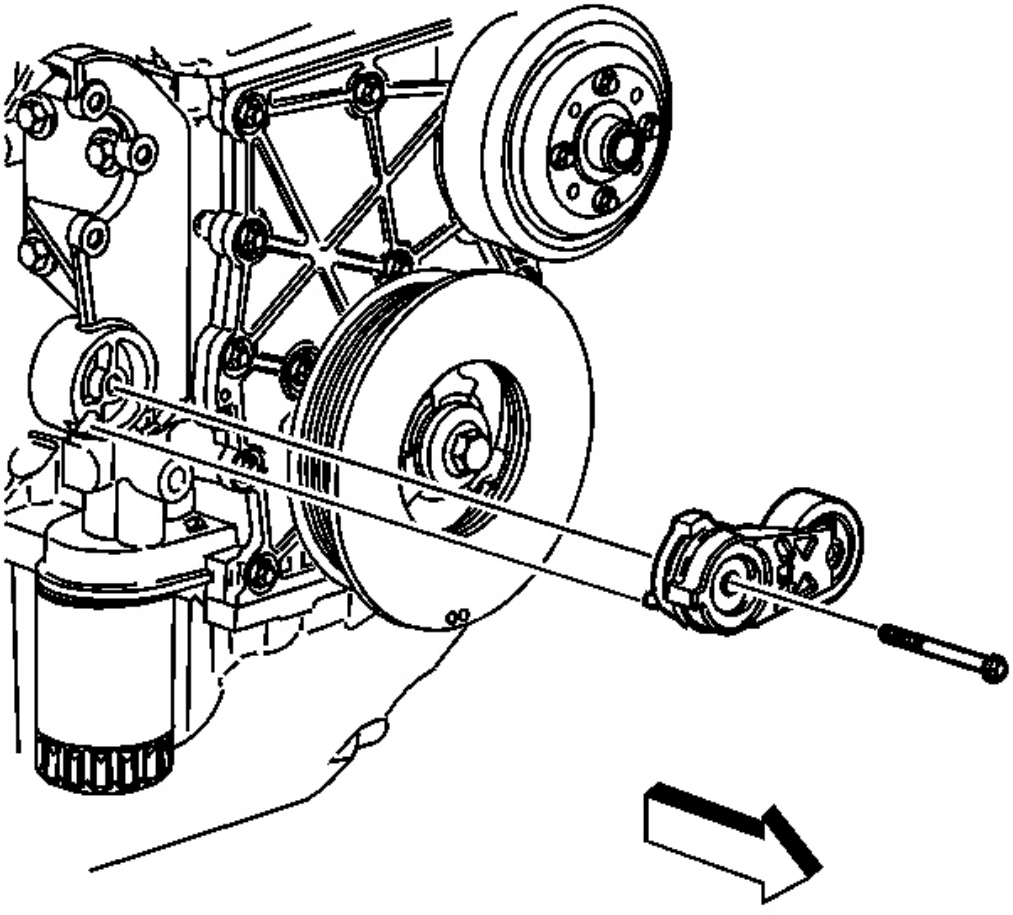


Fig. 39: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

   NOTE: Refer to Fastener Notice .

2. Install the drive belt tensioner bolt.

   Tighten: Tighten the drive belt tensioner bolt to 50 N.m (37 lb ft).

3. Install the drive belt. Refer to **Drive Belt Replacement**.

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the left front wheel. Refer to **Tire and Wheel Removal and Installation** .

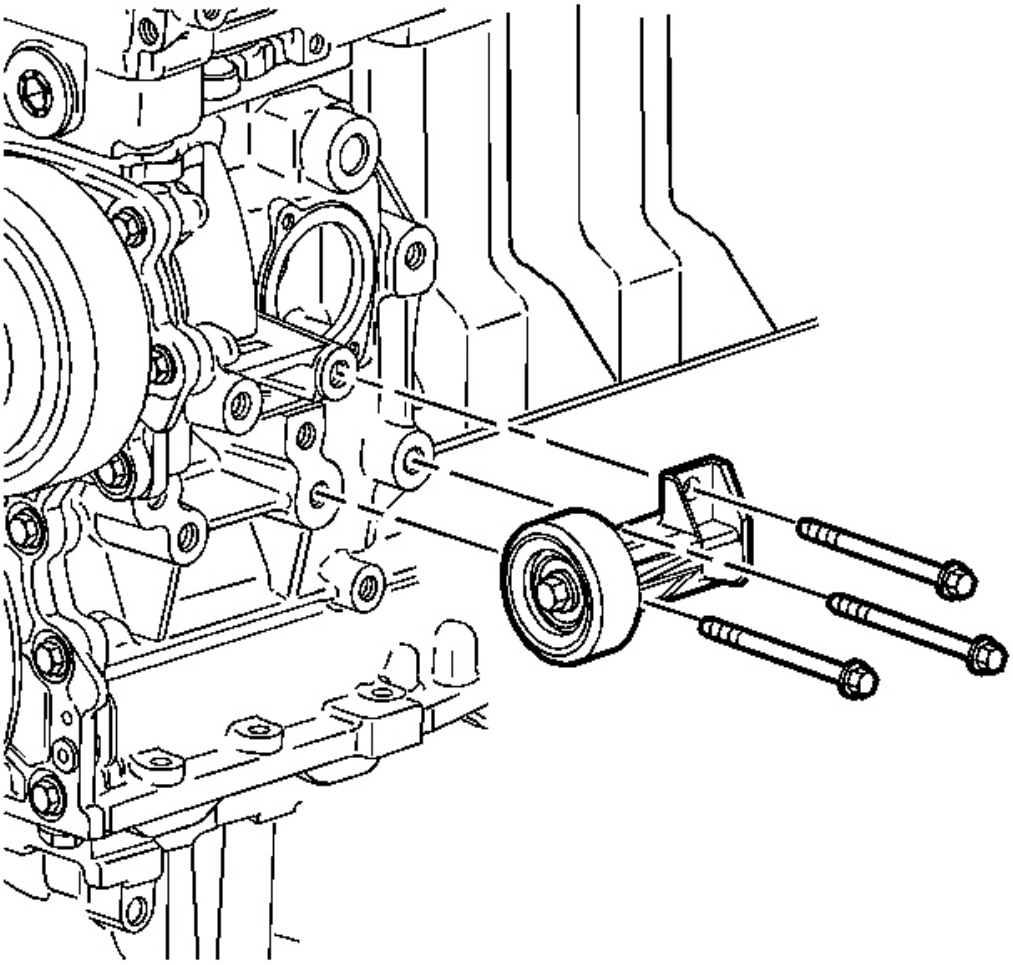


Fig. 40: View Of Drive Belt Idler Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the drive belt idler pulley bracket bolts from inside the left wheel house opening.
4. Lower the vehicle.
5. Remove forward bolt of the drive belt idler pulley bracket from inside the engine compartment.
6. Remove the drive belt pulley from the vehicle.

Installation Procedure

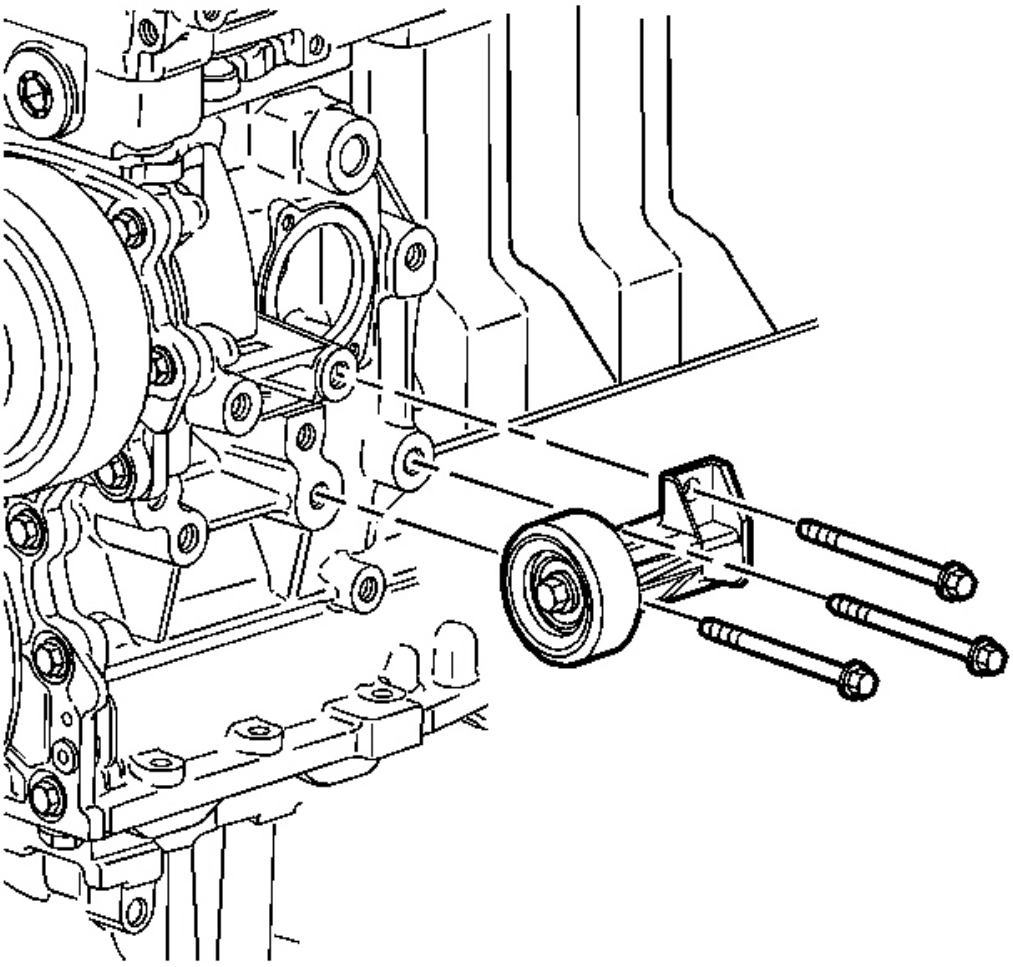


Fig. 41: View Of Drive Belt Idler Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt pulley bracket and the forward bolt of the idler pulley bracket from inside the engine compartment.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .

NOTE: Refer to Fastener Notice .

3. Install the drive belt idler pulley bracket bolts from inside the left wheelhouse opening.

Tighten: Tighten the drive belt idler pulley bracket bolts to 50 N.m (37 lb ft).

4. Install the left front wheel. Refer to **Tire and Wheel Removal and Installation** .
5. Lower the vehicle.
6. Install the drive belt. Refer to **Drive Belt Replacement**.

ENGINE MOUNT INSPECTION

Front Engine Mount

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

1. Install a pole jack underneath the oil pan.

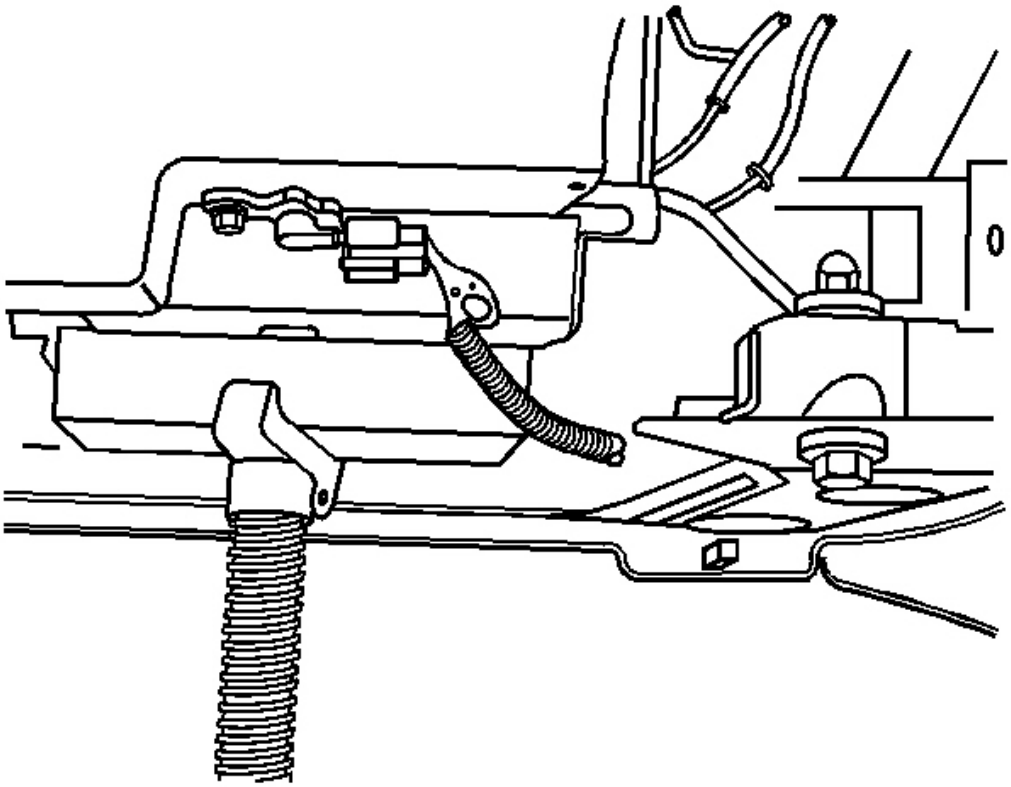


Fig. 42: View Of Wood Block Between Engine Oil Pan & Pole Jack

Courtesy of GENERAL MOTORS CORP.

2. Insert a block of wood between the engine oil pan and the pole jack.
3. Raise the jack until the wooden block contacts the engine oil pan.
4. Raise the engine in order to place a slight tension on the rubber cushion. Observe both mounts while raising the engine.
5. Replace the mounts if any of the following conditions exist:
    - Hard rubber surface covered with heat check cracks
    - The rubber cushion separated from the metal plate of the mount
    - The rubber cushion is split through the center
    - The mount is leaking
6. If there is movement between a metal plate of the mount and its attaching points, lower the engine and tighten the bolts or nuts attaching the mount to the engine, the frame or the bracket.

ENGINE MOUNT & BRACKET REPLACEMENT - LEFT SIDE

Tools Required

J 46406 Fan Clutch Remover and Installer

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

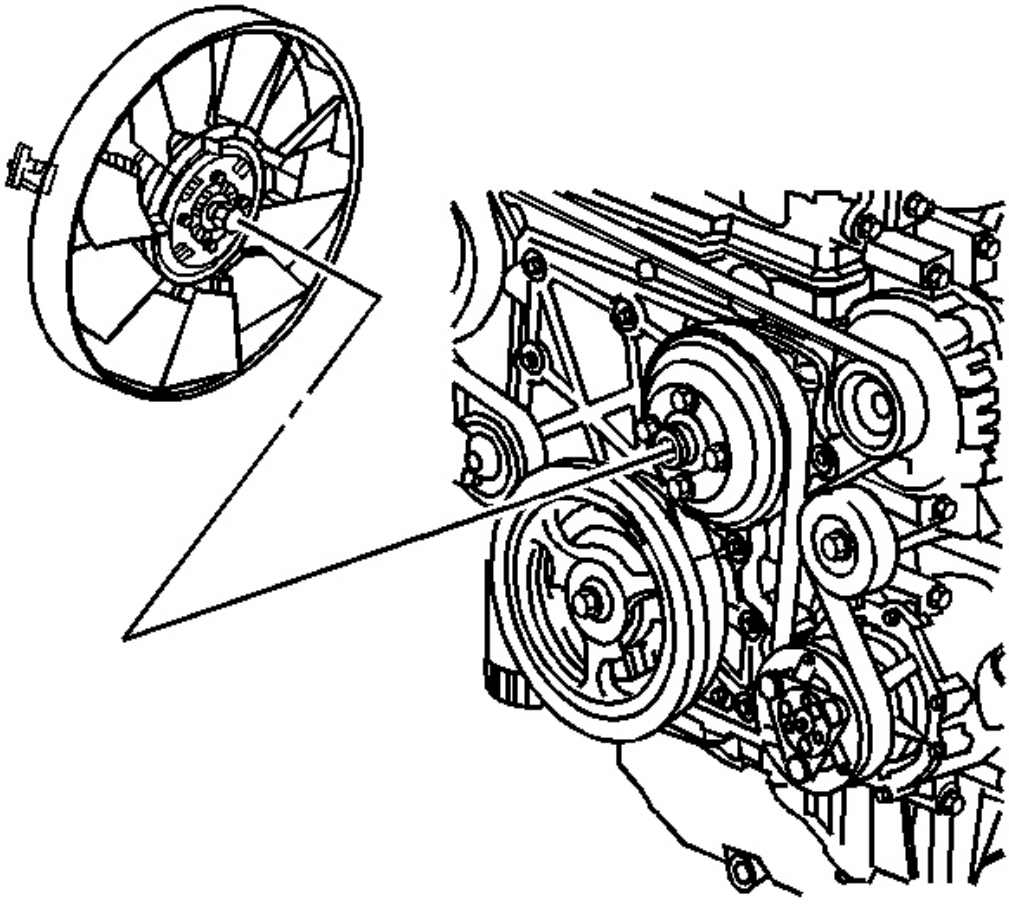


Fig. 43: Identifying Cooling Fan
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the fan clutch electrical connector.
3. Using **J 46406** remove the cooling fan clutch from the water pump pulley and leave loose inside of the fan shroud.

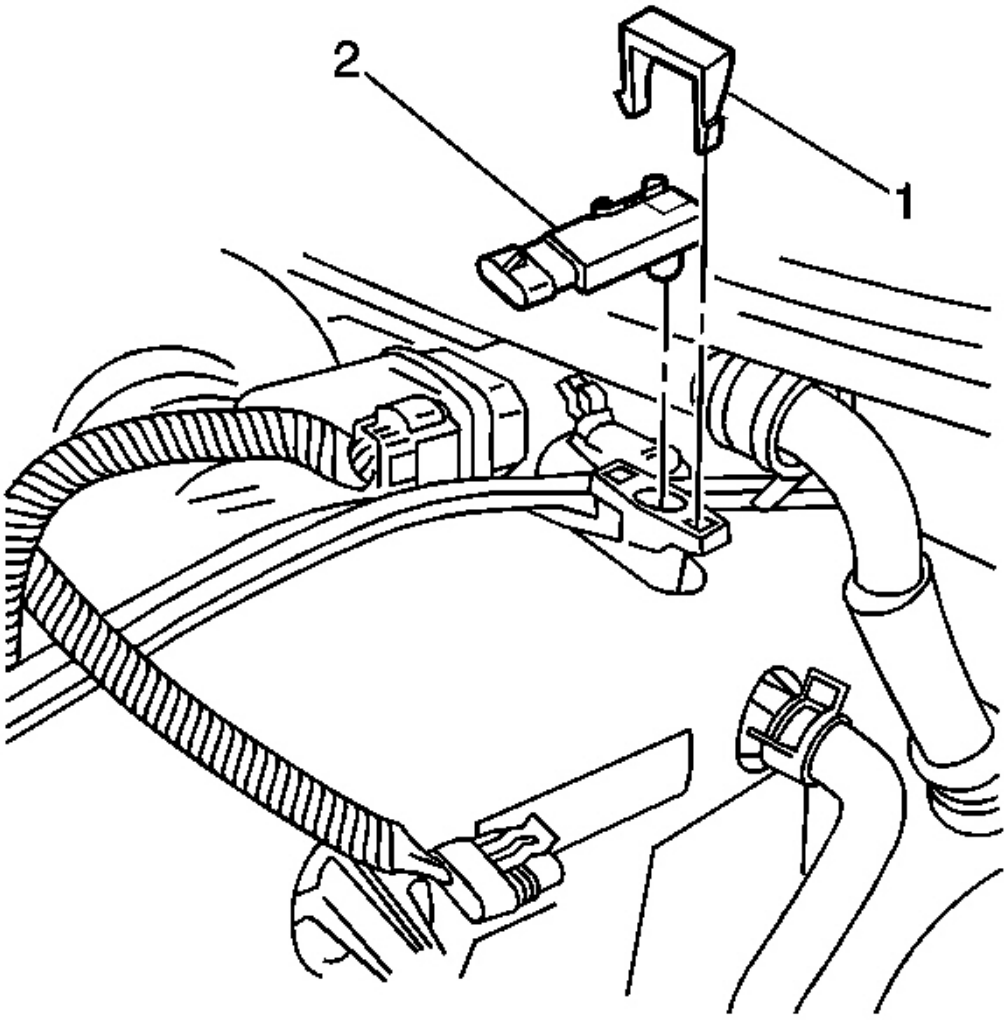


Fig. 44: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

4. Remove the manifold absolute pressure (MAP) sensor electrical connector and the retainer (1).
5. Remove the MAP sensor (2).
6. Remove the left shock module, if frame mount is being removed. Refer to **Shock Absorber and Spring Assembly Replacement** .

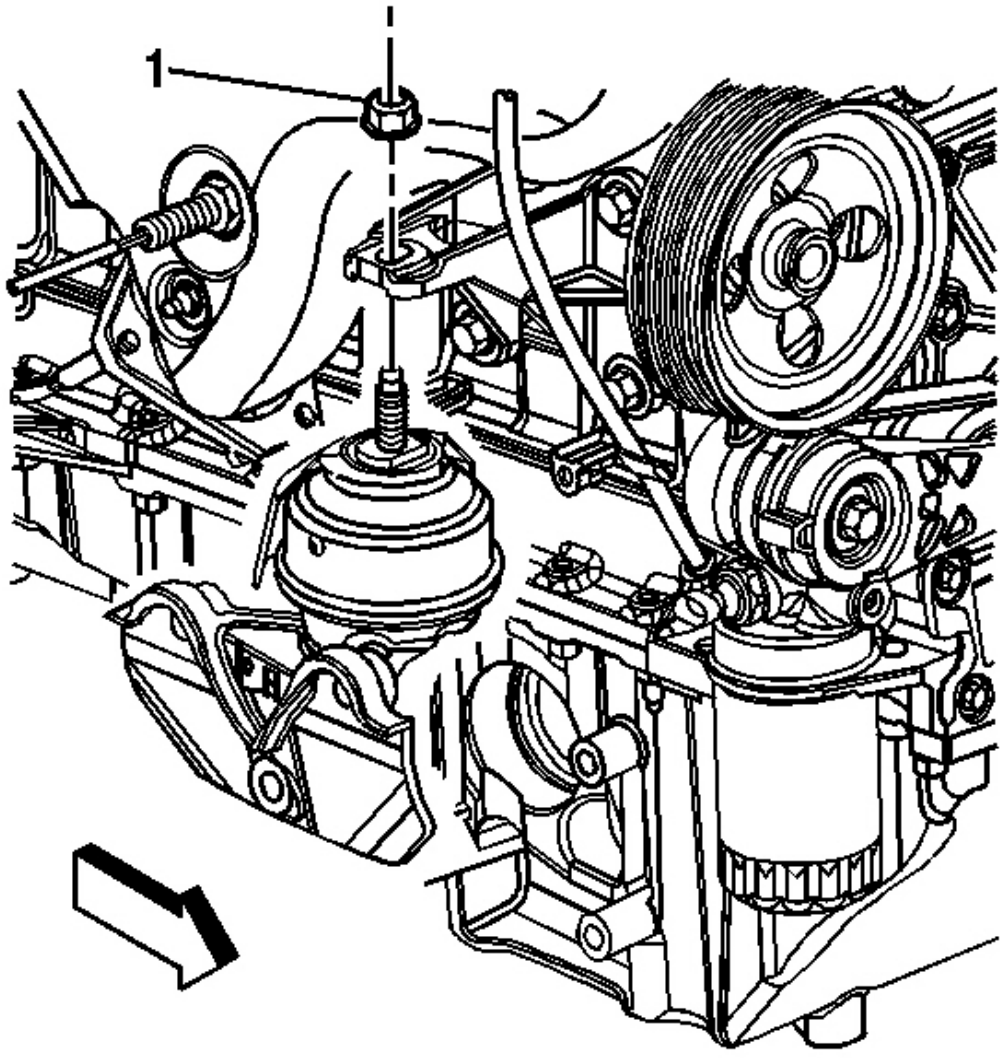


Fig. 45: View Of Upper Engine Mount Nuts
Courtesy of GENERAL MOTORS CORP.

7. Remove the right and the left upper engine mount nuts (1).
8. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
9. Remove the right and the left lower engine mount nuts.
10. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** .

IMPORTANT: When placing jack onto the oil pan, pay close attention to not damage the

oil level sender.

11. Lower the vehicle and place a floor jack under the oil pan with a block of wood.
12. Raise the engine with the jack just enough to clear the engine mount stud.

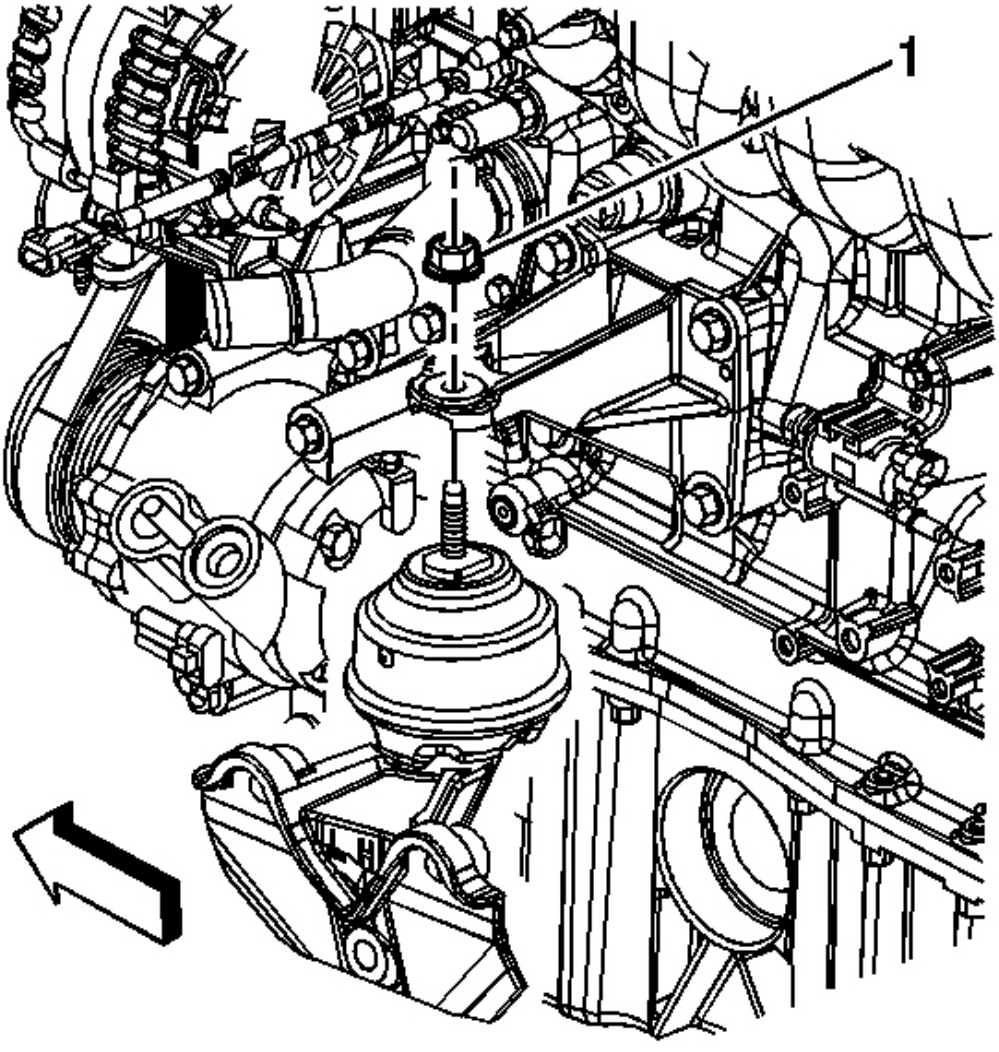


Fig. 46: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

13. Remove the left engine mount to bracket nut (1) and the mount from the bracket.

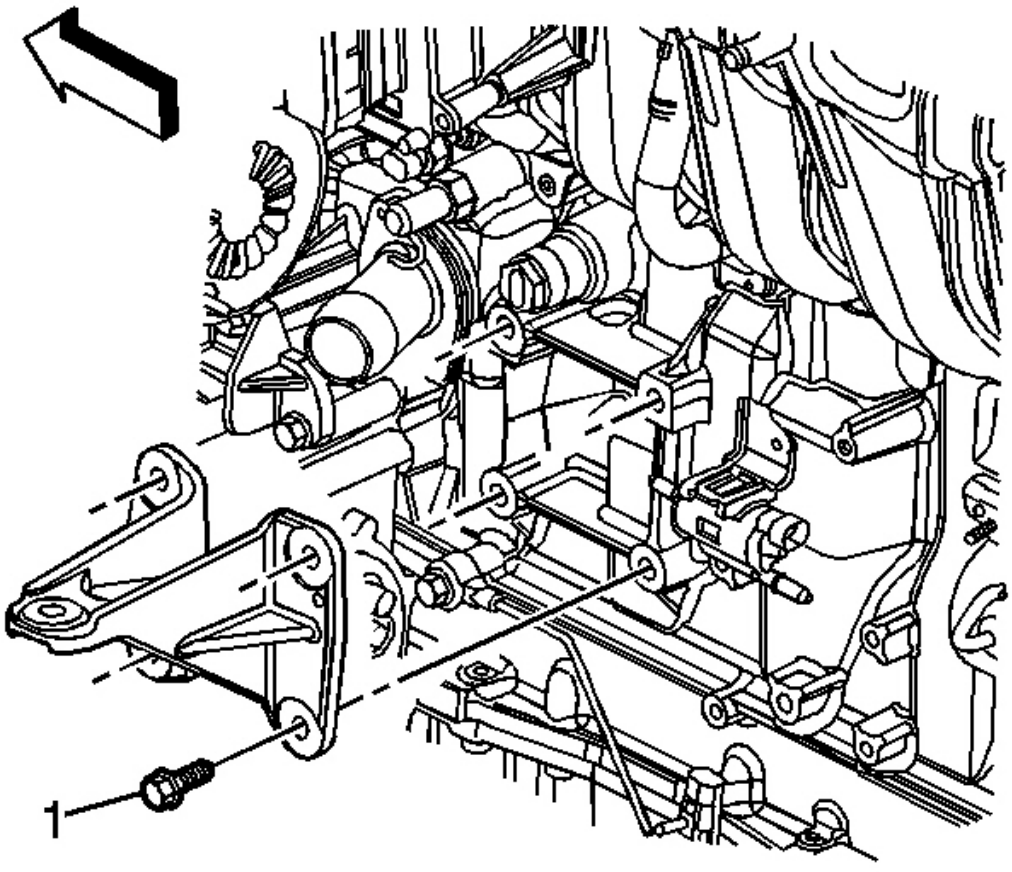


Fig. 47: View Of Left Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the left engine mount bracket bolts (1).
15. Remove the left engine mount bracket.

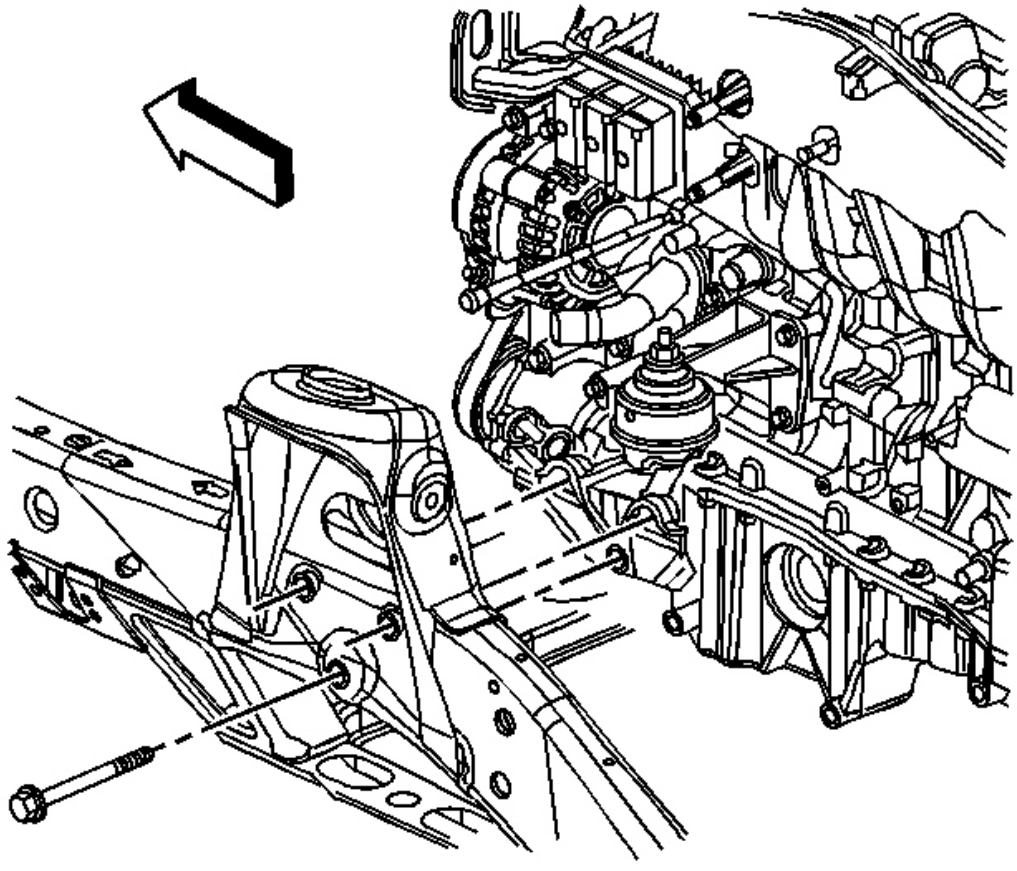


Fig. 48: View Of Left Frame Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the left frame engine mount bracket bolts.
17. Remove the left frame engine mount bracket, if required.

Installation Procedure

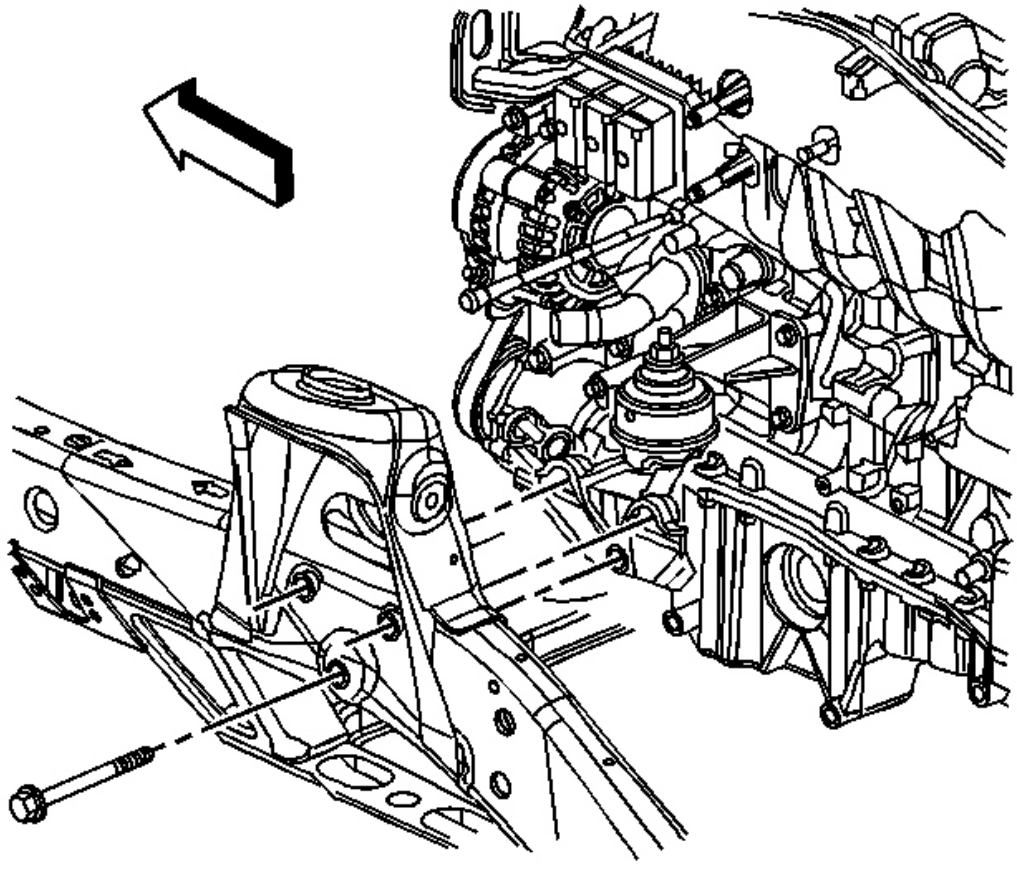


Fig. 49: View Of Left Frame Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the left frame engine mount bracket, if removed.

   NOTE: Refer to Fastener Notice .

2. Install the left frame engine mount bracket bolts, if removed.

   Tighten: Tighten the mount bracket bolts to 110 N.m (81 lb ft).

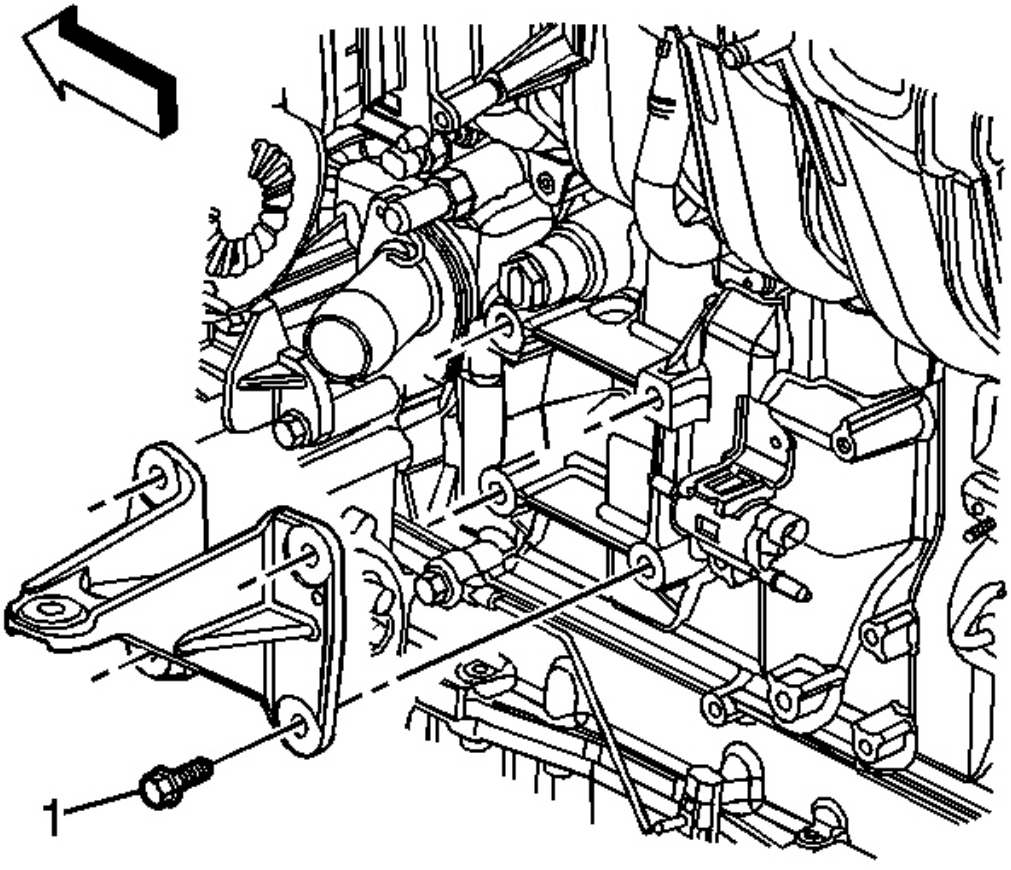


Fig. 50: View Of Left Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the left engine mount bracket and secure the bracket with the bolts (1).

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

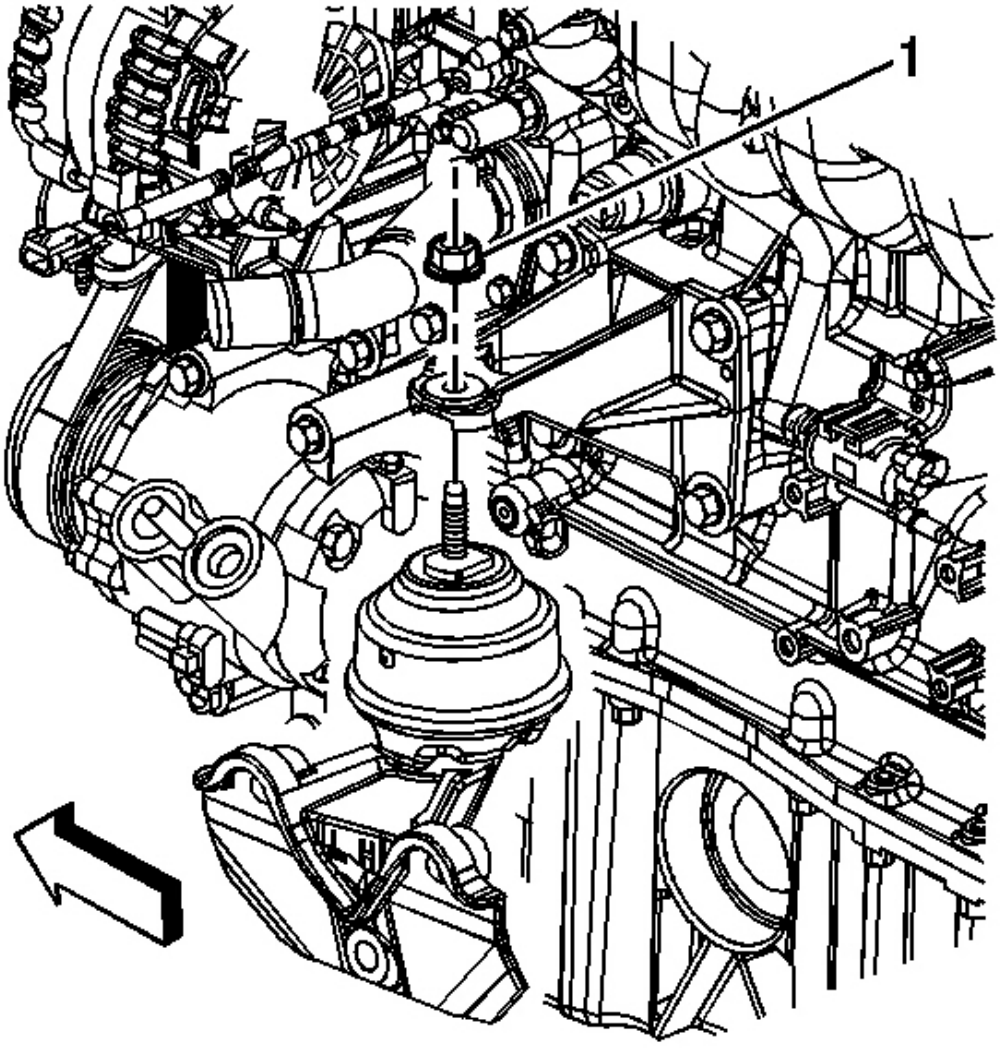


Fig. 51: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Install the left engine mount onto the bracket.
5. Lower the engine onto the engine mounts.
6. Install the right and the left upper engine mount nuts (1).

   Tighten: Tighten the upper engine mount nuts to 70 N.m (52 lb ft).

7. Raise the vehicle and remove the jack from under the vehicle.

8. Install the engine protection shield and secure the shield with the bolts. Refer to **Engine Protection Shield Replacement** .
9. Install the right and the left lower engine mount nuts.

   Tighten: Torque the lower engine mount nuts to 70 N.m (52 lb ft).

10. Lower the vehicle.
11. Install the left shock module. Refer to **Shock Absorber and Spring Assembly Replacement** .

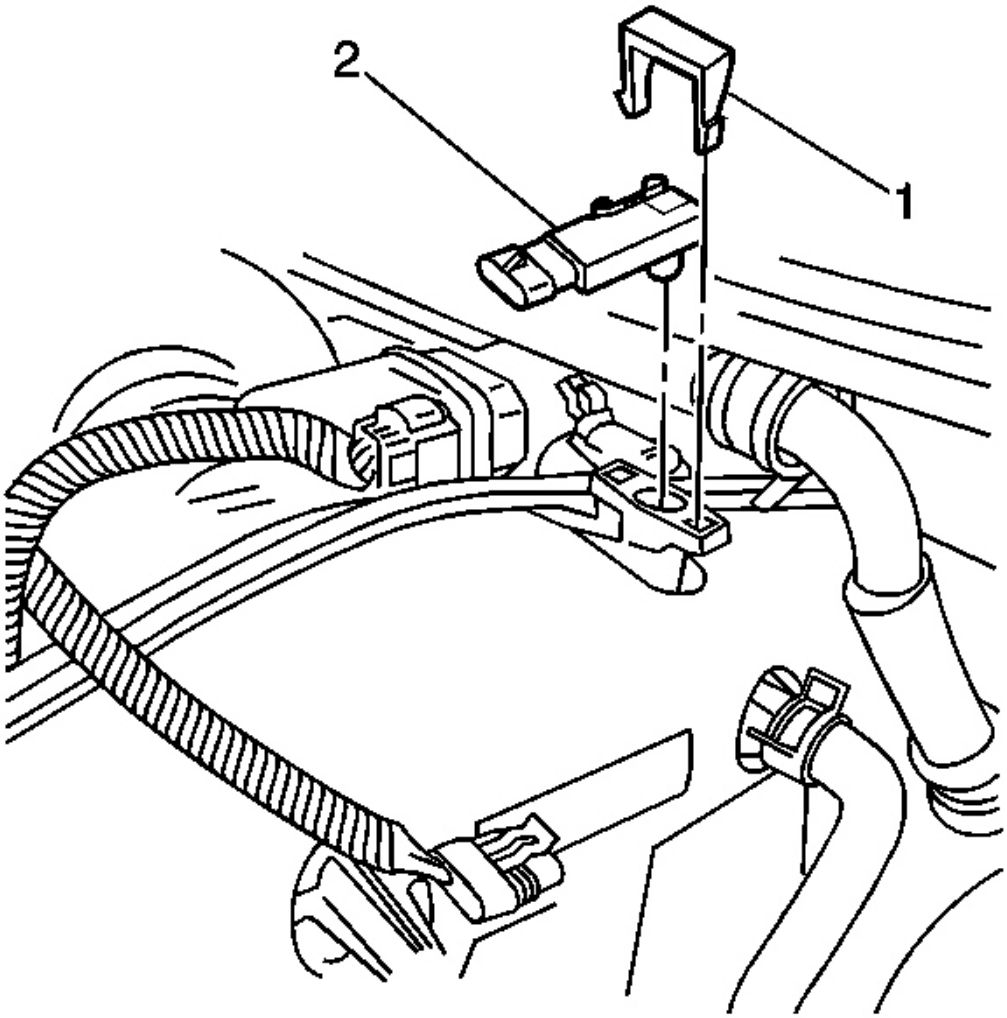


Fig. 52: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Install the MAP sensor (2).
13. Install the MAP sensor retainer (1) and the electrical connector.

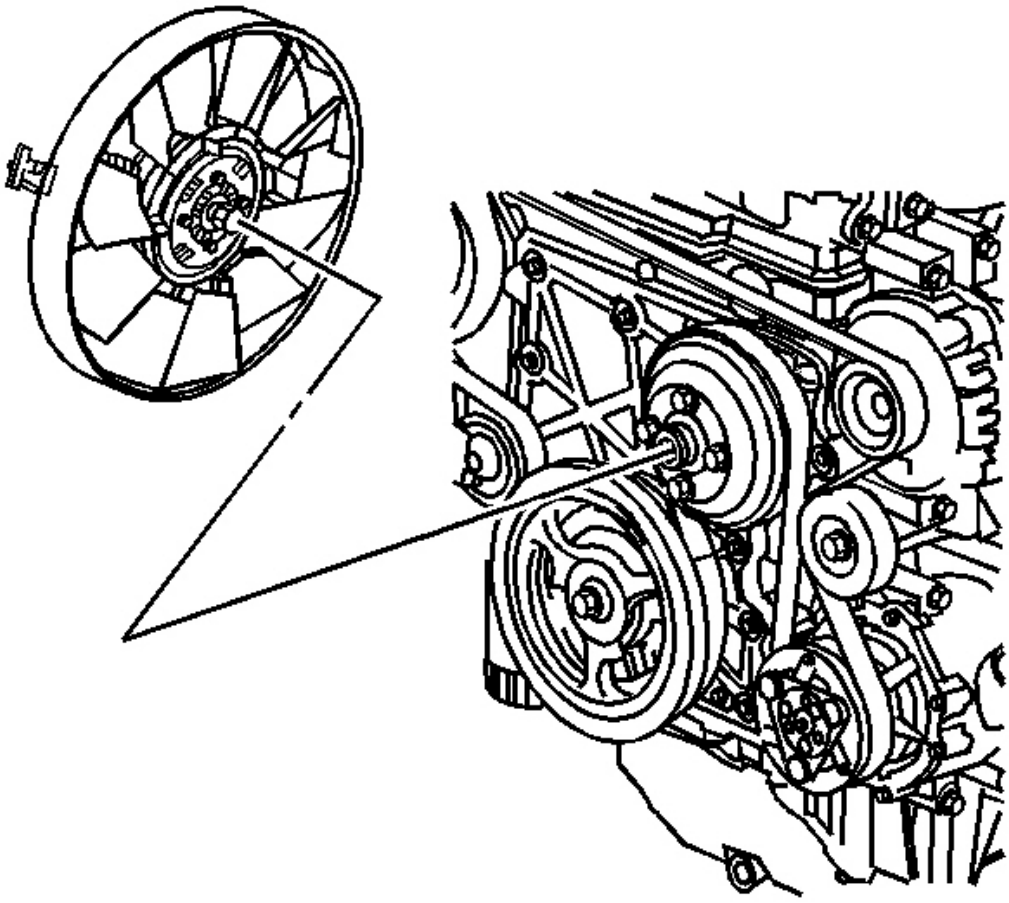


Fig. 53: Identifying Cooling Fan
Courtesy of GENERAL MOTORS CORP.

14. Using **J 46406** , install the fan clutch to the water pump pulley.
15. Connect the fan clutch electrical connector.
16. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .

ENGINE MOUNT & BRACKET REPLACEMENT - RIGHT SIDE

Tools Required

J 46406 Fan Clutch Remover and Installer

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .

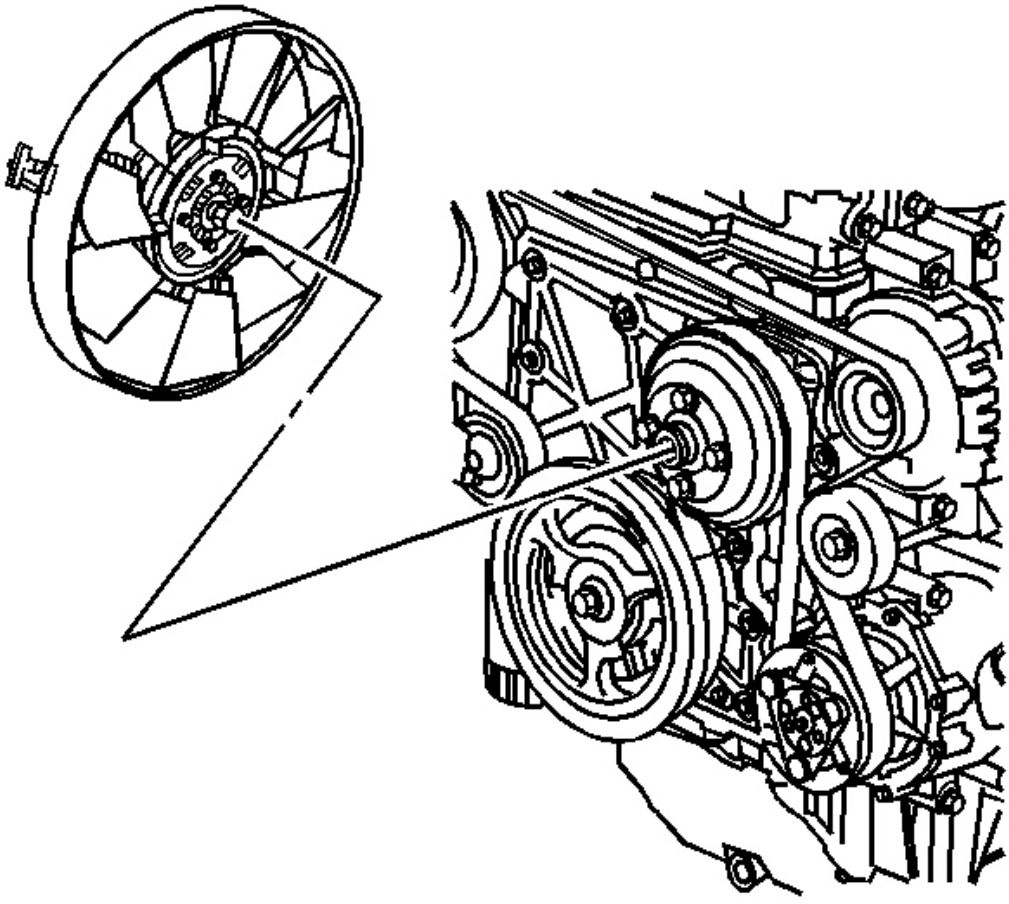


Fig. 54: Identifying Cooling Fan
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the fan clutch electrical connector.
3. Using **J 46406** remove the cooling fan clutch from the water pump pulley and leave loose inside of the fan shroud.

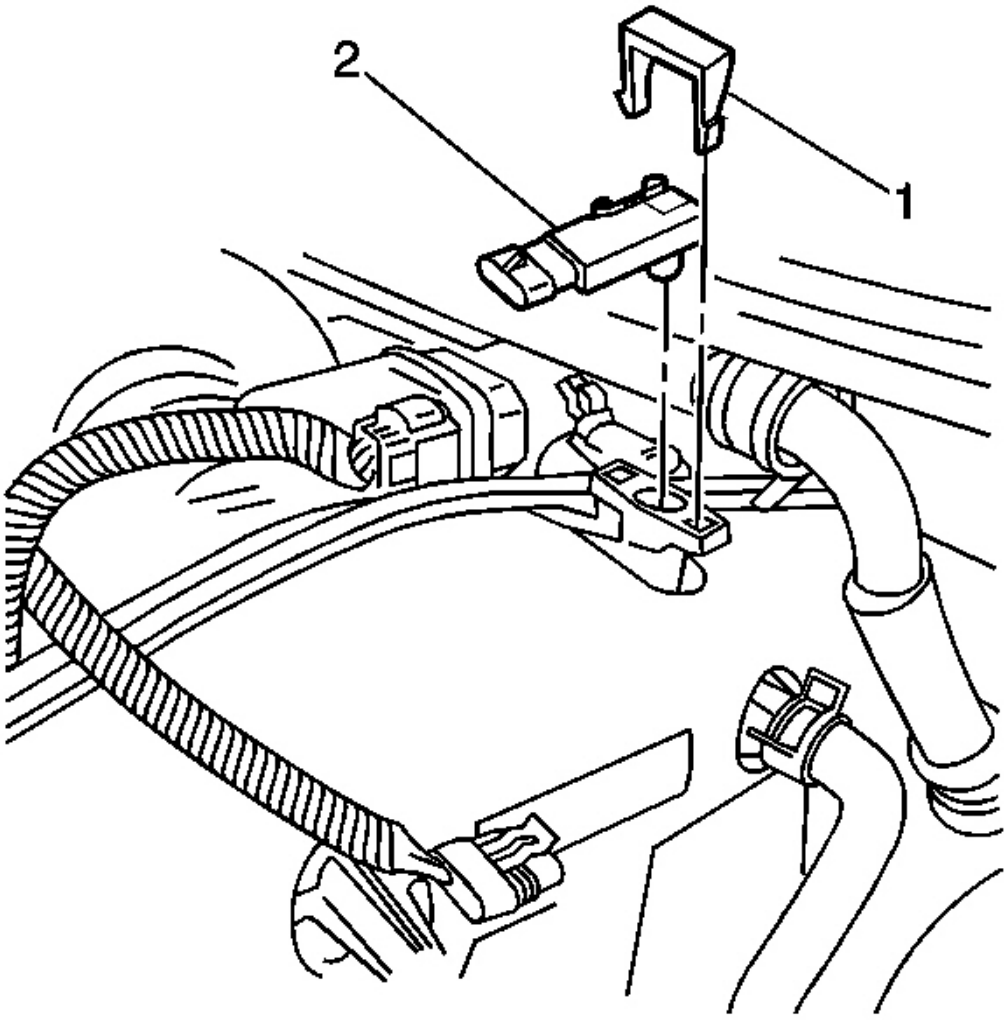


Fig. 55: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

4. Remove the manifold absolute pressure (MAP) sensor electrical connector and retainer (1).
5. Remove the MAP sensor (2).
6. Remove the right shock module, if frame engine mount is being removed. Refer to **Shock Absorber and Spring Assembly Replacement** .

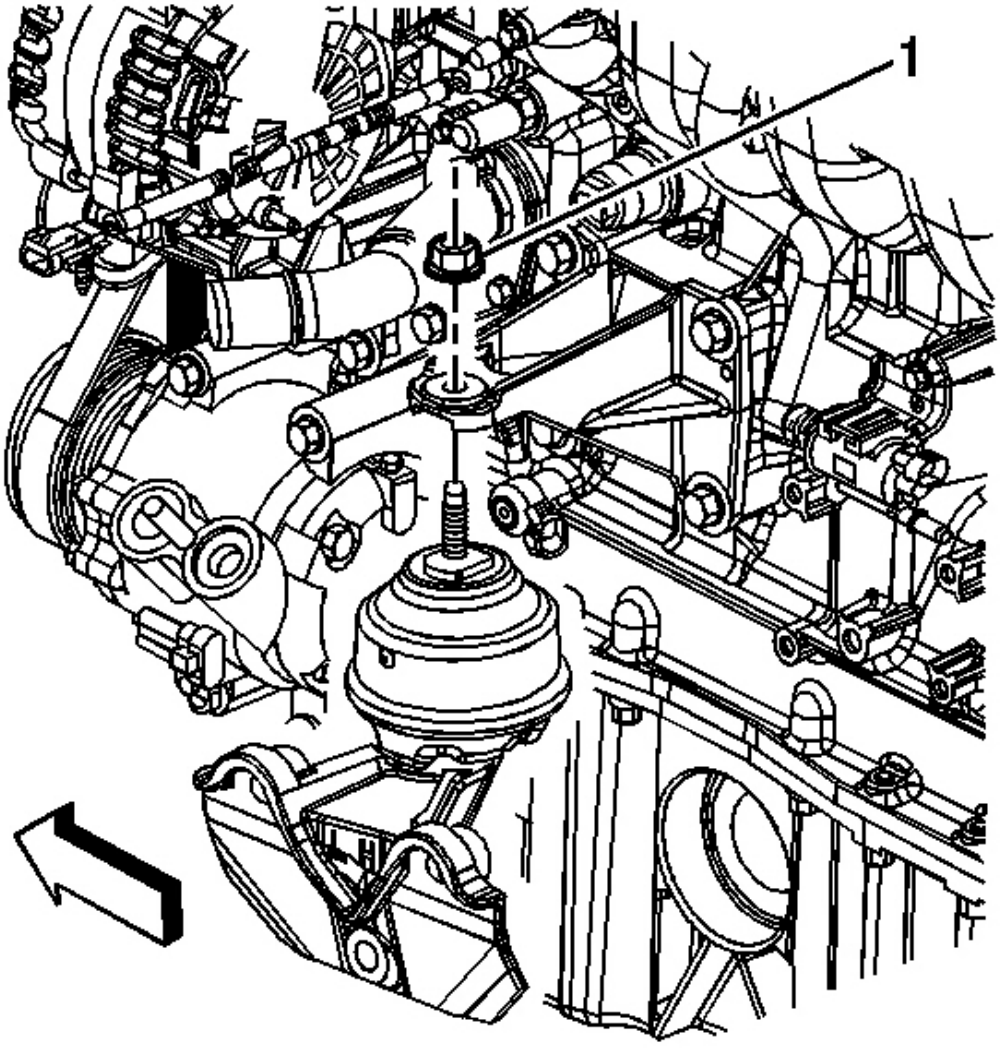


Fig. 56: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

7. Remove the right and the left upper engine mount nuts (1).
8. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
9. Remove the right and the left lower engine mount nuts.
10. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** .

IMPORTANT: When placing jack onto the oil pan, pay close attention to not damaging

the oil level sender.

11. Lower the vehicle and place a floor jack under the oil pan with a block of wood.
12. Raise the engine with the jack just enough to clear the engine mount studs.
13. Remove the right engine mount from the bracket. Note the location of the heat shield for installation.

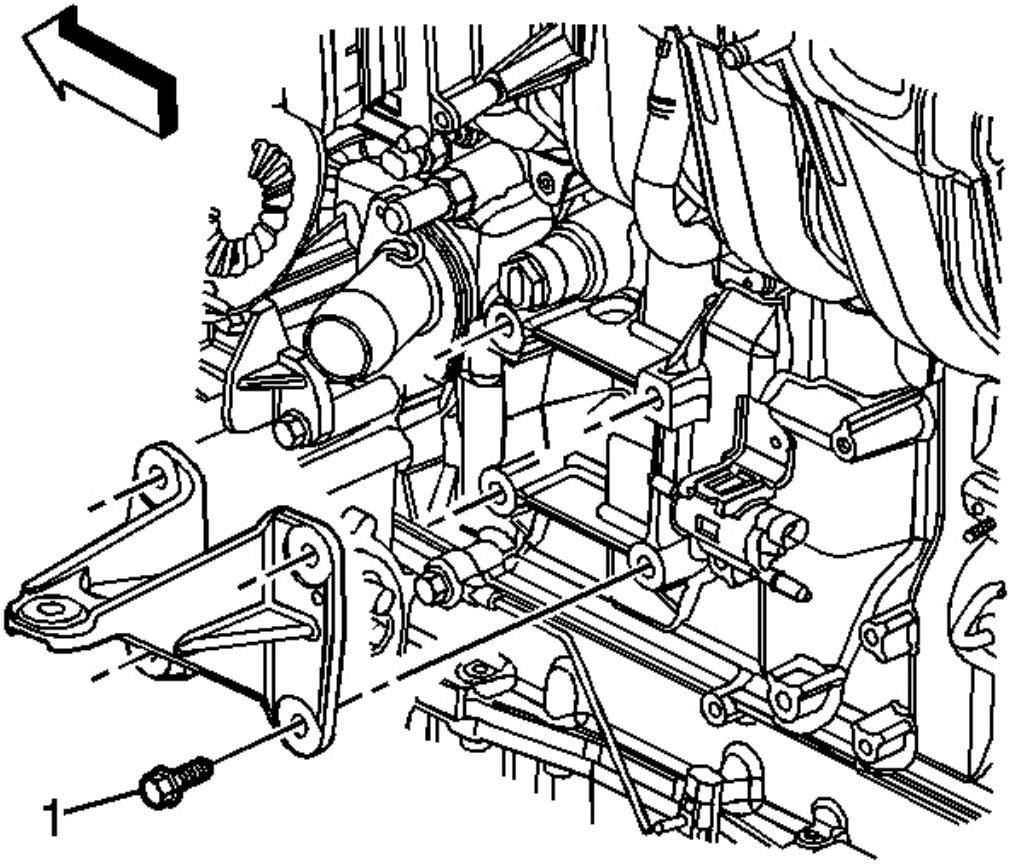


Fig. 57: View Of Left Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

14. Graphic shows left, right is similar.

    Remove the right engine mount bracket bolts (1).

15. Remove the right engine mount bracket.

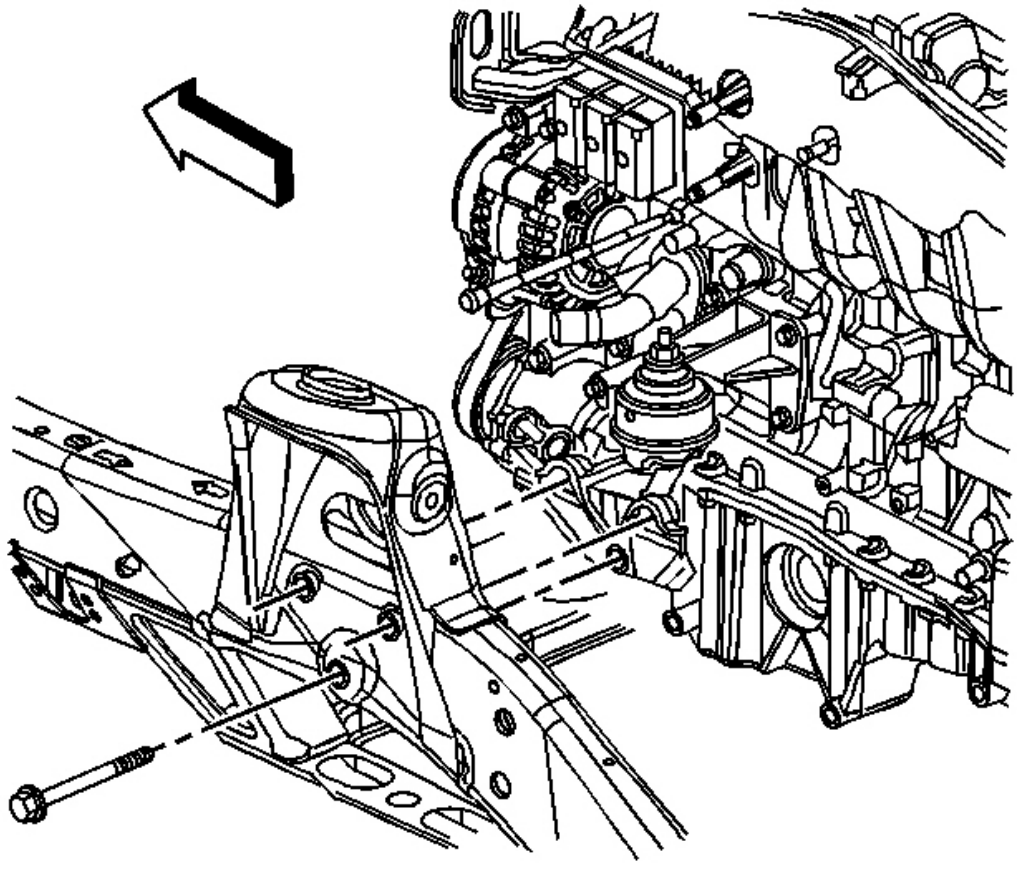


Fig. 58: View Of Left Frame Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

16. Graphic shows left, right is similar.

    Remove the right frame engine mount bracket bolts, if required.

17. Remove the right frame engine mount bracket, if required.

Installation Procedure

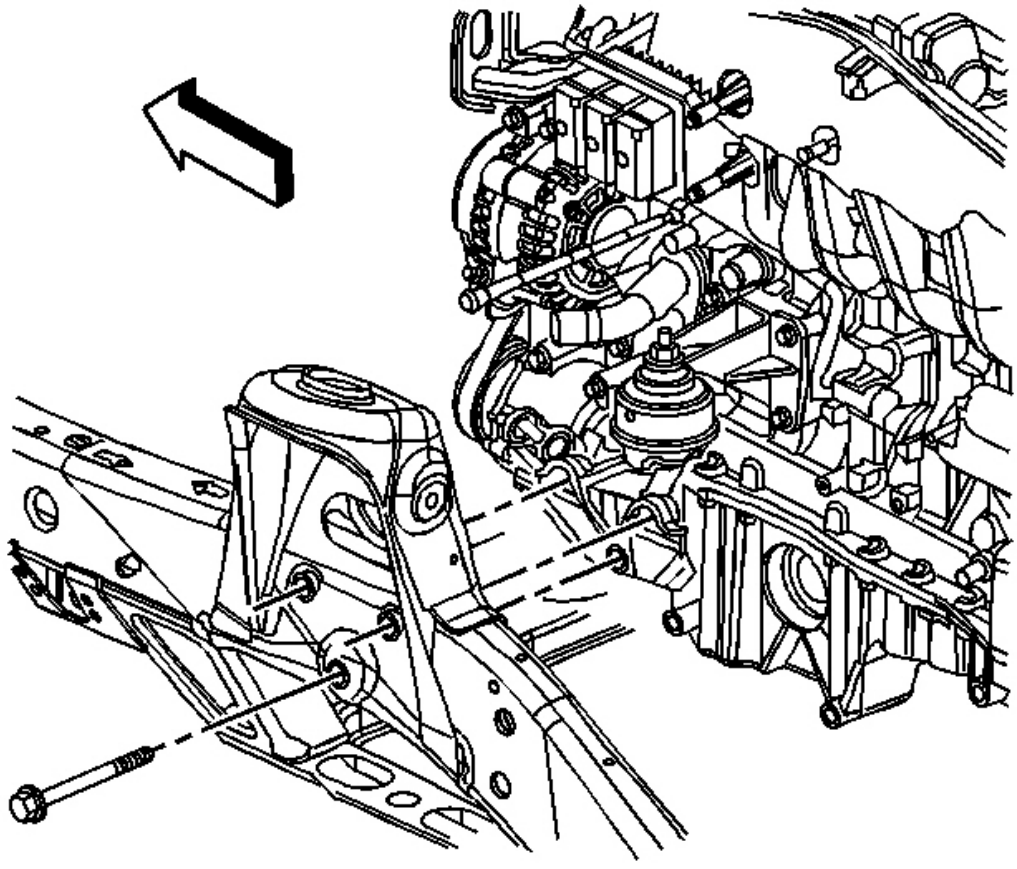


Fig. 59: View Of Left Frame Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Graphic shows left, right is similar.

   Install the right frame engine mount bracket, if removed.

   NOTE: Refer to Fastener Notice .

2. Install the right frame engine mount bracket bolts, if removed.

   Tighten: Tighten the mount bracket bolts to 110 N.m (81 lb ft).

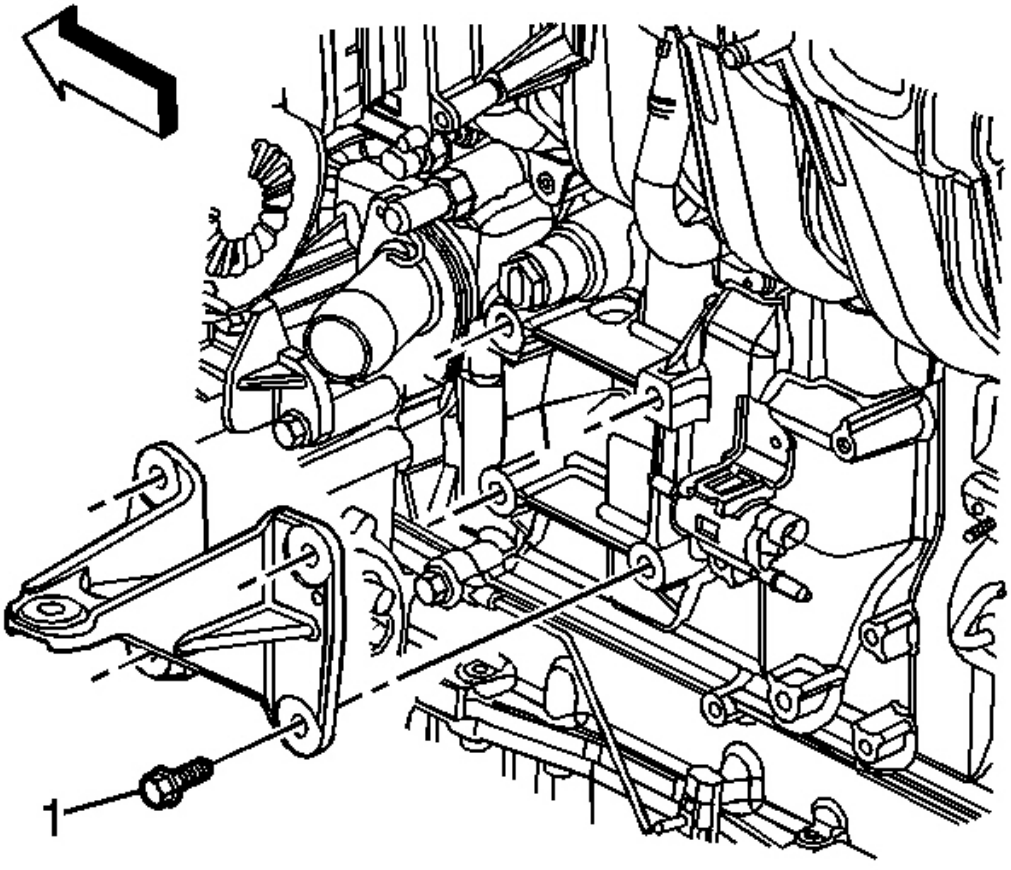


Fig. 60: View Of Left Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

3. Graphic shows left, right is similar.

   Install the right engine mount bracket and secure with the bolts (1).

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

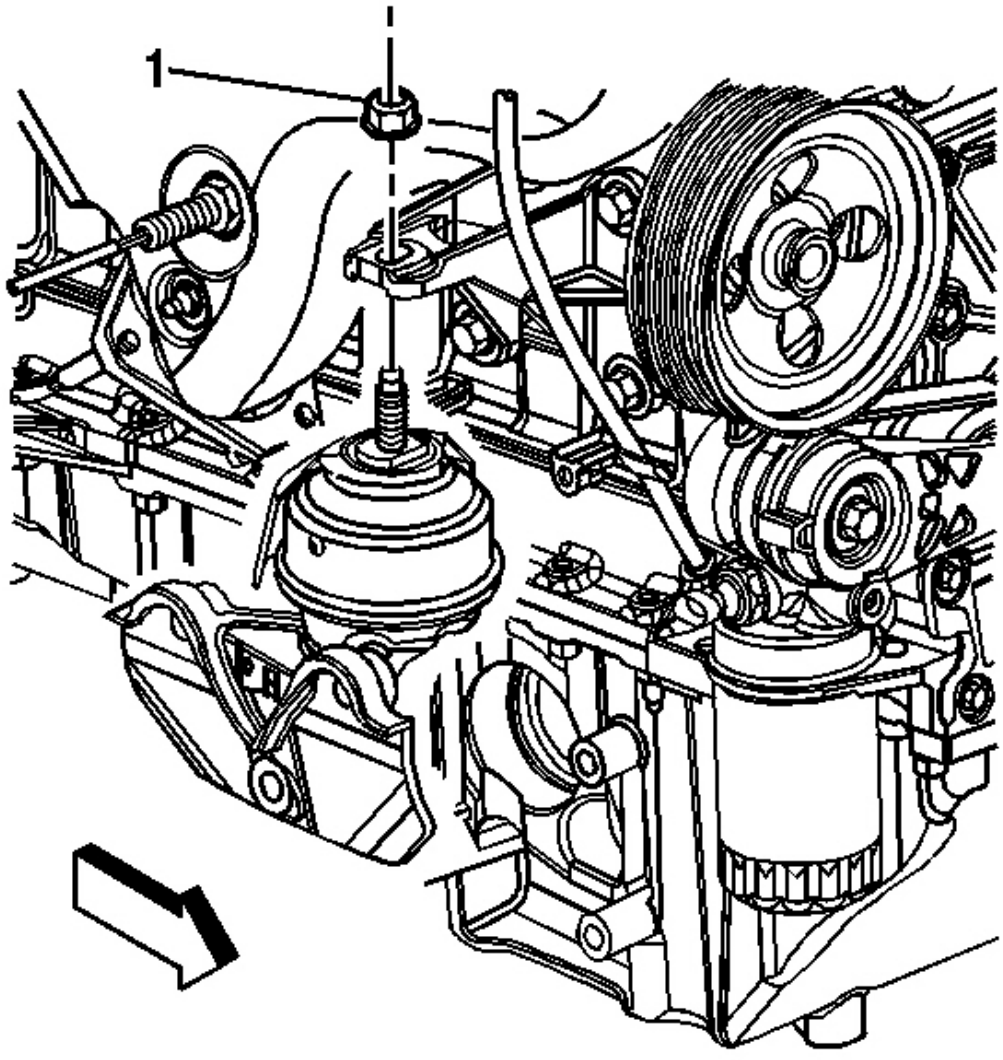


Fig. 61: View Of Upper Engine Mount Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the right engine mount.

IMPORTANT: Ensure that the heat shield is located properly over the anti-rotation feature - right side only.

5. Lower the engine onto the engine mounts.
6. Install the right and the left upper engine mount nuts (1).

Tighten: Tighten the upper engine mount nuts to 70 N.m (52 lb ft).

7. Raise the vehicle and remove the floor jack from under the vehicle.
8. Install the engine protection shield and secure with the bolts. Refer to **Engine Protection Shield Replacement** .
9. Install the right and the left lower engine mount nuts.

   Tighten: Tighten the lower engine mount nuts to 70 N.m (52 lb ft).

10. Lower the vehicle.
11. Install the right shock module. Refer to **Shock Absorber and Spring Assembly Replacement** .

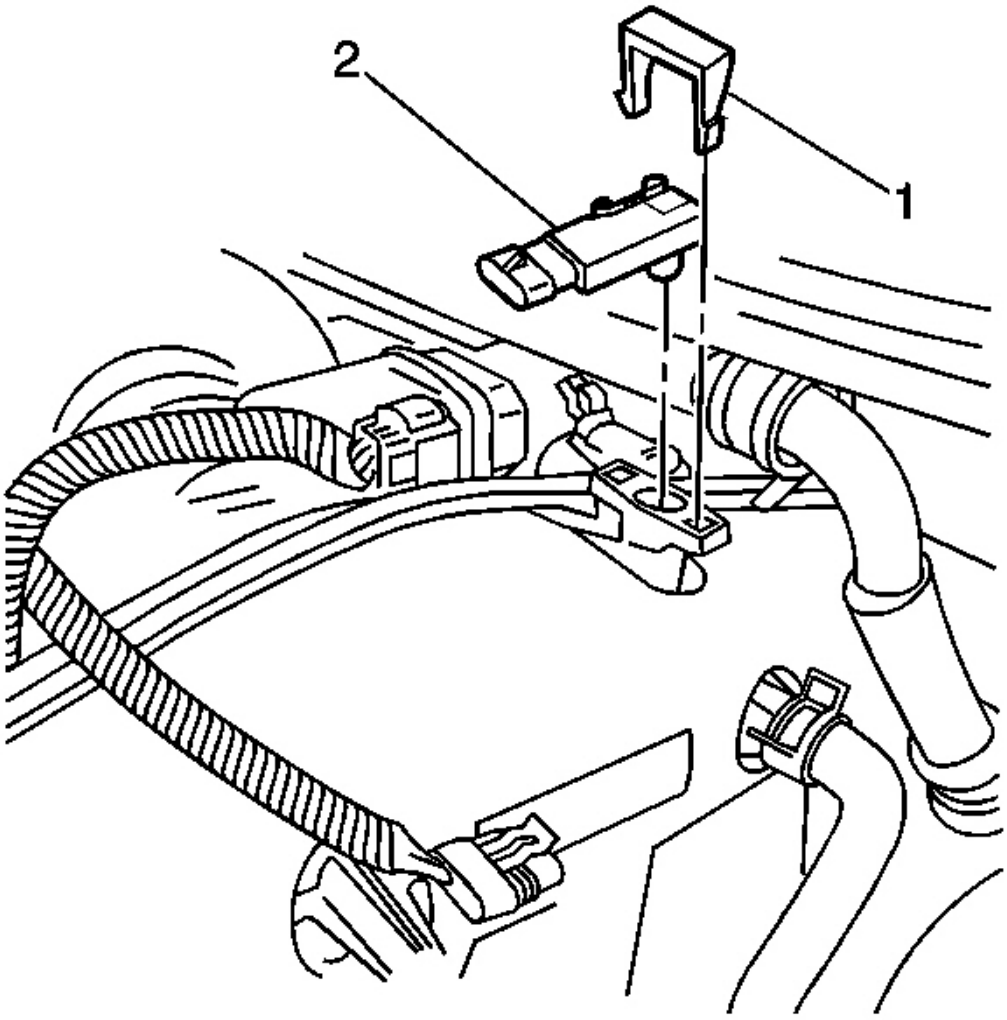


Fig. 62: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Install the MAP sensor (2).
13. Install the MAP sensor retainer (1) and the electrical connector.

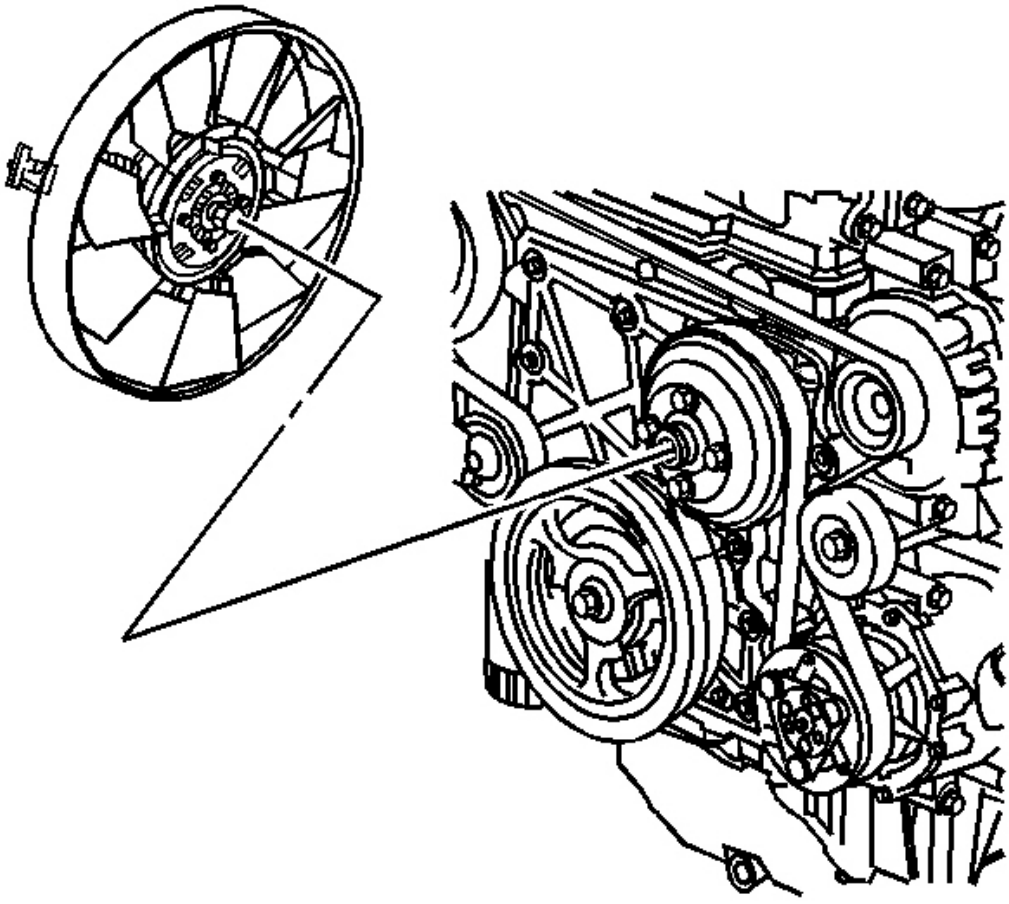


Fig. 63: Identifying Cooling Fan
Courtesy of GENERAL MOTORS CORP.

14. Using **J 46406** install the cooling fan clutch to the water pump pulley.
15. Connect the fan clutch electrical connector.
16. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

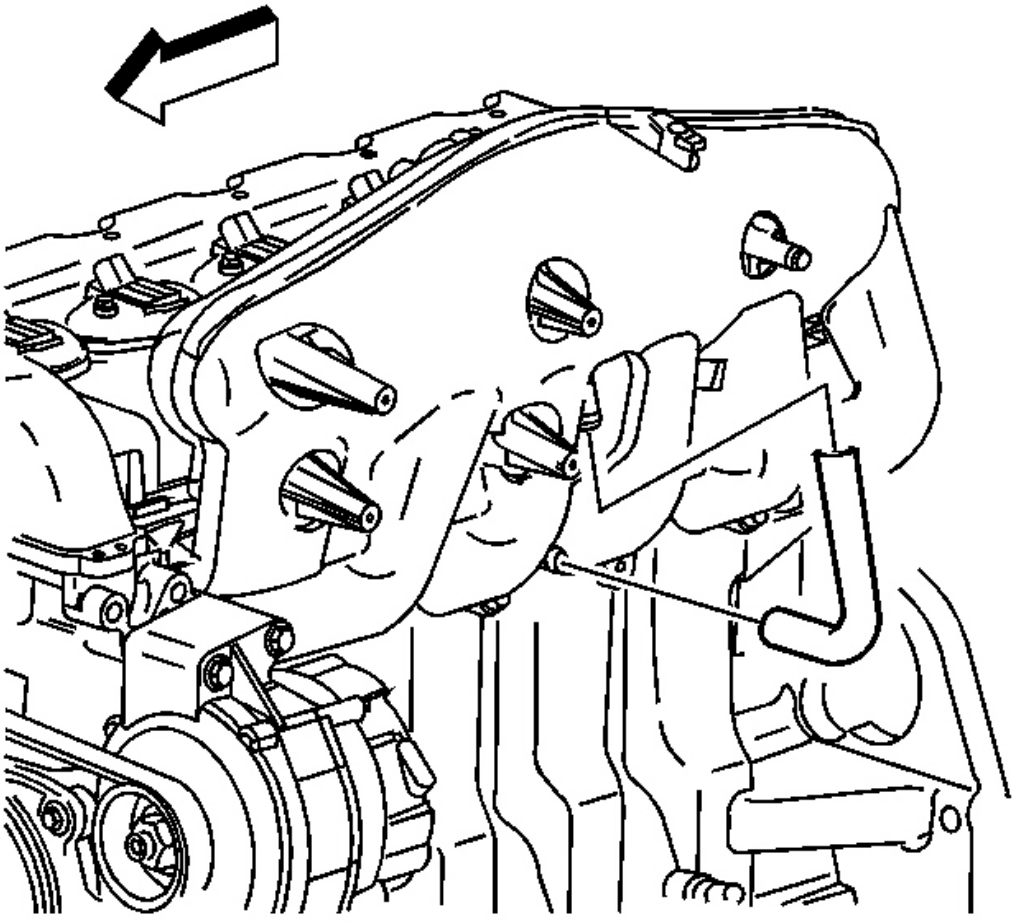


Fig. 64: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the crankcase dirty air hose from the intake manifold.
2. Disconnect the crankcase dirty air hose from the positive crankcase ventilation (PCV) orifice tube.

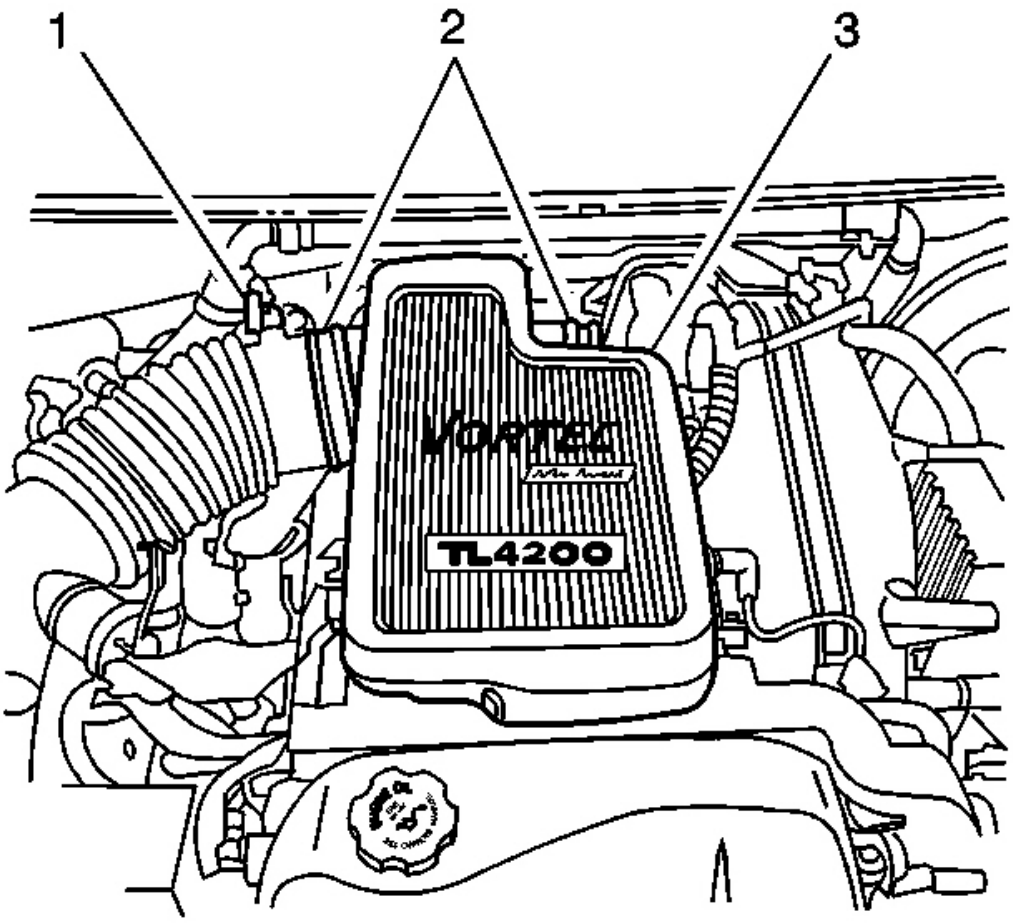


Fig. 65: Top Of Engine View
Courtesy of GENERAL MOTORS CORP.

3. Loosen the throttle body clamps (2).
4. Disconnect the fuel pressure regulator vacuum supply hose from the air cleaner outlet resonator.

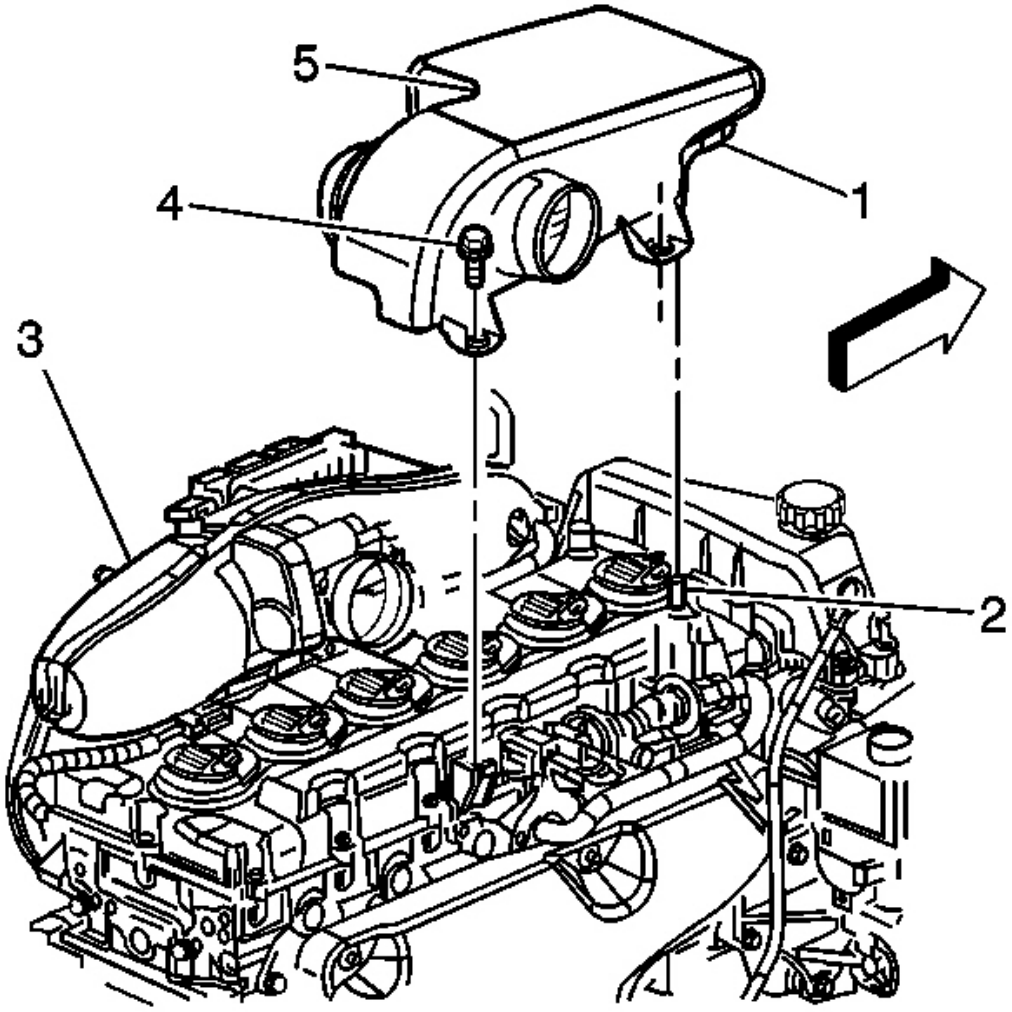


Fig. 66: View Of Engine Bolts & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

5. Remove the 2 resonator to engine bolts (4) from the air cleaner outlet resonator (5).

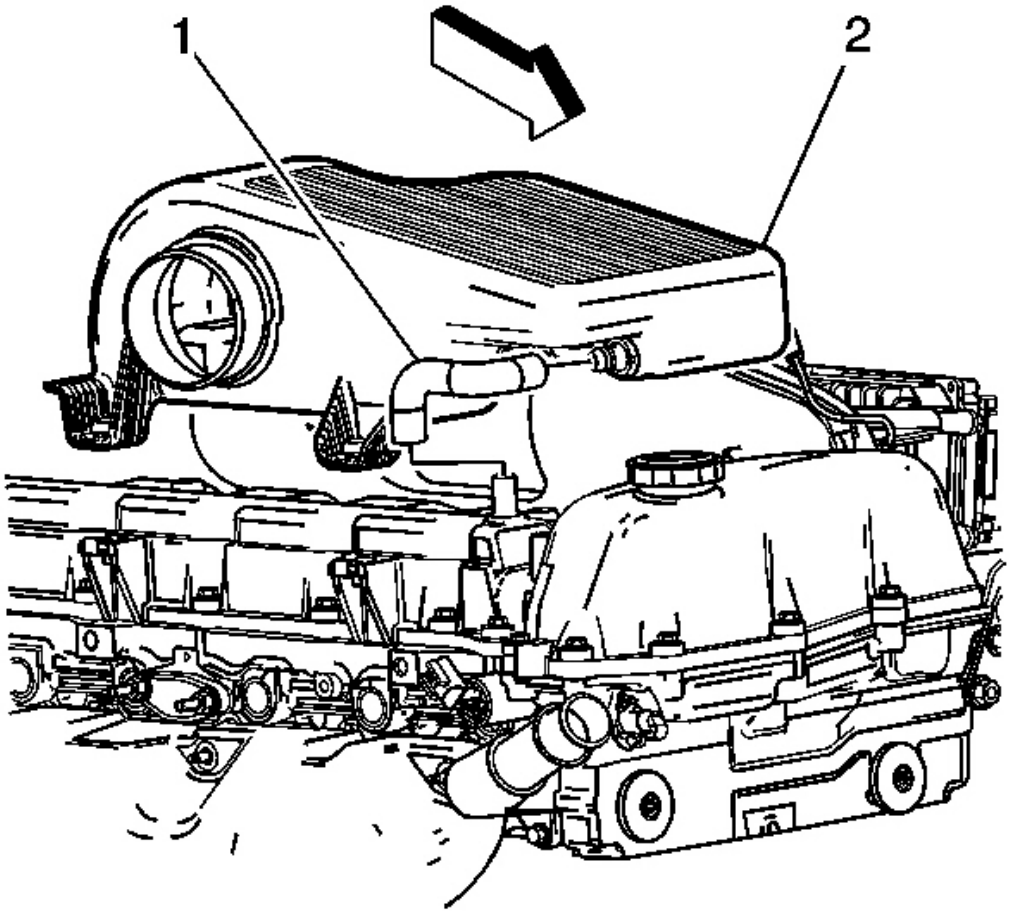


Fig. 67: View Of Crankcase Clean Air Hose & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

6. Lift up the front of the air cleaner outlet resonator (2).
7. Disconnect the crankcase clean air hose from the valve cover port.
8. Disconnect the crankcase clean air hose from the air cleaner outlet resonator (2).

Installation Procedure

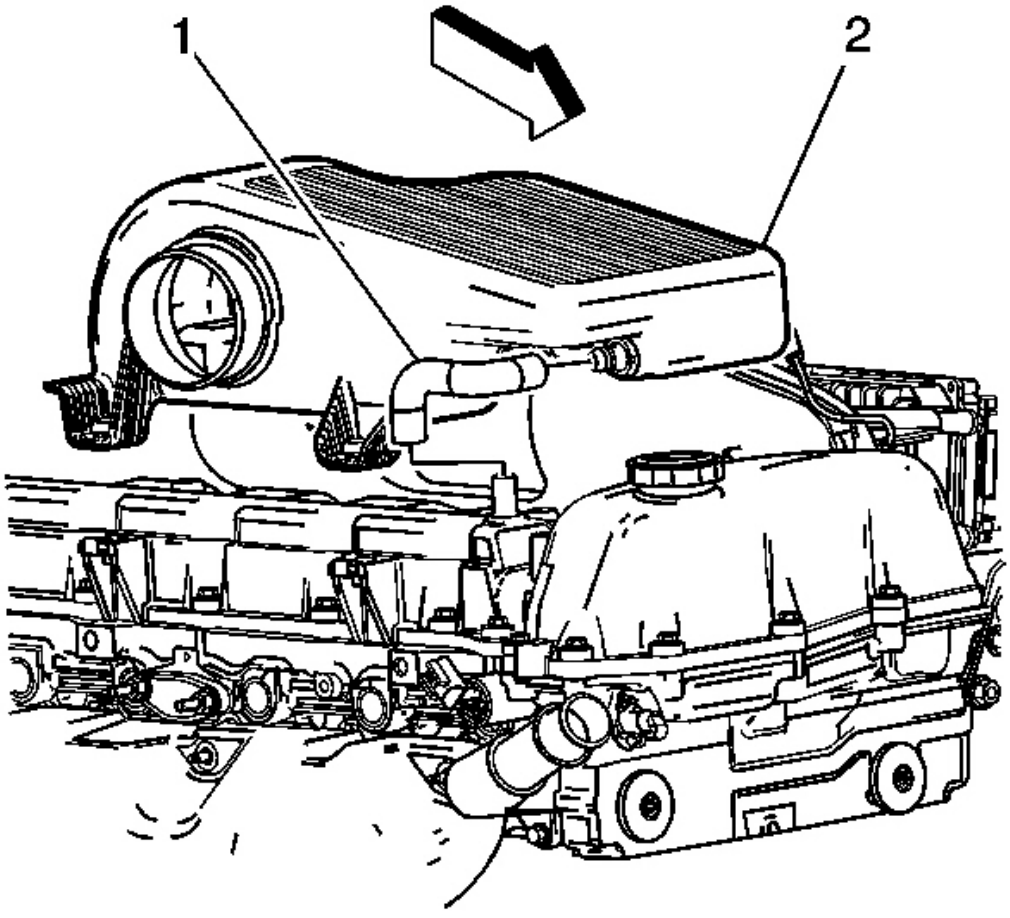


Fig. 68: View Of Crankcase Clean Air Hose & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

1. Connect the crankcase clean air hose to the air cleaner outlet resonator (2).
2. Connect the crankcase clean air hose to the valve cover port.

NOTE: Refer to Fastener Notice .

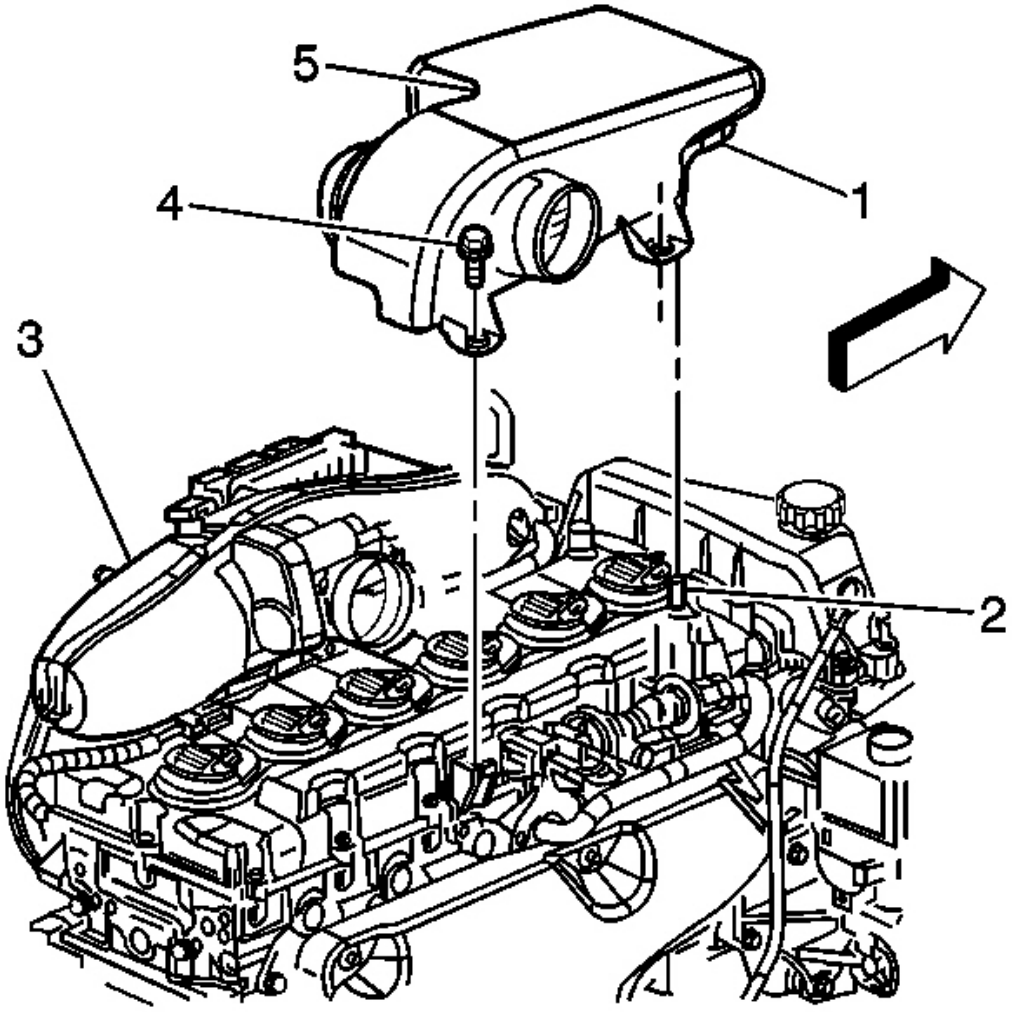


Fig. 69: View Of Engine Bolts & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

3. Install the 2 resonator to engine bolts (4) to the air cleaner outlet resonator (5).

   Tighten: Tighten the bolts to 6 N.m (53 lb in).

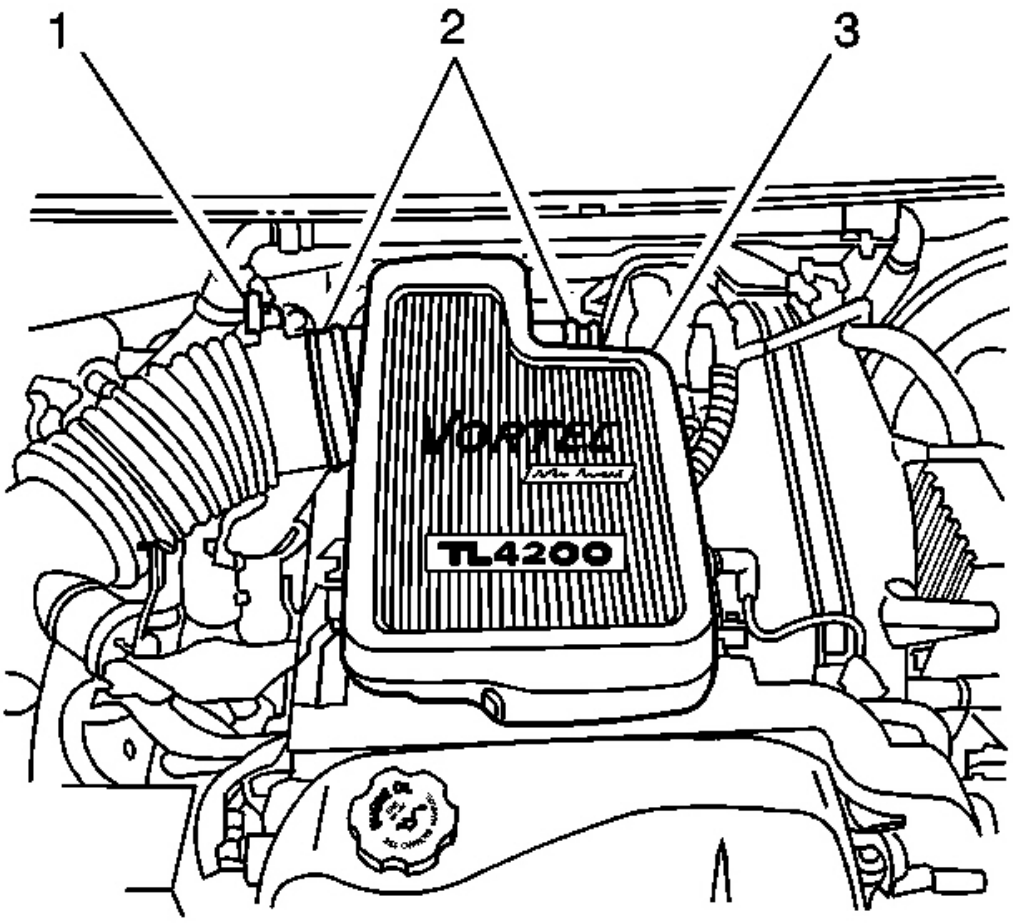


Fig. 70: Top Of Engine View
Courtesy of GENERAL MOTORS CORP.

4. Tighten the throttle body clamps (2).

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

5. Connect the fuel pressure regulator vacuum supply hose to the air cleaner outlet resonator.

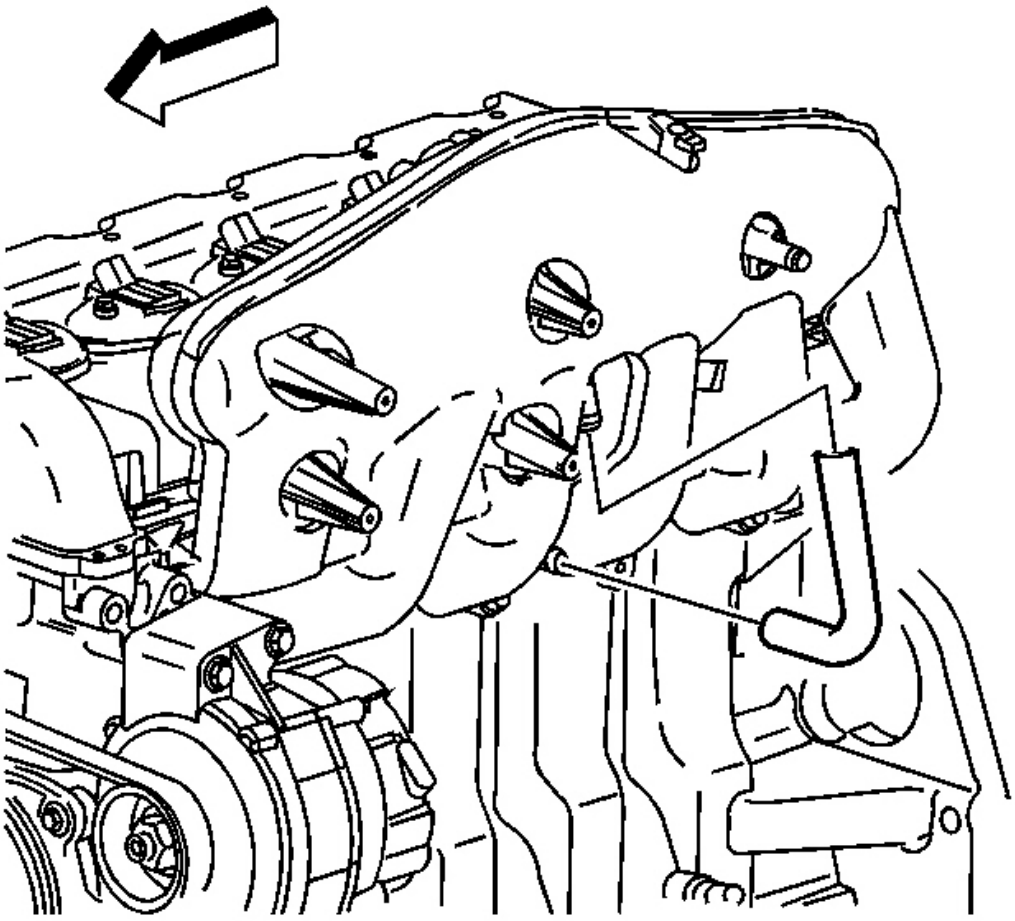


Fig. 71: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the inner diameter of the crankcase ventilation hose. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
7. Connect the crankcase dirty air hose to the intake manifold.
8. Connect the crankcase dirty air hose to the PCV orifice tube.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

2. Relieve the fuel pressure. Refer to **Fuel Pressure Relief (With CH 48027)** or **Fuel Pressure Relief (Without CH 48027)** .
3. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .

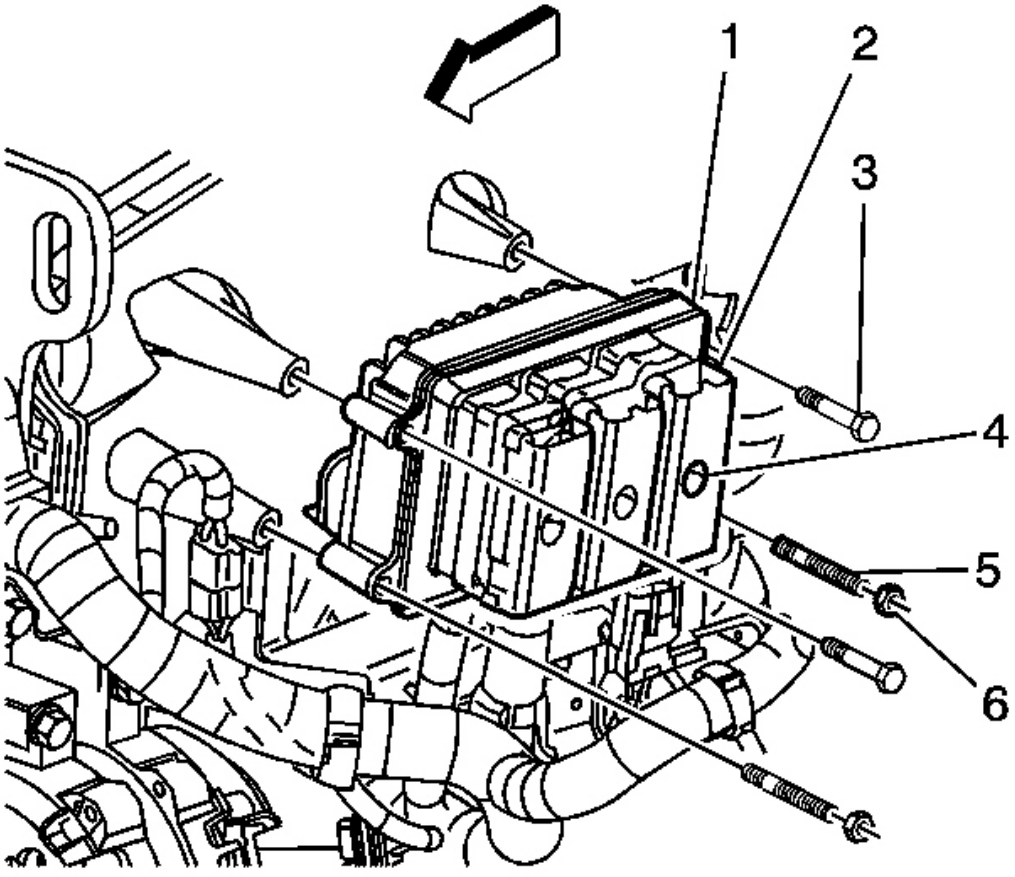


Fig. 72: View Of PCM Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the powertrain control module (PCM) retaining bolts (3) and nuts (6).
5. Remove the ECM. Refer to **Engine Control Module Replacement** .

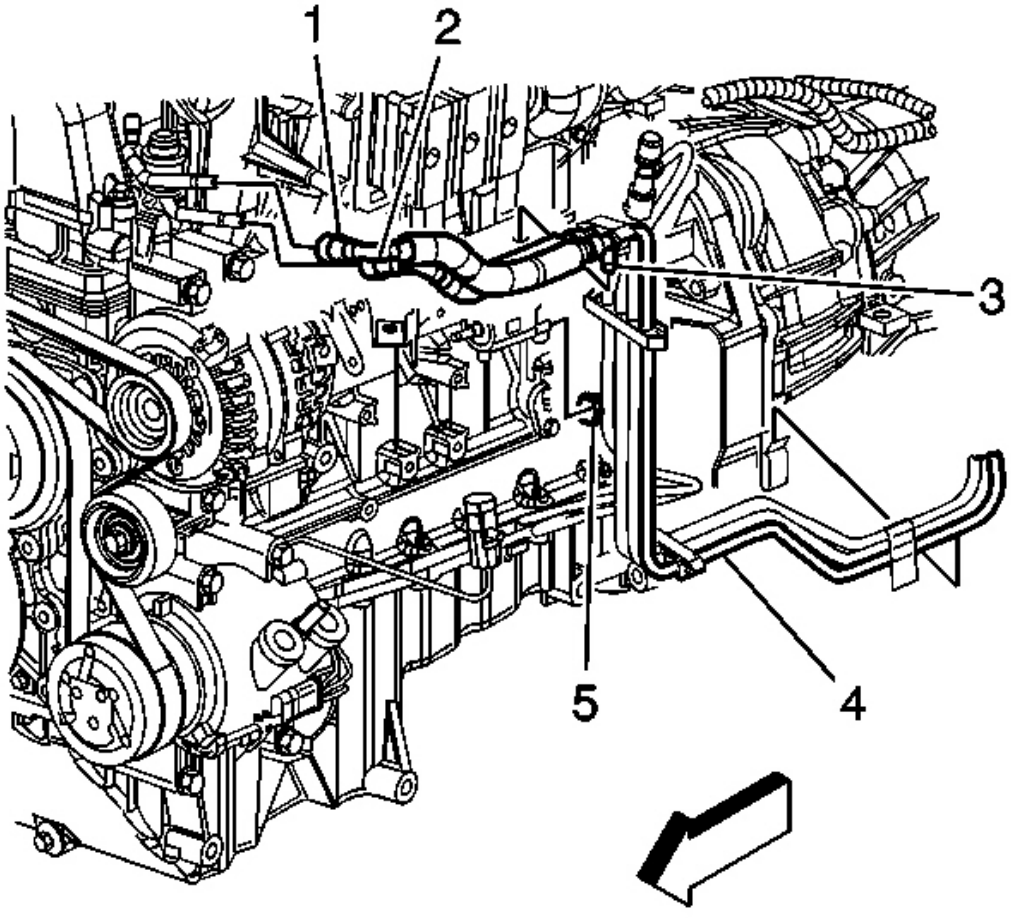


Fig. 73: Identifying Fuel Feed & Fuel Return Pipes (Left Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Notice .**

6. Disconnect the fuel feed pipe (1) from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
7. Disconnect the integral clip (3) from the wire harness bracket.

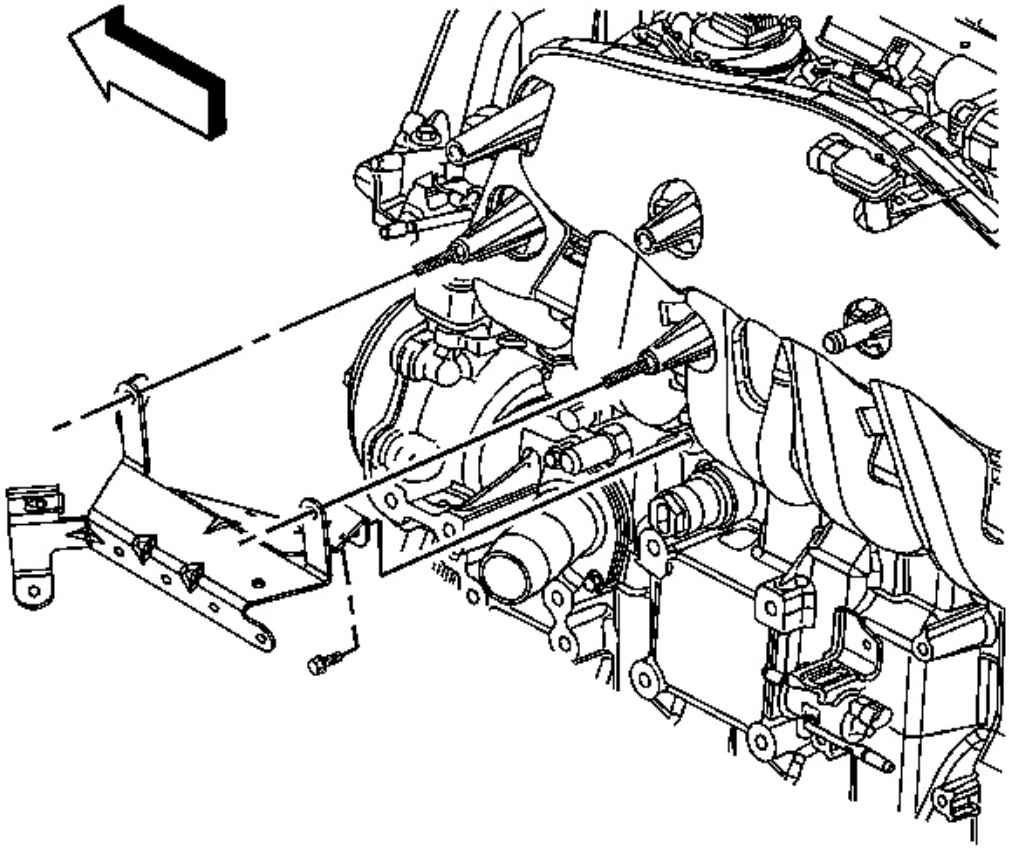


Fig. 74: View Of Engine Wire Harness Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine wire harness bracket bolt.
9. Remove the electrical harness and vacuum lines from the intake manifold.

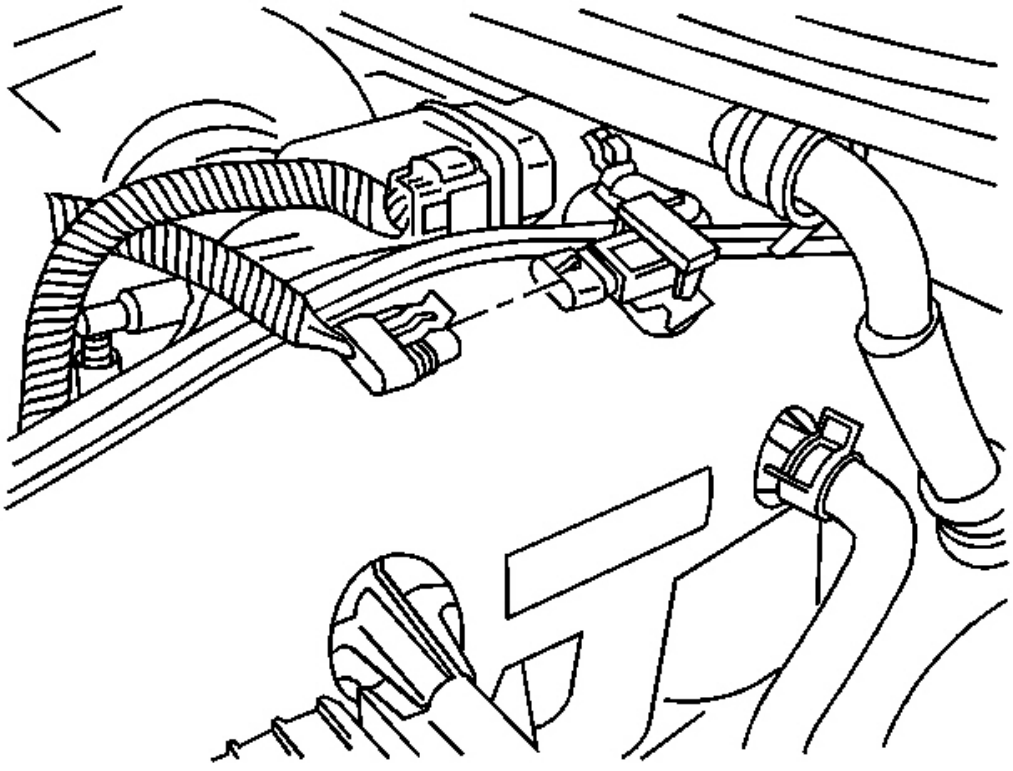


Fig. 75: View Of MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the manifold absolute pressure (MAP) sensor electrical connector.

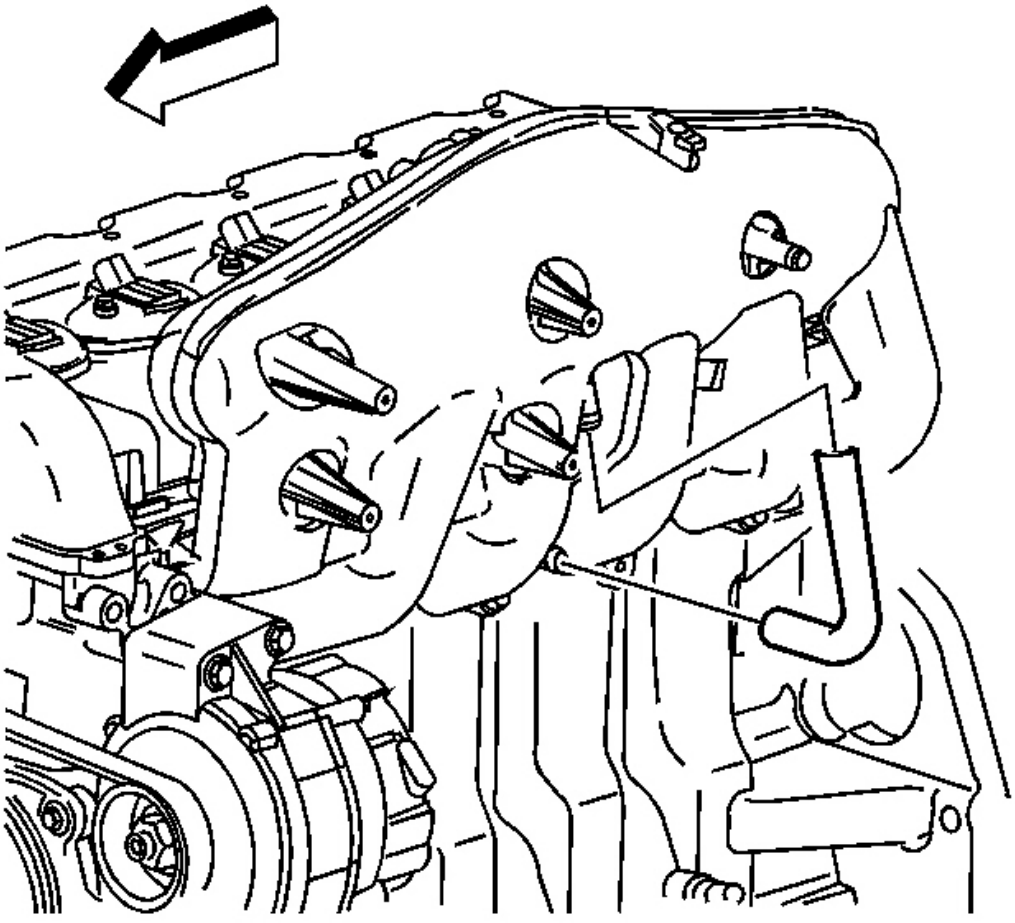


Fig. 76: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the crankcase ventilation hose from the intake manifold.

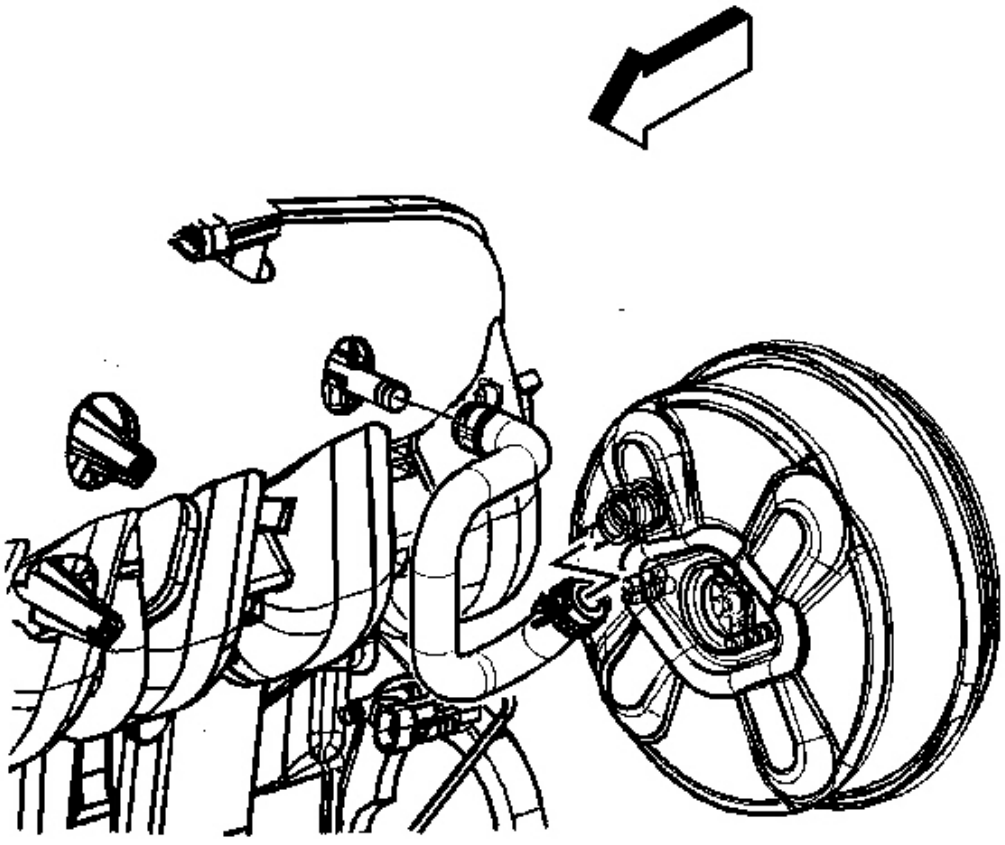


Fig. 77: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the vacuum brake booster hose at the intake manifold.
13. Remove the generator. Refer to **Generator Replacement (With 4.2L Engine)** or **Generator Replacement (With V8 Engine)** .

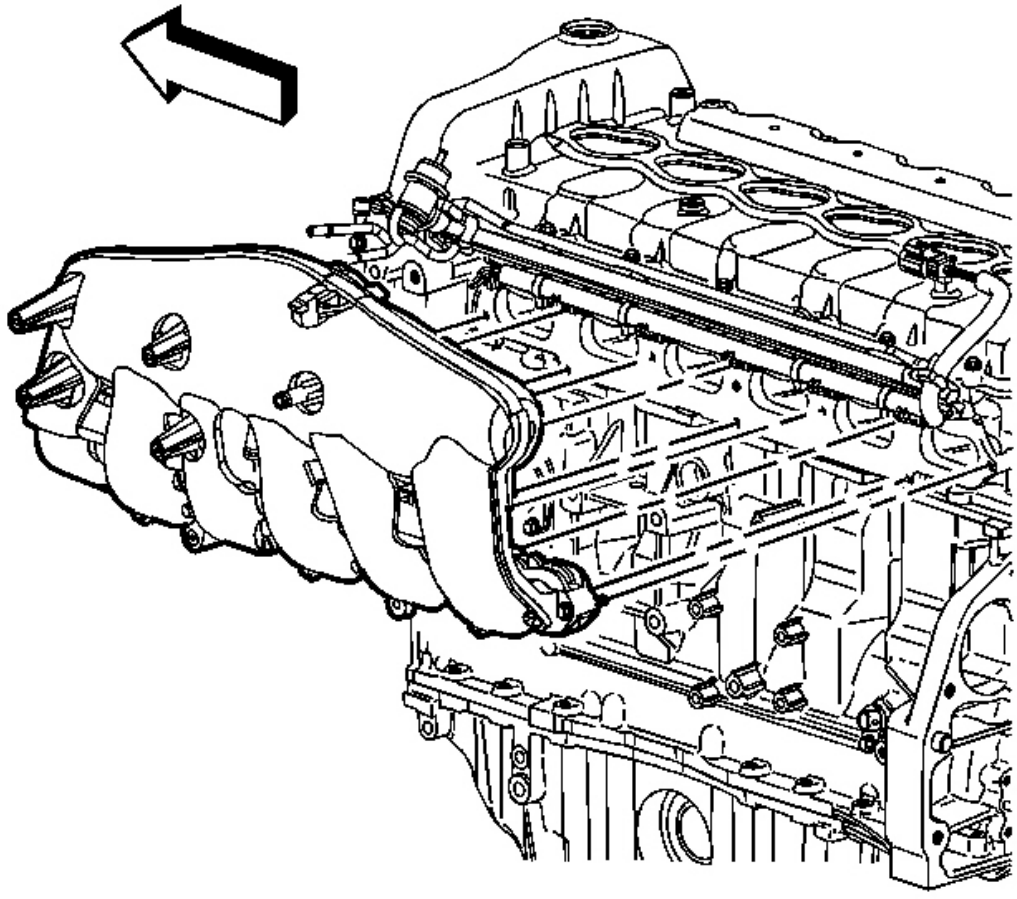


Fig. 78: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold bolts are captured within the intake manifold. Do not attempt to remove the bolts from the intake manifold.

14. Loosen the intake manifold bolts.
15. Remove the intake manifold.

Installation Procedure

1. Install a new intake manifold gasket to the intake manifold.

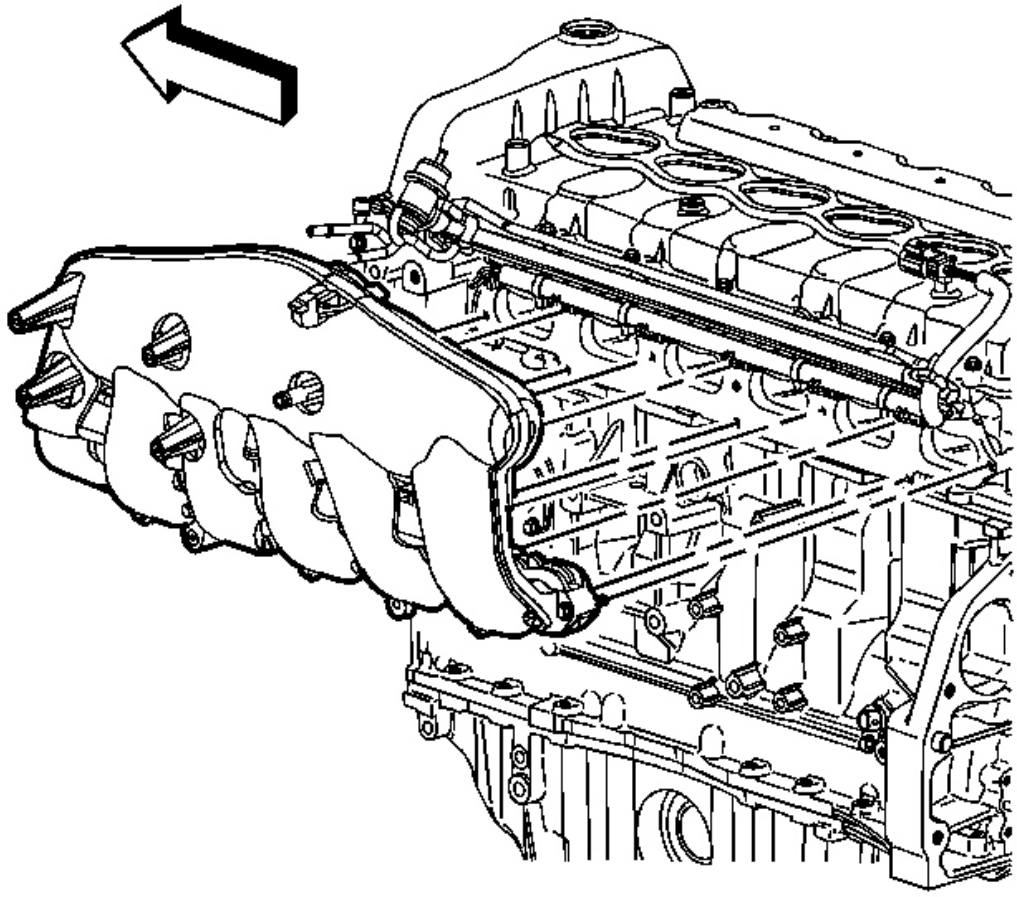


Fig. 79: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the intake manifold onto the engine and secure the manifold with the bolts.

   Tighten: Tighten the intake manifold bolts to 10 N.m (89 lb in).

3. Install the generator. Refer to **Generator Replacement (With 4.2L Engine)** or **Generator Replacement (With V8 Engine)** .

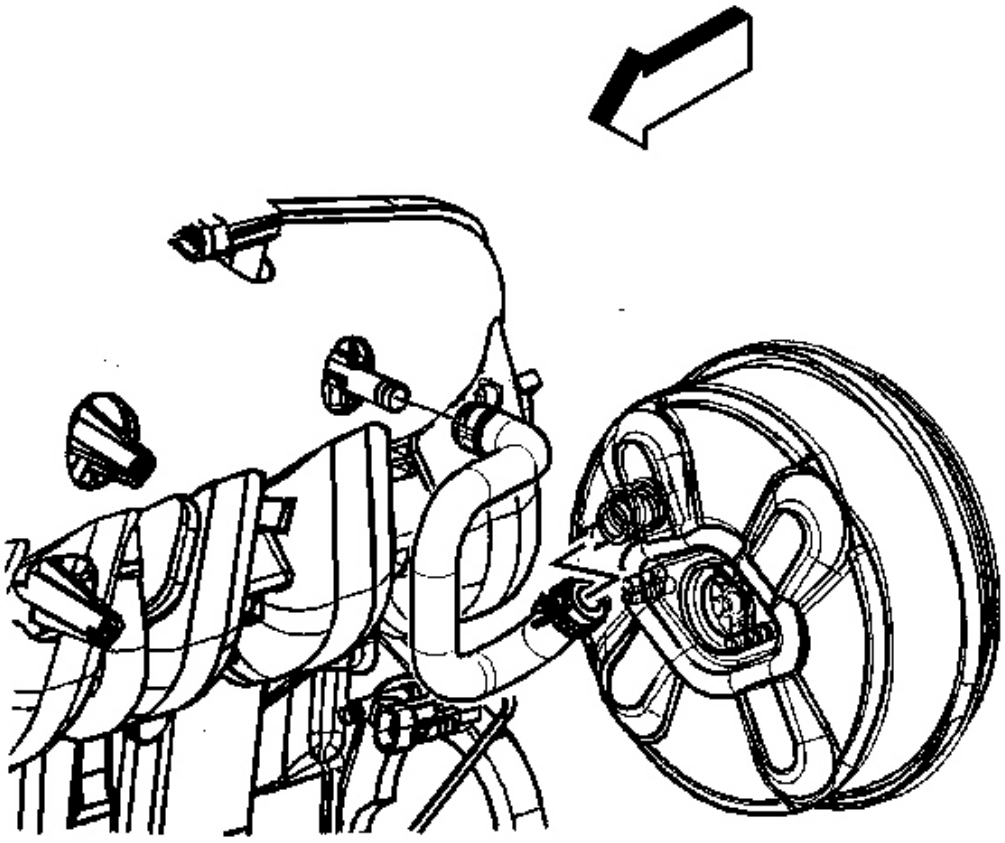


Fig. 80: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

4. Install the vacuum brake booster hose to the intake manifold.

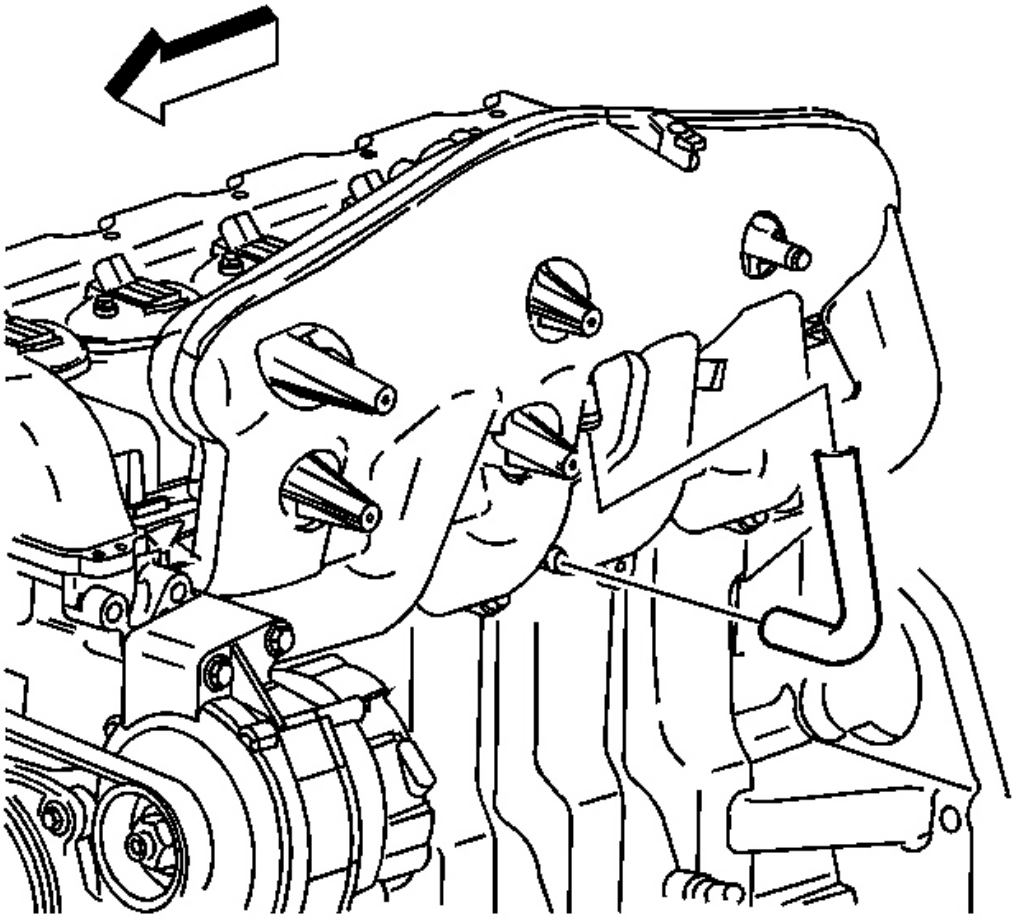


Fig. 81: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

5. Lubricate the inner diameter of the crankcase ventilation hose. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Install the crankcase ventilation hose.

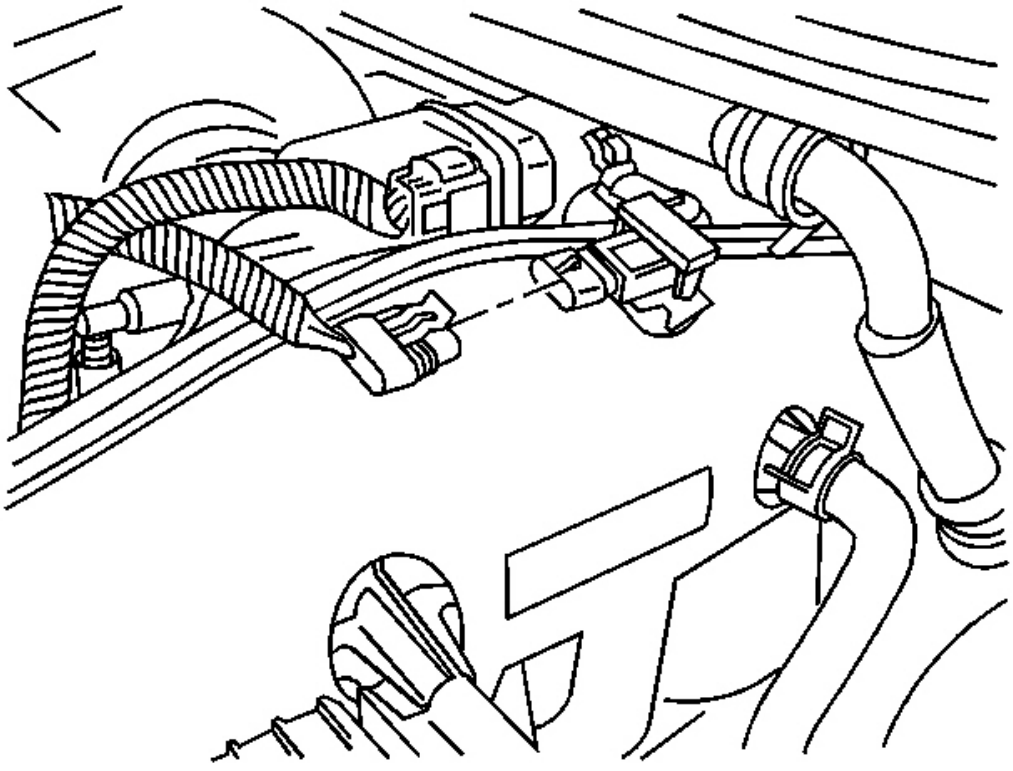


Fig. 82: View Of MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Connect the MAP sensor electrical connector.
8. Install the electrical harness and vacuum lines to the intake manifold.

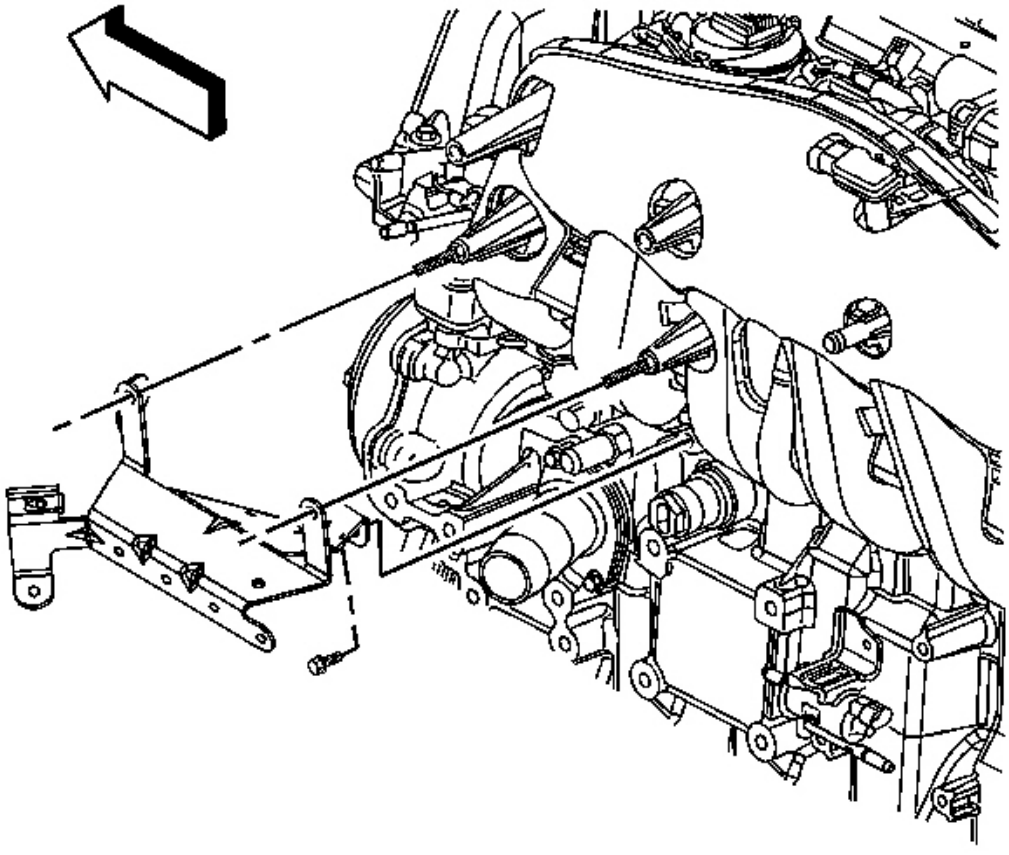


Fig. 83: View Of Engine Wire Harness Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the engine electrical harness bracket bolt.

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

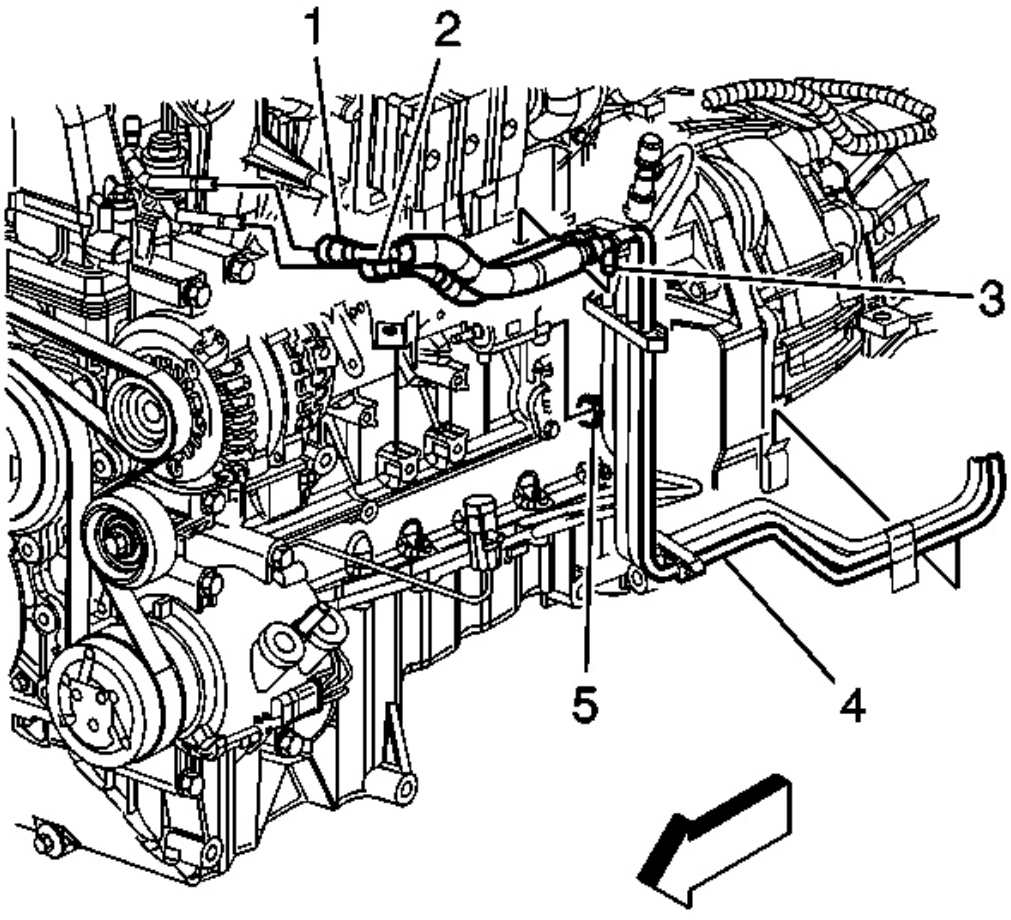


Fig. 84: Identifying Fuel Feed & Fuel Return Pipes (Left Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

10. Connect the integral clip (3) to the wire harness bracket.
11. Connect the fuel feed pipe (1) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .

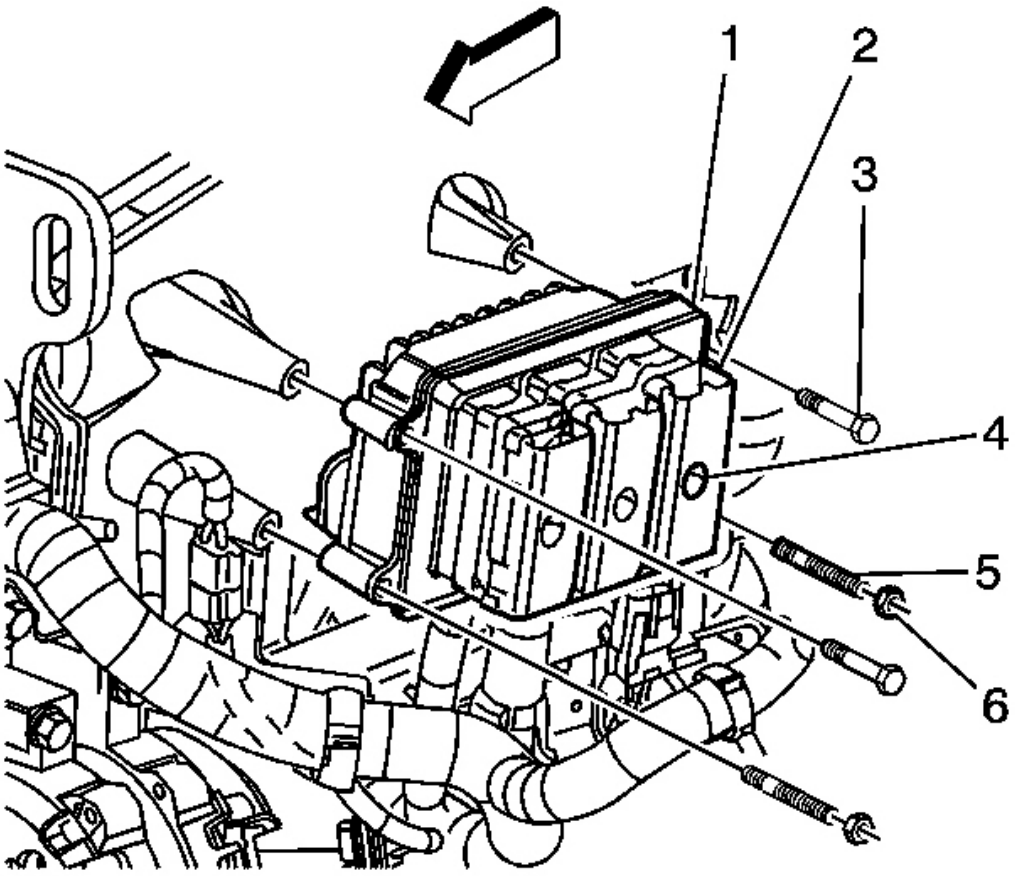


Fig. 85: View Of PCM Assembly
Courtesy of GENERAL MOTORS CORP.

12. Install the PCM mounting studs (5) to the intake manifold.

    Tighten: Tighten the studs to 6 N.m (53 lb in).

13. Install the PCM (1) onto the studs (5).
14. Install the PCM retaining bolts (3).

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

15. Install the PCM retaining nuts (6).

    Tighten: Tighten the nuts to 8 N.m (71 lb in).

16. Install the PCM harness connectors (2) to the PCM body.
17. Tighten the PCM harness connector retaining bolts (4).

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

18. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .
19. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
20. Inspect for leaks using the following procedure:
    1. Turn ON the ignition, with the engine OFF for 2 seconds.
    2. Turn OFF the ignition for 10 seconds.
    3. Turn ON the ignition, with the engine OFF.
    4. Inspect for fuel leaks.

CAMSHAFT COVER REPLACEMENT

Removal Procedure

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.

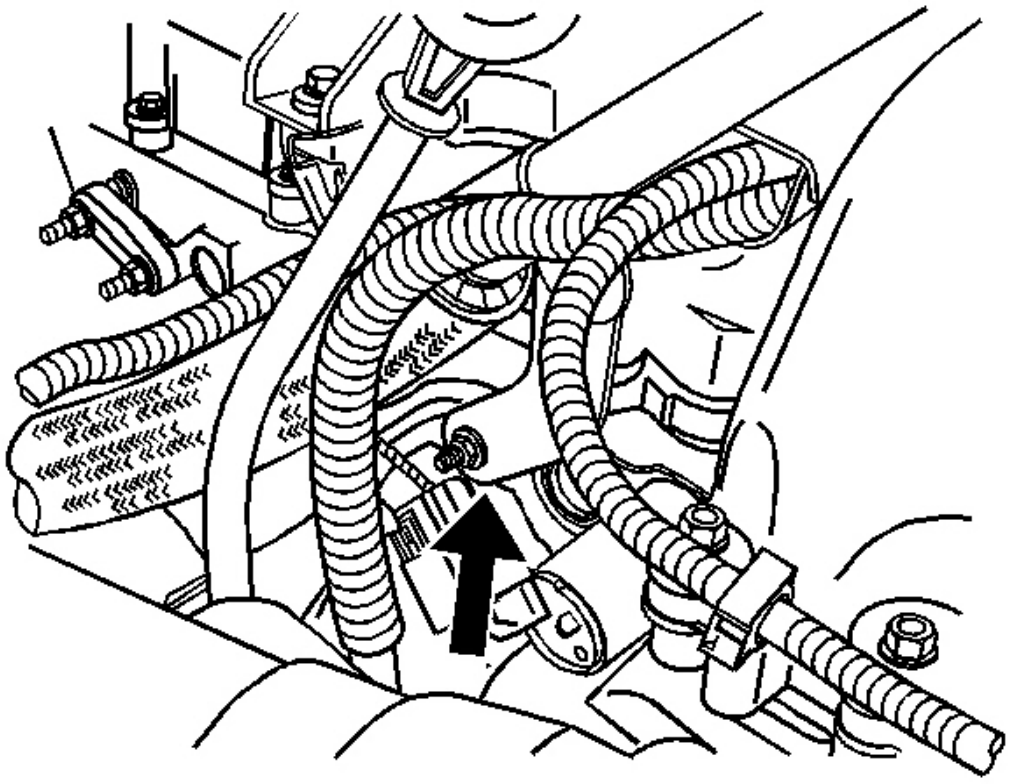


Fig. 86: View Of Oil Level Indicator Tube Bracket Nut
Courtesy of GENERAL MOTORS CORP.

2. Remove the A/C line at the oil level indicator tube bracket nut.

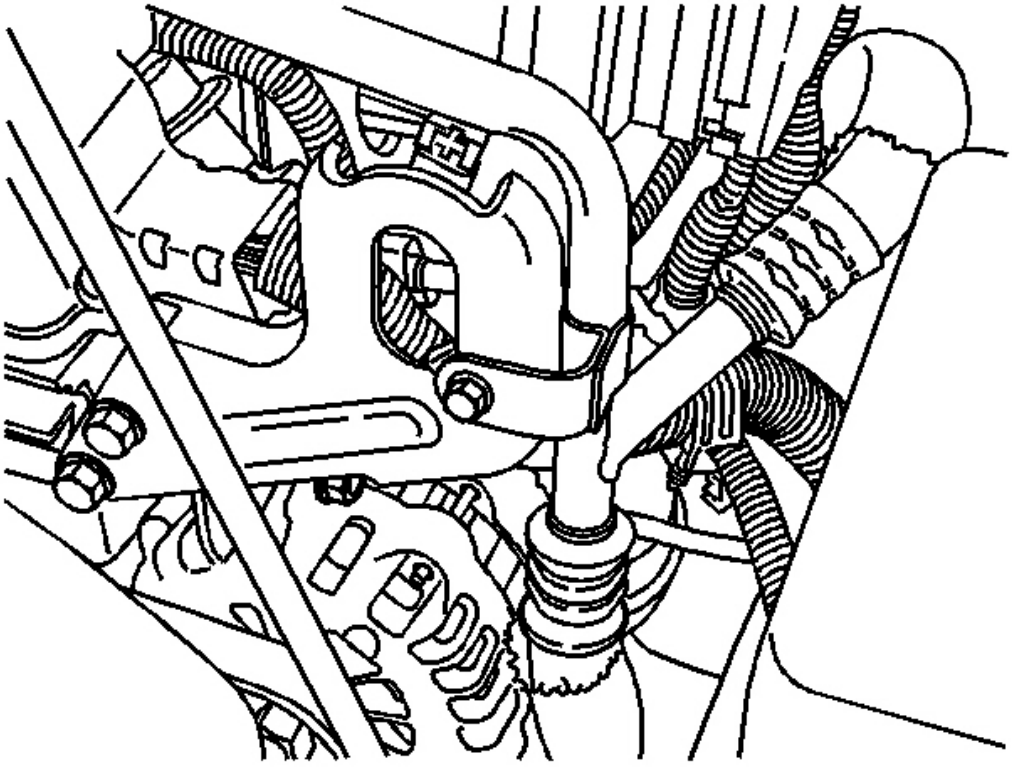


Fig. 87: View Of Engine Lift Hook & A/C Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the A/C bracket bolt from the engine lift hook.
4. Position the A/C line out of the way.

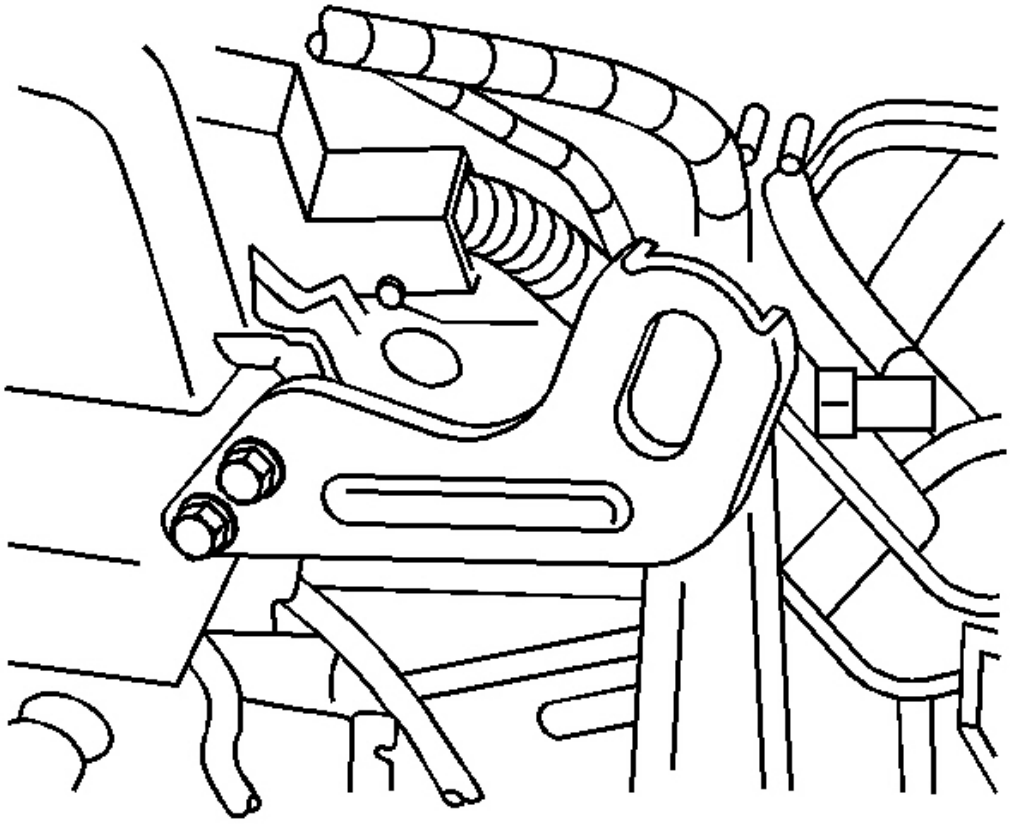


Fig. 88: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine lift bracket.
6. Disconnect the ignition control module electrical connectors.
7. Loosen the ignition control module bolts.

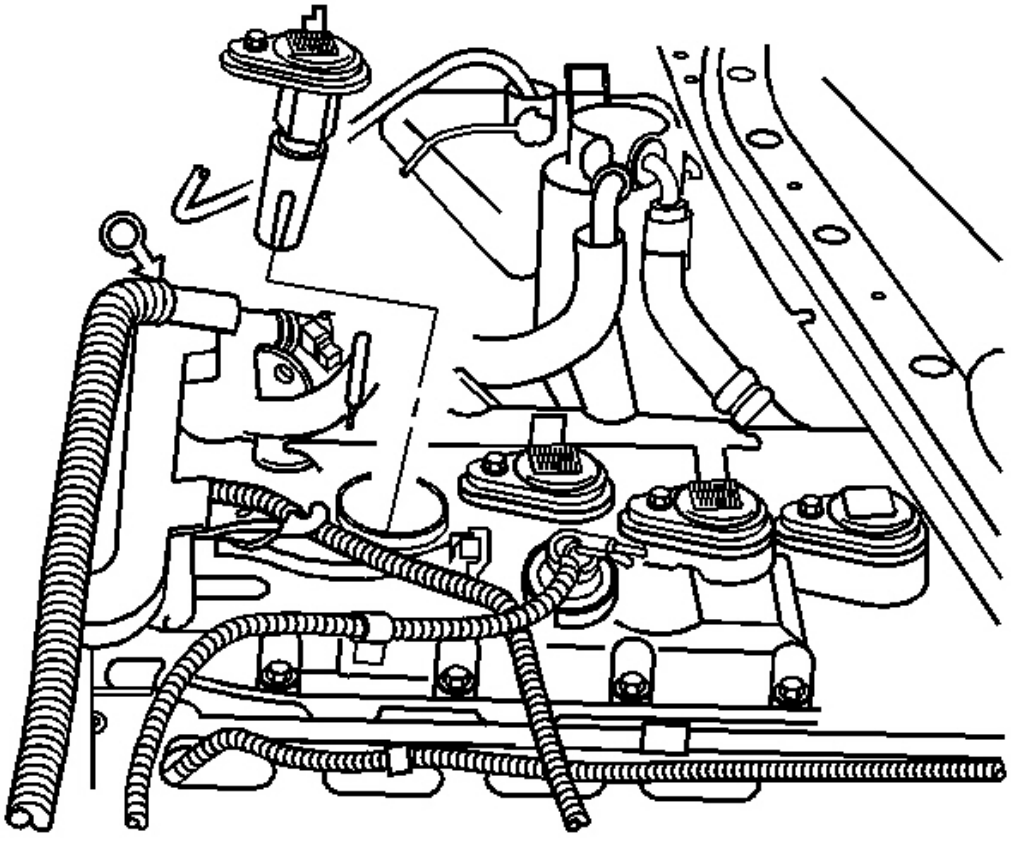


Fig. 89: View Of Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

8. Remove the ignition control module.

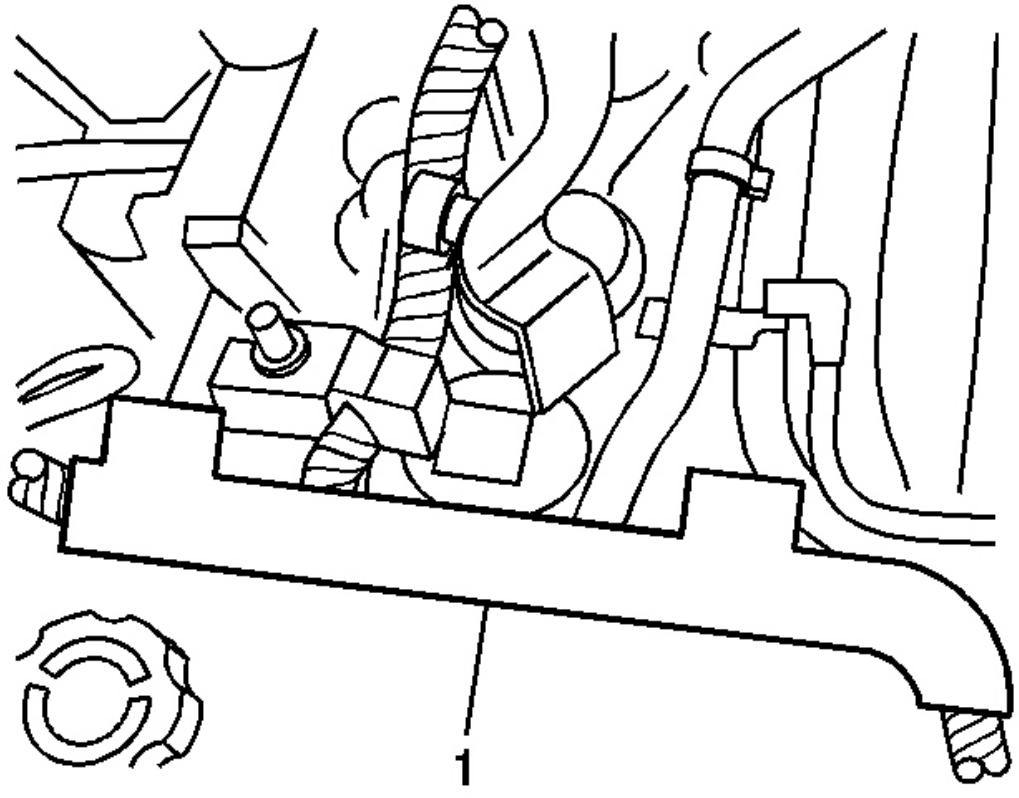


Fig. 90: View Of Engine Electrical Harness Housing
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine electrical harness housing from the camshaft cover (1) taking care not to damage the clips that hold the housing in place.
10. Disconnect the fuel injection harness electrical connector.

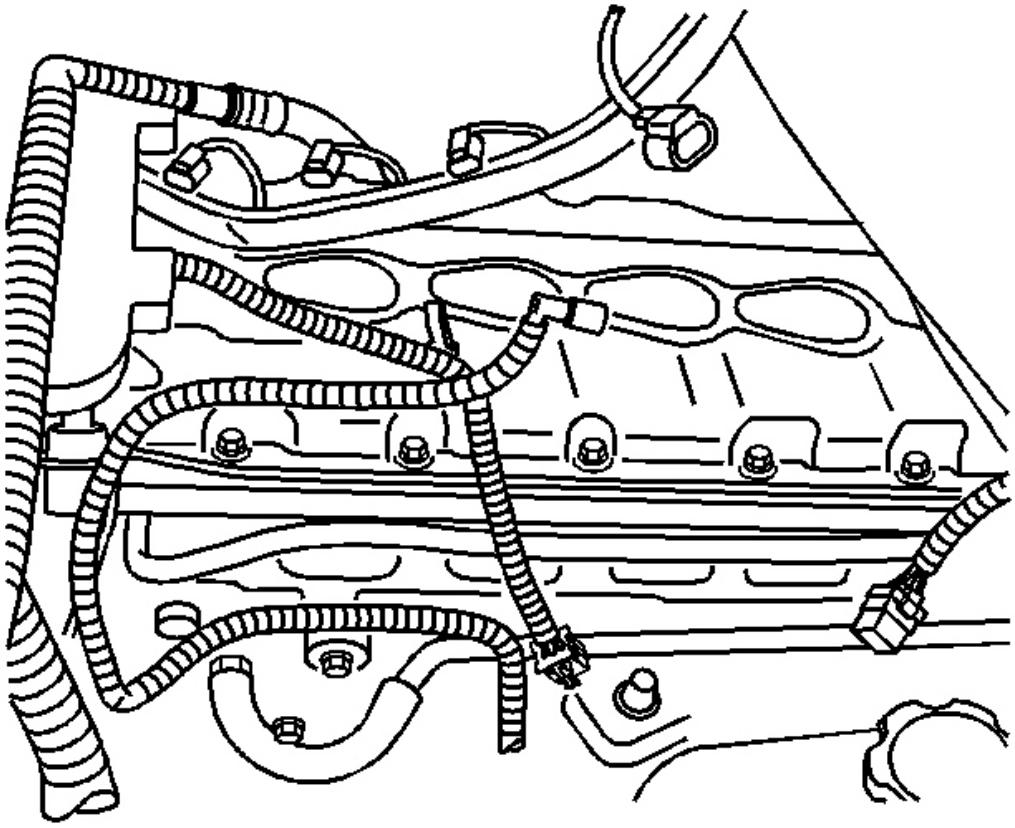


Fig. 91: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

11. Loosen and remove the camshaft cover bolts.

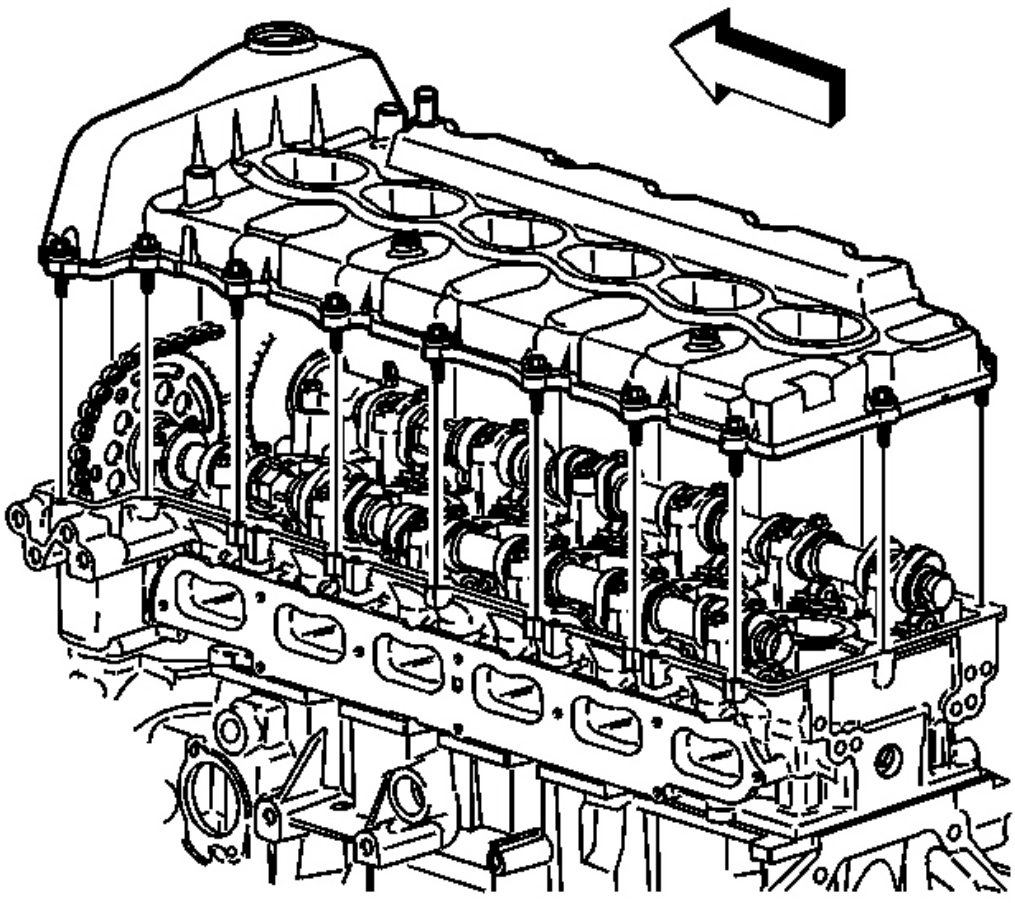


Fig. 92: View Of Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the camshaft cover.
13. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection**.

Installation Procedure

1. Install a new camshaft cover seal.
2. Install new rubber ignition control module seals.

NOTE: Refer to Fastener Notice .

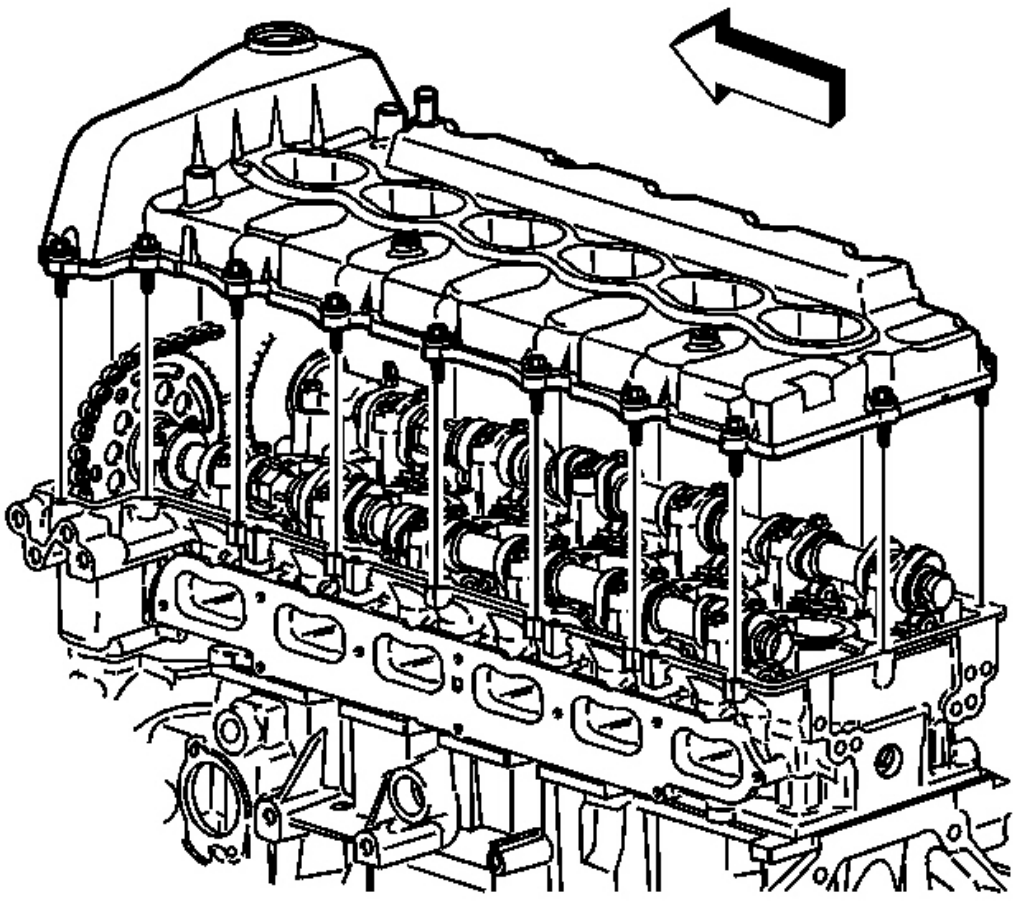


Fig. 93: View Of Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft cover and secure with the cam cover bolts.

   Tighten: Tighten the camshaft cover bolts to 10 N.m (89 lb in).

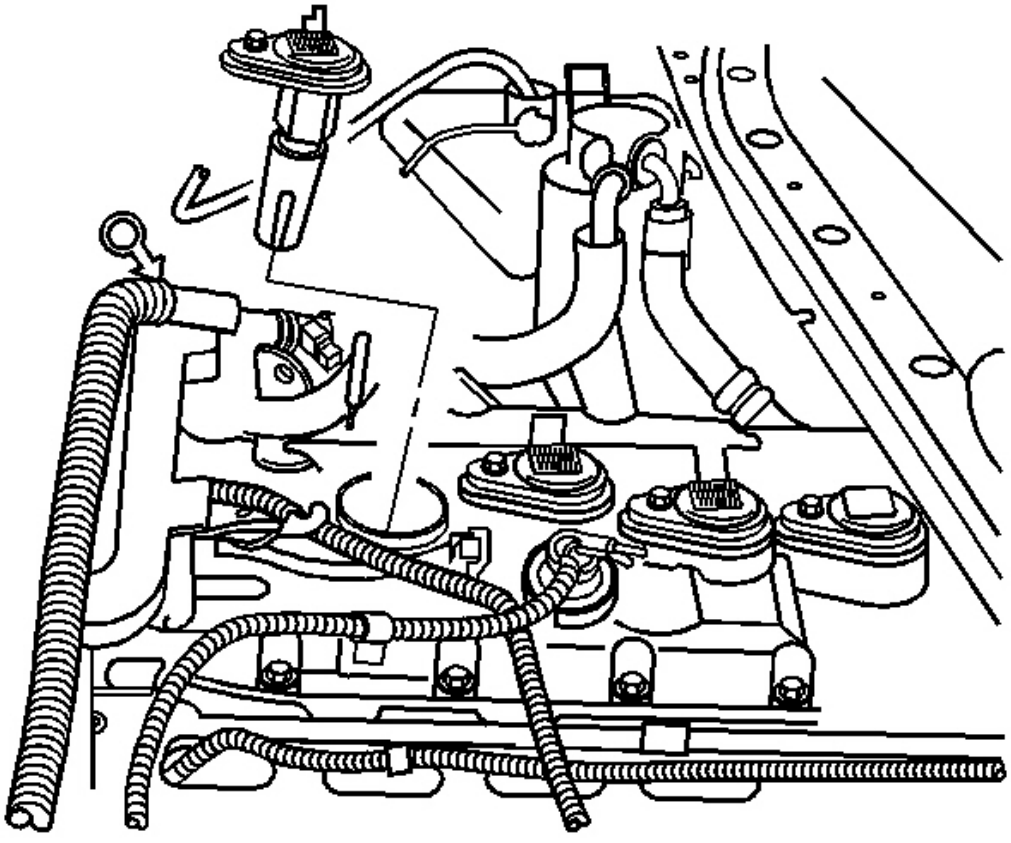


Fig. 94: View Of Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

4. Install the ignition control modules and secure the modules with bolts.

   Tighten: Tighten the ignition coil bolts to 10 N.m (89 lb in).

5. Connect the ignition control module electrical connectors.
6. Install the fuel injector electrical connectors.

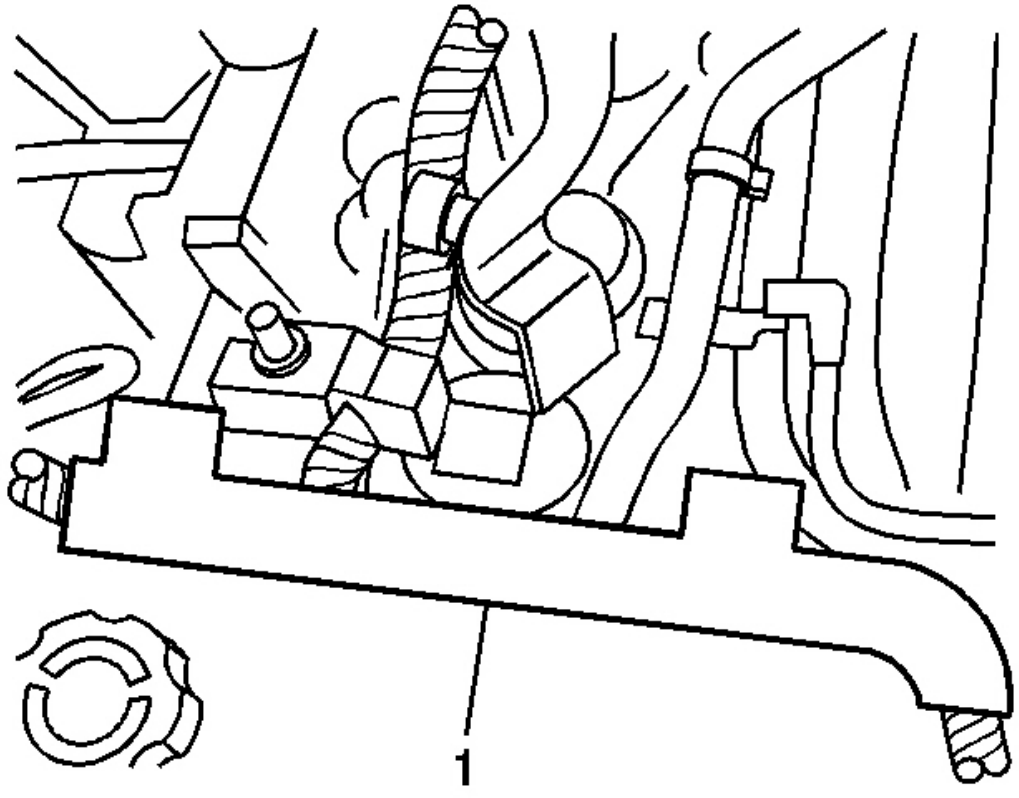


Fig. 95: View Of Engine Electrical Harness Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the engine electrical harness housing (1).

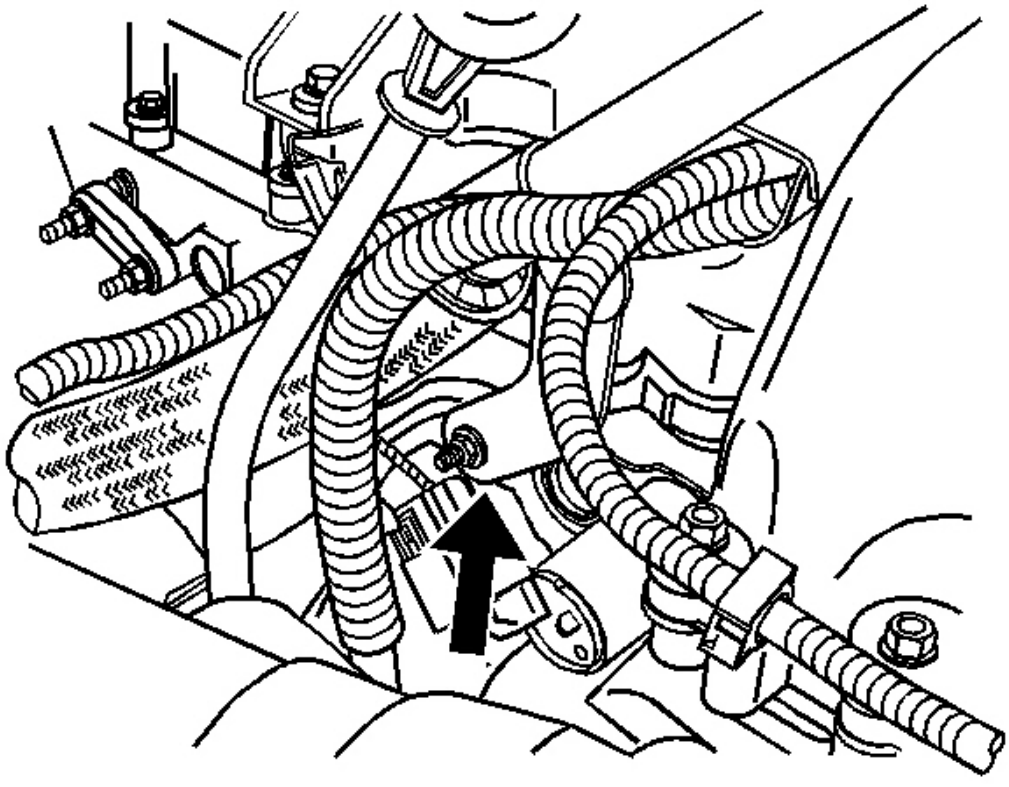


Fig. 96: View Of Oil Level Indicator Tube Bracket Nut
Courtesy of GENERAL MOTORS CORP.

8. Install the A/C line bracket to the oil level indicator tube stud and secure the bracket with the nut.

   Tighten: Tighten the A/C line bracket nut to 7 N.m (62 lb in).

9. Install the engine lift bracket and secure the lift hook with the bolts.

   Tighten: Tighten the lift bracket bolts to 50 N.m (37 lb ft).

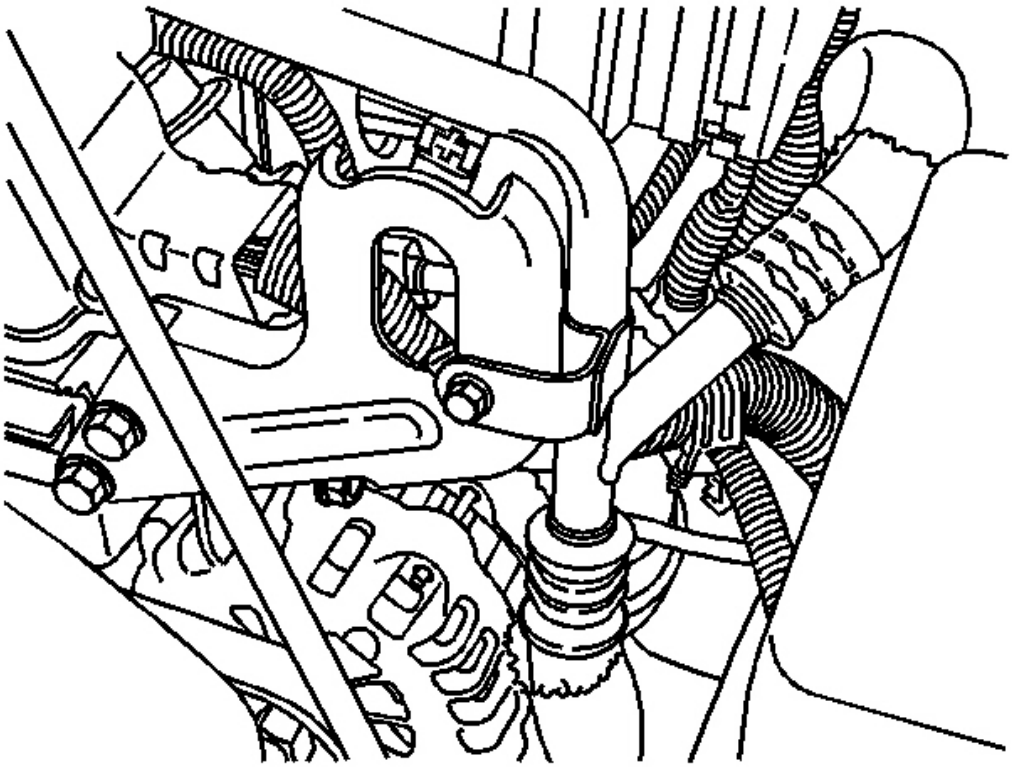


Fig. 97: View Of Engine Lift Hook & A/C Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

10. Install the A/C line bracket to the engine lift bracket and secure the A/C bracket with the bolt.

    Tighten: Tighten the A/C bracket bolt to 10 N.m (89 lb in).

11. Install the intake manifold. Refer to **Intake Manifold Replacement**.

VALVE ROCKER ARM & VALVE LASH ADJUSTER REPLACEMENT

Tools Required

EN-47945 Valve Spring Compressor

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Rotate the crankshaft until the affected cylinder valve is fully open (cam lobe fully depressing the spring).

IMPORTANT: Engine design and packaging does not allow all cylinder locations to use both fasteners for holding the tool to the cylinder head. One fastener is sufficient in these locations.

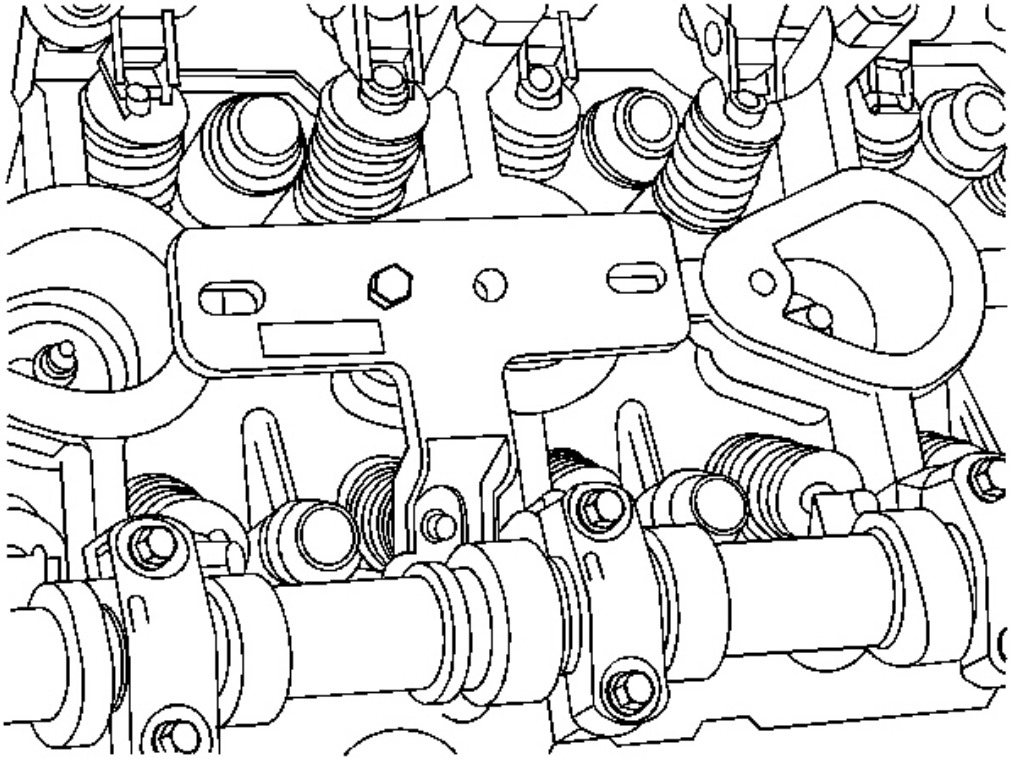


Fig. 98: EN-47945 Installed On Engine Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN-47945** on the engine cylinder head using either one or two of the supplied fasteners installed in the coil fastener hole.

IMPORTANT: DO NOT rotate the engine with the tool installed. It is possible to damage the valves if they contact the piston. Rotate the engine enough to come back to the base circle of the cam.

4. Rotate the engine clockwise enough to ensure the cam is on the base circle (spring will stay compressed by the tool).

   This will allow the lash adjuster and rocker to be removed.

5. Remove the valve rocker arm and valve lash adjuster.
6. Clean and inspect the valve rocker arm and valve lash adjuster. Refer to **Valve Rocker Arm and Valve Lash Adjuster Cleaning and Inspection**.

Installation Procedure

1. Lubricate the valve rocker arm and fill the valve lash adjuster with oil.
2. Install the valve rocker arm and valve lash adjuster.
3. When the valve rocker arm and valve lash adjuster are in place, slowly rotate the engine counterclockwise enough that the cam lobe fully depresses the spring again.

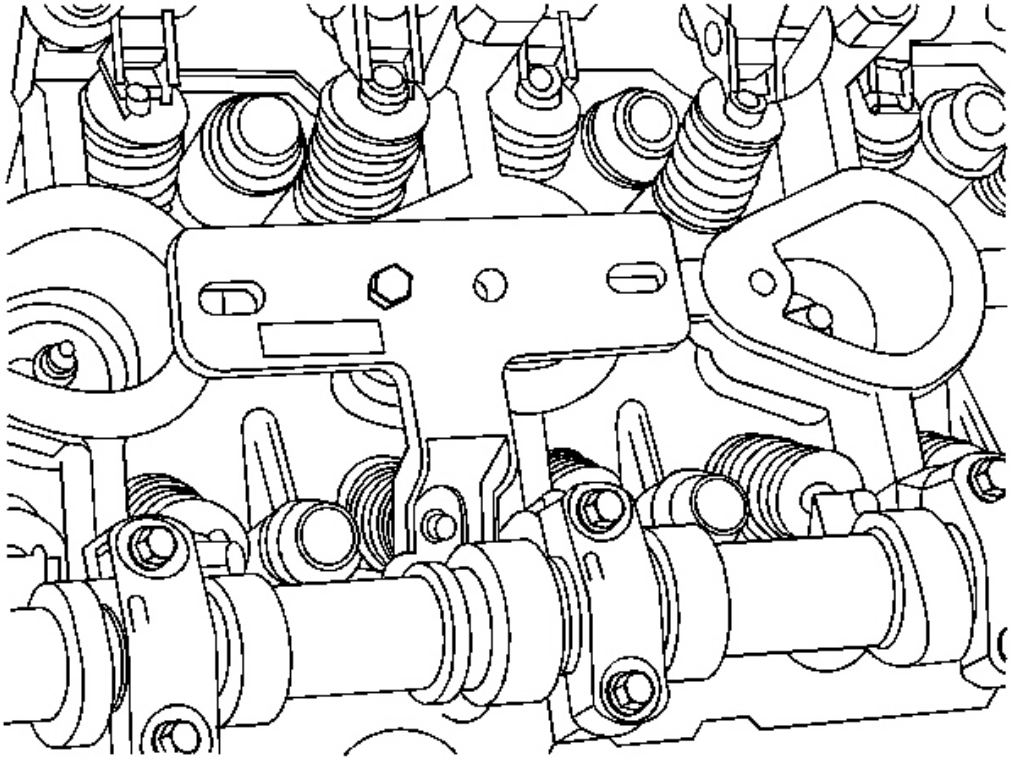


Fig. 99: EN-47945 Installed On Engine Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Remove the **EN-47945** from the cylinder head and repeat as required.
5. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

VALVE STEM OIL SEAL & VALVE SPRING REPLACEMENT

Tools Required

- **J 38820** Valve Stem Seal Remover and Installer. See **Special Tools**.
- **J 44222** Camshaft Sprocket Holding Tool. See **Special Tools**.
- **J-44228-A** Valve Spring Compressor. See **Special Tools**.
- **J 44226** Crankshaft Balancer Remover. See **Special Tools**.

Removal Procedure

IMPORTANT:

- **Organize the valve train components when disassembling so they can be reassembled in the same location and matched up with the same components, as previously installed.**
- **Regulate the air pressure to 50 psi before pressurizing the cylinder to help prevent the crankshaft from turning.**

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

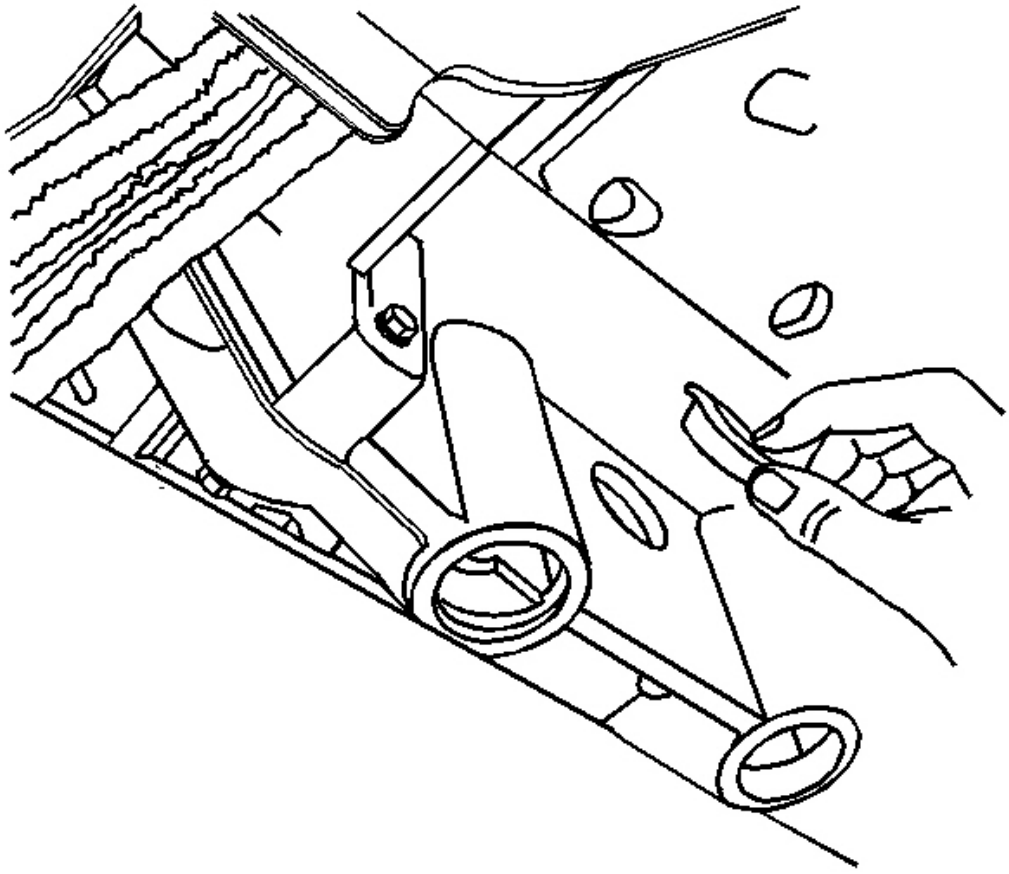


Fig. 100: View Of Torque Converter Access Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the torque converter access plug.
3. Use the J 44226-3A 15 mm holding bar on a torque converter bolt to prevent the crankshaft from turning.
4. Lower the vehicle.

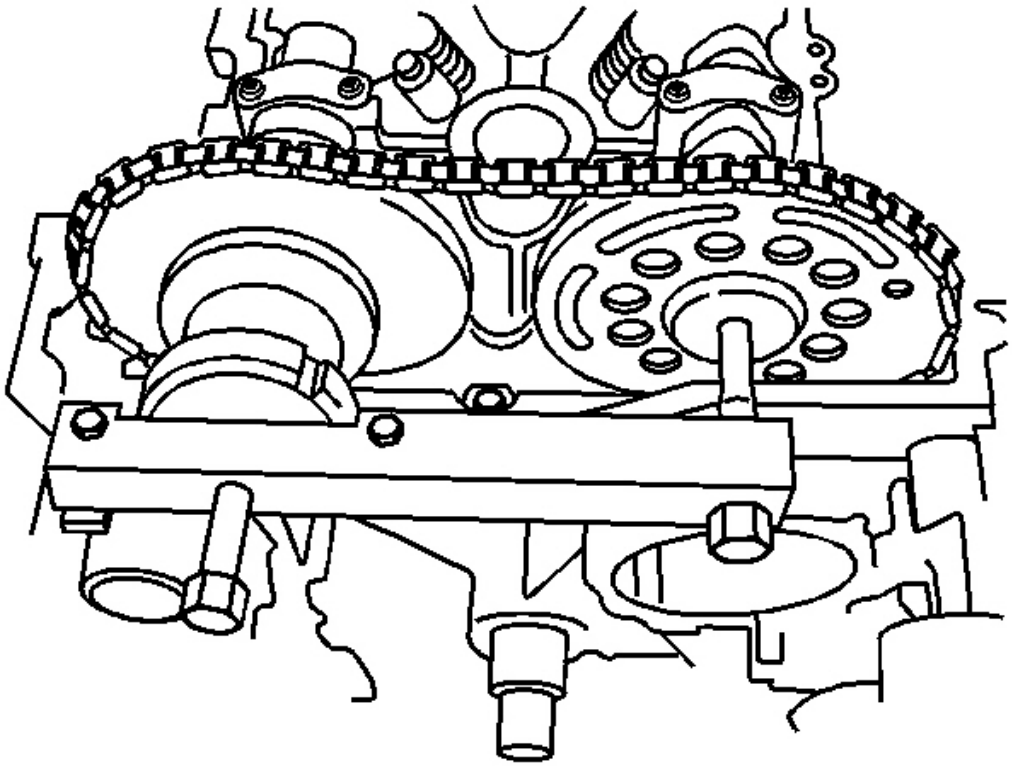


Fig. 101: View Of J 44222 Installed Onto Camshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the timing gear bolts.
6. Install the **J 44222** onto the cylinder head in order to keep from disturbing the timing chain components. See **Special Tools**.
7. Adjust the 2 horizontal bolts into the camshaft sprockets to maintain chain tension.
8. Carefully move the sprockets with the timing chain, off of the camshafts.
9. Remove the camshaft cap bolts.

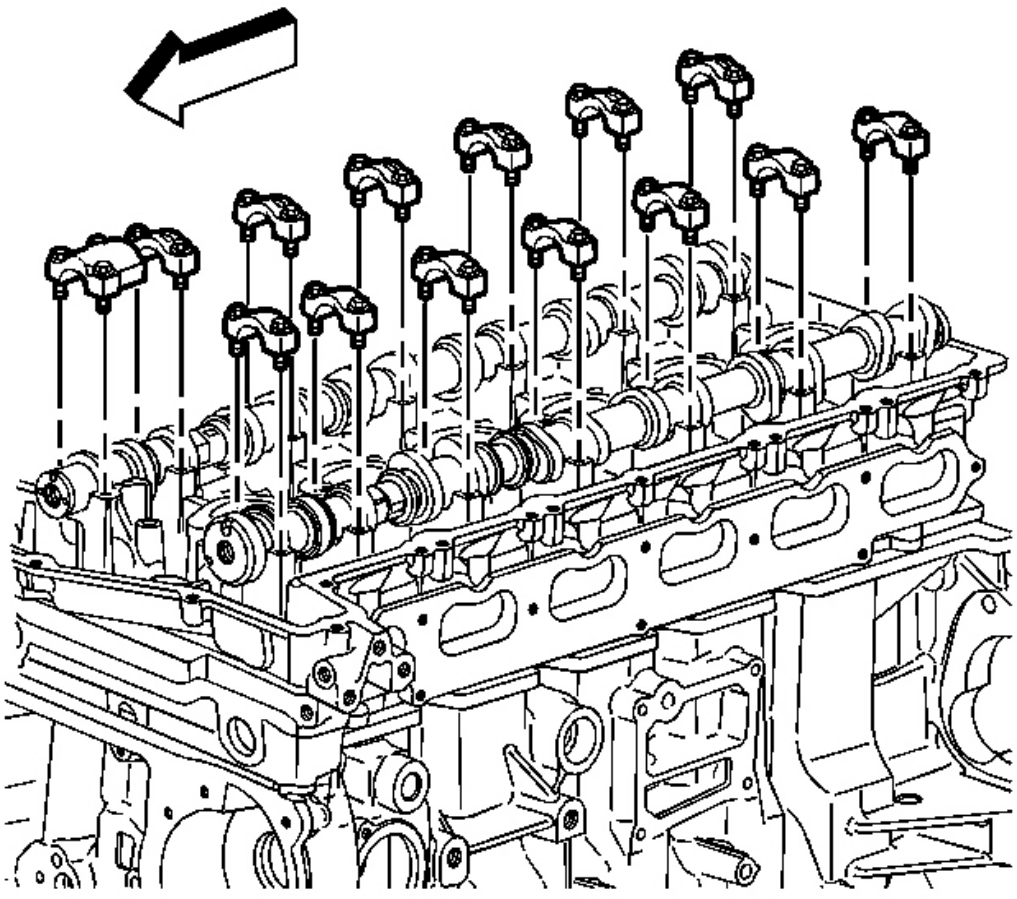


Fig. 102: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the camshaft caps in a rack to ensure the caps are installed in the same location from which they were removed.

10. Remove the camshaft caps.

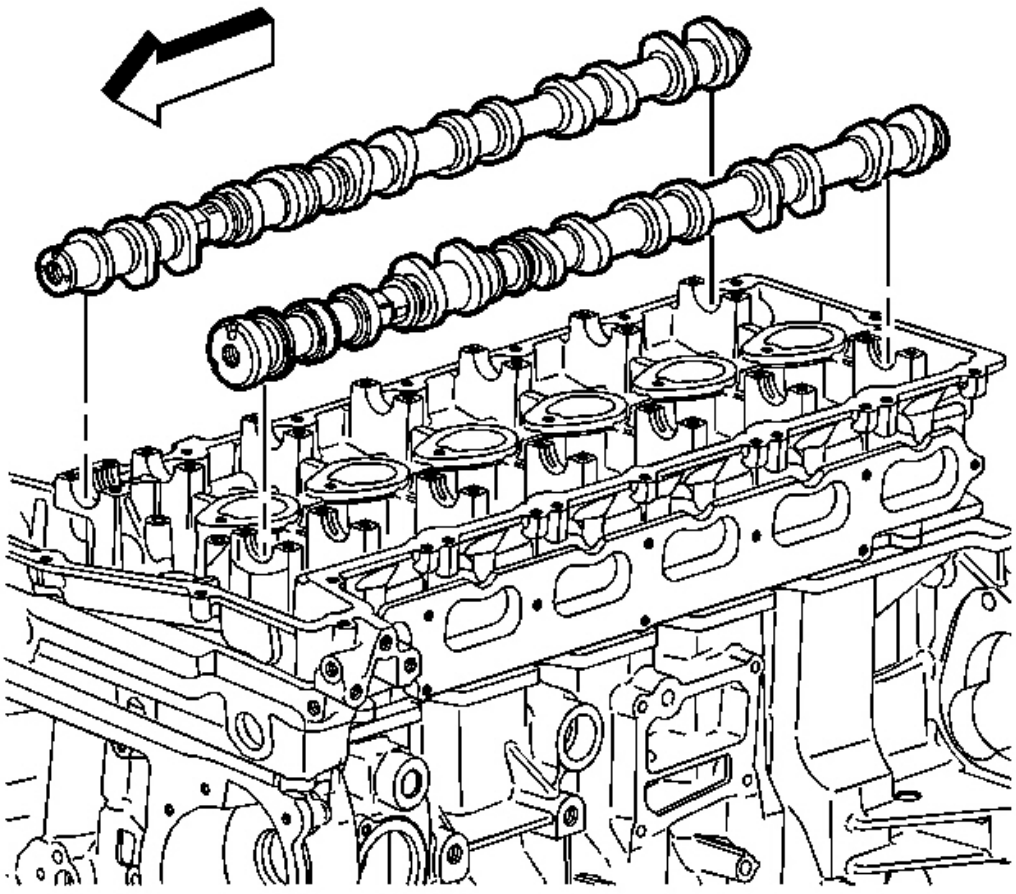


Fig. 103: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

11. Remove the camshafts.
12. Using a suitable adapter, apply air pressure to the cylinder.

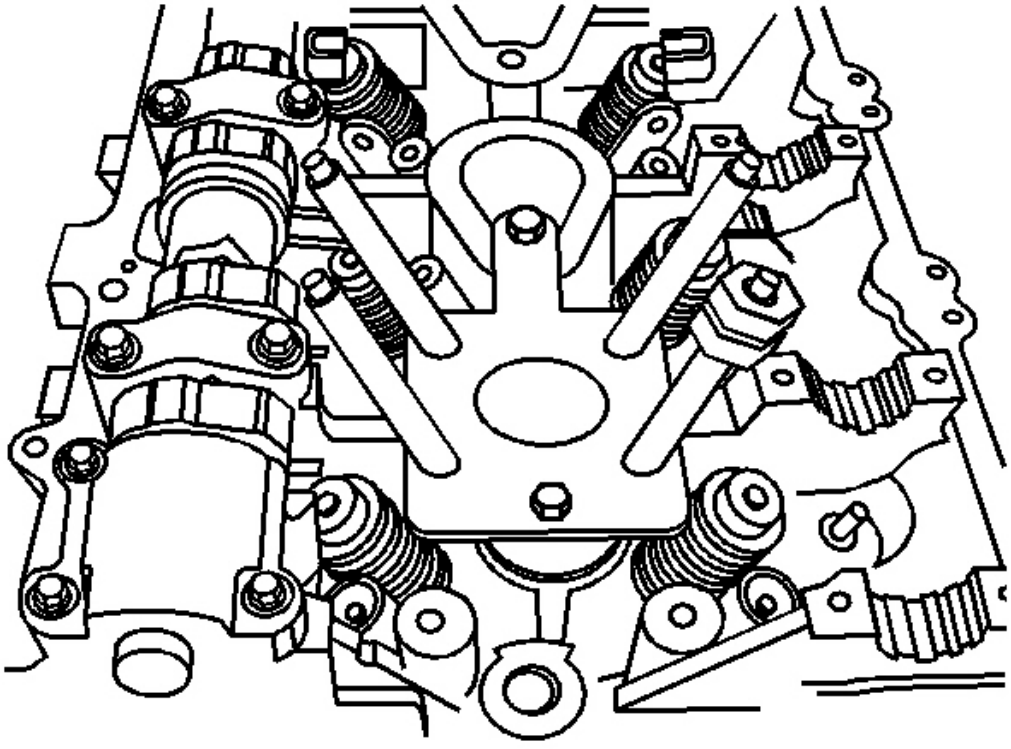


Fig. 104: View Of J 44228 Base Plate
Courtesy of GENERAL MOTORS CORP.

13. Install the **J-44228-A** and compress the valve springs. See **Special Tools**.

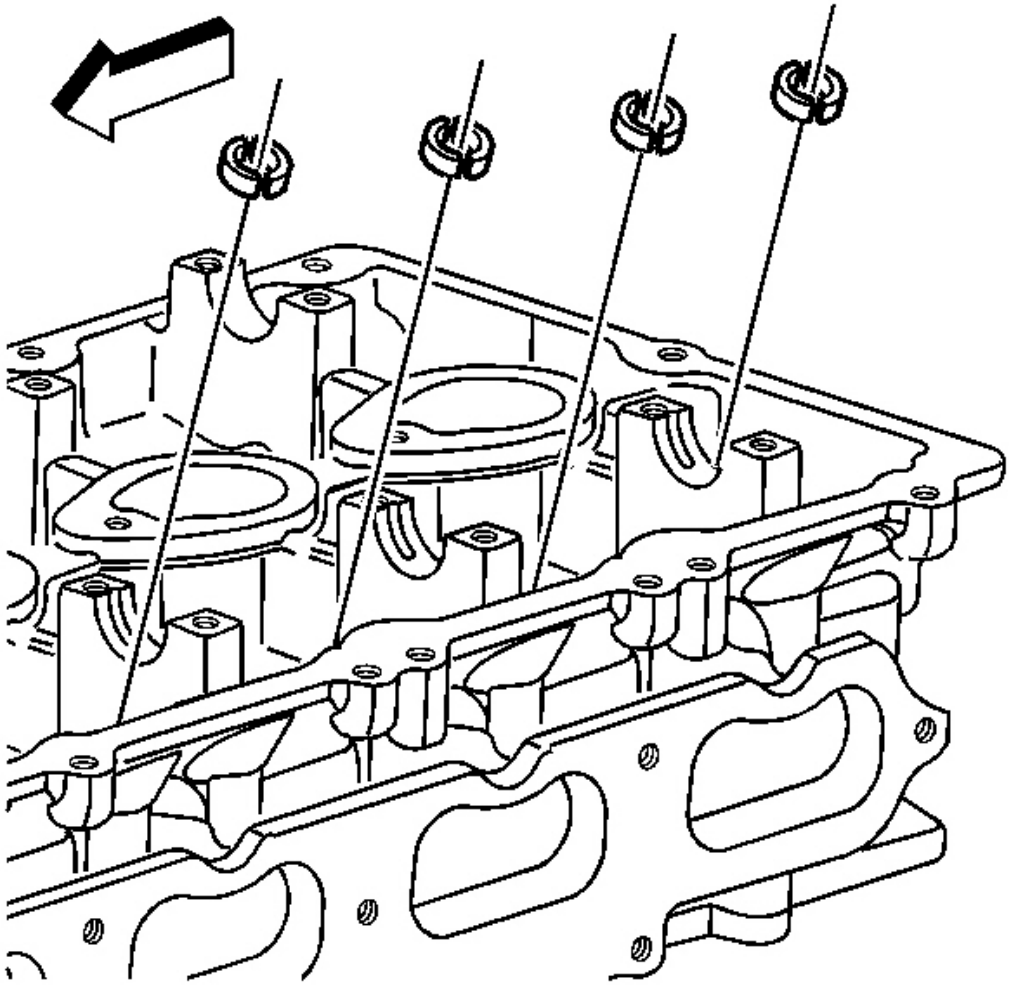


Fig. 105: View Of Valve Keys
Courtesy of GENERAL MOTORS CORP.

14. Remove the valve keys.
15. Remove the **J-44228-A** . See **Special Tools**.

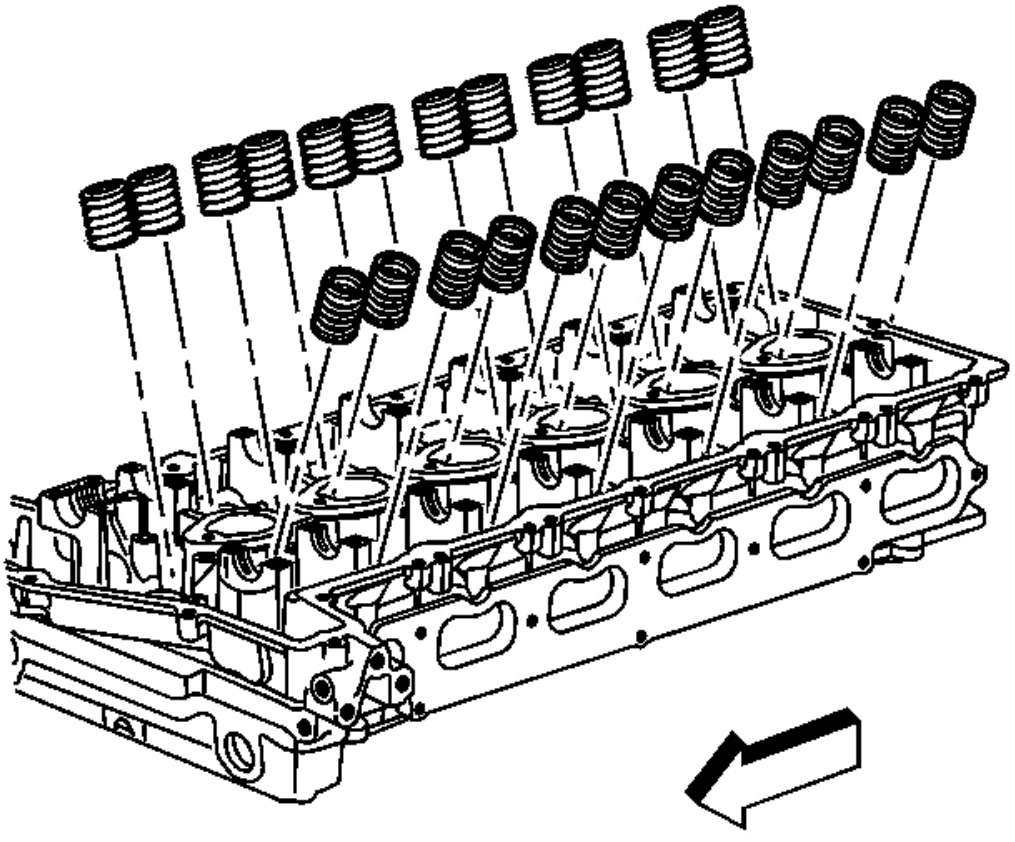


Fig. 106: View Of Valve Springs & Retainer
Courtesy of GENERAL MOTORS CORP.

16. Remove the valve spring retainer and the valve spring.

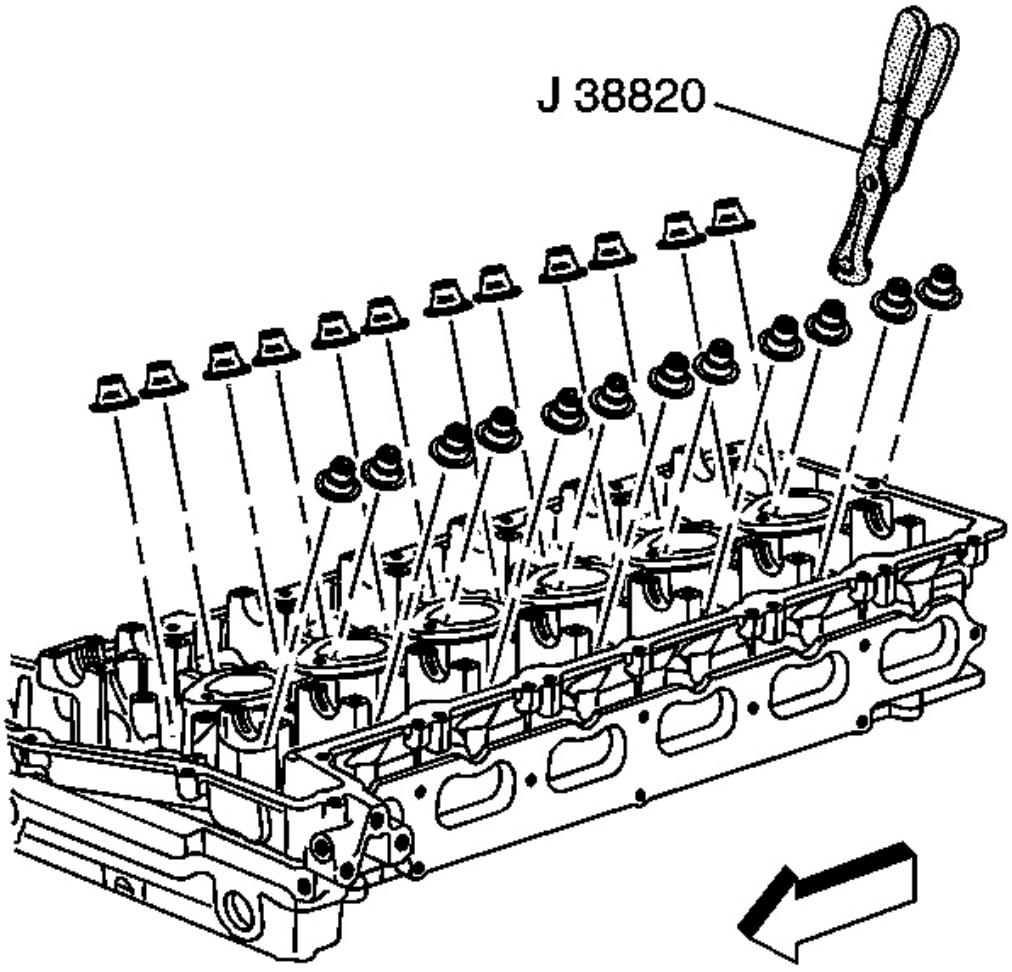


Fig. 107: View Of J 38820 & Valve Seals
Courtesy of GENERAL MOTORS CORP.

17. Use the **J 38820** and remove the seals. See **Special Tools**.
18. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Lubricate the valve stems with clean engine oil before installing.

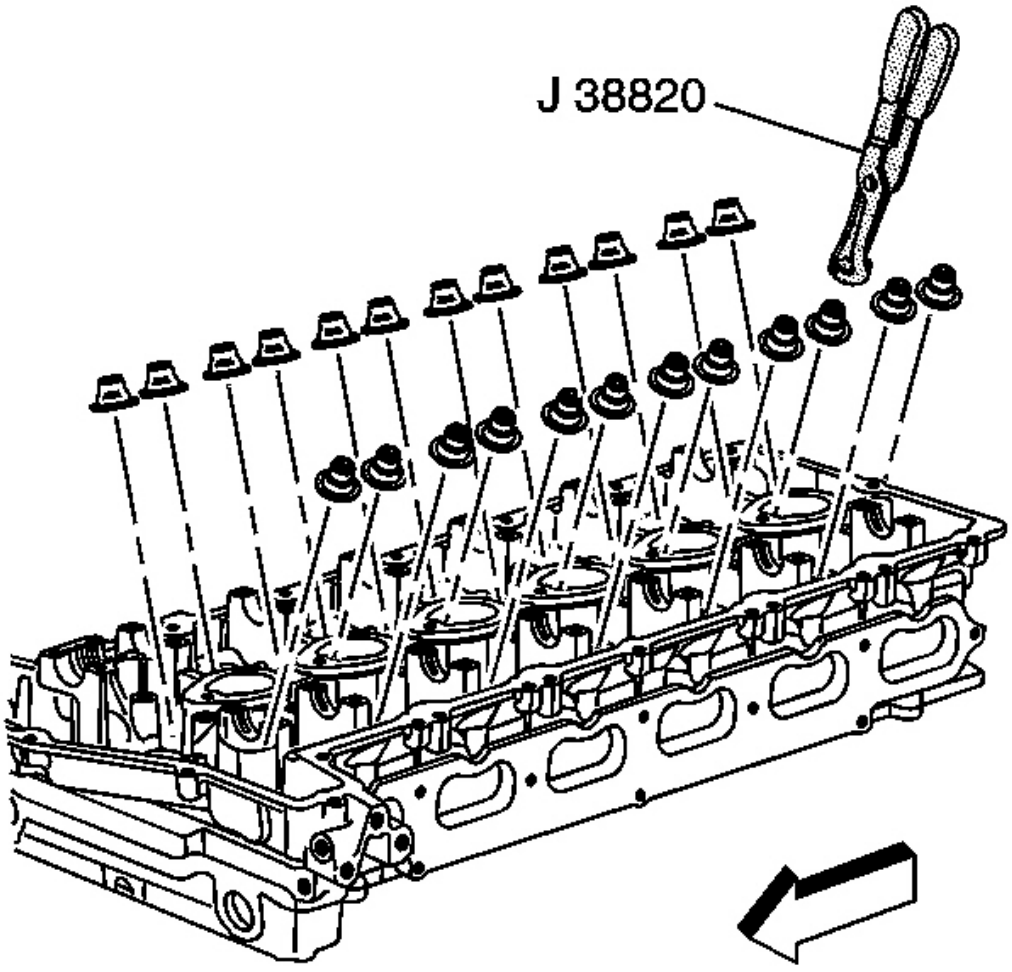


Fig. 108: View Of J 38820 & Valve Seals
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 38820** to install the valve seals. See **Special Tools**. There is only one size seal.

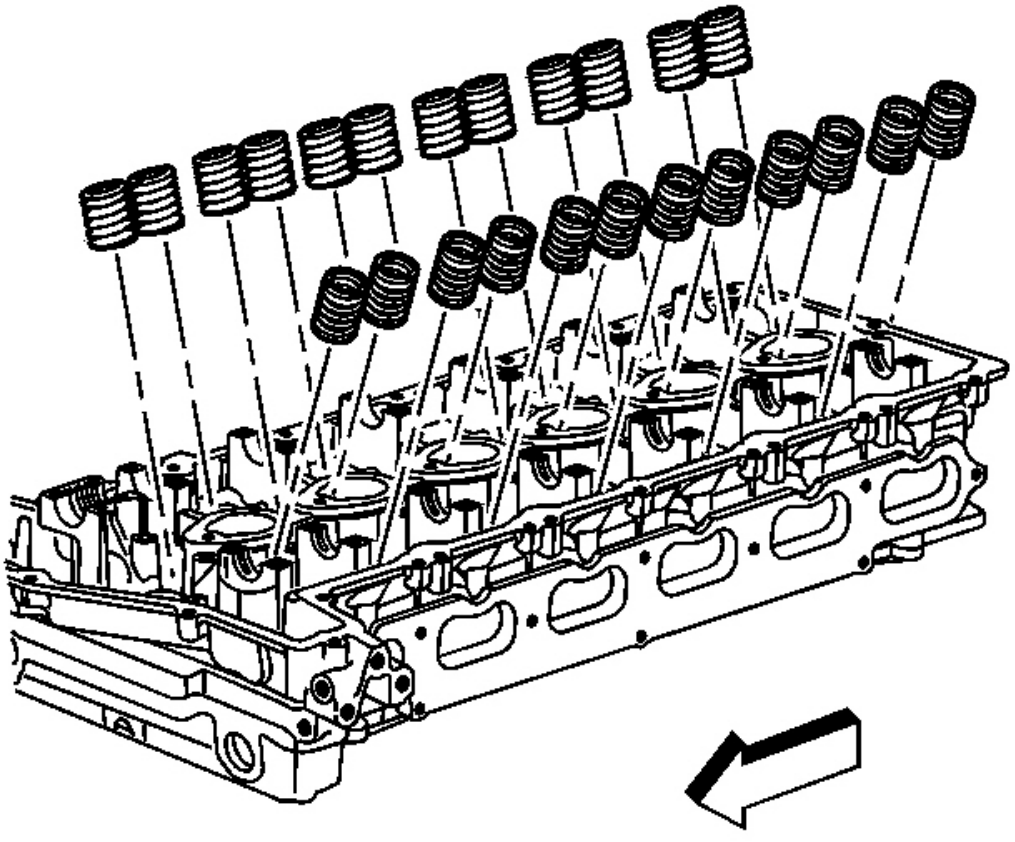


Fig. 109: View Of Valve Springs & Retainer
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring and the valve spring retainer.

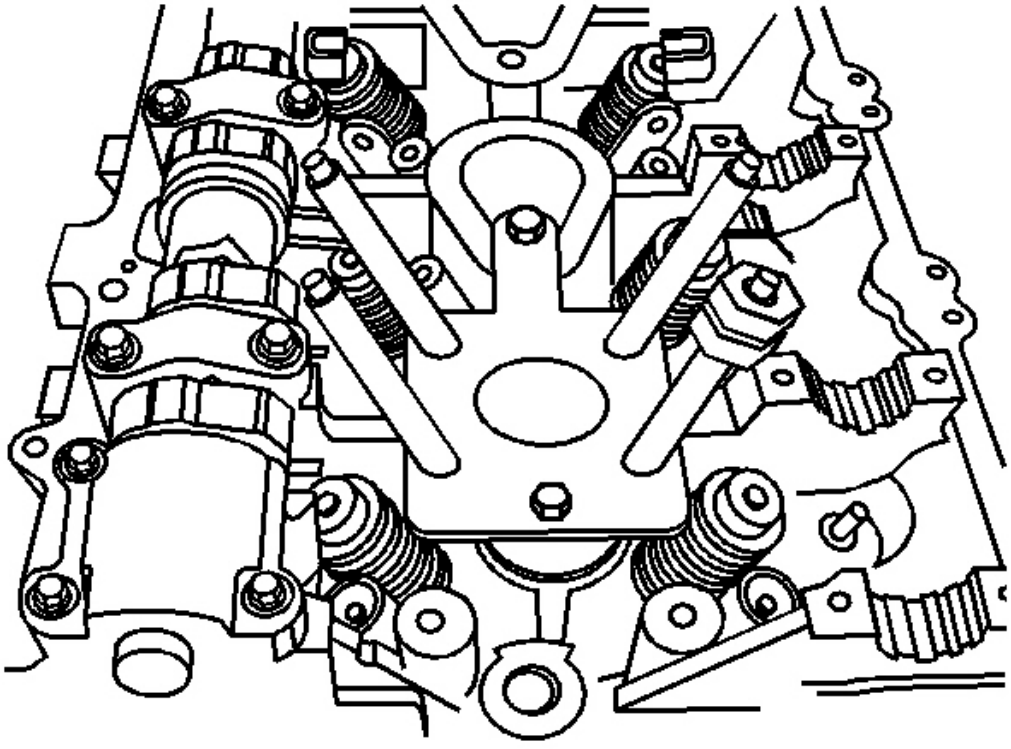


Fig. 110: View Of J 44228 Base Plate
Courtesy of GENERAL MOTORS CORP.

3. Use the **J-44228-A** and compress the valve springs. See **Special Tools**.

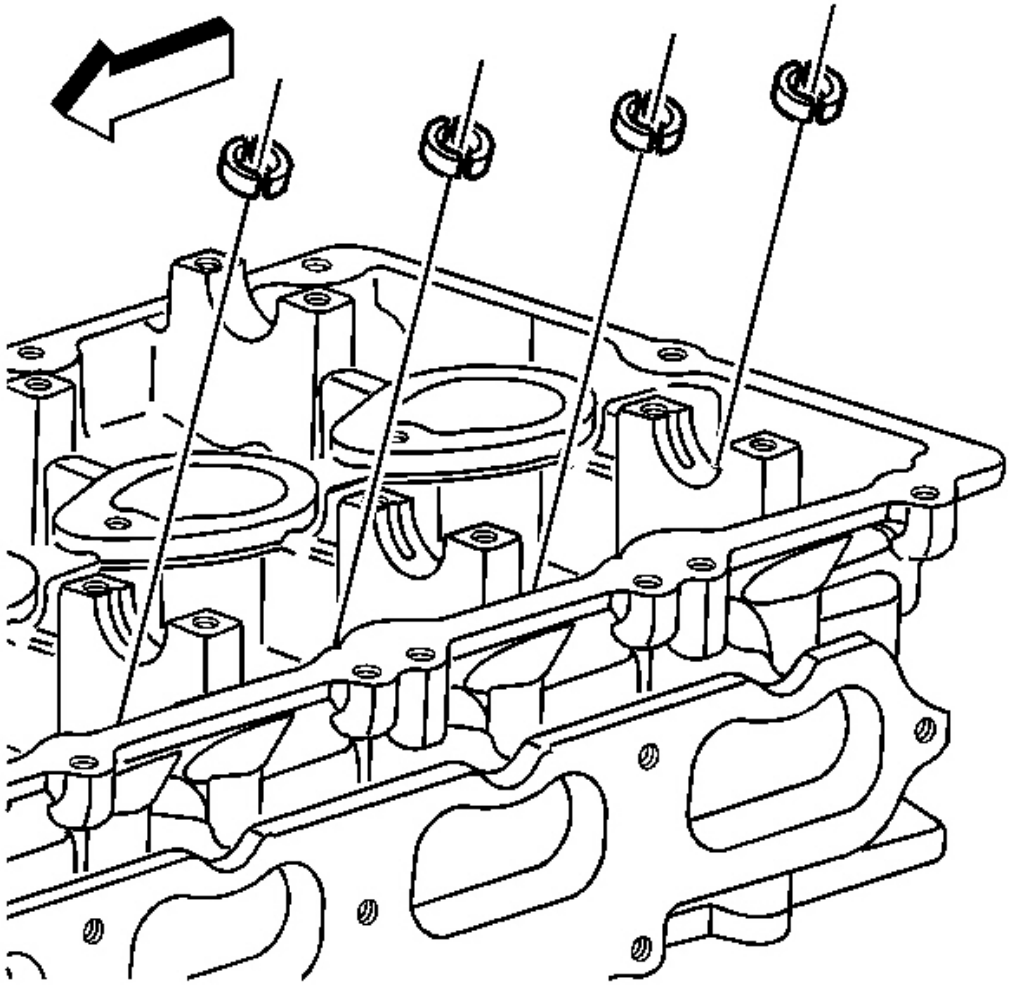


Fig. 111: View Of Valve Keys
Courtesy of GENERAL MOTORS CORP.

4. Install the valve keys.
5. Remove the **J-44228-A** . See **Special Tools**.
6. Remove the air pressure to the cylinder.
7. Coat the camshaft journals, the camshaft journal thrust face, and the camshaft lobes with clean engine oil.

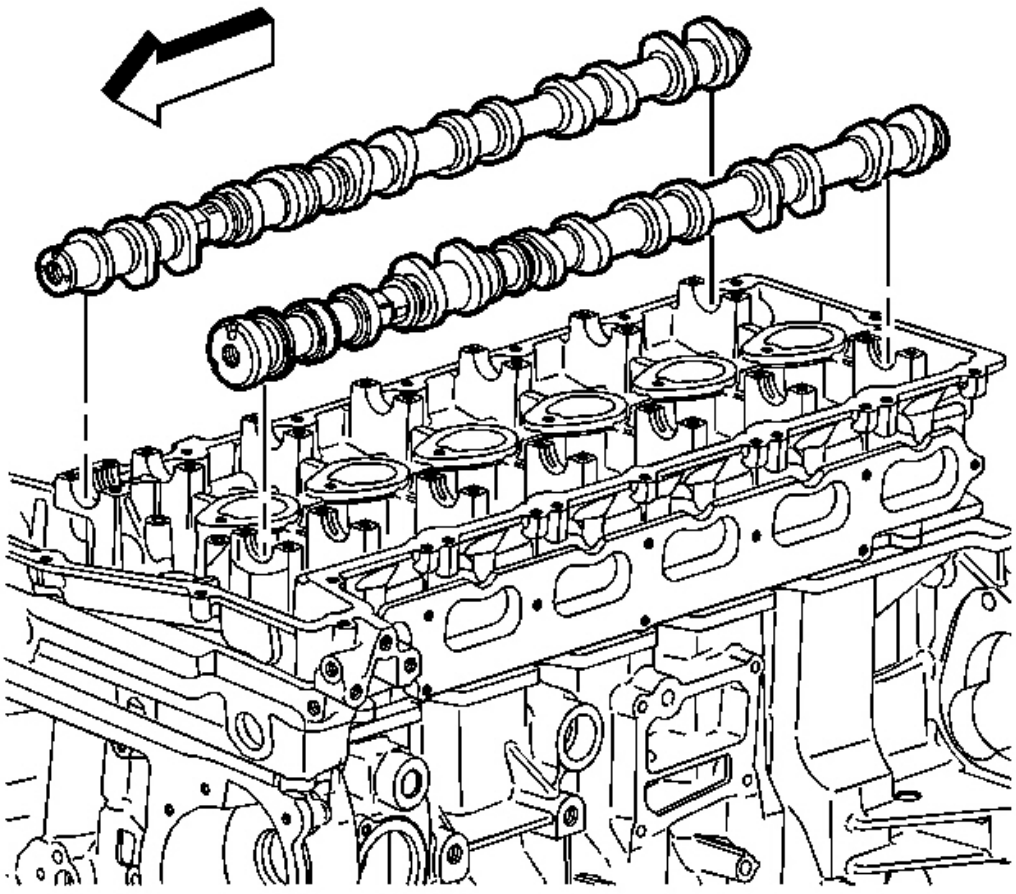


Fig. 112: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

8. Install the camshafts to their original position.

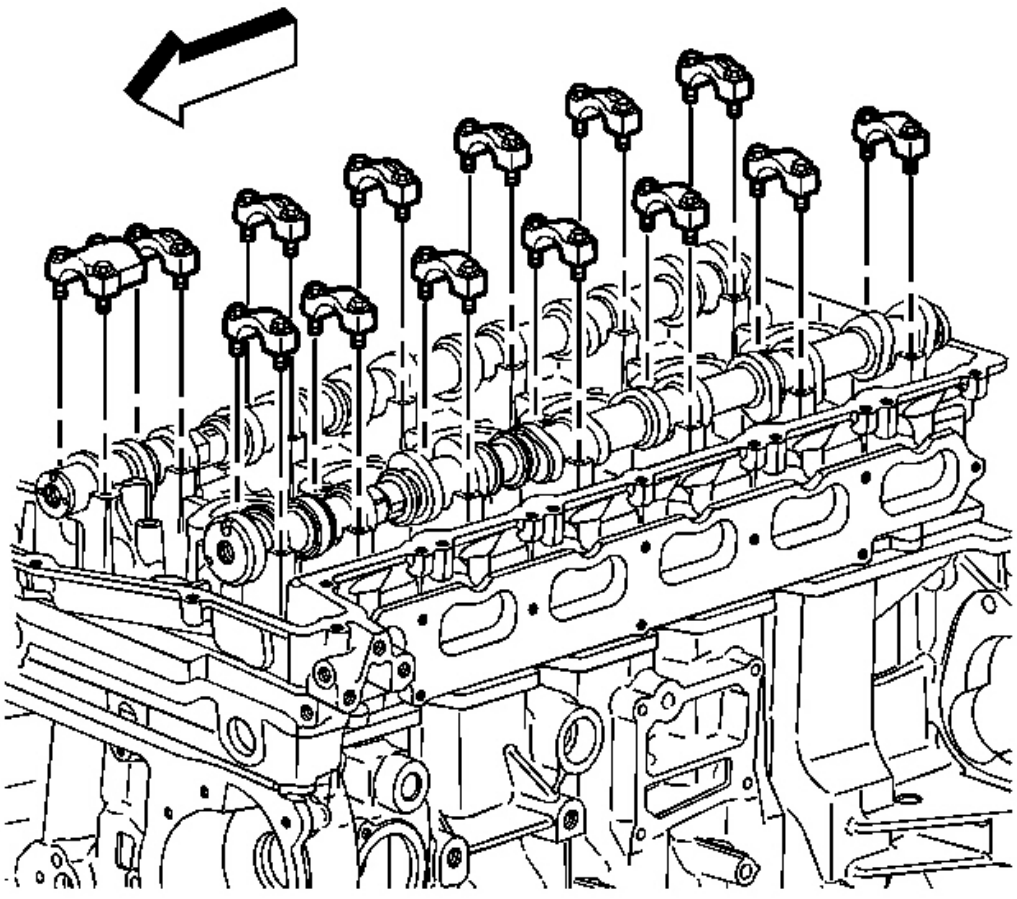


Fig. 113: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Install the camshaft caps onto their original journal.

   Tighten: Tighten the camshaft cap bolts to 12 N.m (106 lb in).

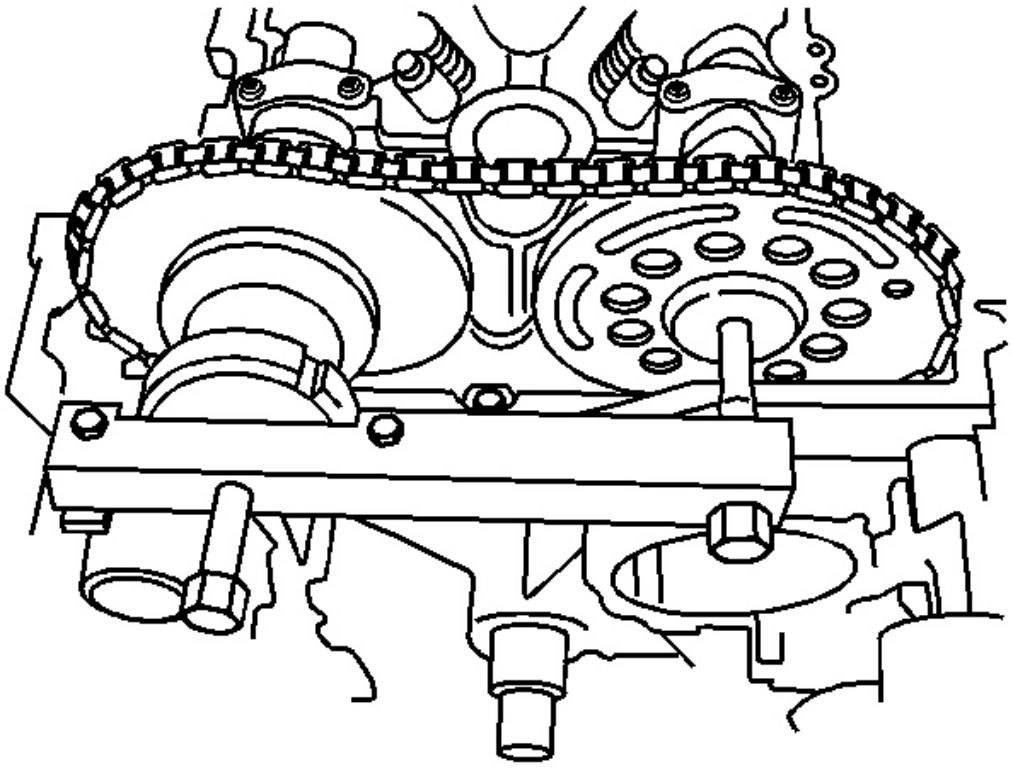


Fig. 114: View Of J 44222 Installed Onto Camshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

10. Carefully move the camshaft sprockets back onto the camshafts and remove the **J 44222** . See **Special Tools**.
11. Install a NEW intake camshaft sprocket washer and bolt, and a NEW exhaust camshaft actuator bolt.

Tighten:

- Tighten the intake camshaft sprocket bolt the first pass to 20 N.m (15 lb ft).
- Use the **J 36660-A** to tighten the intake camshaft sprocket bolt the final pass and additional 100 degrees. See **Special Tools**.
- Tighten the exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
- Use the **J 36660-A** to tighten the exhaust camshaft actuator bolt a final pass an additional 135 degrees. See **Special Tools**.

12. Install the spark plugs. Refer to **Spark Plug Replacement** .
13. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
14. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
15. Remove the J 44226-3A from the torque converter bolt.

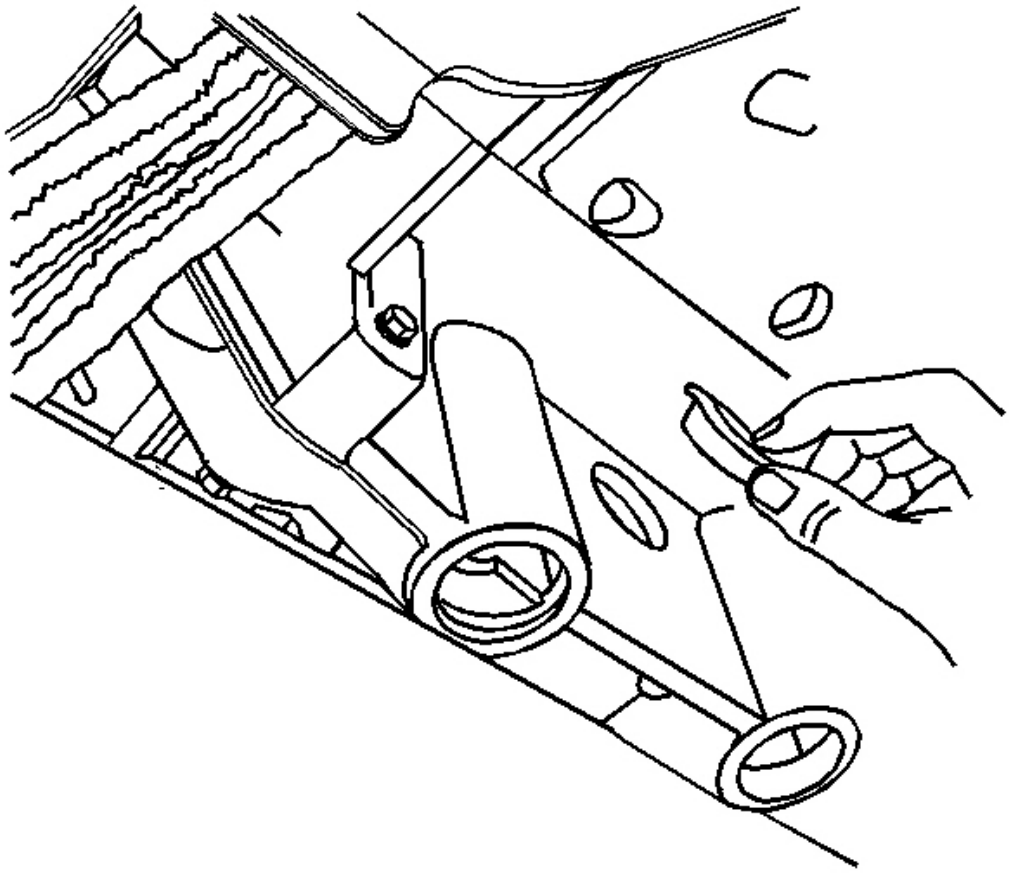


Fig. 115: View Of Torque Converter Access Plug
Courtesy of GENERAL MOTORS CORP.

16. Install the torque converter access plug.
17. Lower the vehicle.

OIL LEVEL INDICATOR & TUBE REPLACEMENT

Removal Procedure

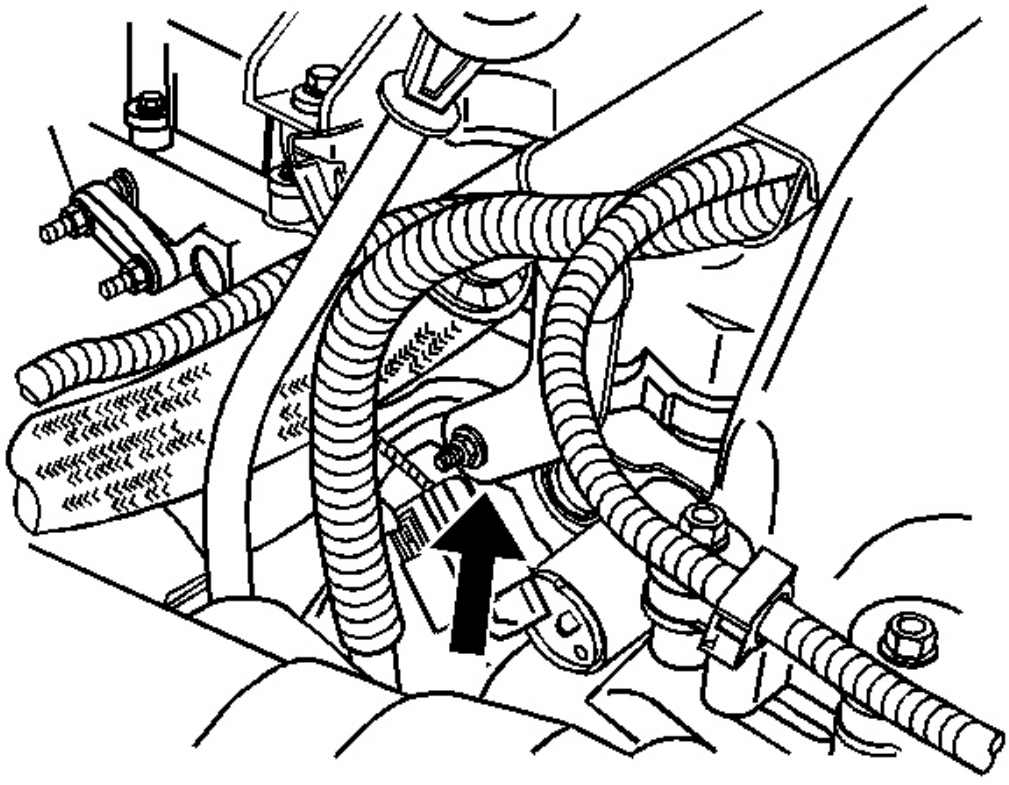


Fig. 116: View Of Oil Level Indicator Tube Bracket Nut
Courtesy of GENERAL MOTORS CORP.

1. Remove the A/C line bracket nut.
2. Remove the A/C line bracket from the oil level indicator tube stud.
3. Disconnect the oxygen (O2) sensor electrical connector from the oil level indicator bracket.

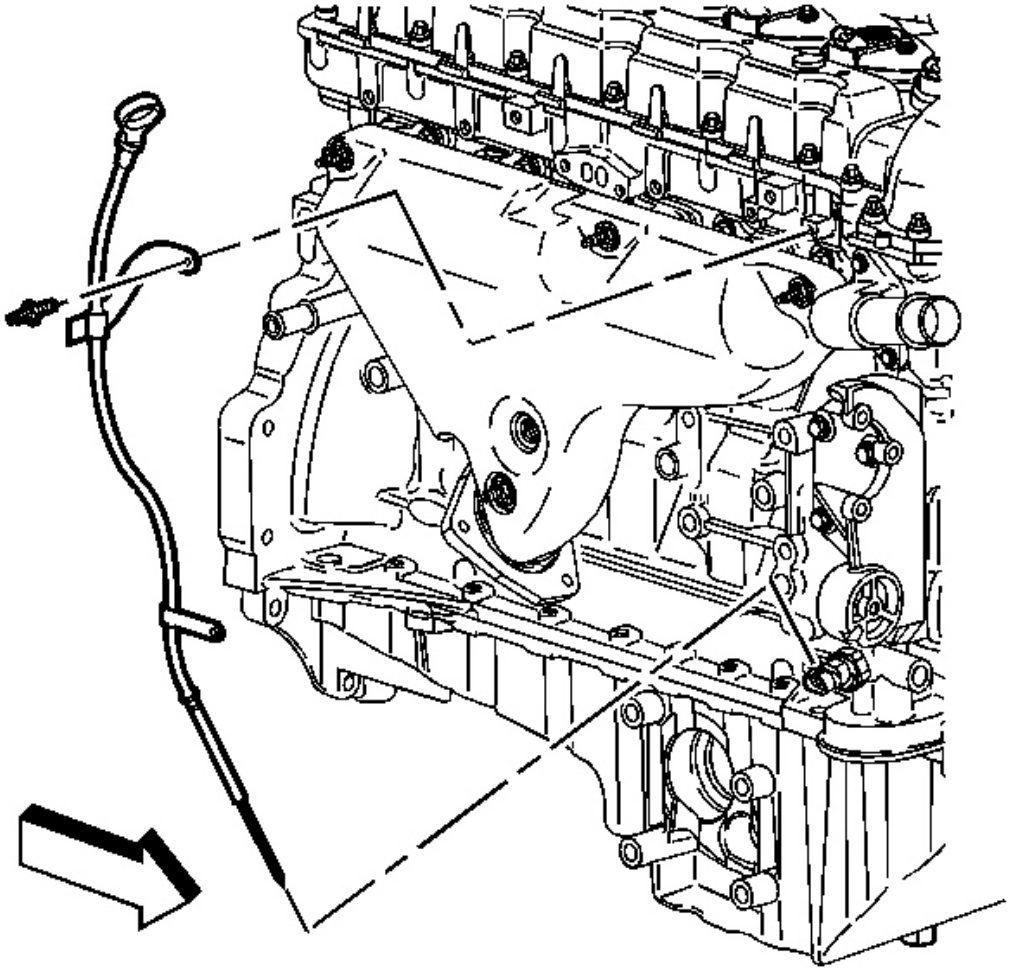


Fig. 117: View Of Oil Level Indicator Tube Stud
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level indicator tube stud.
5. Pull the indicator out of the tube.
6. Pull the tube out of the block.

Installation Procedure

1. Install the oil level indicator tube into the engine block.
2. Add sealant to the oil level indicator tube stud threads. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

NOTE: **Refer to Fastener Notice .**

3. Install the oil level indicator tube stud.

   Tighten: Tighten the oil level indicator tube stud to 10 N.m (89 lb in).

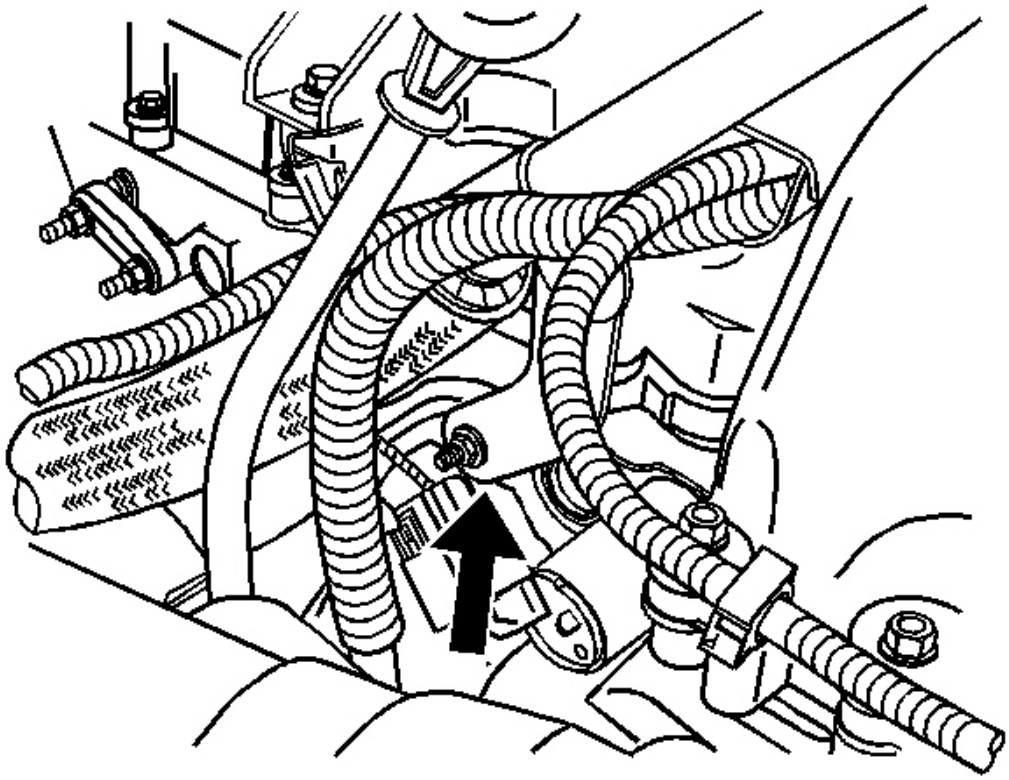


Fig. 118: View Of Oil Level Indicator Tube Bracket Nut
Courtesy of GENERAL MOTORS CORP.

4. Install the A/C line bracket to oil level indicator tube and secure with the nut.

   Tighten: Tighten the A/C line bracket nut to 7 N.m (6 lb in).

5. Connect the O2 sensor electrical connector.
6. Install the oil level indicator into the tube.

CYLINDER HEAD REPLACEMENT

Special Tools

- **EN-47702** Bolt Extractor Kit. See **Special Tools**.
- **EN-48464** Lower Timing Gear Tensioner Holding Tool. See **Special Tools**.
- **J 44221** Camshaft Holding Tool. See **Special Tools**.
- **J 44226** Crankshaft Balancer Remover. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

1. Remove the air cleaner element. Refer to **Air Cleaner Element Replacement** .
2. Remove the air cleaner outlet resonator. Refer to **Air Cleaner Outlet Resonator Replacement** .
3. Remove the powertrain control module (ECM) and engine wire harness bracket and related hoses and connections. Refer to **Engine Control Module Replacement** .
4. Remove the generator. Refer to **Generator Replacement (With 4.2L Engine)** or **Generator Replacement (With V8 Engine)** .
5. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
6. Remove the exhaust manifold. Do not remove the exhaust pipe from the manifold. Only have the manifold pushed off to the side of the engine. Refer to **Exhaust Manifold Replacement (LL8)** .
7. Position the A/C line out of the way towards the front of the vehicle.
8. Disconnect the following cross-vehicle engine wiring harness connectors:
    - Engine coolant temperature sensor
    - Manifold absolute pressure (MAP) sensor
    - Ignition coils
    - Harness clamps at power steering pump
    - Wiring harness fastener at the right front inner fender
    - Throttle body
    - Camshaft sensors
    - Camshaft actuators
    - Fuel rail
    - Heated oxygen sensor (HO2S)
9. Set aside the cross-vehicle engine wiring harness on the left side of the vehicle.
10. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

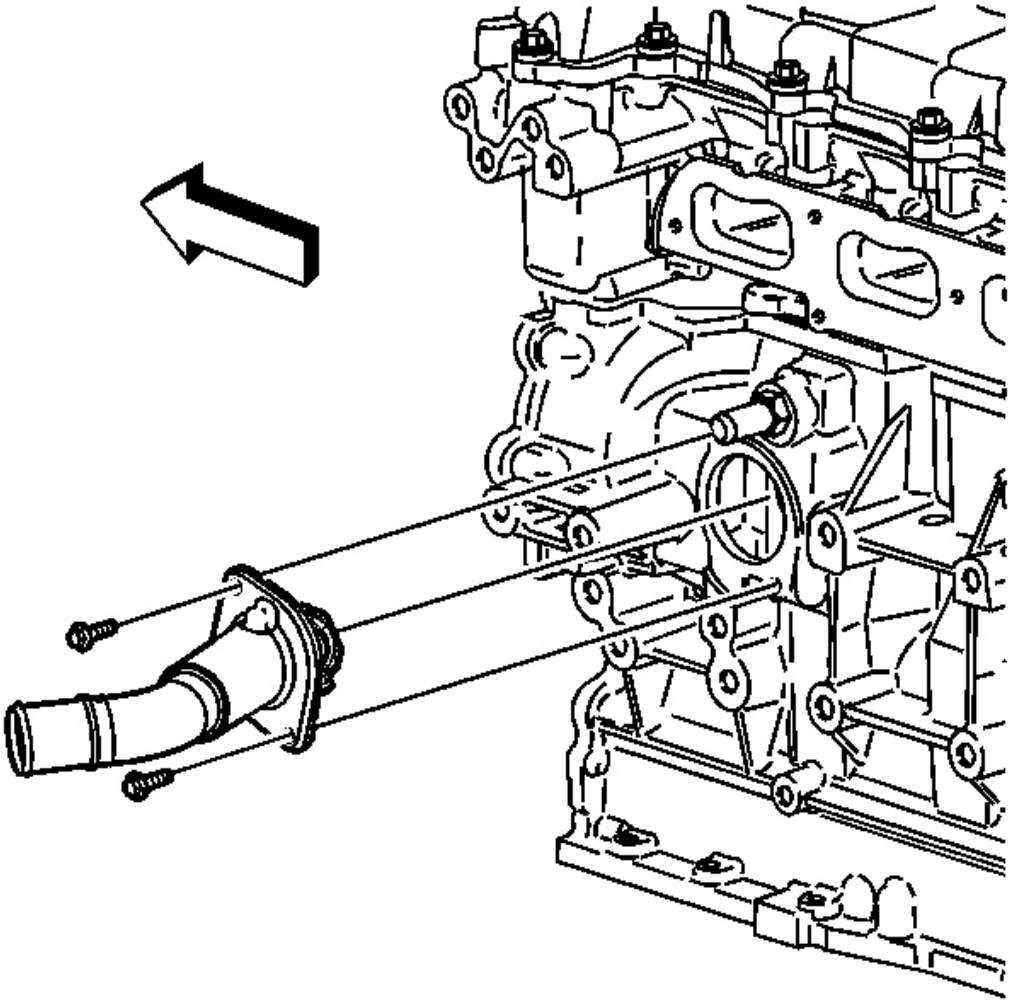


Fig. 119: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Partially drain the cooling system.
    1. Raise and support the vehicle only high enough to access the thermostat housing through the wheelhouse. Refer to **Lifting and Jacking the Vehicle** .
    2. Place an approved container under the thermostat housing.

IMPORTANT: Do not completely remove the thermostat housing. Complete removal of the thermostat housing will not provide steady drain path and will increase clean up time.

3. Loosen the thermostat housing bolts and slowly pull the thermostat housing back away from the engine. This will allow for a steady drain path for coolant.
4. Once coolant is drained remove the thermostat housing bolts, thermostat housing, and thermostat. Inspect and replace as necessary.
5. Clean and inspect the O-ring. Replace as necessary.
6. Clean and inspect the sealing surface of the engine block.

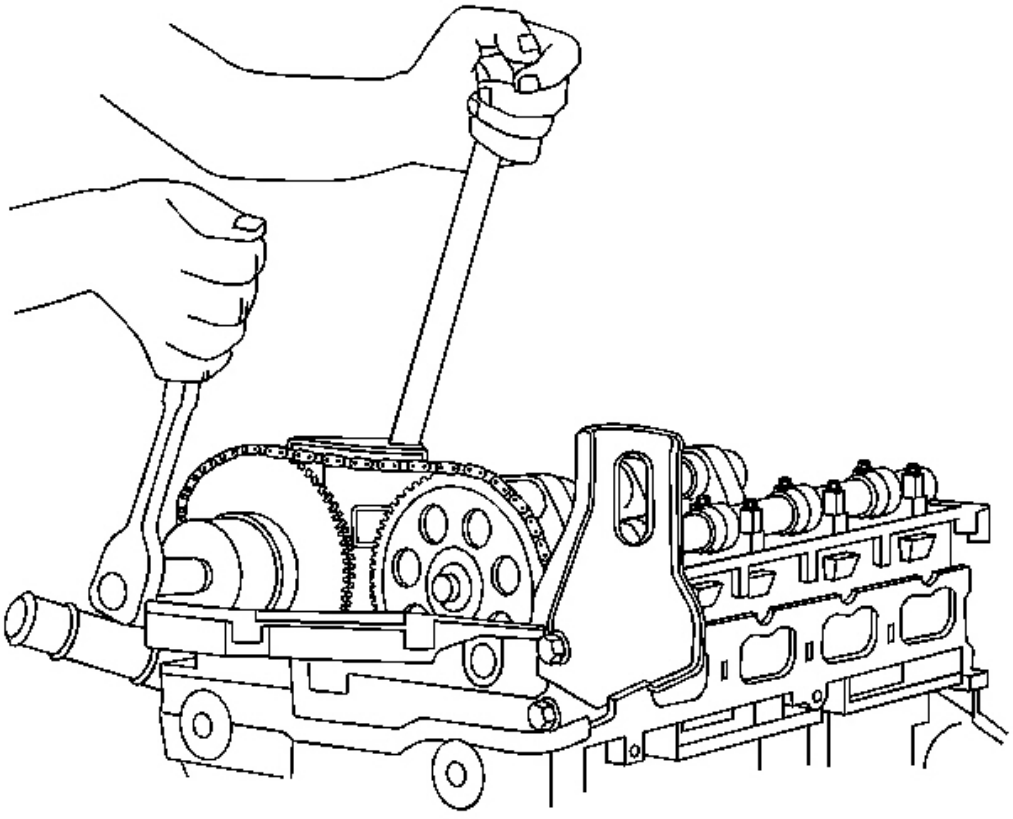


Fig. 120: Loosening Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

12. Before performing one of the top dead center (TDC) procedures, break loose both the exhaust and intake camshaft sprocket bolts. Use a 25 mm (1 in) open end wrench on the camshaft hexes to hold the camshaft from turning. DO NOT remove the bolts.
13. Perform one of the following methods for the service timing procedure.

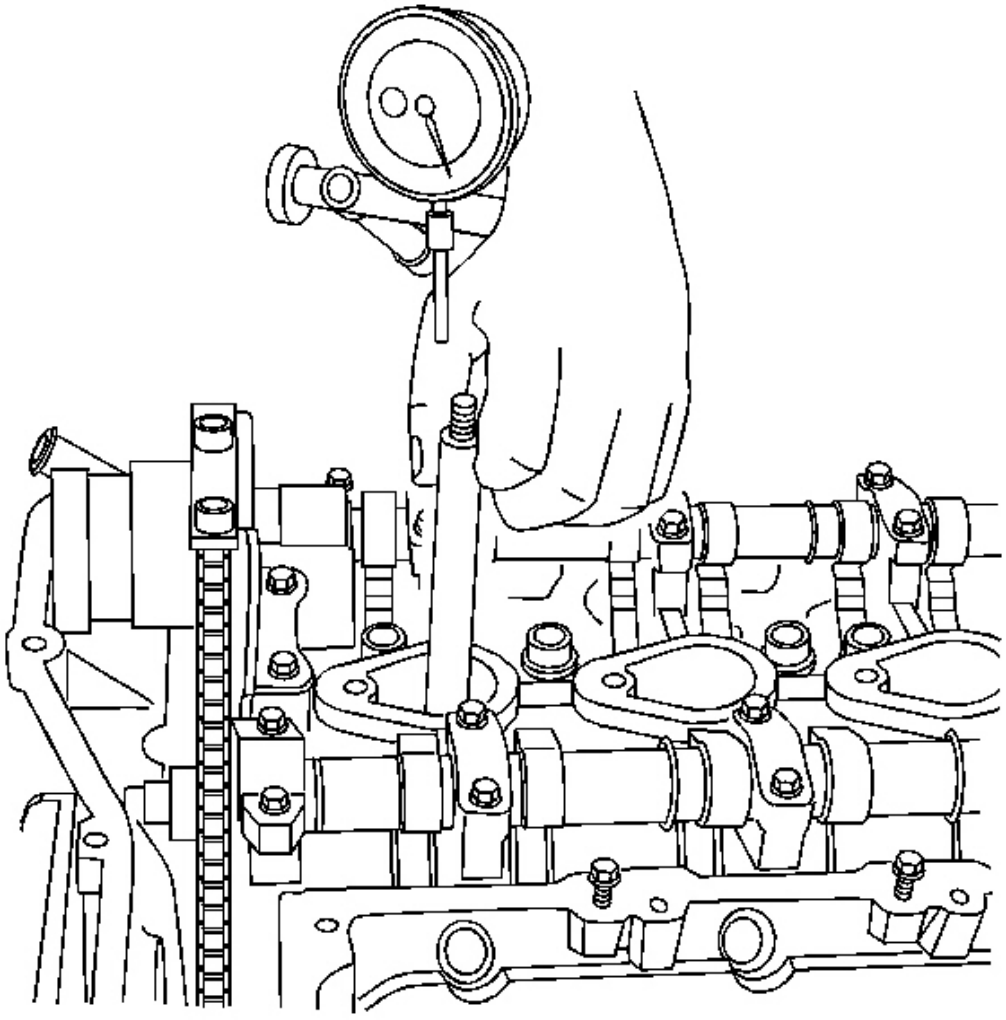


Fig. 121: View Of Piston TDC Indicator Tool
Courtesy of GENERAL MOTORS CORP.

14. First Method-Rotate the engine clockwise by hand to TDC on the compression stroke by using a piston TDC indicator tool and/or dial indicator in the number 1 cylinder.

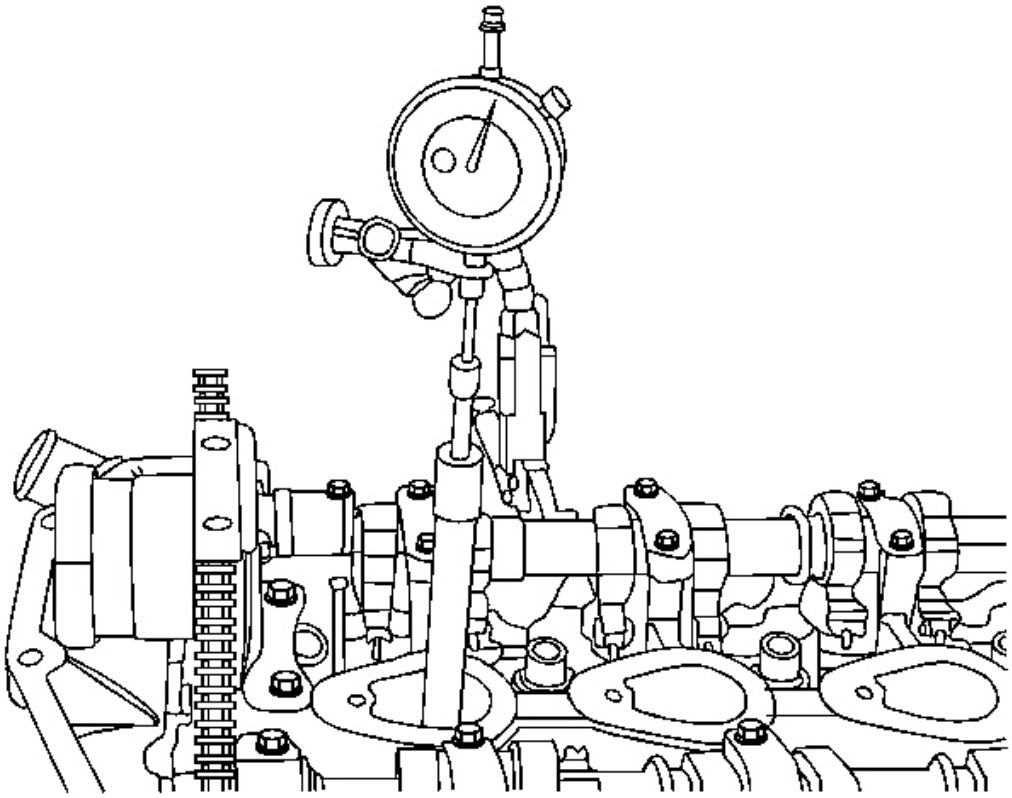


Fig. 122: View Of TDC Indicator Tool
Courtesy of GENERAL MOTORS CORP.

15. First Method (continued) - The TDC indicator tool graduation marks on the shaft should note top of the piston stroke.

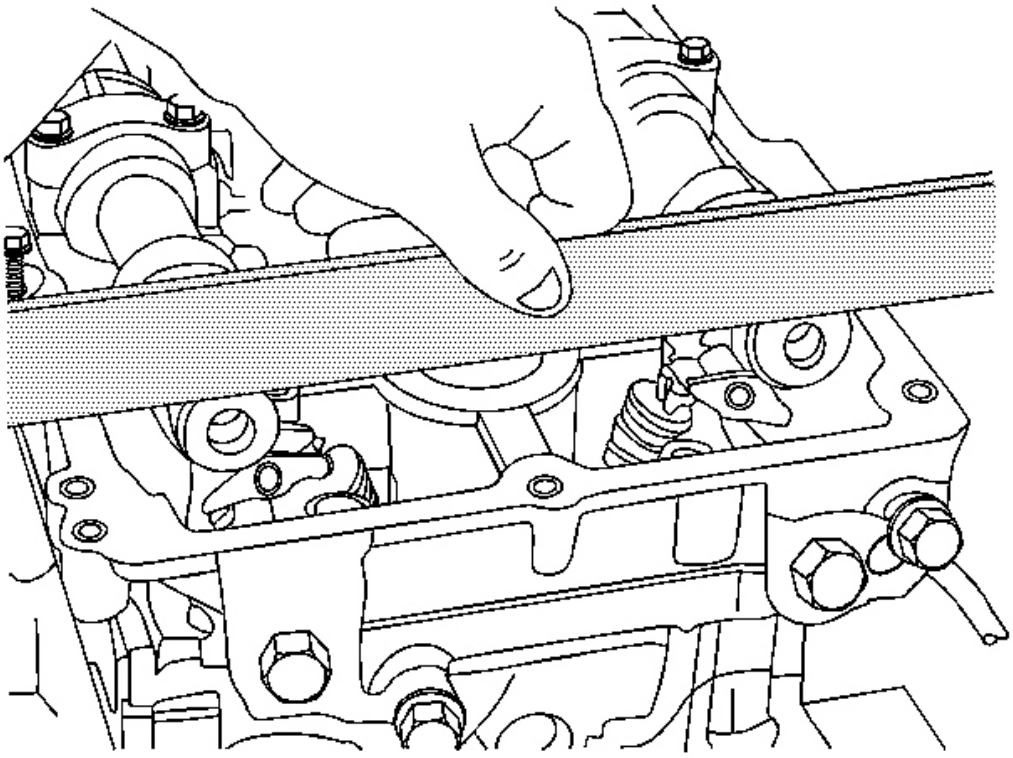


Fig. 123: Using A Straight Edge Across Camshaft Flats
Courtesy of GENERAL MOTORS CORP.

16. First Method (continued) - When the piston is at TDC, the flats at the rear of the camshafts will be facing up and level when using a straight edge across the camshaft flats.

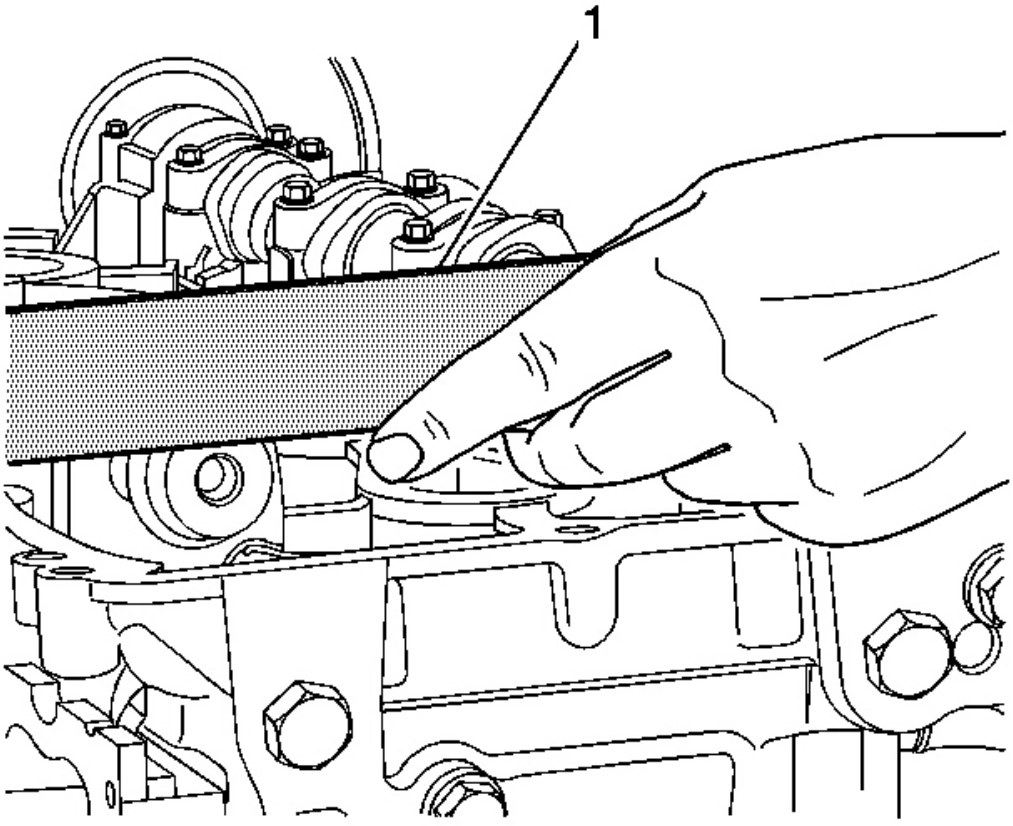


Fig. 124: Using A Straight Edge Across Camshaft Flats
Courtesy of GENERAL MOTORS CORP.

17. Second Method-Rotate the crankshaft in the engine rotational direction clockwise until the number 1 piston is at TDC on the compression stroke. The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface. When the piston is at TDC, the flats at the rear of the camshafts will be facing up and level when using a straight edge across the camshaft flats. A 0.005 inch feeler gage should not slide under the straight edge (1).

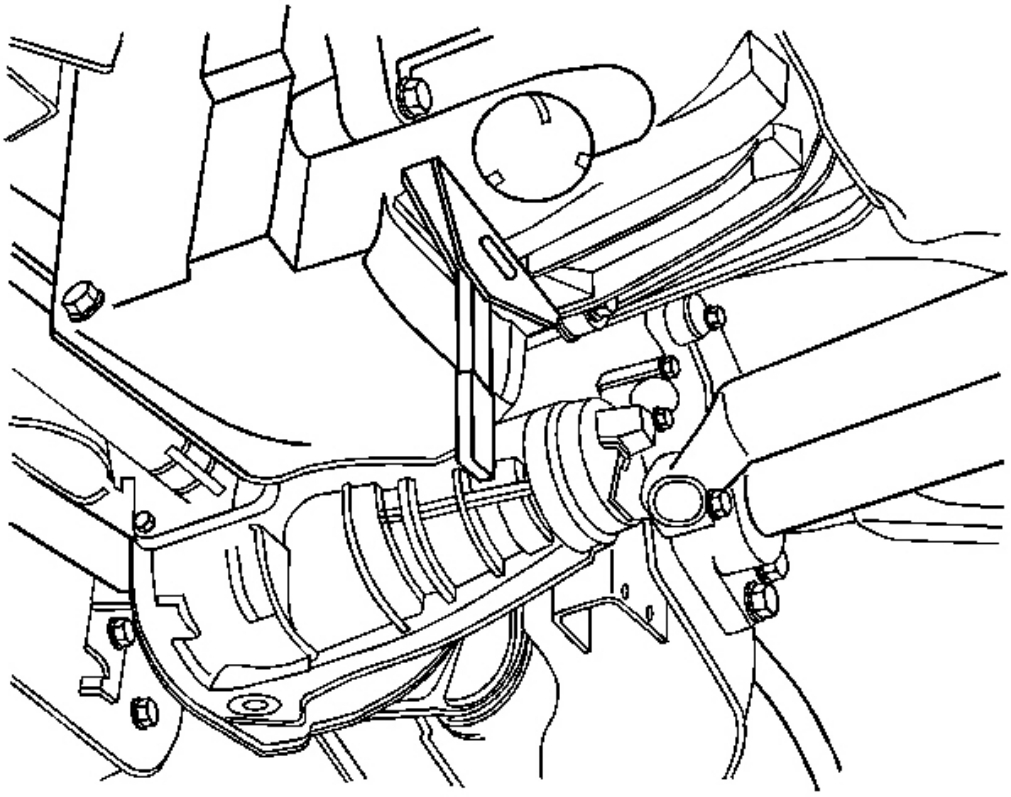


Fig. 125: Locking Flywheel With J 44226
Courtesy of GENERAL MOTORS CORP.

18. Once TDC is located for the number 1 cylinder using above methods, raise the vehicle and lock the flywheel with the **J 44226** . See **Special Tools**.

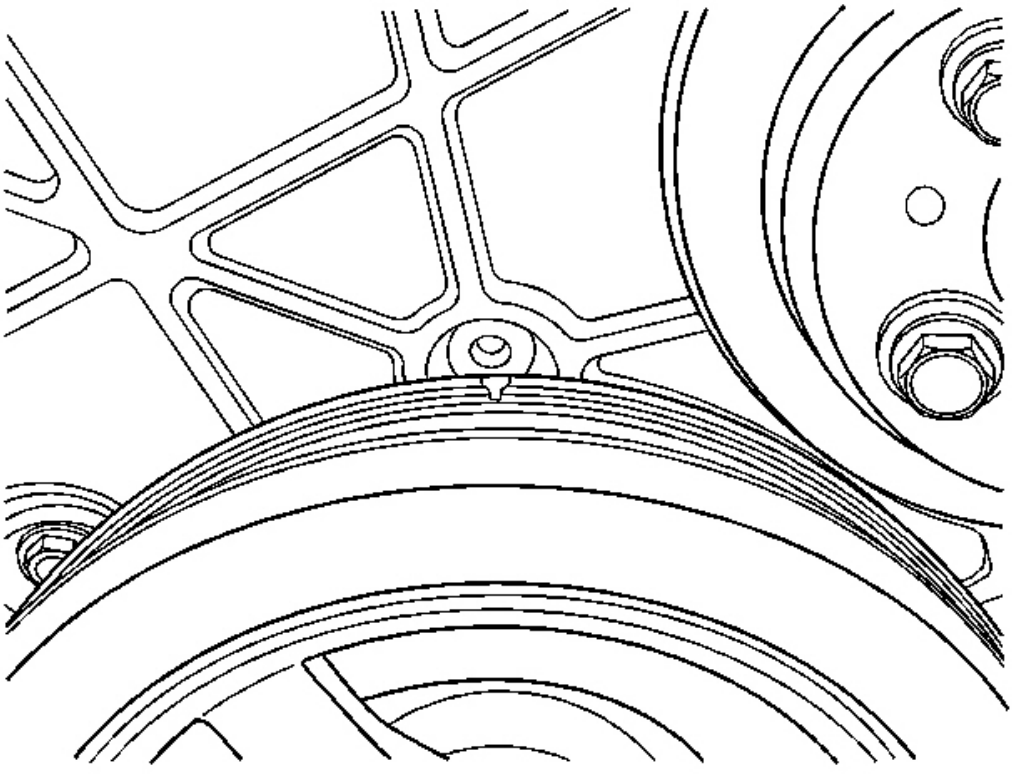


Fig. 126: View Of Reference Mark On Harmonic Balancer
Courtesy of GENERAL MOTORS CORP.

19. Use a white paint pen or equivalent to place a reference mark on the harmonic balancer to the front cover for alignment purposes.
20. Lower the vehicle.

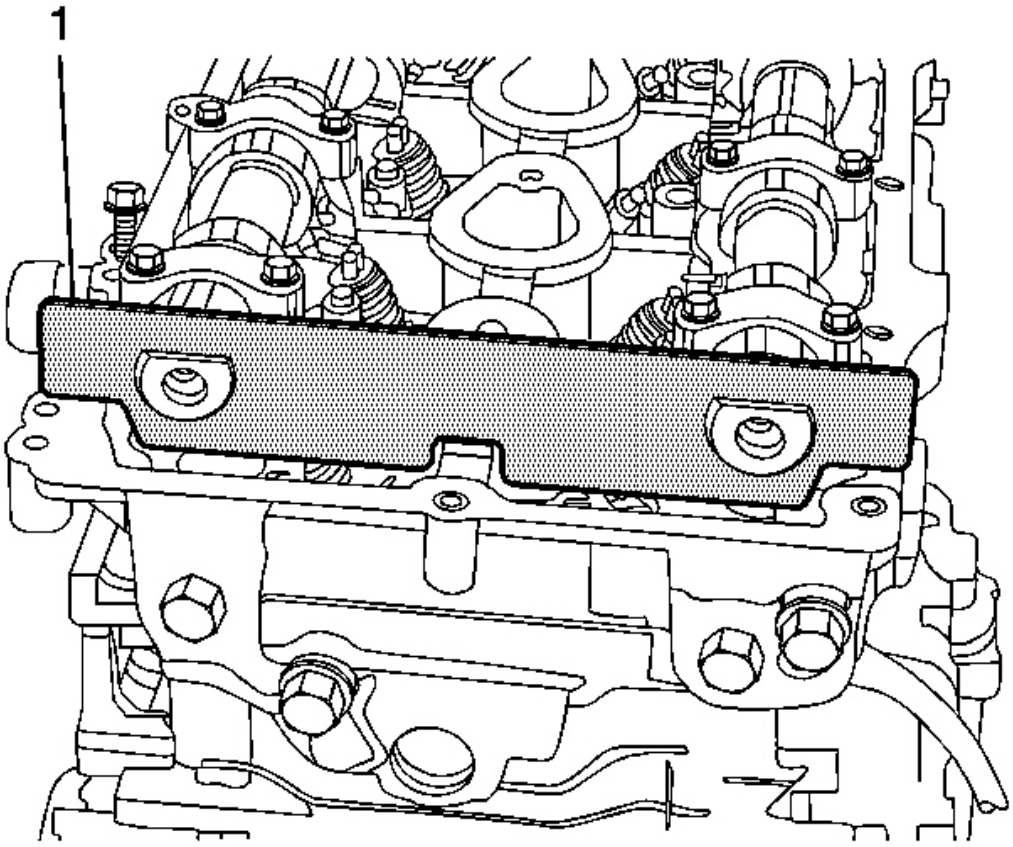


Fig. 127: J 44221 Installed To Back Of Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

IMPORTANT: If the timing is correct-TDC compression stroke number 1 cylinder-the camshaft flats will be in the up position.

21. Install **J 44221** (1) to the back of the camshafts. See **Special Tools**.
22. Remove the upper timing chain guide to the cylinder head.

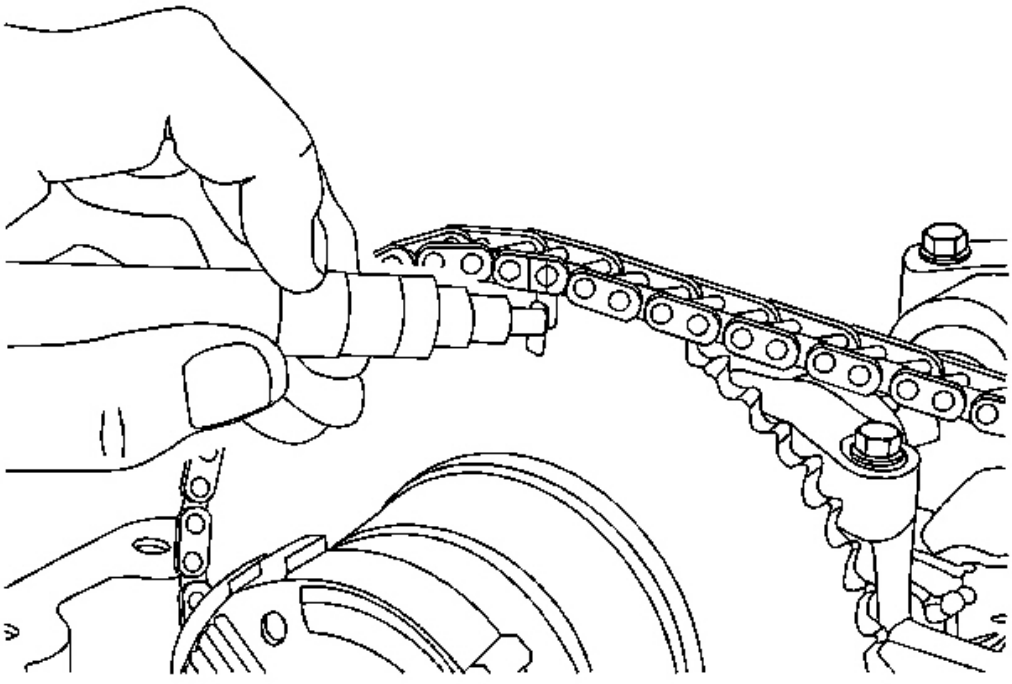


Fig. 128: Cleaning Timing Chain
Courtesy of GENERAL MOTORS CORP.

23. Clean the timing chain and gears with brake cleaner or suitable solvent. Use a white paint pen or equivalent to place a reference mark on both timing gear sprockets and the timing chain to mark location prior to disassembly. It is recommended that the paint marks be in the 12 o'clock position.

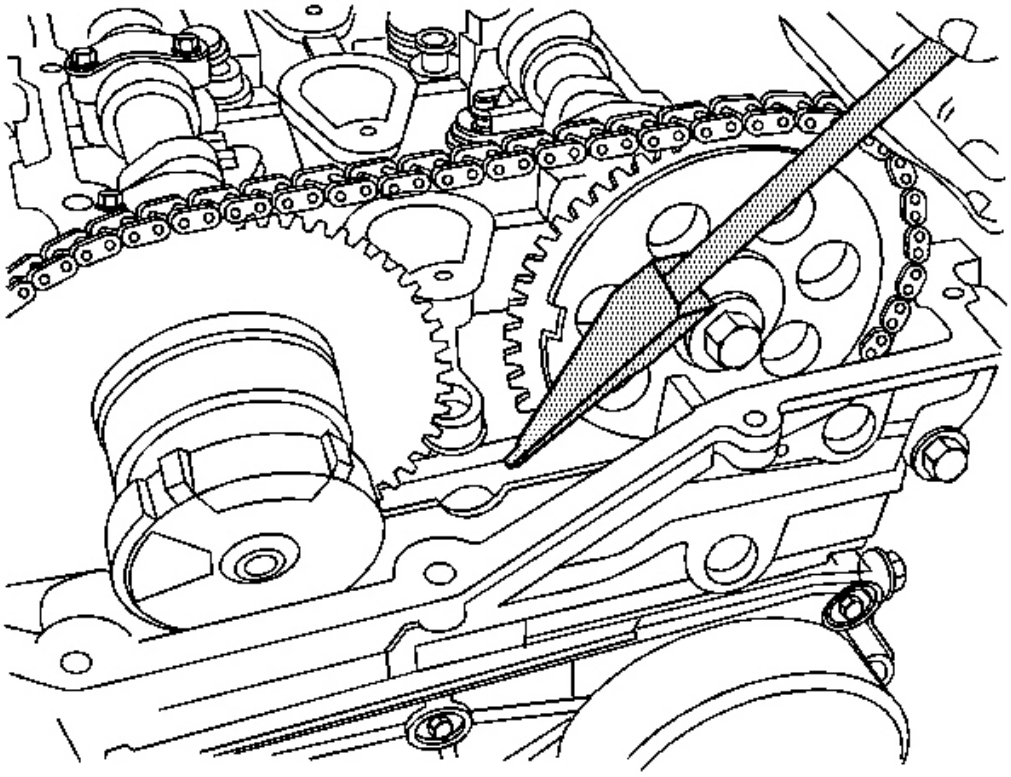


Fig. 129: Installing Wedge Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use excessive force to seat the wedge tool. If excessive force is used, you may damage the timing chain tensioner or break the front cover bolt requiring complete disassembly of the front engine.

24. Install **EN-48464** . See **Special Tools**. It is important to install the tool with the proper orientation and to ensure that it is seated square against the timing chain and against the timing cover center bolt.

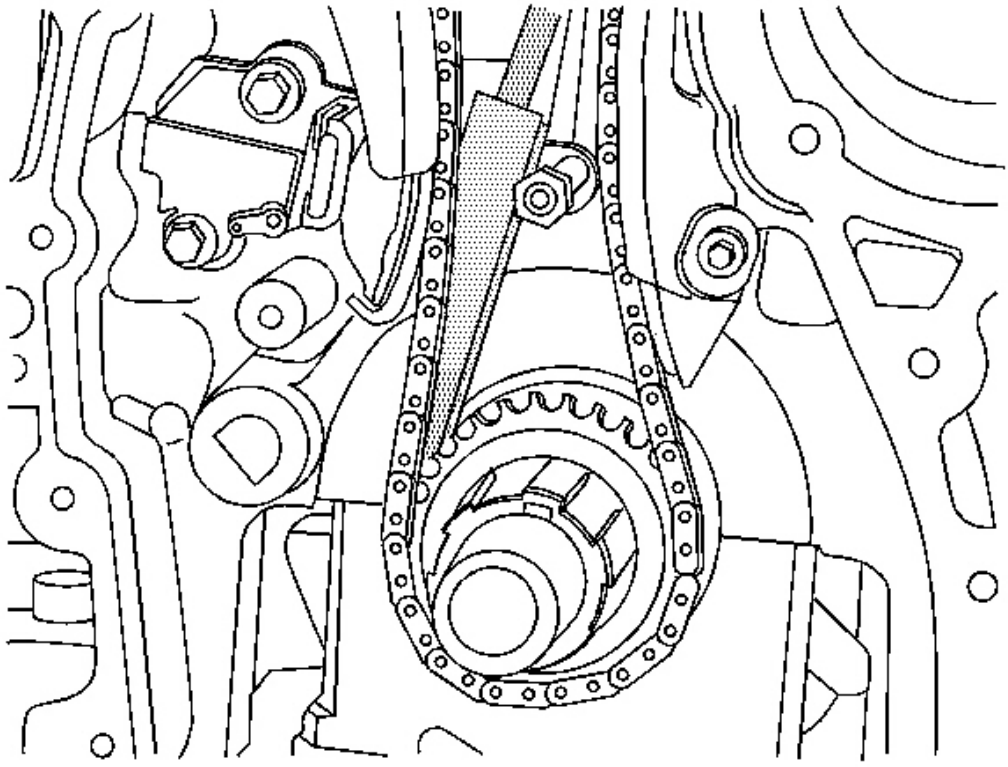


Fig. 130: Ensuring Proper Placement Of Wedge Tool
Courtesy of GENERAL MOTORS CORP.

25. The narrow ramp of the wedge tool needs to be placed so that it faces the timing chain. Front cover removed for illustration purposes.

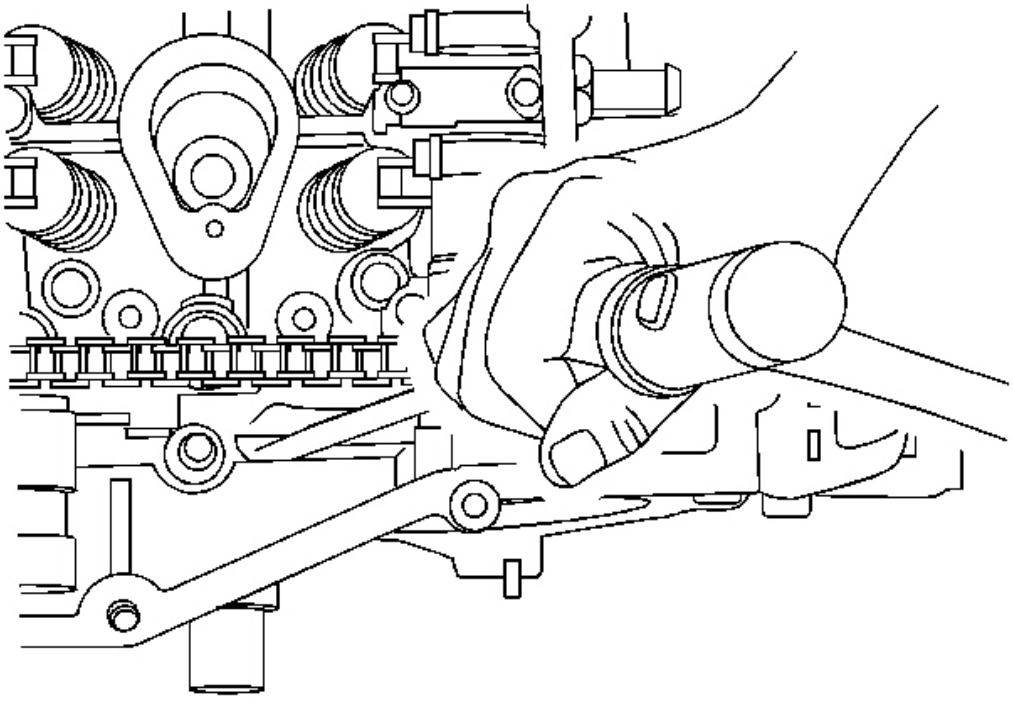


Fig. 131: Lightly Seating Wedge Tool
Courtesy of GENERAL MOTORS CORP.

26. The wedge tool should be lightly seated using a couple of very light taps with a small plastic or brass hammer.
27. Once the tool is correctly installed, unscrew the handle and remove the handle.

IMPORTANT:

- **Use a 25 mm (1 in) open end wrench on the camshaft hexes to hold the camshaft from turning. It is critical that the crankshaft does not move and is held at TDC when the intake and exhaust camshaft sprocket bolts are removed.**
- **If the crankshaft is not held in place, the wedge tool could be dislodged. If the crankshaft moves, or if the tool is not seated properly allowing the timing chain tensioner to extend, the repair will have to be completed by removing the front cover to release the timing chain tensioner.**

28. Remove both upper cylinder head access hole plugs from the front of the cylinder head.
29. Remove the 1 long and 2 short cylinder head bolts next to the exhaust and intake timing chain tensioner

shoes and discard the bolts.

30. Remove both upper timing chain tensioner shoe bolts.
31. Remove the exhaust and the intake camshaft sprocket bolts. Discard the bolts.

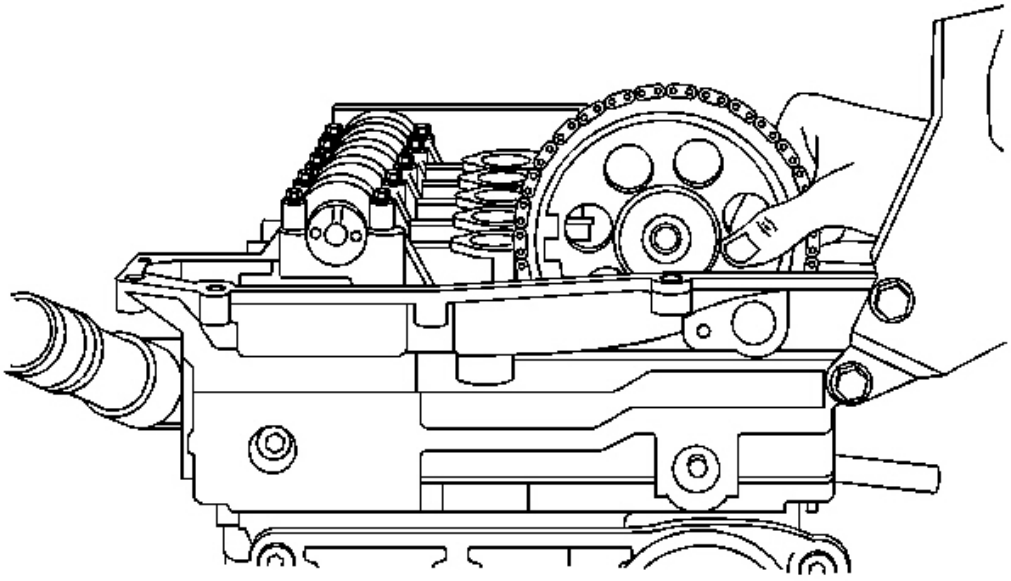


Fig. 132: View Of Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

32. Carefully remove the exhaust and intake camshaft sprockets with the timing chain from the exhaust and intake camshafts. The illustration shows the exhaust camshaft sprocket already removed.

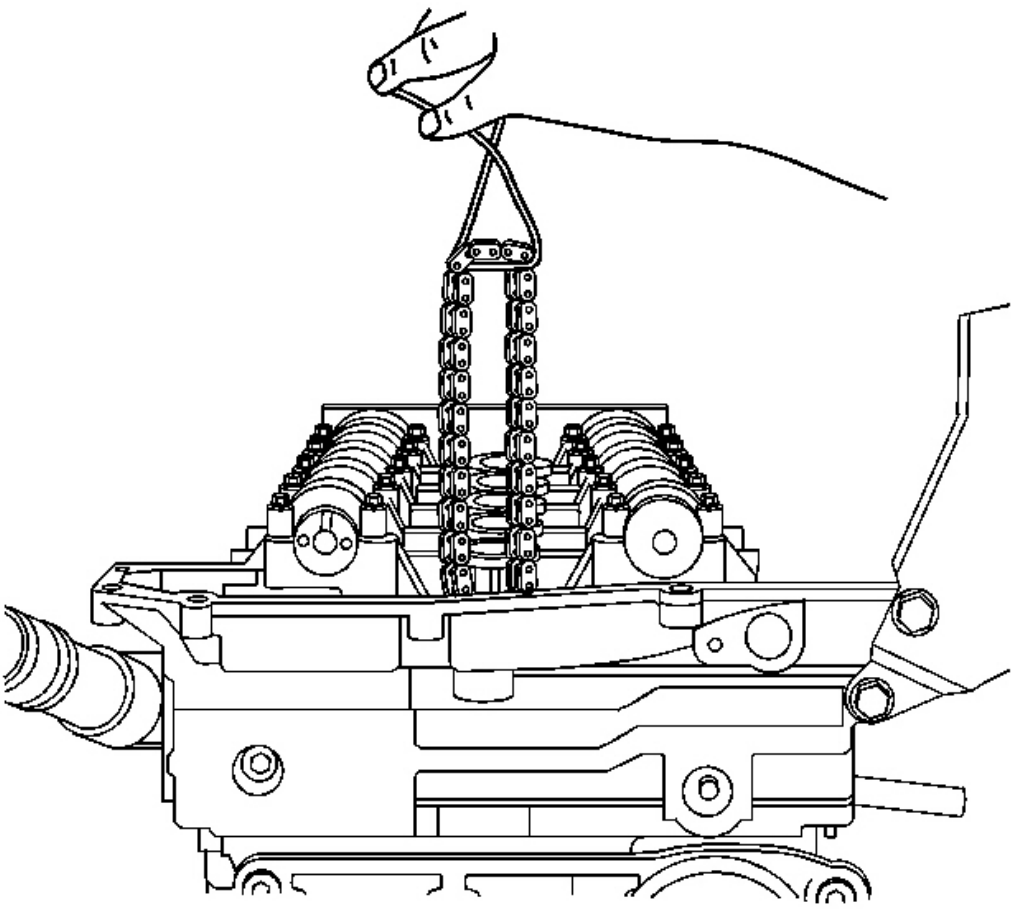


Fig. 133: Attaching Wire To Timing Chain
Courtesy of GENERAL MOTORS CORP.

33. Remove the sprockets from the chain, tie a piece of mechanics wire on the timing chain and let it drop.

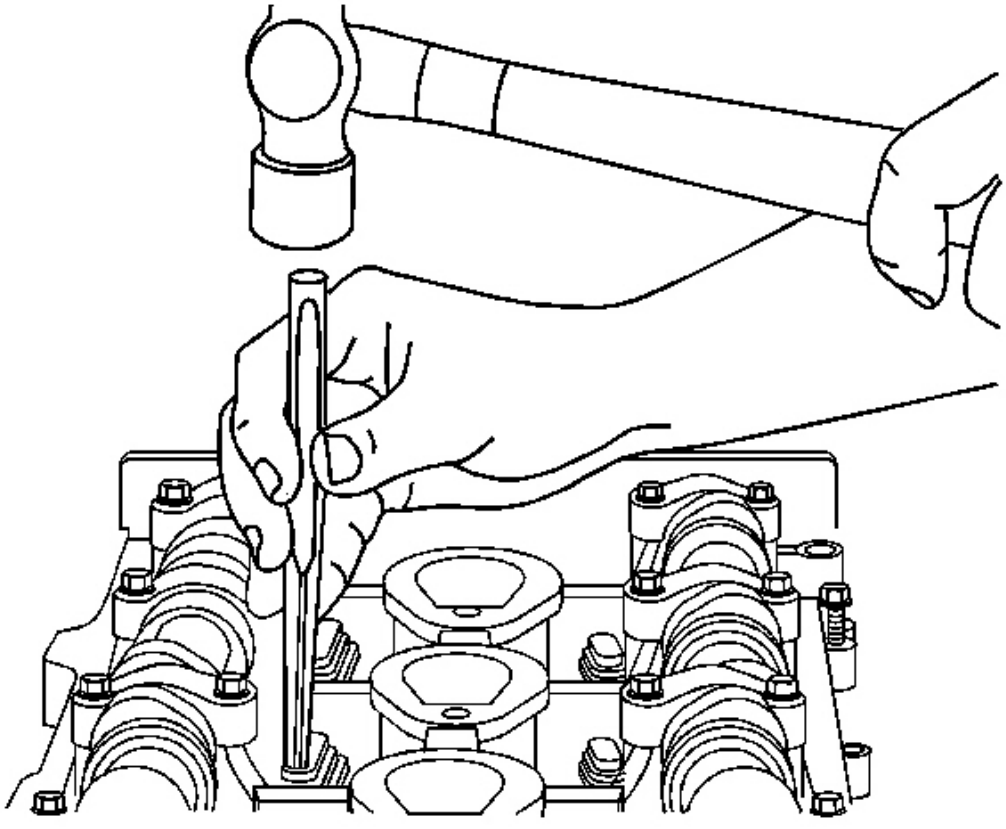


Fig. 134: Striking Head Bolts With Hammer Prior To Removal
Courtesy of GENERAL MOTORS CORP.

34. Before removing the cylinder head bolts, use a drift punch and hammer to shock the bolts. This will ensure that the cylinder head bolts will not strip out the threads in the engine block or break. If a bolt breaks during engine disassembly, **EN-47702** is available to assist in the removal of the remaining bolt segment. See **Special Tools**.

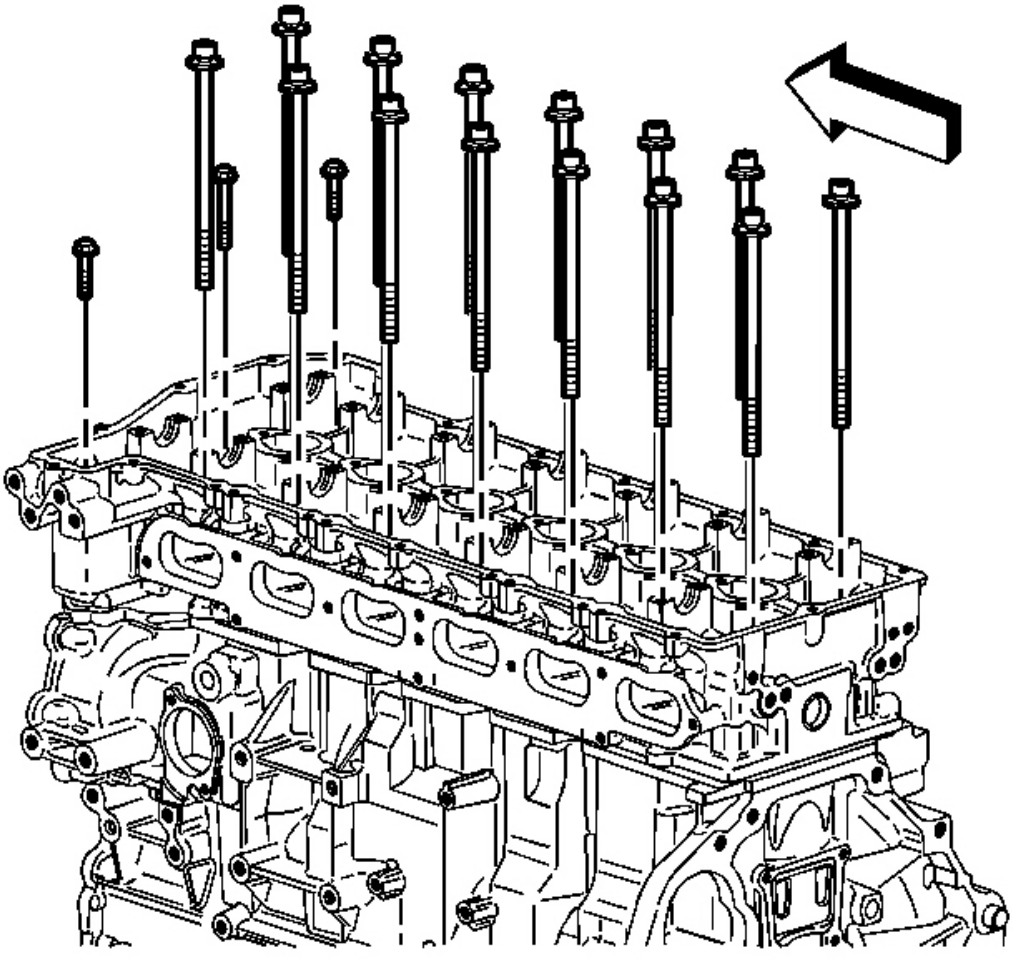


Fig. 135: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

35. Remove the cylinder head bolts. Discard the bolts.

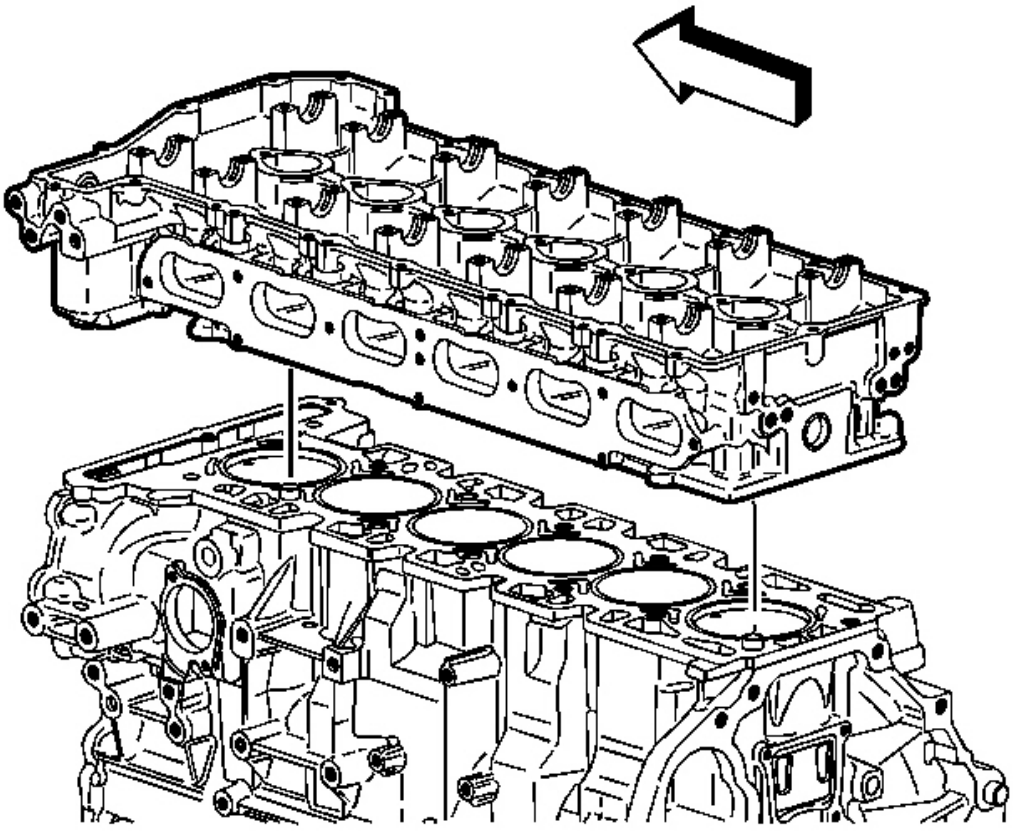


Fig. 136: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

36. Remove the cylinder head.
37. Place the cylinder head on a flat, clean surface with the combustion chambers face up, in order to prevent damage to the deck face.

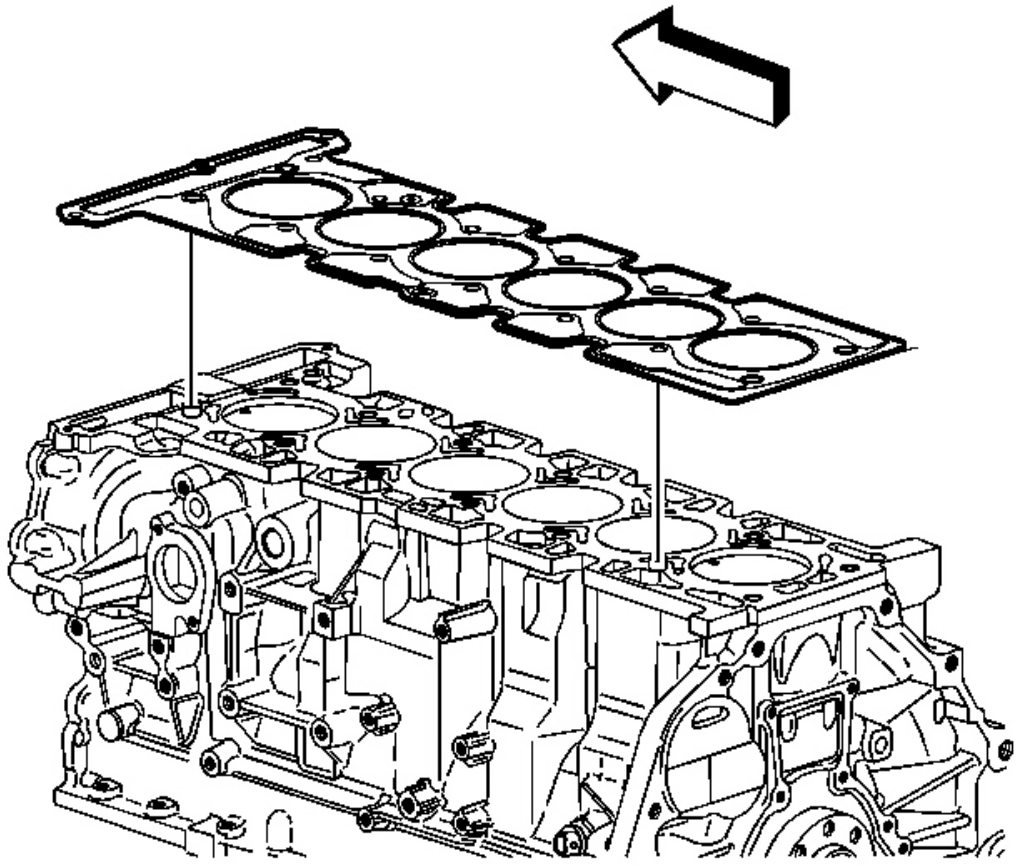


Fig. 137: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

38. Remove the cylinder head gasket.

    Discard the gasket.

39. Remove all remaining gasket material from the engine block.
40. Inspect the cylinder head gasket mating surface on the engine block.
41. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.
42. Disassemble the cylinder head if necessary. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. Assemble the cylinder head if necessary. Refer to **Cylinder Head Assemble**.

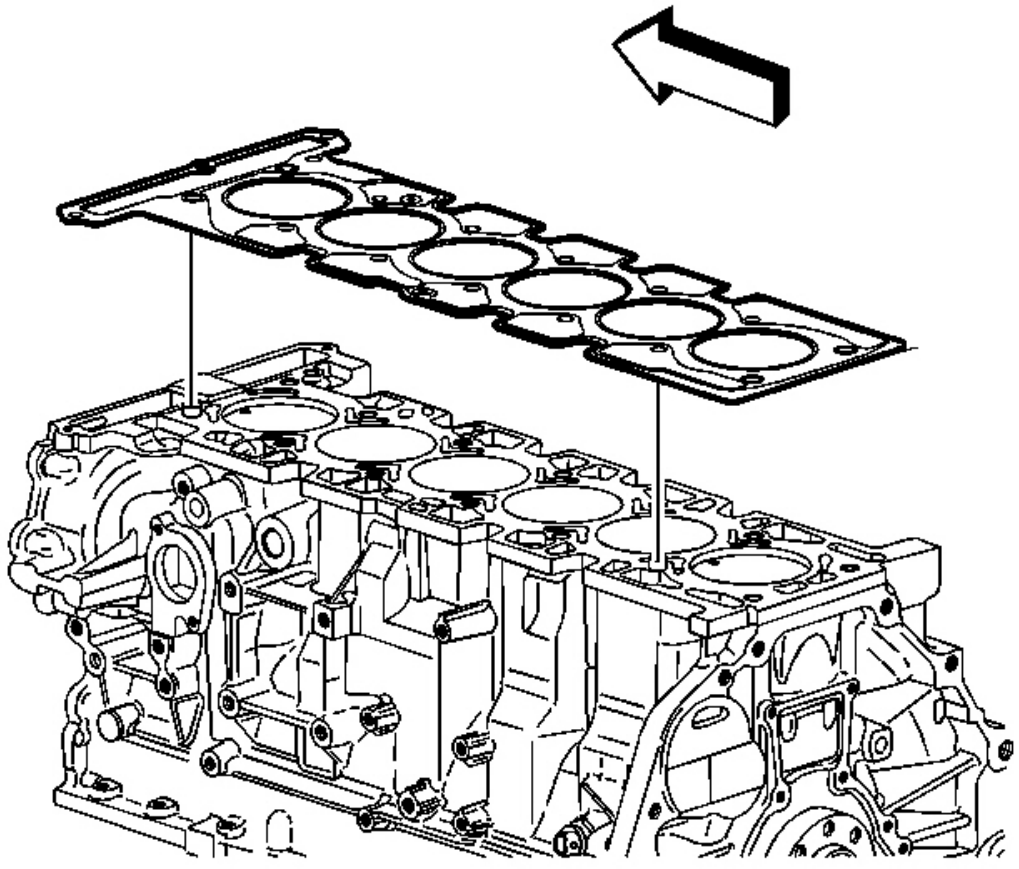


Fig. 138: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the dowel pins, cylinder head locator, if necessary.
3. Position a NEW cylinder head gasket to the engine block.

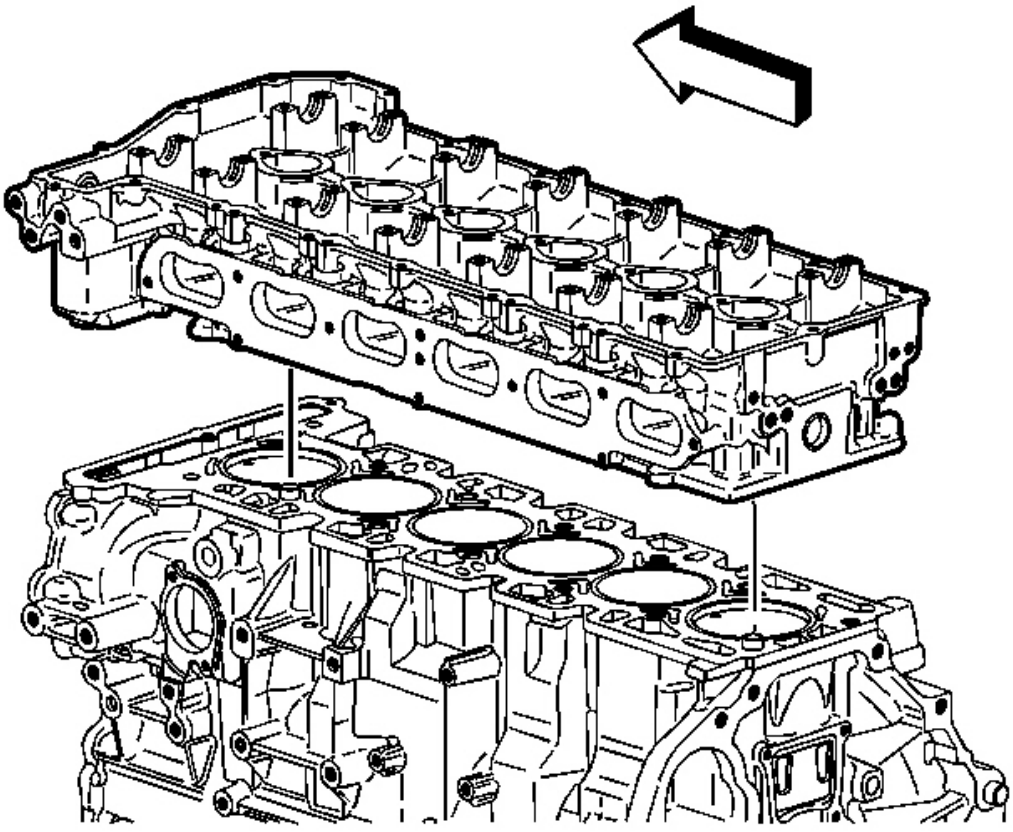


Fig. 139: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure all wires, components, etc. are out of the way when installing the cylinder head.

4. Install the cylinder head.

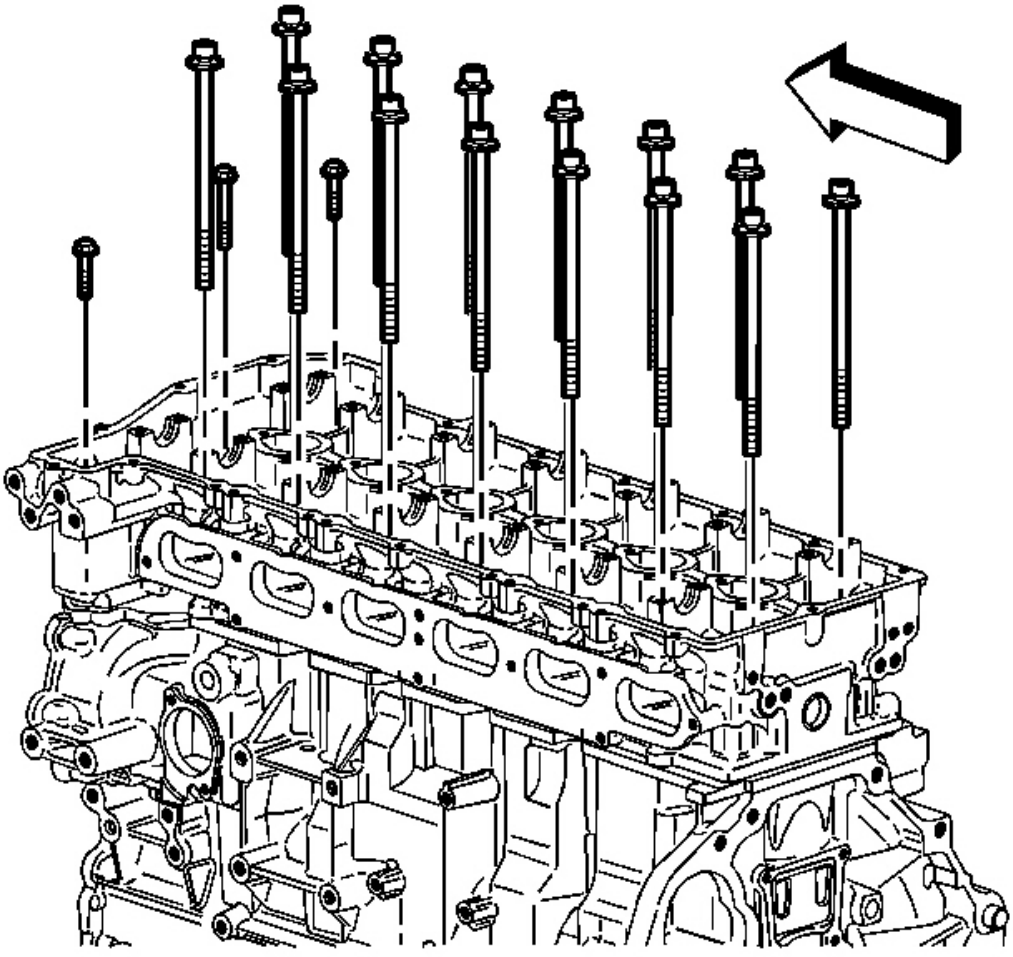


Fig. 140: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

5. Install NEW cylinder head bolts.

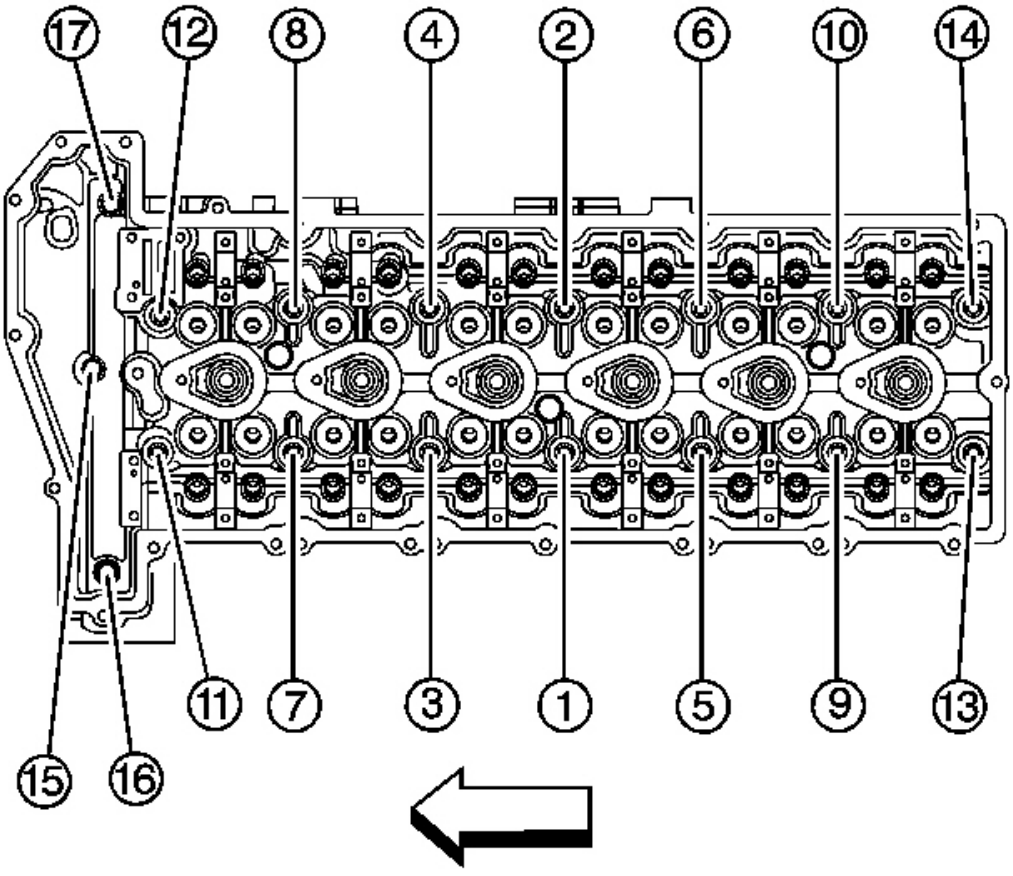


Fig. 141: Tightening Sequence For Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Tighten the NEW cylinder head bolts in the following sequence:

Tighten:

1. Tighten the cylinder head bolts (1-14) in sequence to 30 N.m (22 lb ft).

   Use the **J 45059** to rotate the cylinder head bolts (1-14) in sequence an additional 155 degrees. See **Special Tools**.

2. Tighten the 2 short end bolts to 7 N.m (62 lb in).

Use the **J 45059** to rotate the short cylinder head end bolts an additional 60 degrees. See **Special Tools**.

3. Tighten the 1 long end bolt to 7 N.m (62 lb in).

   Use the **J 45059** to rotate the long cylinder head end bolt an additional 120 degrees. See **Special Tools**.

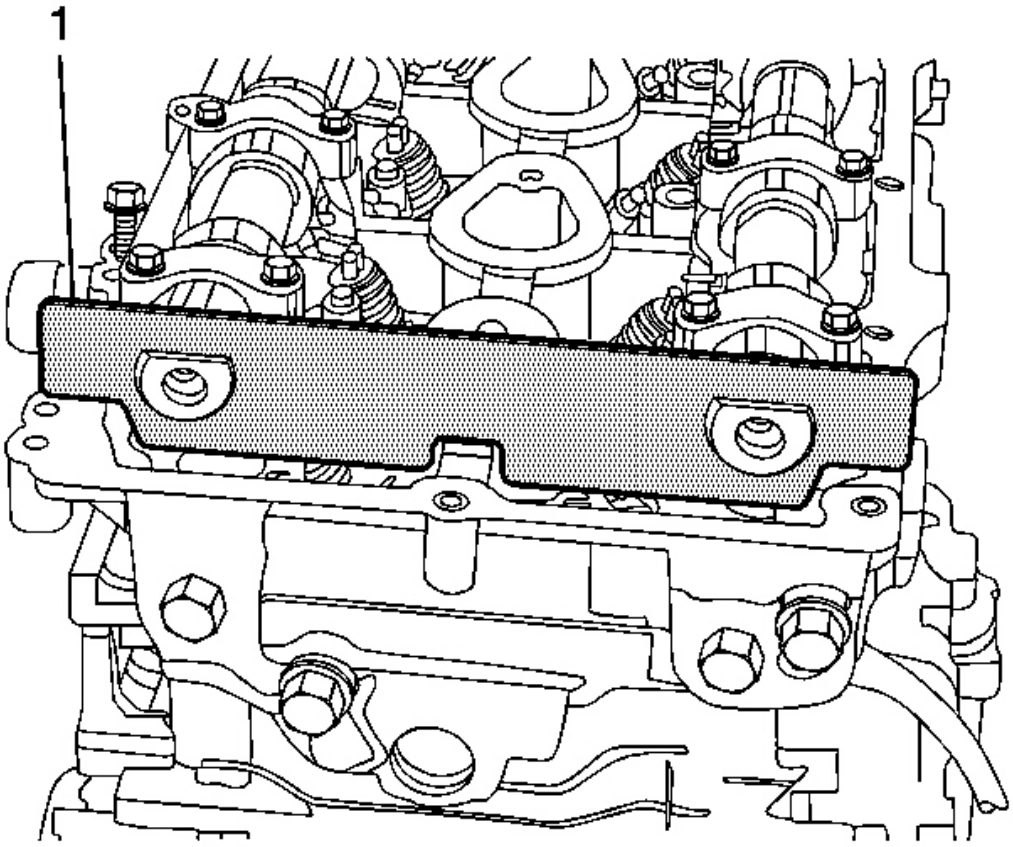


Fig. 142: J 44221 Installed To Back Of Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

IMPORTANT: Before installing the camshafts, refer to Camshafts Cleaning and Inspection.

7. Install the camshafts with the flats up using **J 44221** (1). See **Special Tools**. Refer to **Camshaft Installation**.

NOTE: Tension must be always kept on the intake side of the timing chain to properly keep the engine in time. If the chain is loose the timing will be off, which may cause internal engine damage or set DTC P0017.

NOTE: The exhaust camshaft actuator must be fully advanced during installation. Engine damage may occur if the camshaft actuator is not fully advanced.

8. Ensure that the camshaft position actuator is in the fully advanced position. Refer to **Camshaft Position Actuator Diagnosis**.

IMPORTANT: To aid in aligning the actuator to the camshaft, use a 25 mm (1 in) open end wrench on the hex of the camshaft to rotate. This will ensure the alignment pin is properly engaged with the camshaft and hand tighten the new exhaust camshaft sprocket bolt.

9. Install the exhaust camshaft actuator/sprocket and chain onto the exhaust camshaft. Use the paint marks as an alignment guide.

IMPORTANT: To aid in aligning the intake sprocket to the camshaft, use a 25 mm (1 in) open end wrench on the hex of the camshaft to rotate. This will ensure the alignment pin is properly engaged with the camshaft and hand tighten the new intake camshaft sprocket bolt.

10. Install the intake camshaft sprocket and chain onto the intake camshaft. Use paint marks as alignment guide.

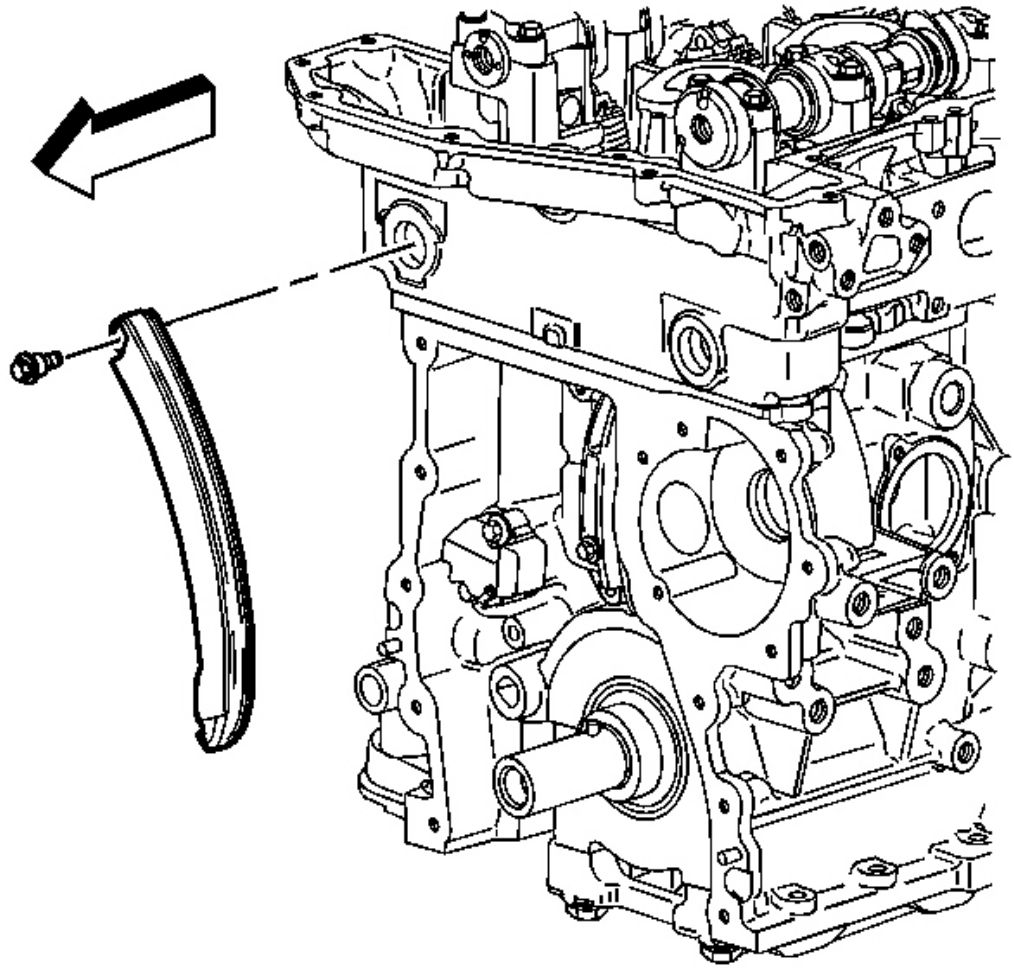


Fig. 143: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Position the timing chain tensioner shoe to the engine.
12. Install the timing chain tensioner shoe bolt.

Tighten: Tighten the timing chain tensioner shoe bolt to 25 N.m (18 lb ft).

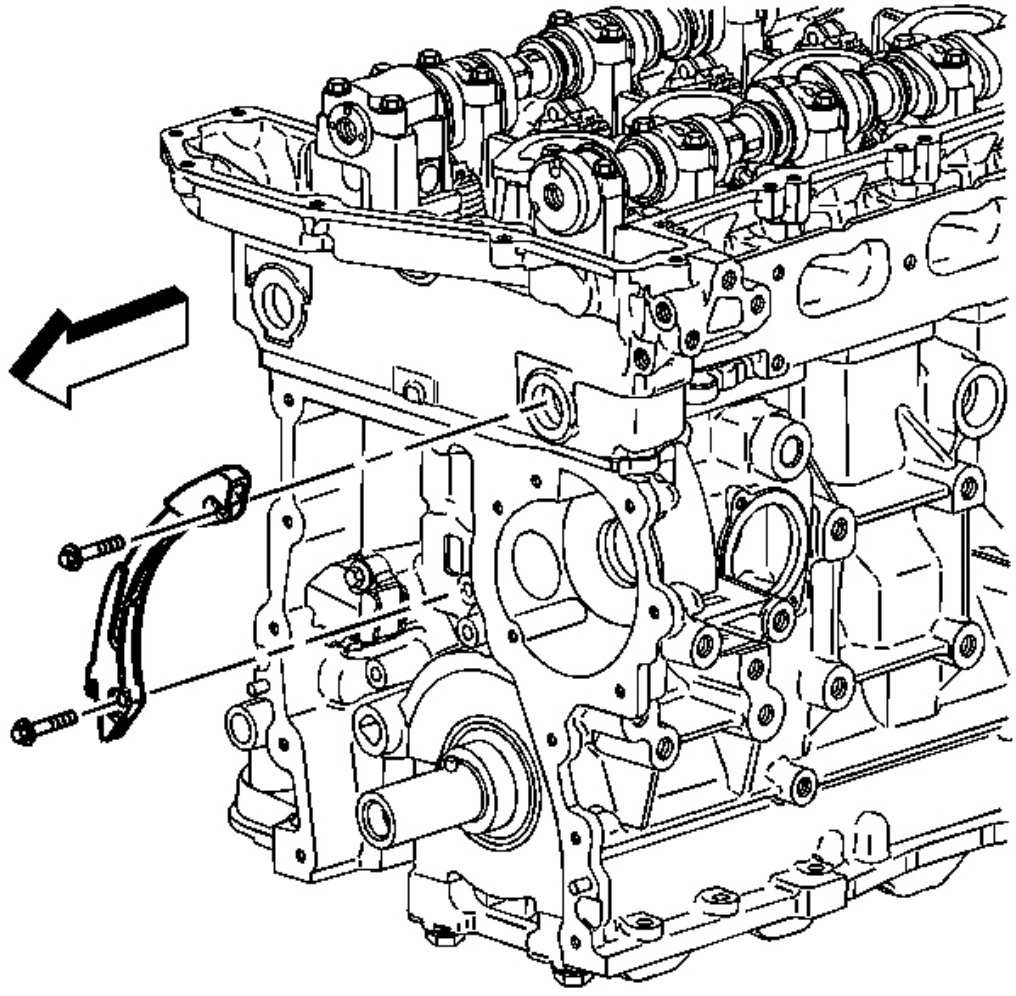


Fig. 144: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Position the lower timing chain guide to the engine.
14. Install the lower timing chain guide bolts.

    Tighten: Tighten the lower timing chain guide bolts to 12 N.m (107 lb in).

15. Install both upper timing chain tensioner shoe bolts.

    Tighten: Tighten the tensioner shoe bolts to 25 N.m (18 lb ft).

16. Install both upper cylinder head access hole plugs to the front of the cylinder head.

    Tighten: Tighten the plugs to 5 N.m (44 lb in).

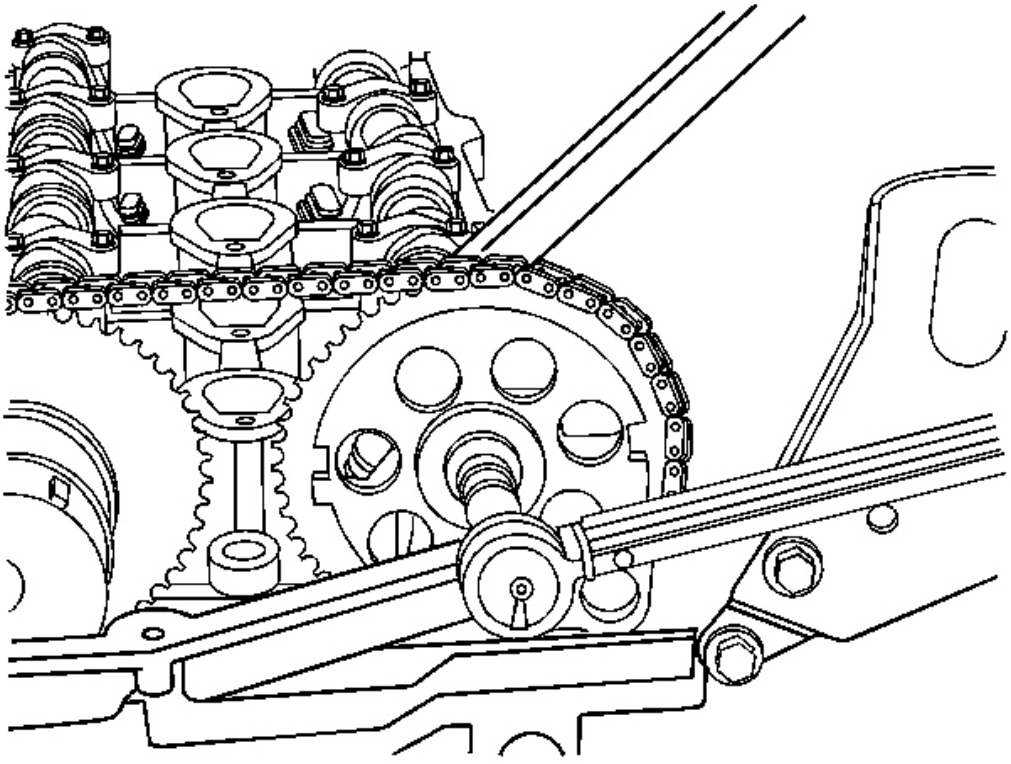


Fig. 145: Tightening Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

17. Tighten the new intake camshaft sprocket bolt.

    Tighten: Using **J 45059** , tighten the intake camshaft sprocket bolt to 20 N. See **Special Tools**.m (15 lb ft) plus 100 degrees.

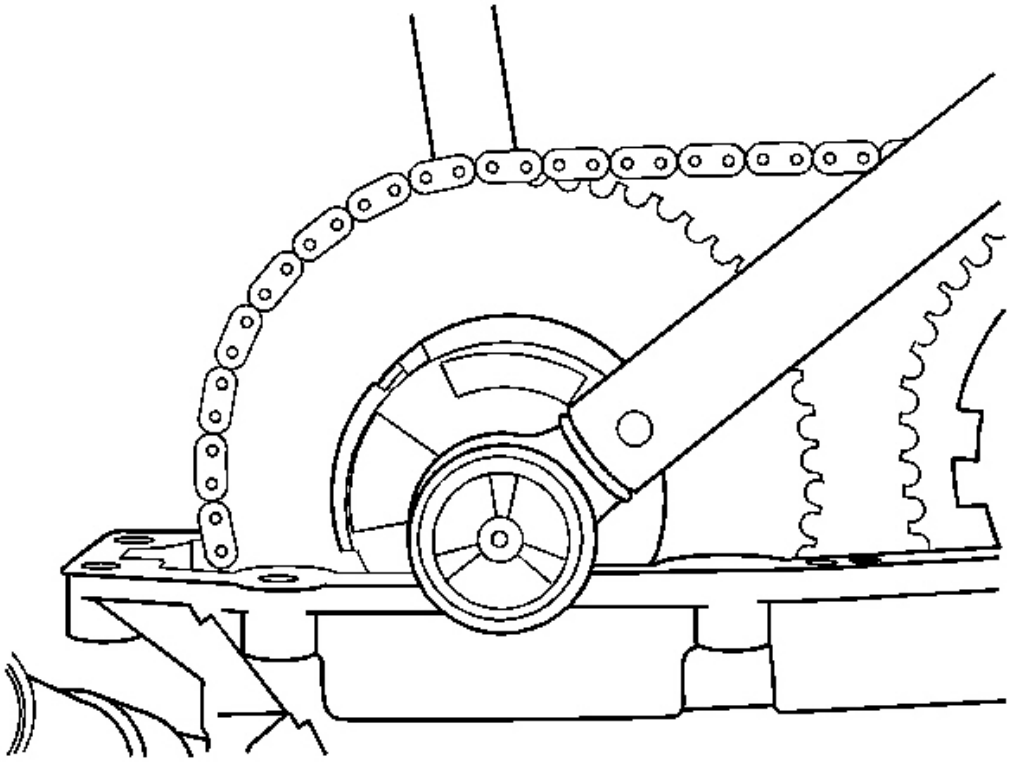


Fig. 146: Tightening Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

18. Tighten the new exhaust camshaft actuator sprocket bolt.

    Tighten: Using **J 45059** , tighten the exhaust camshaft actuator sprocket bolt to 25 N. See **Special Tools**.m (18 lb ft) plus 135 degrees.

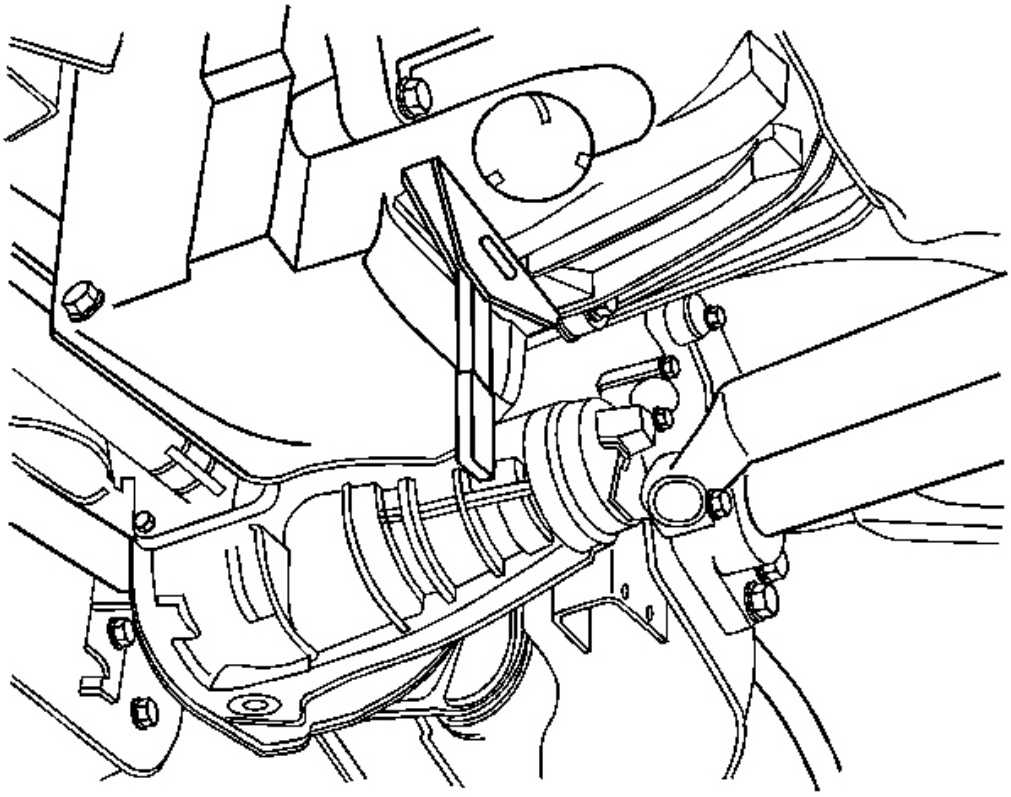


Fig. 147: View Of J 44226
Courtesy of GENERAL MOTORS CORP.

19. Lift the vehicle and remove the **J 44226** . See **Special Tools**.
20. Lower the vehicle.
21. Remove the **J 44221** from the back of the camshafts. See **Special Tools**.

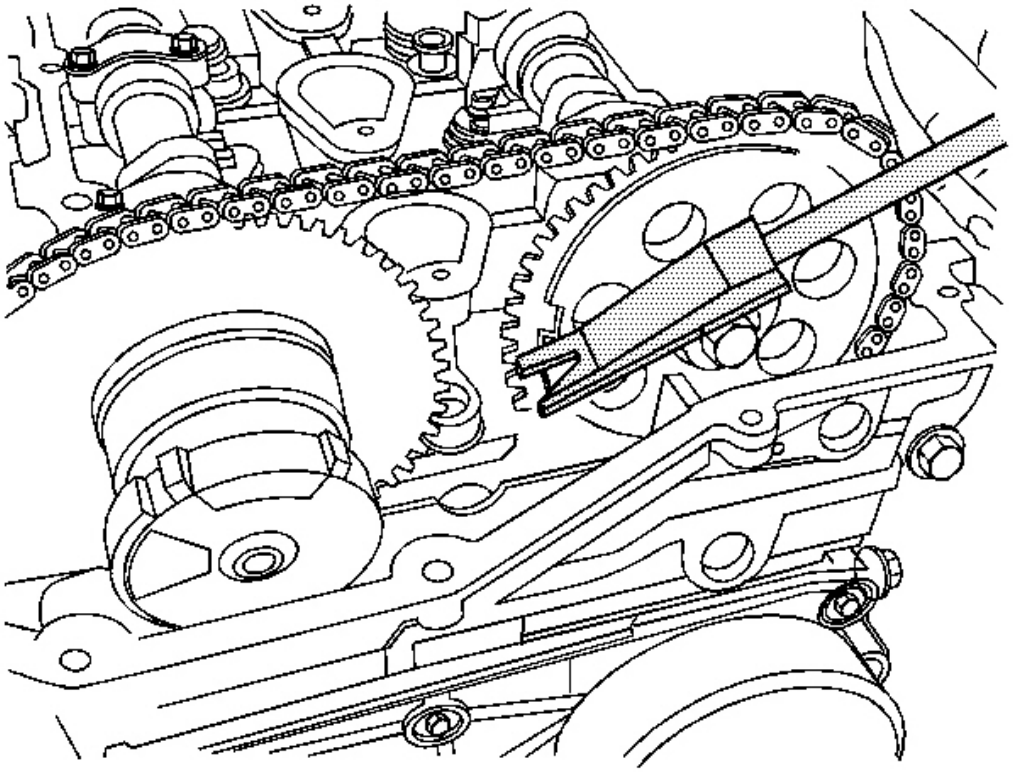


Fig. 148: Wedge Tool Handle
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the wedge tool is removed from engine prior to rotation. If the wedge tool is not removed, engine damage will result.

22. Install the handle of **EN-48464** and remove the wedge portion of the tool from the engine. See **Special Tools**.

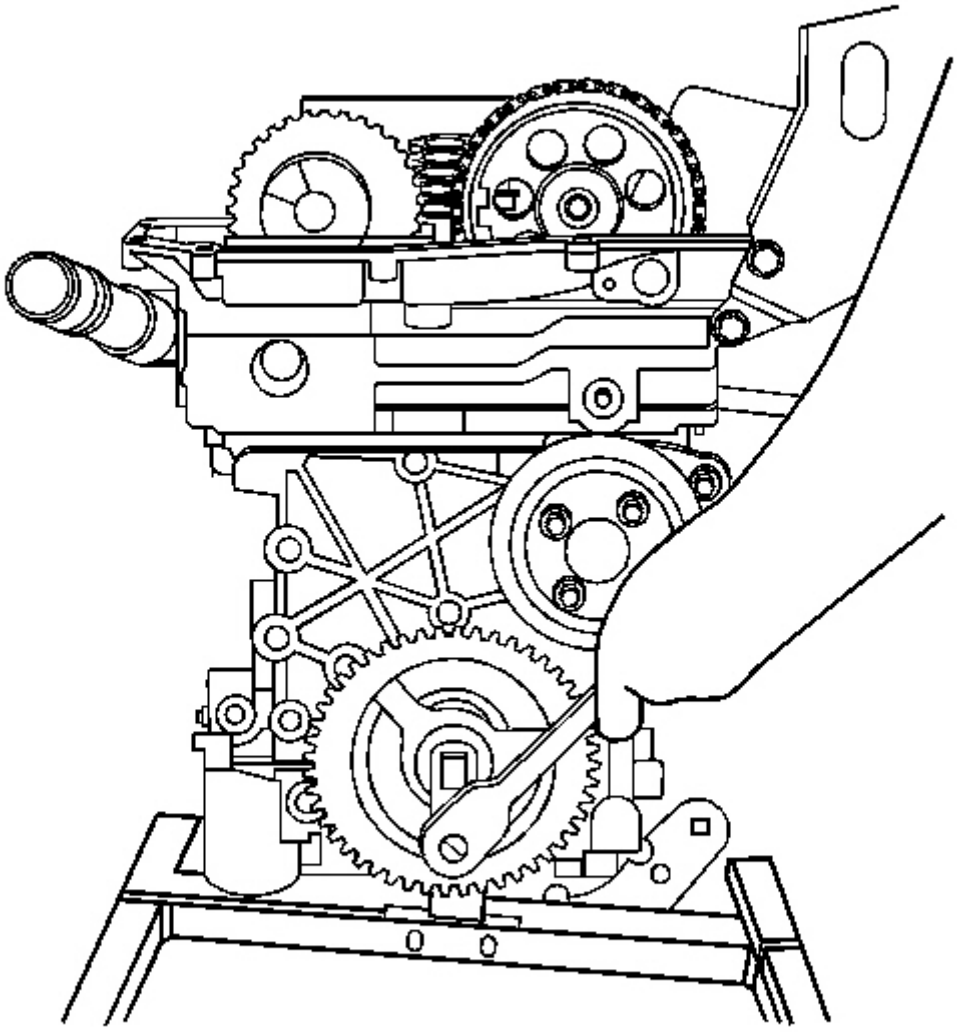


Fig. 149: Rotating Engine Clockwise
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It is critical that the engine is at TDC and not a couple of degrees off. If in doubt, repeat this step.

23. Rotate the engine clockwise by hand two complete revolutions to TDC number 1 on the compression stroke. Refer to First Method or Second Method for TDC. If you go past TDC, rotate the engine back approximately 45 degrees before TDC and then rotate clockwise up to TDC to ensure that the timing chain is tight (no slack) between the crank sprocket and the timing gears.

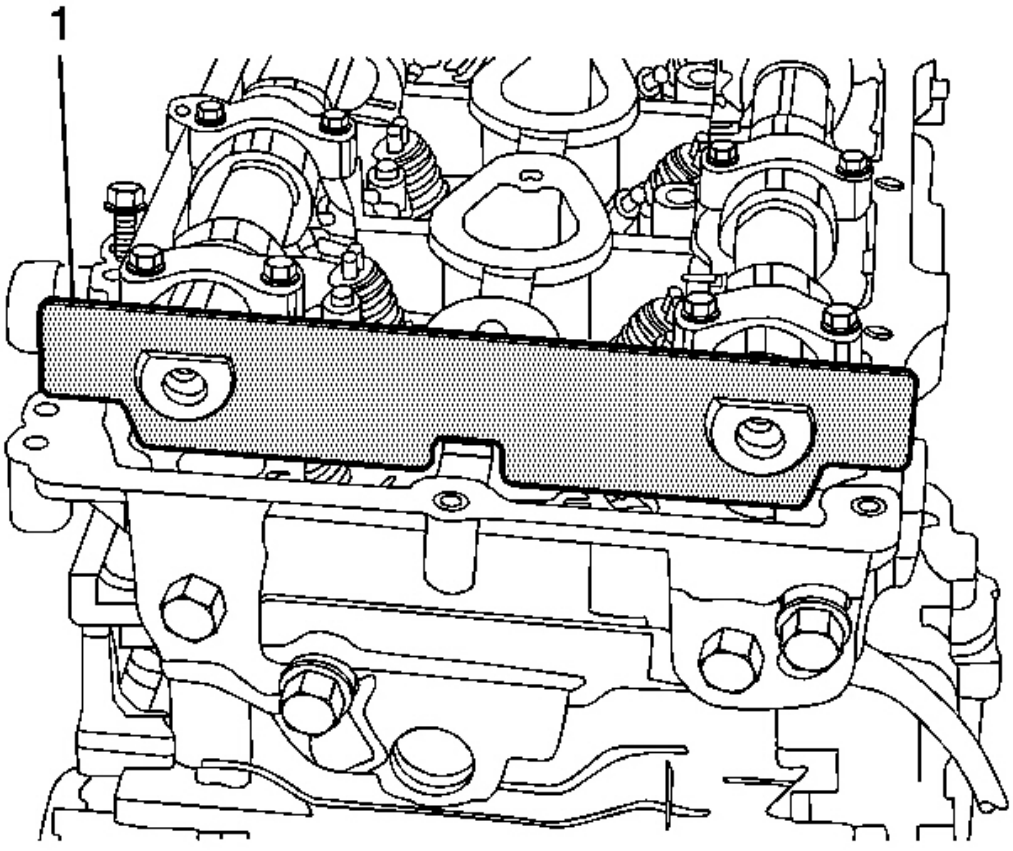


Fig. 150: J 44221 Installed To Back Of Camshafts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use the J 44221 (1), installed to the back of the camshafts, as a method to verify timing. See Special Tools.

24. Both intake and exhaust camshaft flats should be facing up and flat and level with the cylinder head. If **J 44221** is used to verify cam timing, you could be off approximately one tooth and cause DTC P0017 to set. See **Special Tools**. If a worn or new **J 44221** is used to verify timing, the timing will be off. See **Special Tools**.

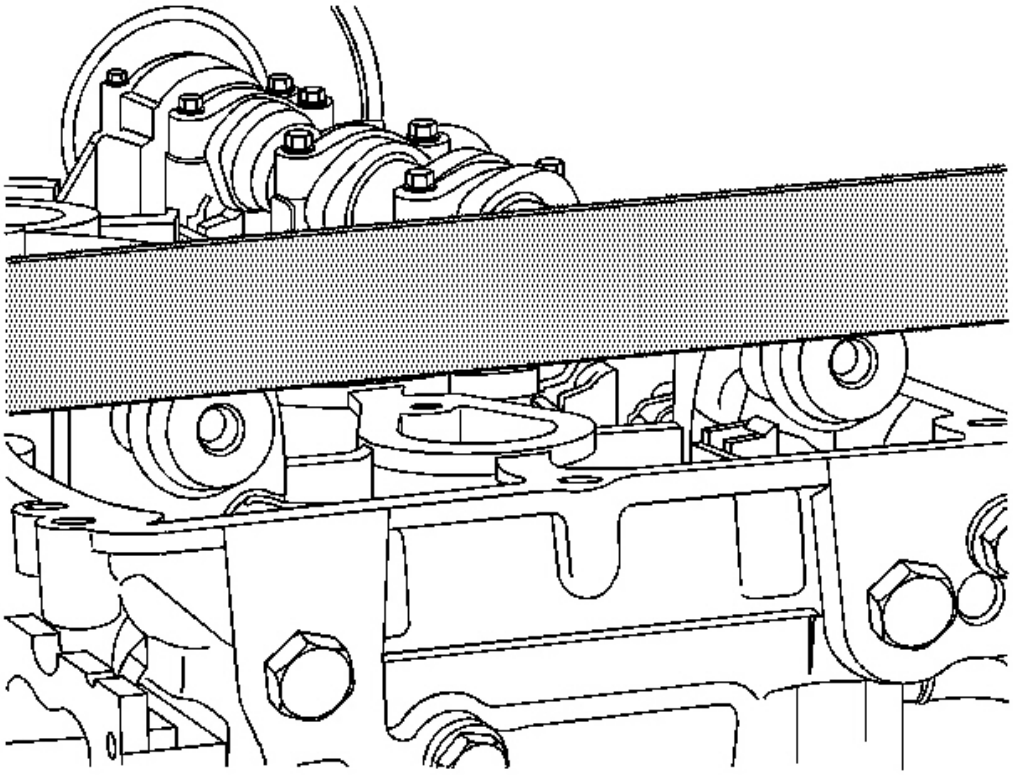


Fig. 151: Verifying Camshaft Timing With Straightedge
Courtesy of GENERAL MOTORS CORP.

25. To verify timing, set a straight edge across the flats of the camshafts.

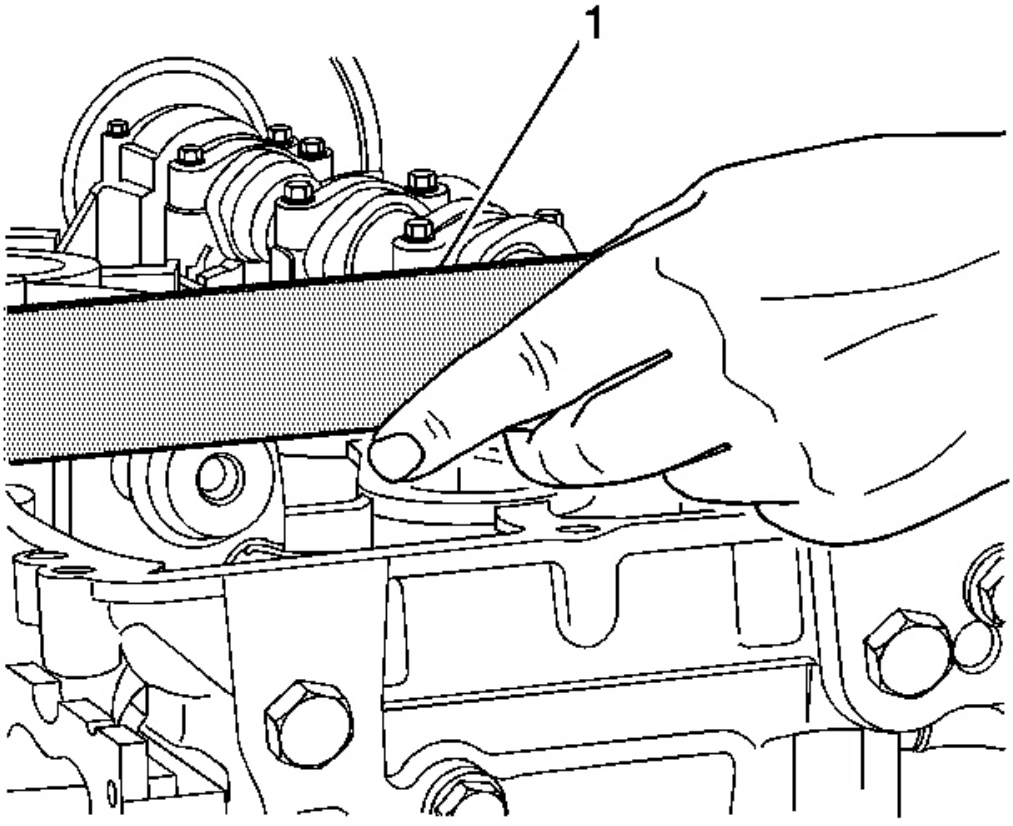


Fig. 152: Measuring Clearance Under Camshaft Flats
Courtesy of GENERAL MOTORS CORP.

26. A 0.005 inch feeler gage should not be able to slip under the straight edge (1). If the feeler gage slips under one or both camshaft flats, then the timing is off. Repeat step 20 and recheck. If the camshaft flats are still not flat, the camshaft timing will have to be reset. This may require removal and reinstallation of one or both camshaft sprockets.
27. Install the 1 long and 2 short cylinder head bolts next to the exhaust and intake timing chain tensioner shoes and tighten the bolts.
28. Position the upper timing chain guide to the cylinder head. Apply threadlocker GM P/N 89021297 (Canadian P/N 10953488) to the upper timing chain guide bolt threads.
29. Install the upper timing chain guide bolts.

    Tighten: Tighten the bolts to 10 N.m (89 lb in).

30. Install the radiator inlet hose and clamp to the cylinder head. Refer to **Radiator Inlet Hose Replacement (LL8)** or **Radiator Inlet Hose Replacement (LH6, LS2)** .

31. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection**.

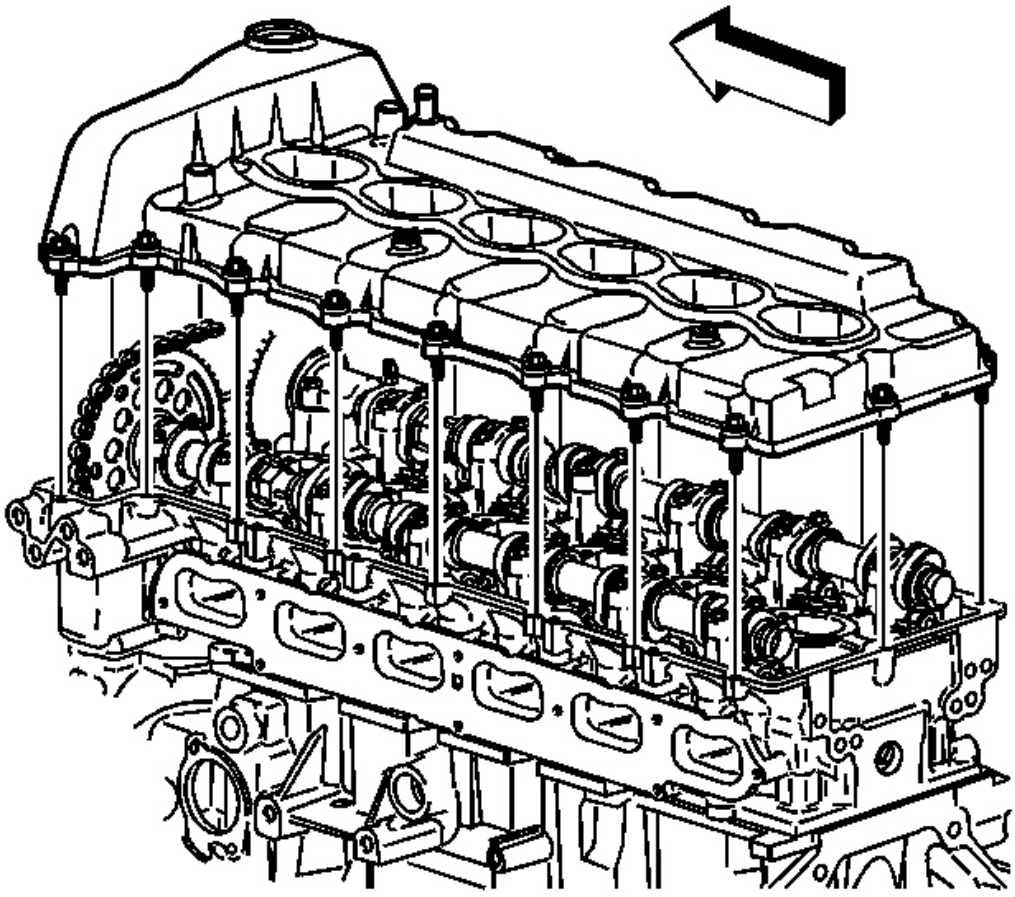


Fig. 153: View Of Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

32. Install a NEW camshaft cover seal and NEW ignition control module seals to the cam cover. Position the camshaft cover to the cylinder head.
33. Install the camshaft cover bolts.

    Tighten: Tighten the bolts to 10 N.m (89 lb in).

34. Check the gap on all of the spark plugs. The gap should be 1.08 mm (0.042 in). Tighten all of the spark plugs.

    Tighten: Tighten the spark plug to 18 N.m (13 lb ft).

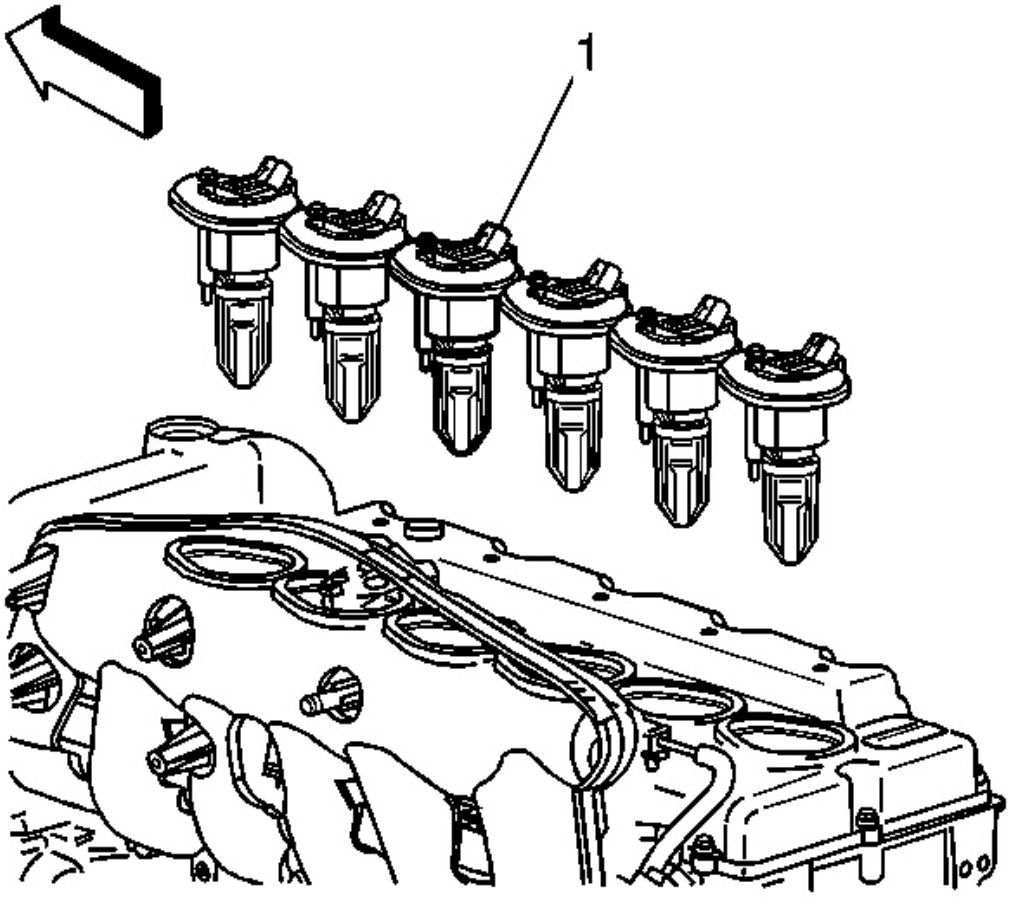


Fig. 154: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

35. Install the ignition coils (1) into the camshaft cover.

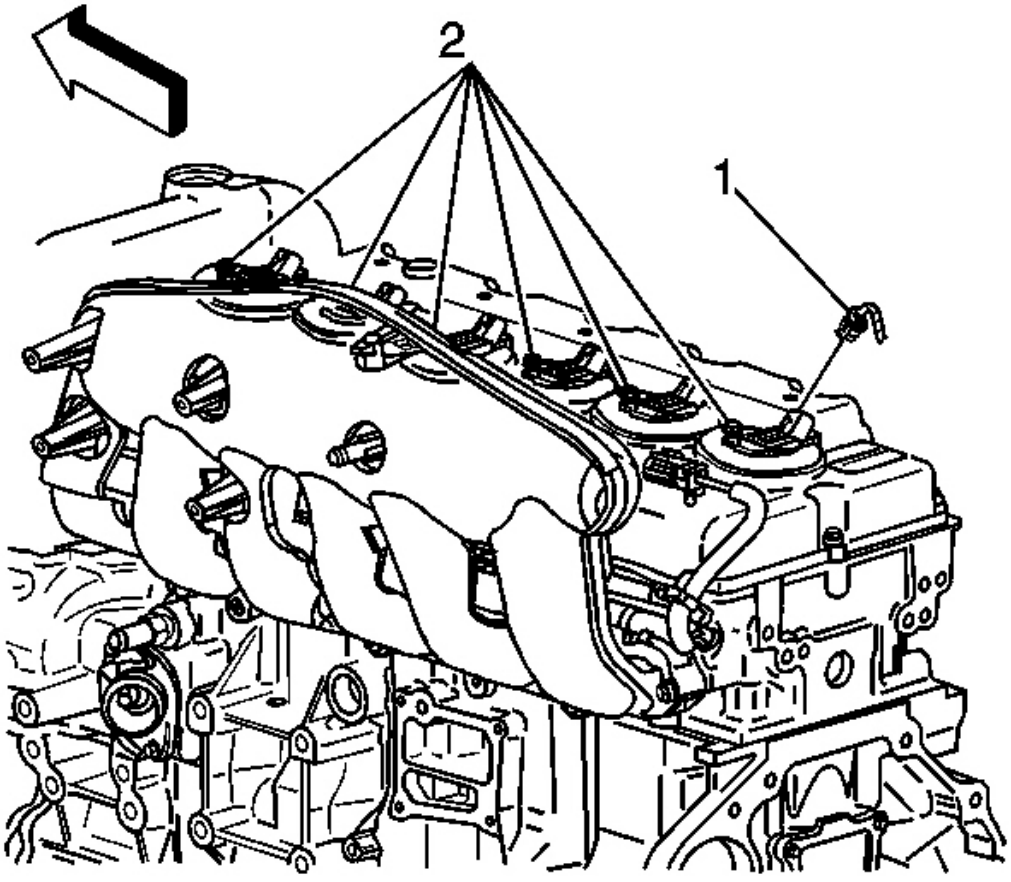


Fig. 155: Locating Ignition Coil Components
Courtesy of GENERAL MOTORS CORP.

36. Install the ignition coil bolts (2).

    Tighten: Tighten the bolts to 10 N.m (89 lb in).

37. Reposition the exhaust manifold to cylinder head and install the exhaust manifold bolts to the cylinder head. Refer to **Exhaust Manifold Replacement (LL8)** .
38. If equipped, install a NEW AIR injection gasket, then the cover and pipe studs to the cylinder head.

    Tighten: Tighten the pipe studs to 25 N.m (18 lb ft).

39. Install the exhaust manifold heat shield to the exhaust manifold.
40. Apply anti-seize GM P/N 12371386 (Canadian P/N 89021945) to the exhaust manifold heat shield nuts.

41. Install the exhaust manifold heat shield nuts.

    Tighten: Tighten the nuts to 10 N.m (89 lb in).

42. Install the intake manifold to the cylinder head. Refer to **Intake Manifold Replacement**.

    Four-wheel drive-Raise the vehicle and install the blind intake manifold bolts from the left front wheelhouse access.

    Two-wheel drive-The bolts are accessible from the top of the engine.

43. Reposition the engine wiring harness bracket to the engine and harnesses. Install the engine wiring harness bracket bolts.

    Tighten: Tighten the bracket bolts to 10 N.m (89 lb in).

44. Install the left front wheelhouse panel and the left wheel and tire. Refer to **Wheelhouse Panel Replacement (Front End)** .
45. Drain the engine oil again.
46. If removed, install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LL8)** or **Radiator Outlet Hose Replacement (LH6, LS2)** .
47. Install the cross-vehicle wiring harness connectors to the following components:
    - ECM
    - Map sensor
    - Ignition coils
    - Harness clamps at power steering pump
    - Wiring harness fastener at right front inner fender
    - Throttle body
    - Camshaft sensors
    - Exhaust camshaft actuator
    - Fuel injectors
    - HO2S
    - AIR valve and connectors
48. Install the PCV pipes to the intake manifold. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.
49. Reposition the Fuel/EVAP lines to the intake manifold retainer. Refer to **Evaporative Emission Hoses/Pipes Replacement - Engine/Chassis** .
50. Install the following components:
    - Thermostat-Refer to **Engine Coolant Thermostat Replacement (4.2L Engine)** or **Engine Coolant Thermostat Replacement (5.3L and 6.0L Engines)** .
    - Generator-Refer to **Generator Replacement (With 4.2L Engine)** or **Generator Replacement (With V8 Engine)** .

- Drive belt-Refer to **Drive Belt Replacement**.

51. Install the air cleaner element and resonator. Refer to **Air Cleaner Element Replacement** and **Air Cleaner Outlet Resonator Replacement** .
52. Install NEW engine oil. Refer to **Engine Mechanical Specifications**.
53. Install NEW coolant. Refer to **Cooling System Draining and Filling (LL8)** or **Cooling System Draining and Filling (LH6, LS2)** .
54. Install a scan tool and start the engine.
    - Check for DTCs.
    - Road test vehicle.

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

- **J 36660-A** Torque Angle Meter. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 44226** Crankshaft Balancer Remover/Holder. See **Special Tools**.

Removal Procedure

1. Remove the cooling fan and shroud. Refer to **Cooling Fan and Shroud Replacement** .
2. Remove the drive belt. Refer to **Drive Belt Replacement**.

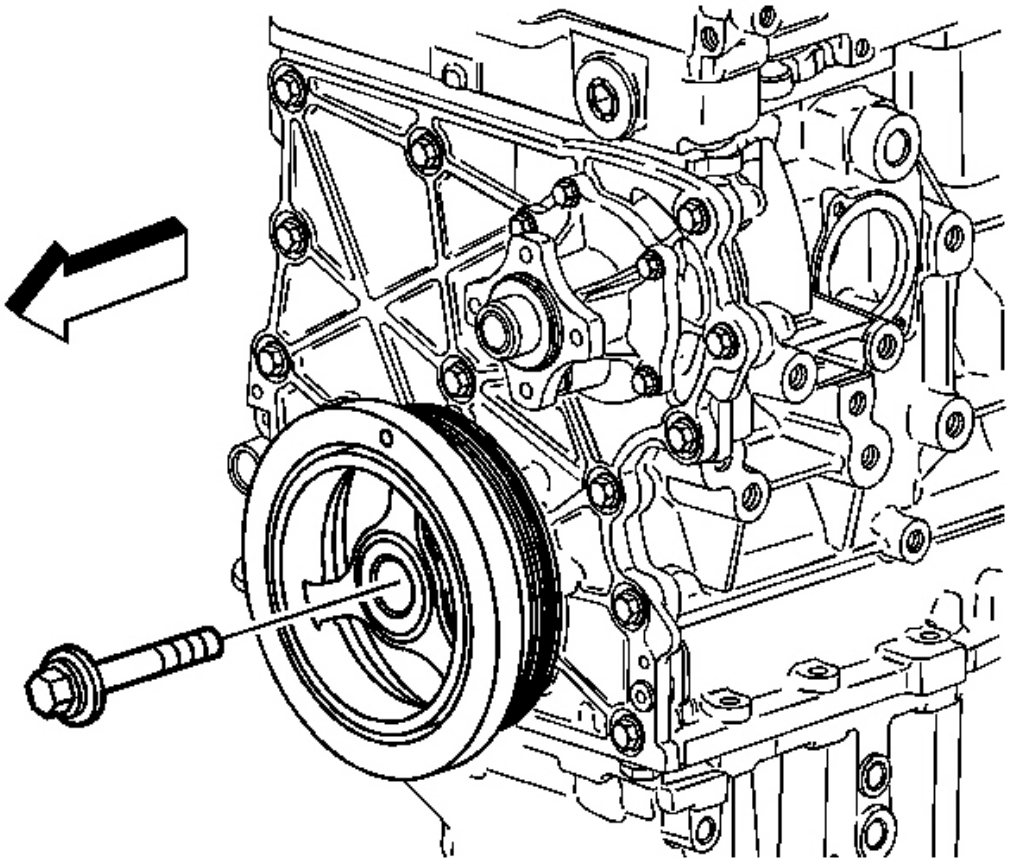


Fig. 156: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

3. Carefully loosen and remove the balancer bolt.

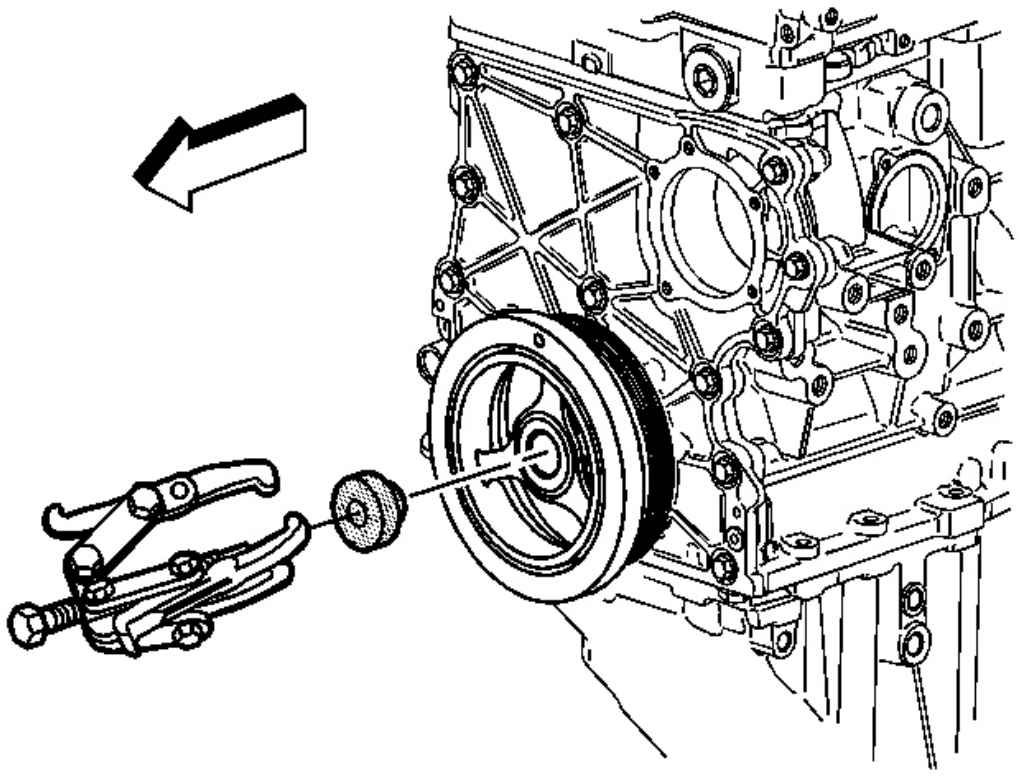


Fig. 157: View Of Crankshaft Balancer & J 41816-2
Courtesy of GENERAL MOTORS CORP.

4. Install **J 41816-2** into the end of the crankshaft. See **Special Tools**.

IMPORTANT: Do not pull on outer edge of the crankshaft balancer.

5. Use a 3 jaw puller to remove the crankshaft balancer.
6. Remove the 3 jaw puller and the **J 41816-2** . See **Special Tools**.
7. Remove the crankshaft balancer shim from the crankshaft snout.
8. Clean and inspect the crankshaft balancer. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

IMPORTANT: The crankshaft balancer does not have a key-way; so the crankshaft could turn when tightening, causing an improper torque. Make sure to follow the installation procedure to prevent damage.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the torque converter access plug in the dry part of the oil pan.
3. Use the torque converter holding tool from the **J 44226** kit and secure the torque converter while tightening the crankshaft balancer. See **Special Tools**.
4. Install a new crankshaft balancer shim GM P/N 12573950 over the crankshaft snout, against the crankshaft gear.

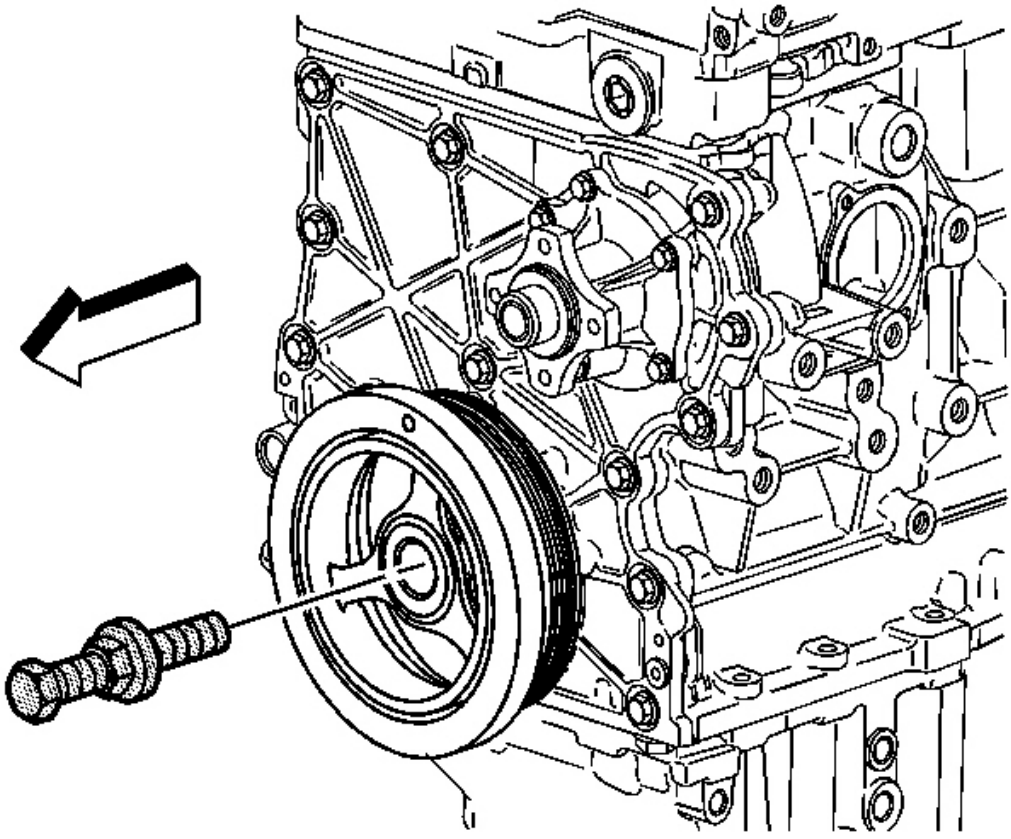


Fig. 158: Installing Crankshaft Balancer Using The J 41478
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 41478** install and seat the crankshaft balancer. See **Special Tools**.
6. Remove the **J 41478** . See **Special Tools**.

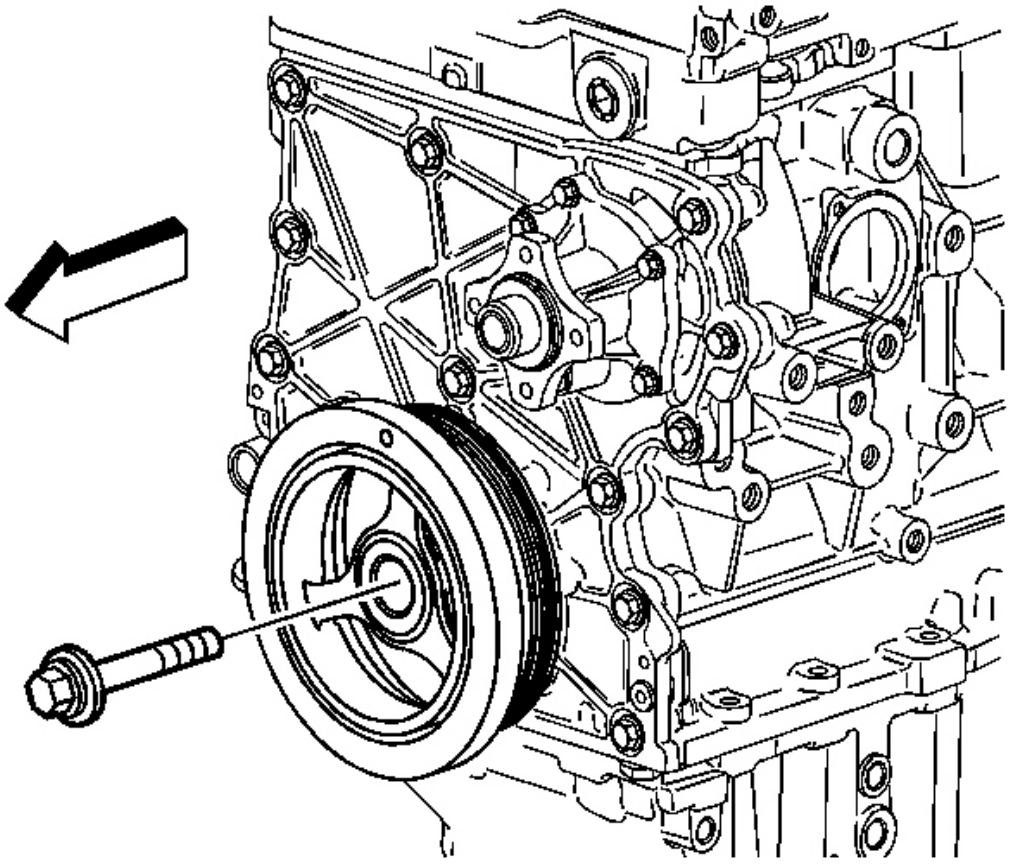


Fig. 159: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. While still holding the flywheel, install the balancer washer and the bolt.

   Tighten: Tighten the crankshaft balancer bolt to 150 N.m (110 lb ft). Use the **J 36660-A** in order to tighten the balancer bolt an additional 180 degrees. See **Special Tools**.

8. Remove the torque converter holding tool.
9. Install the torque converter access plug into the oil pan.
10. Lower the vehicle.
11. Install the drive belt. Refer to **Drive Belt Replacement**.
12. Install the cooling fan and shroud. Refer to **Cooling Fan and Shroud Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

J 44218 Seal Installer. See **Special Tools**.

Removal Procedure

IMPORTANT: Do not damage the engine front cover or the crankshaft.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

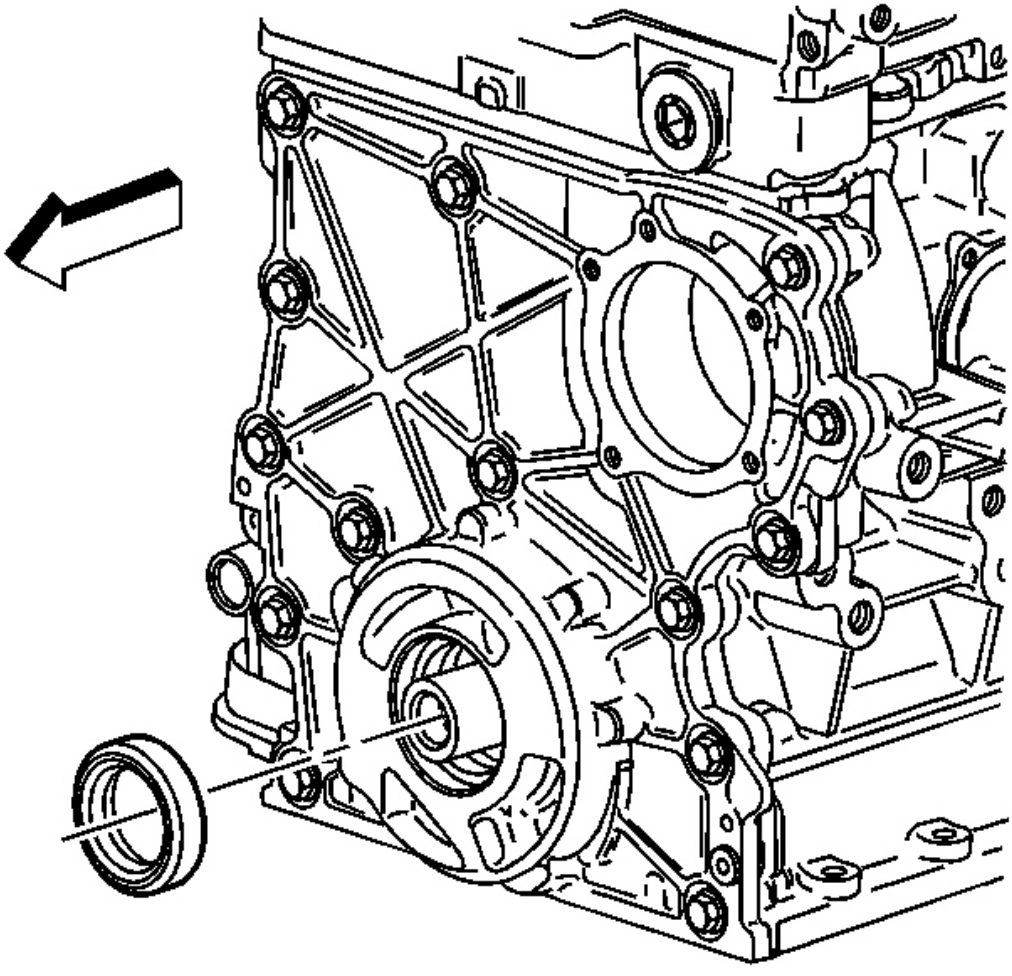


Fig. 160: View Of Crankshaft Front Oil Seal

Courtesy of GENERAL MOTORS CORP.

2. Pry out the crankshaft front oil seal using a suitable tool. Use the provided slots for prying out the seal.

Installation Procedure

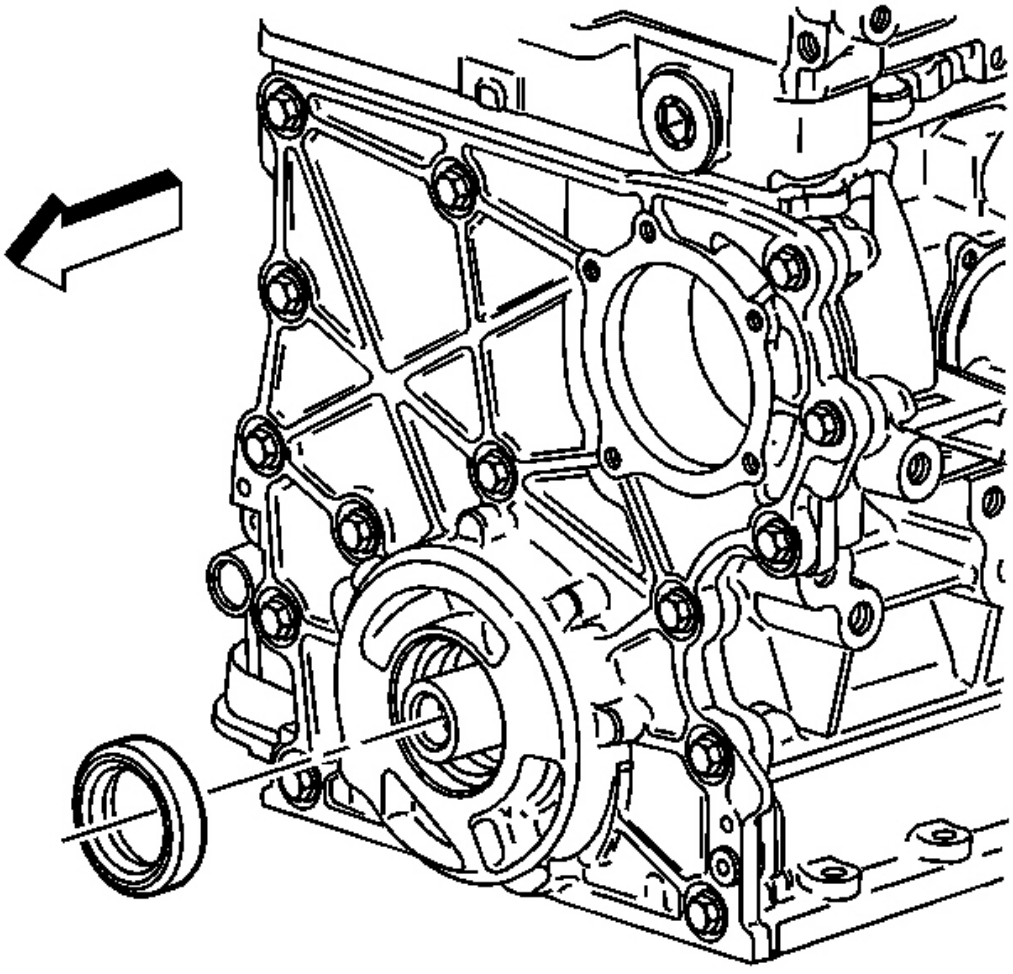


Fig. 161: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Apply the engine oil to the outside diameter of the crankshaft front oil seal.

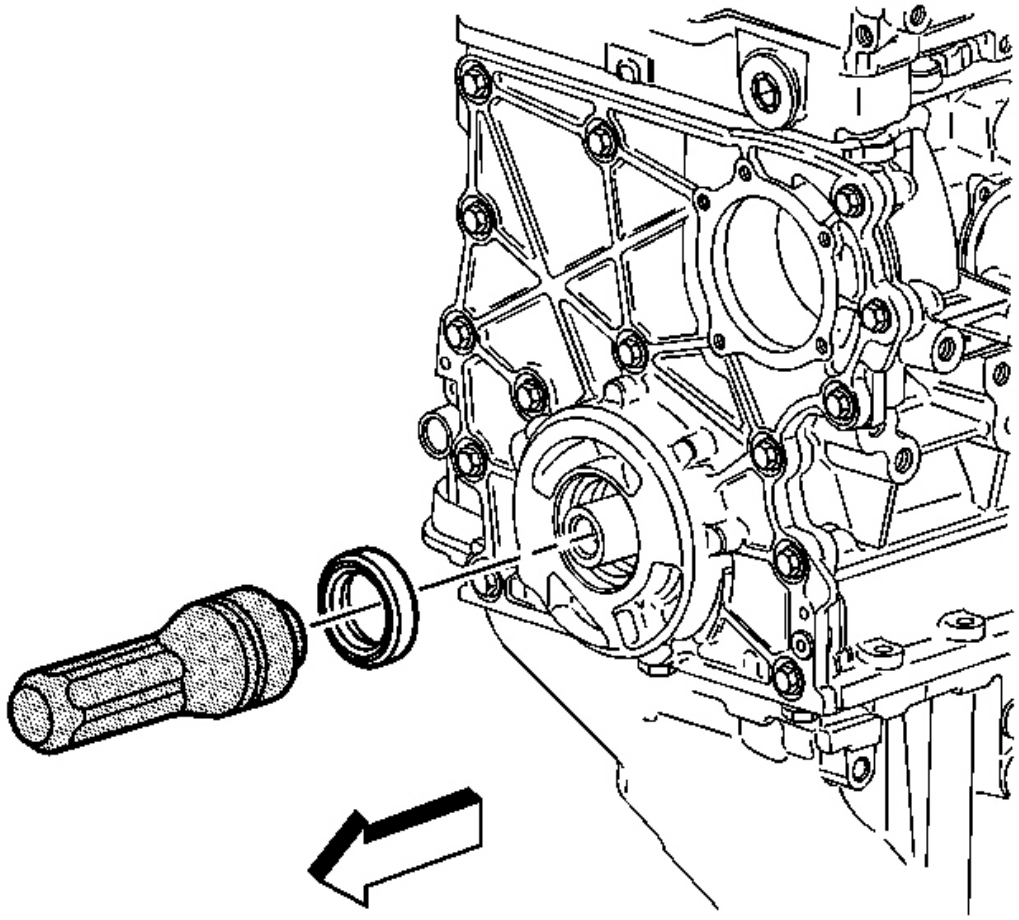


Fig. 162: View Of Front Oil Seal & J 44218
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 44218** to install the front oil seal. See **Special Tools**.
3. Remove the **J 44218** . See **Special Tools**.
4. Install the crank balancer shaft. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Tools Required

J 44219 Cover Alignment Pins. See **Special Tools**.

Removal Procedure

1. Drain the engine coolant. Refer to **Cooling System Draining and Filling (LL8)** or **Cooling System Draining and Filling (LH6, LS2)** .
2. Remove the cooling fan and the shroud. Refer to **Cooling Fan and Shroud Replacement** .
3. Remove the drive belt. Refer to **Drive Belt Replacement**.
4. Remove the water pump. Refer to **Water Pump Replacement** .
5. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
6. Remove the power steering pump. Refer to **Power Steering Pump Replacement (4.2L)** or **Power Steering Pump Replacement (Except 4.2L)** .
7. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
8. Remove the oil pan. Refer to **Oil Pan Replacement**.
9. Lower the vehicle.

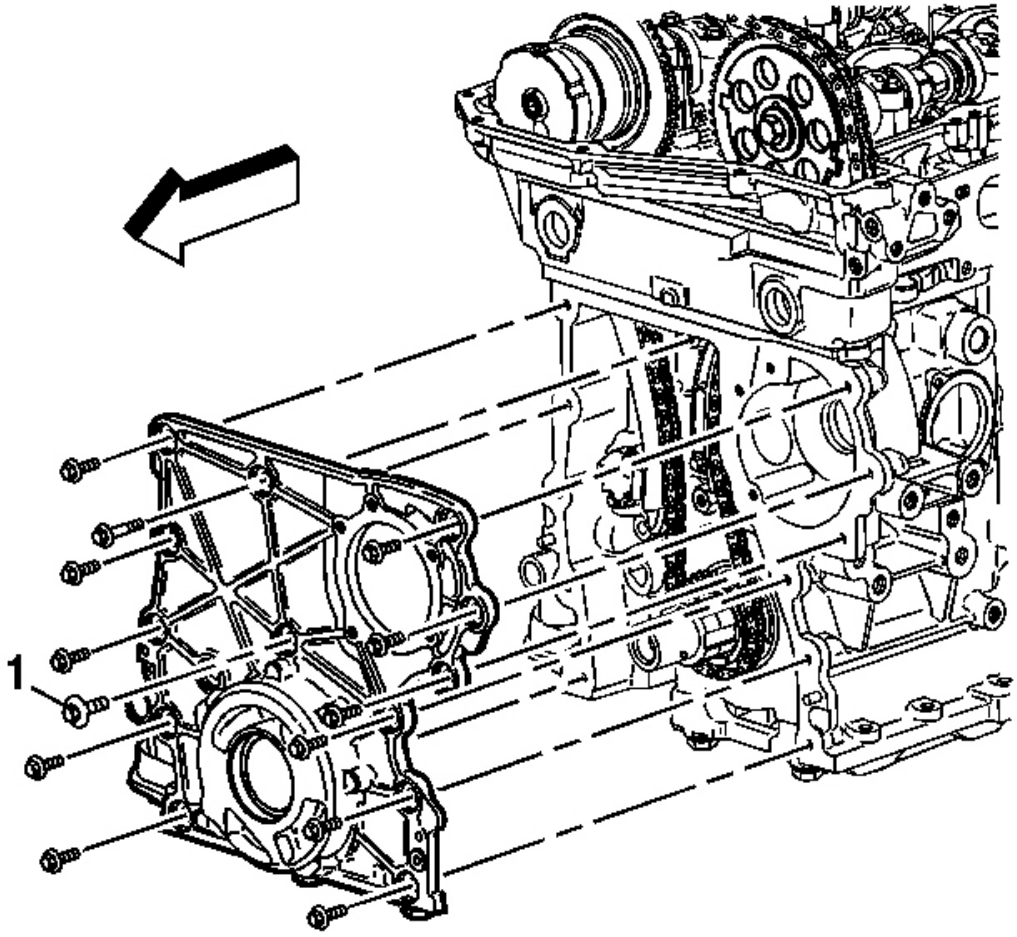


Fig. 163: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the 7 mm center bolt (1).
11. Loosen and remove the remaining engine front cover bolts.
12. Place 2 of the front cover bolts in the jack screw holes on the front cover and tighten the bolts evenly to release the front cover from the engine.
13. Remove the 2 bolts from the front cover.
14. Remove the oil pump. Refer to **Oil Pump Replacement**.
15. Clean and inspect the front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

Installation Procedure

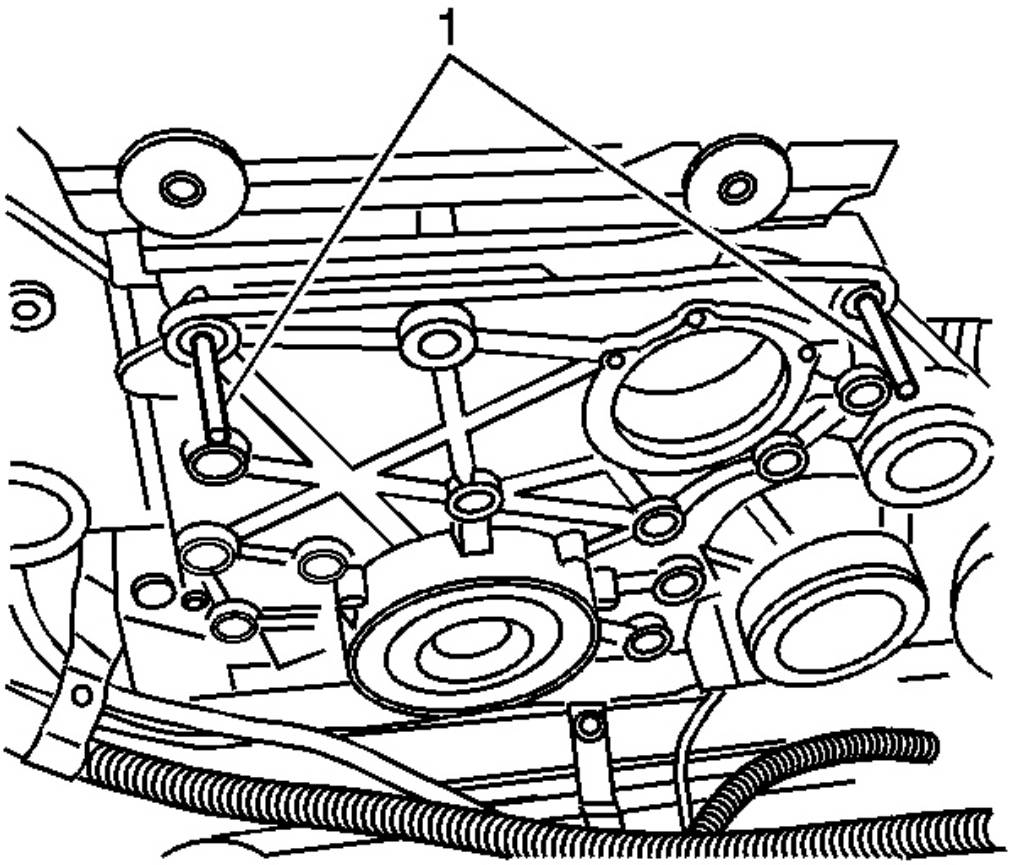


Fig. 164: Aligning Engine Front Cover Using J 44219
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 44219** onto the engine. See **Special Tools**.

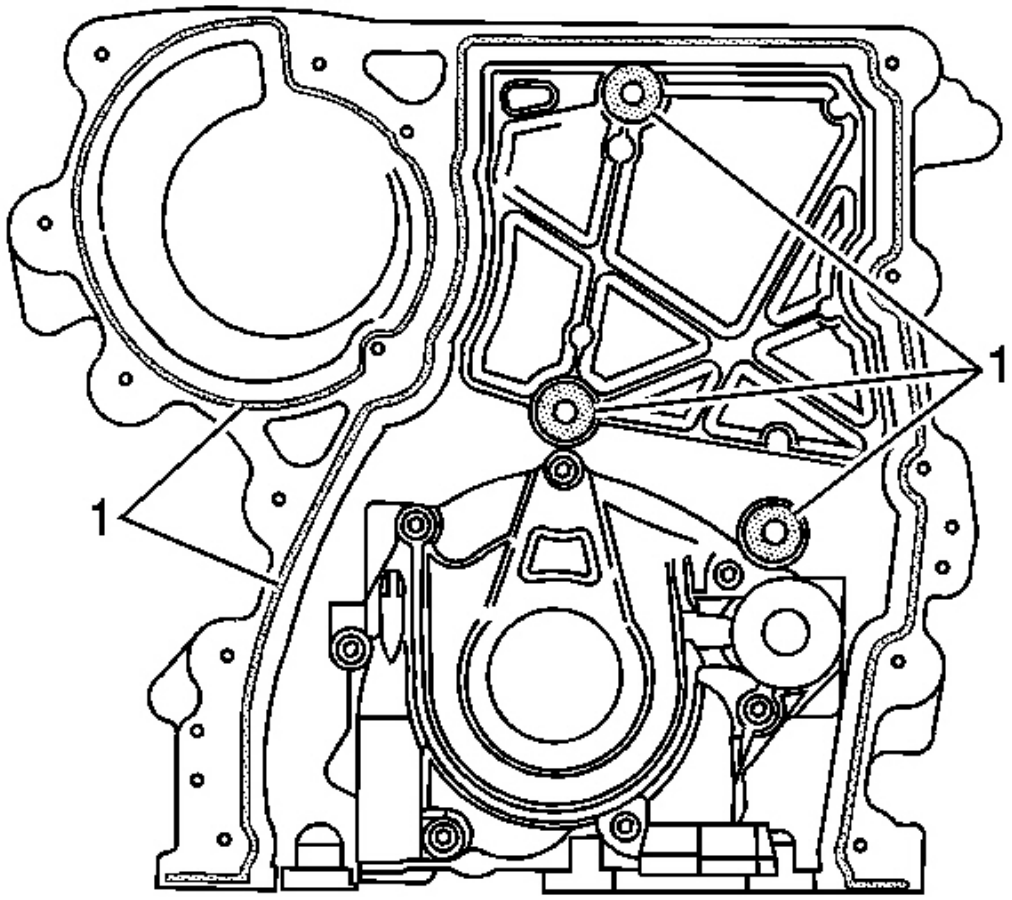


Fig. 165: Locating Sealer Application Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine front cover must be installed within 10 minutes from when the sealer was applied.

2. Apply a 3 mm (0.12 in) bead of sealer to the trace grooves on back side of the engine front cover (1). Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
3. Also apply sealant on the inside 3 bolt hole bosses on the cover.
4. Align the oil pump to the crankshaft sprocket splines.

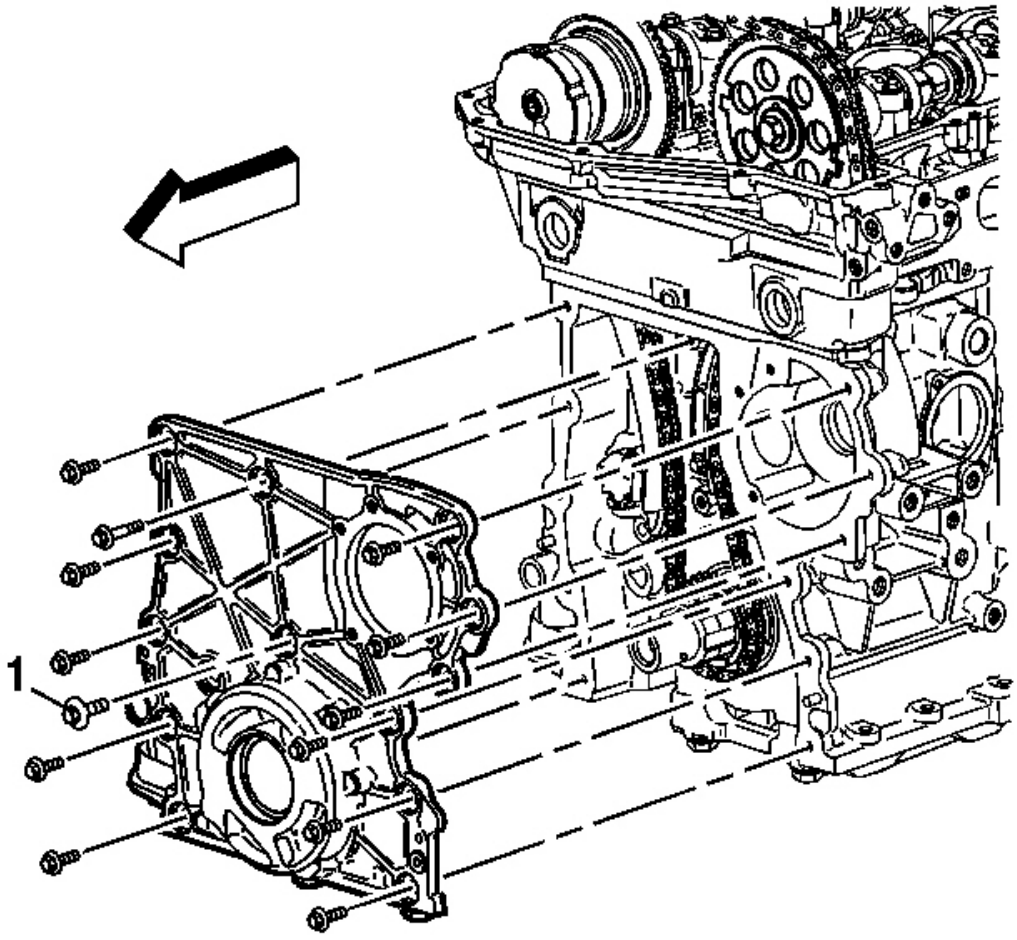


Fig. 166: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the front cover.

NOTE: **Refer to Fastener Notice .**

6. Install the front cover bolts, tightening the center bolt (1) last.

Tighten: Tighten the front cover bolts to 10 N.m (89 lb in).

7. Remove the **J 44219** . See **Special Tools**.
8. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .

9. Install the oil pan. Refer to **Oil Pan Replacement**.
10. Lower the vehicle.
11. Install the power steering pump. Refer to **Power Steering Pump Replacement (4.2L)** or **Power Steering Pump Replacement (Except 4.2L)** .
12. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
13. Install the water pump. Refer to **Water Pump Replacement** .
14. Install the drive belt. Refer to **Drive Belt Replacement**.
15. Install the cooling fan and shroud. Refer to **Cooling Fan and Shroud Replacement** .
16. Fill the engine with coolant. Refer to **Cooling System Draining and Filling (LL8)** or **Cooling System Draining and Filling (LH6, LS2)** .

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

Special Tools

- **J 36660-A** Torque Angle Meter. See **Special Tools**.
- **J 44217** Timing Chain Retention Tool

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Rotate the engine until the word Delphi on the exhaust camshaft position actuator (1) is lined up parallel with the cylinder head to cam cover mating surface.

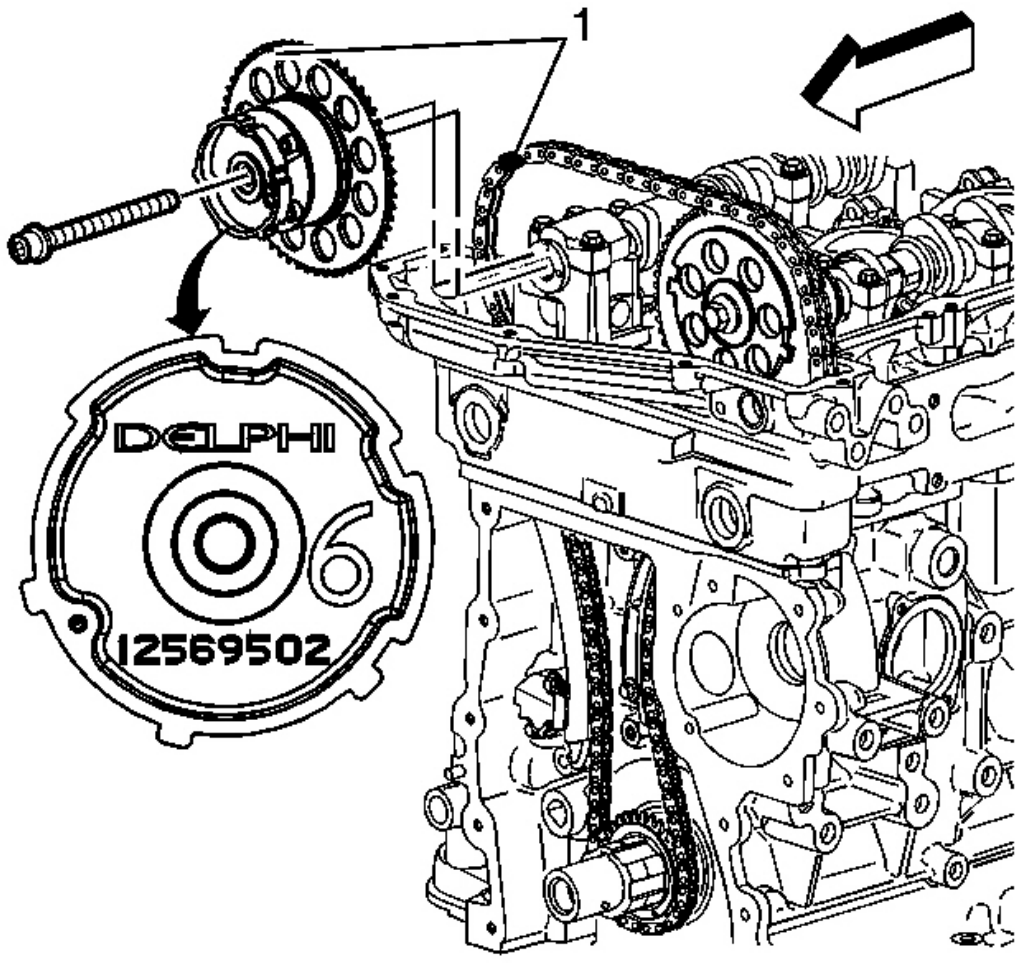


Fig. 167: View Of J 45059 Angle Meter
Courtesy of GENERAL MOTORS CORP.

3. Using the timing mark on the exhaust camshaft position actuator sprocket as a reference, make a mark on the timing chain link across from it.

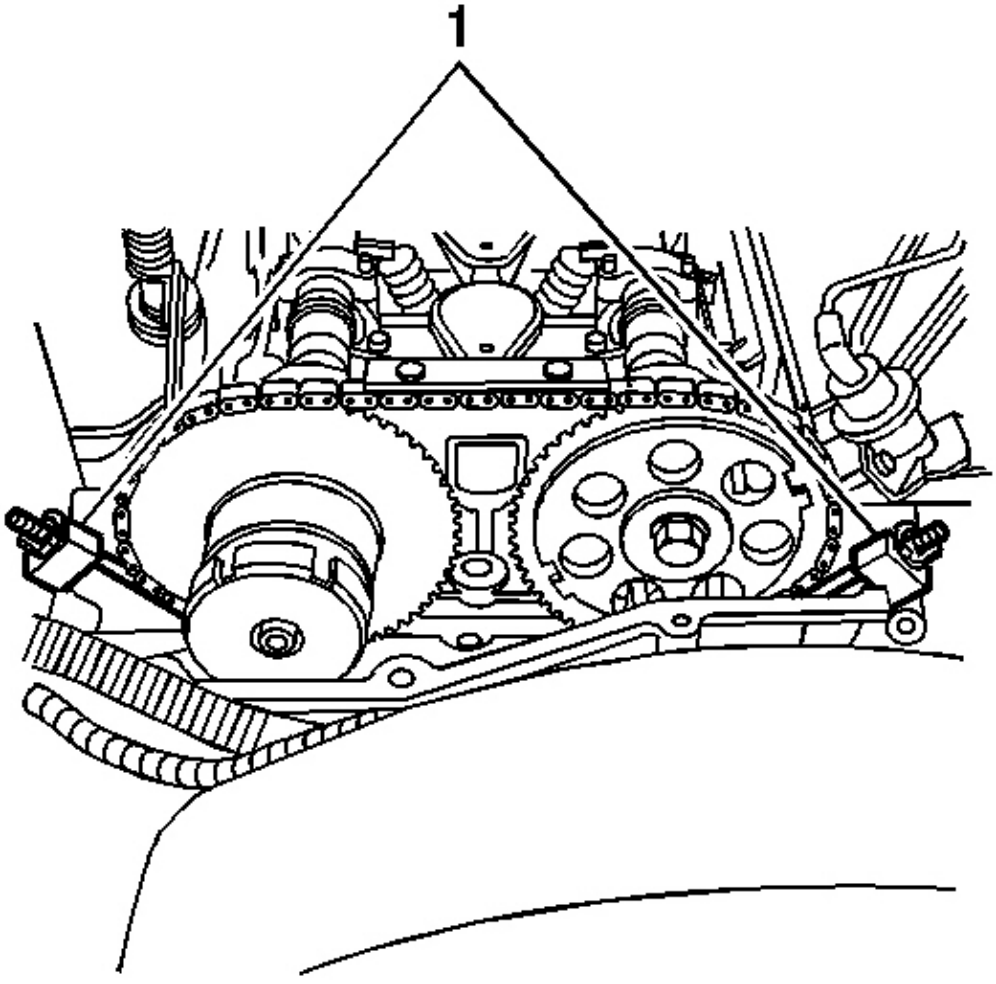


Fig. 168: View Of J 44217 & EN-44217-45 At Timing Chains
Courtesy of GENERAL MOTORS CORP.

4. Install the **J-44217** (1).
    1. Install the hook portion of the timing chain retention tools into one of the timing chain links near the timing chain shoe on both sides of the engine.
    2. Tighten the wingnuts.
    3. Ensure the hooks are still in one of the links and the gage blocks of the tool are firmly in place on the edge of the head.

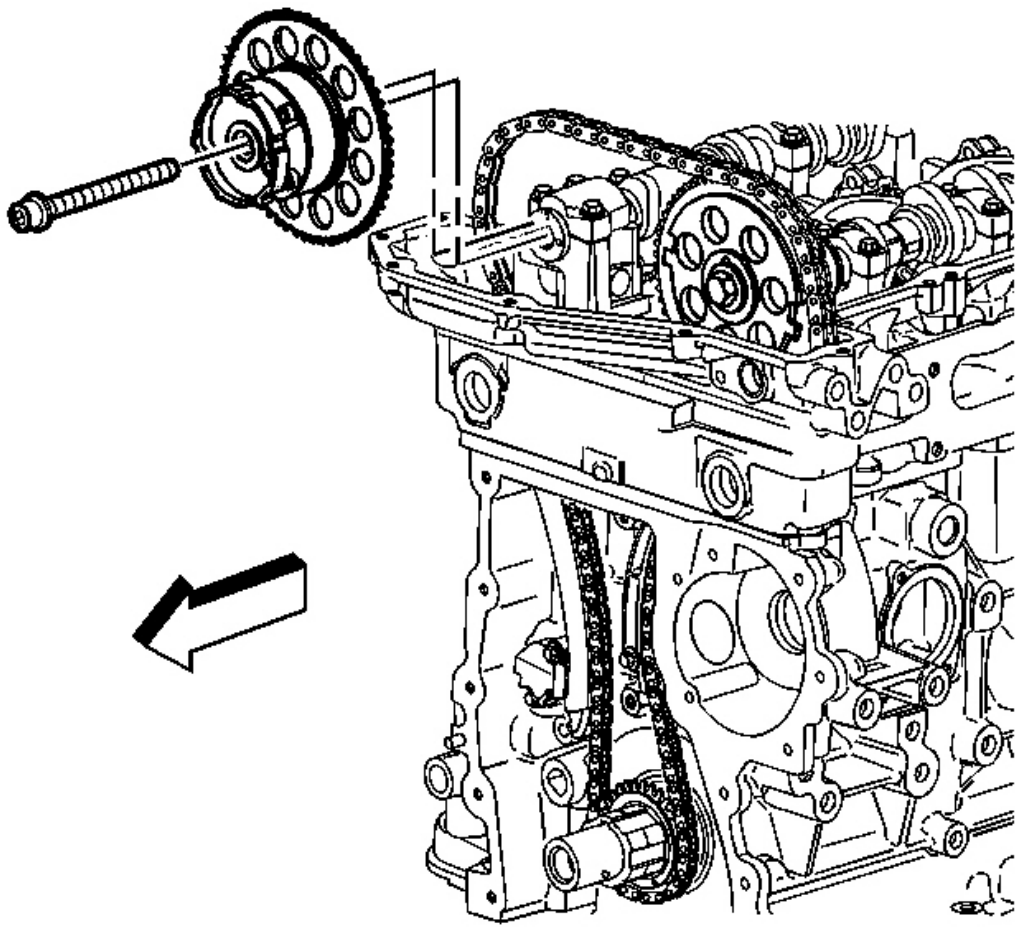


Fig. 169: Identifying Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft position actuator bolt.
6. Remove the exhaust camshaft position actuator.

Installation Procedure

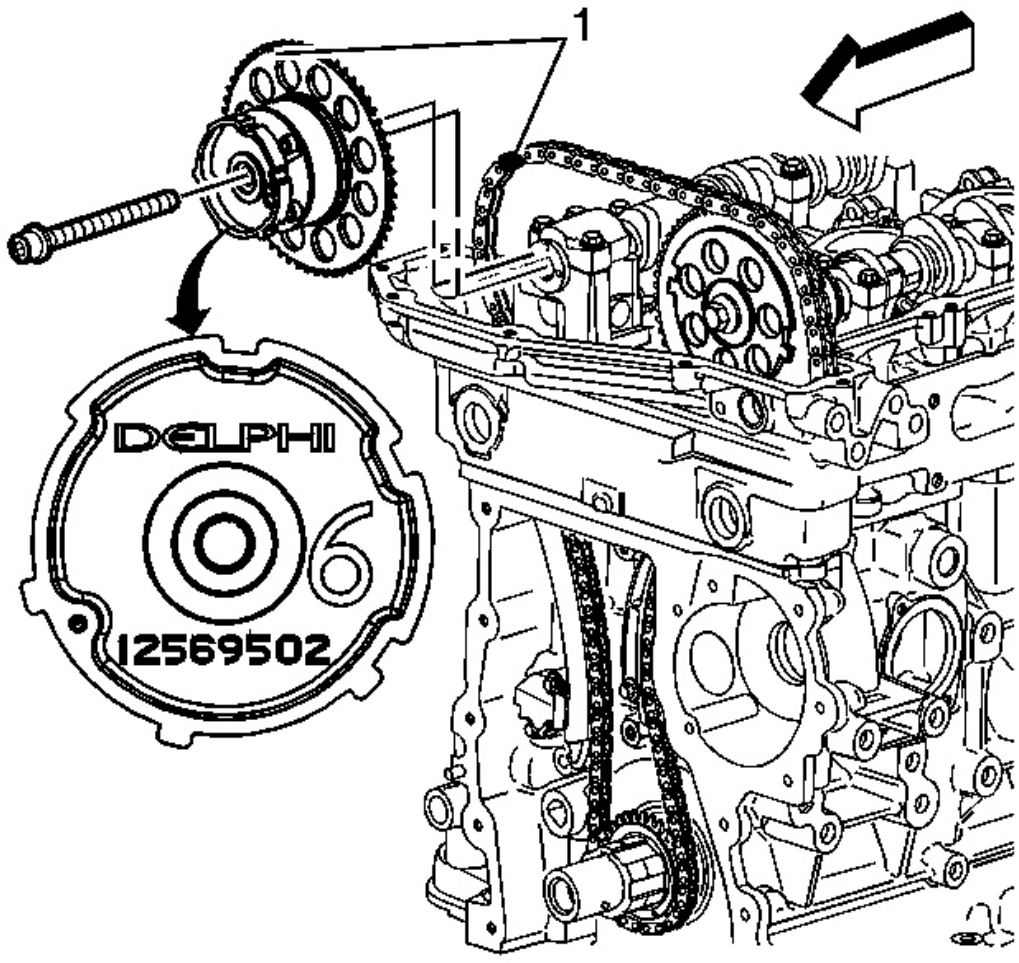


Fig. 170: View Of J 45059 Angle Meter
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust camshaft actuator into the timing chain.
2. Align the marked link of the timing chain with the timing mark on the exhaust camshaft position actuator sprocket (1).

IMPORTANT: Ensure the alignment pin is engaged between the camshaft and the exhaust camshaft position actuator.

3. Install the exhaust camshaft actuator onto the exhaust camshaft.

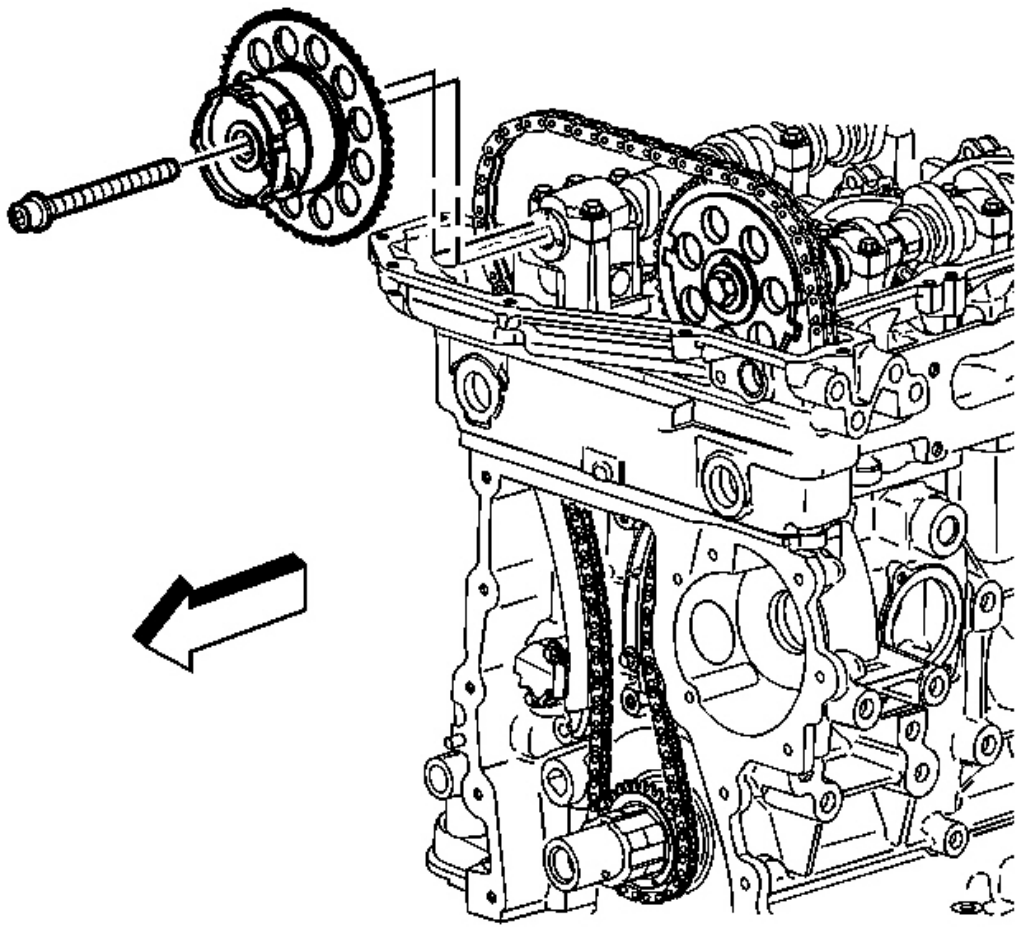


Fig. 171: Identifying Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the exhaust camshaft actuator bolt.

   Tighten:

   - Tighten the exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
   - Use the **J 36660-A** to tighten the exhaust camshaft actuator bolt the final pass an additional 135 degrees. See **Special Tools**.

5. Remove the **J-44217** .

6. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT TIMING CHAIN, SPROCKET & TENSIONER REPLACEMENT

Special Tools

- **J 36660-A** Torque Angle Meter. See **Special Tools**.
- **J 44221** Camshaft Holding Tool. See **Special Tools**.

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

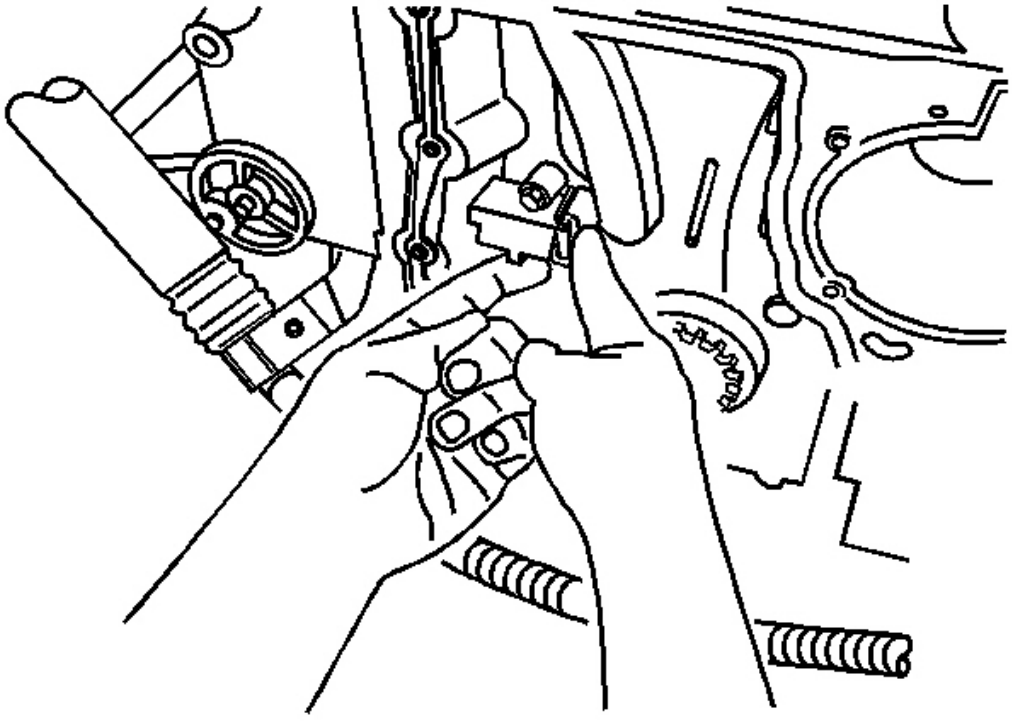


Fig. 172: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS CORP.

3. Release the tension on the timing chain by moving the tensioner shoe in.

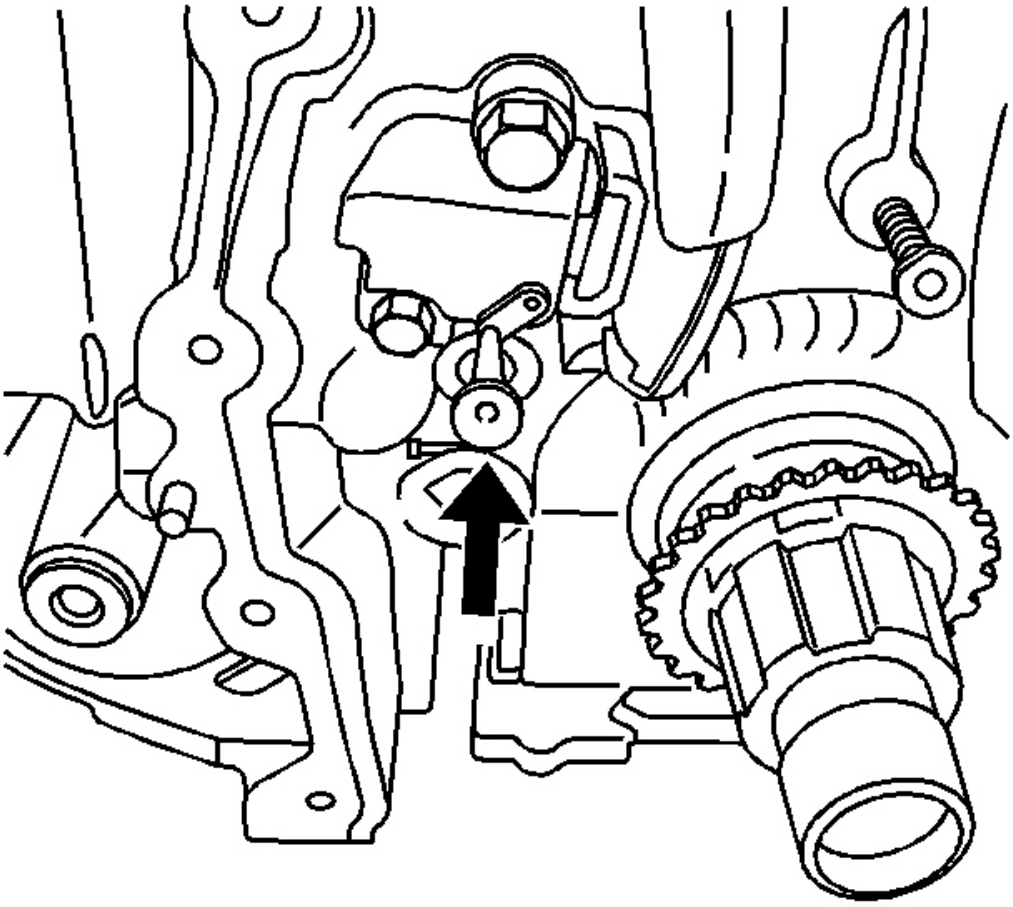


Fig. 173: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Place the tee into the tensioner to hold the shoe in place.

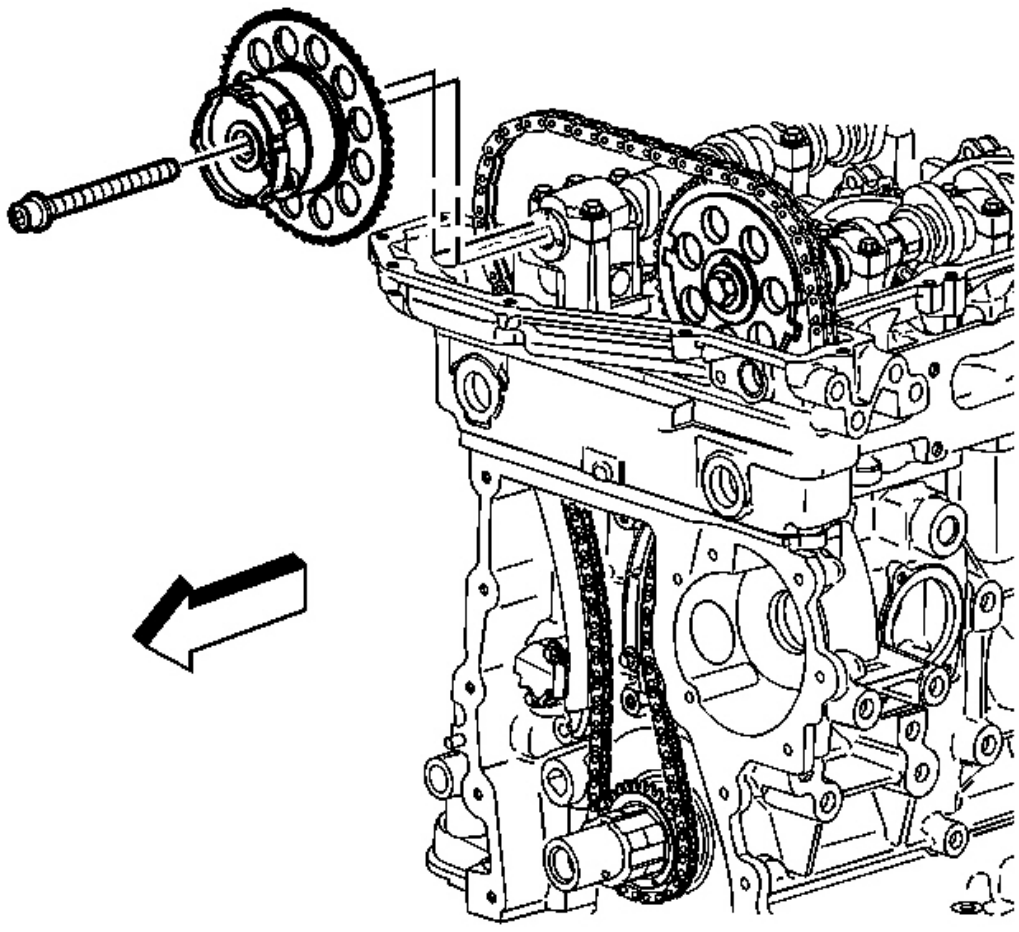


Fig. 174: Identifying Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft position actuator bolt.
6. Remove the exhaust camshaft position actuator.

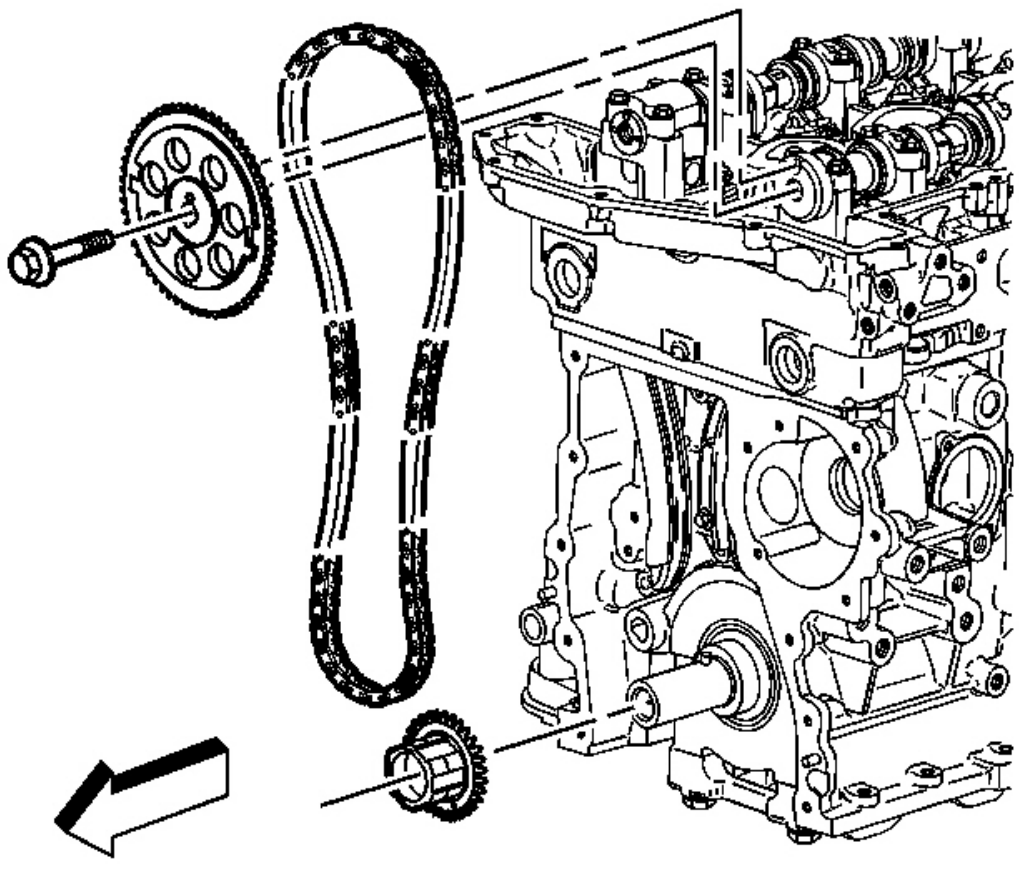


Fig. 175: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

7. Remove the intake camshaft sprocket bolt.
8. Remove the intake camshaft sprocket.
9. Remove the timing chain.
10. Remove the crankshaft sprocket.

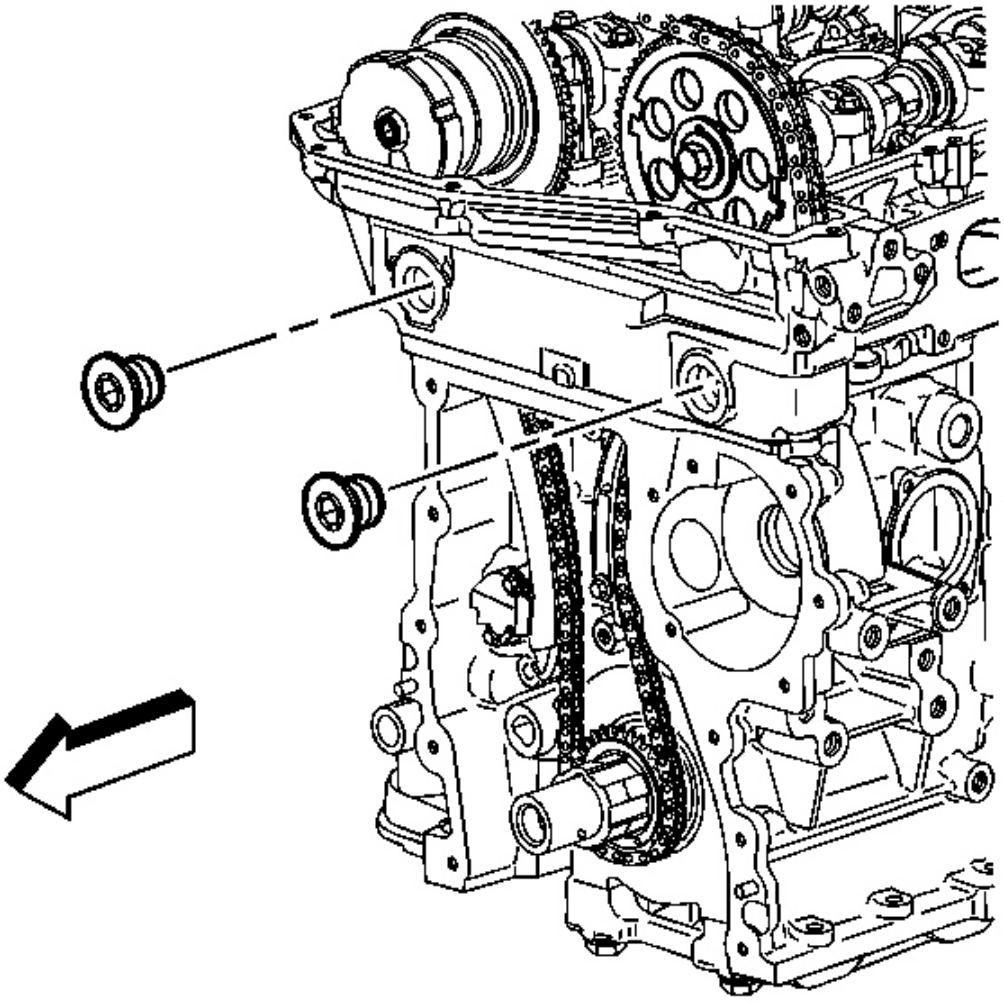


Fig. 176: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

11. Remove the cylinder head access hole plugs.

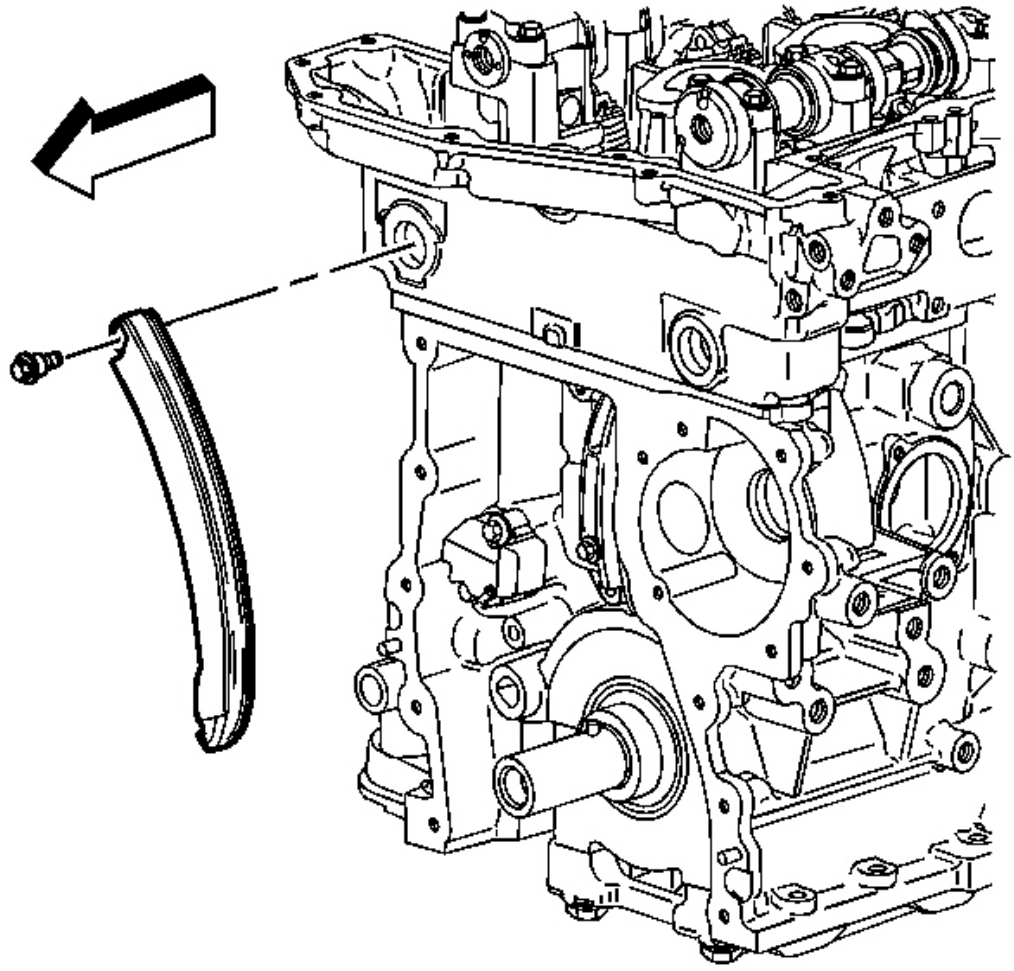


Fig. 177: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the timing chain tensioner shoe bolt.
13. Remove the timing chain tensioner shoe.

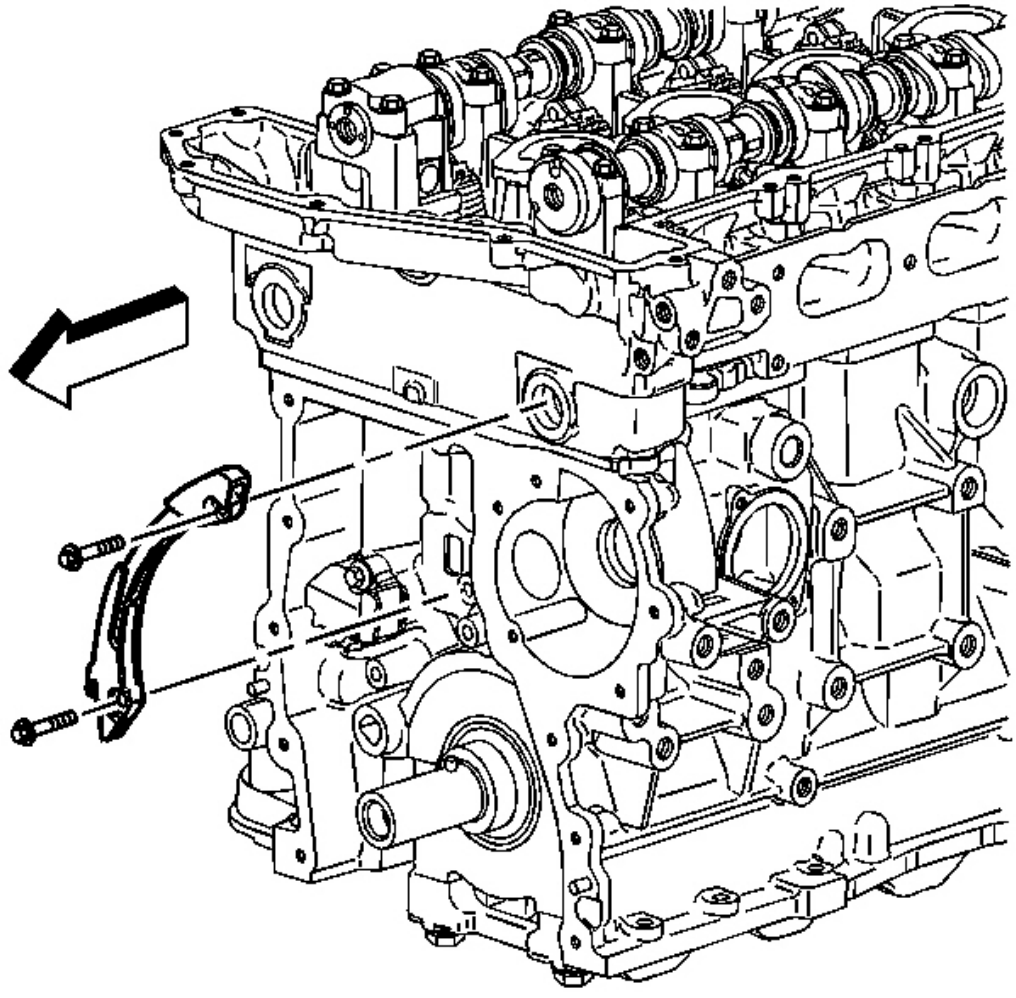


Fig. 178: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the timing chain tensioner guide bolts.
15. Remove the timing chain tensioner guide.

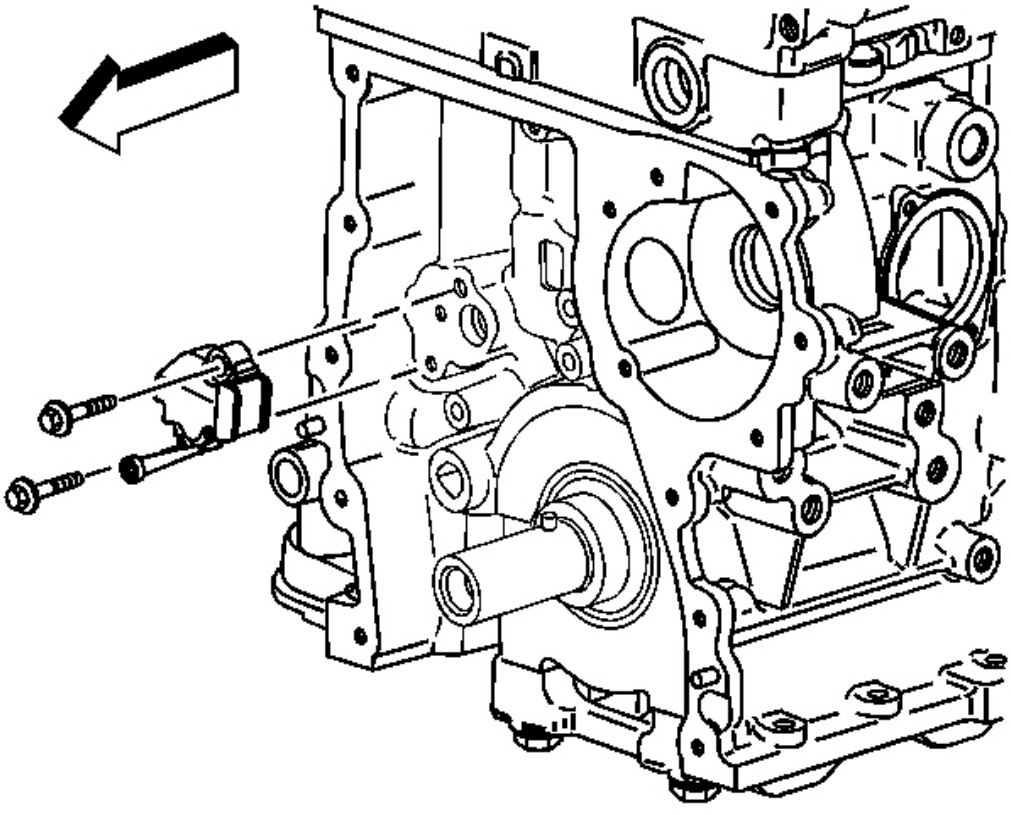


Fig. 179: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the timing chain tensioner bolts.
17. Remove the timing chain tensioner.

Installation Procedure

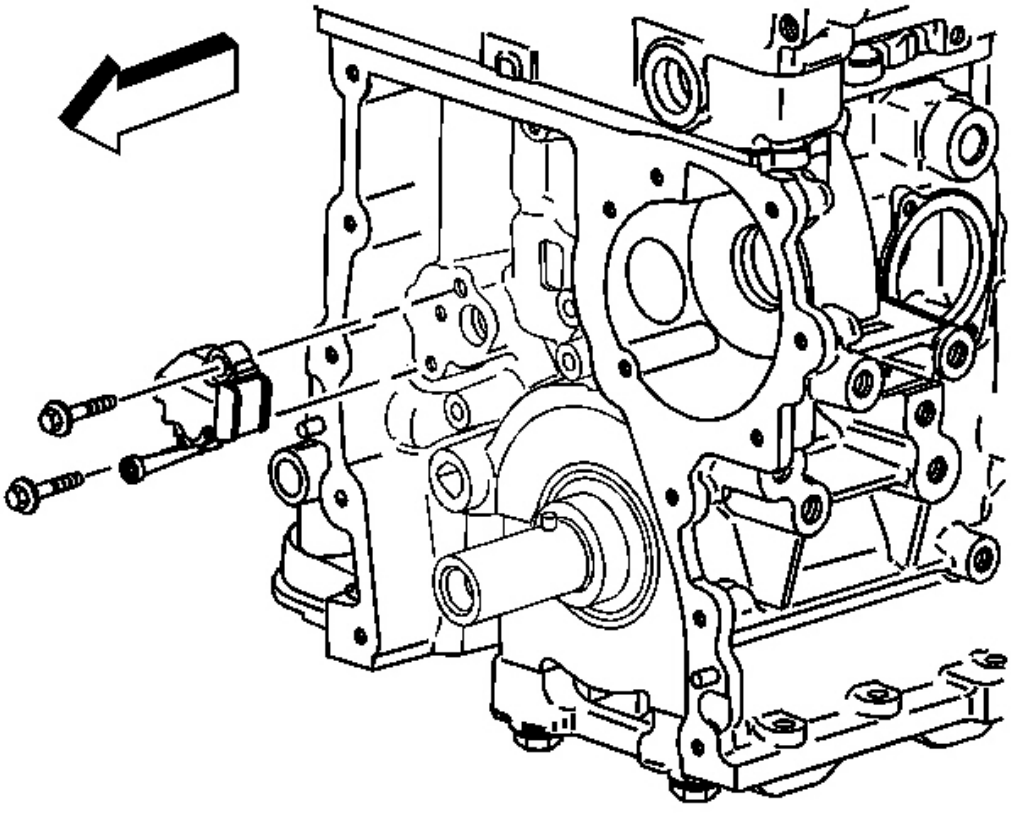


Fig. 180: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Every seventh link of the timing chain is darkened to aid in aligning the timing marks.

1. Install the timing chain tensioner and secure the tensioner with the bolts.

   Tighten: Tighten the timing chain tensioner bolts to 25 N.m (18 lb ft).

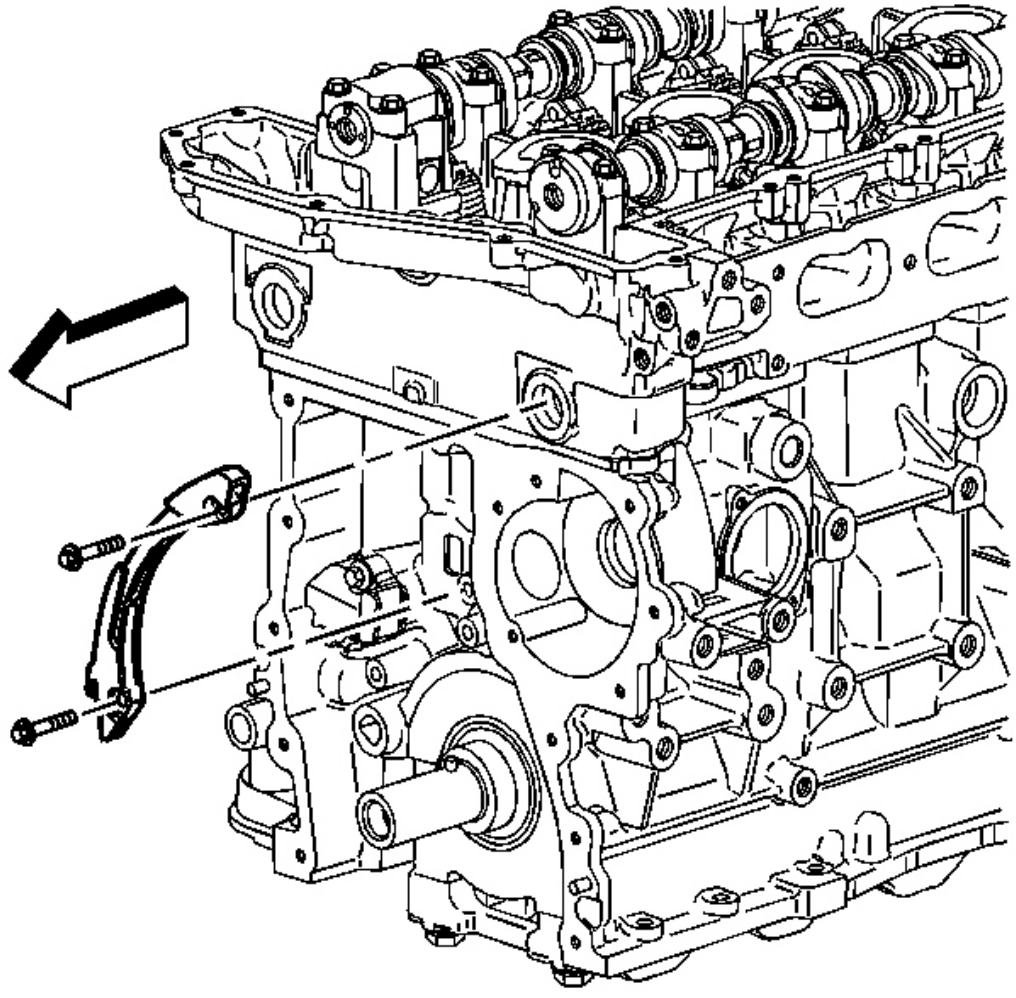


Fig. 181: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the timing chain tensioner guide and secure the guide with the bolts.

   Tighten: Tighten the timing chain tensioner guide to 10 N.m (89 lb in).

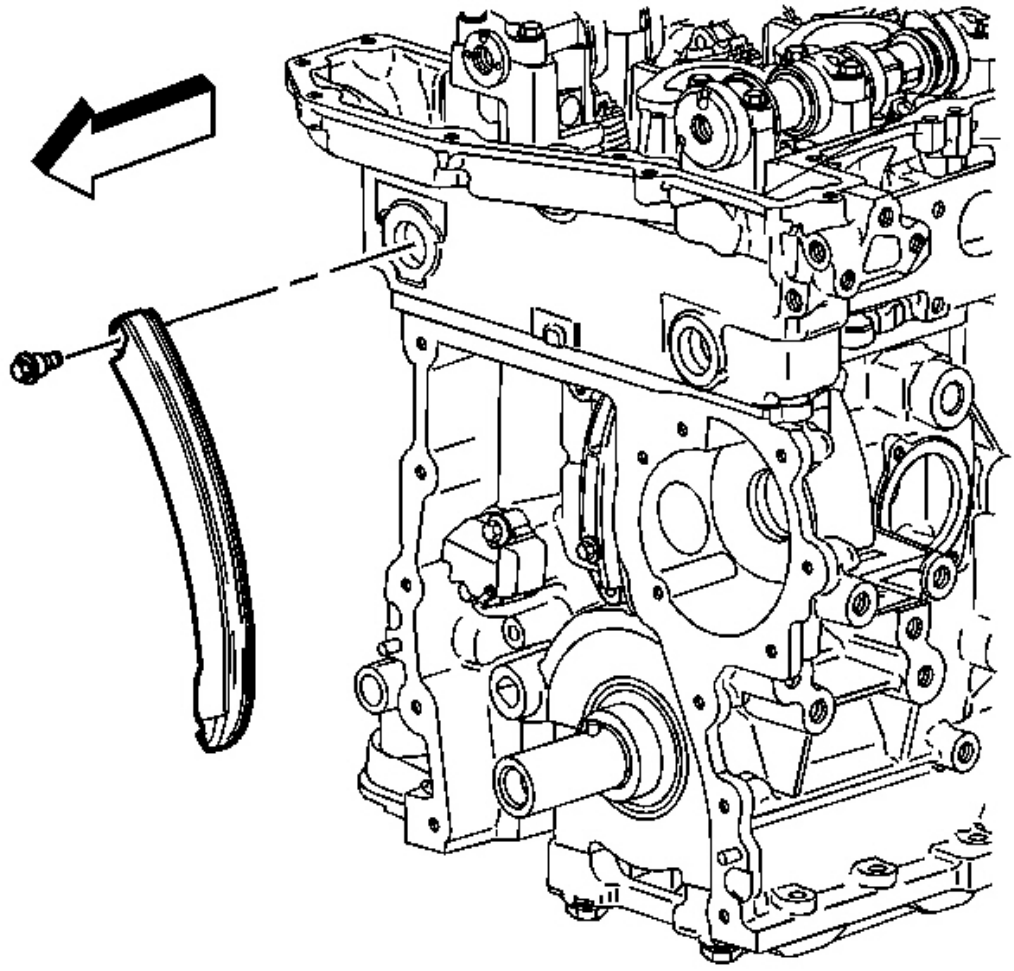


Fig. 182: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain tensioner shoe and secure the shoe with the bolt.

   Tighten: Tighten the timing chain tensioner shoe bolt to 26 N.m (19 lb ft).

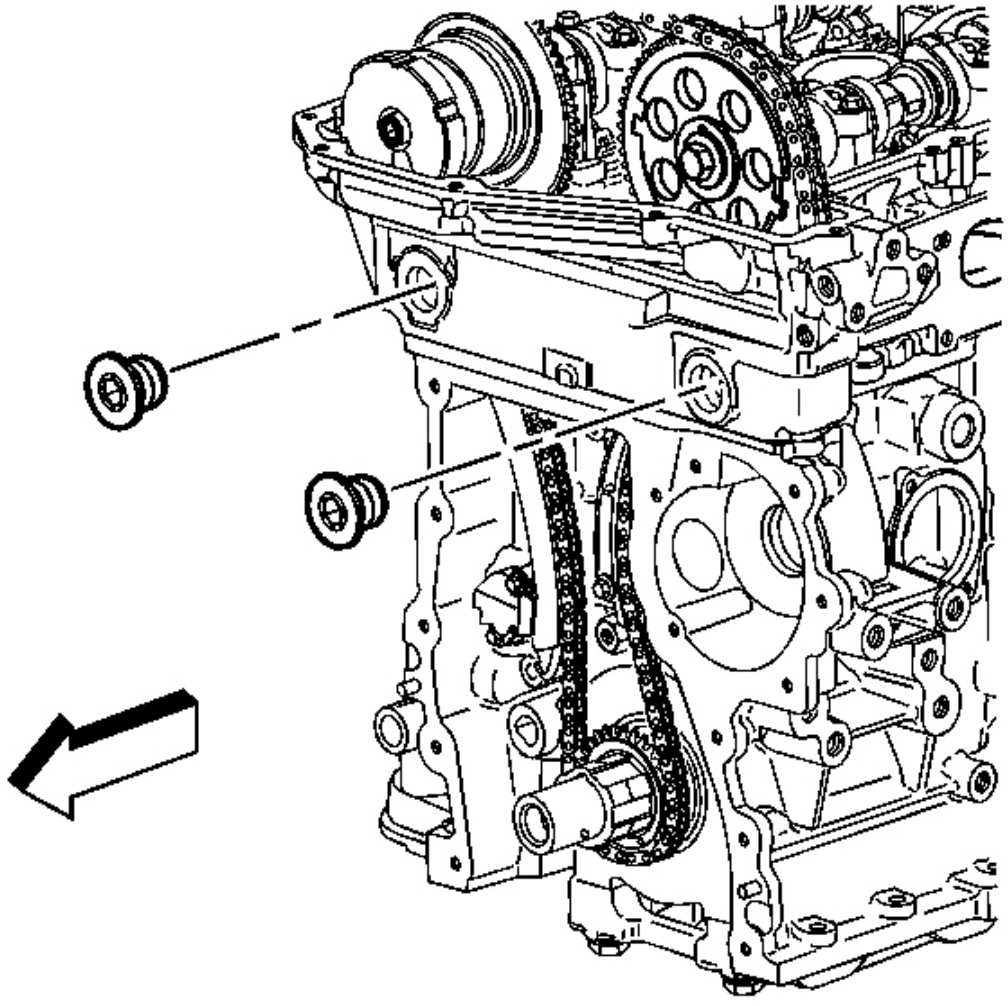


Fig. 183: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head access hole plugs.

   Tighten: Tighten the cylinder head access hole plugs to 5 N.m (44 lb in).

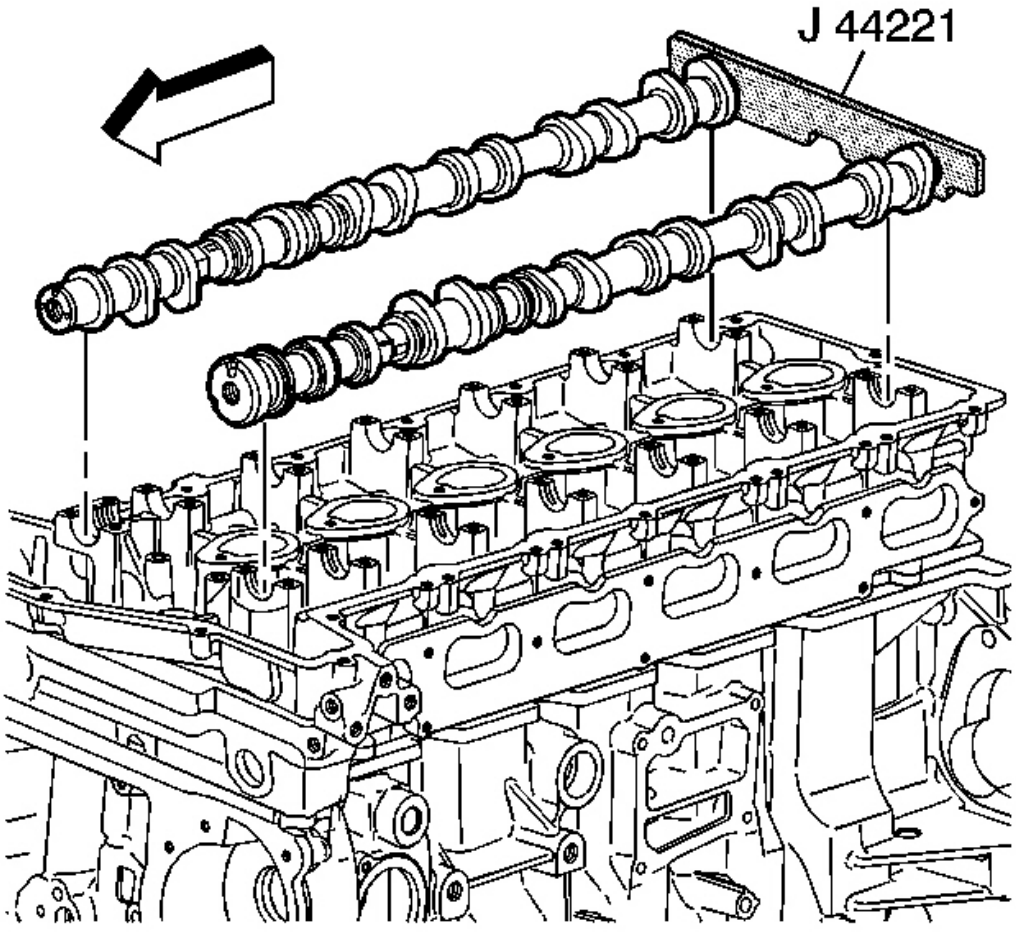


Fig. 184: Identifying J 44221 Installed Onto Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 44221** with the camshaft flats up and the number 1 piston at top dead center. See **Special Tools**. The crank pin will be at 12 o'clock when the number 1 piston is at top dead center.

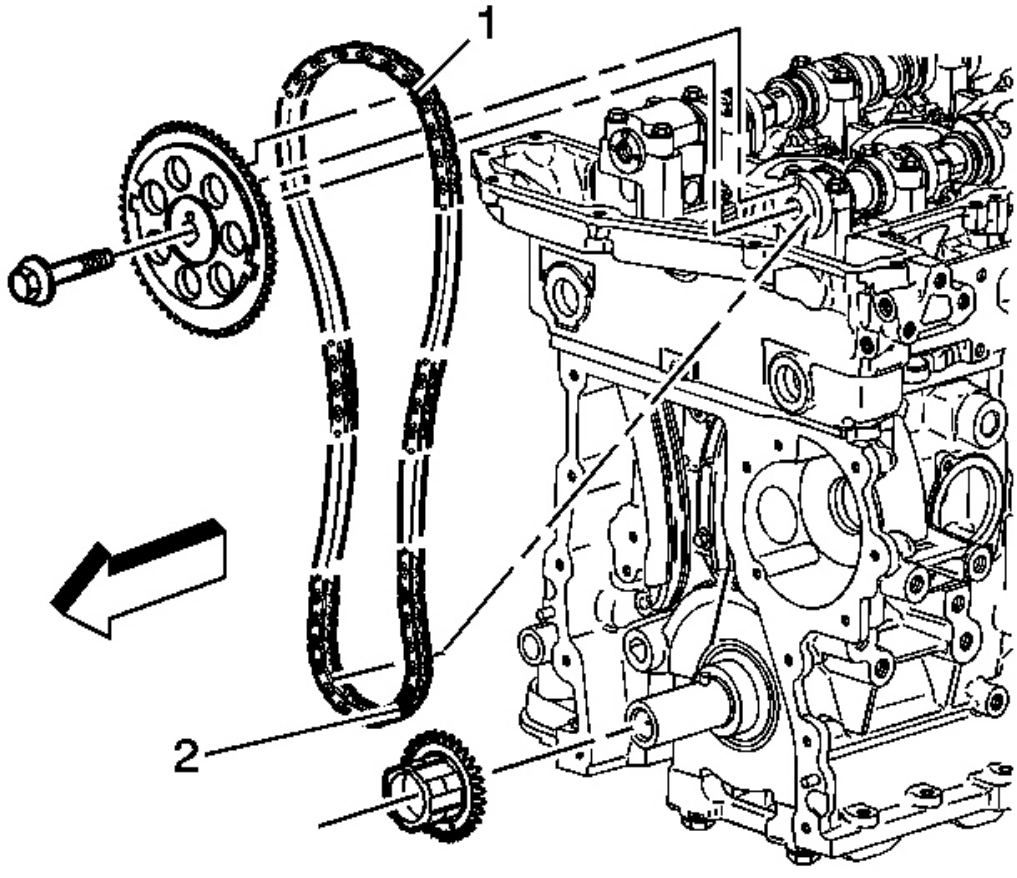


Fig. 185: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft sprocket (1).
7. Install the intake camshaft sprocket into the timing chain. Refer to **Camshaft Position Actuator Diagnosis**.
8. Align the dark link of the timing chain with the timing mark on the intake camshaft sprocket (1).
9. Feed the timing chain down through the opening in the head.
10. Install the timing chain on the crankshaft sprocket. Align the dark link of the timing chain with the timing mark on to the crankshaft sprocket.

IMPORTANT: It may be necessary to remove J 44221 to rotate and hold the camshaft (hex) to align the pin to the camshaft sprocket. See Special Tools.

11. Install the intake camshaft sprocket onto the intake camshaft.

12. Install the intake camshaft sprocket washer and bolt.

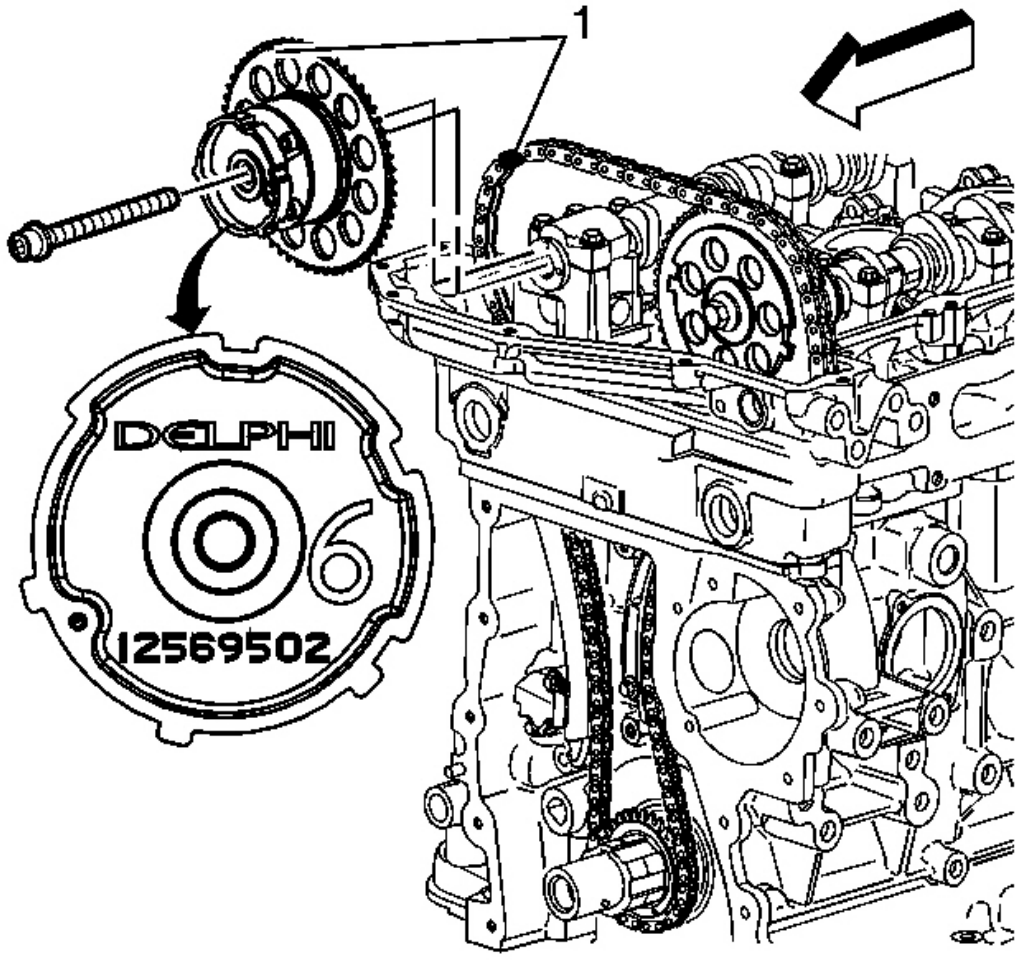


Fig. 186: View Of J 45059 Angle Meter
Courtesy of GENERAL MOTORS CORP.

13. Install the exhaust camshaft actuator into the timing chain.
14. Align the dark link of the timing chain with the timing mark on the exhaust camshaft actuator (1).

IMPORTANT: It may be necessary to remove the J 44221 to rotate and hold the camshaft hex to align the pin to the camshaft sprocket. See Special Tools.

15. Install the exhaust camshaft actuator onto the exhaust camshaft.

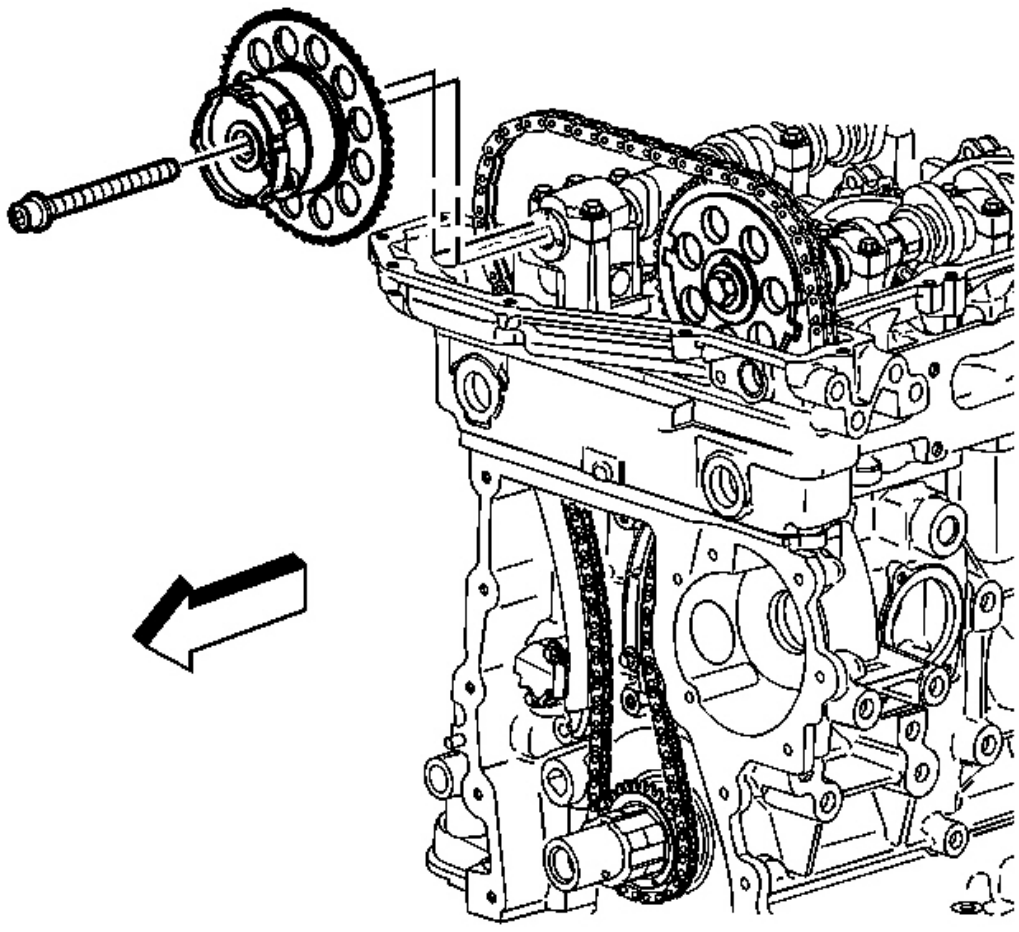


Fig. 187: Identifying Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

16. Install the exhaust camshaft actuator bolt.

    Tighten:

    - Tighten the exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
    - Use **J 36660-A** to tighten the exhaust camshaft actuator bolt the final pass an additional 135 degrees. See **Special Tools**.

17. Install the intake camshaft sprocket bolt.

    Tighten:

    - Tighten the intake camshaft sprocket bolt the first pass to 20 N.m (15 ft lb).

- Use **J 36660-A** to tighten the intake camshaft sprocket bolt the final pass an additional 100 degrees. See **Special Tools**.

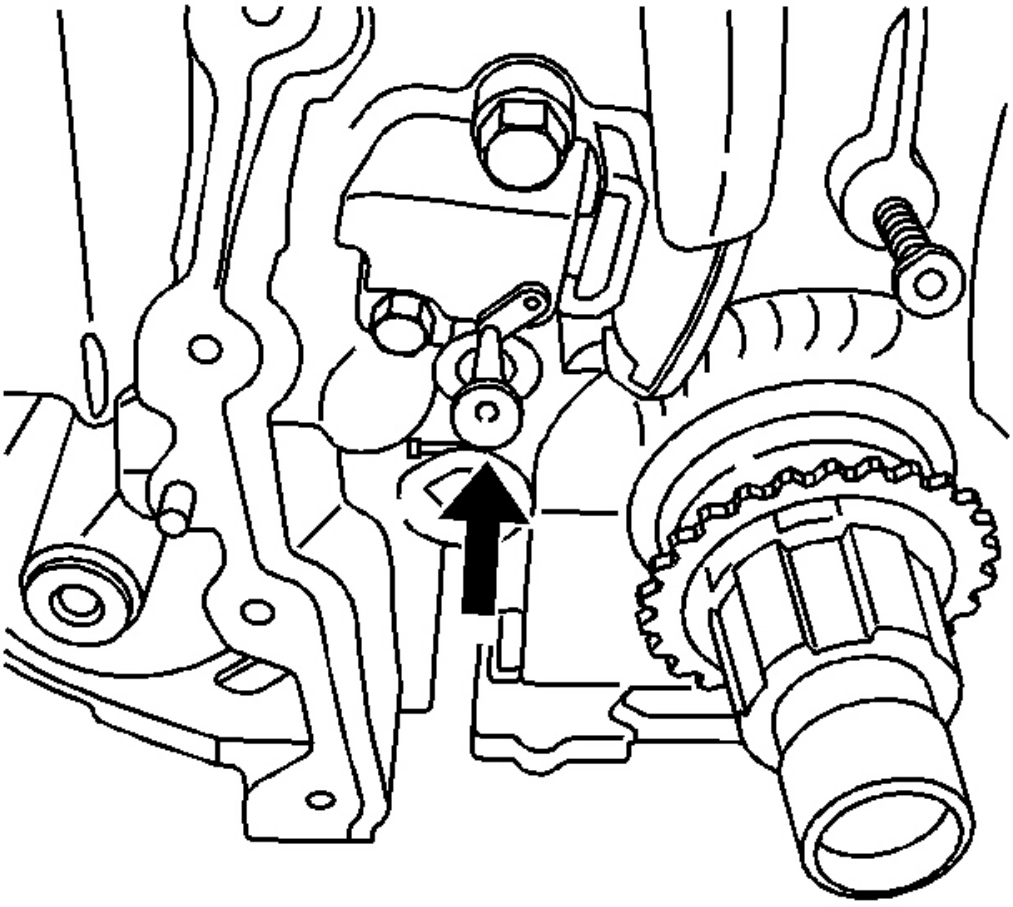


Fig. 188: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

18. Remove the tee in the timing chain tensioner to regain tension on the timing chain.
19. Remove the **J 44221** . See **Special Tools**.

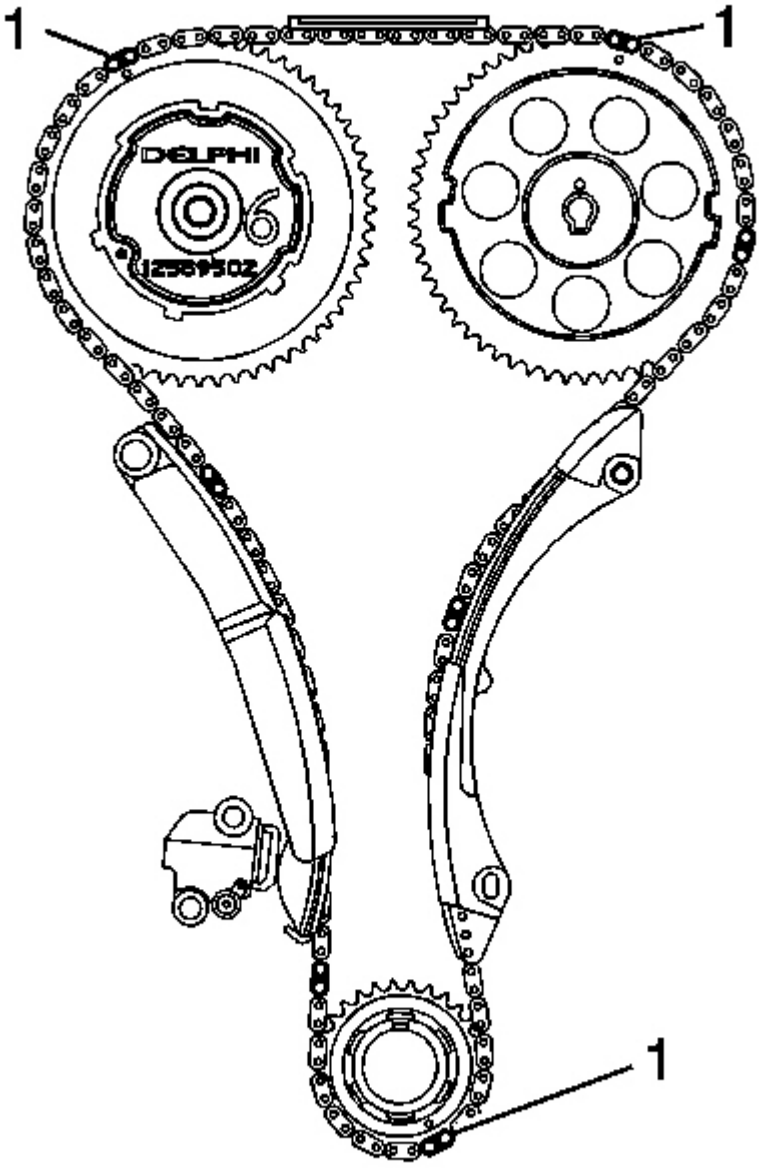


Fig. 189: Locating Timing Chain Dark Links
Courtesy of GENERAL MOTORS CORP.

20. The dark lines (1) on the chain should be aligned with the marks on the sprockets as shown.
21. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
22. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT REPLACEMENT

Tools Required

- **J 44221** Camshaft Holding Tool. See **Special Tools**.
- **J 44222** Camshaft Sprocket Holding Tool. See **Special Tools**.
- **J 36660-A** Torque/Angle Meter. See **Special Tools**.

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the intake and the exhaust camshaft sprocket bolts.

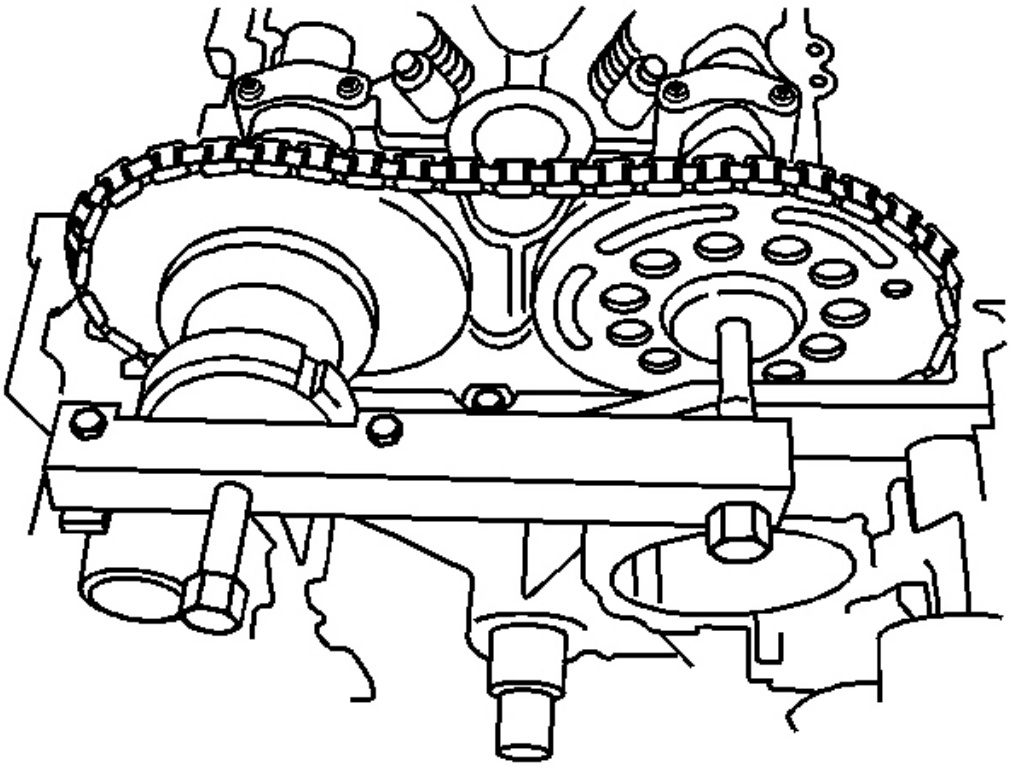


Fig. 190: View Of J 44222 Installed Onto Camshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 44222** onto the cylinder head and adjust the horizontal bolts into the camshaft sprockets in order to maintain chain tension and keep from disturbing the timing chain components. See **Special Tools**.
4. Carefully move the sprockets with the timing chain, off of the camshafts.
5. Remove the camshaft cap bolts.

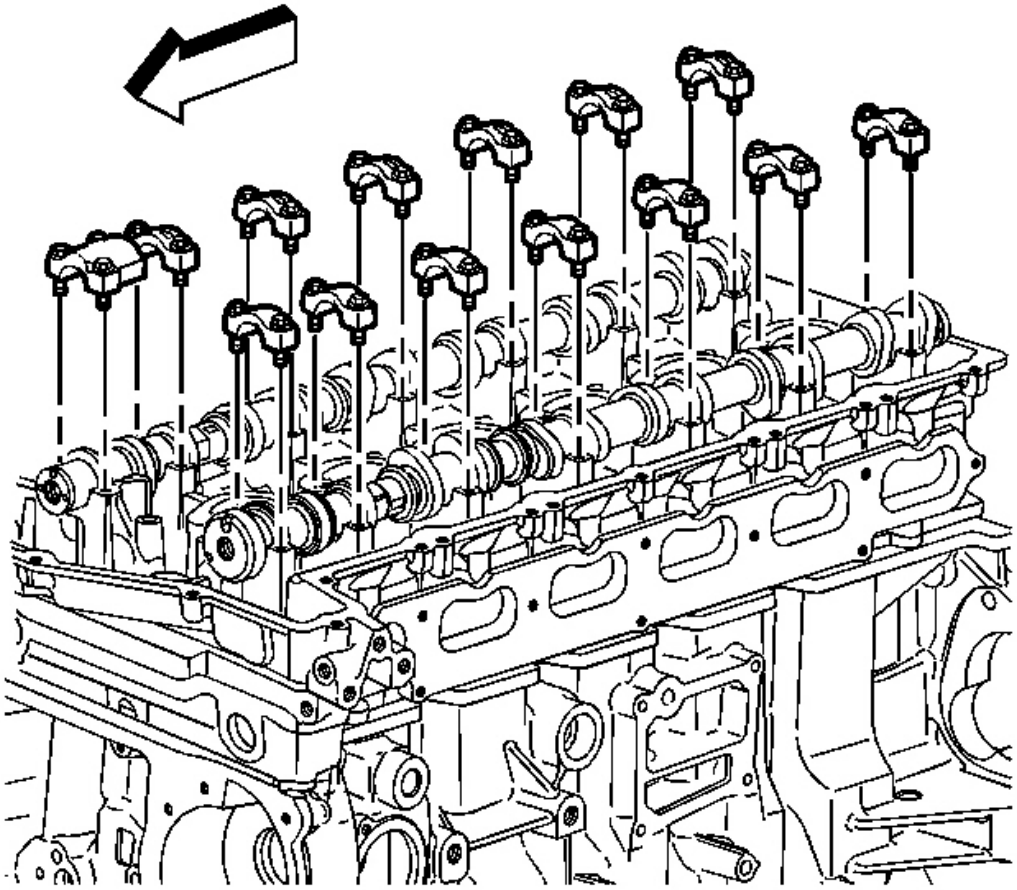


Fig. 191: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the camshaft caps in a rack to ensure the caps are installed in the same location from which they were removed.

6. Remove the camshaft caps and store.

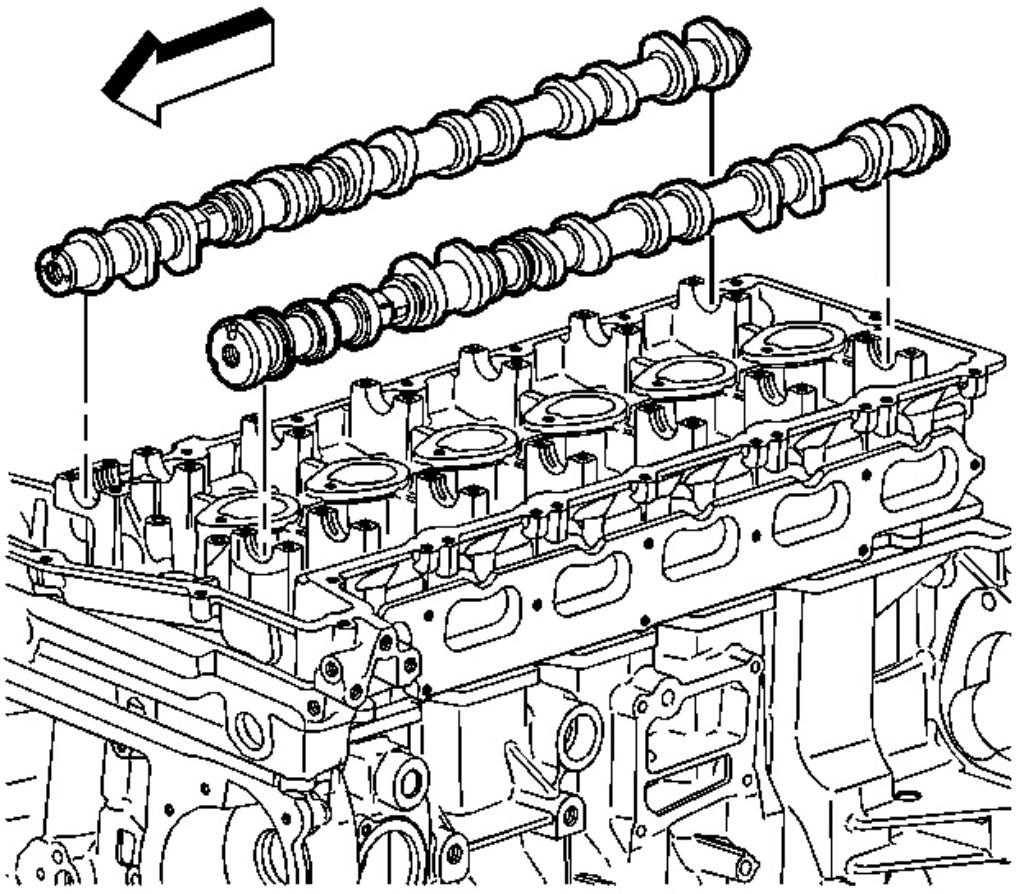


Fig. 192: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshafts.

Installation Procedure

1. Coat the camshaft journals, camshaft journal thrust face, and camshaft lobes with clean engine oil.

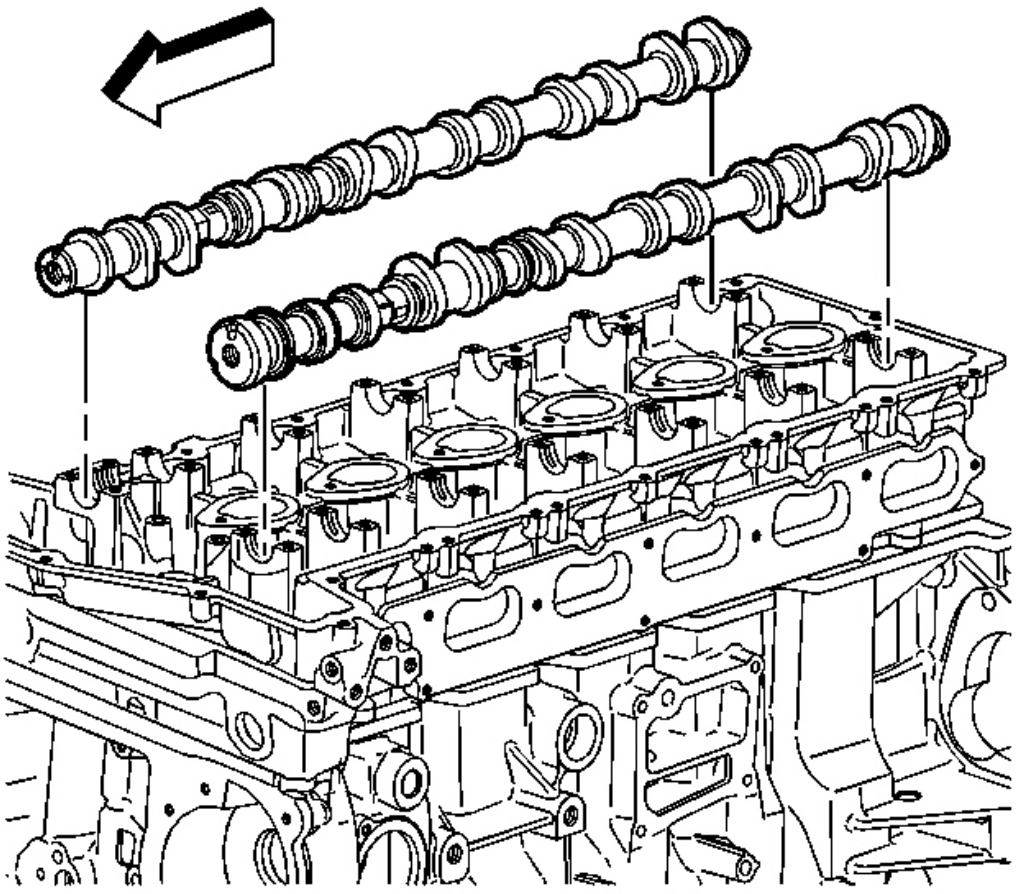


Fig. 193: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

2. Install the intake and exhaust camshafts to their original positions.
3. Install the **J 44221** with the camshaft flats up and the number 1 cylinder at top dead center. See **Special Tools**.

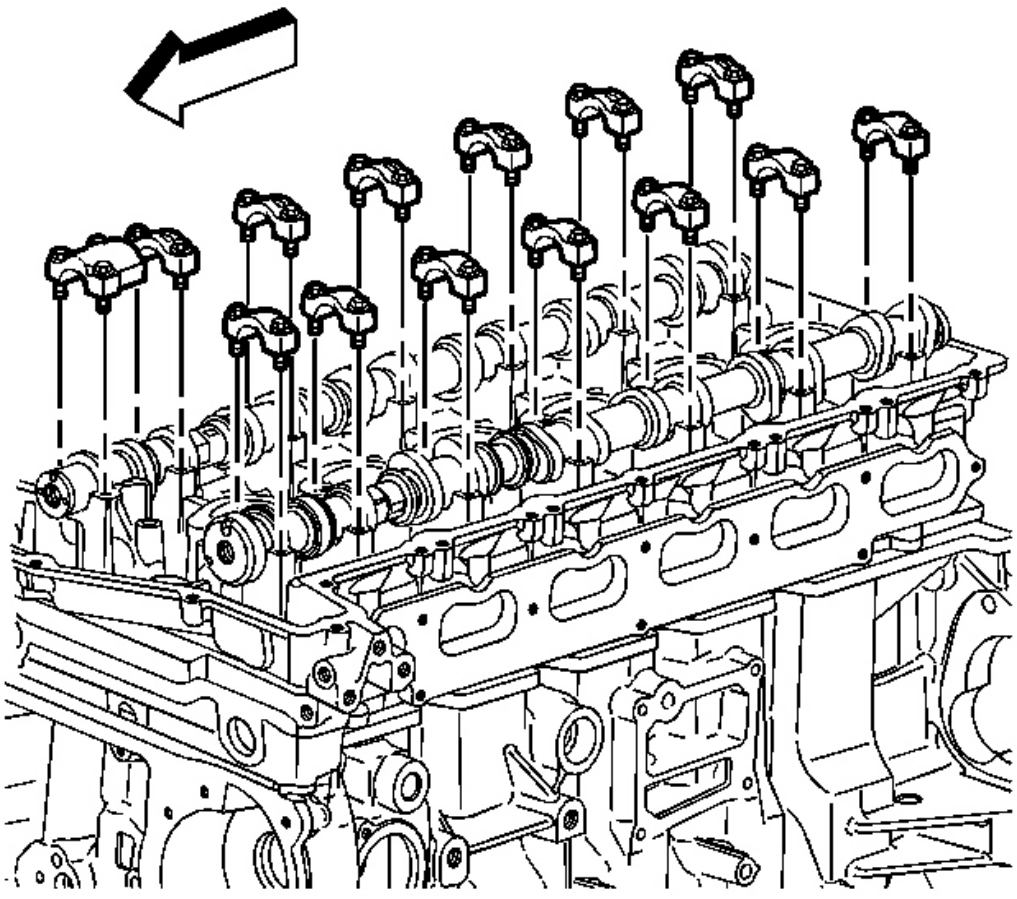


Fig. 194: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Install the camshaft caps onto their original locations. The camshaft caps are pin stamped for direction and numerical order.

4. Install the camshaft caps and bolts.

   Tighten: Tighten the camshaft cap bolts to 12 N.m (106 lb in).

5. Remove the **J 44221** . See **Special Tools**.

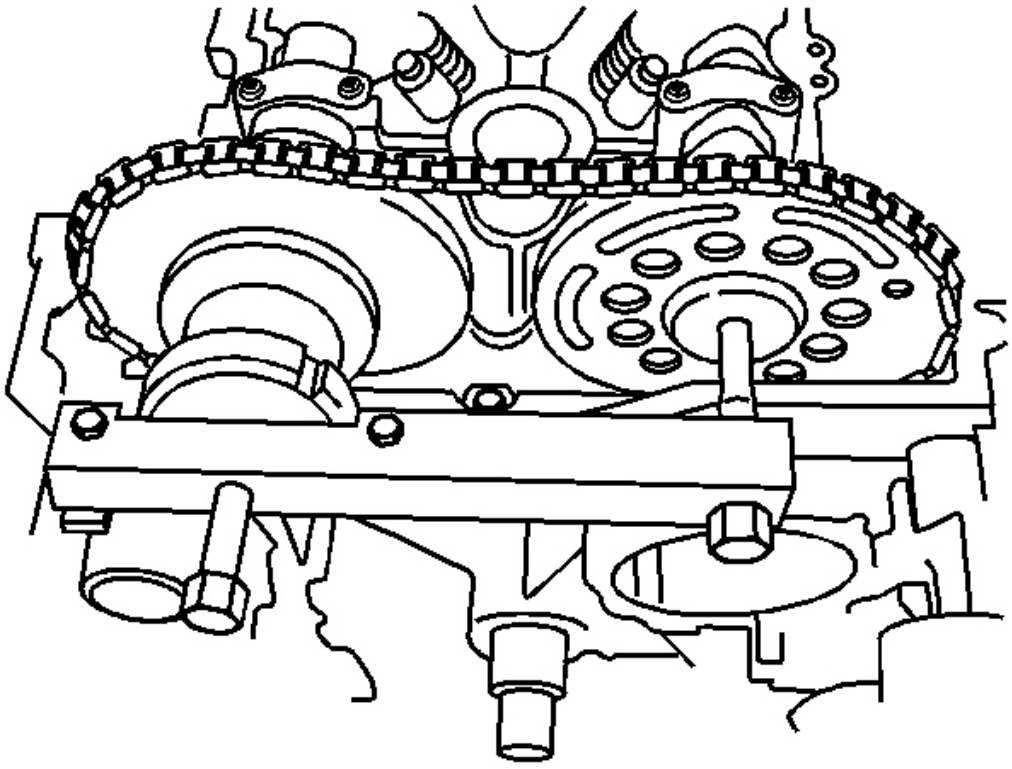


Fig. 195: View Of J 44222 Installed Onto Camshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

6. Carefully move the sprockets back onto the camshafts and remove the **J 44222** . See **Special Tools**.
7. Install the intake camshaft sprocket washer and bolt, and the exhaust camshaft actuator bolt.

Tighten:

- Tighten the intake camshaft sprocket bolt the first pass to 20 N.m (15 lb ft).
- Use the **J 36660-A** to tighten the intake camshaft sprocket bolt the final pass an additional 100 degrees. See **Special Tools**.
- Tighten the exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
- Use the **J 36660-A** to tighten the exhaust camshaft actuator bolt a final pass an additional 135 degrees. See **Special Tools**.

8. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

OIL FILTER ADAPTER & BYPASS VALVE ASSEMBLY REPLACEMENT

Removal Procedure

1. Remove the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

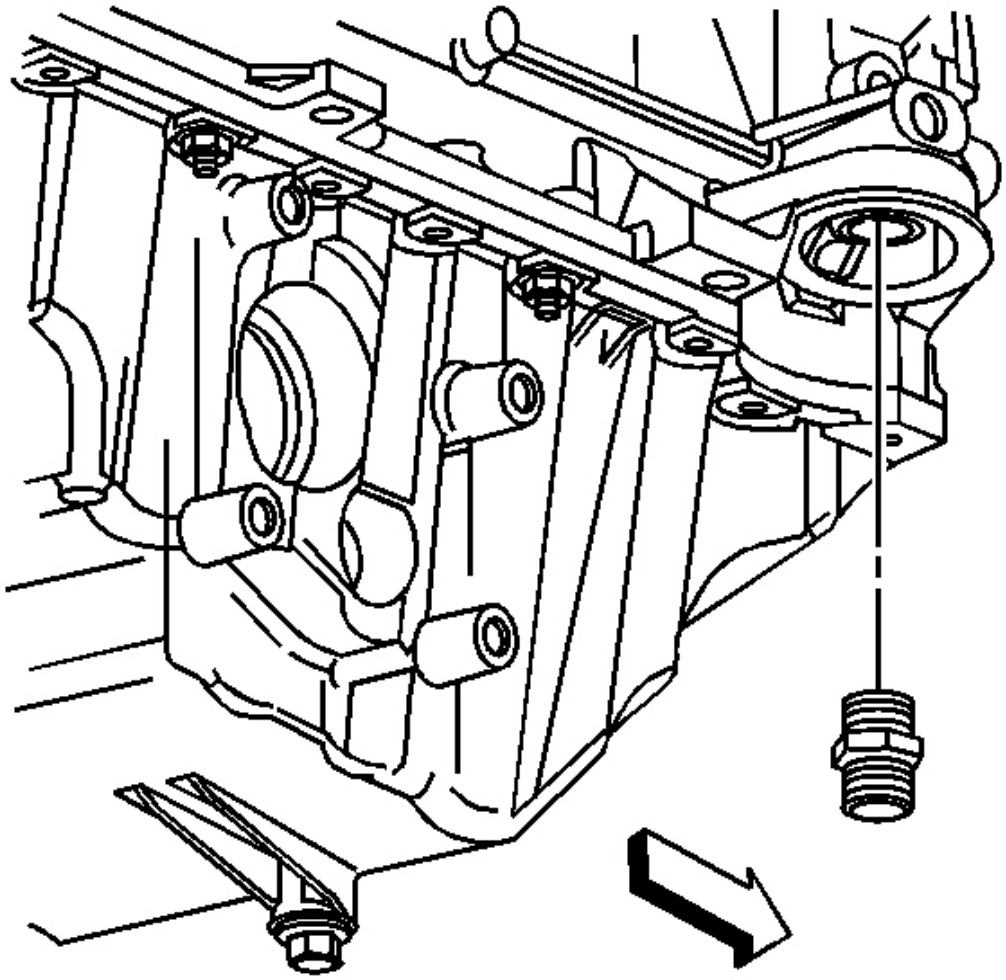


Fig. 196: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter adapter.

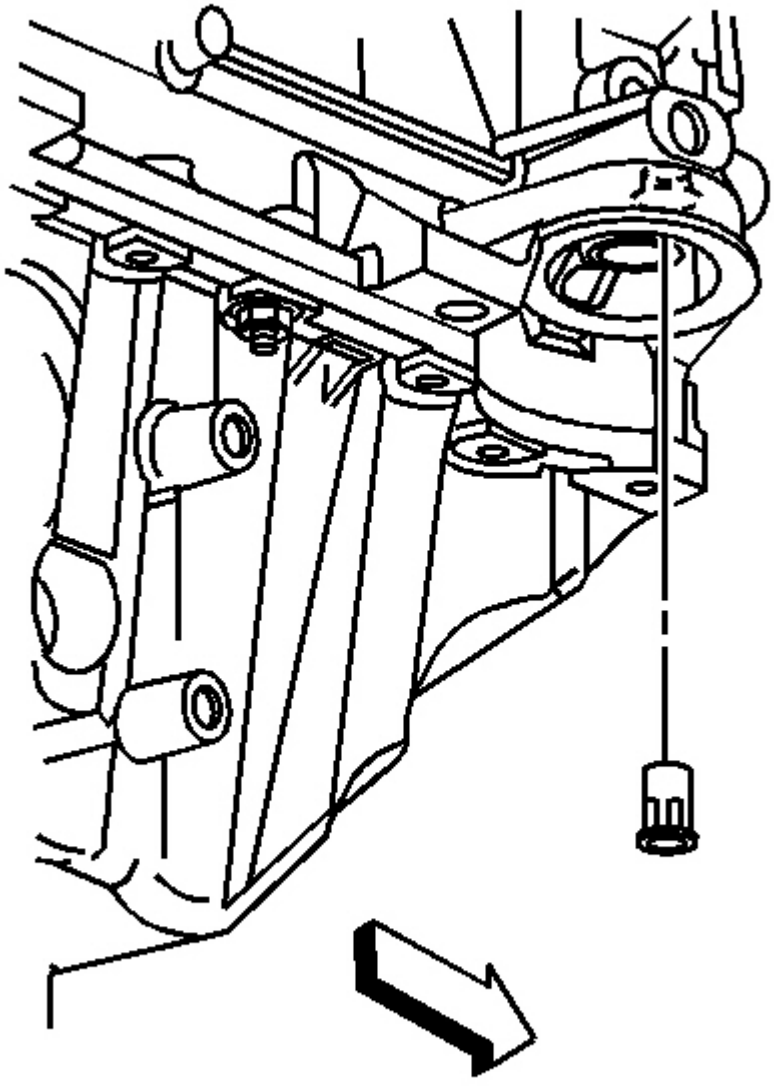


Fig. 197: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter bypass valve.

Installation Procedure

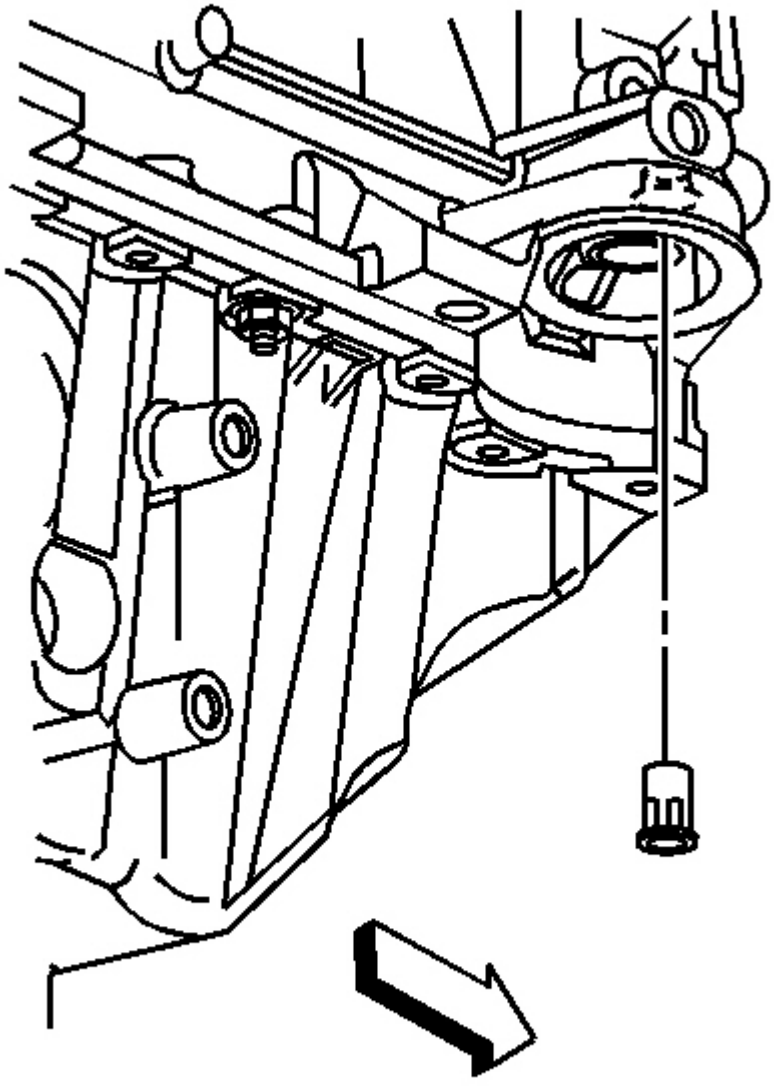


Fig. 198: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil filter bypass valve.

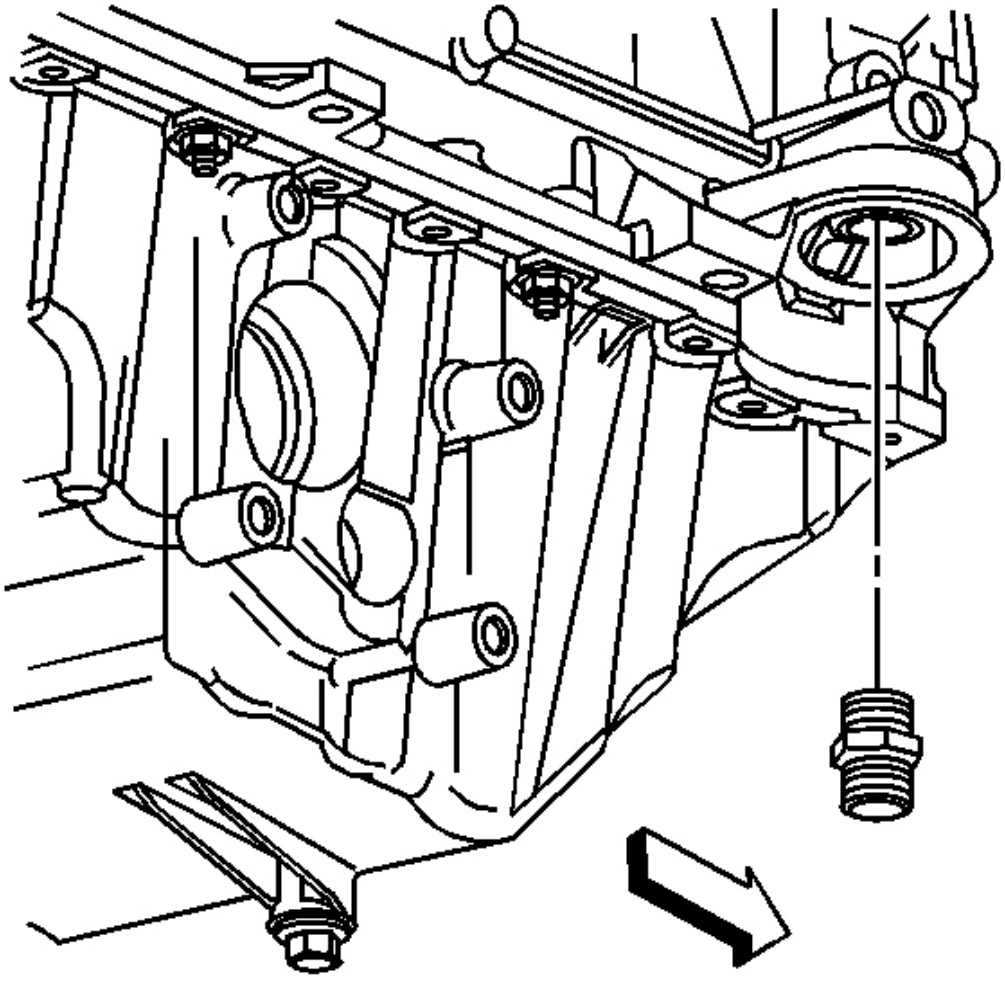


Fig. 199: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the oil filter adapter.

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

3. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

OIL PAN REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

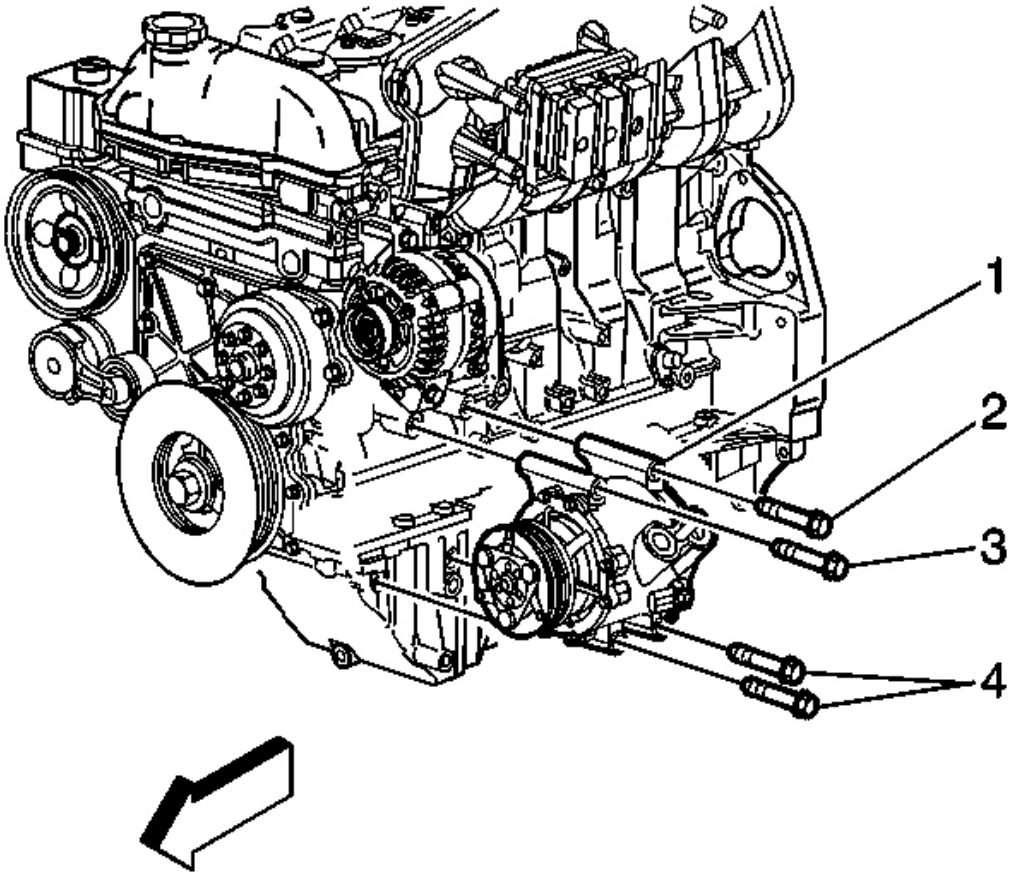


Fig. 200: View Of A/C Compressor & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the A/C compressor bottom bolts (4) and loosen the top bolts (2, 3).
3. Remove the oil level indicator and tube. Refer to **Oil Level Indicator and Tube Replacement**.
4. Remove the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .

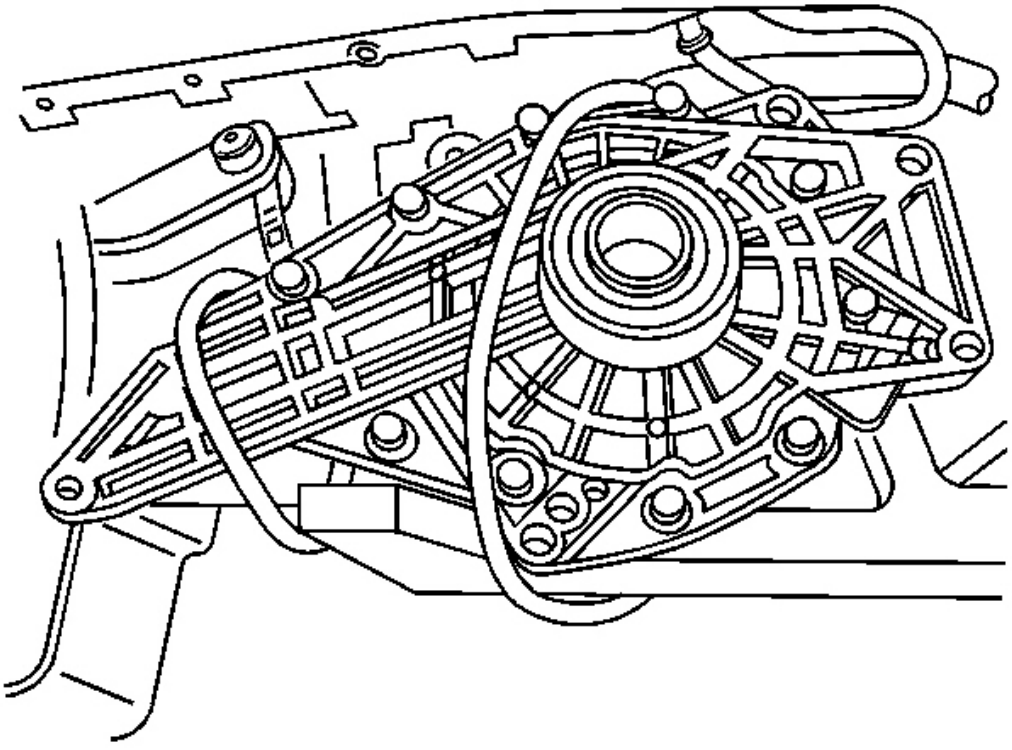


Fig. 201: Securing Front Differential To Frame
Courtesy of GENERAL MOTORS CORP.

5. Remove the front differential and secure to the frame. Refer to **Differential Carrier Assembly Replacement (4.2L In-Line Six Cylinder)** or **Differential Carrier Assembly Replacement (5.3L V-8)** .
6. Remove the front drive axle intermediate shaft bearing assembly. Refer to **Front Drive Axle Intermediate Shaft Bearing Assembly Replacement (S4WD)** or **Front Drive Axle Intermediate Shaft Bearing Assembly Replacement (A4WD)** .
7. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

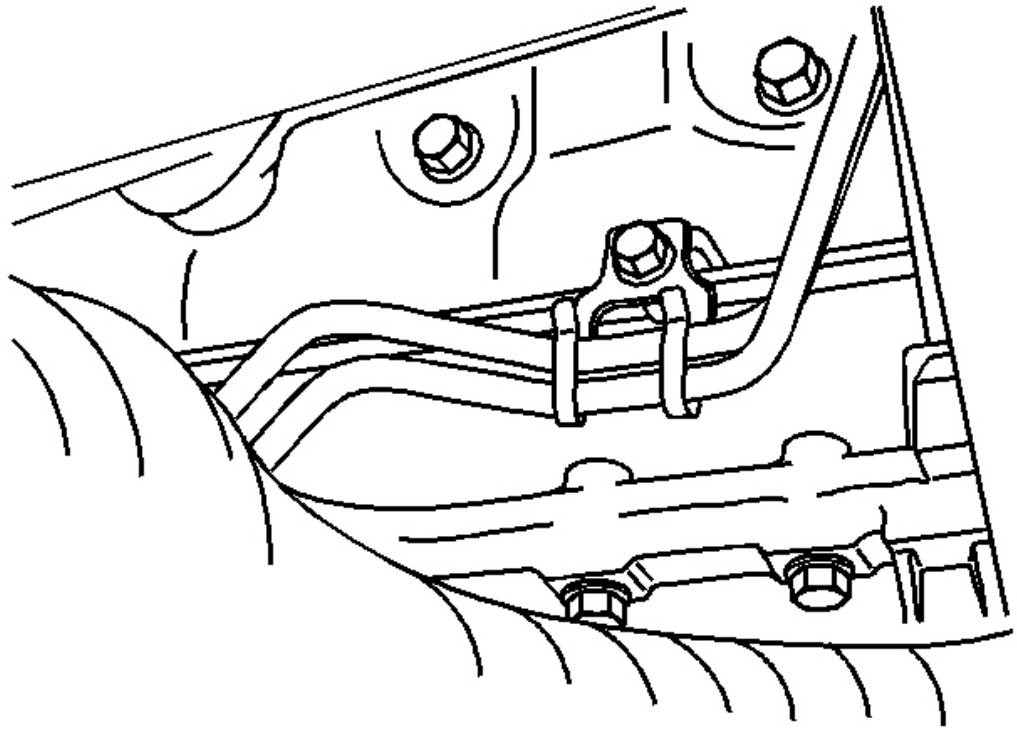


Fig. 202: View Of Transmission Cooler Lines & Clips
Courtesy of GENERAL MOTORS CORP.

8. Unclip the transmission cooler lines from the engine block.
9. Remove 4 transmission bell housing bolts that are attached to the oil pan.

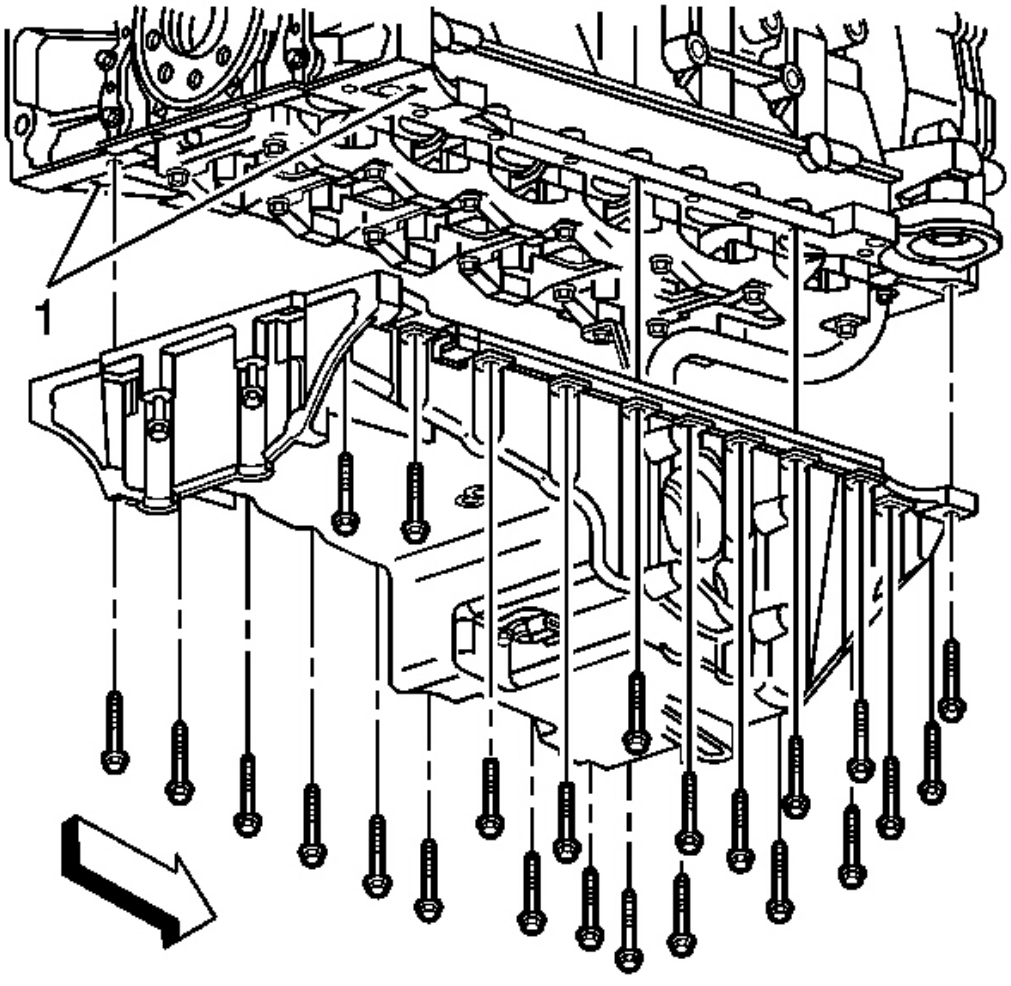


Fig. 203: View Of Engine & Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the remaining oil pan bolts.
11. Place 2 oil pan bolts in the jack screws on the oil pan and tighten evenly to release the oil pan from the engine (1).
12. Clean and inspect the oil pan.

Installation Procedure

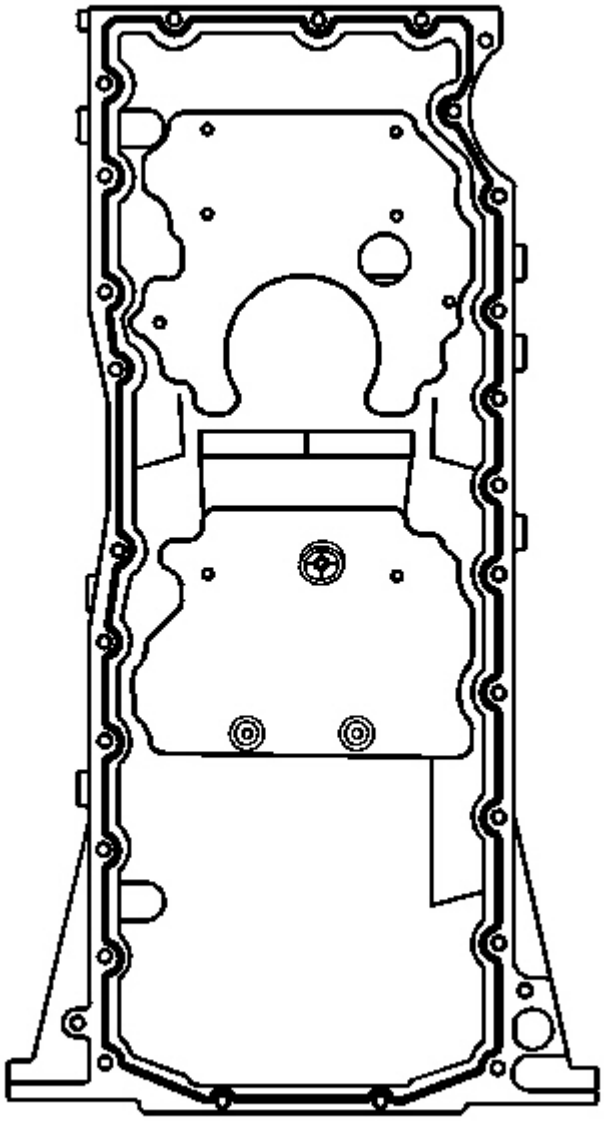


Fig. 204: Applying Sealant To Oil Pan
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan must be installed within 10 minutes from when sealer was applied.

1. Apply a 3 mm (0.12 in) bead of sealer to the block, rather than the oil pan. Refer to **Sealers, Adhesives,**

and Lubricants.

IMPORTANT: When you install the oil pan, it could be shifted front or back a little which could cause a transmission alignment problem. The back of the oil pan needs to be flush with the block.

2. Install the oil pan, maneuvering the oil pan to clear the oil pump and screen assembly.
3. Install the oil pan bolts.

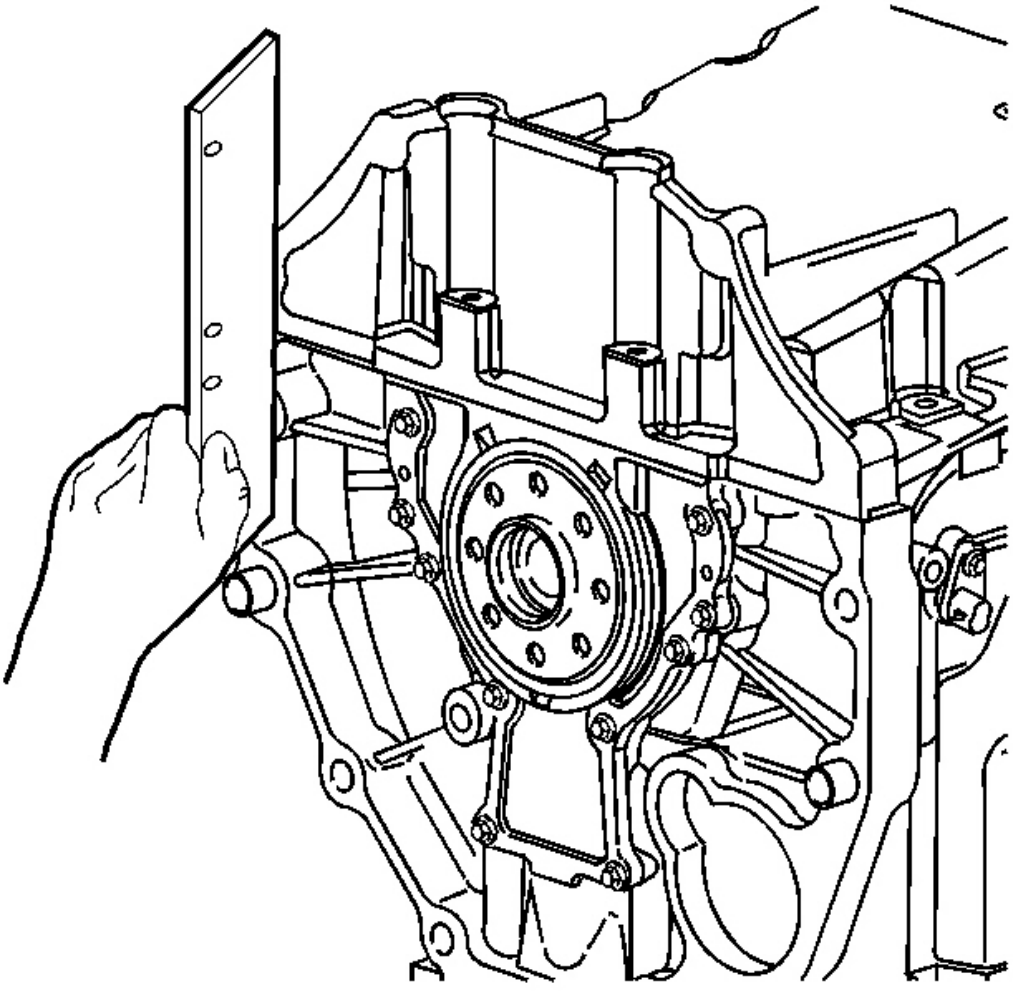


Fig. 205: Inspecting Oil Pan Alignment
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

4. Inspect the oil pan alignment. Use a straight edge on the back of the block and the oil pan transmission mounting surface.

   Tighten:
   - Tighten the oil pan side bolts to 25 N.m (18 lb ft).
   - Tighten the oil pan end bolts to 10 N.m (89 lb in).

5. Install the 4 transmission bell housing bolts that attach to the oil pan.

   Tighten: Tighten bolts to 47 N.m (35 lb ft).

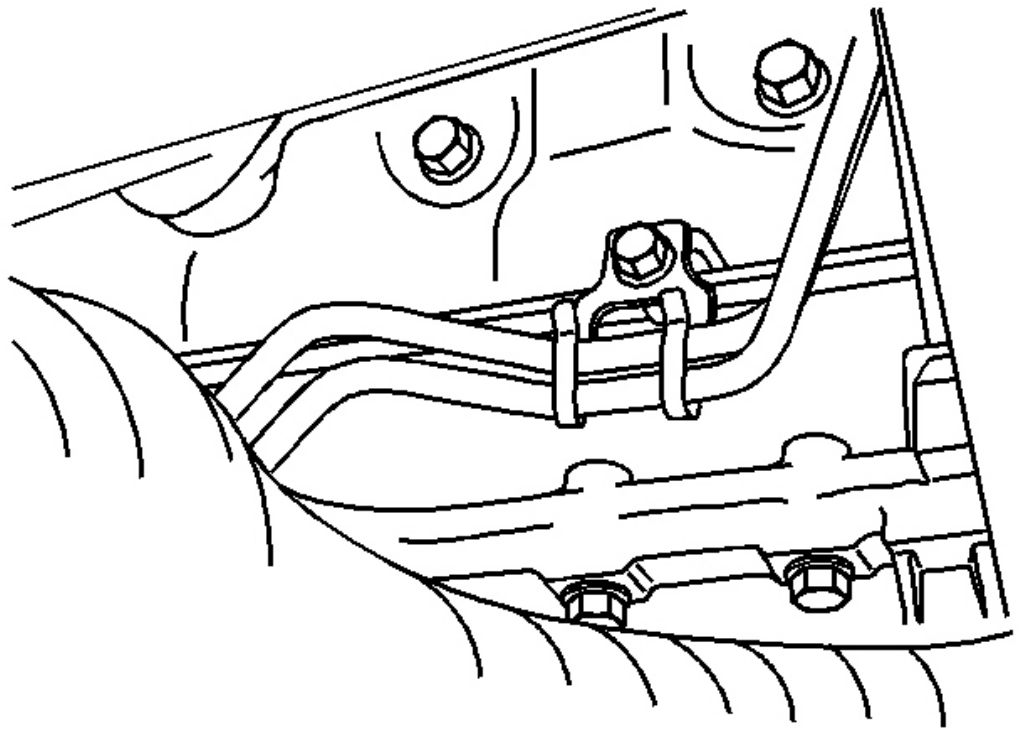


Fig. 206: View Of Transmission Cooler Lines & Clips
Courtesy of GENERAL MOTORS CORP.

6. Clip transmission cooler lines to the engine block.
7. Install the front drive axle intermediate shaft bearing assembly. Refer to **Front Drive Axle Intermediate Shaft Bearing Assembly Replacement (S4WD)** or **Front Drive Axle Intermediate Shaft Bearing**

Assembly Replacement (A4WD) .

8. Install the oil drain plug and filter. Refer to **Engine Oil and Oil Filter Replacement**.

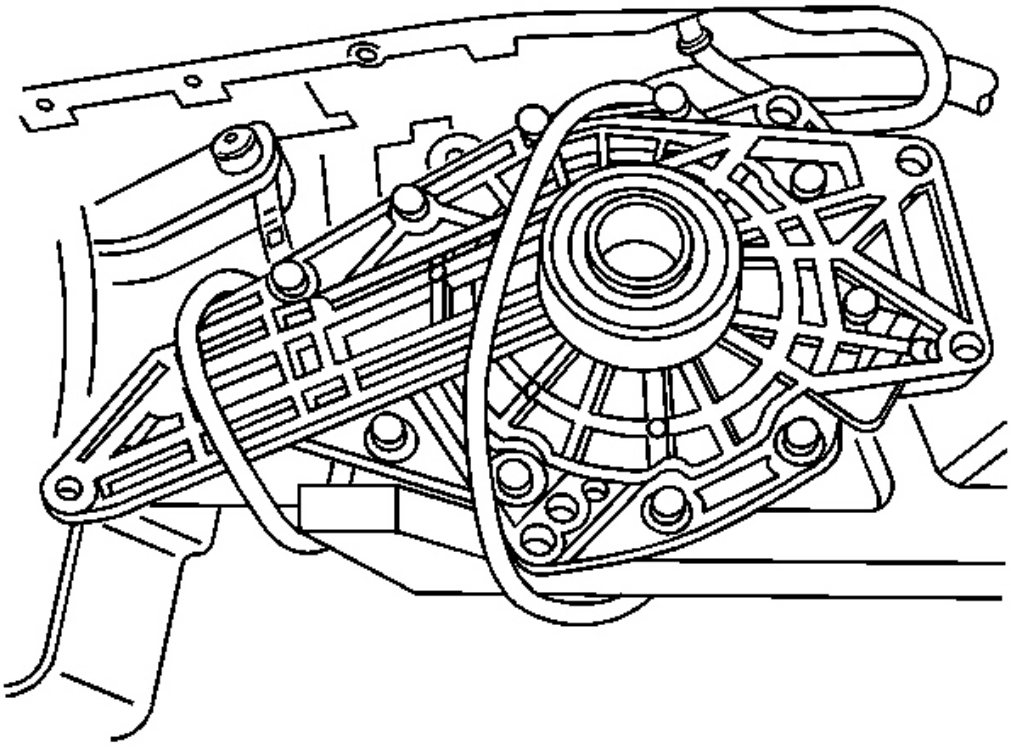


Fig. 207: Securing Front Differential To Frame
Courtesy of GENERAL MOTORS CORP.

9. Install the front differential to the engine. Refer to **Differential Carrier Assembly Replacement (4.2L In-Line Six Cylinder)** or **Differential Carrier Assembly Replacement (5.3L V-8)** .
10. Install the stabilizer shaft. Refer to **Stabilizer Shaft Replacement** .

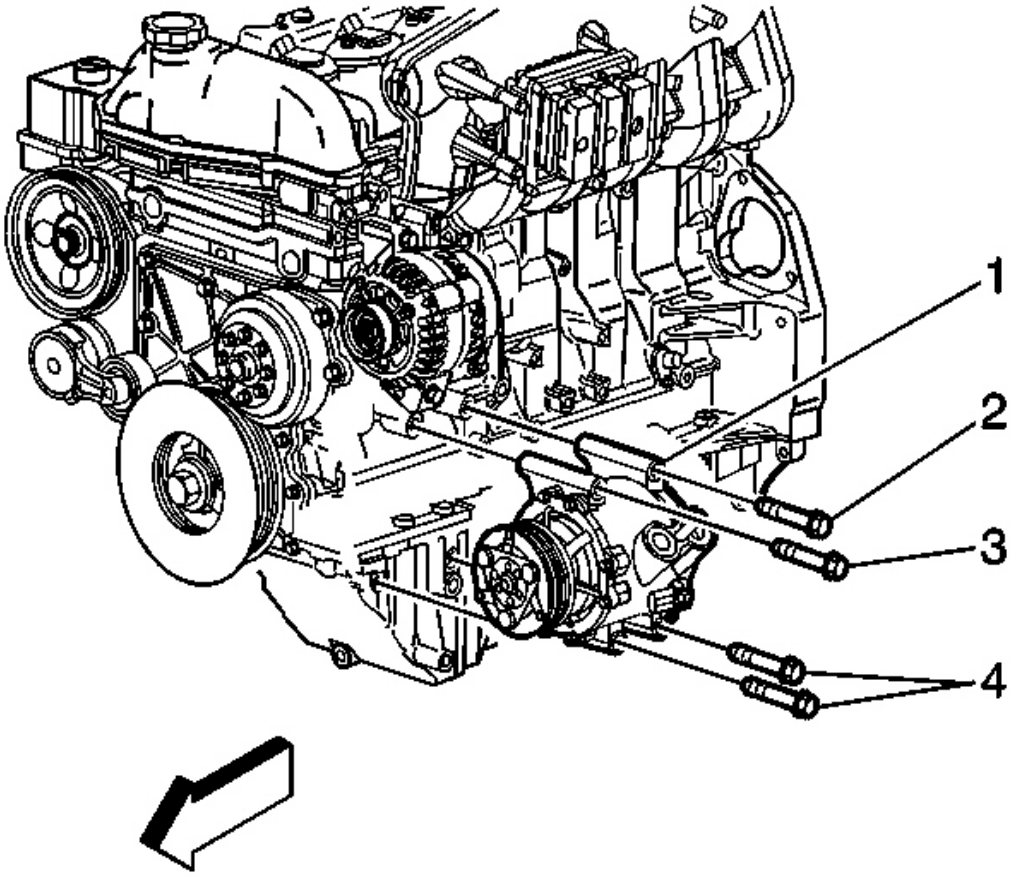


Fig. 208: View Of A/C Compressor & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the A/C compressor 2 bottom bolts (4).

    Tighten: Tighten all 4 bolts (2, 3, 4) to 50 N.m (37 lb ft).

12. Install the oil level indicator and tube. Refer to **Oil Level Indicator and Tube Replacement**.
13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

IMPORTANT: Inspect the engine for oil leaks in order to ensure all sealing surfaces are sealed.

14. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.

ENGINE OIL PRESSURE SENSOR & SWITCH REPLACEMENT

Removal Procedure

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the engine shield. Refer to **Engine Protection Shield Replacement** .

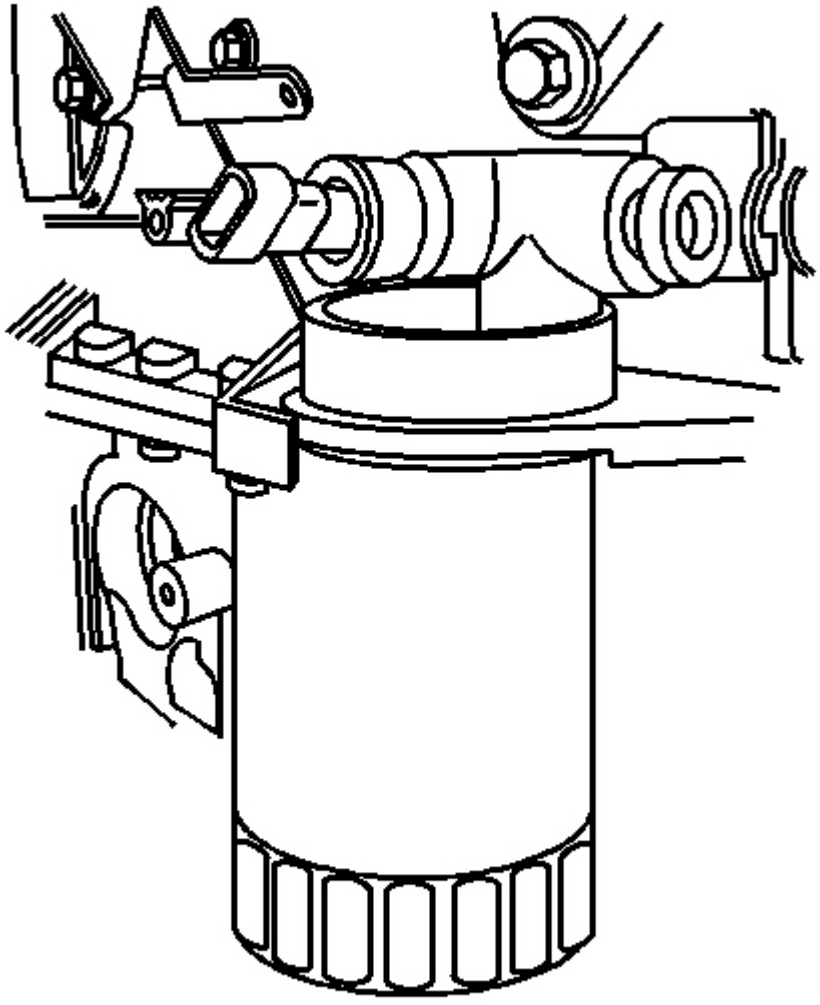


Fig. 209: View Of Oil Pressure Switch & Connector
Courtesy of GENERAL MOTORS CORP.

3. Remove the electrical connector from the oil pressure switch.

4. Remove the oil pressure switch.

Installation Procedure

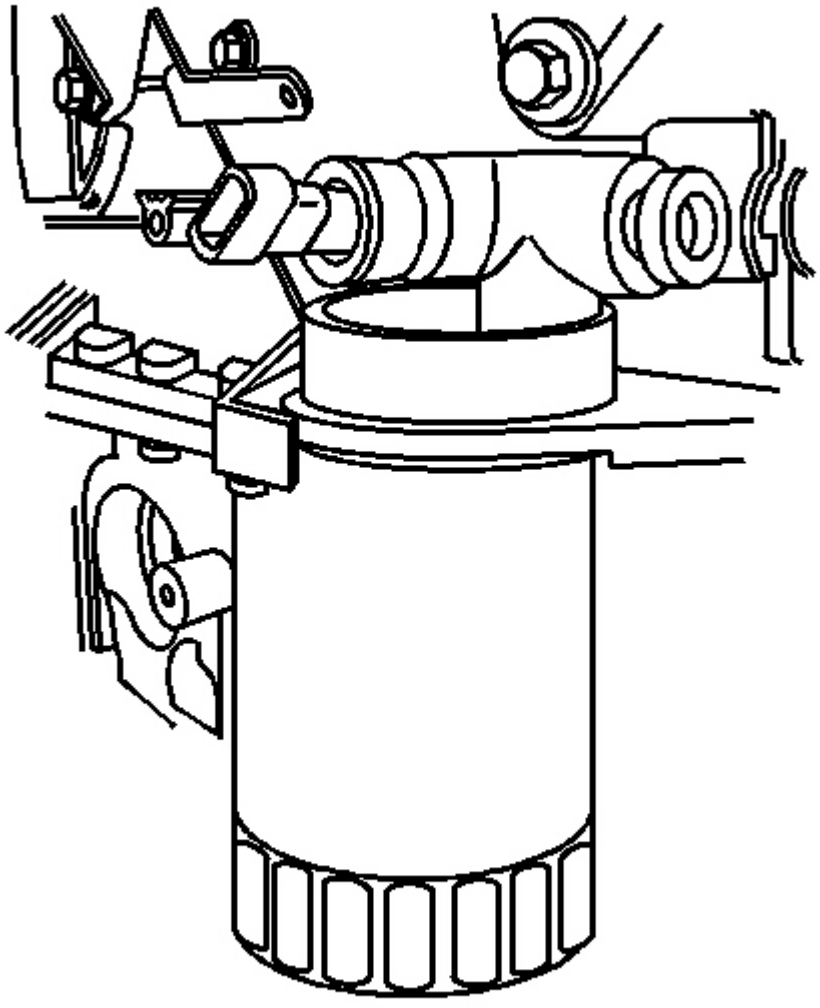


Fig. 210: View Of Oil Pressure Switch & Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil pressure switch.

Tighten: Tighten the oil pressure switch to 20 N.m (15 lb ft).

2. Install the electrical connector to the oil pressure switch.
3. Install the engine shield. Refer to **Engine Protection Shield Replacement** .
4. Lower the vehicle.

OIL PUMP REPLACEMENT

Removal Procedure

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

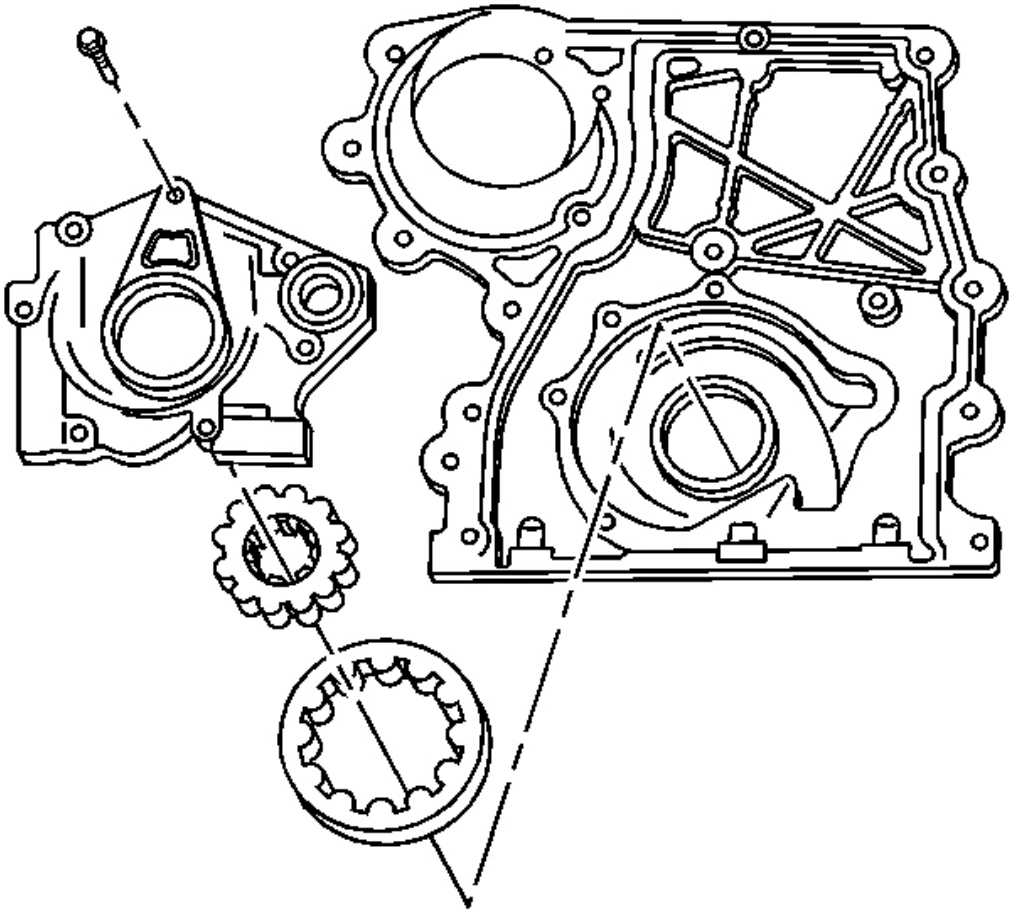


Fig. 211: View Of Oil Pump Outer & Inner Gears, Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump cover bolts.
3. Remove the oil pump cover.
4. Mark the inner and the outer gears in relation to the oil pump housing.
5. Remove the inner and the outer oil pump gears.
6. Remove the oil pump pressure relief valve plug.
7. Remove the oil pump pressure relief valve and the spring.

Installation Procedure

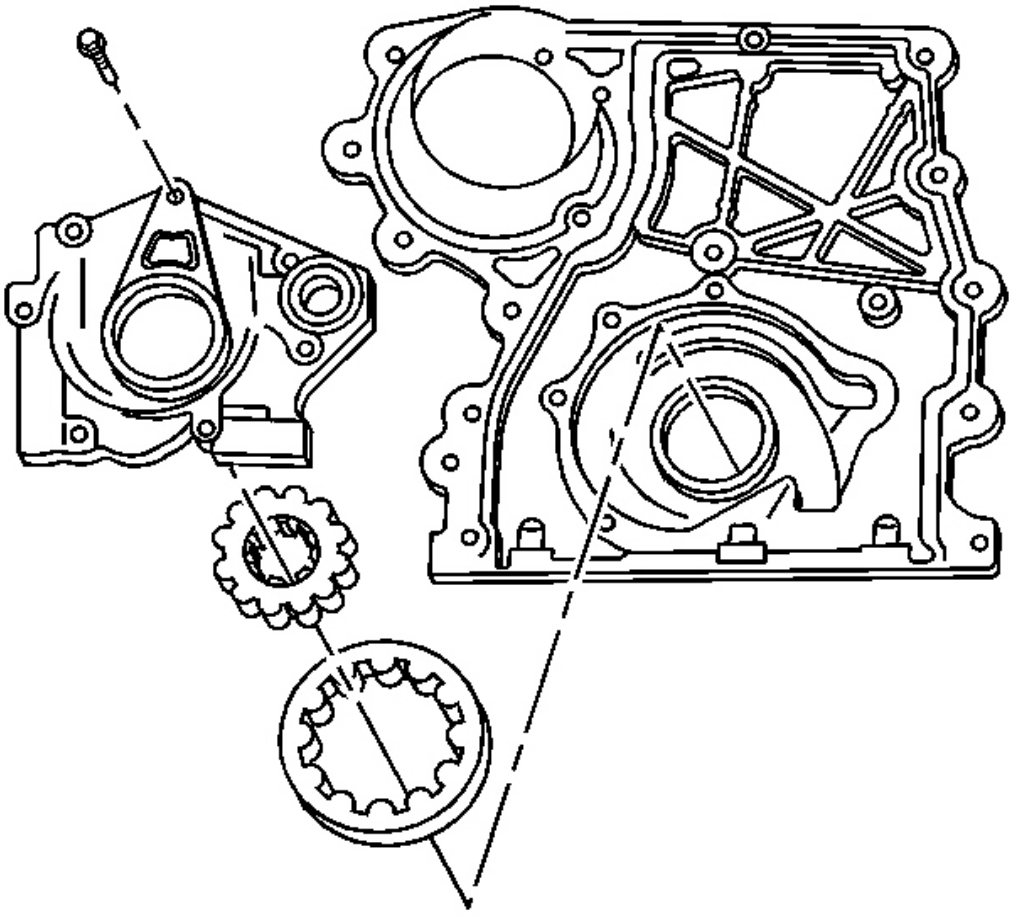


Fig. 212: View Of Oil Pump Outer & Inner Gears, Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump pressure relief valve and the spring.

NOTE: **Refer to Fastener Notice .**

2. Install the oil pump pressure relief valve plug.

   Tighten: Tighten the oil pump pressure relief valve to 14 N.m (124 lb in).

3. Install the oil pump outer and inner gears as removed.
4. Install the oil pump cover.
5. Install the oil pump cover bolts.

   Tighten: Tighten the oil pump cover bolts to 10 N.m (89 lb in).

6. Install the front cover. Refer to **Engine Front Cover Replacement**.

CRANKSHAFT REAR OIL SEAL & HOUSING REPLACEMENT

Tools Required

- **J 36660-A** Torque Angle Meter. See **Special Tools**.
- **J 44219** Cover Alignment Pins. See **Special Tools**.
- **J 44227** Rear Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .

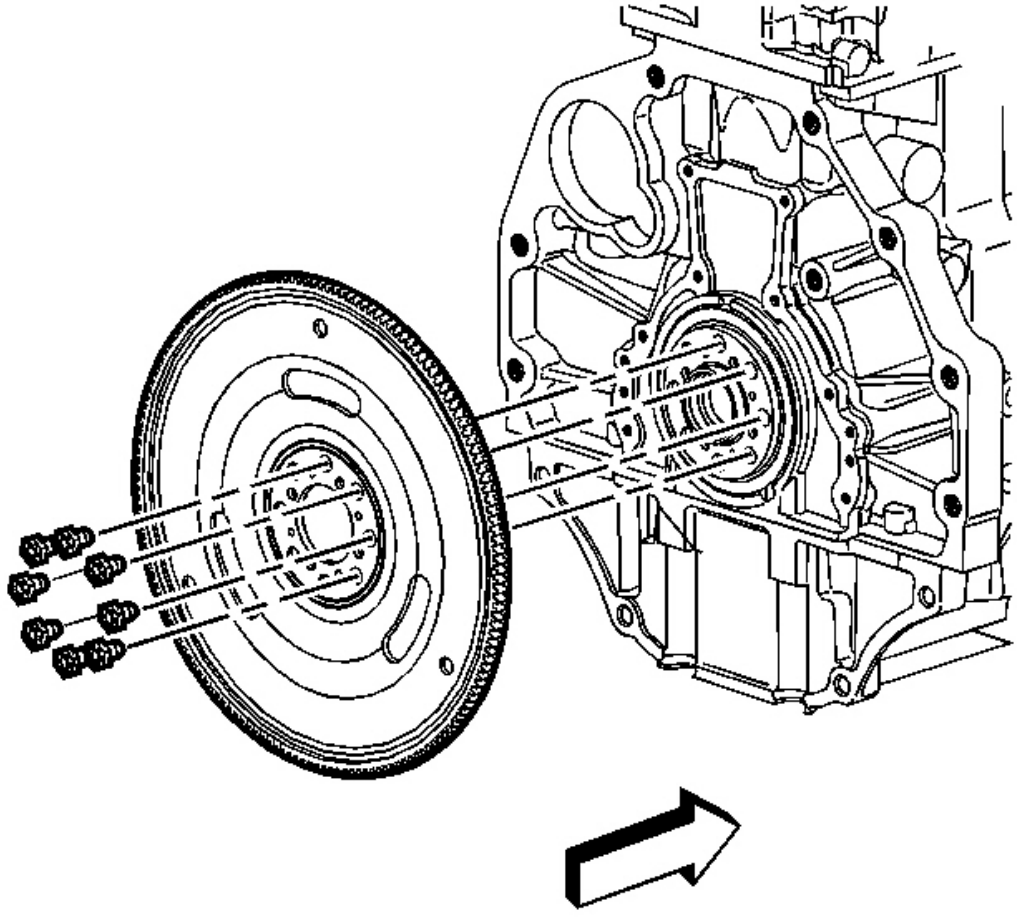


Fig. 213: View Of Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel bolts and remove the flywheel.

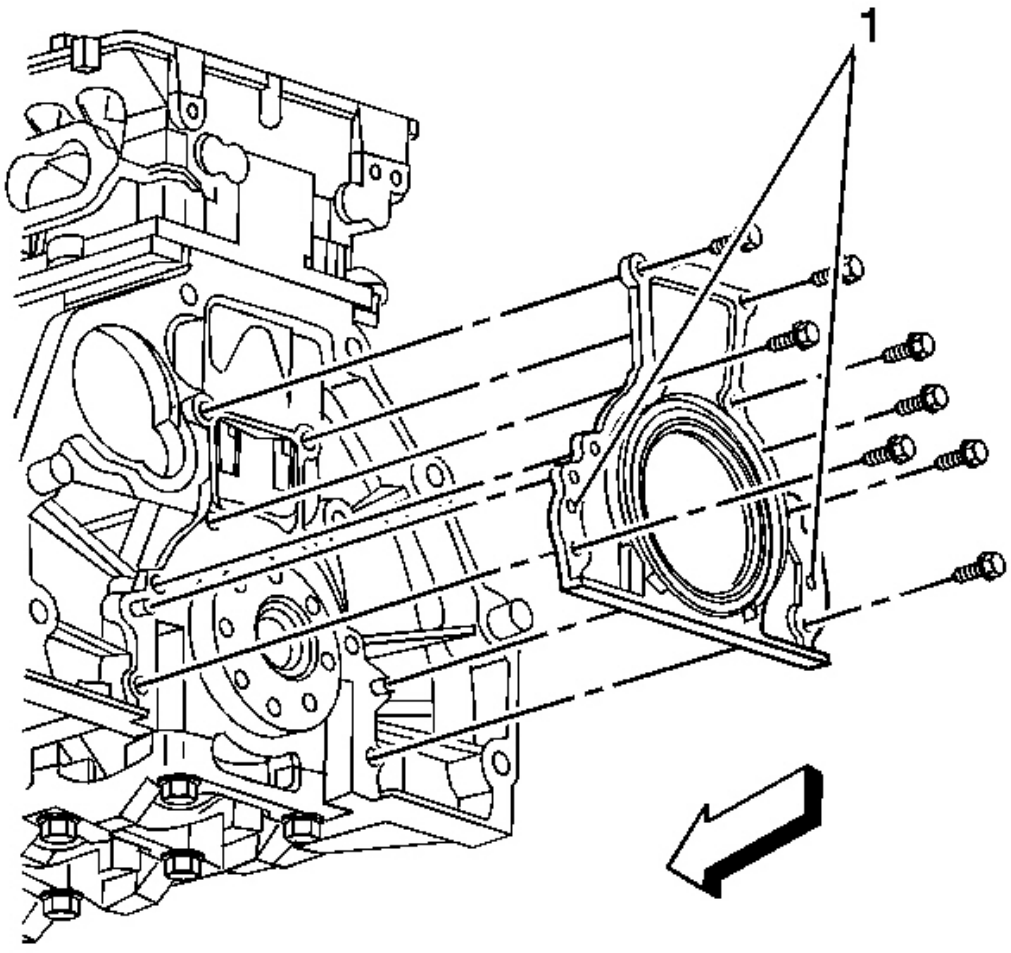


Fig. 214: View Of Crankshaft Rear Oil Seal Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft rear oil seal housing bolts.
4. Install 2 bolts into the jackscrew holes (1) to release the cover from the block.
5. Remove the crankshaft and rear oil seal housing.
6. Remove the oil seal from the crankshaft snout.

Installation Procedure

1. Use the **J 44227** to install the crankshaft rear oil seal. See **Special Tools**.
2. Remove the **J 44227** . See **Special Tools**.

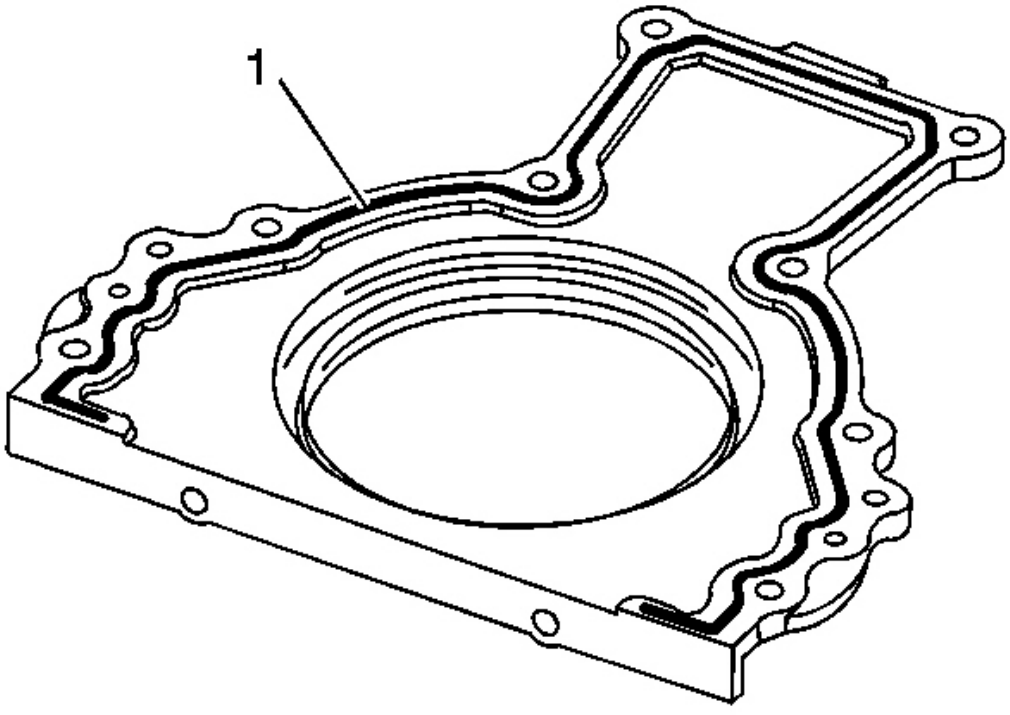


Fig. 215: Applying Sealant To Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft rear oil seal housing must be installed within 10 minutes from when the sealer is applied.

3. Apply a 3 mm (0.12 in) bead of sealant (1) to the following:
   - The crankshaft rear oil seal housing, where the housing meets the engine block
   - The surface of the crankshaft rear oil seal housing, where the housing meets the oil pan
   - The surface of the oil pan, where the oil pan meets the housing

   Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

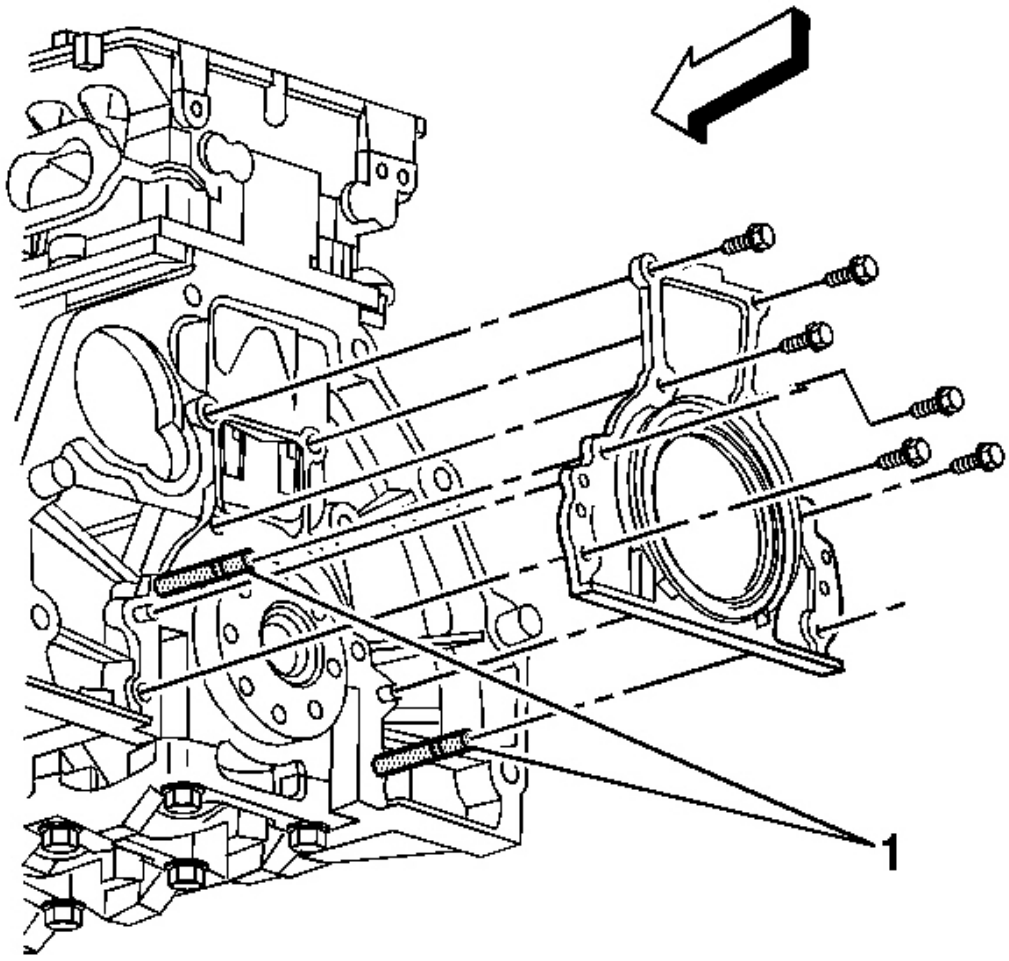


Fig. 216: View Of J 44219 Guide Pins & Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 44219** guide pins (1) into the block. See **Special Tools**.

IMPORTANT:

- **When installing a new seal, use the plastic installation sleeve supplied with the new seal.**
- **The seal installation sleeve should come off after the seal is installed. Discard the sleeve.**

5. Slide the crankshaft rear oil seal housing over the alignment pins **J 44219** and crankshaft. See **Special Tools**.

6. Install the crankshaft rear oil seal housing bolts, except the 2 in place of the guide pins.
7. Remove the **J 44219** guide pins. See **Special Tools**.

NOTE: Refer to Fastener Notice .

8. Install the remaining 2 crankshaft rear oil seal housing bolts.

Tighten: Tighten all the oil seal housing bolts to 10 N.m (89 lb in).

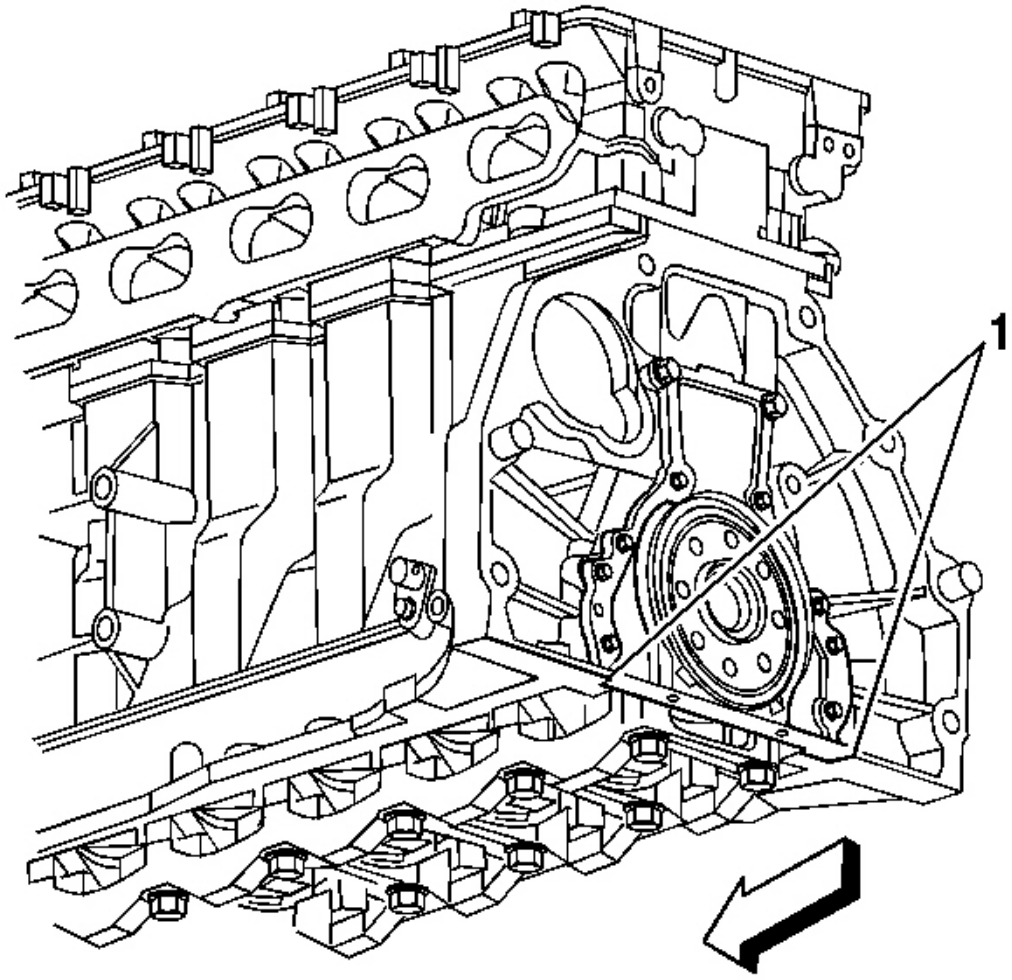


Fig. 217: View Of Oil Pan Sealing Area On Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

9. Wipe off any excess material from the bottom of the oil pan sealing area (1).

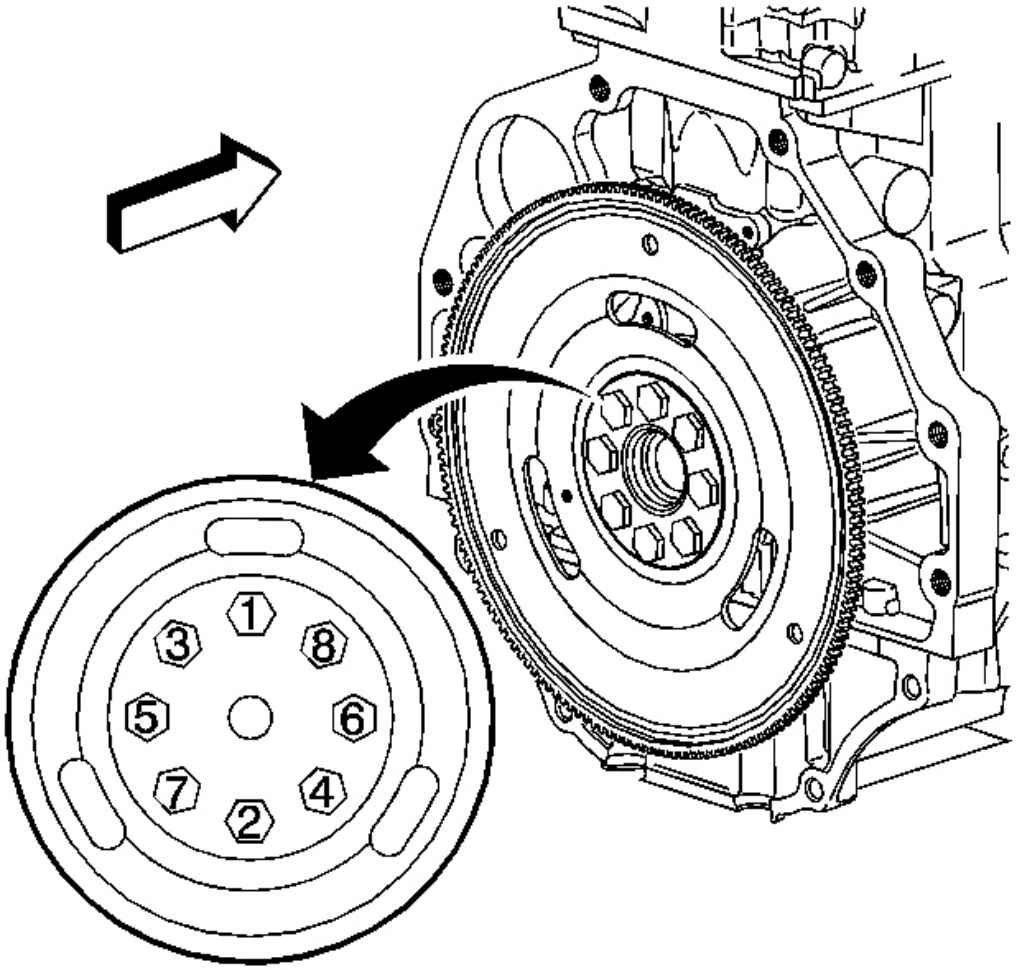


Fig. 218: Tightening Sequence For Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the flywheel and secure with the bolts.

    Tighten: Tighten the flywheel bolts in sequence to 25 N.m (18 lb ft).

11. Use the **J 36660-A** to tighten the bolts an additional 50 degrees. See **Special Tools**.
12. Install the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

J 44227 Rear Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .
2. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

IMPORTANT: Do not damage the crankshaft or seal bore.

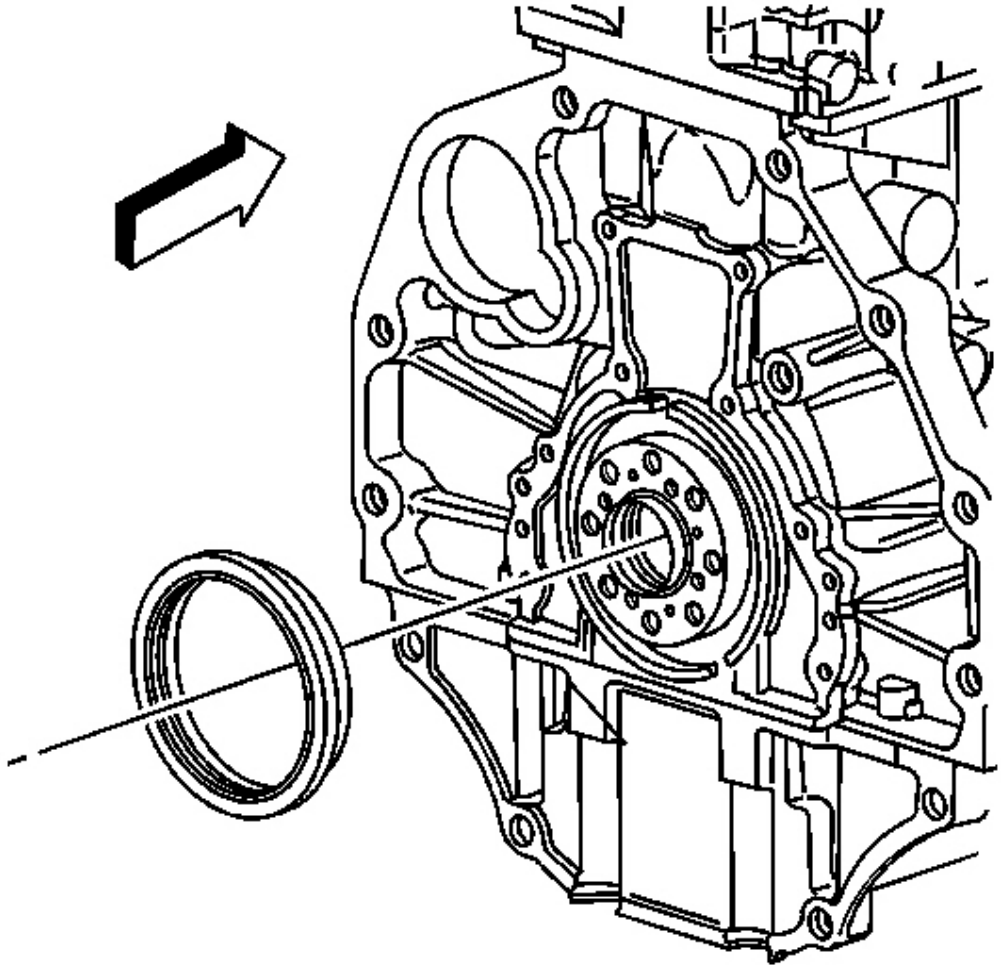


Fig. 219: View Of Crankshaft Rear Oil Seal Housing & Seal
Courtesy of GENERAL MOTORS CORP.

3. Pry the crankshaft rear oil seal out of the rear oil seal housing using a suitable tool.

Installation Procedure

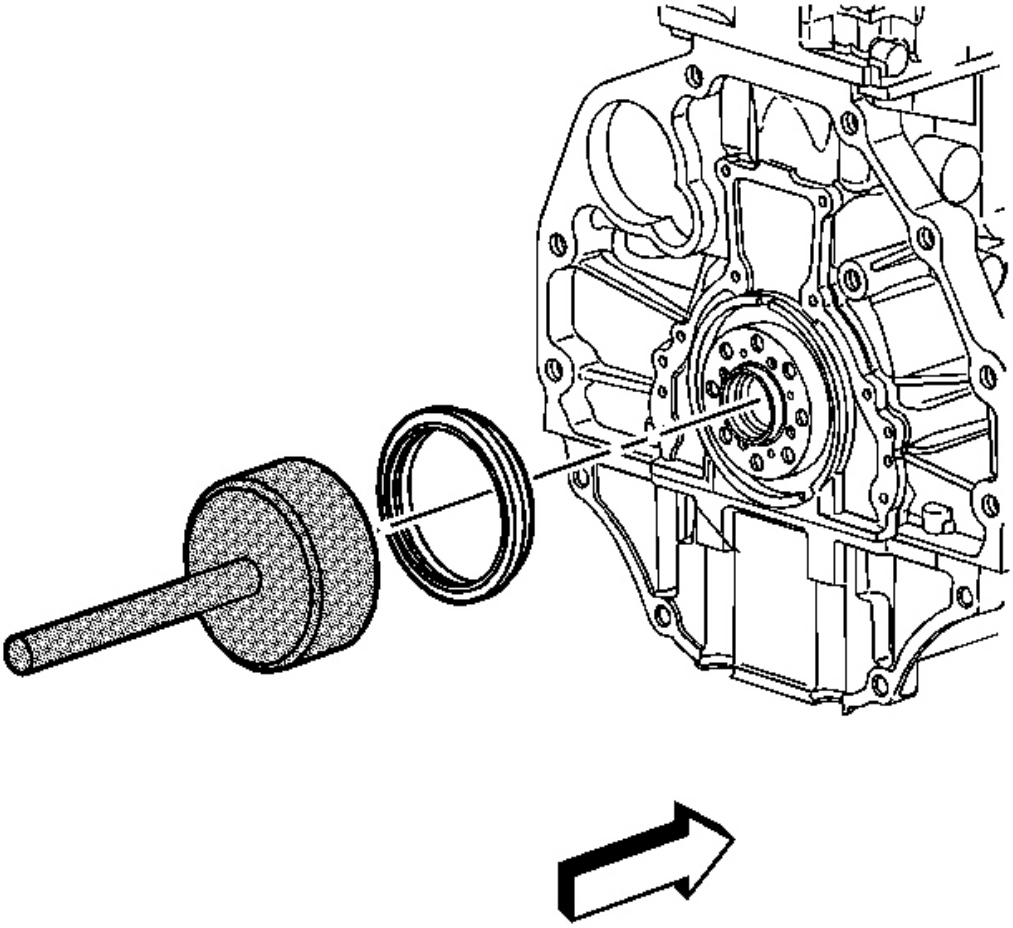


Fig. 220: View Of Crankshaft Rear Oil Seal & J 44227
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use the plastic installation sleeve supplied with the new seal when installing a new seal.

1. Use **J 44227** to install the crankshaft rear oil seal. See **Special Tools**.
2. Remove the **J 44227** . See **Special Tools**.
3. Remove the seal installation sleeve after the seal is installed. Discard the sleeve.
4. Install the flywheel. Refer to **Engine Flywheel Replacement**.
5. Install the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .

ENGINE FLYWHEEL REPLACEMENT

Tools Required

J 36660-A Torque Angle Meter. See **Special Tools**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .

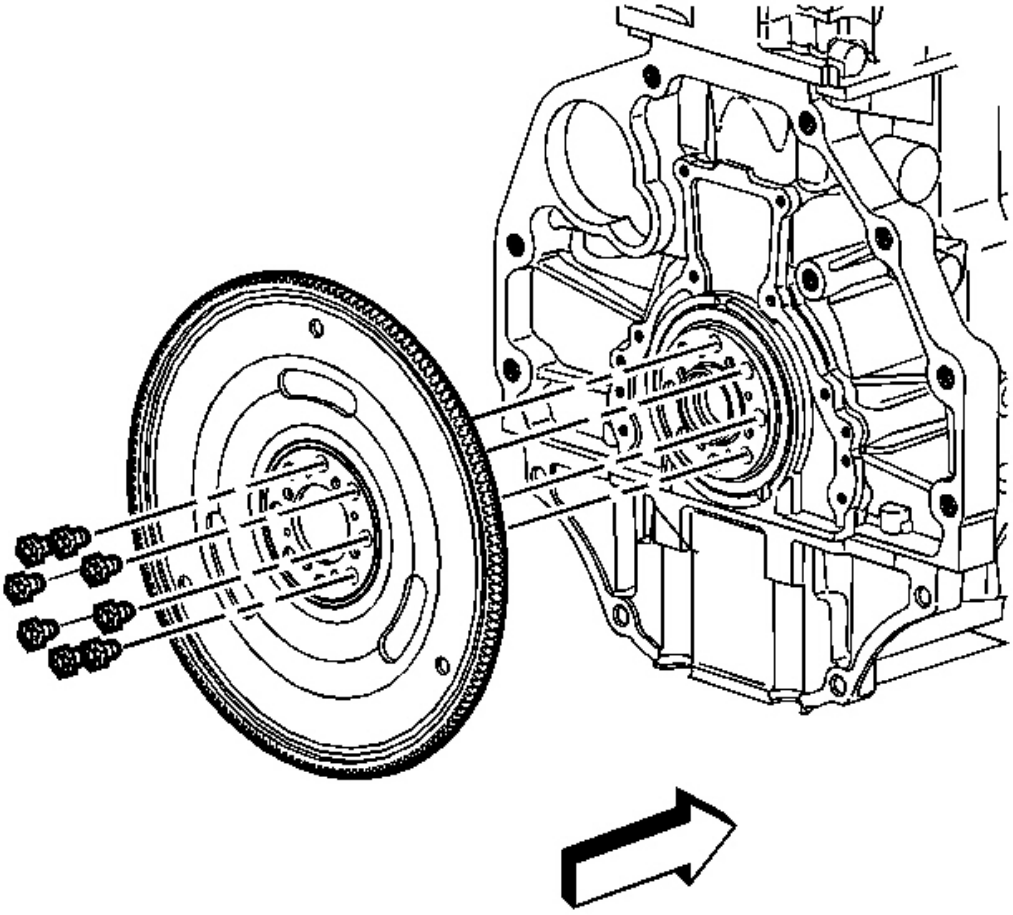


Fig. 221: View Of Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the flywheel bolts.
3. Remove the flywheel.
4. Clean and Inspect the flywheel. Refer to **Engine Flywheel Cleaning and Inspection**.

Installation Procedure

1. Add threadlock to the new flywheel bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

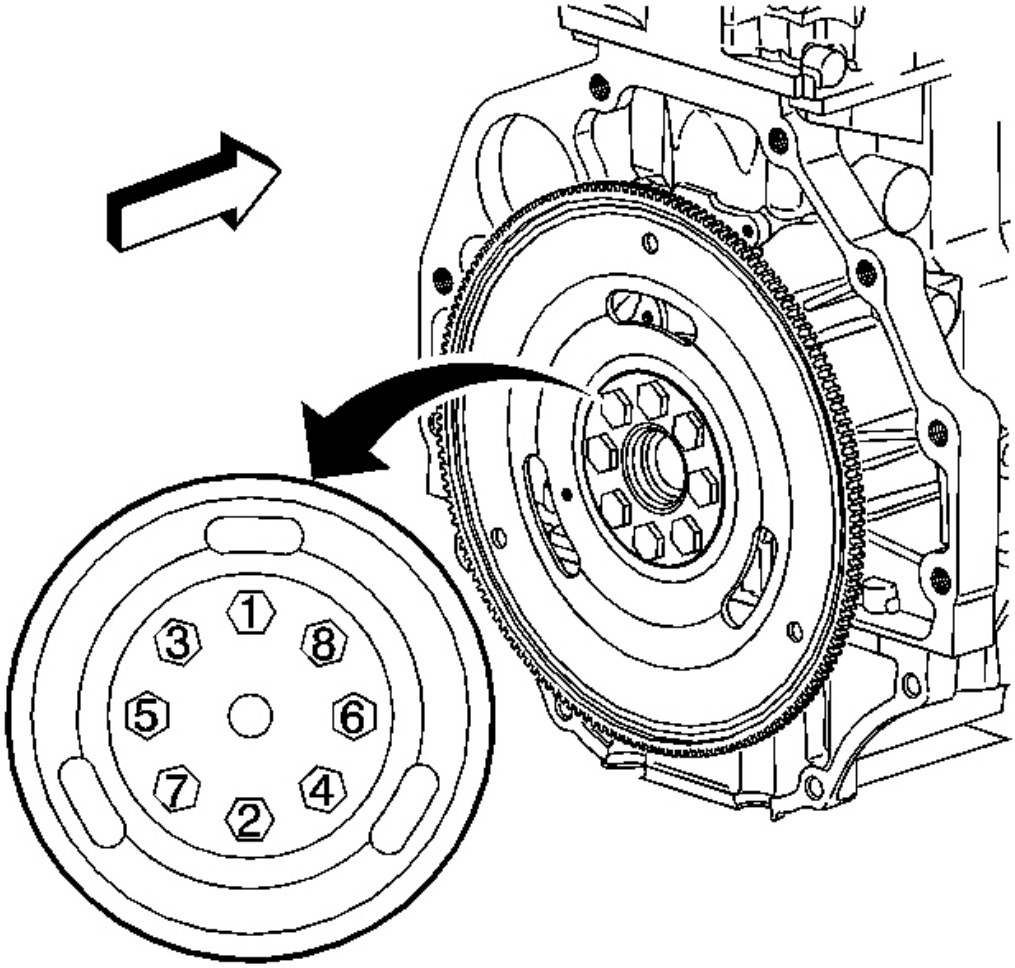


Fig. 222: Tightening Sequence For Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the flywheel and secure the flywheel with the new bolts.

   Tighten:

   1. Tighten the bolts in sequence to 25 N.m (18 lb ft).
   2. Use the **J 36660-A** in order to tighten the bolts an additional 50 degrees. See **Special Tools**.

3. Install the transmission. Refer to **Transmission Replacement (LL8)** or **Transmission Replacement (LM4, LS2)** .

ENGINE REPLACEMENT

Special Tools

J 44220 Engine Lift Bracket. See **Special Tools**.

Removal Procedure

1. Remove the hood. Refer to **Hood Replacement** .
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
3. Drain engine coolant. Refer to **Cooling System Draining and Filling (LL8)** or **Cooling System Draining and Filling (LH6, LS2)** .
4. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging** .

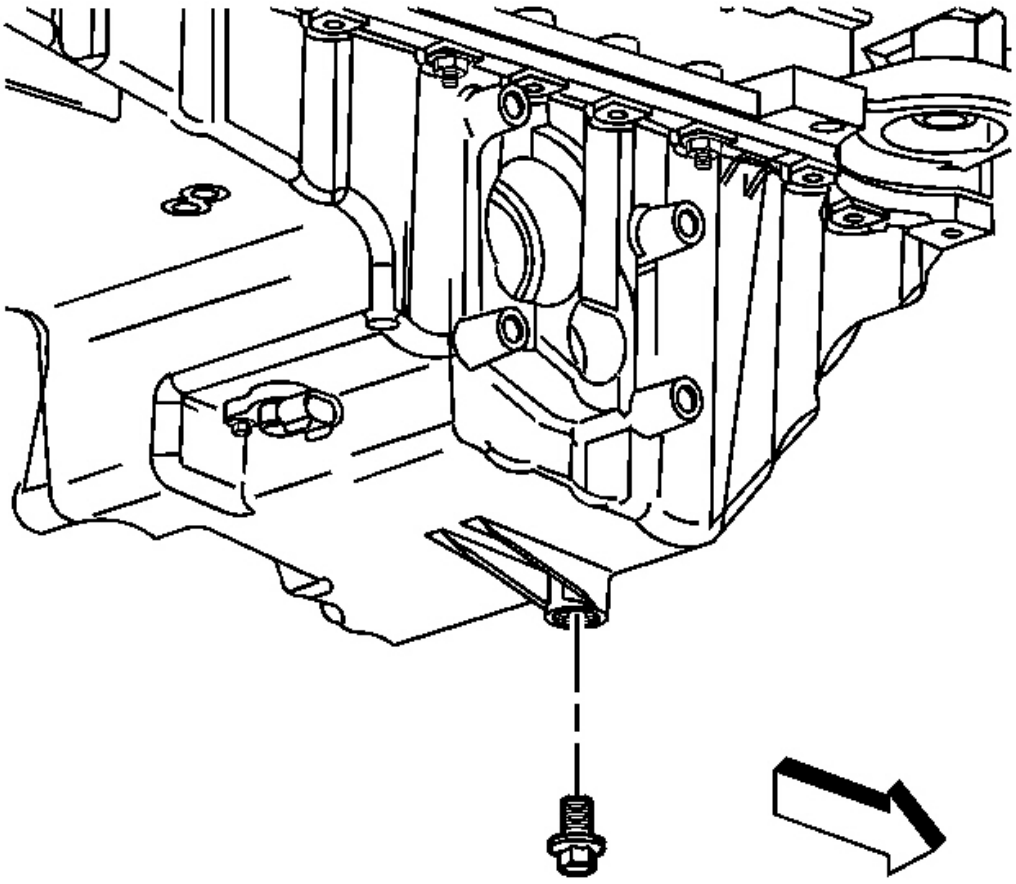


Fig. 223: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep drain plug removed during engine removal and installation.

5. Remove the oil pan drain plug and drain the oil.
6. Install a suitable plug into the oil pan after draining to prevent any oil leakage during the rest of the procedure.
7. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
8. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
9. Remove the manifold absolute pressure (MAP) sensor. Refer to **Manifold Absolute Pressure Sensor Replacement** .
10. Remove the washer solvent container. Refer to **Windshield Washer Solvent Container Replacement (Envoy, TrailBlazer)** .

11. Remove the grille. Refer to **Grille Replacement (Envoy)** or **Grille Replacement (TrailBlazer)** .
12. Remove the headlamp housing. Refer to **Headlamp Housing Panel Replacement (Envoy, Rainier)** or **Headlamp Housing Panel Replacement (TrailBlazer)** .
13. Remove the radiator support brace. Refer to **Radiator Support Diagonal Brace Replacement** .
14. Remove the hood latch. Refer to **Hood Latch Support Replacement** .
15. Disconnect A/C lines at the condenser.
16. Disconnect the transmission cooler lines at the engine, not the radiator.
17. Remove the cooling fan and the shroud tilting the radiator forward, and the cooling fan and the shroud rearward for clearance. Refer to **Cooling Fan and Shroud Replacement** .
18. Remove the radiator with condenser and transmission cooler lines. Refer to **Radiator Replacement (LL8)** or **Radiator Replacement (LH6, LS2)** .
19. Remove the drive belt. Refer to **Drive Belt Replacement**.
20. Remove the power steering pump bolts and lay the pump aside.

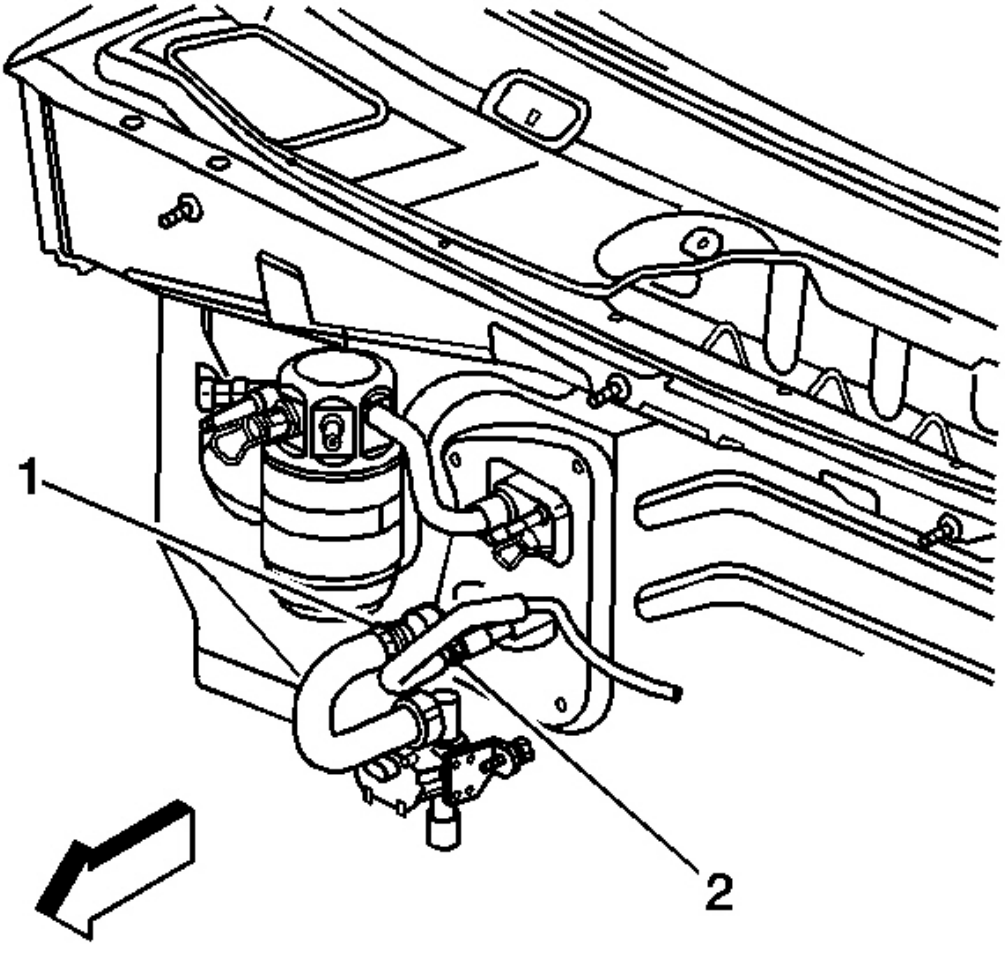


Fig. 224: View Of Heater Hoses & Secondary AIR Reaction Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

21. Ensure the heater hoses (1, 2) at the heater core are disconnected.
22. Remove the secondary air injection (AIR) reaction solenoid valve. Refer to **Secondary Air Injection Solenoid Valve Replacement** .

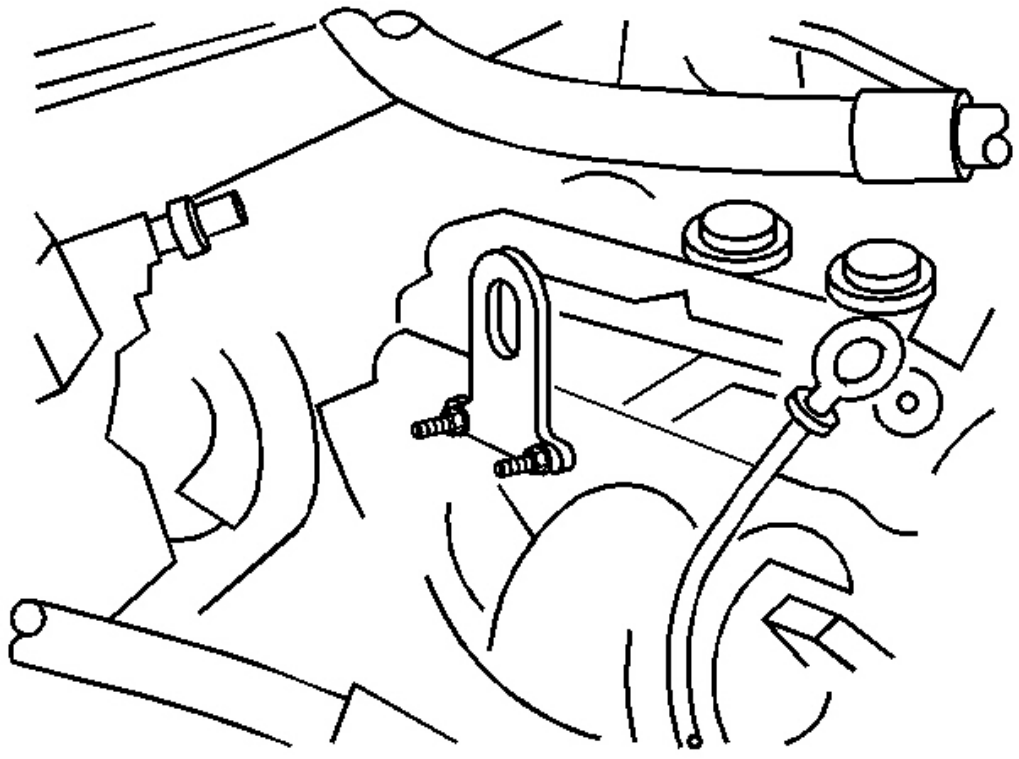


Fig. 225: View Of Lift Hook
Courtesy of GENERAL MOTORS CORP.

23. Install the lift hook **J 44220** to the AIR port on the engine head. See **Special Tools**.
24. Disconnect the oxygen sensor electrical connector.
25. Disconnect the A/C line at the accumulator.
26. Disconnect the front axle actuator electrical connector.
27. Disconnect the camshaft phaser actuator valve electrical connector.

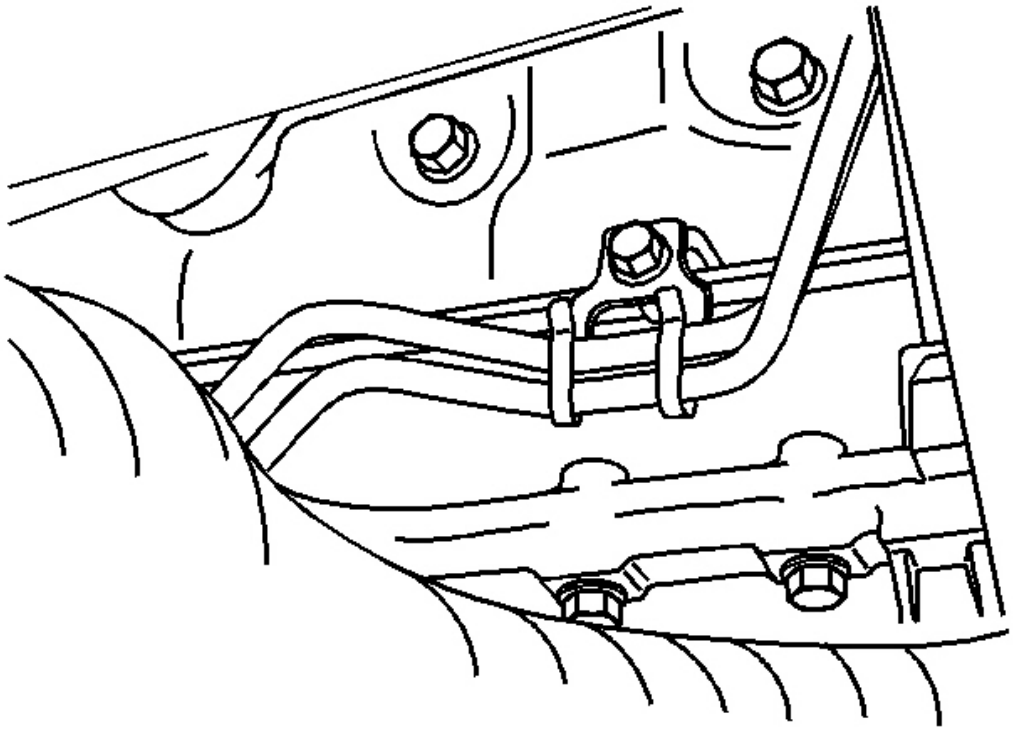


Fig. 226: View Of Transmission Cooler Lines & Clips
Courtesy of GENERAL MOTORS CORP.

28. Unclip the transmission cooler lines from right side of the engine block.
29. Disconnect the ignition coil harness connectors.

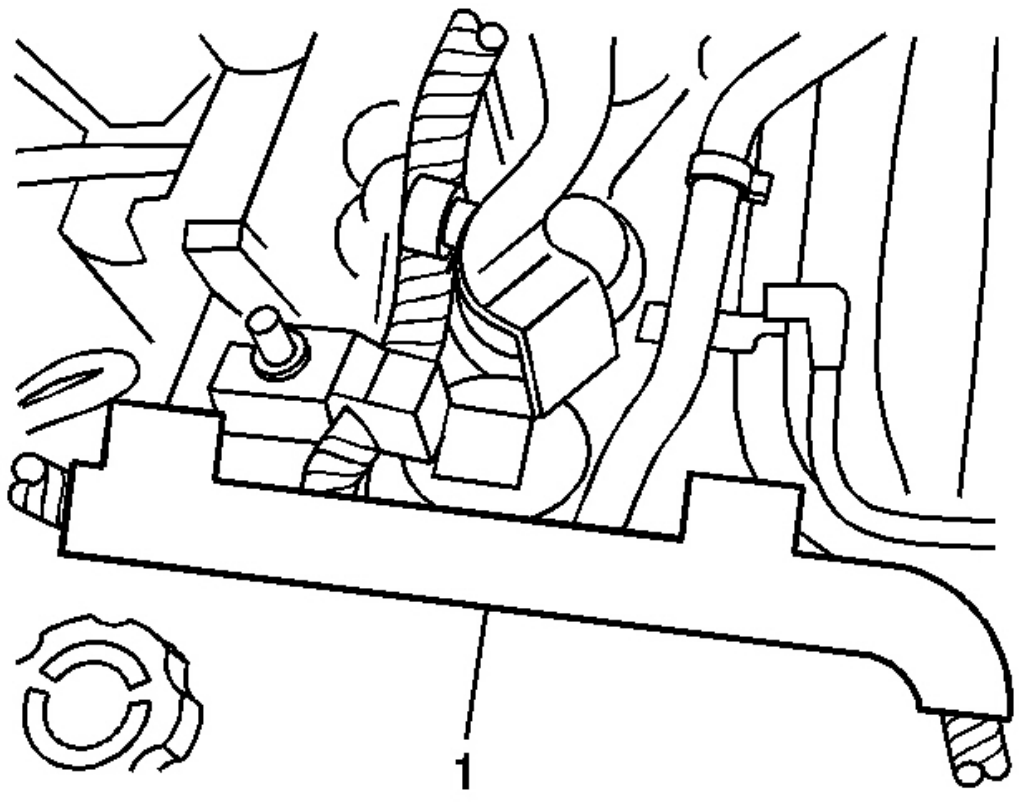


Fig. 227: View Of Engine Electrical Harness Housing
Courtesy of GENERAL MOTORS CORP.

30. Carefully disconnect harness retainer at clips (1) and remove.
31. Remove power brake hose at booster.

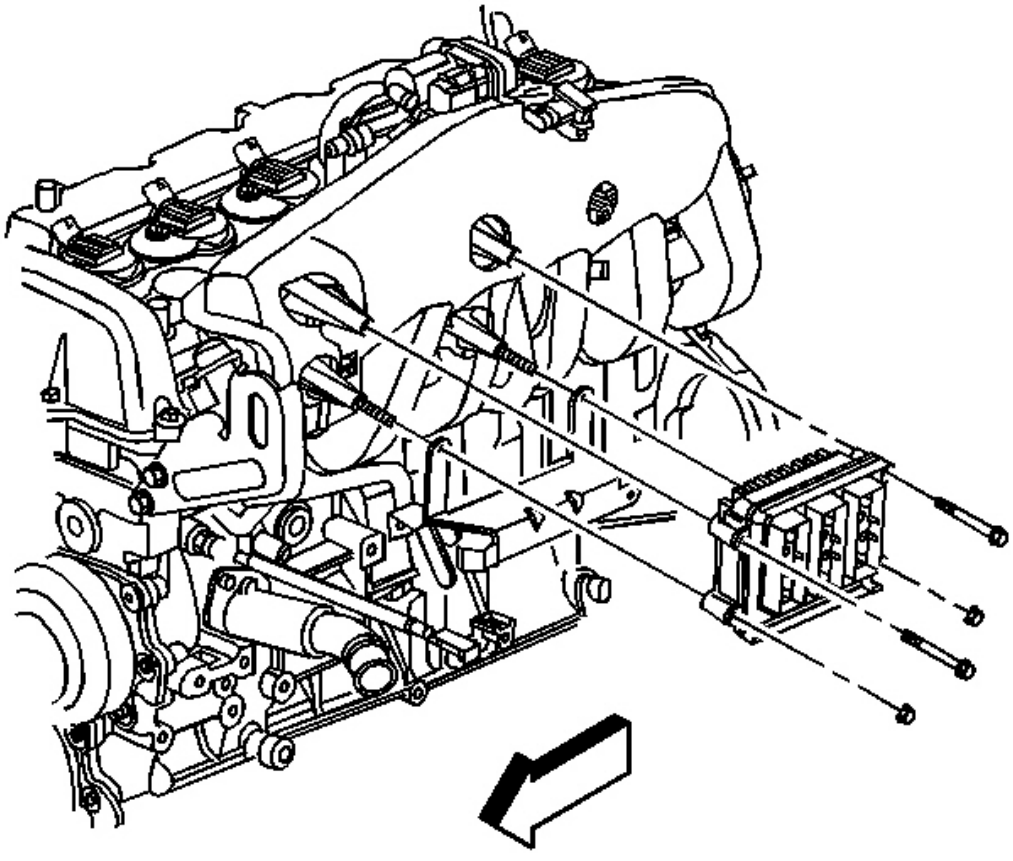


Fig. 228: View Of PCM
Courtesy of GENERAL MOTORS CORP.

32. Remove the engine control module (ECM). Refer to **Engine Control Module Replacement** .
33. Remove all harnesses from the engine harness bracket.
34. Disconnect the front differential vent hose from the engine harness bracket.

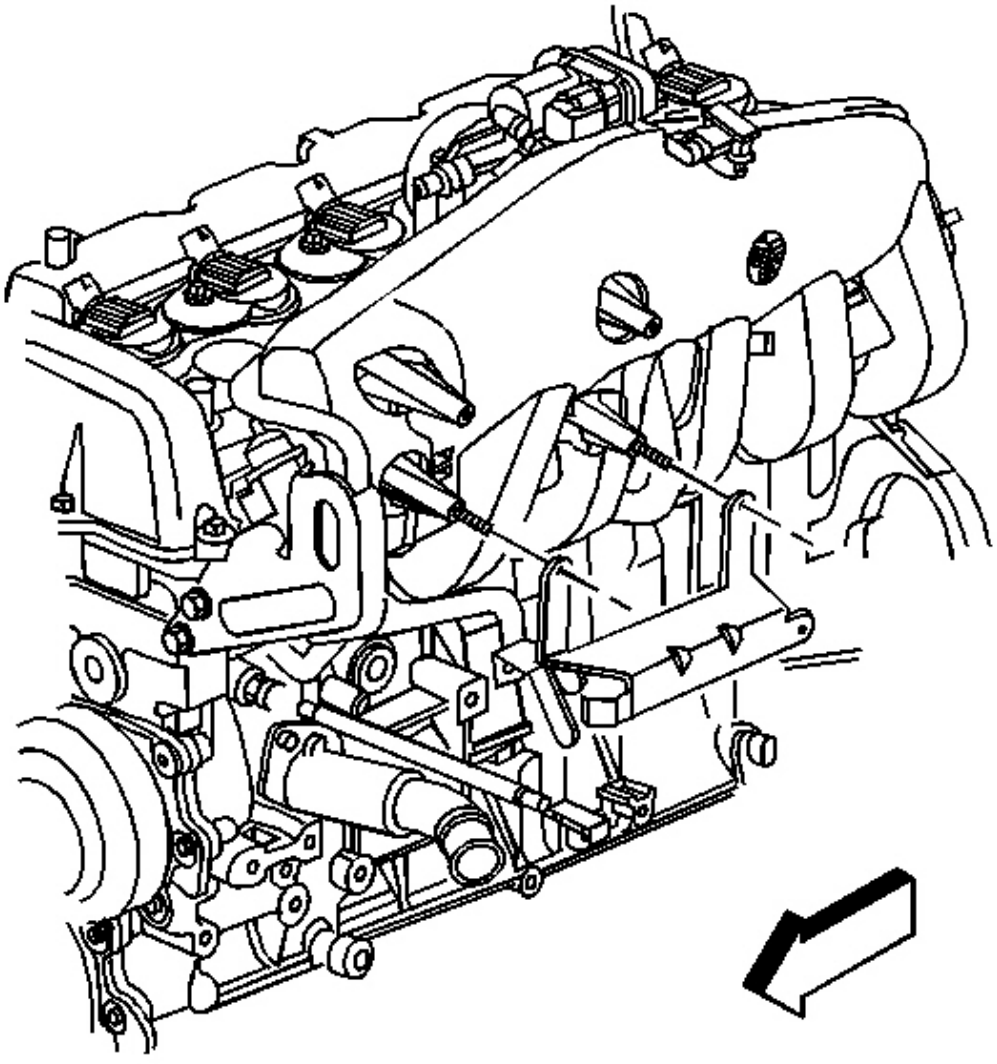


Fig. 229: View Of Engine Harness Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

35. Remove the engine harness bracket bolt and remove bracket.

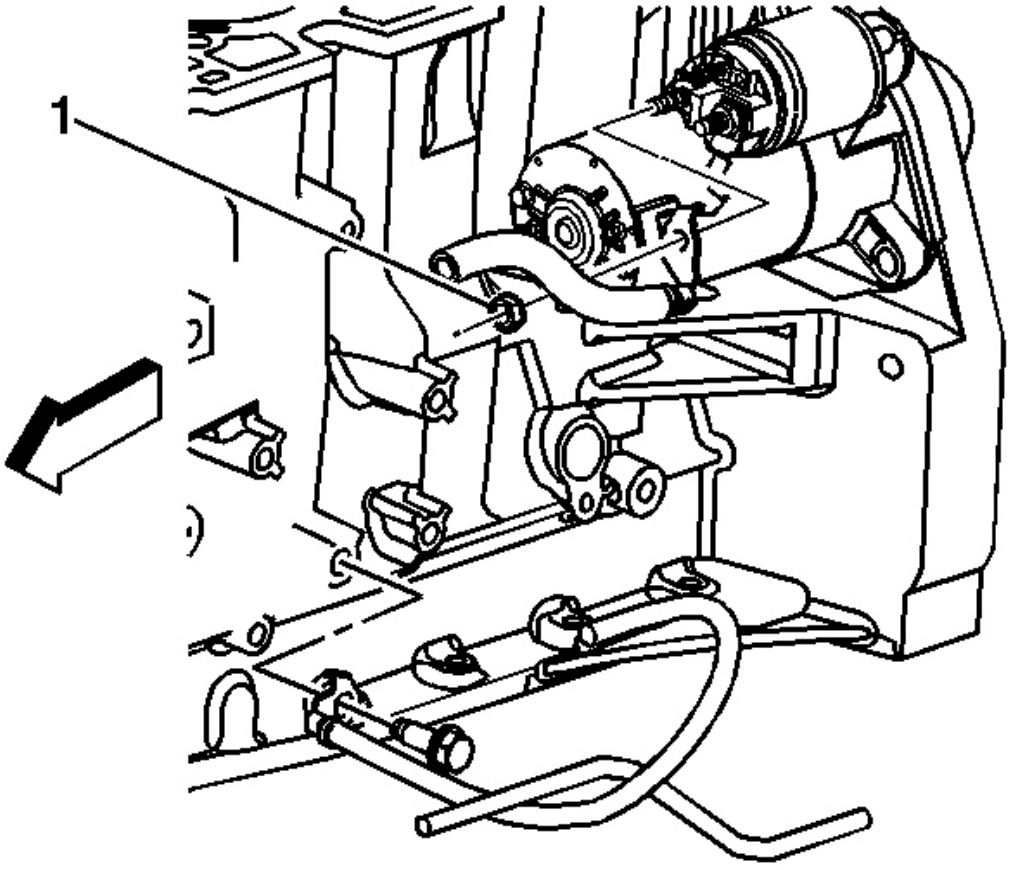


Fig. 230: View Of Starter & Related Components
Courtesy of GENERAL MOTORS CORP.

36. Disconnect starter electrical connections (1).
37. Disconnect the A/C pressure sensor and clutch electrical connector.

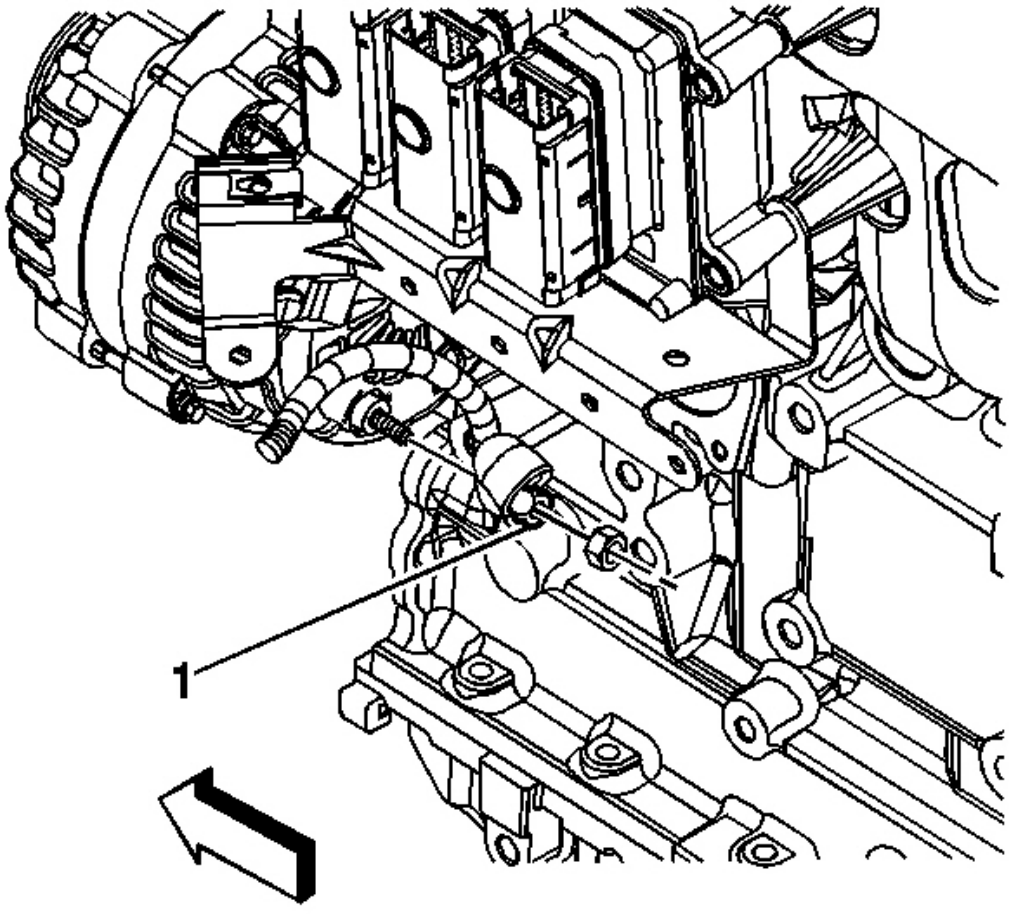


Fig. 231: Rear Of Generator (Alternator) View
Courtesy of GENERAL MOTORS CORP.

38. Disconnect generator electrical connector and battery lead (1).
39. Disconnect the knock sensor electrical connector.
40. Disconnect the crankshaft sensor electrical connector.
41. Disconnect the camshaft sensor electrical connector.

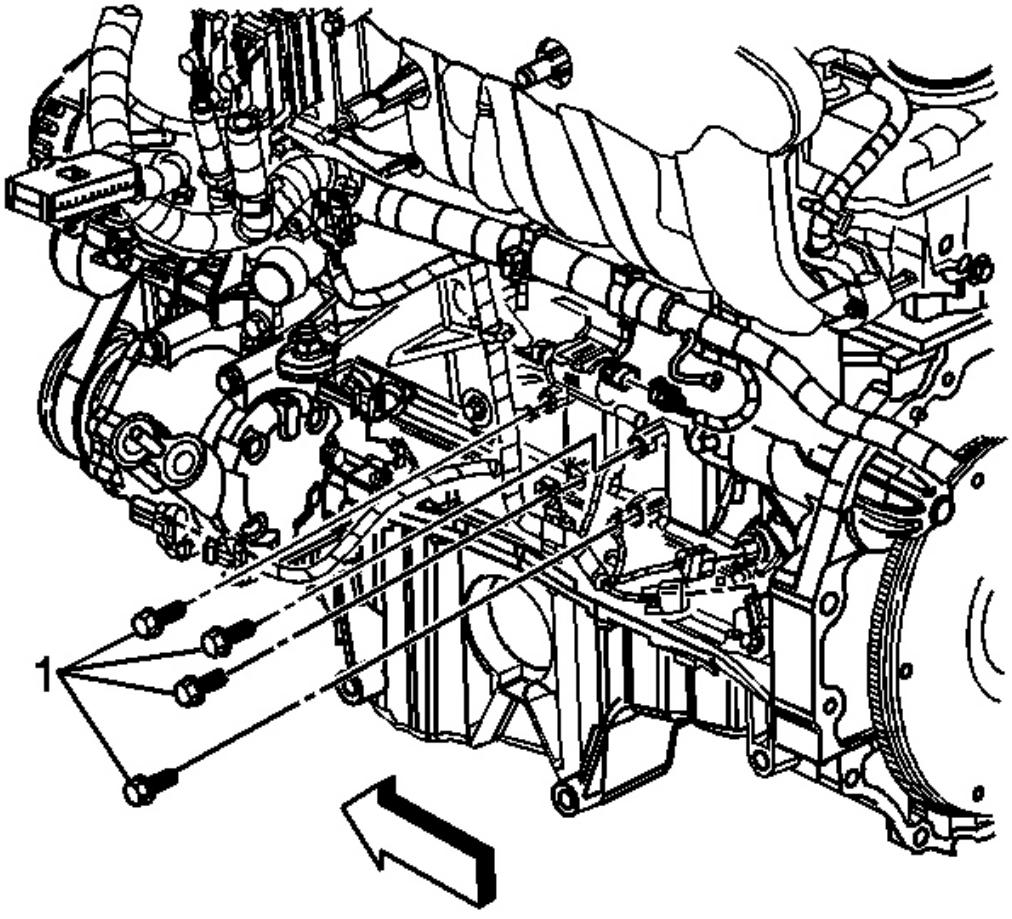


Fig. 232: View Of Left Side Of Block
Courtesy of GENERAL MOTORS CORP.

42. Remove 4 grounds on the left side of the block (1).
43. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
44. Remove the wheel drive shafts, left and right. Refer to **Wheel Drive Shaft Replacement** .
45. Remove the propeller shaft from the front axle pinion yoke. Refer to **Front Propeller Shaft Replacement** .
46. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** .

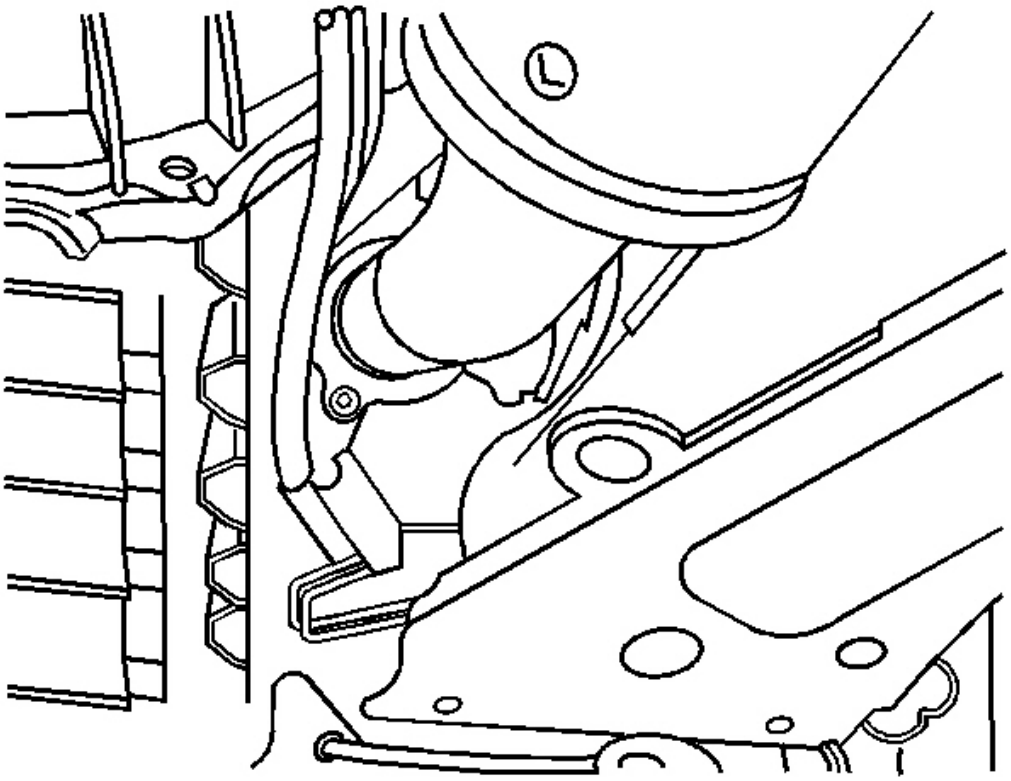


Fig. 233: View Of Exhaust Pipe At Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

47. Disconnect the exhaust pipe from the exhaust manifold and slide the exhaust pipe backward slightly.
48. Remove the fuel tank shield, if equipped. Refer to **Fuel Tank Shield Replacement** .

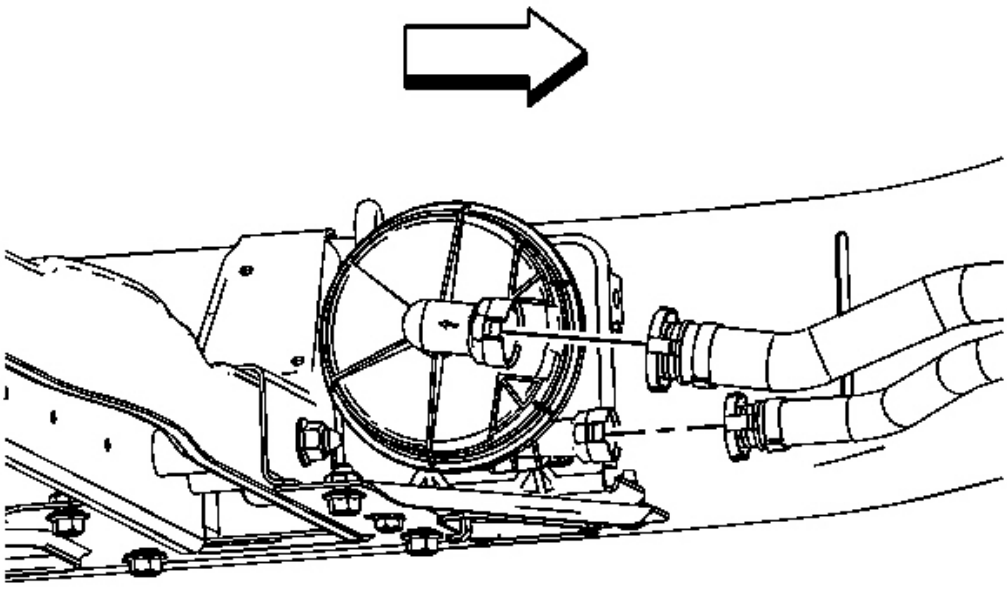


Fig. 234: View Of Secondary AIR Pipes & Pump
Courtesy of GENERAL MOTORS CORP.

49. Disconnect the AIR pipes from the AIR pump.
50. Remove the torque converter bolt access cover.
51. Remove the torque converter bolts.
52. Place a jack on the transmission oil pan for support.
53. Remove the transmission support. Refer to **Transmission Support Replacement** .
54. Lower the transmission enough to reach the top bell housing bolts.

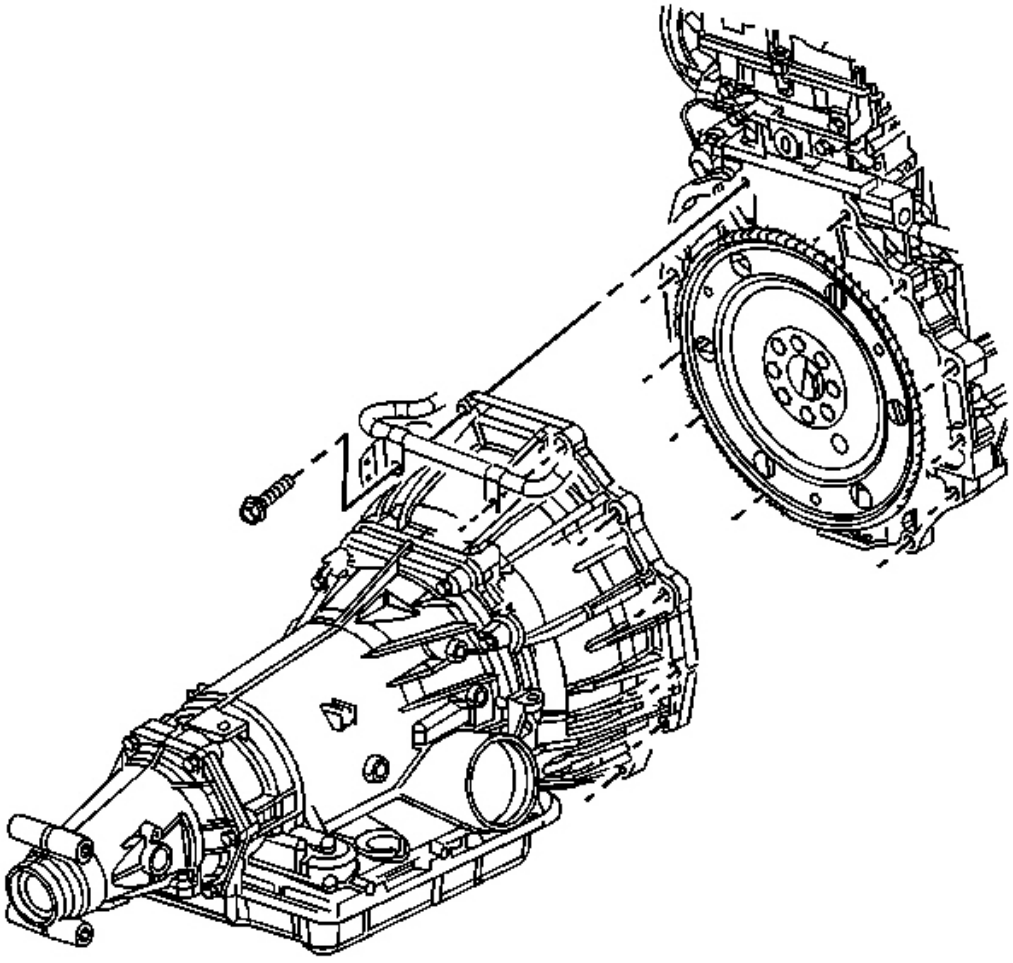


Fig. 235: View Of Bell Housing Bolts
Courtesy of GENERAL MOTORS CORP.

55. Remove the top 4 bell housing bolts. There may be 2 harness clips that will need to be removed in order to have access to 2 of the top bolts.
56. Raise the transmission.
57. Reinstall the transmission support using only 2 through bolts.
58. Remove the remaining bell housing bolts, for a total of 11 bolts.
59. Remove the left and right engine lower mount nuts.
60. Disconnect the oil pressure switch electrical connector.
61. Lower the vehicle.

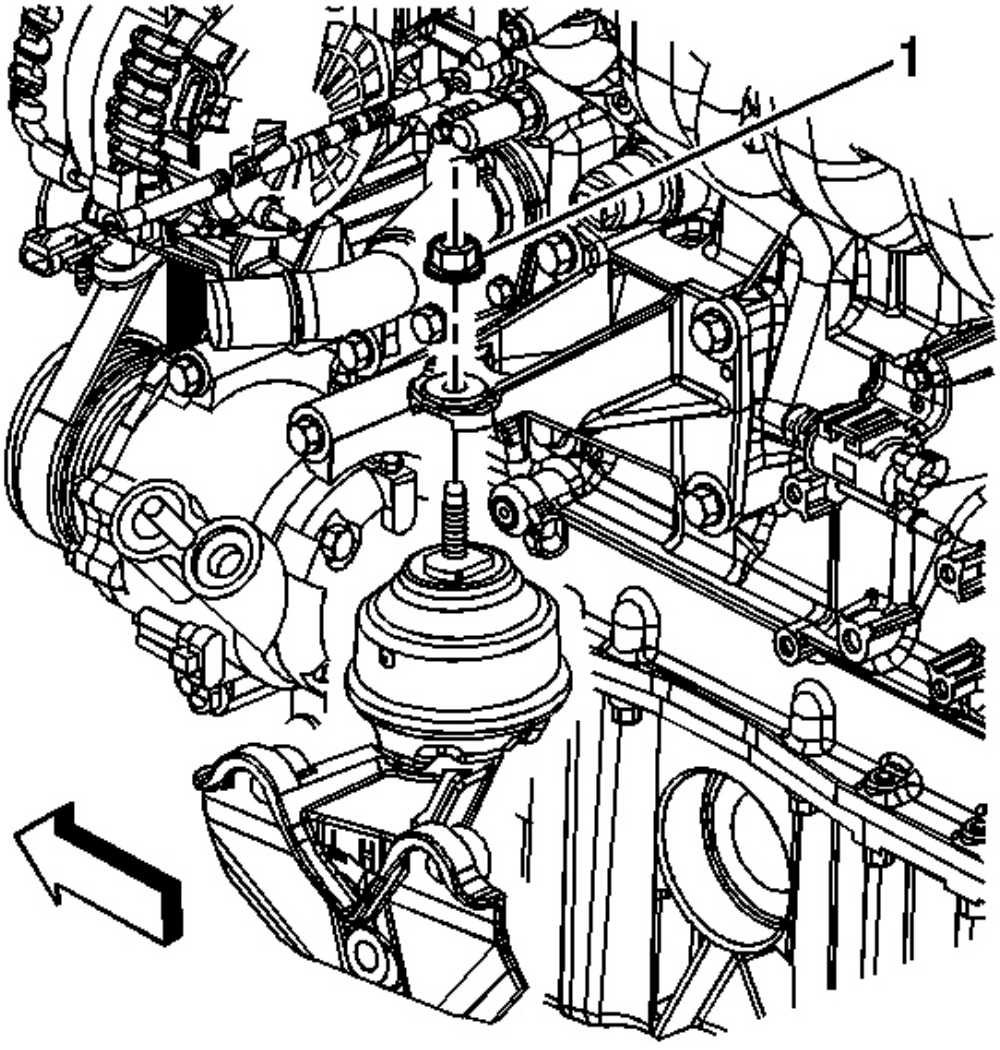


Fig. 236: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

62. Remove the left upper engine mount nut (1).

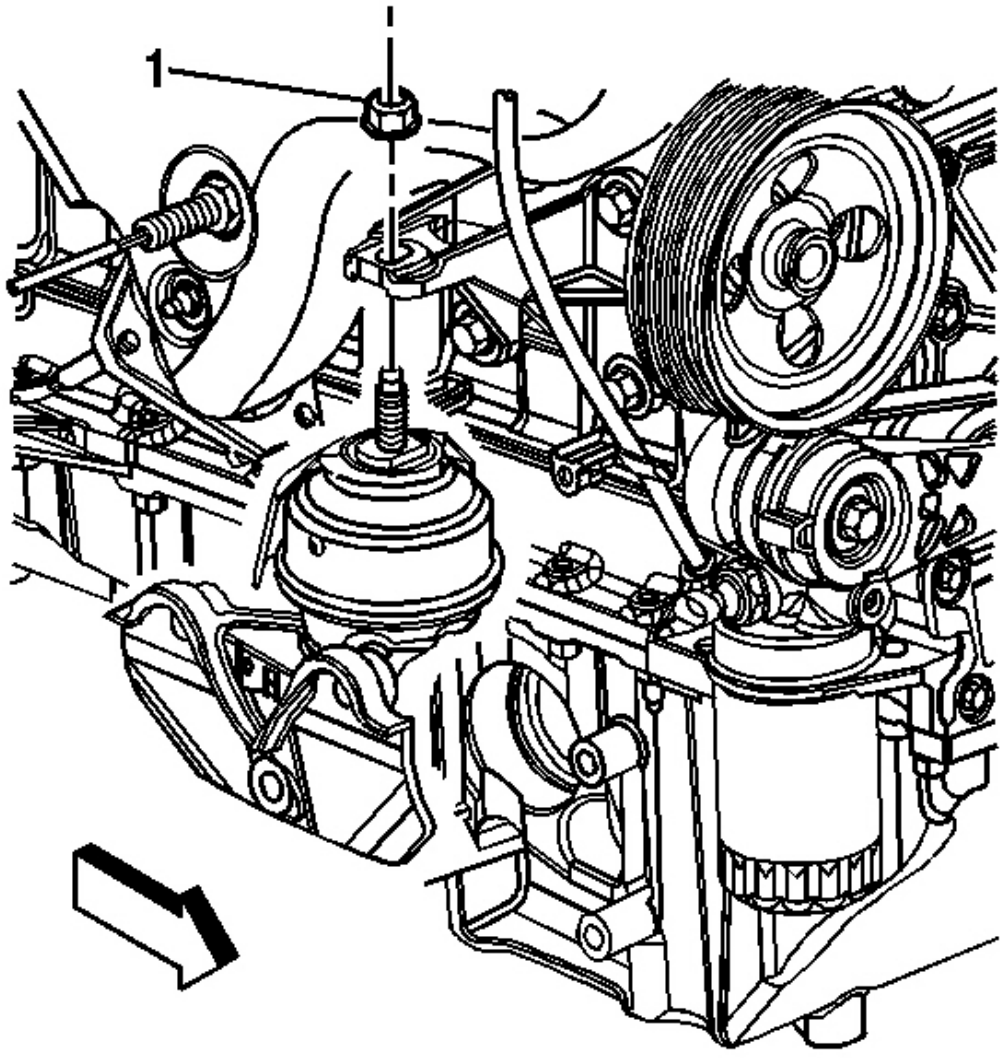


Fig. 237: View Of Upper Engine Mount Nuts
Courtesy of GENERAL MOTORS CORP.

63. Remove the right upper engine mount nut (1).
64. Install the engine hoist.
65. Raise the engine out of the compartment slowly keeping the transmission supported.
66. Remove both engine mounts for clearance.
67. Remove the fasteners securing the AIR pipes to the back of the engine head.
68. Remove the AIR pipes from the vehicle.

69. Continue raising the engine out of the vehicle.
70. Install the engine to the engine stand.

Installation Procedure

1. Remove the engine from the engine stand.
2. Slowly install the engine into the engine compartment aligning the engine mounts with the brackets.
3. Install the AIR pipes to the engine.
4. Install the fasteners securing the AIR pipes to the back of the engine head.
5. When the engine mounts are aligned, install the engine mounts, putting the mount up through the engine mount brackets before inserting into the chassis mount brackets.

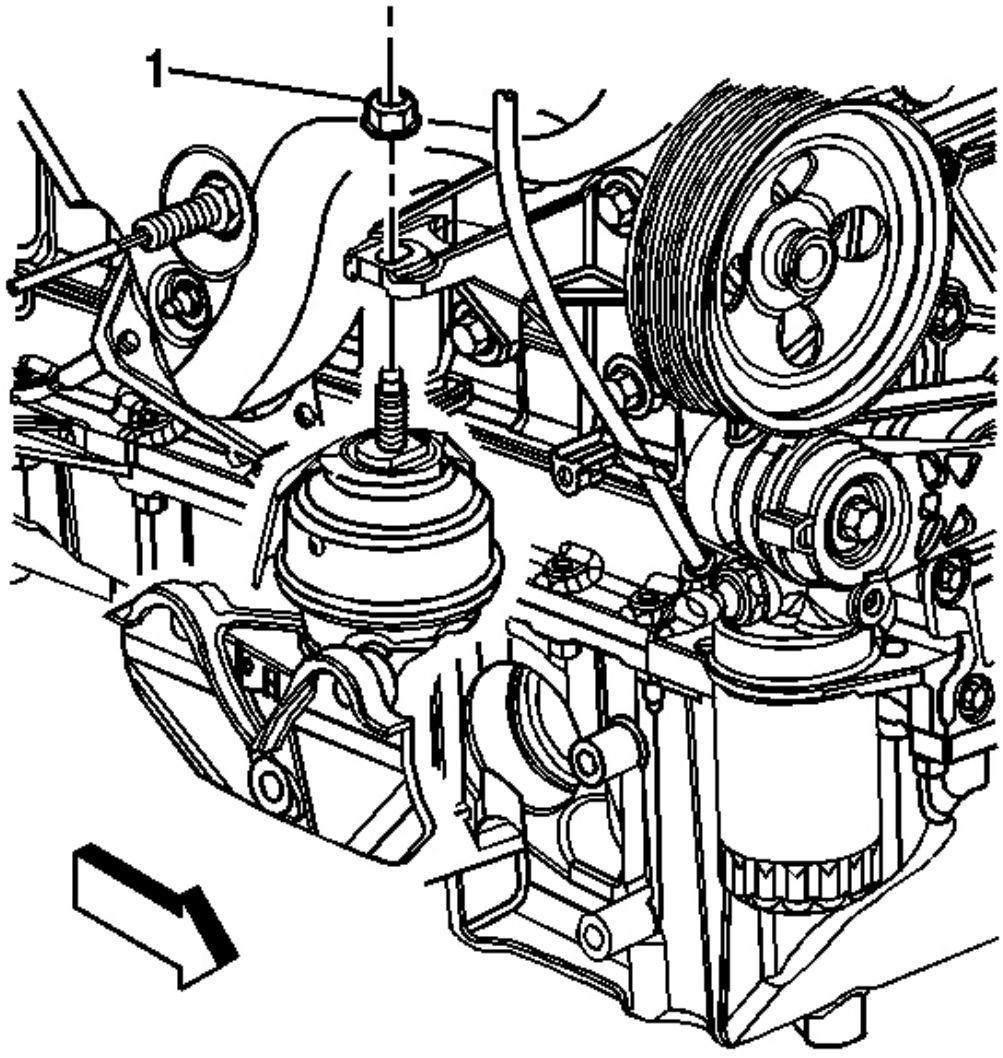


Fig. 238: View Of Upper Engine Mount Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

6. Lower the engine onto the mounts and install the upper engine mount nuts (1).

   Tighten: Tighten the nuts to 70 N.m (51 lb ft).

7. Remove the engine hoist.

8. Lay the radiator into the radiator support, but do not install the radiator completely.
9. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .

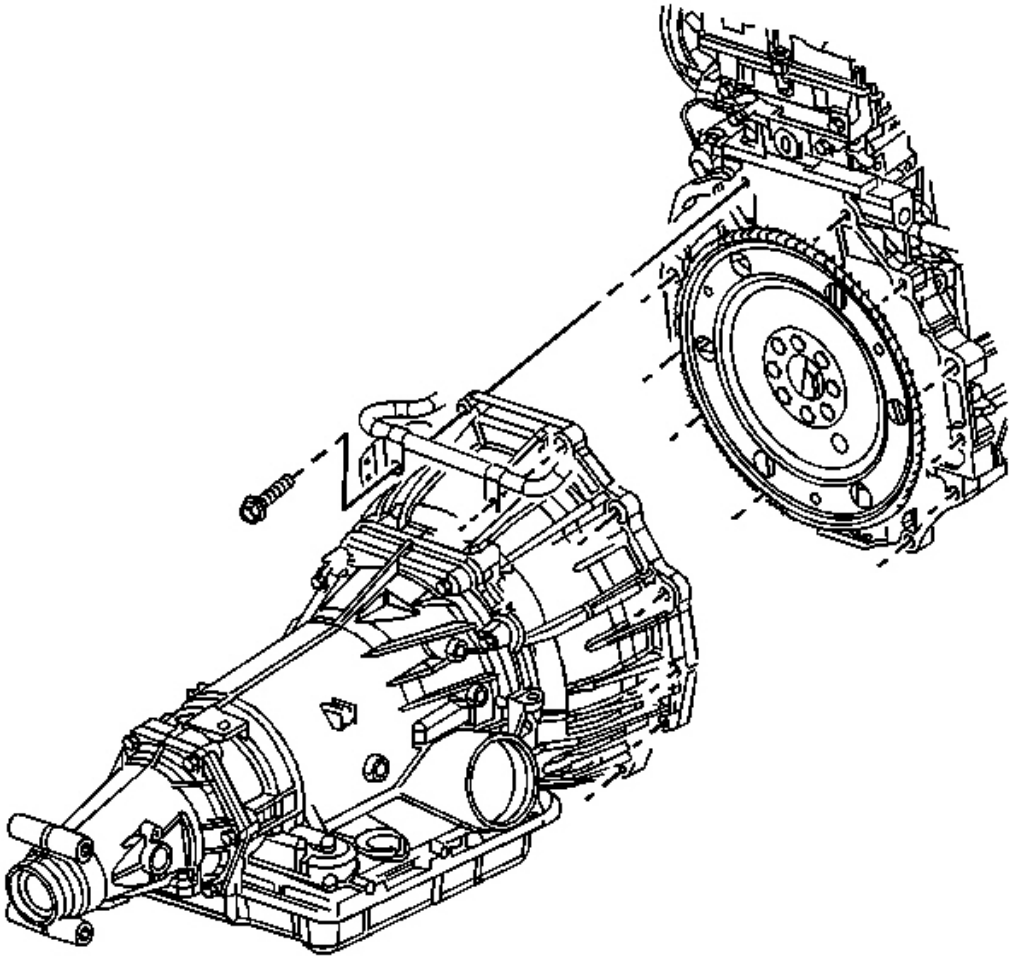


Fig. 239: View Of Bell Housing Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install all of the lower bell housing bolts, excluding the top 4.
11. Remove the 2 through bolts securing the transmission support.
12. Lower the transmission.
13. Install the top 4 bell housing bolts.

Tighten: Tighten all 11 bell housing bolts to 50 N.m (37 lb ft).

14. Raise the transmission.
15. Install the transmission support. Refer to **Transmission Support Replacement** .
16. Install the 3 torque converter bolts.

    Tighten: Tighten the torque converter bolts to 60 N.m (44 lb ft).

17. Install the torque converter bolt cover.
18. Install the fuel tank shield, if removed. Refer to **Fuel Tank Shield Replacement** .

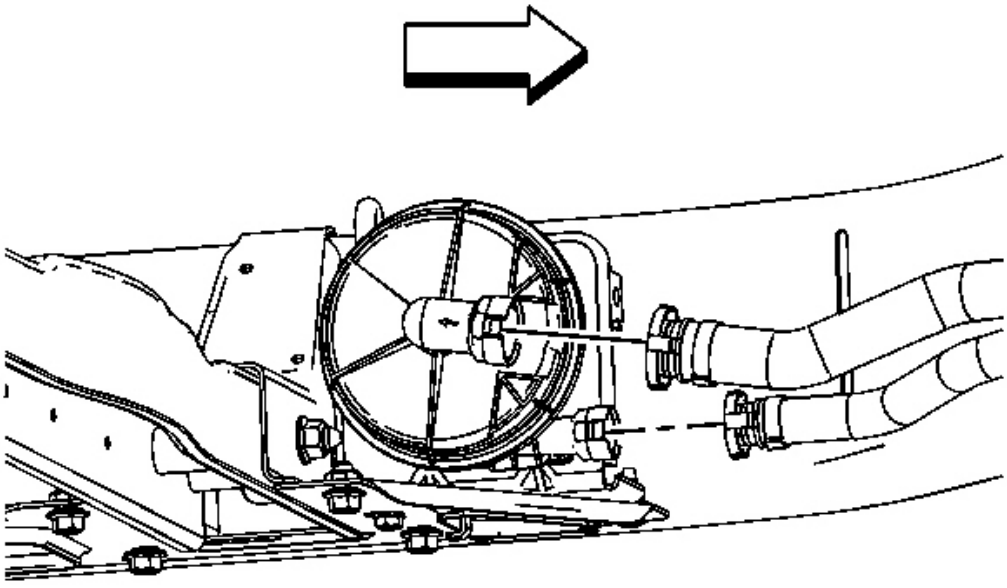


Fig. 240: View Of Secondary AIR Pipes & Pump
Courtesy of GENERAL MOTORS CORP.

19. Connect the AIR pipes to the AIR pump.
20. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** .
21. Install the propeller shaft to the front axle pinion yoke. Refer to **Front Propeller Shaft Replacement** .

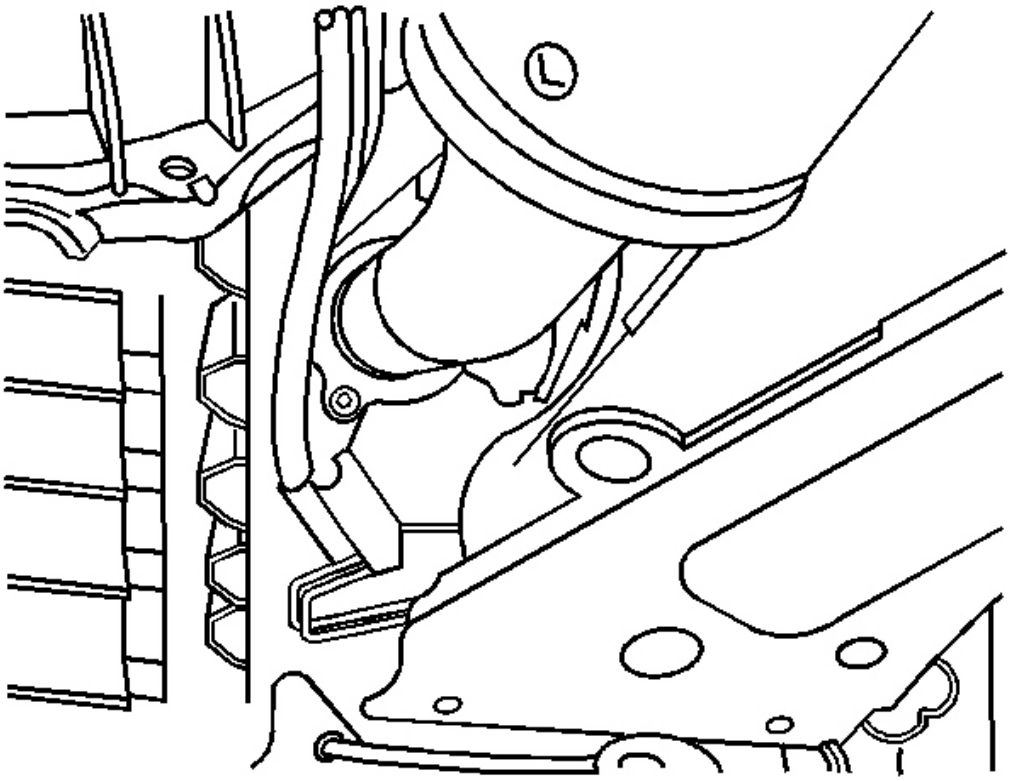


Fig. 241: View Of Exhaust Pipe At Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

22. Connect the exhaust pipe to the manifold and secure the pipe with the bolts.

    Tighten: Tighten the exhaust pipe bolts to 50 N.m (37 lb ft).

23. Connect the oil pressure sensor electrical connector.

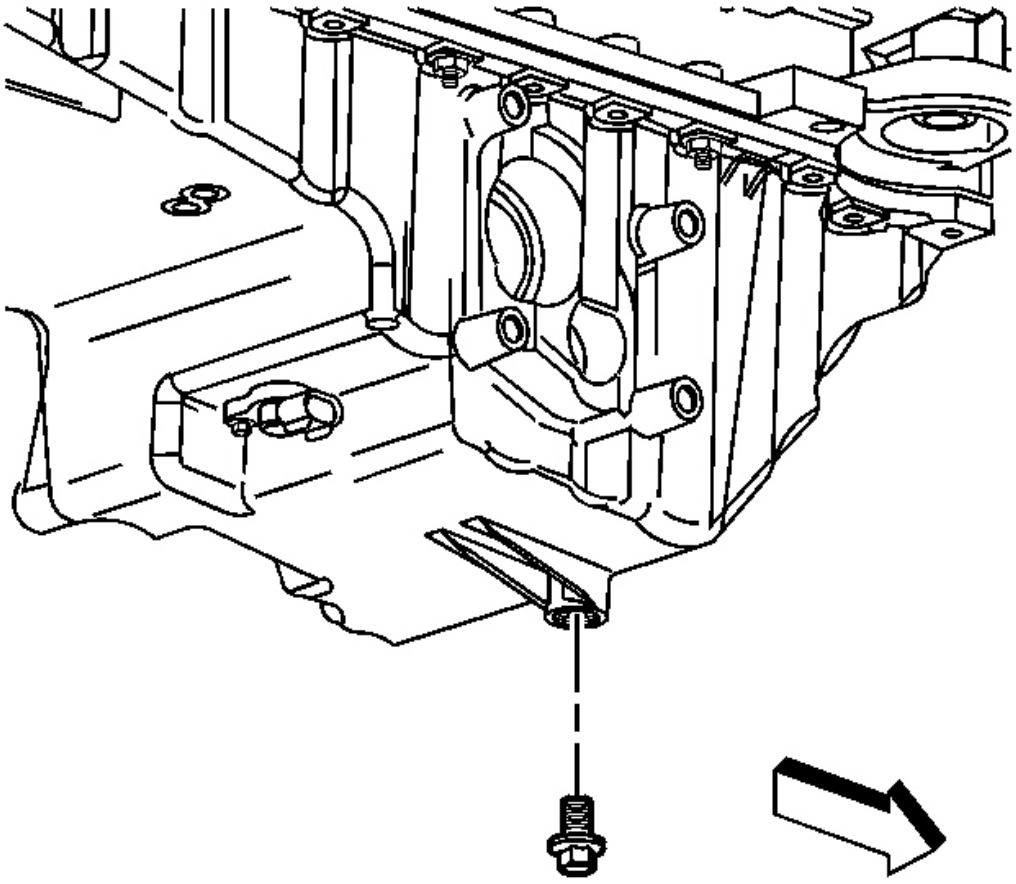


Fig. 242: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

24. Install the oil pan drain plug.

    Tighten: Tighten the plug to 26 N.m (19 lb ft).

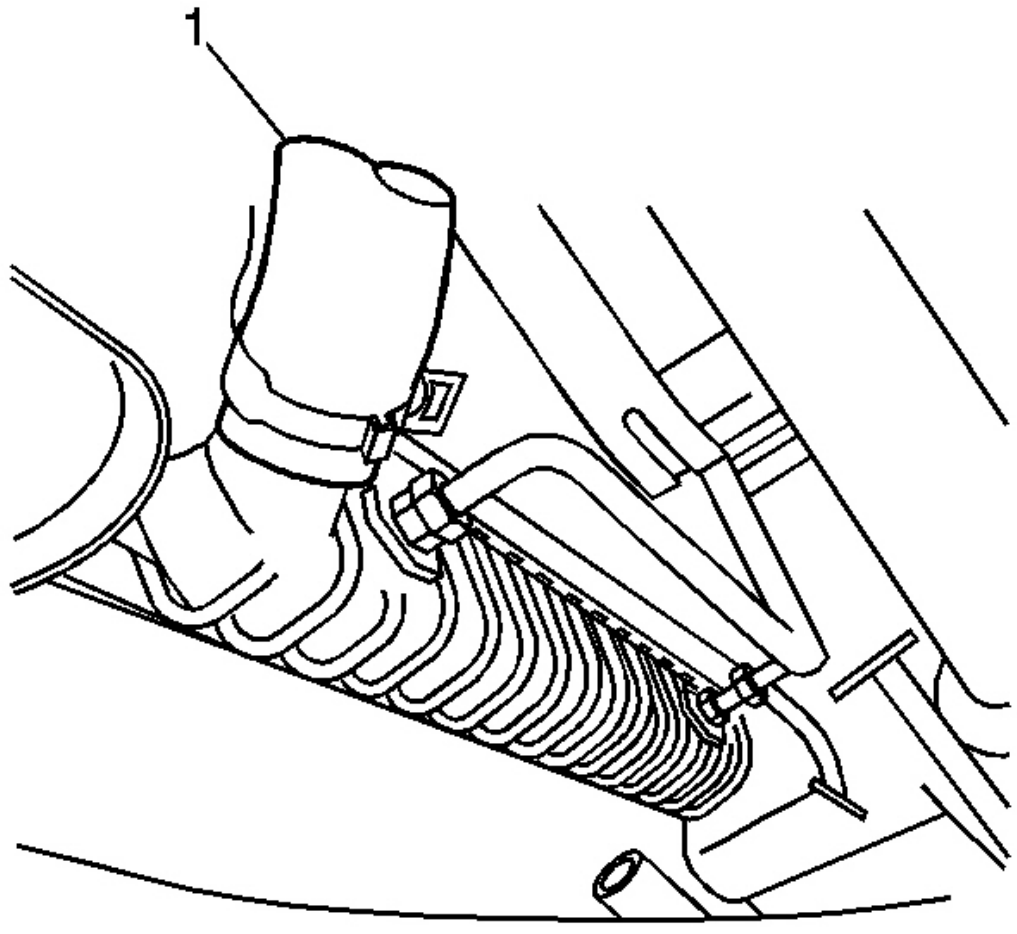


Fig. 243: View Of Radiator Hose
Courtesy of GENERAL MOTORS CORP.

25. Install the lower radiator hose (1).
26. Install the left and right wheel drive shafts. Refer to **Wheel Drive Shaft Replacement** .
27. Lower the vehicle.

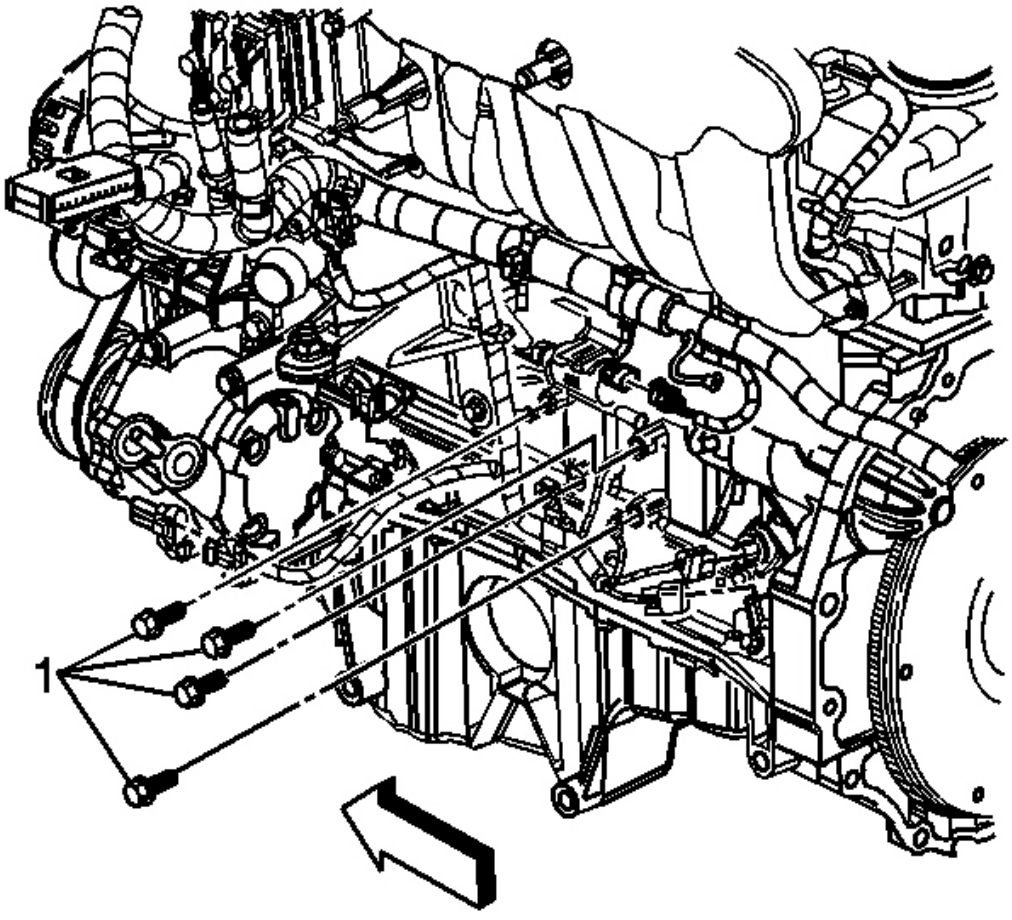


Fig. 244: View Of Left Side Of Block
Courtesy of GENERAL MOTORS CORP.

28. Install the 4 grounds on the left side of the block (1).
29. Install the camshaft sensor electrical connectors.
30. Install the crankshaft sensor electrical connector.
31. Install the knock sensor electrical connector.

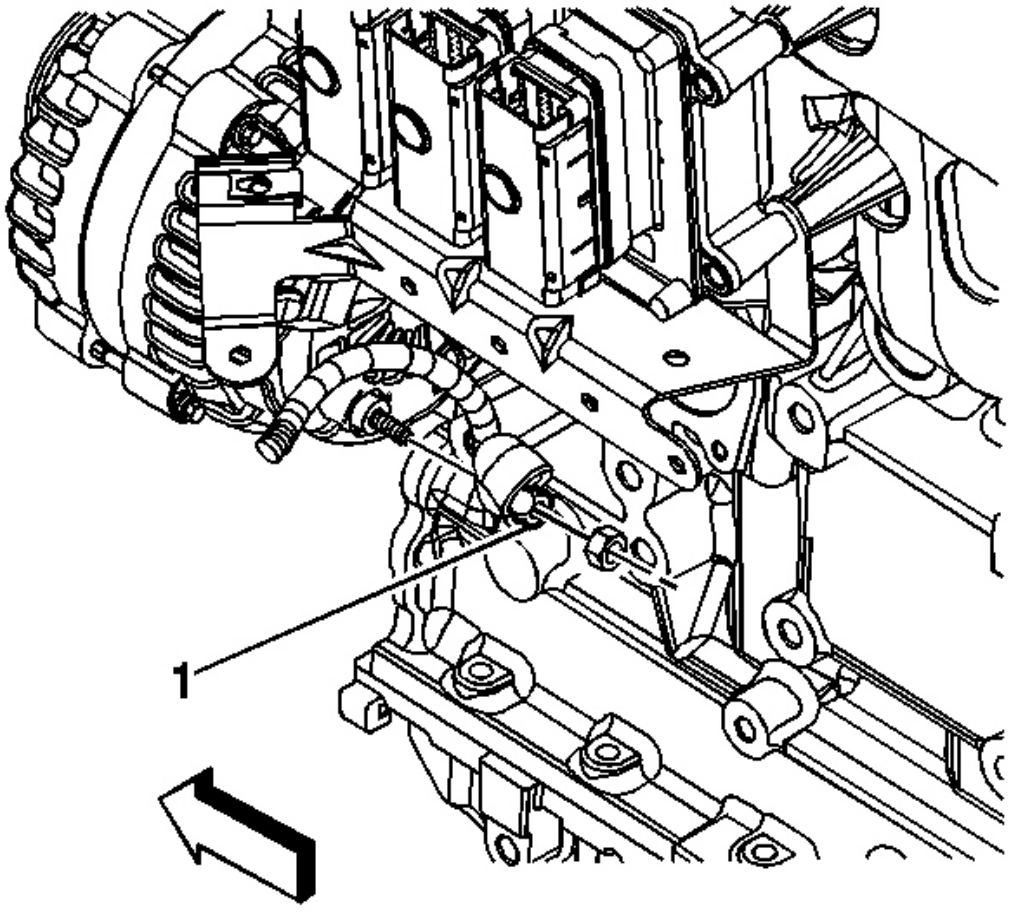


Fig. 245: Rear Of Generator (Alternator) View
Courtesy of GENERAL MOTORS CORP.

32. Install the generator electrical connector and battery lead (1).

    Tighten: Tighten the generator battery lead nut to 9 N.m (80 lb in).

33. Install the A/C pressure sensor and clutch electrical connector.

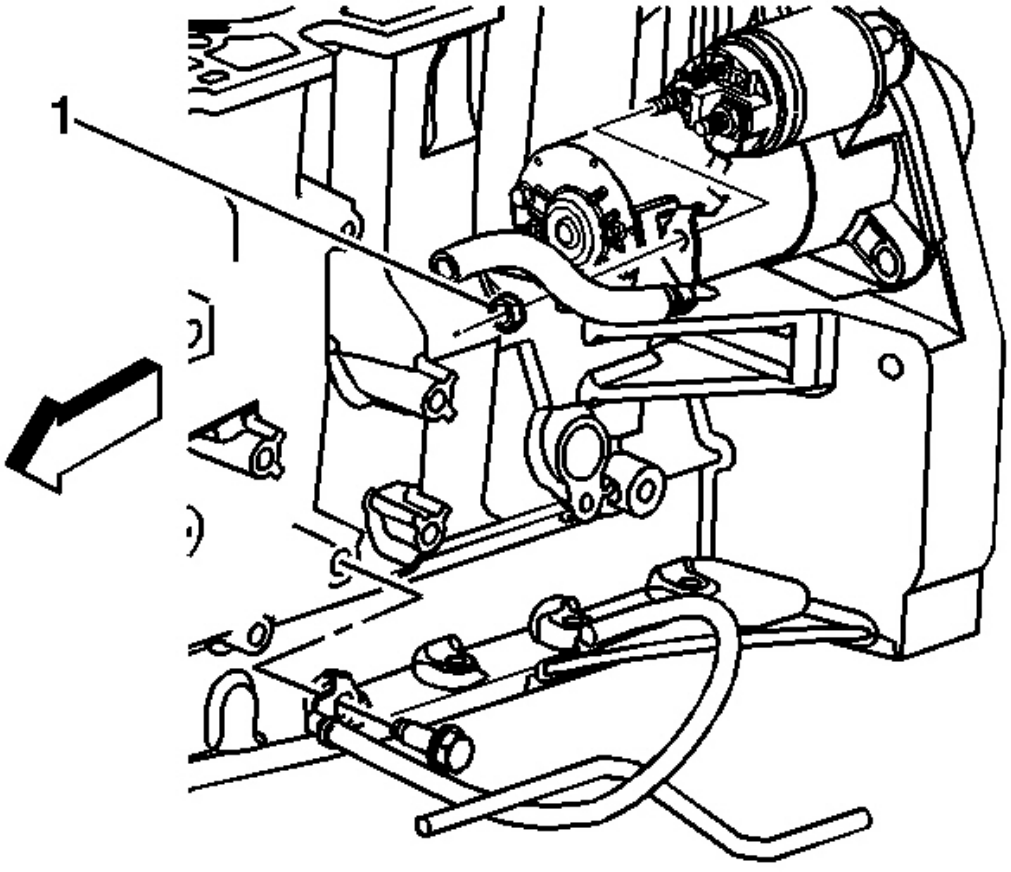


Fig. 246: View Of Starter & Related Components
Courtesy of GENERAL MOTORS CORP.

34. Install starter electrical connectors and battery lead (1).

    Tighten: Tighten the starter battery lead to 9 N.m (80 lb in).

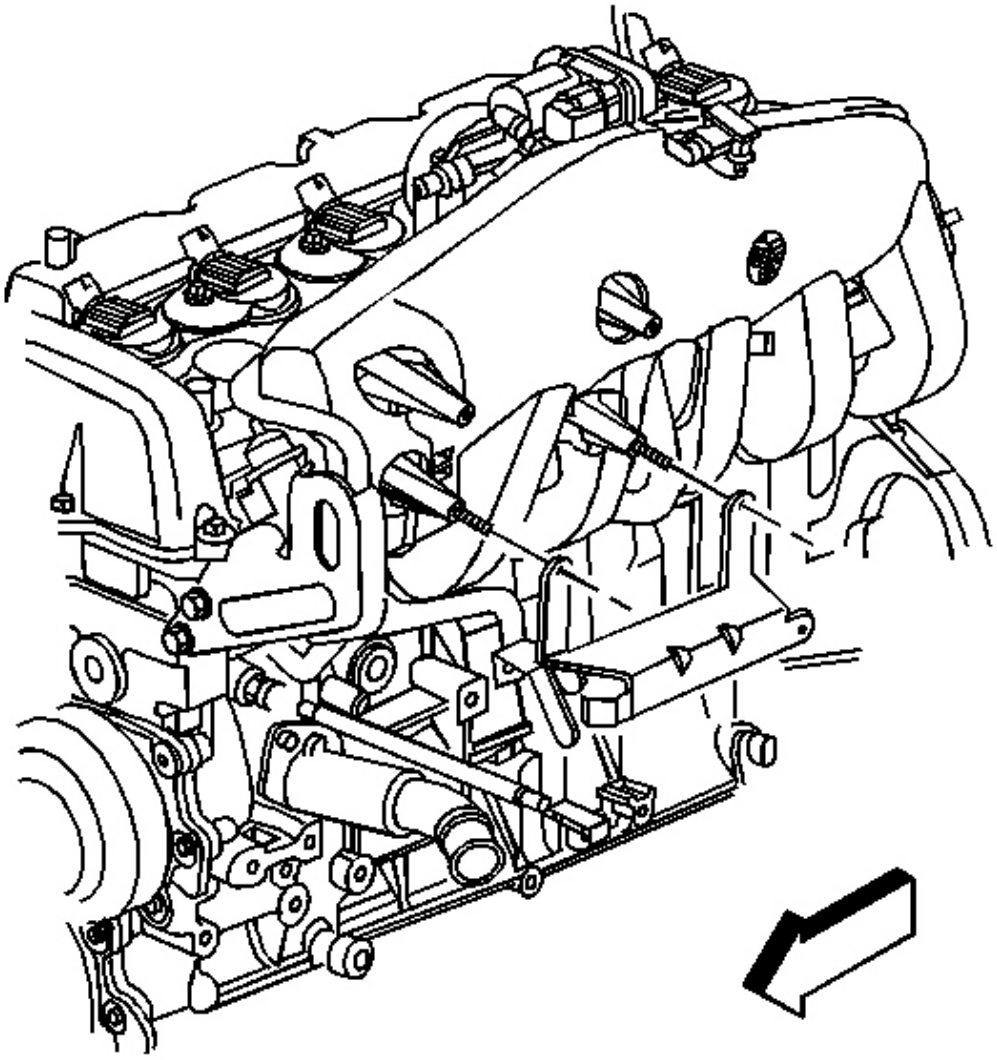


Fig. 247: View Of Engine Harness Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

35. Install the engine harness bracket and bolt.

    Tighten: Tighten the engine harness bracket bolt to 50 N.m (37 lb ft).

36. Install the front differential vent hose, to the engine harness bracket.
37. Install all the harnesses to the engine harness bracket.

38. Install the ECM. Refer to **Engine Control Module Replacement** .
39. Install the power brake hose at booster.

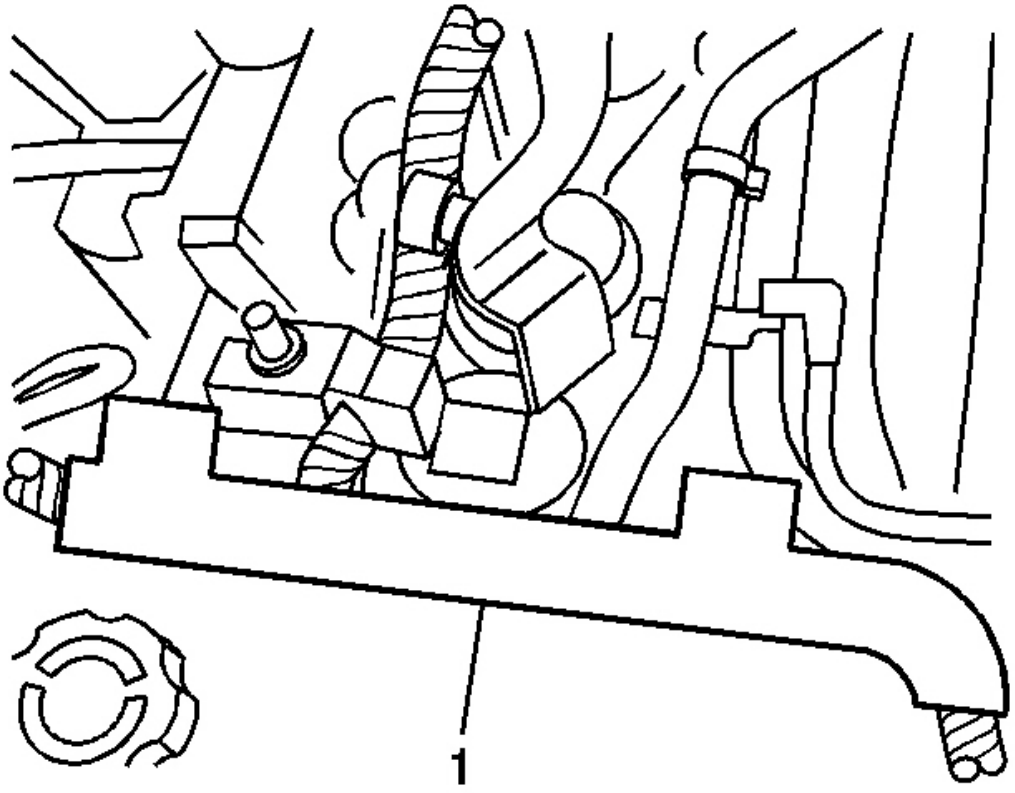


Fig. 248: View Of Engine Electrical Harness Housing
Courtesy of GENERAL MOTORS CORP.

40. Install the harness retainer (1) to the original location.
41. Install the ignition coil harness electrical connectors.

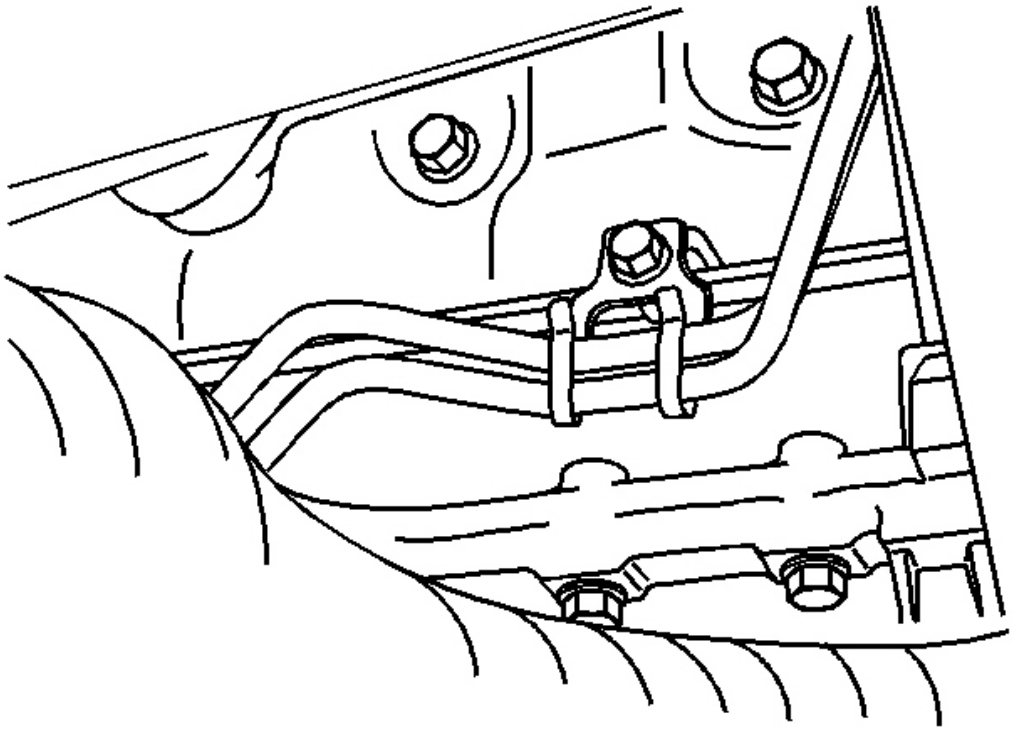


Fig. 249: View Of Transmission Cooler Lines & Clips
Courtesy of GENERAL MOTORS CORP.

42. Clip the transmission cooler lines to the right side of the engine block.
43. Connect the camshaft phaser actuator valve electrical connector.
44. Connect the front axle actuator electrical connector.
45. Connect the A/C line at the accumulator.
46. Install the oxygen sensor electrical connector.

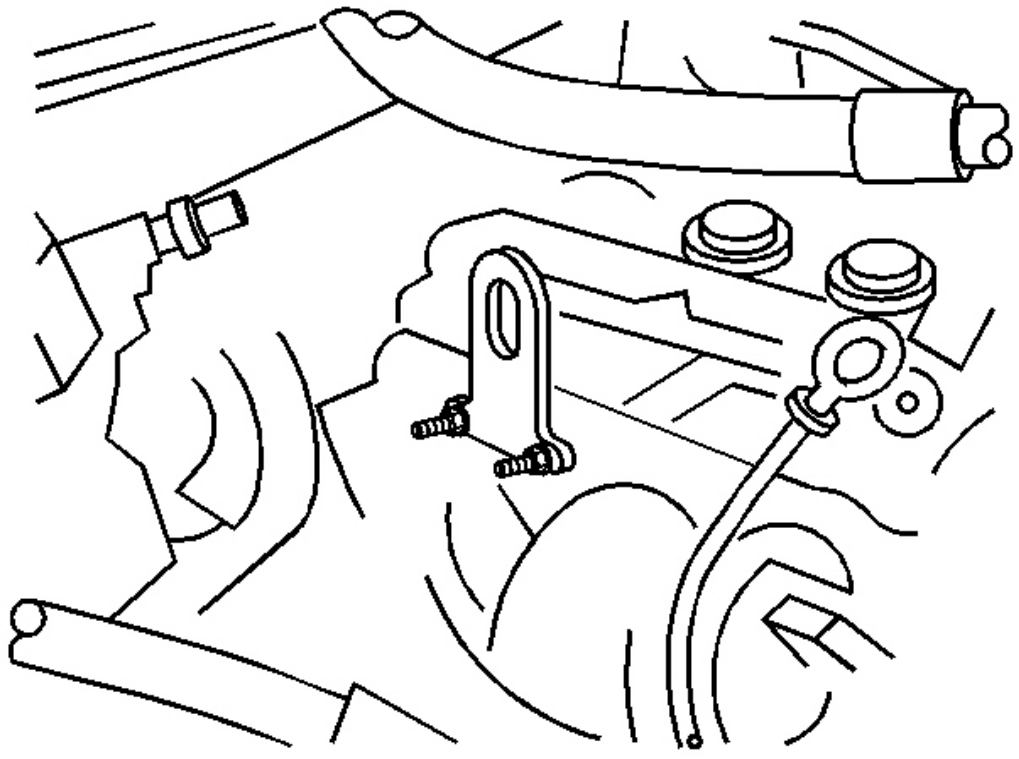


Fig. 250: View Of Lift Hook
Courtesy of GENERAL MOTORS CORP.

47. Remove the lift hook **J 44220** . See **Special Tools**.
48. Install the secondary AIR solenoid valve. Refer to **Secondary Air Injection Solenoid Valve Replacement** .
49. Install the heater hoses to the heater core. Refer to **Heater Inlet Hose Replacement (LL8)** or **Heater Inlet Hose Replacement (LH6, LS2)** and **Heater Outlet Hose Replacement (LL8)** or **Heater Outlet Hose Replacement (LH6, LS2)** .
50. Install the power steering pump.

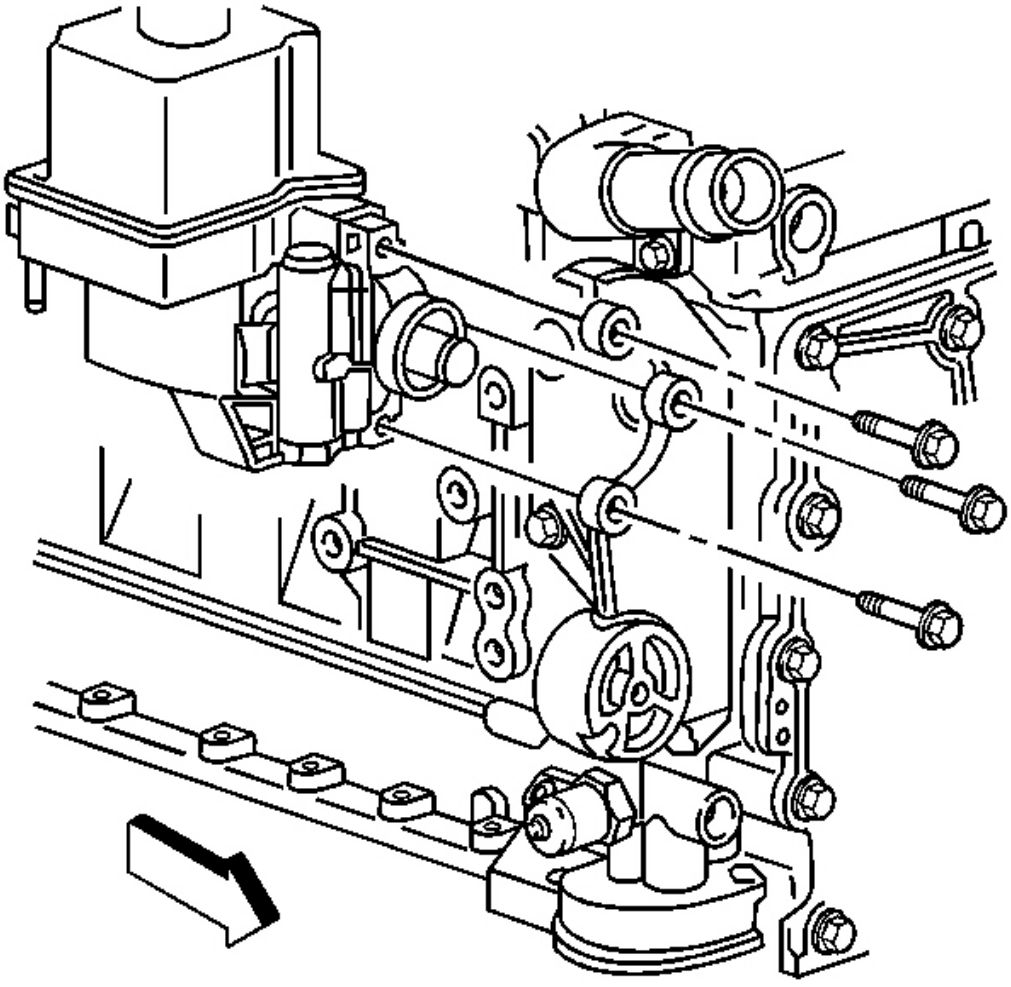


Fig. 251: View Of Power Steering Pump Bolts
Courtesy of GENERAL MOTORS CORP.

51. Install the power steering pump bolts.

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

52. Install the drive belt. Refer to **Drive Belt Replacement**.
53. Install cooling fan and shroud, tilting the radiator forward for clearance.
54. Finish installing the radiator. Refer to **Radiator Replacement (LL8)** or **Radiator Replacement (LH6, LS2)** .
55. Install transmission cooler lines together.

56. Install the MAP sensor. Refer to **Manifold Absolute Pressure Sensor Replacement** .
57. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .
58. Install the hood latch. Refer to **Hood Latch Support Replacement** .
59. Install the head lamp housing. Refer to **Headlamp Housing Panel Replacement (Envoy, Rainier)** or **Headlamp Housing Panel Replacement (TrailBlazer)** .
60. Install the grill. Refer to **Grille Replacement (Envoy)** or **Grille Replacement (TrailBlazer)** .
61. Install the washer solvent container. Refer to **Windshield Washer Solvent Container Replacement (Envoy, TrailBlazer)** .
62. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
63. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
64. Install the hood. Refer to **Hood Replacement** .
65. Service the engine oil.
66. Fill the cooling system. Refer to **Cooling System Draining and Filling (LL8)** or **Cooling System Draining and Filling (LH6, LS2)** .
67. Recharge the refrigerant. Refer to **Refrigerant Recovery and Recharging** .
68. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

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

- Disable the ignition system.
- Crank the engine several times. Listen for unusual noises or evidence that parts are binding.
- Enable the ignition system.
- Start the engine and listen for unusual noises.
- Check the vehicle oil pressure gage or light and confirm that the engine has acceptable oil pressure.
- Run the engine speed at about 1000 RPM until the engine has reached normal operating temperature.
- Listen for a sticking lifter and other unusual noises.
- Inspect for fuel, oil and/or coolant leaks while the engine is running.
- Perform a final inspection for the proper engine oil and coolant levels.

69. Install the hood. Refer to **Hood Replacement** .

ENGINE OIL & OIL FILTER REPLACEMENT

Removal Procedure

1. Remove the oil fill cap.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the oil pan drain plug and drain the oil into a suitable container.

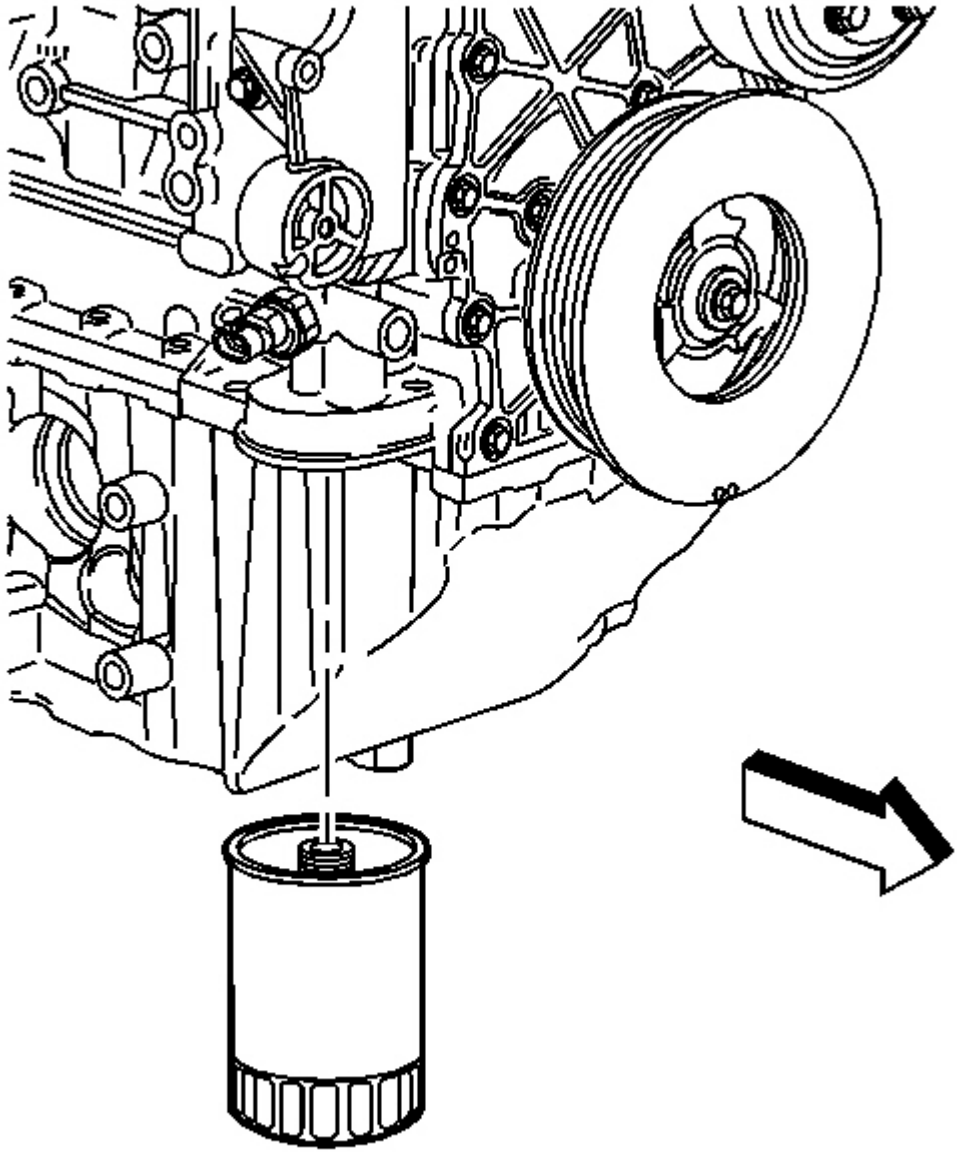


Fig. 252: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter using a suitable wrench.
5. Inspect the old oil filter to ensure the filter seal is not left on the engine block.

Installation Procedure

1. Wipe the excess oil from the oil filter housing.
2. Lubricate the oil filter seal with clean engine oil.

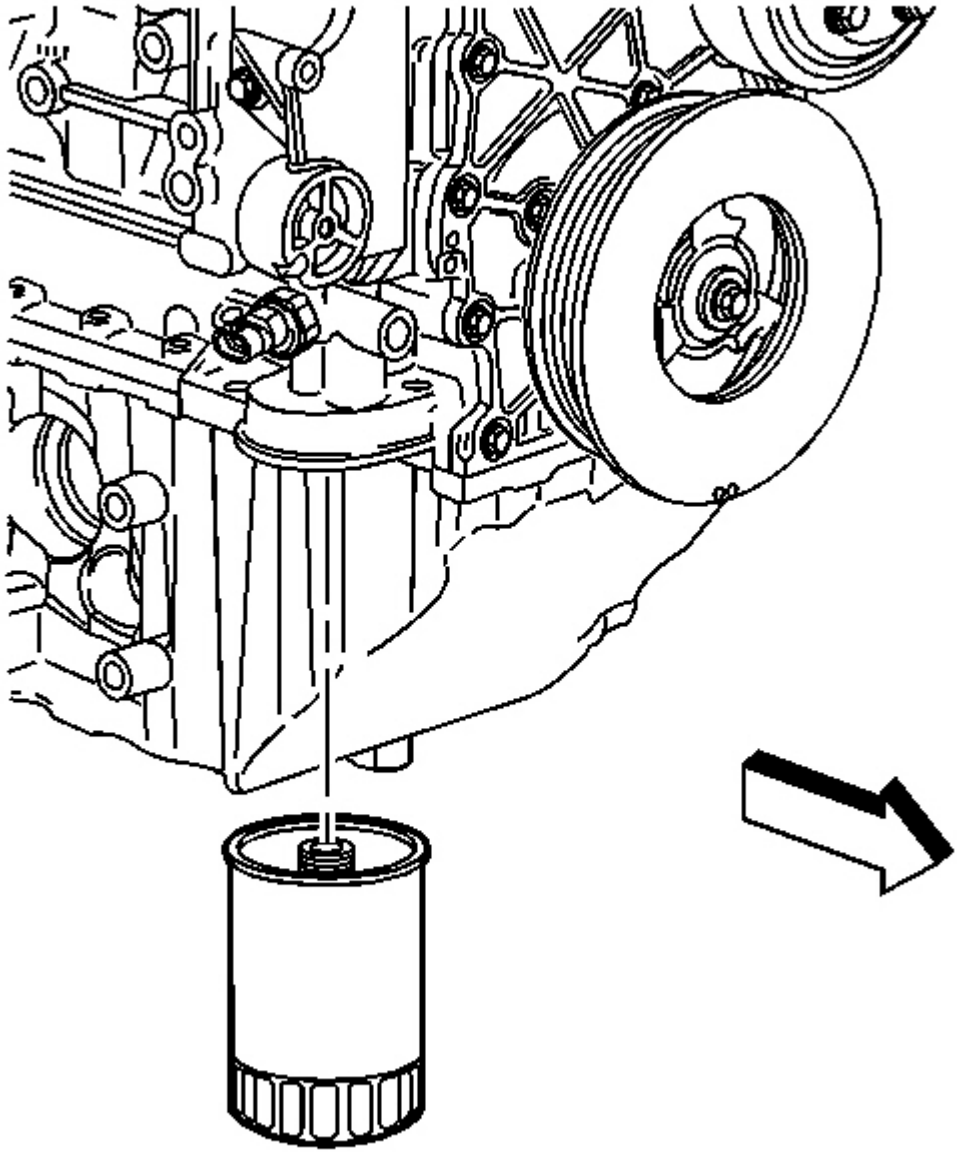


Fig. 253: View Of Oil Filter

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the new oil filter.

   Tighten: Tighten the oil filter to 17 N.m (22 lb ft) plus 150 degrees.

4. Install the oil pan drain plug.

   Tighten: Tighten the oil pan drain plug to 26 N.m (19 lb ft).

5. Lower the vehicle.
6. Fill the crankcase with the proper quantity of engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations** .
7. Remove the oil level indicator.
8. Wipe the indicator with a clean cloth.
9. Install the oil level indicator.
10. Remove the oil level indicator and check the oil level.
11. Add oil if necessary.
12. Check for any oil leaks.

REPAIR INSTRUCTIONS - OFF VEHICLE

ENGINE FLYWHEEL REMOVAL

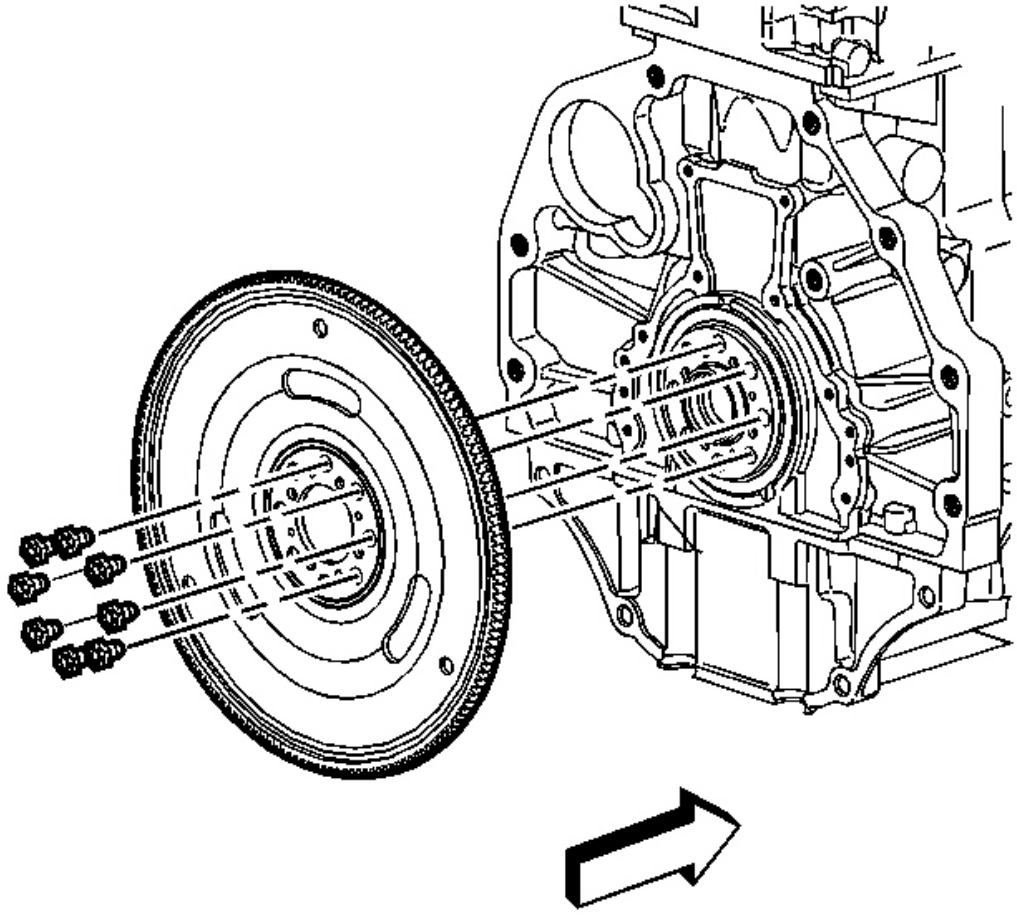


Fig. 254: View Of Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel bolts.
2. Remove the flywheel.

DRAINING FLUIDS & OIL FILTER REMOVAL

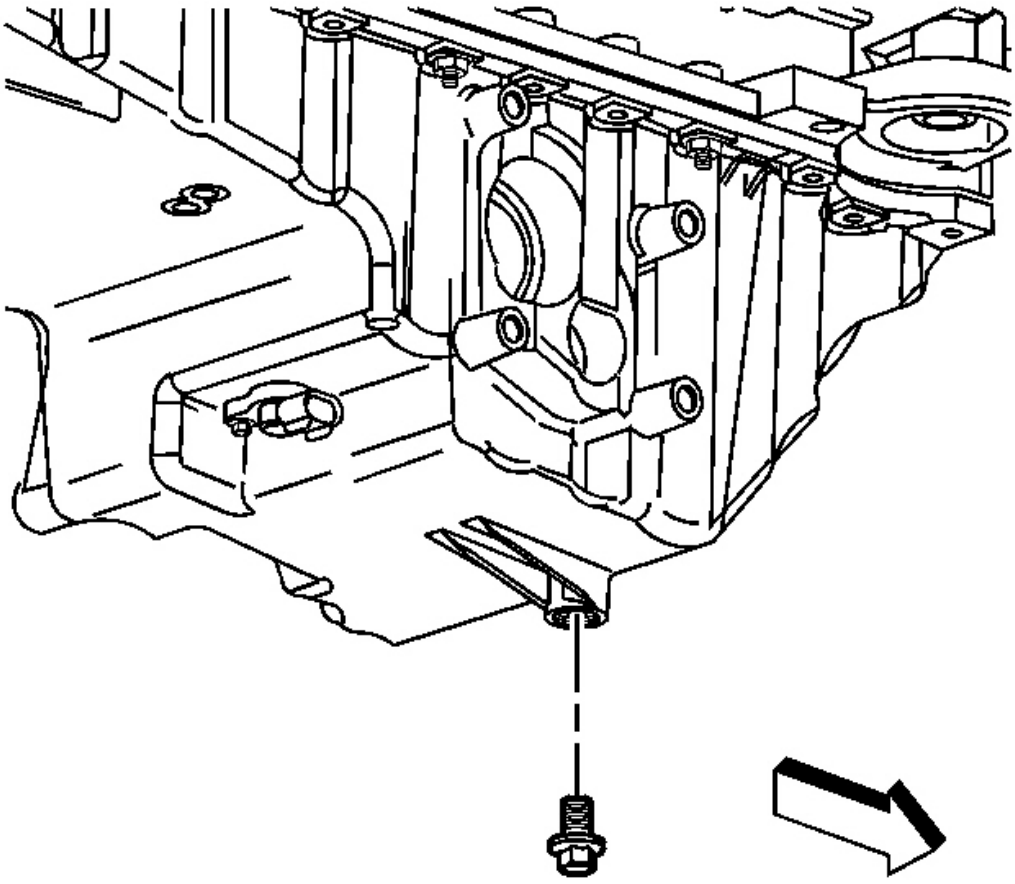


Fig. 255: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug.
2. Drain the engine oil.

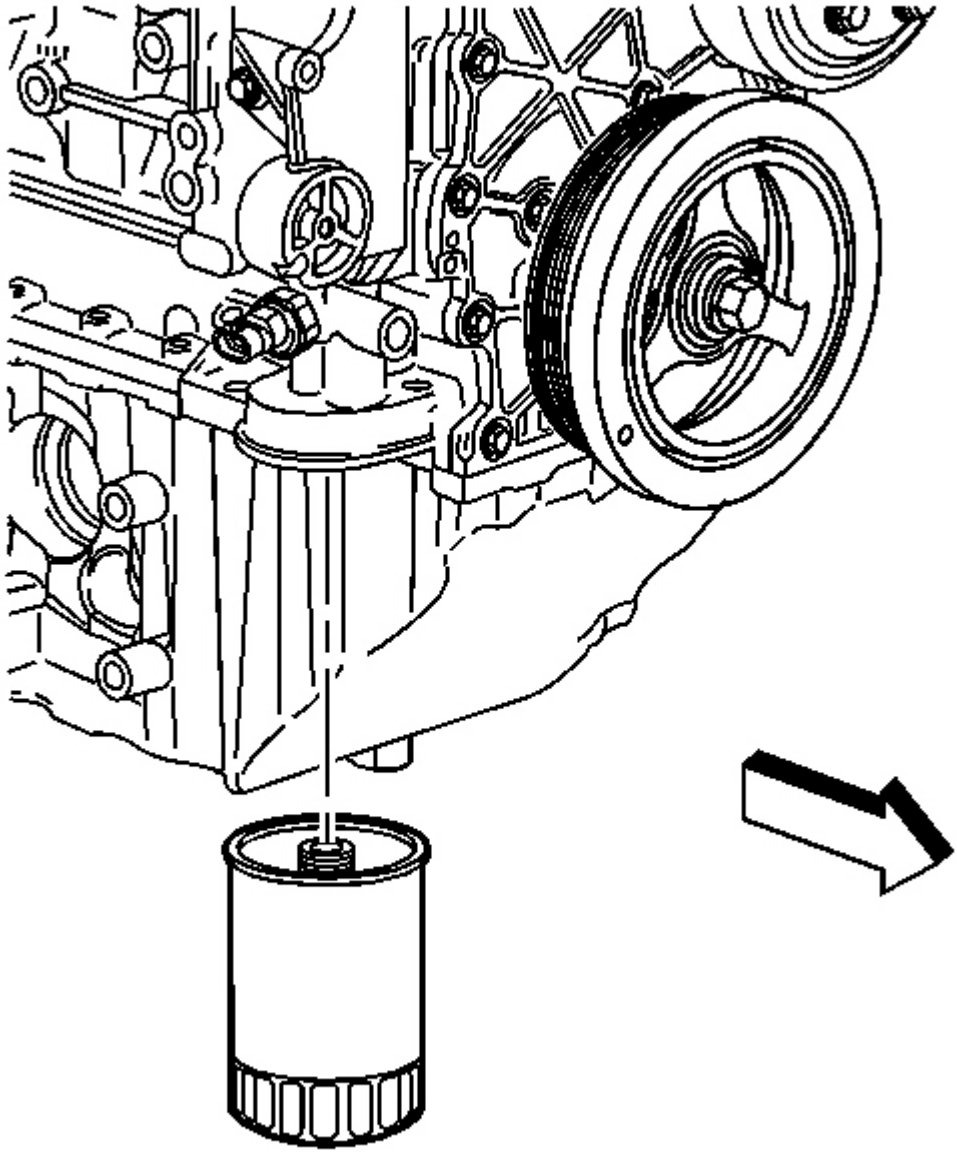


Fig. 256: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

DRIVE BELT TENSIONER REMOVAL

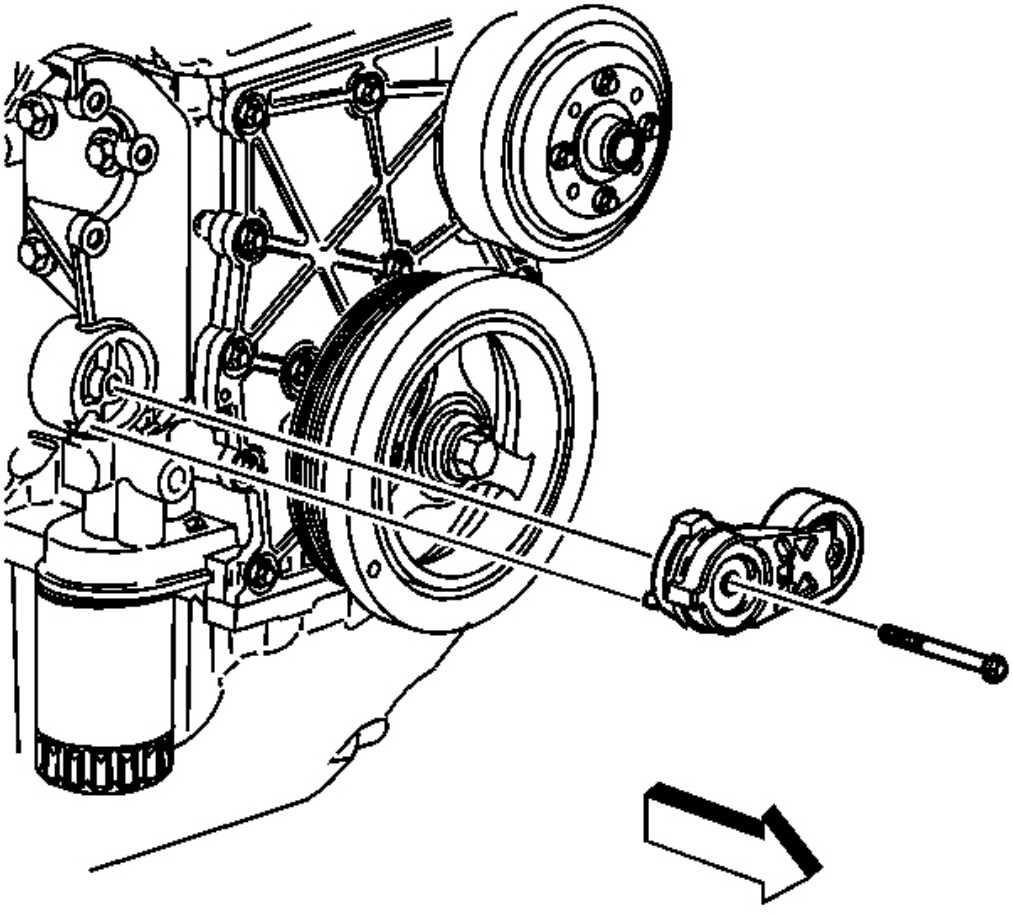


Fig. 257: View Of Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

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

POWER STEERING PUMP BRACKET REMOVAL

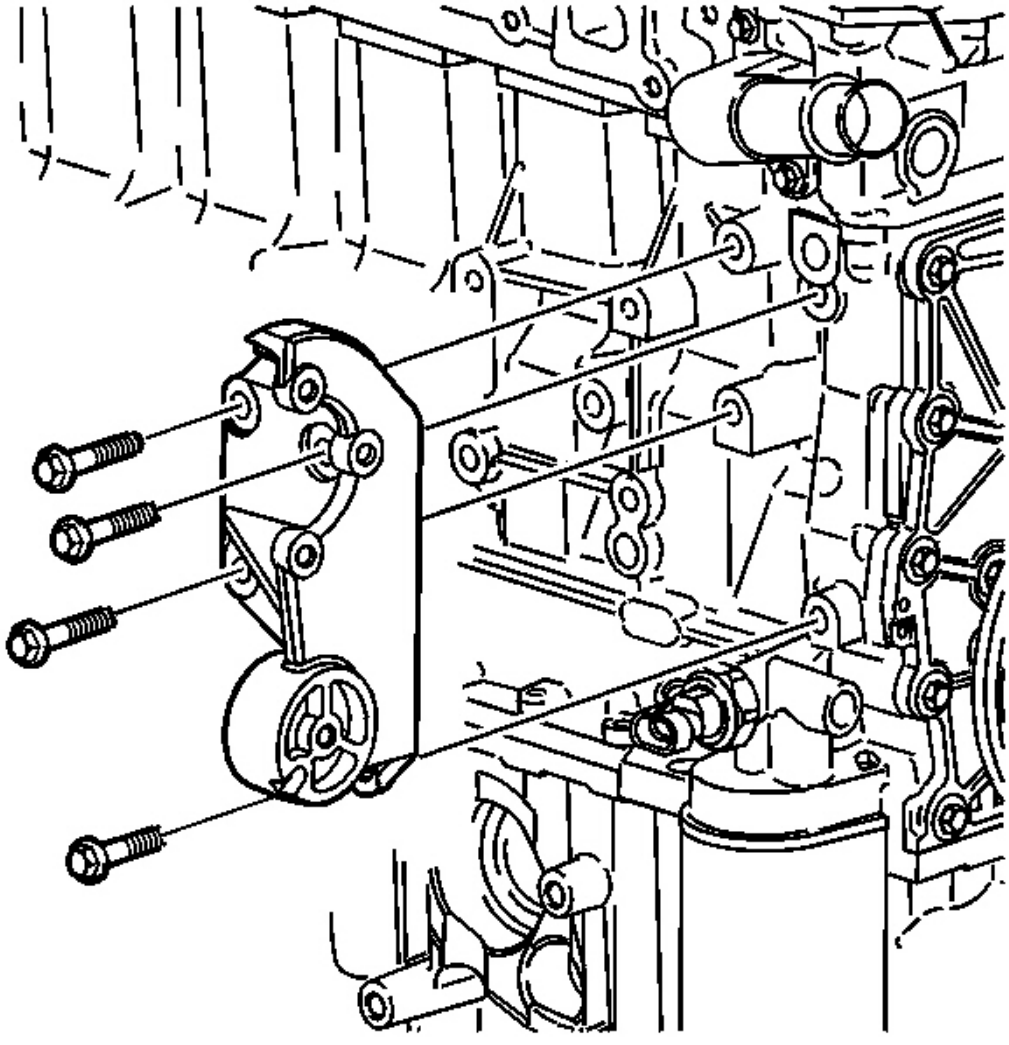


Fig. 258: View Of Power Steering Pump Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

DRIVE BELT IDLER PULLEY REMOVAL

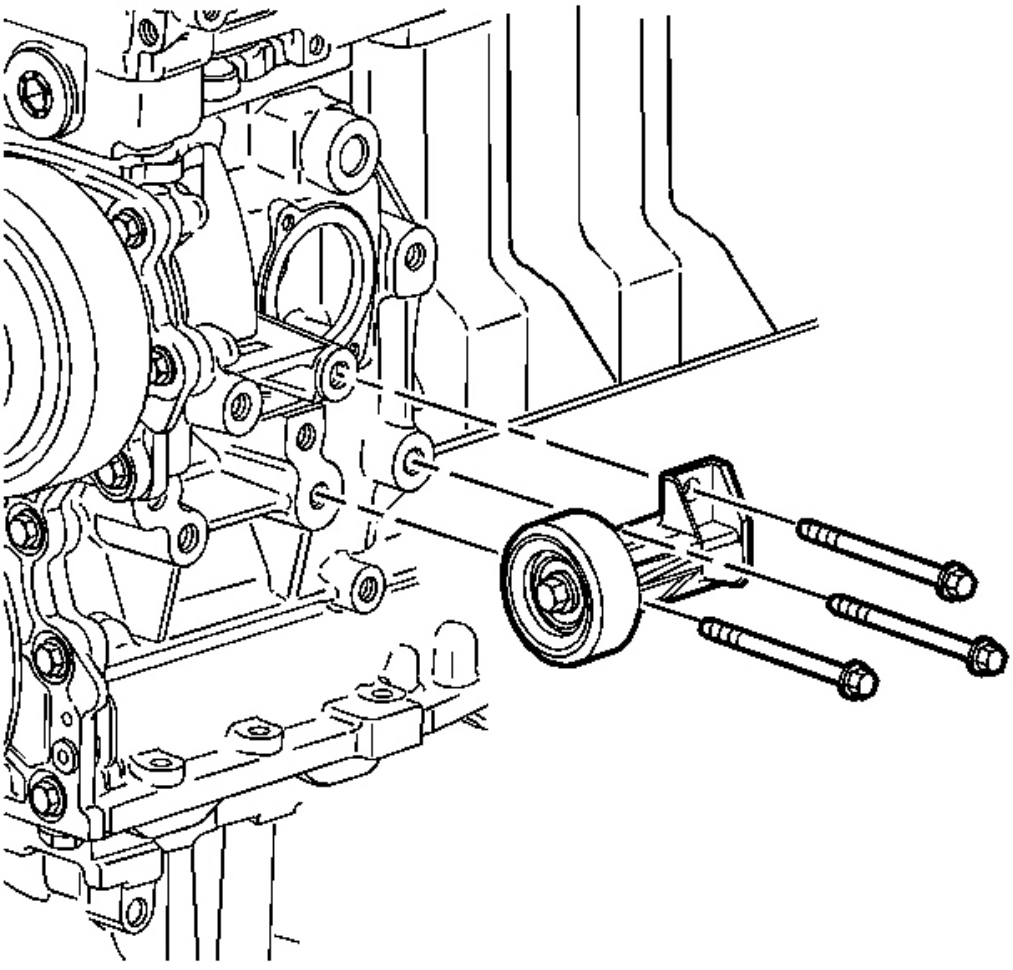


Fig. 259: View Of Drive Belt Idler Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt idler pulley bolts.
2. Remove the drive belt idler pulley.

OIL LEVEL INDICATOR & TUBE REMOVAL

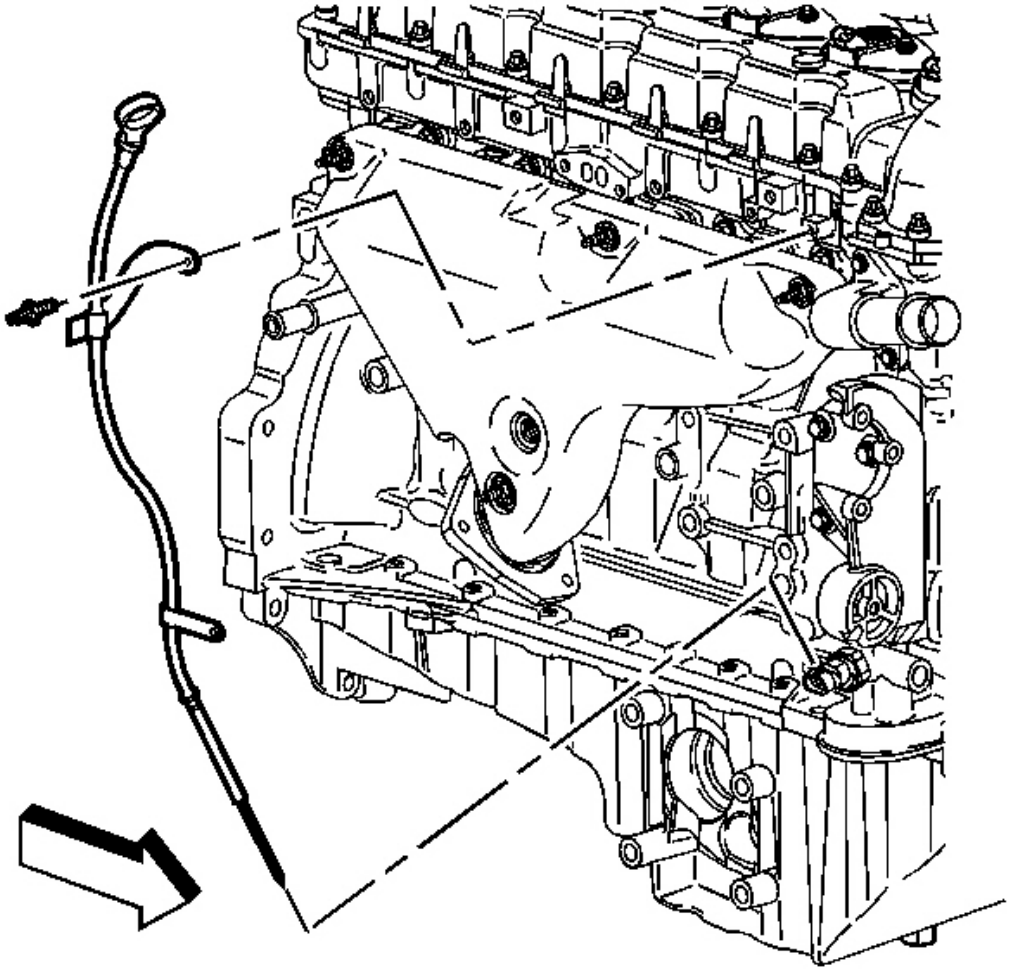


Fig. 260: View Of Oil Level Indicator Tube Stud
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Remove the oil level indicator tube stud.
3. Remove the oil level indicator tube.

EXHAUST MANIFOLD REMOVAL

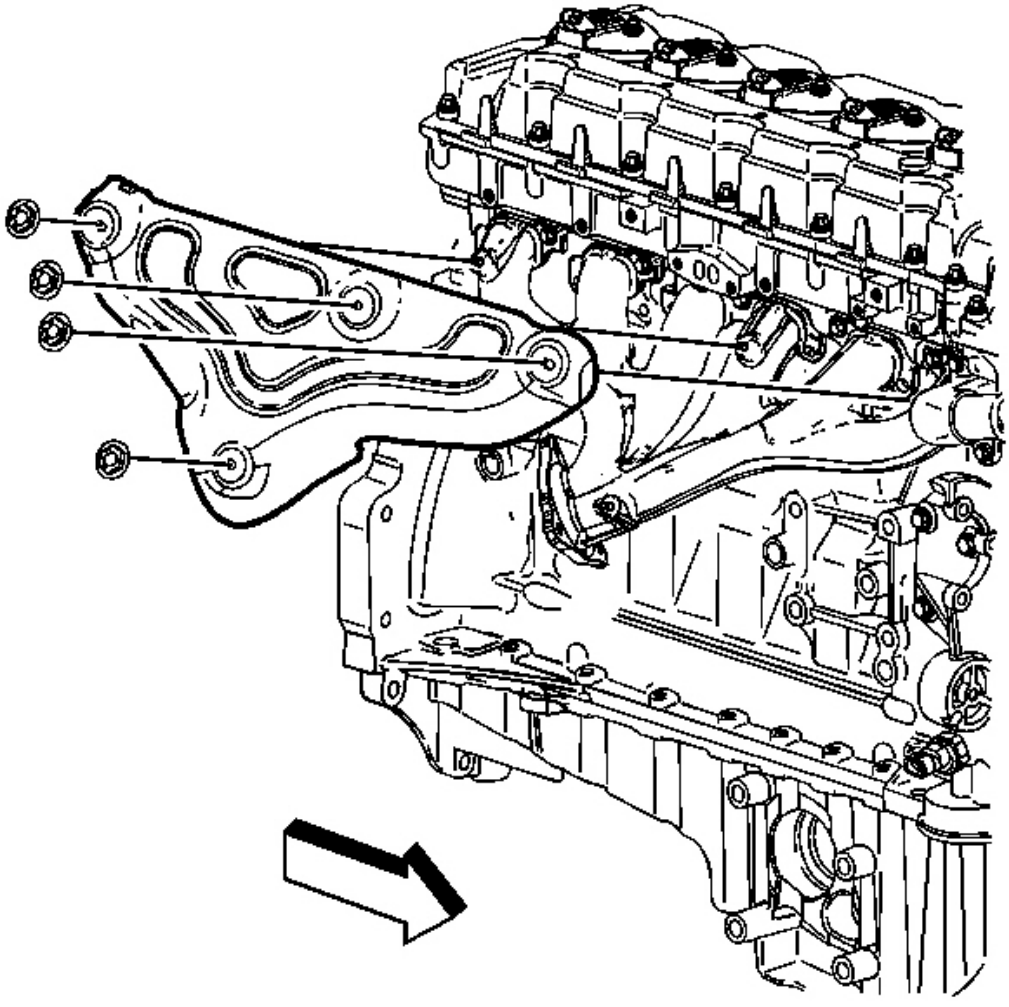


Fig. 261: View Of Exhaust Manifold Heat Shield & Nuts
Courtesy of GENERAL MOTORS CORP.

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

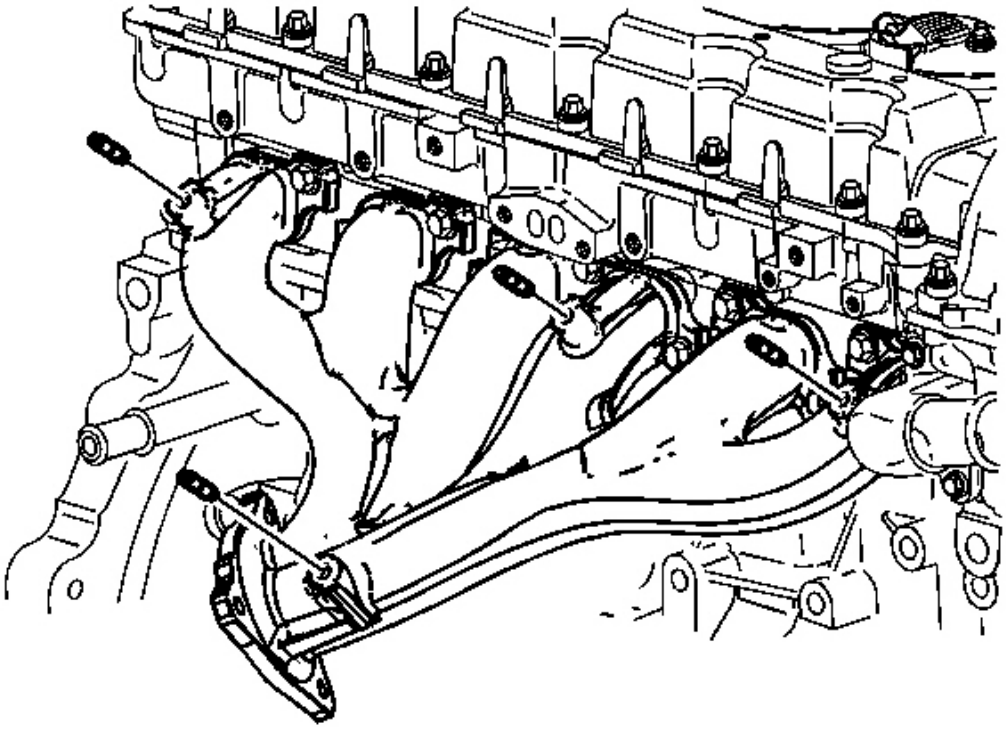


Fig. 262: Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

3. Remove the exhaust manifold studs (if needed).

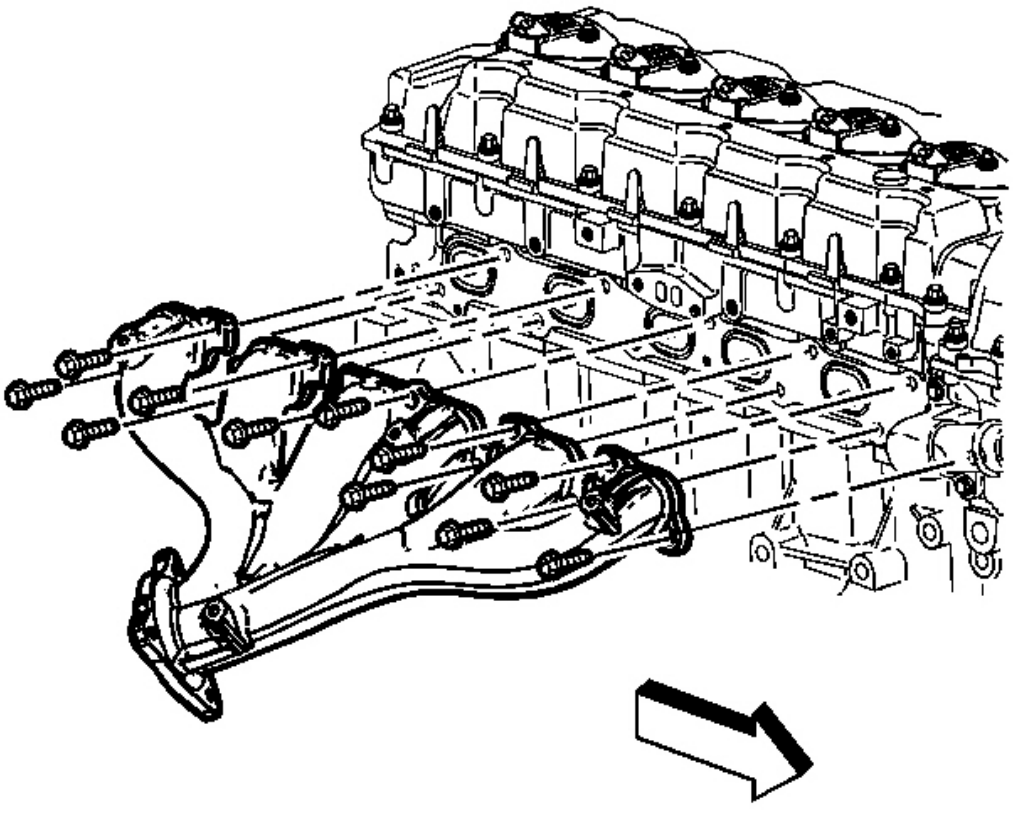


Fig. 263: View Of Exhaust Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold bolts.
5. Remove the exhaust manifold.

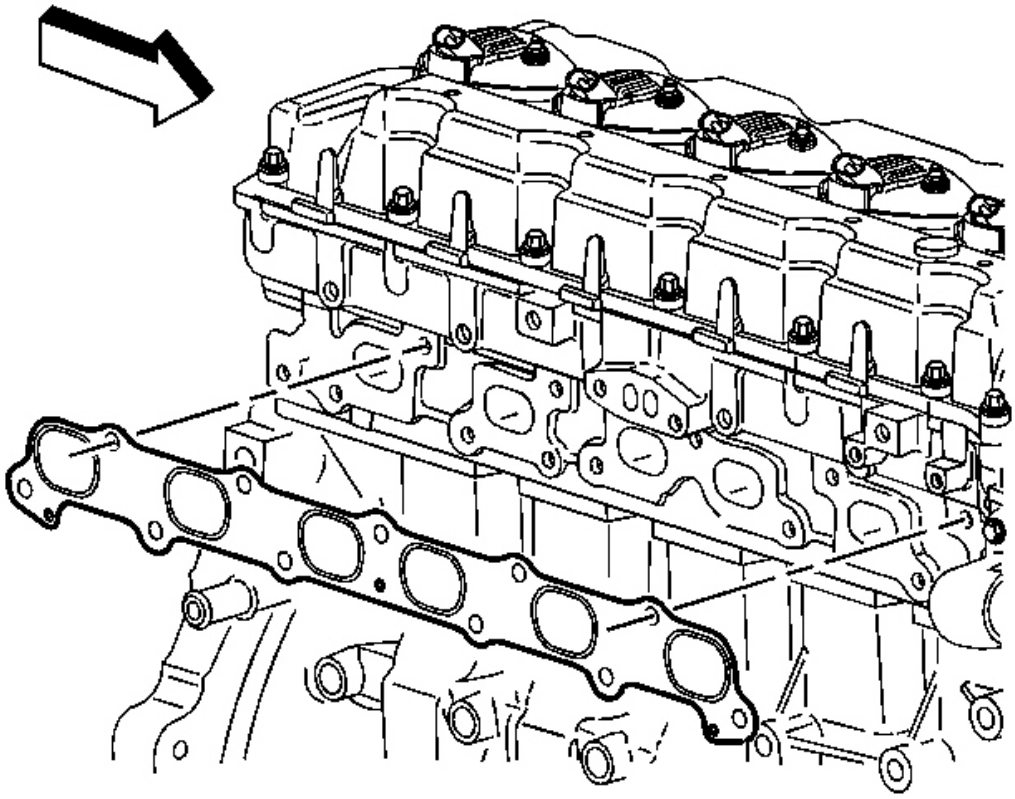


Fig. 264: View Of Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the exhaust manifold gasket.

OIL FILTER ADAPTER REMOVAL

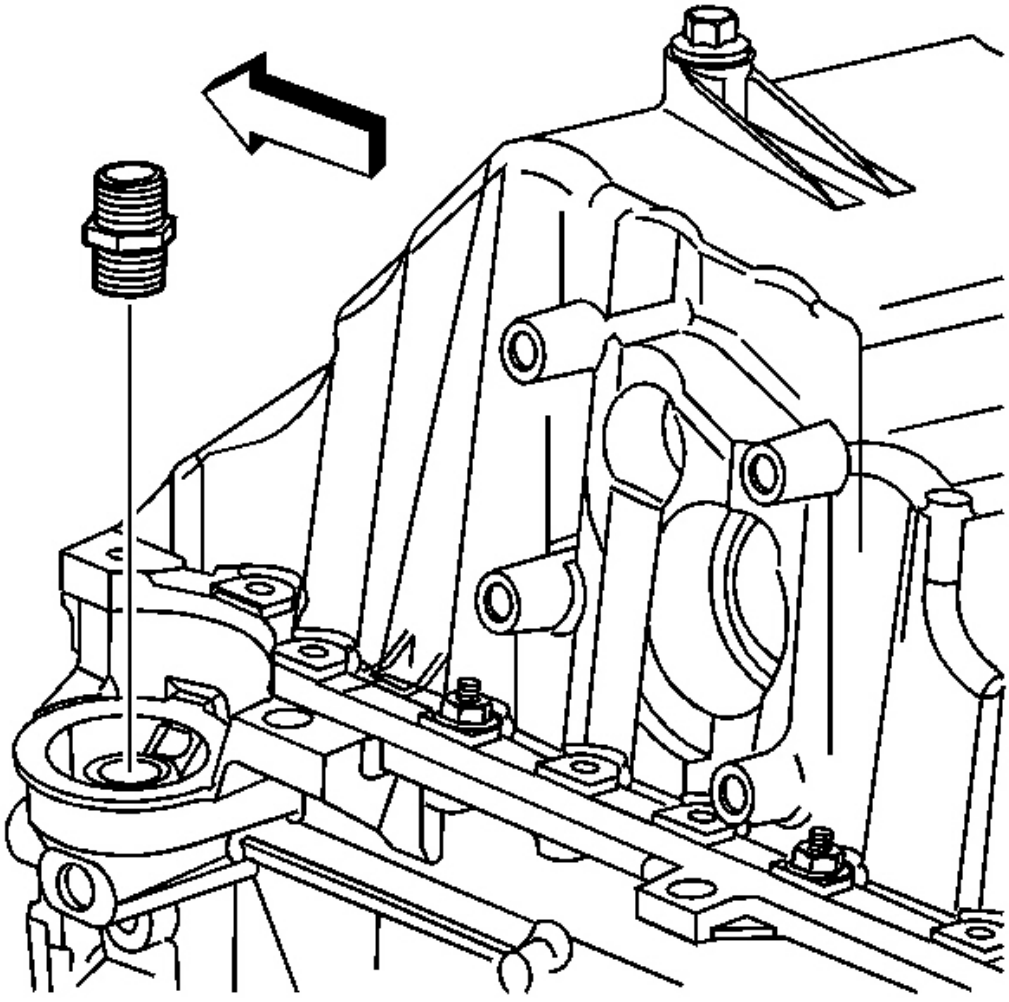


Fig. 265: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter.

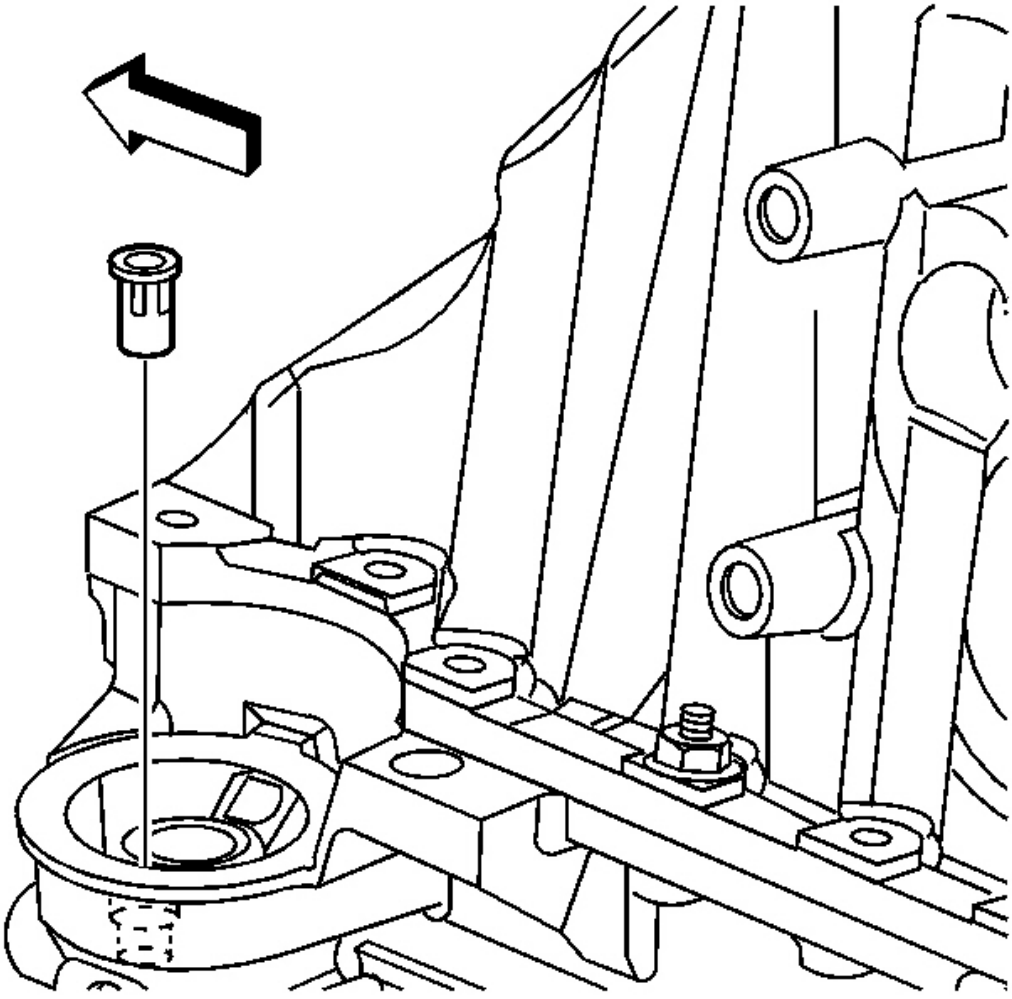


Fig. 266: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter bypass valve.

HEATER INLET PIPE REMOVAL

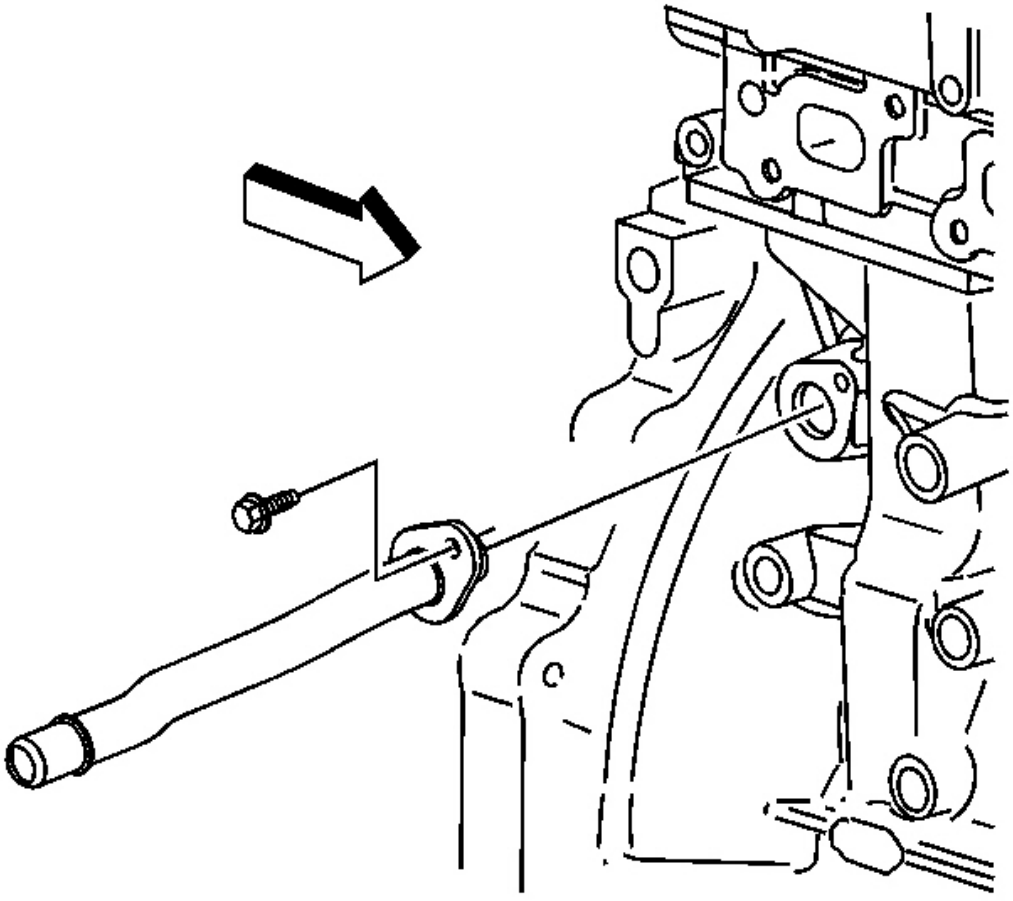


Fig. 267: View Of Heater Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater inlet pipe bolt.
2. Remove the heater inlet pipe.

HEATER OUTLET HOSE FITTING REMOVAL

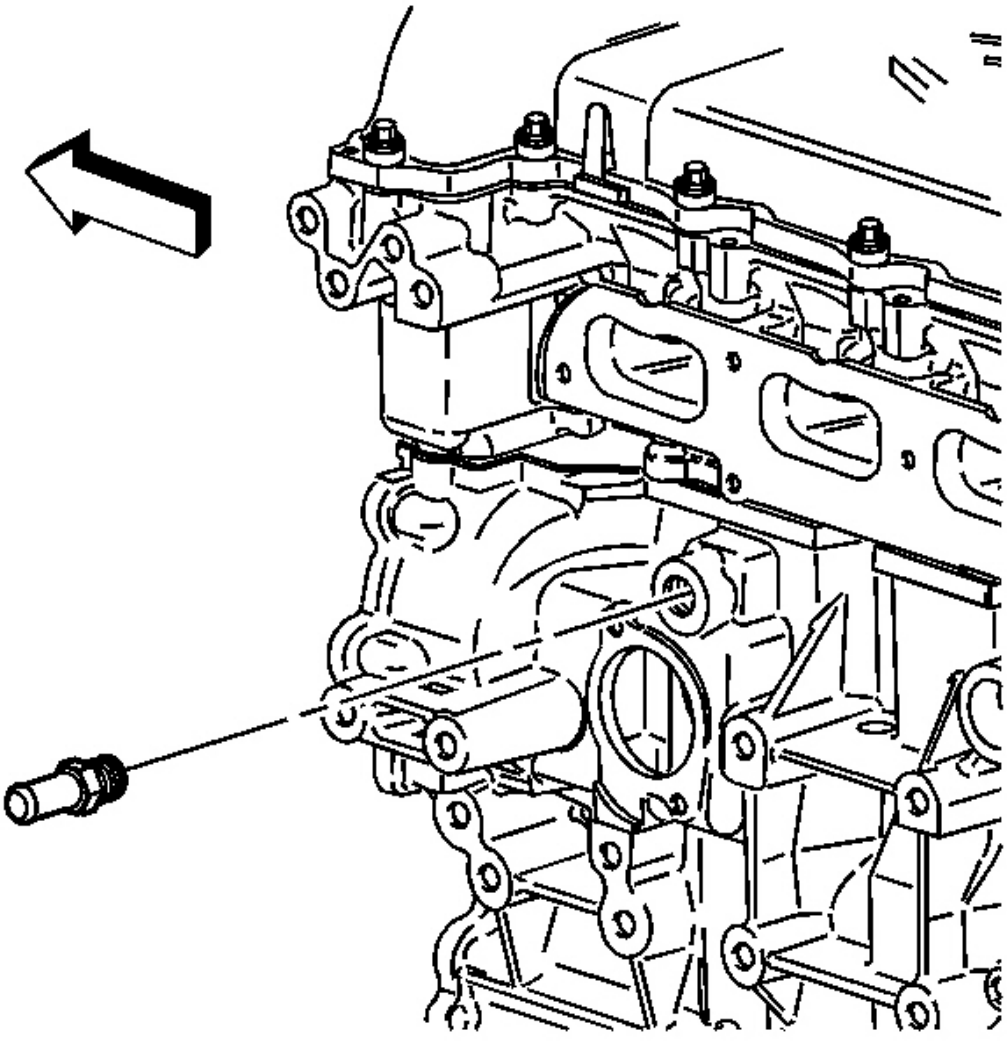


Fig. 268: View Of Heater Outlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

Remove the heater outlet hose fitting.

WATER OUTLET REMOVAL

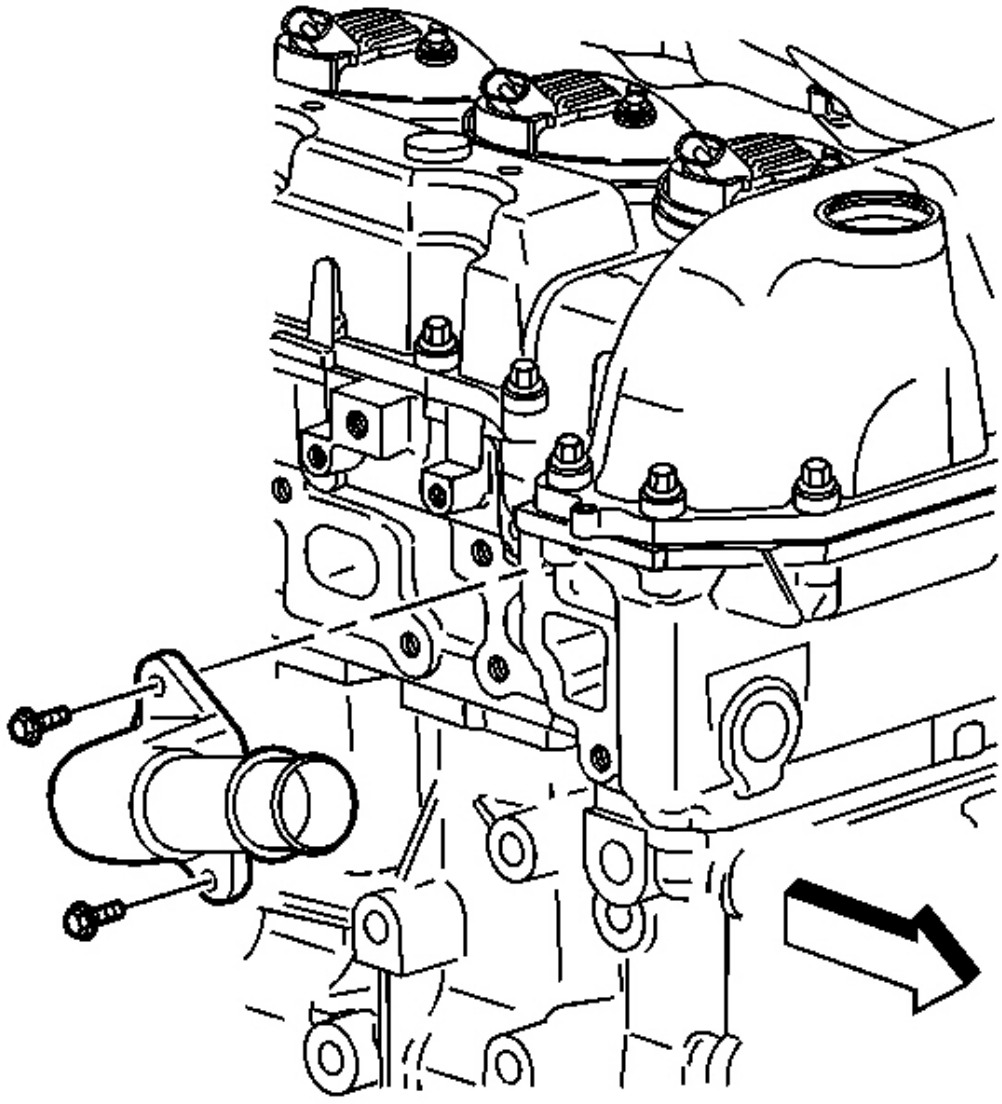


Fig. 269: View Of Water Outlet
Courtesy of GENERAL MOTORS CORP.

1. Remove the water outlet bolts.
2. Remove the water outlet.

WATER PUMP REMOVAL

Removal Procedure

Tool Required

J 41240 Fan Clutch Remover and Installer

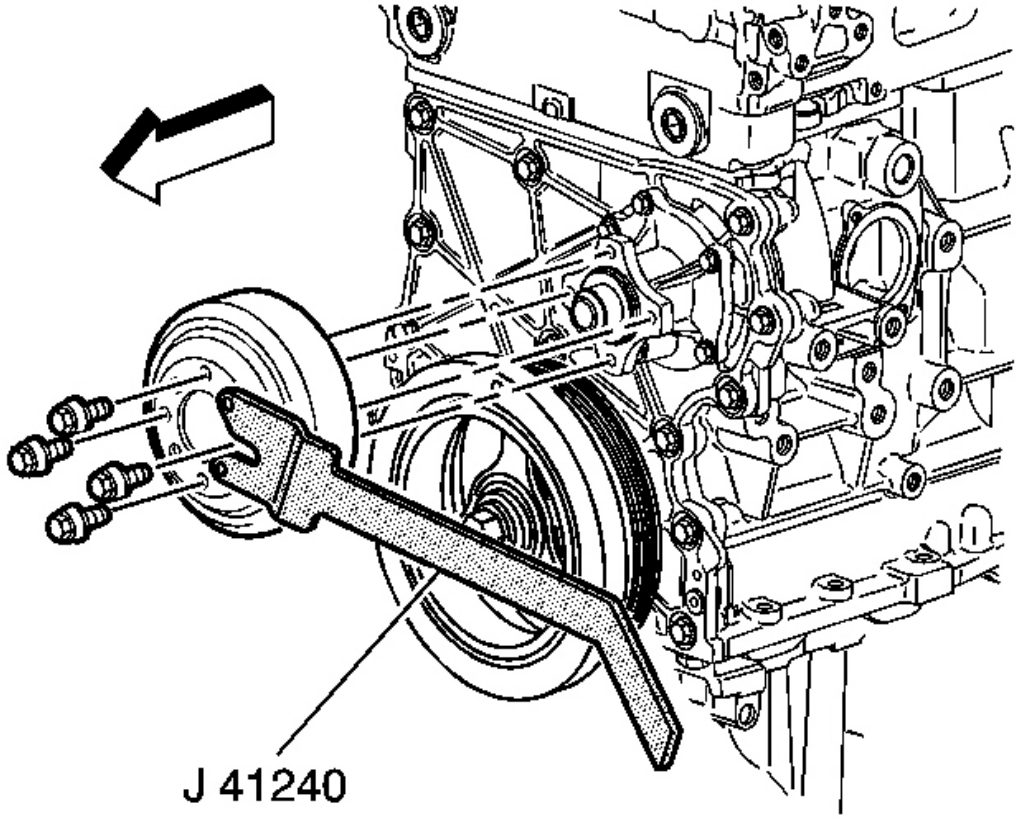


Fig. 270: View Of Water Pump Pulley, Bolts & J 41240
Courtesy of GENERAL MOTORS CORP.

1. Install **J 41240** to hold the pulley.
2. Remove the water pump pulley bolts.
3. Remove **J 41240** .
4. Remove the water pump pulley

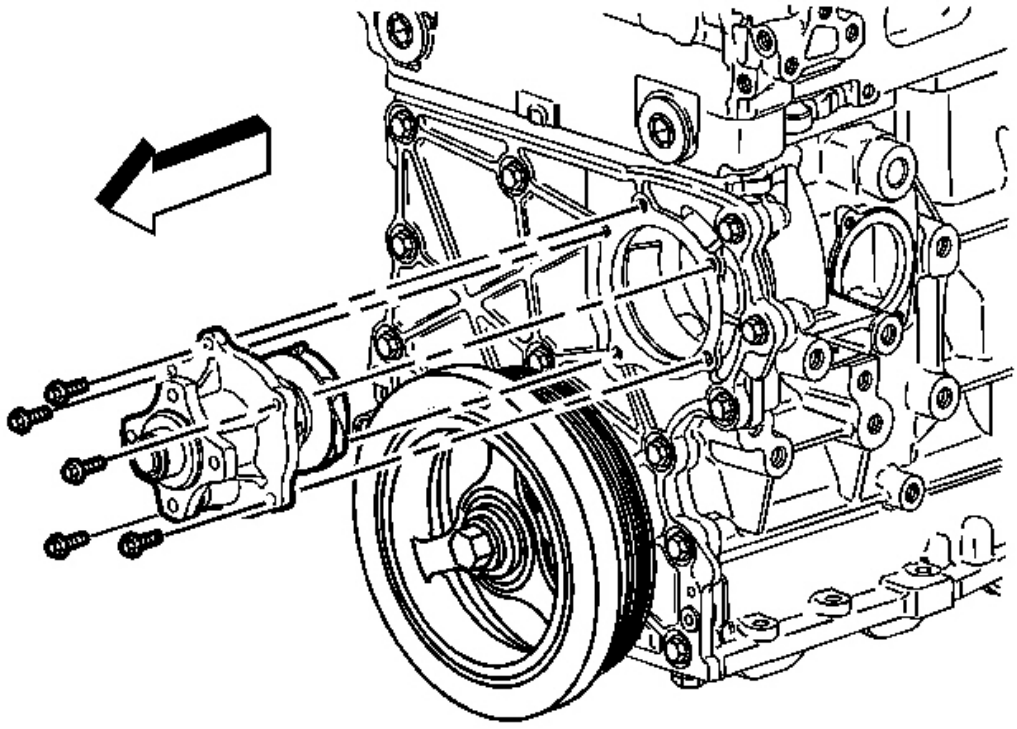


Fig. 271: View Of Water Pump, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the water pump bolts.
6. Remove the water pump.
7. Remove the water pump gasket.

ENGINE COOLANT THERMOSTAT HOUSING REMOVAL

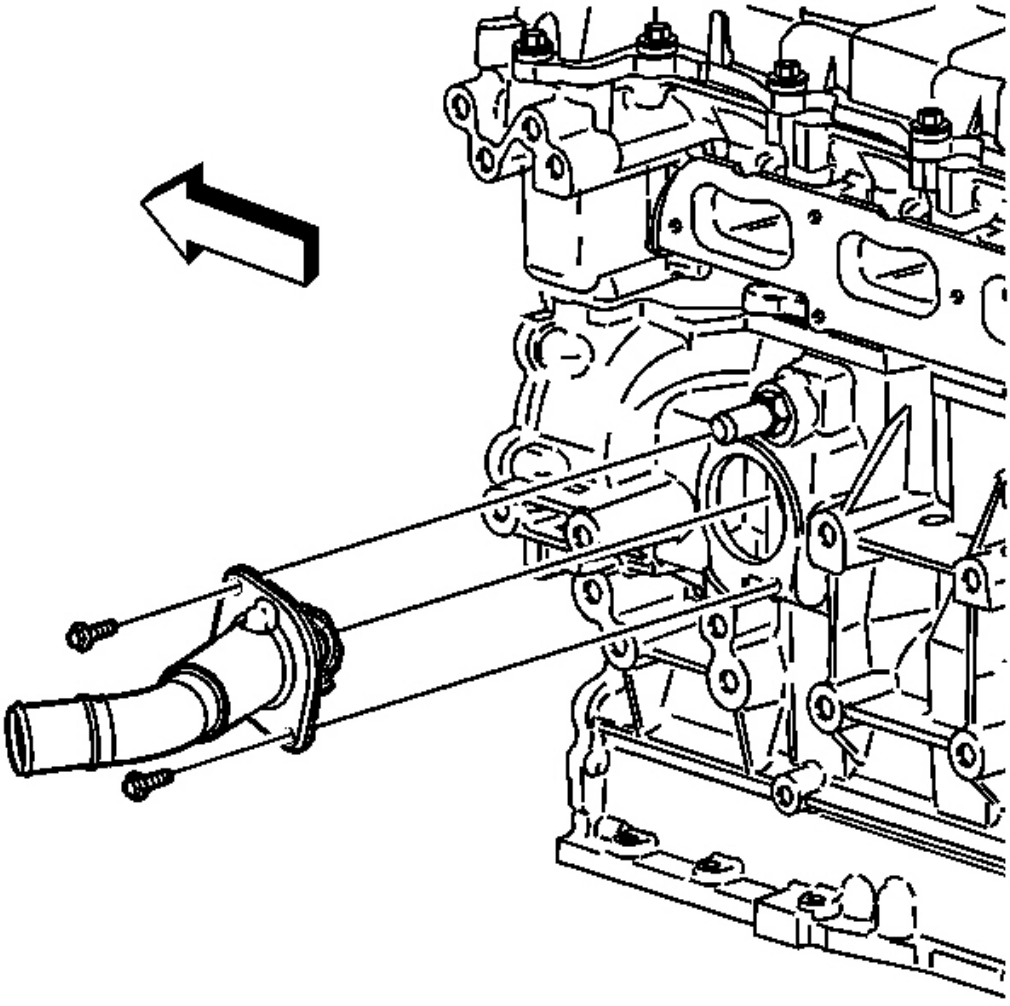


Fig. 272: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the thermostat housing bolts.
2. Remove the thermostat housing.

INTAKE MANIFOLD REMOVAL

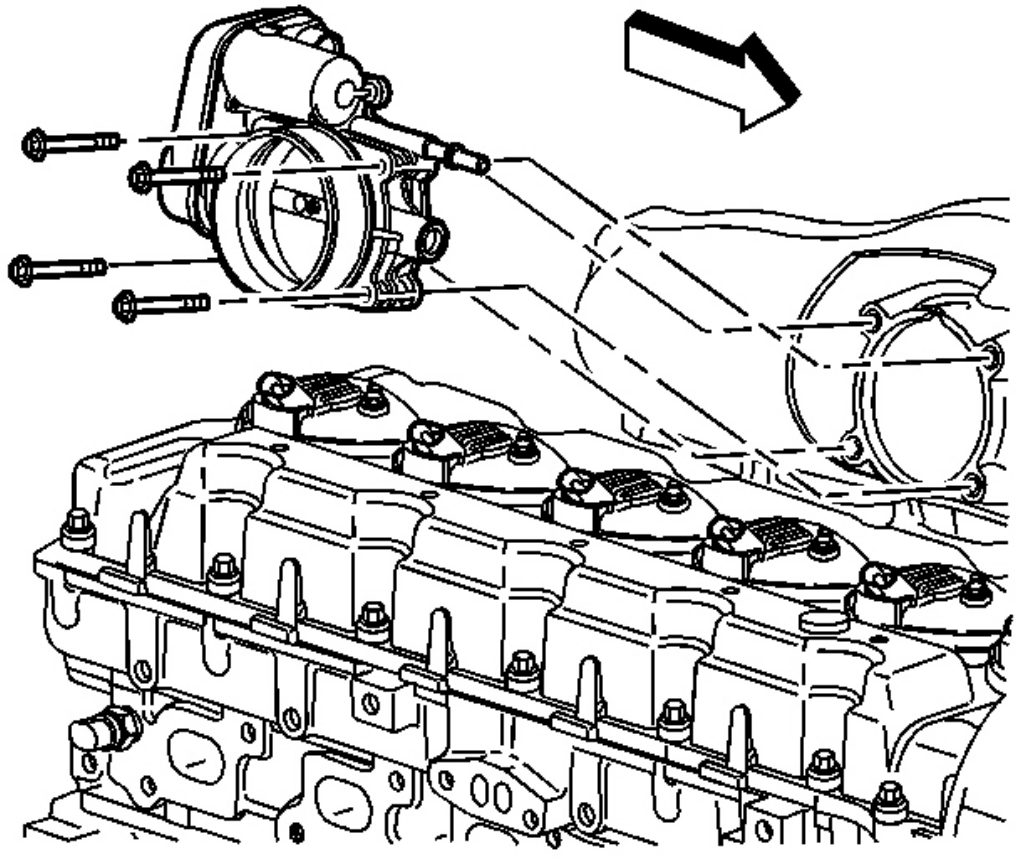


Fig. 273: View Of Throttle Control Module & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle control module bolts.
2. Remove the throttle control module.
3. Remove the throttle control module gasket.

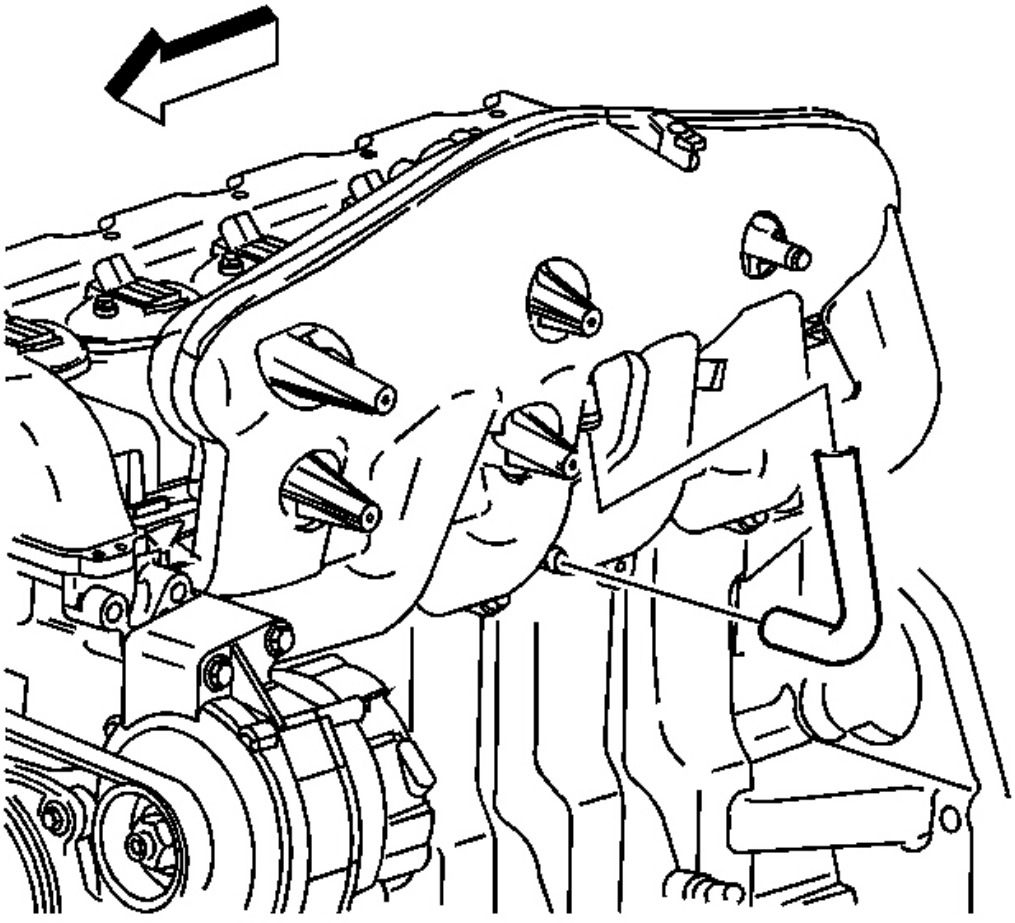


Fig. 274: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankcase ventilation hose.

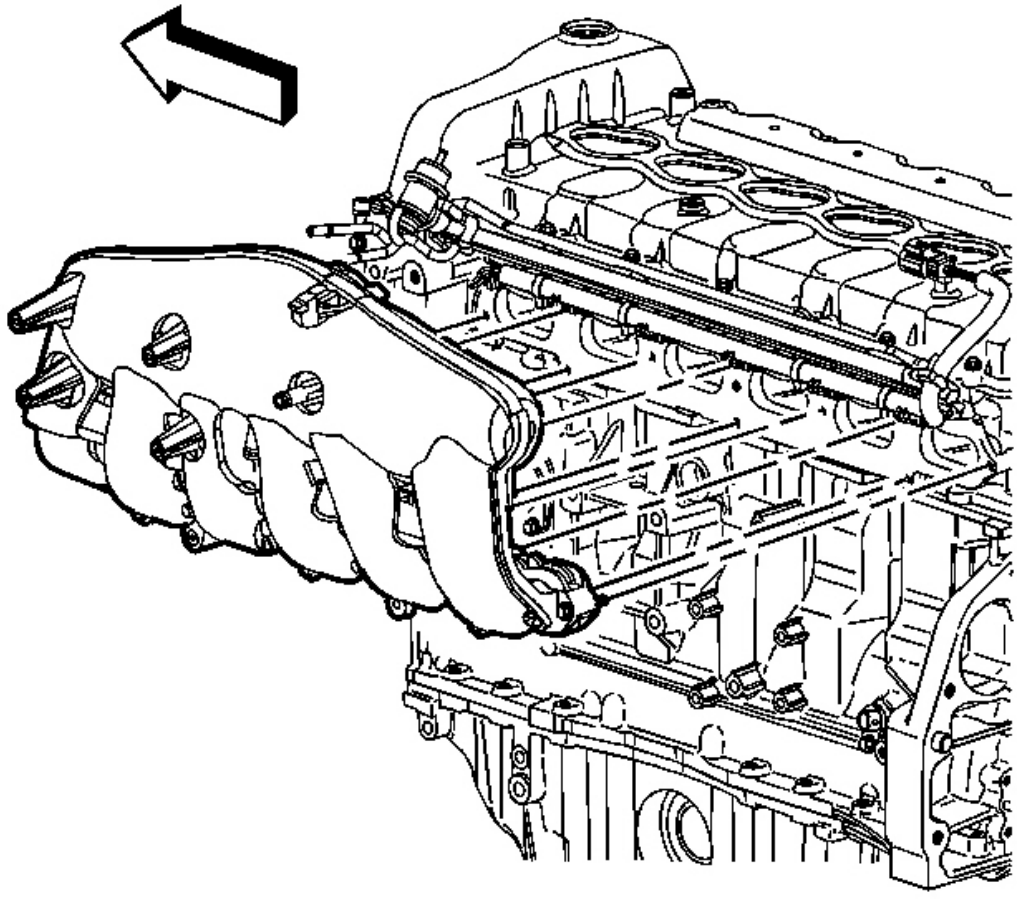


Fig. 275: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake manifold and bolts.

FUEL RAIL AND INJECTORS REMOVAL

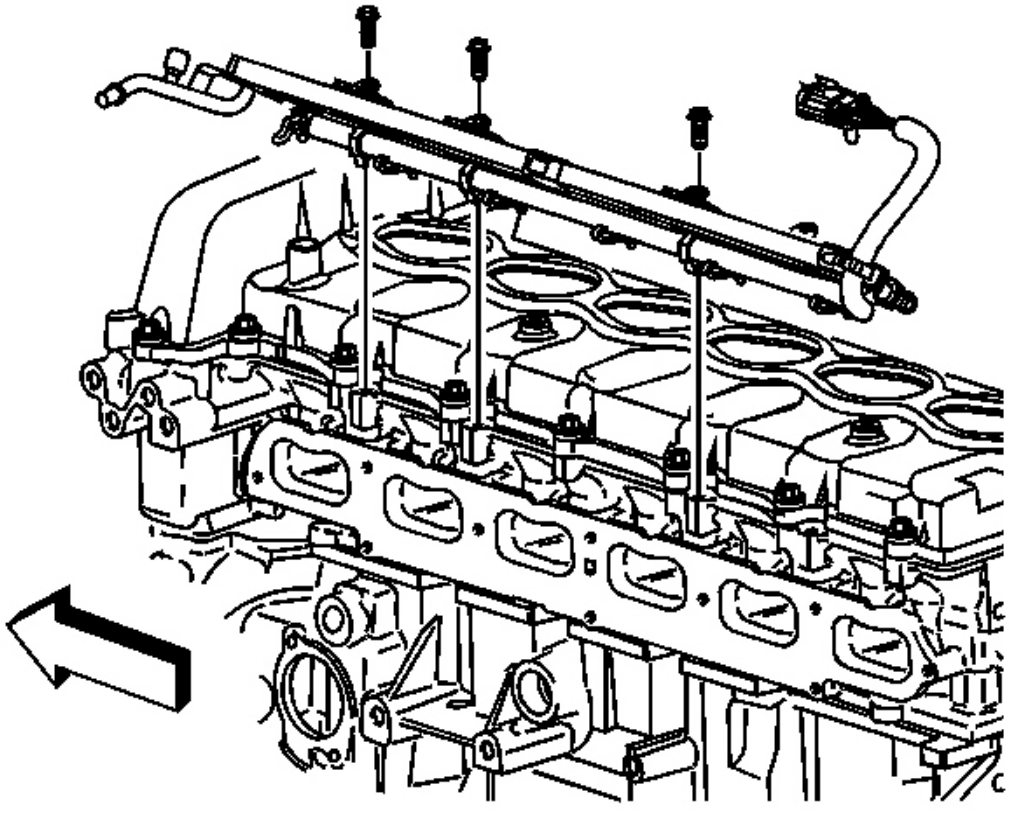


Fig. 276: View Of Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector rail bolts.
2. Remove the fuel injector rail.

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REMOVAL

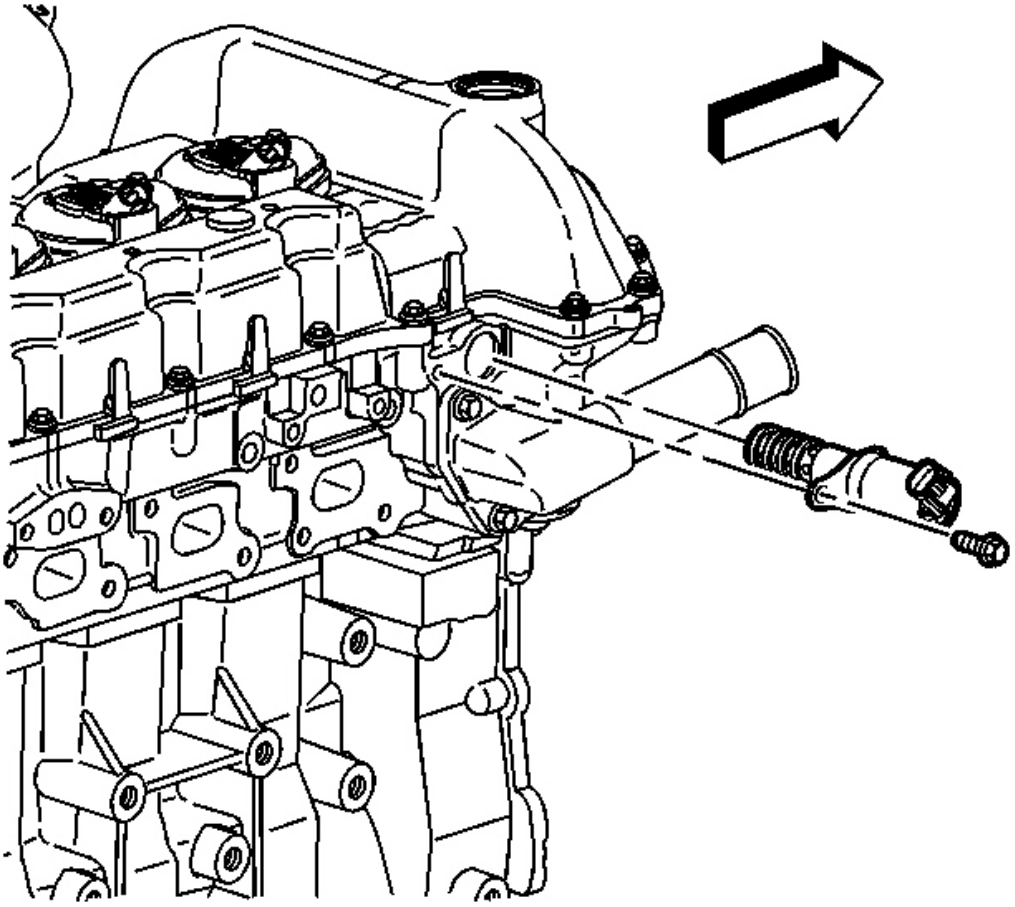


Fig. 277: View Of Camshaft Position Actuator Valve & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position actuator valve bolt.
2. Remove the camshaft position actuator valve.

CAMSHAFT COVER REMOVAL

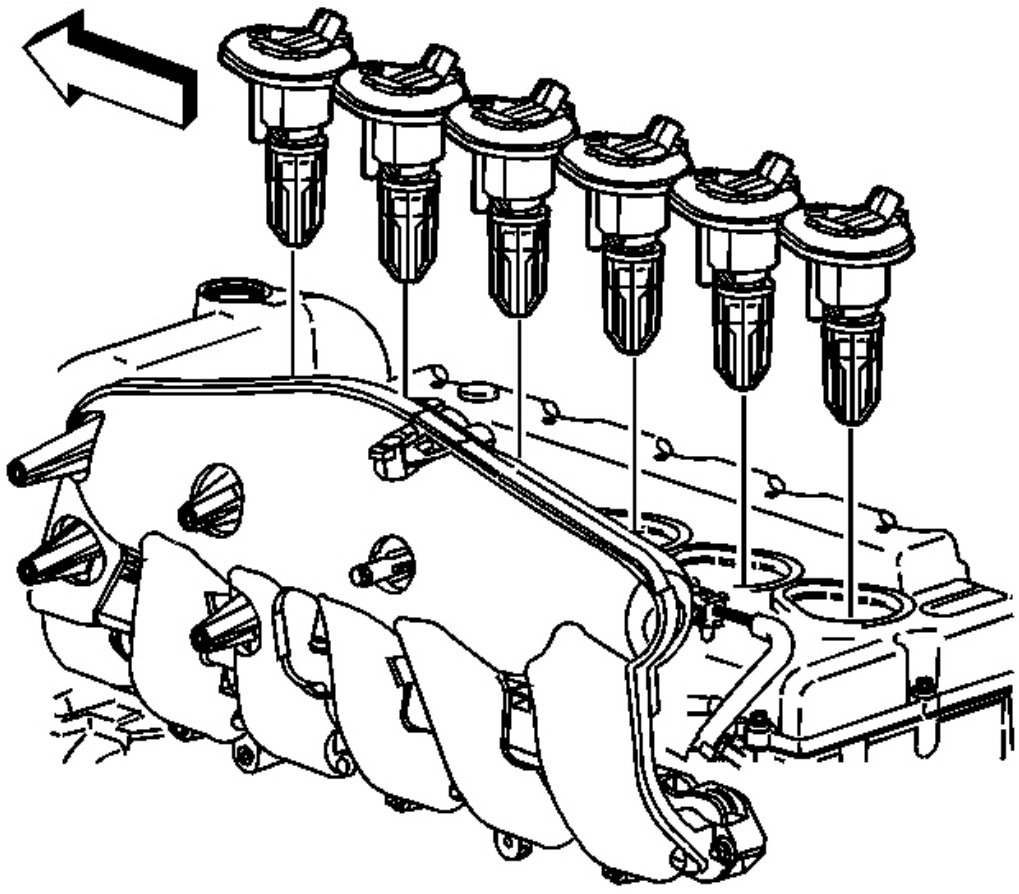


Fig. 278: View Of Ignition Control Modules & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition control modules and bolts.

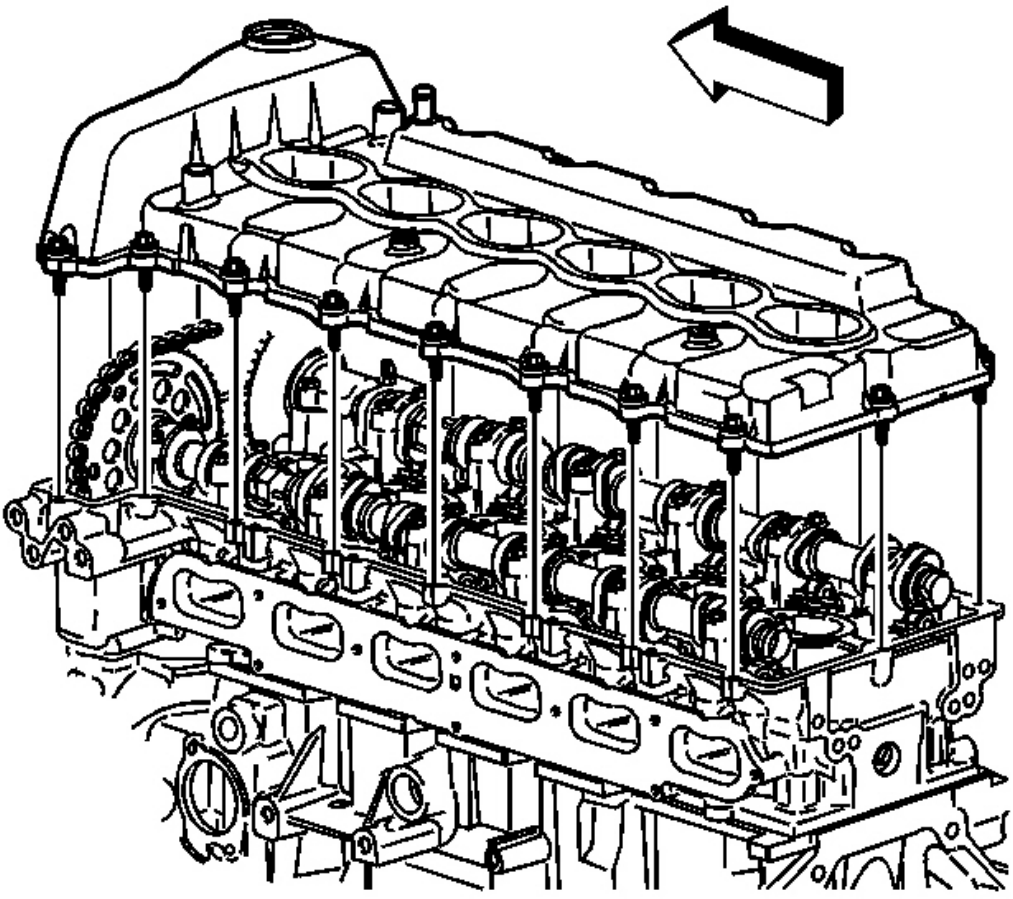


Fig. 279: View Of Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft cover and bolts.

OIL PAN REMOVAL

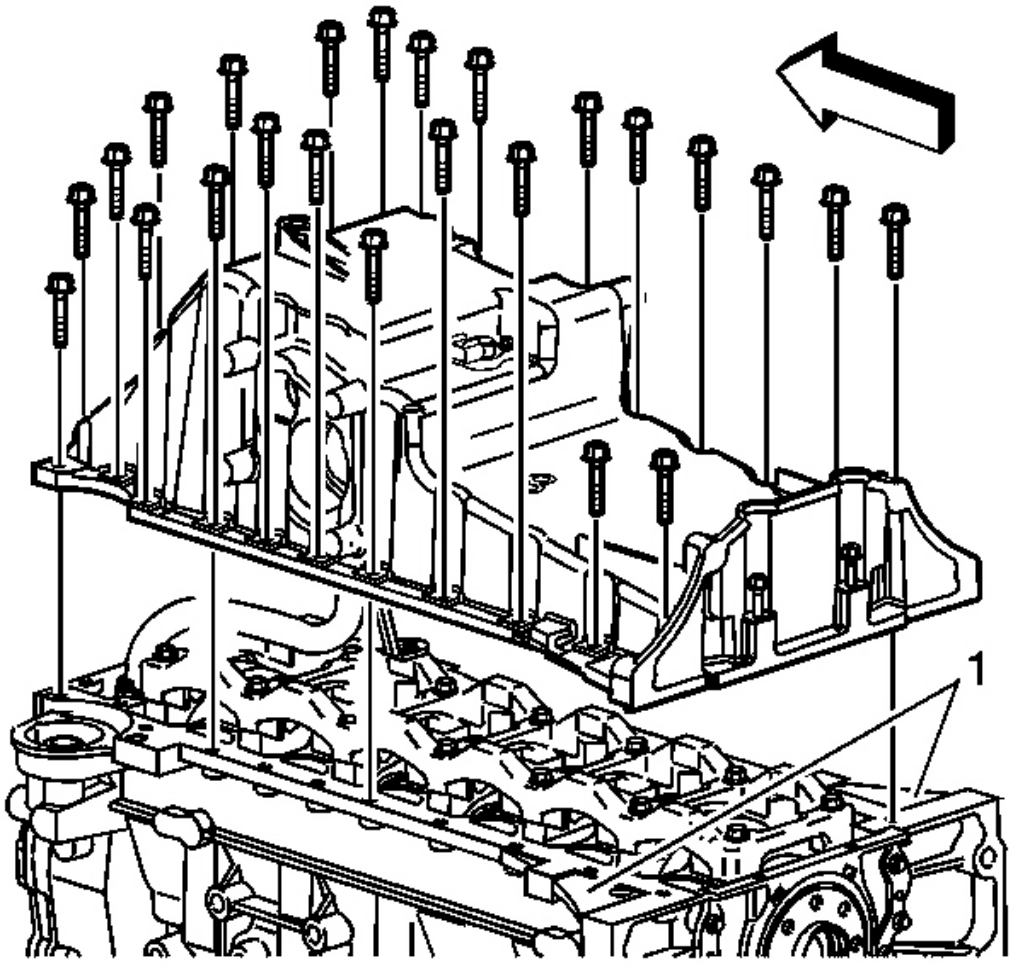


Fig. 280: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Remove the oil level sensor, located in the oil pan, before the oil pan is removed. The sensor may be damaged if the oil pan is removed first.

1. Remove the oil level sensor.
2. Remove the oil pan bolts and nuts.
3. Install two of the oil pan bolts into the threaded holes (jack bolts) to break the seal of oil pan (1).
4. Remove the oil pan.

OIL PUMP SUCTION PIPE & SCREEN ASSEMBLY REMOVAL

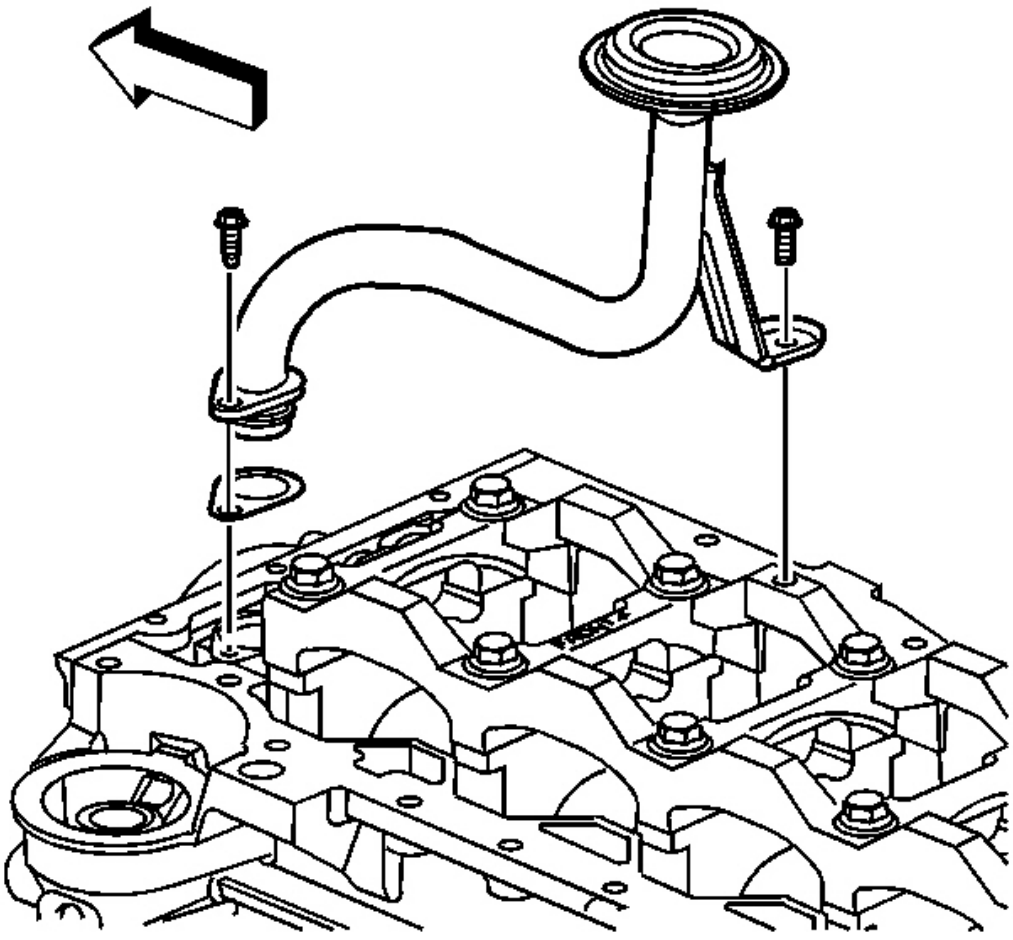


Fig. 281: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump pipe bolts.
2. Remove the oil pump pipe.
3. Discard the gasket.

CRANKSHAFT BALANCER REMOVAL

Tools Required

J 41816-2 Crankshaft End Protector. See **Special Tools**.

Removal Procedure

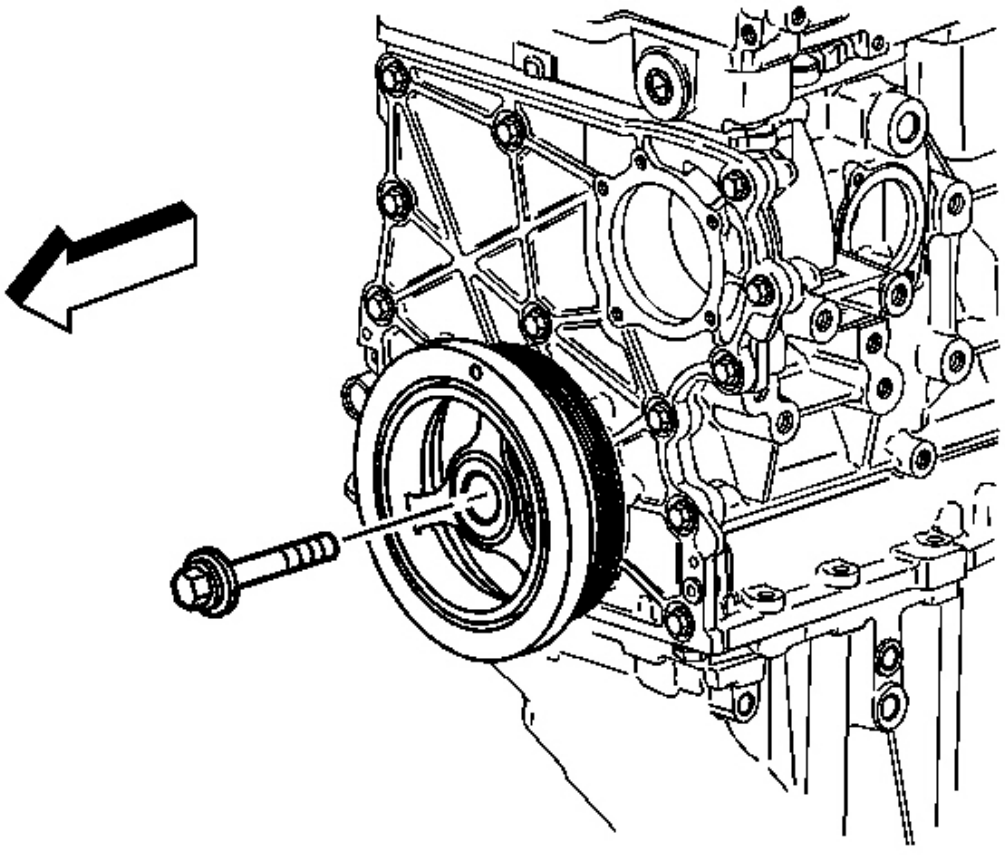


Fig. 282: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt.

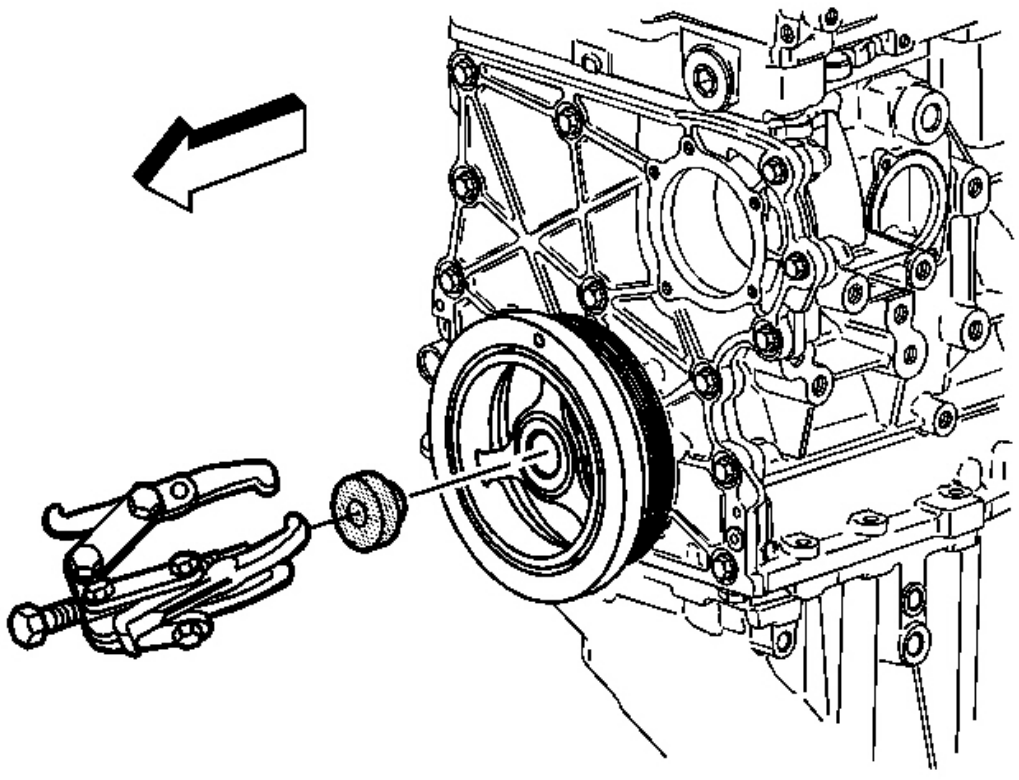


Fig. 283: View Of Crankshaft Balancer & J 41816-2
Courtesy of GENERAL MOTORS CORP.

2. Install **J 41816-2** into the end of the crankshaft. See **Special Tools**.

IMPORTANT: Do not pull on outer edge of the crankshaft balancer.

3. Use a three jaw puller to remove the crankshaft balancer.
4. Remove **J 41816-2** . See **Special Tools**.

ENGINE FRONT COVER REMOVAL

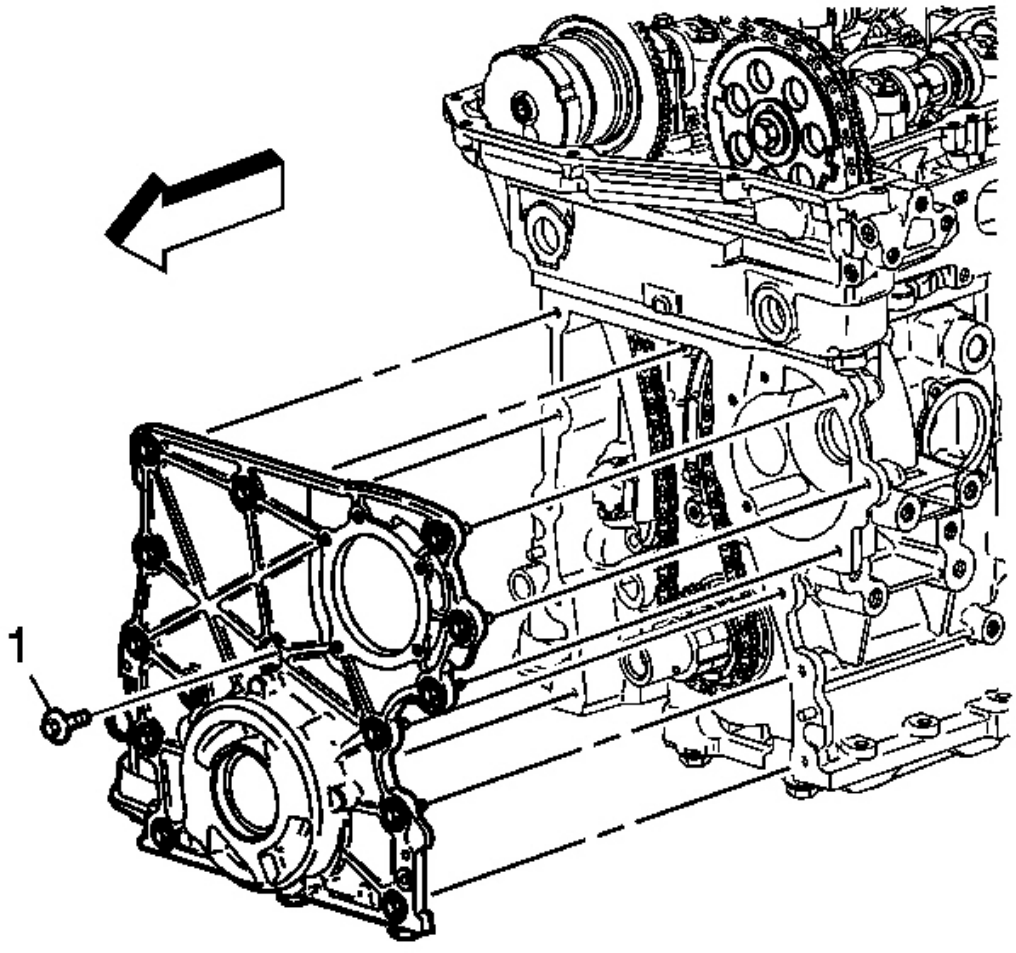


Fig. 284: View Of 7 mm Center Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the 7 mm center bolt (1) first.
2. Loosen the engine front cover bolts.
3. Remove the engine front cover and bolts.

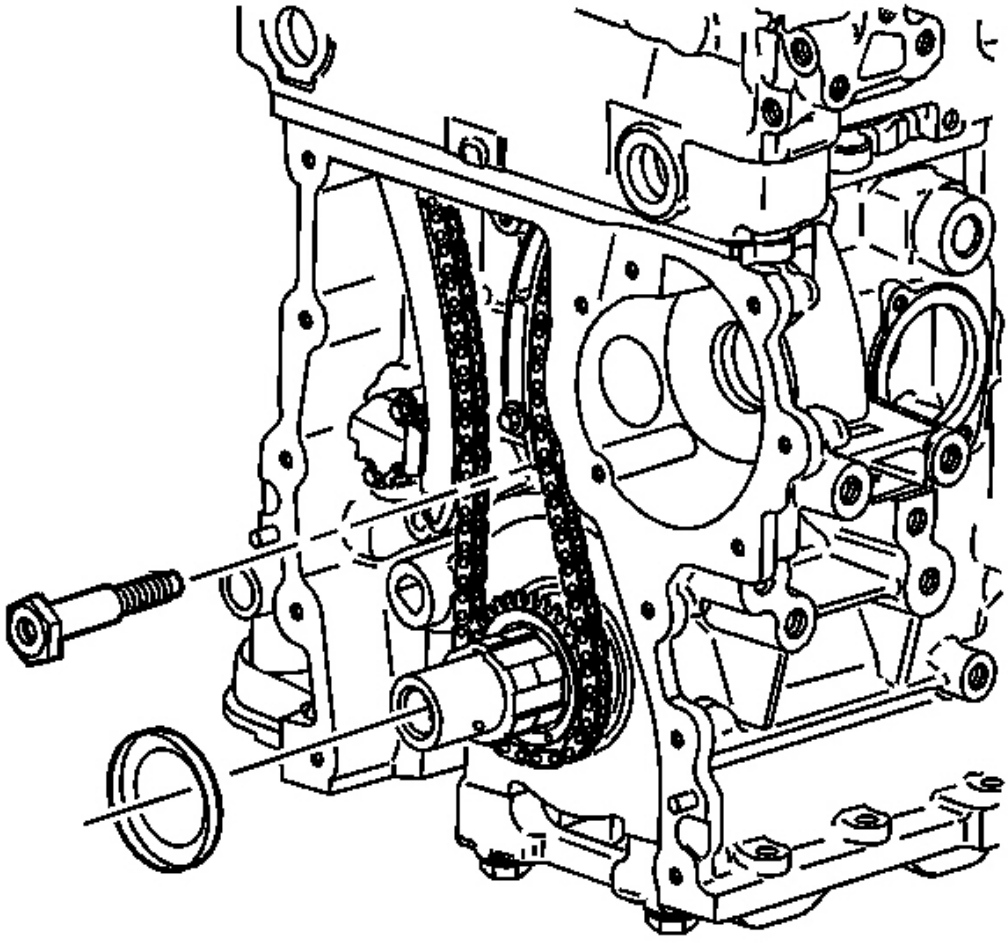


Fig. 285: View Of Spacer Bolt & Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the spacer bolt.

IMPORTANT: The friction washer may have come off with the crankshaft balancer.

5. Remove the crankshaft balancer friction washer from the crankshaft snout.

OIL PUMP REMOVAL

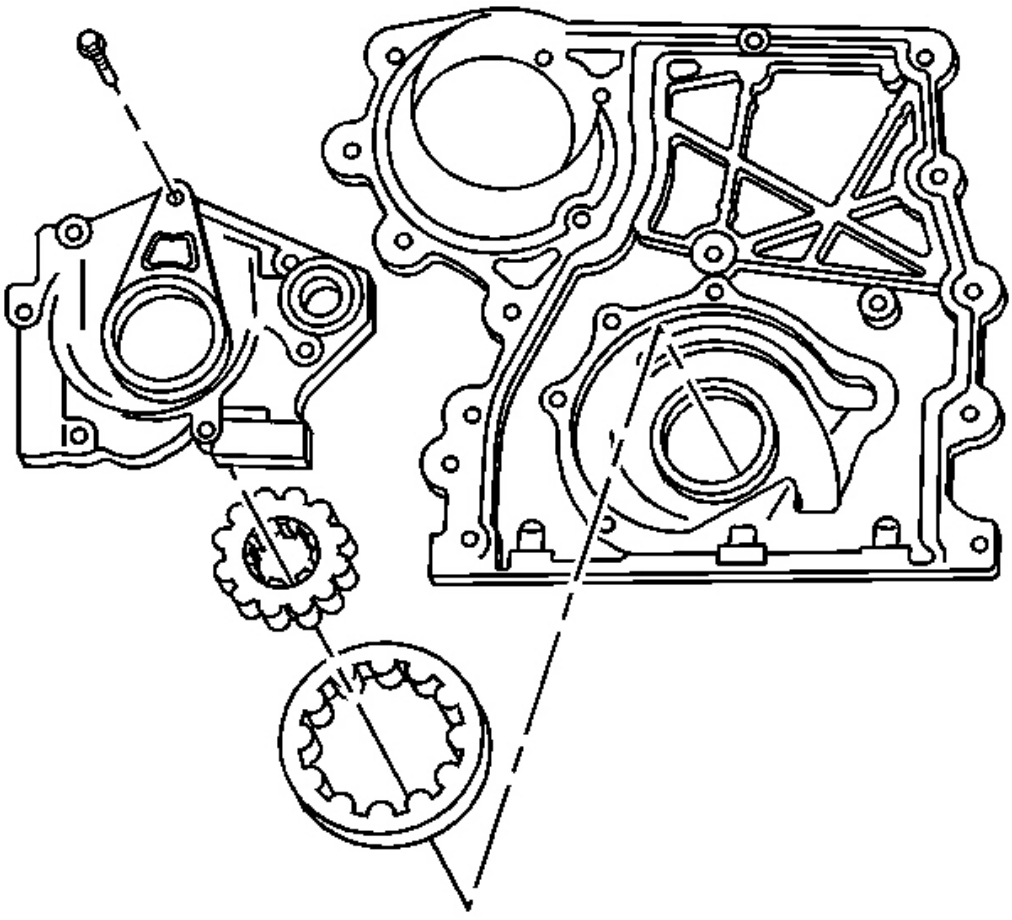


Fig. 286: View Of Oil Pump Outer & Inner Gears, Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump cover bolts.
2. Remove the oil pump cover.
3. Mark the inner and outer gears in relation to the oil pump housing.
4. Remove the inner and outer oil pump gears.
5. Remove the oil pump pressure relief valve plug.
6. Remove the oil pump pressure relief valve and spring.

CRANKSHAFT FRONT OIL SEAL REMOVAL

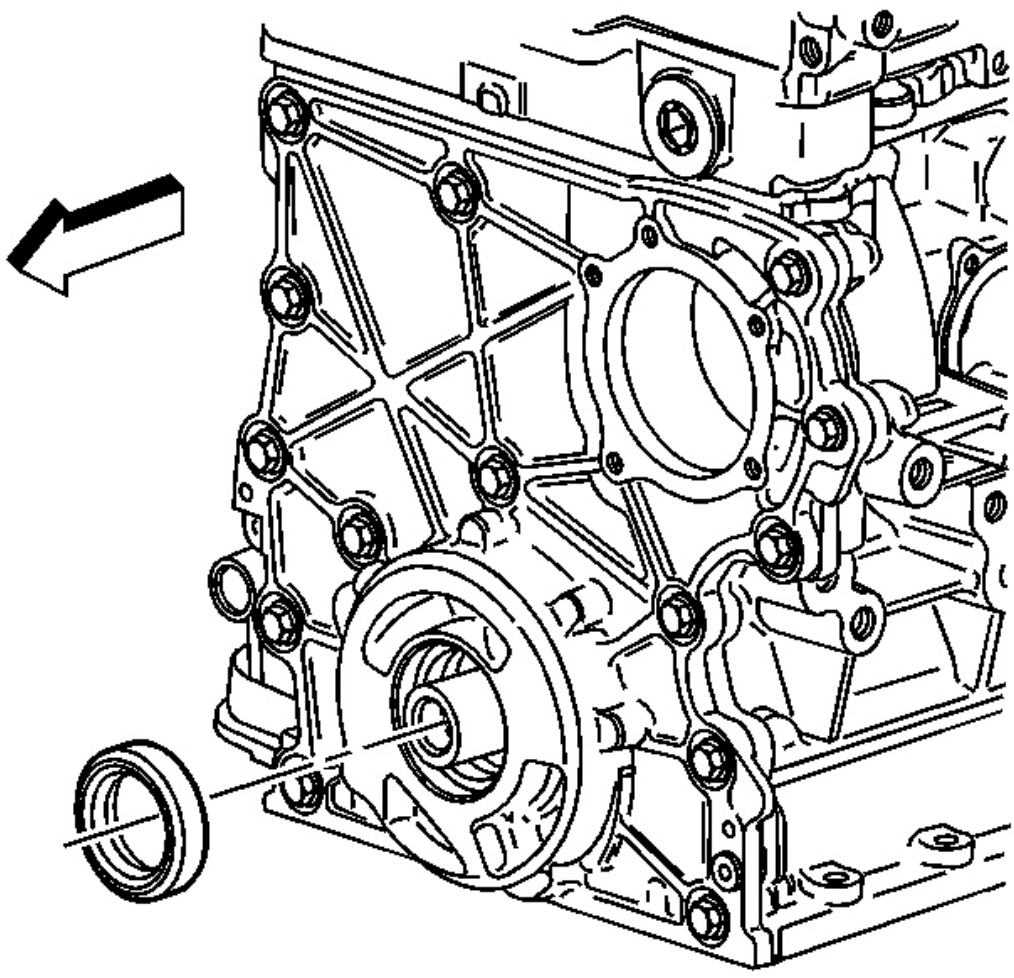


Fig. 287: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the engine front cover or the crankshaft.

Pry out the crankshaft front oil seal using a suitable tool.

TIMING CHAIN & SPROCKETS REMOVAL

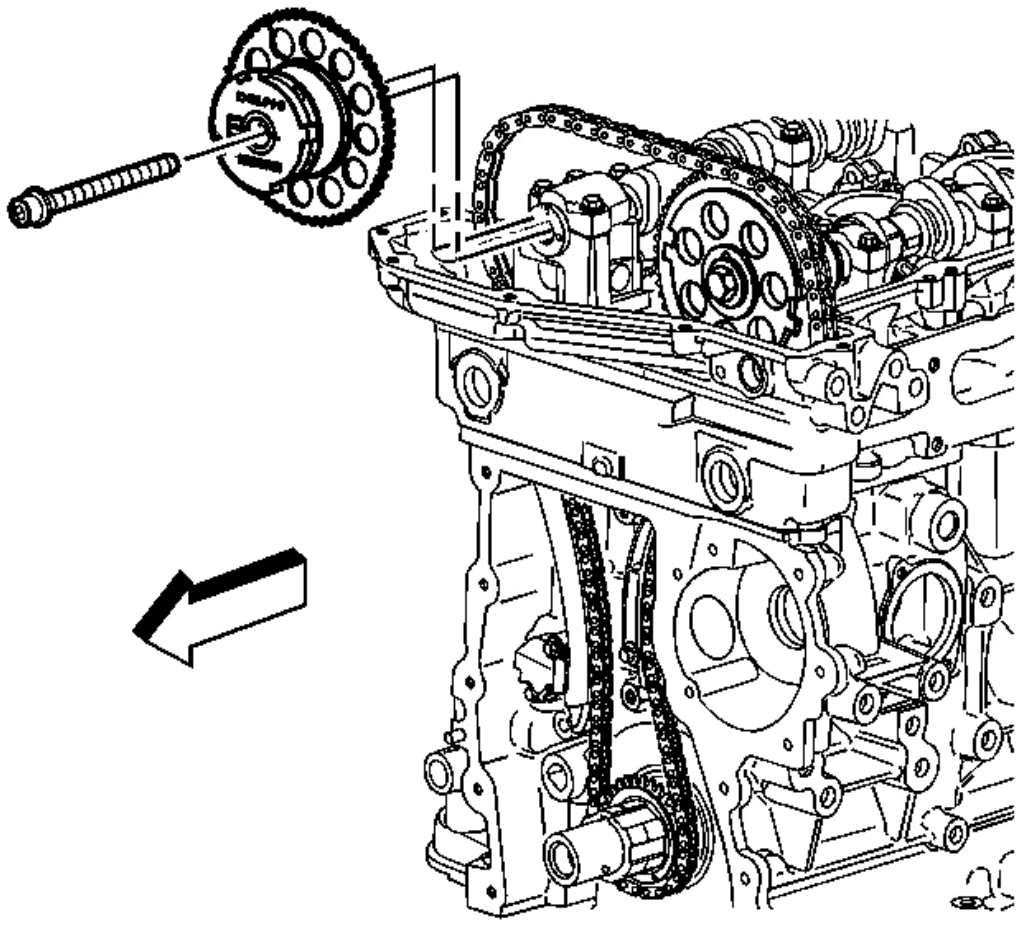


Fig. 288: View Of Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator bolt.
2. Remove the exhaust camshaft position actuator.

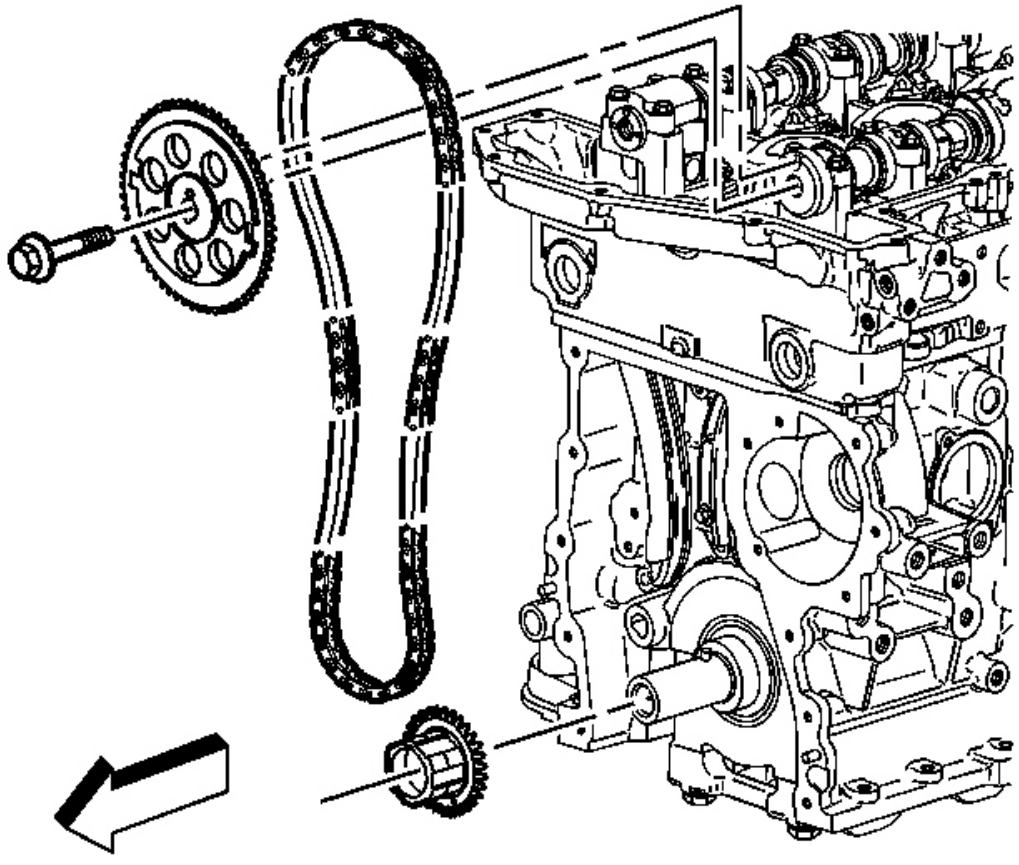


Fig. 289: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake camshaft sprocket bolt.
4. Remove the intake camshaft sprocket.
5. Remove the timing chain.
6. Remove the crankshaft sprocket.

CRANKSHAFT REAR OIL SEAL & HOUSING REMOVAL

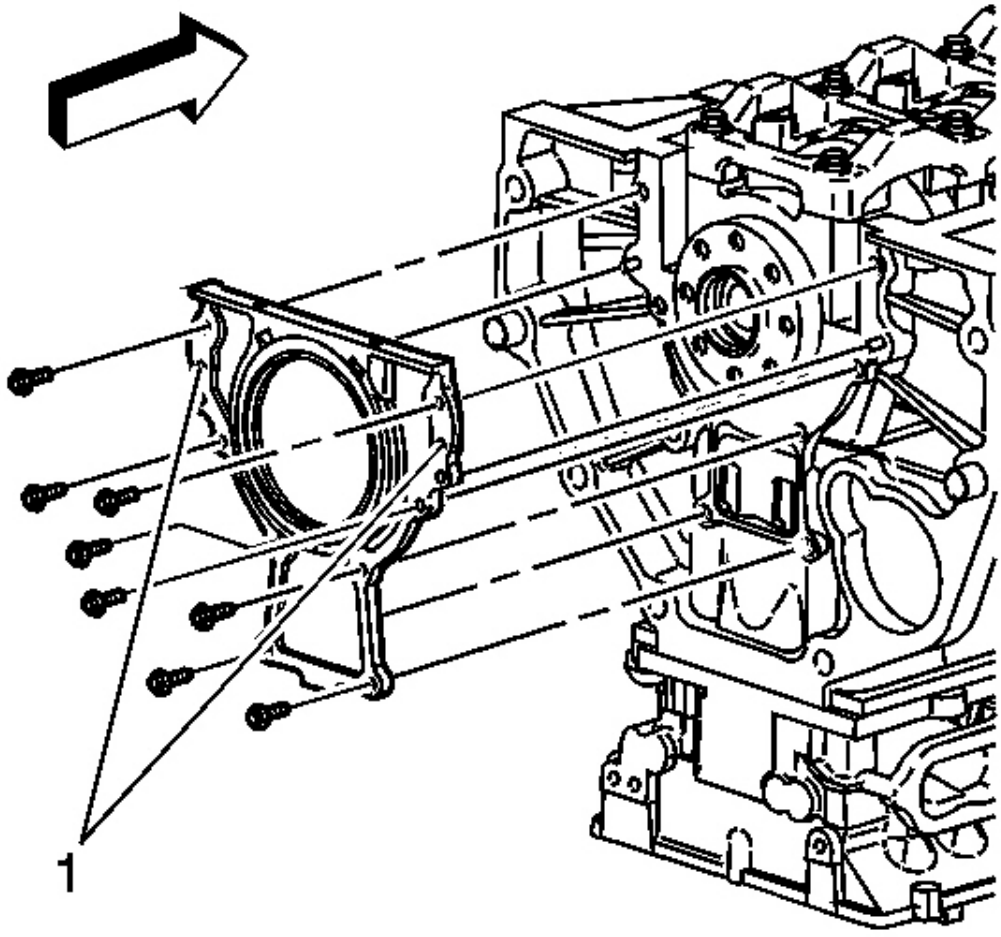


Fig. 290: View Of Crankshaft Rear Oil Seal Housing, Bolts & Threaded Holes
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal housing bolts.
2. Install two bolts (Jack Screws) into the threaded holes (1) to break the seal of the housing.
3. Remove the crankshaft rear oil seal housing.

CRANKSHAFT REAR OIL SEAL REMOVAL

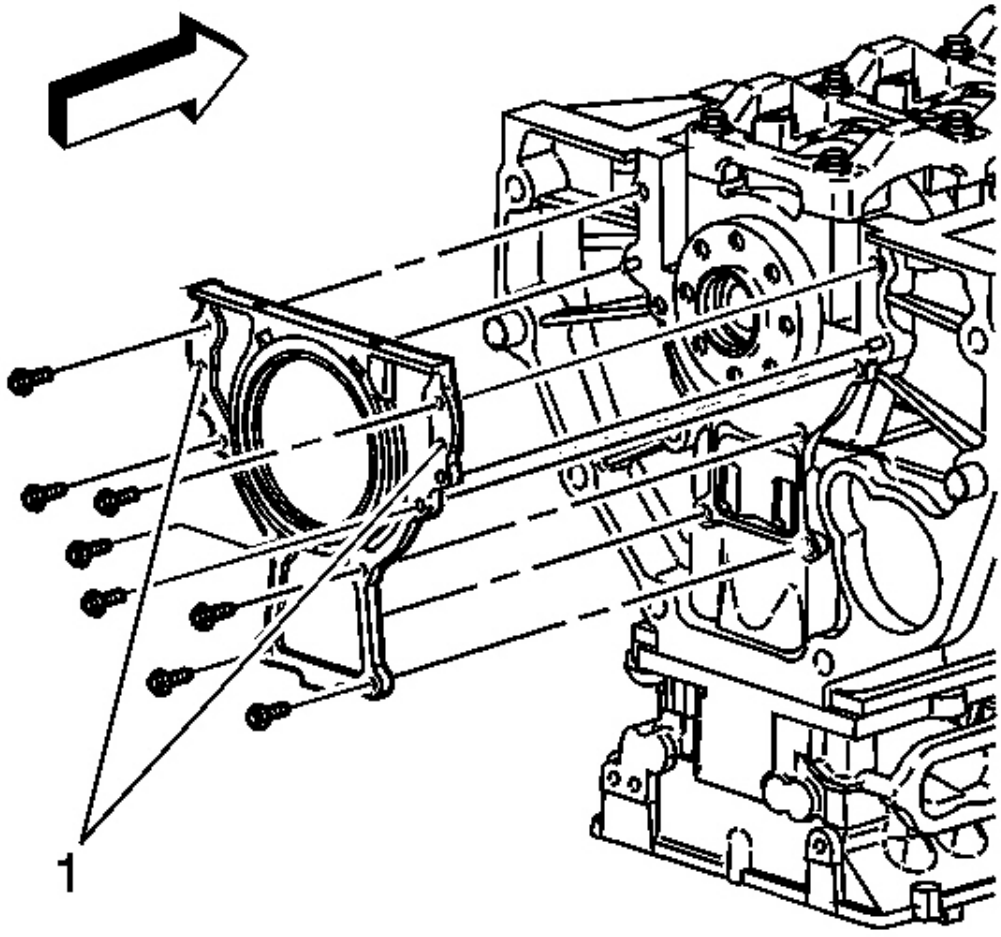


Fig. 291: View Of Crankshaft Rear Oil Seal Housing, Bolts & Threaded Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the crankshaft or seal bore. Pry out the crankshaft rear oil seal out using a suitable tool.

Remove the crankshaft rear oil seal.

TIMING CHAIN TENSIONER REMOVAL

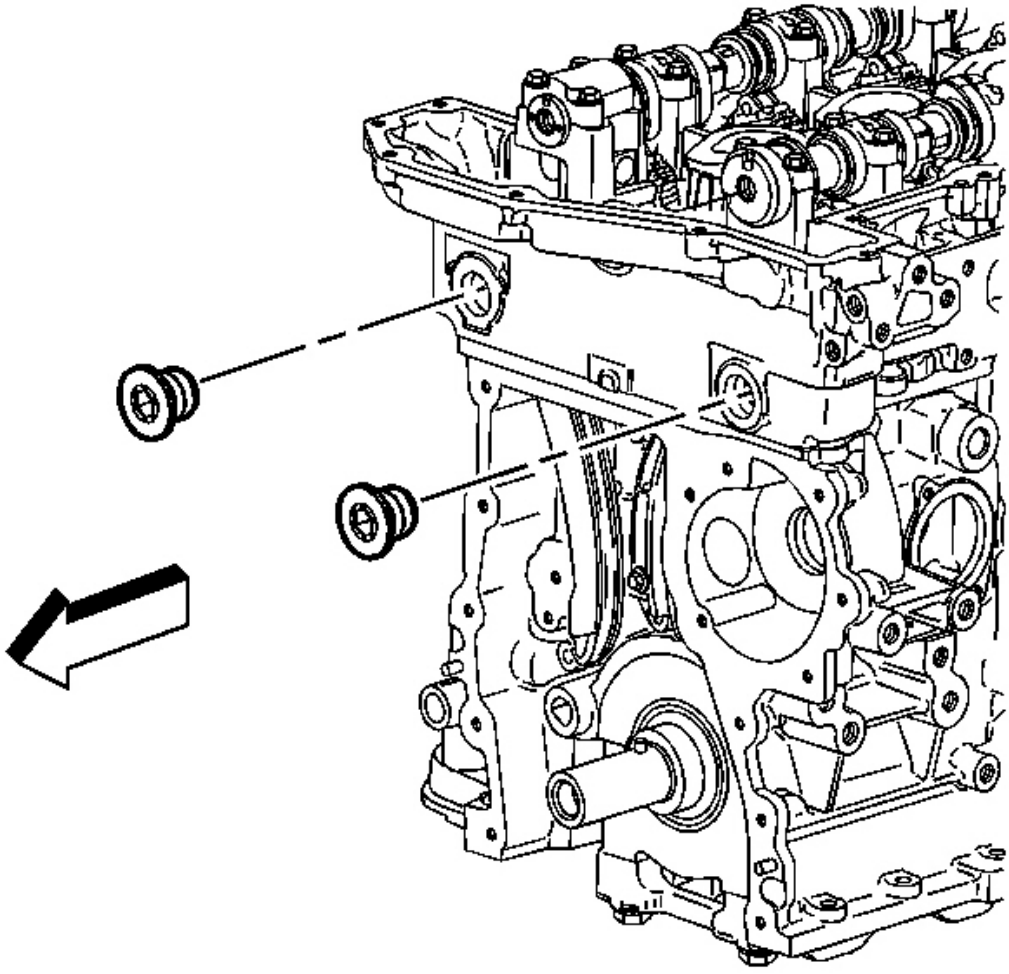


Fig. 292: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head access hole plugs.

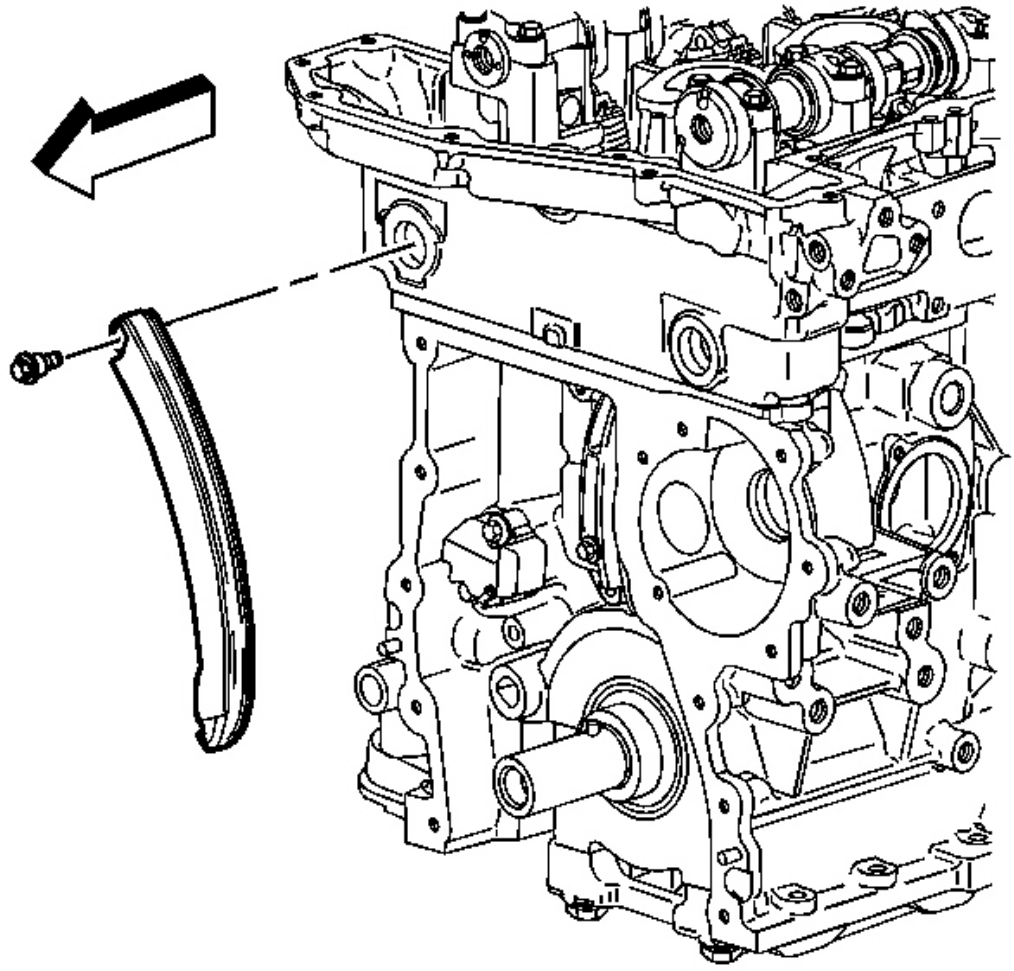


Fig. 293: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing chain tensioner shoe bolt.
3. Remove the timing chain tensioner shoe.

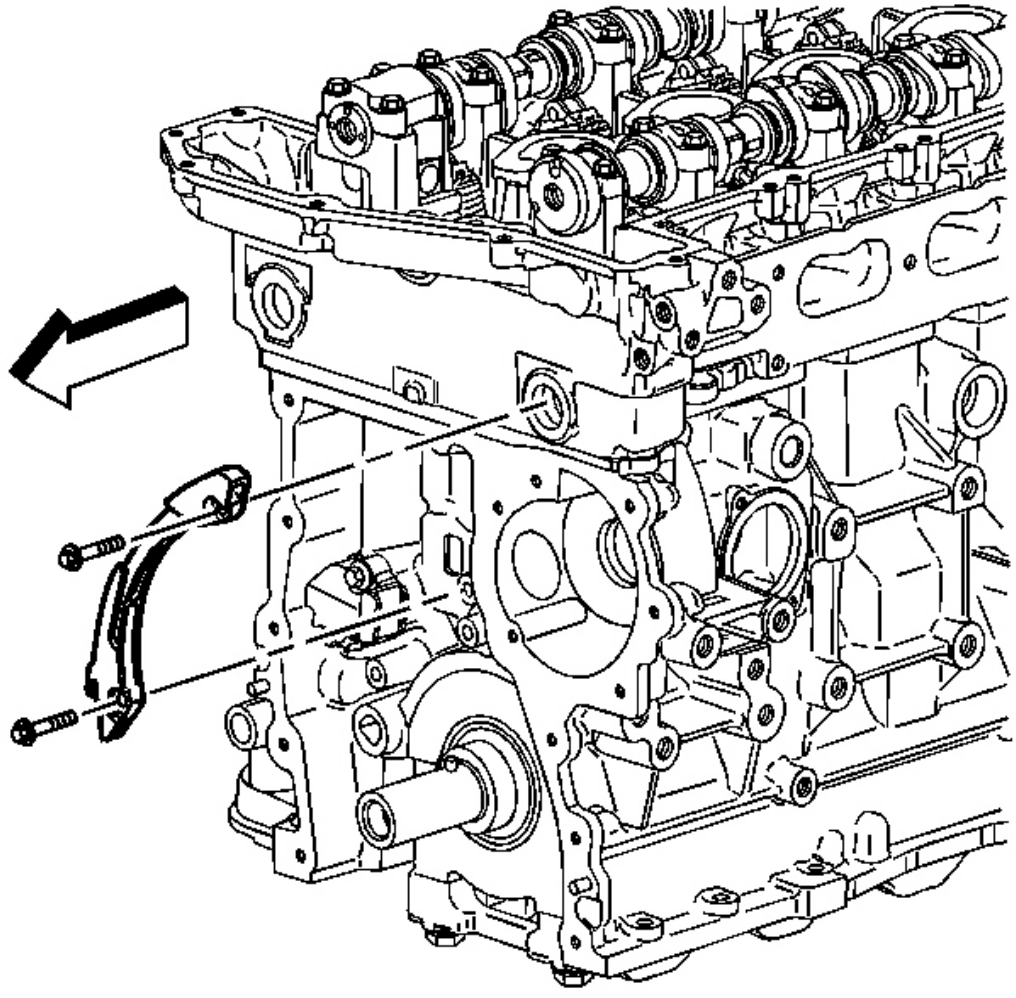


Fig. 294: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain tensioner guide bolts.
5. Remove the timing chain tensioner guide.

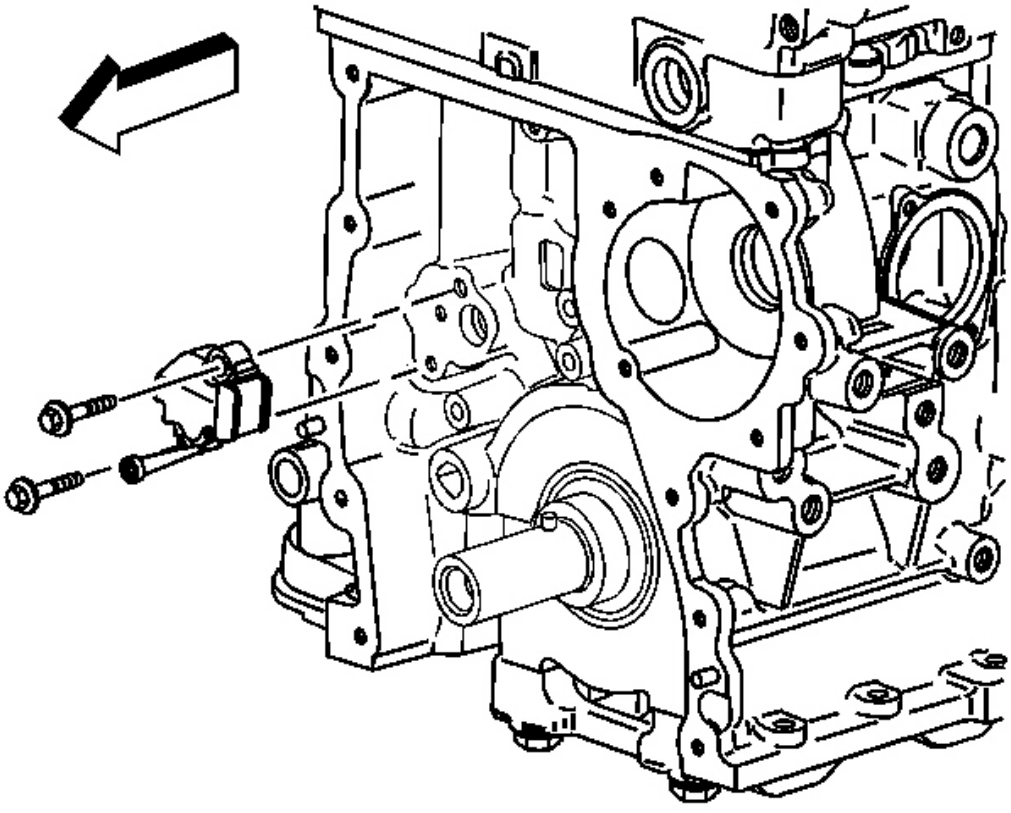


Fig. 295: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing chain tensioner bolts.
7. Remove the timing chain tensioner.

ENGINE LIFT BRACKET REMOVAL

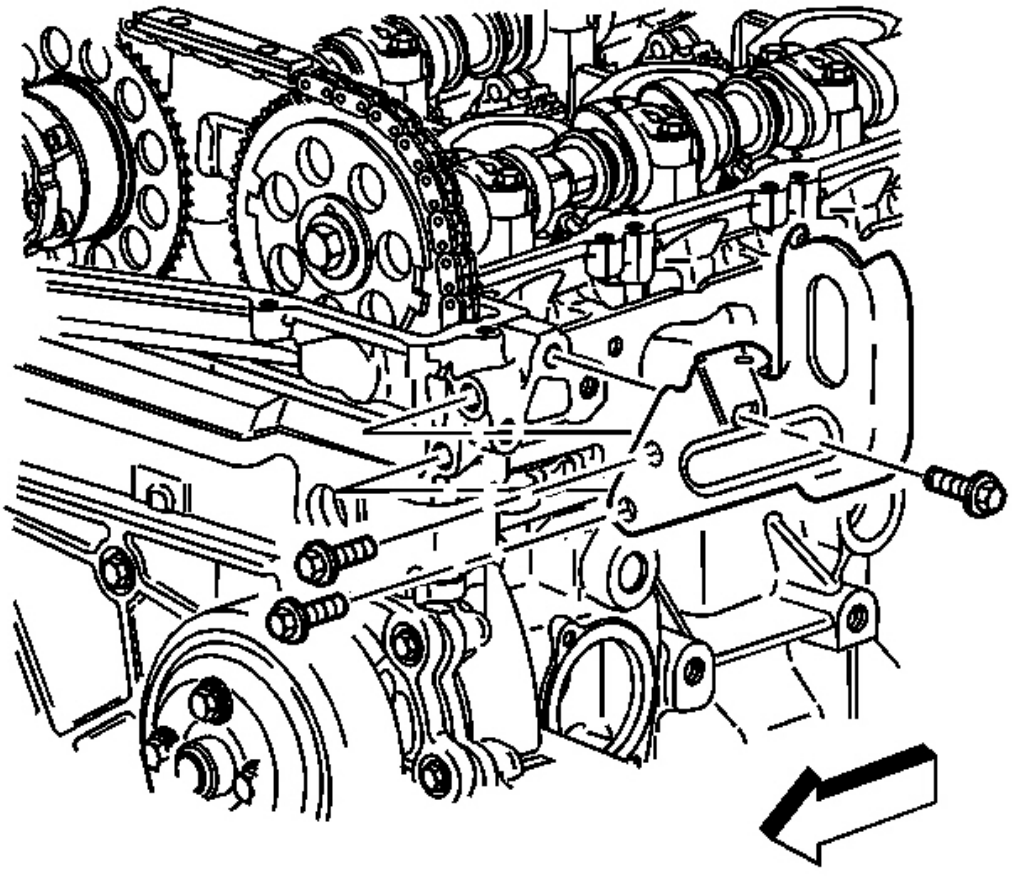


Fig. 296: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine lift bracket bolts.
2. Remove the engine lift bracket.

CAMSHAFT REMOVAL

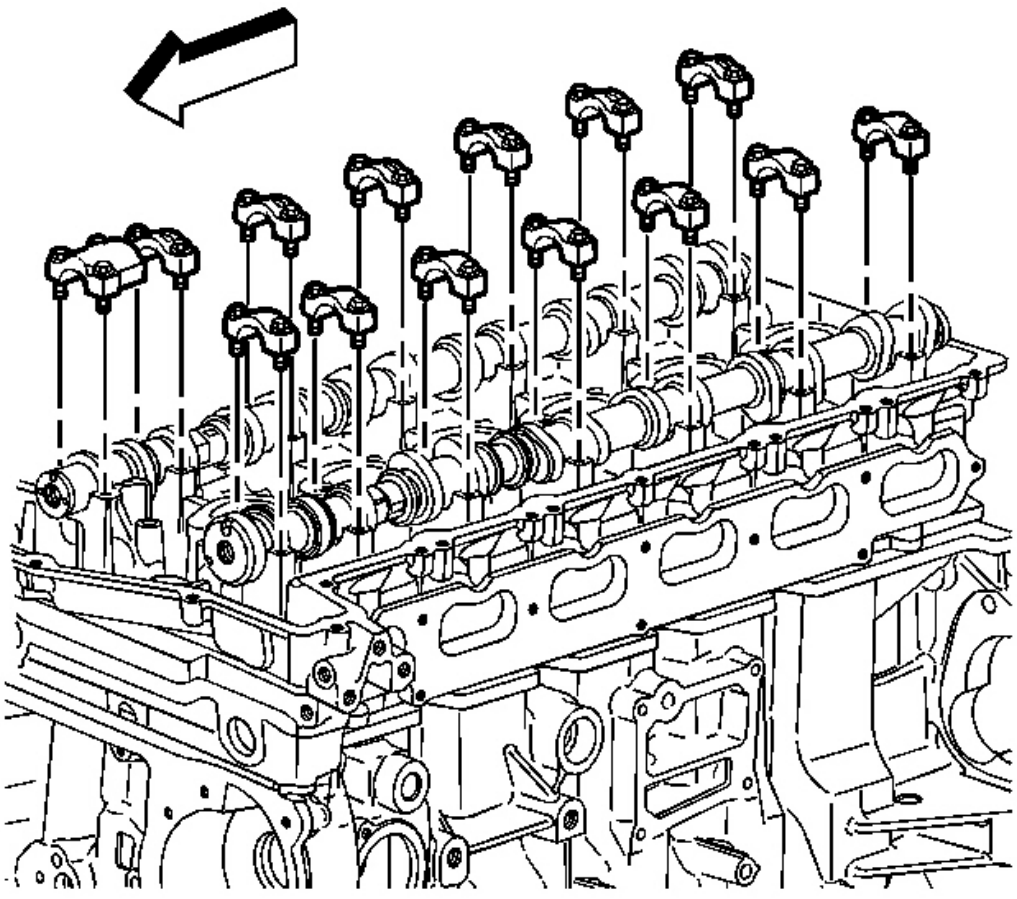


Fig. 297: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cap bolts.

IMPORTANT: Place the camshaft caps in a rack to ensure the caps are installed in the same location from which they were removed.

2. Remove the camshaft caps.

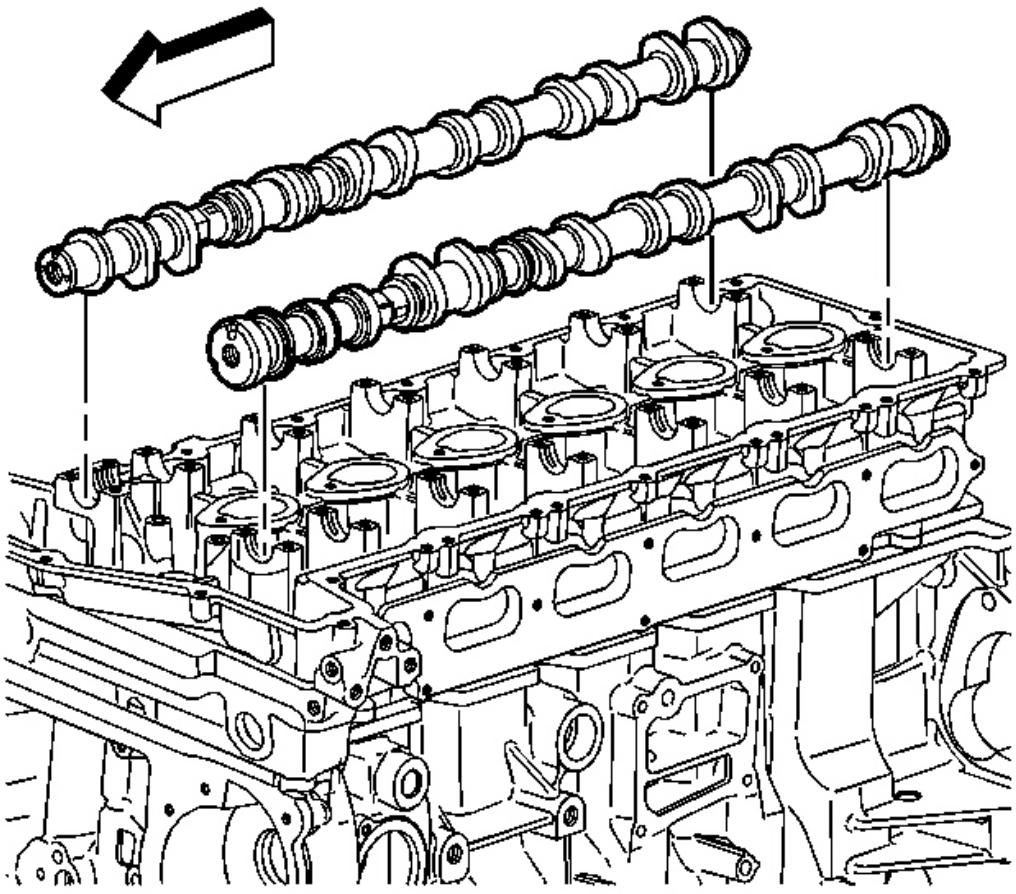


Fig. 298: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshafts.

VALVE ROCKER ARM & VALVE LASH ADJUSTER REMOVAL

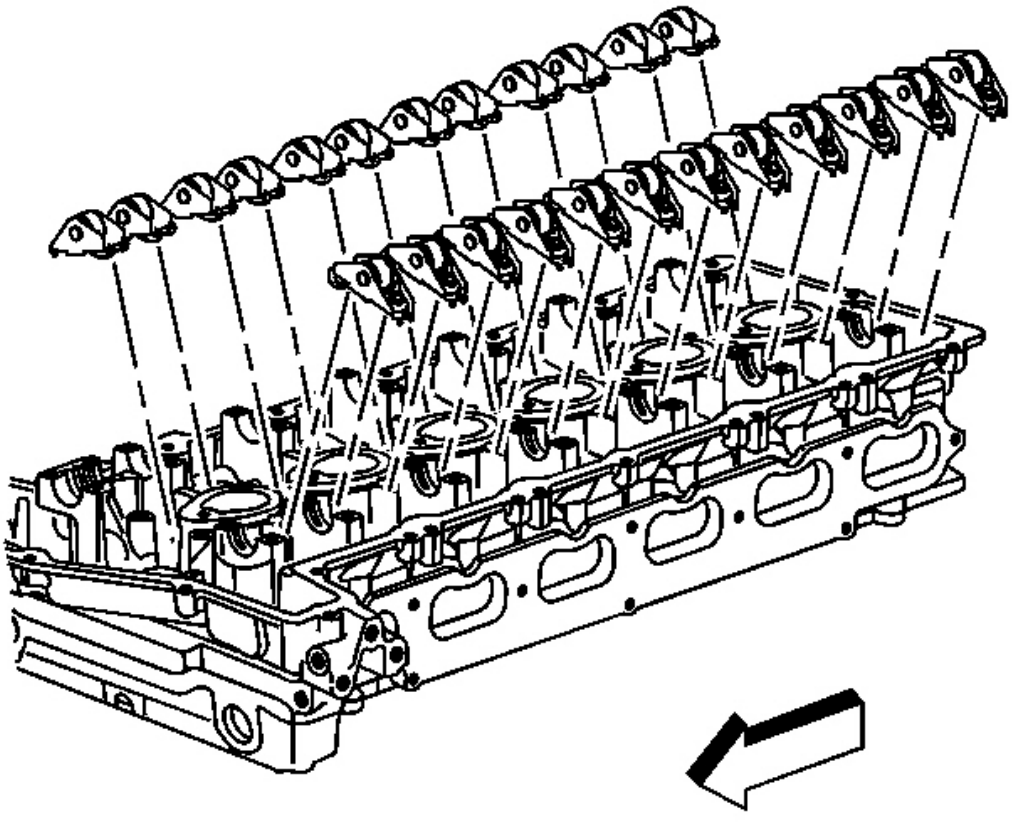


Fig. 299: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Once removed, place the valve rocker arms and valve lash adjusters in an organized order so the components can be installed into the original locations.

1. Remove the valve rocker arms.

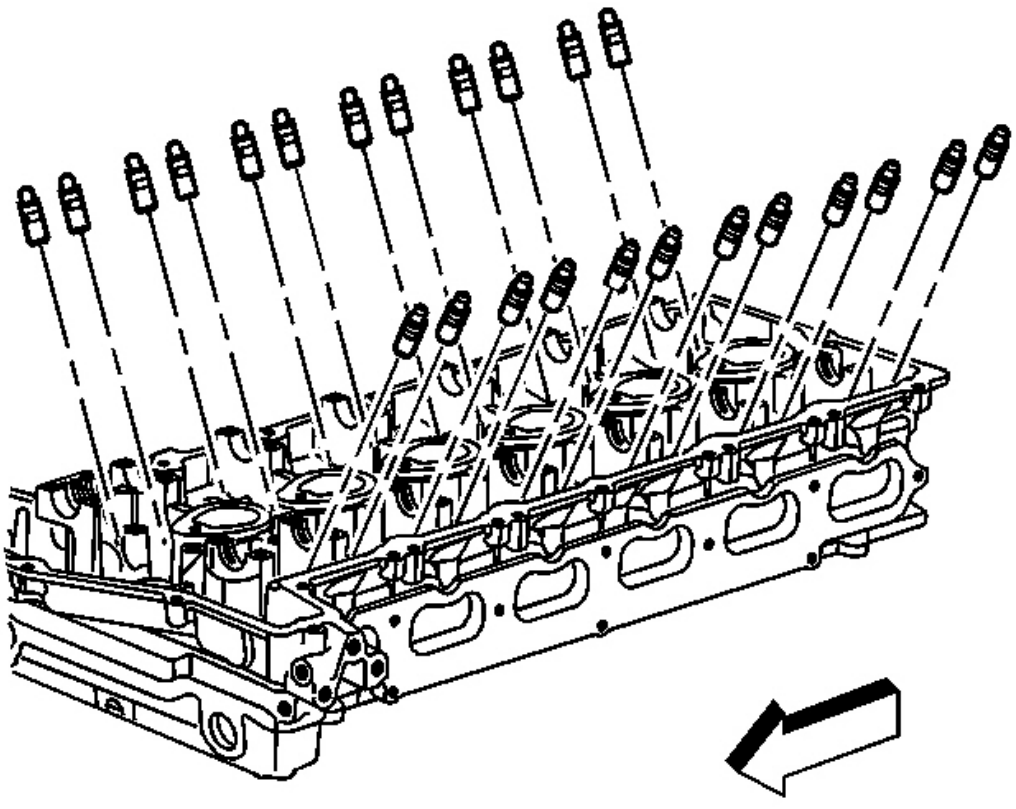


Fig. 300: View Of Valve Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve lash adjusters.

CYLINDER HEAD REMOVAL

Tools Required

EN-47702 Bolt Extractor Kit. See **Special Tools**.

Removal Procedure

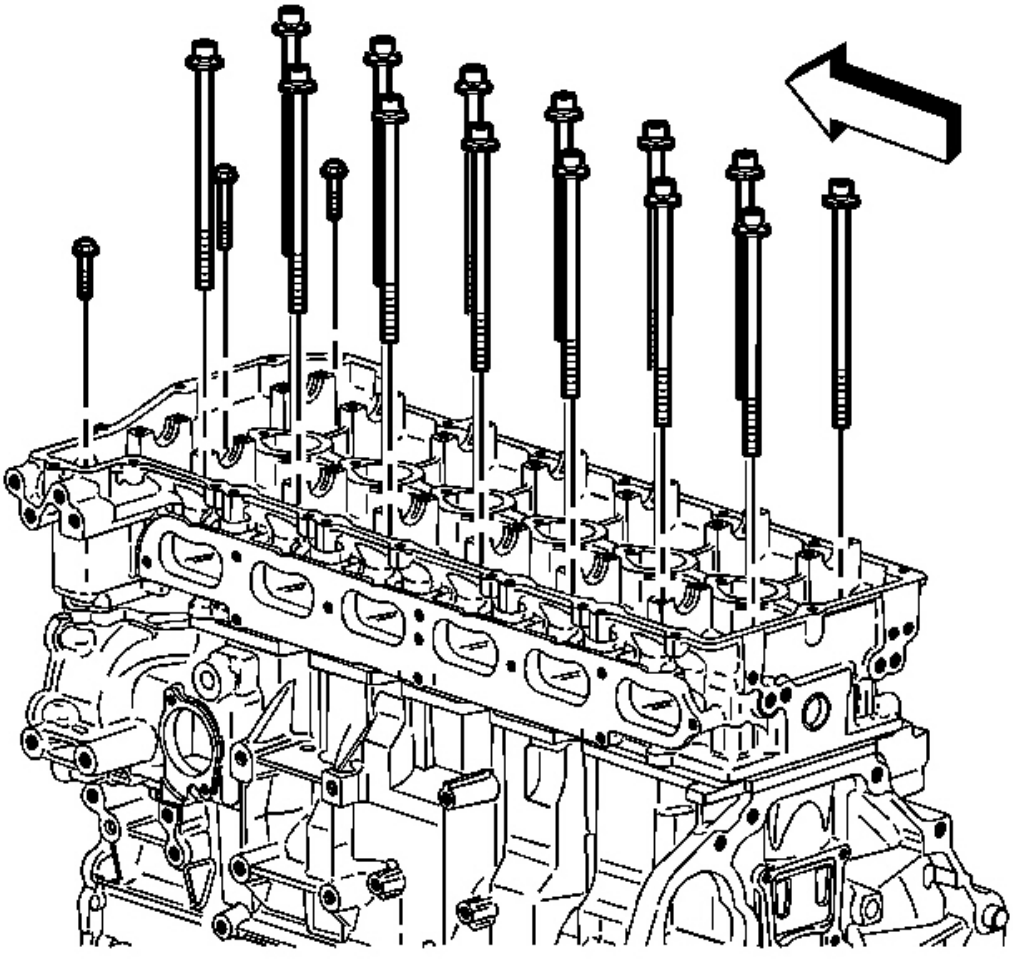


Fig. 301: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rap on the head of each bolt using an appropriate size punch and hammer. The vibration produced by this procedure assists in successful removal. If a bolt breaks during engine disassembly, a broken bolt extractor kit EN-47702 is available to assist in removal of the remaining bolt segment. See Special Tools.

1. Remove the cylinder head bolts.

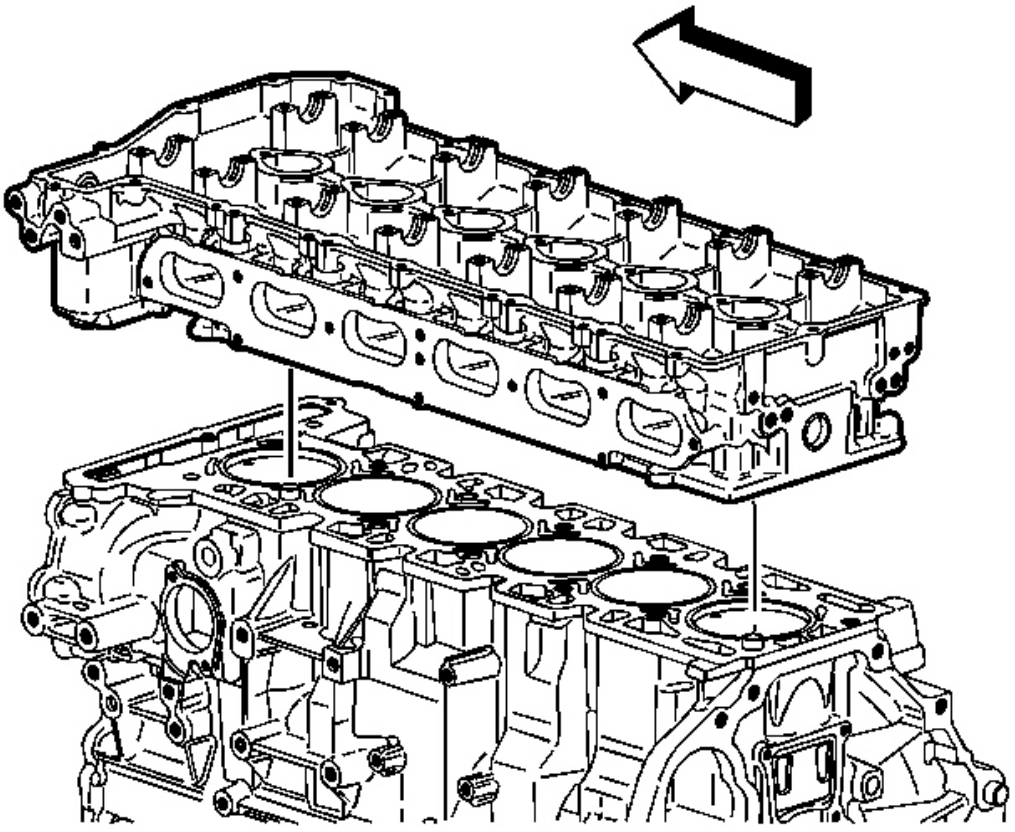


Fig. 302: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Remove the cylinder head.

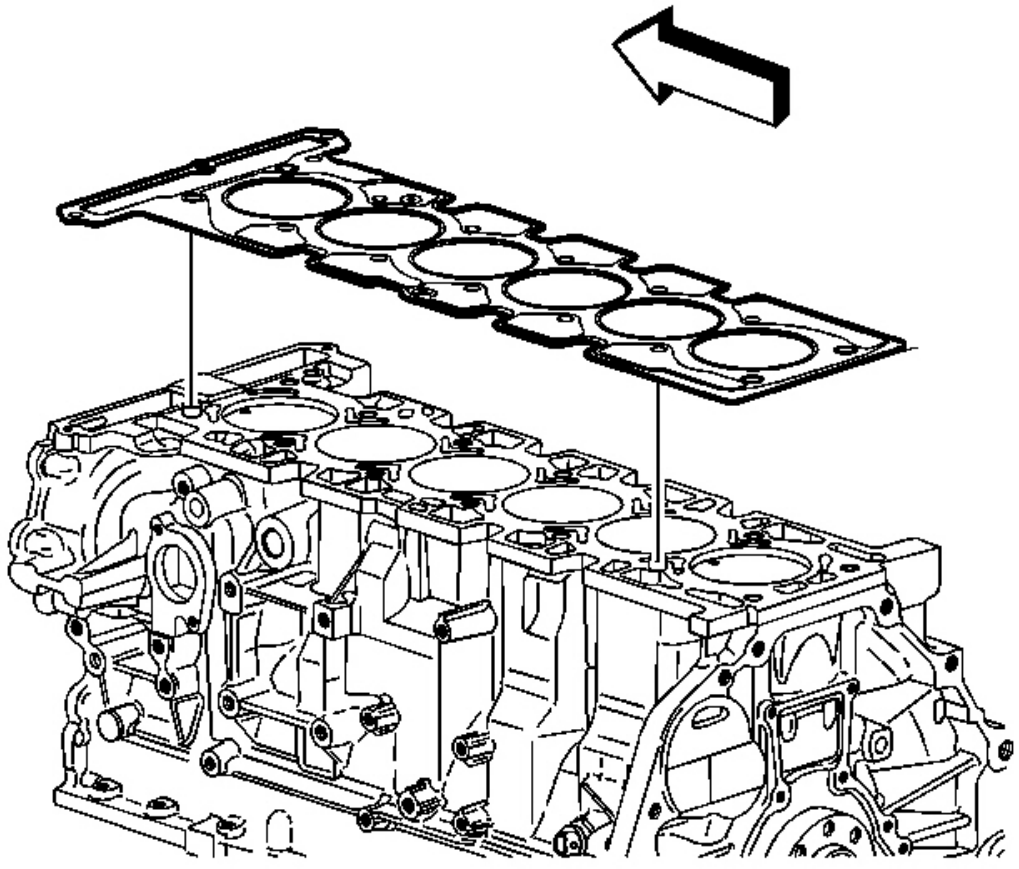


Fig. 303: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.

PISTON, CONNECTING ROD & BEARING REMOVAL

Tools Required:

J 41556 Connecting Rod Guides. See **Special Tools**.

Removal Procedure

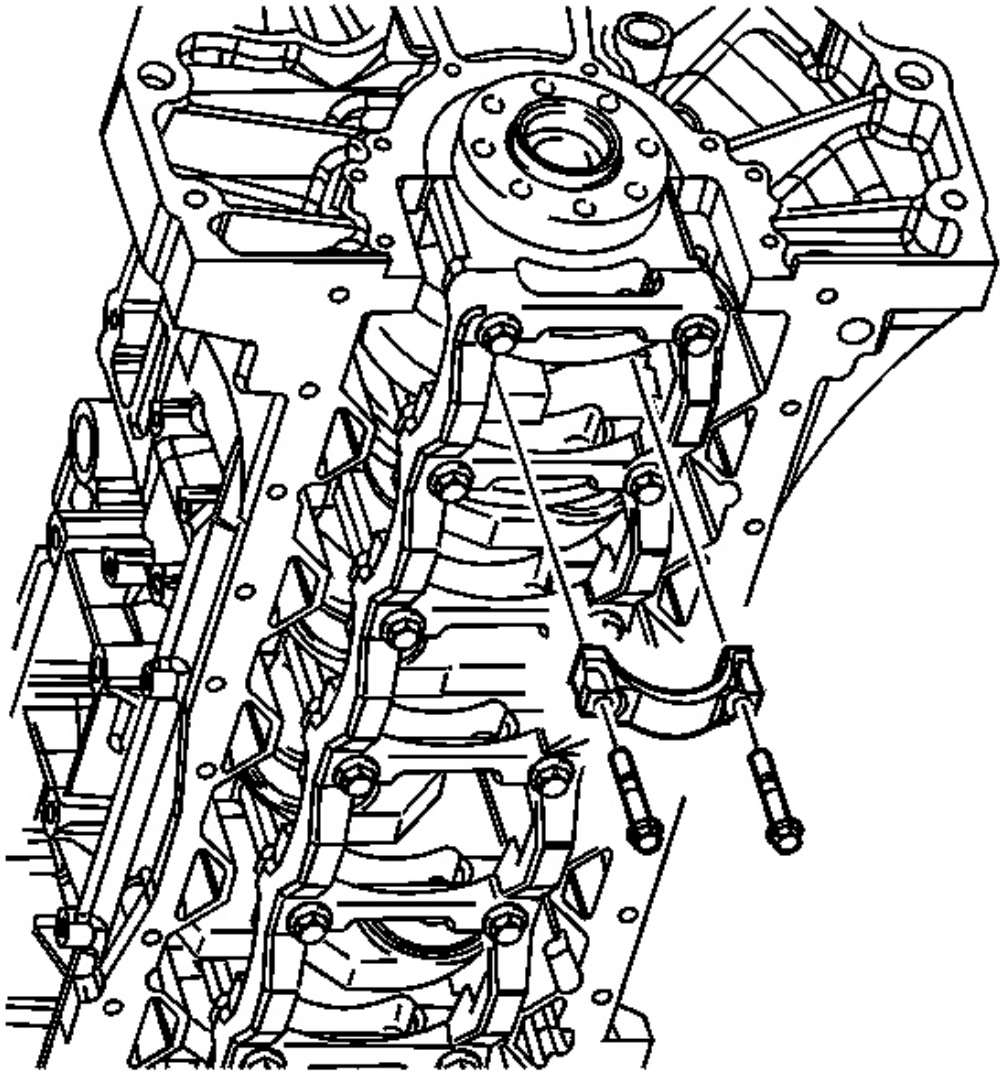


Fig. 304: View Of Connecting Rod, Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Mark the piston with the number of the cylinder from which the piston is being removed.
2. Mark the connecting rod and the connecting rod cap with the cylinder position. Also mark the orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove the connecting rod bolts.
4. Remove the connecting rod cap and bearing half.

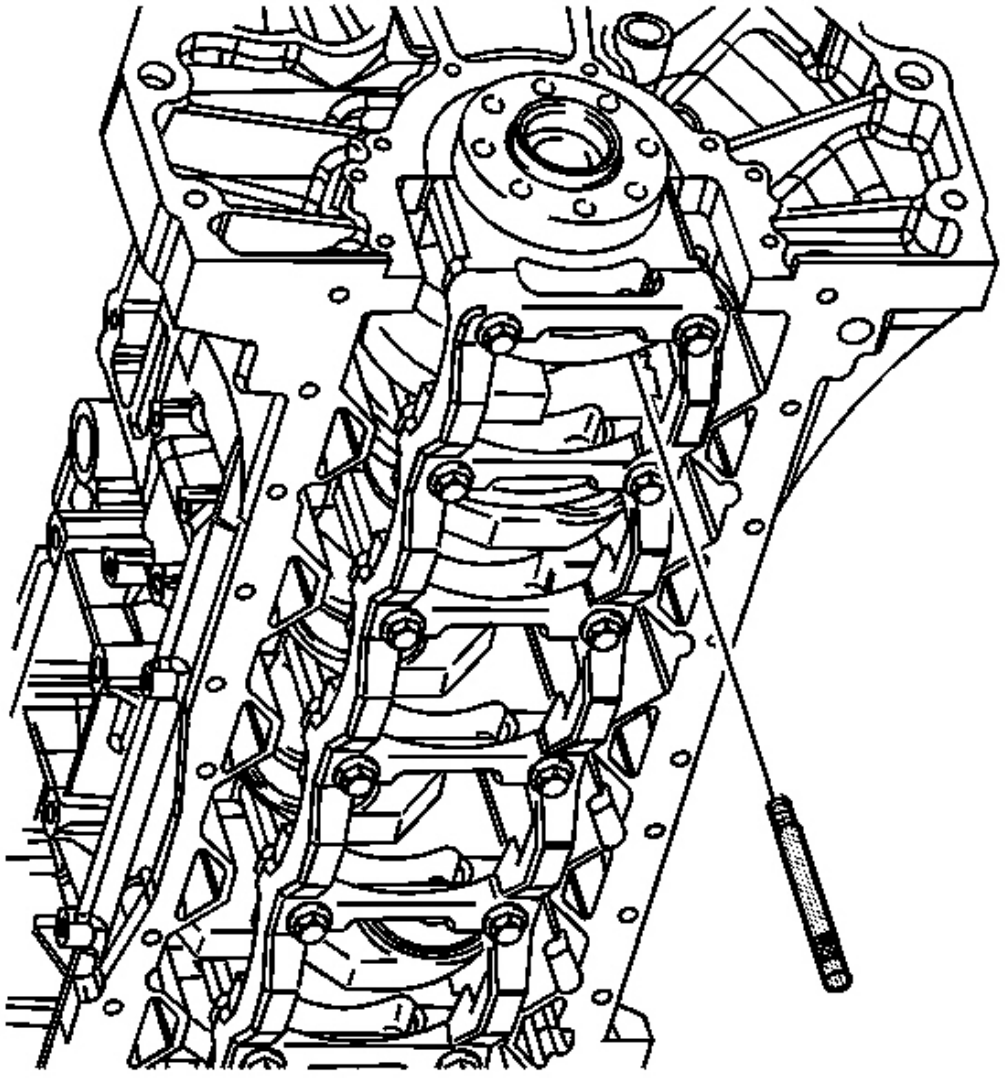


Fig. 305: View Of J 41556
Courtesy of GENERAL MOTORS CORP.

5. Install **J 41556** on the connecting rod. See **Special Tools**.

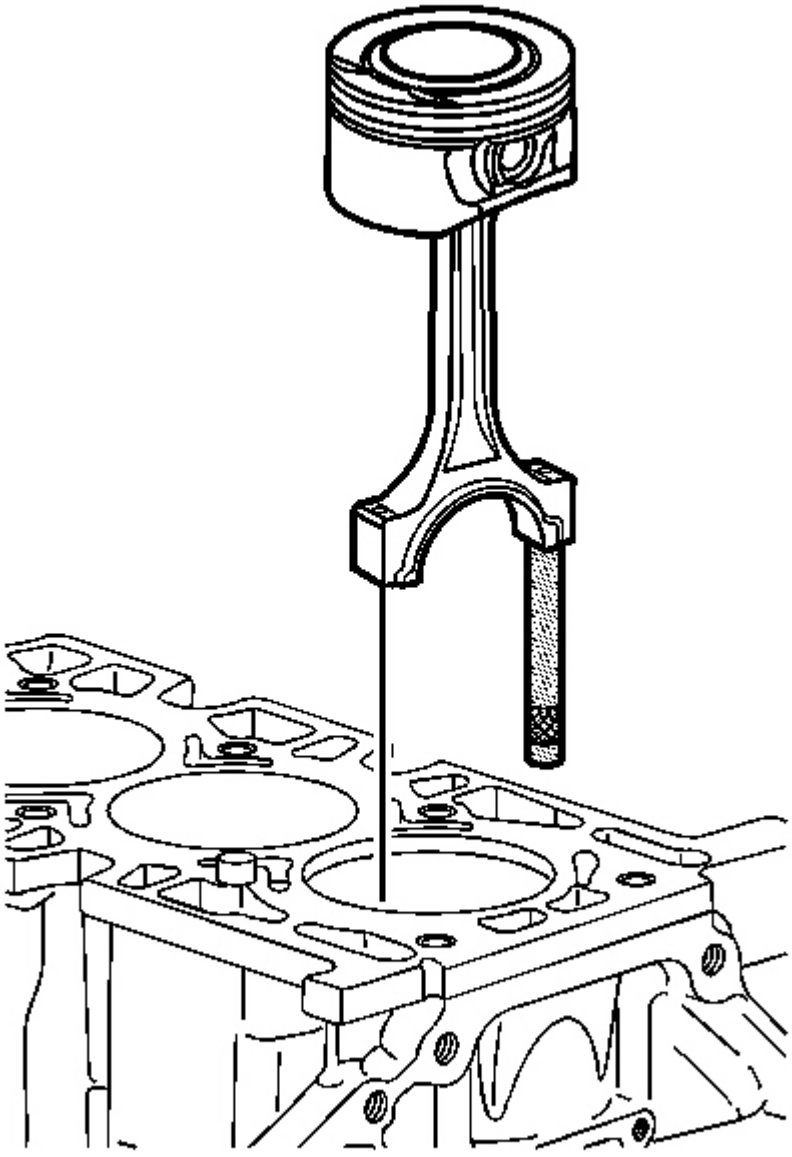


Fig. 306: Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

6. Remove the connecting rod and piston assembly. Push out the assembly.
7. Remove **J 41556** . See **Special Tools**.

CRANKSHAFT & BEARING REMOVAL

Tools Required

- **EN-47702** Bolt Extractor Kit. See **Special Tools**.
- **EN-48268** Main Bearing Cap Remover. See **Special Tools**.
- **J 6125-1B** Slide Hammer with Adapter. See **Special Tools**.

Removal Procedure

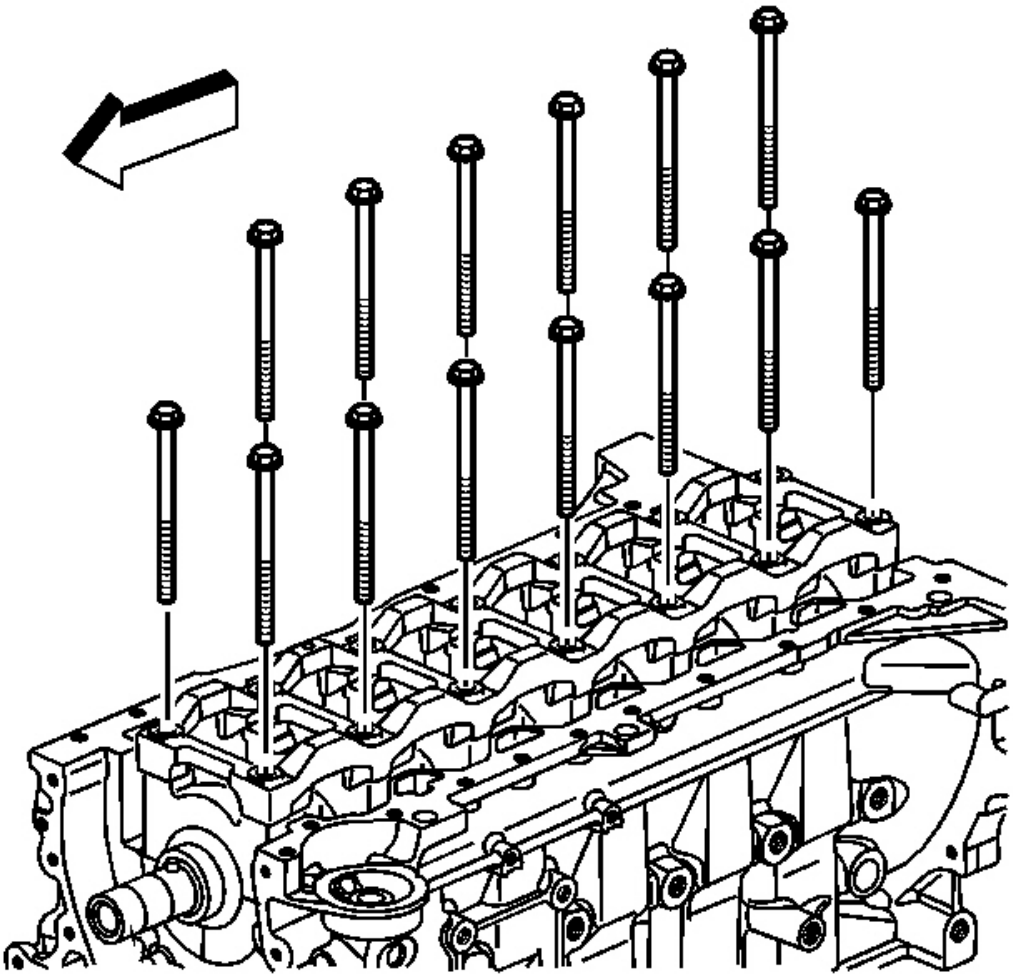


Fig. 307: View Of Crankshaft Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rap on the head of each bolt using an appropriate size punch and hammer. The vibration produced by this procedure assists in successful removal. If a bolt breaks during engine disassembly, a broken bolt extractor kit EN-47702 is available to assist in removal of the remaining bolt segment. See Special Tools.

1. Remove the crankshaft main bearing cap bolts.

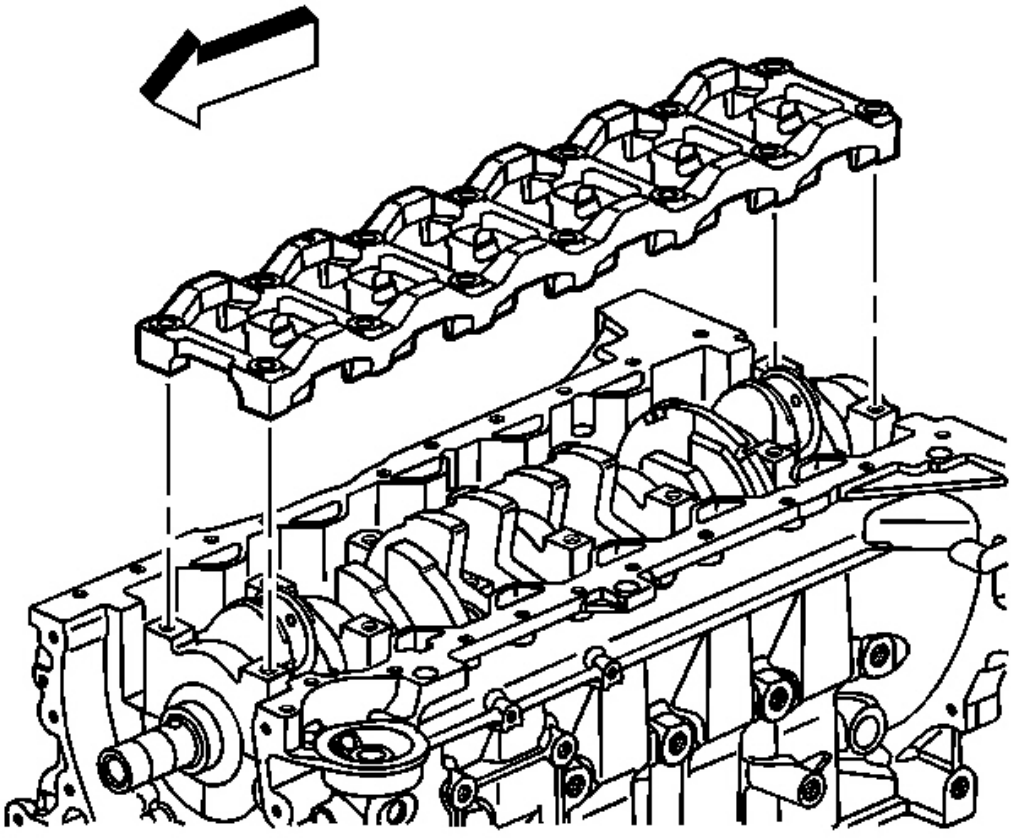


Fig. 308: View Of Crankshaft Main Bearing Cap Stiffener
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft main bearing cap stiffener.

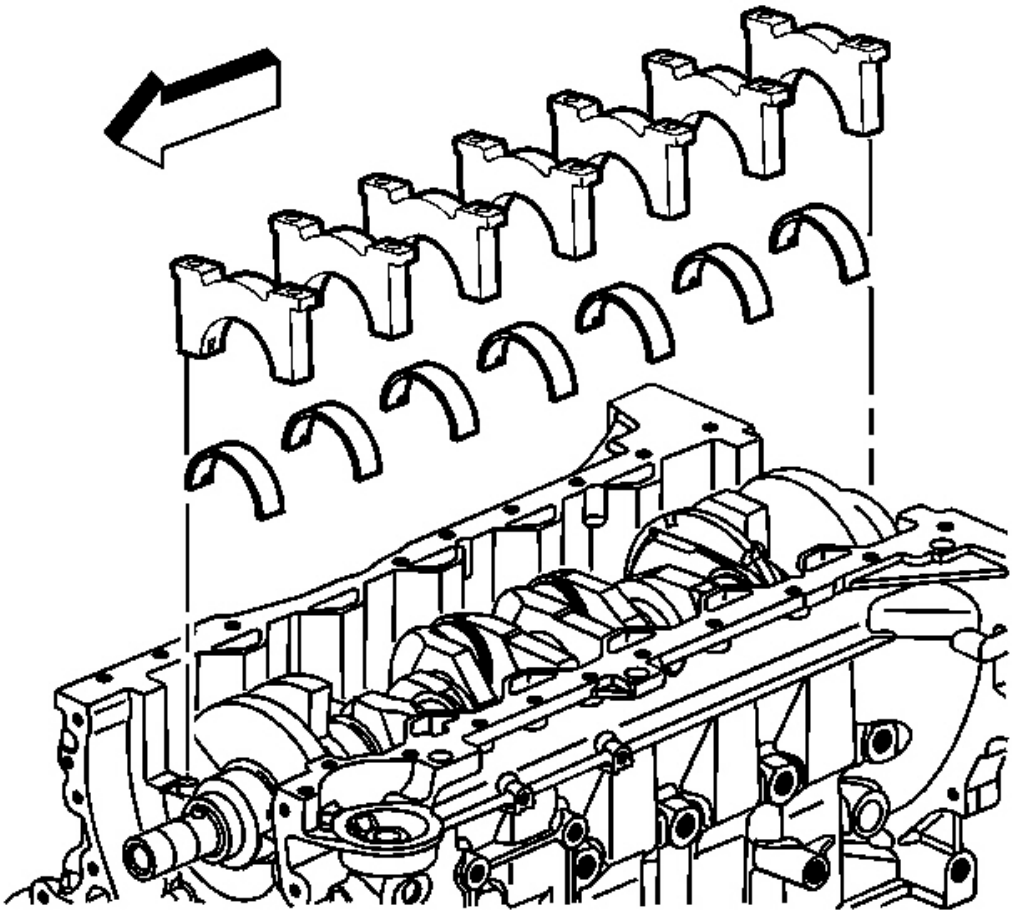


Fig. 309: View Of Crankshaft Main Bearing Caps & Lower Bearings
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft main bearing caps using **EN-48268** and **J 6125-1B** . See **Special Tools**.
4. Remove the lower crankshaft main bearing halves.

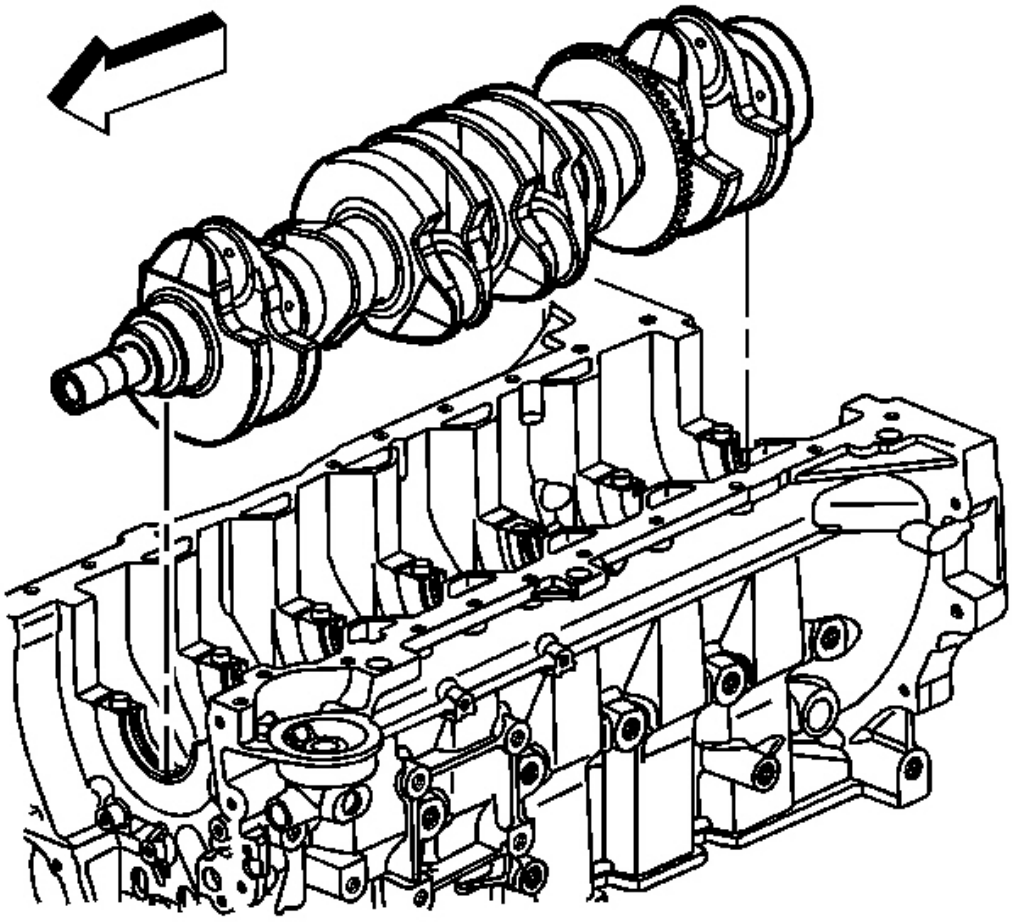


Fig. 310: View Of Crankshaft & Block
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft.

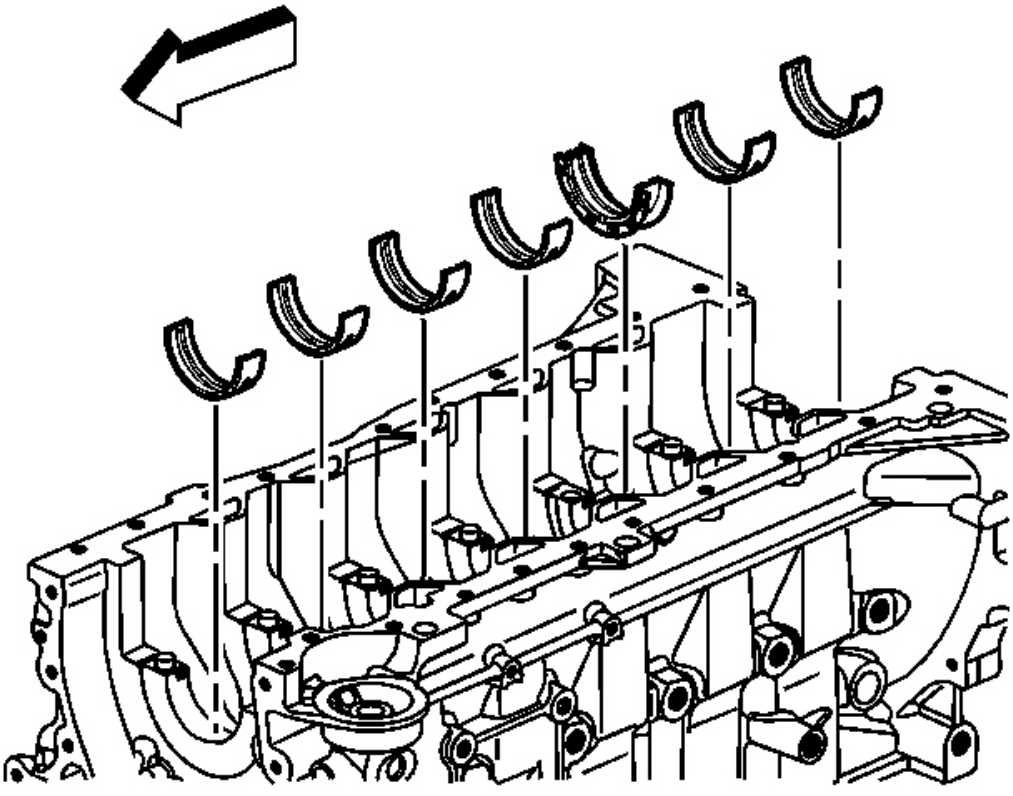


Fig. 311: View Of Upper Crankshaft Main Bearing Halves
Courtesy of GENERAL MOTORS CORP.

6. Remove the upper crankshaft main bearing halves.

ENGINE BLOCK PLUG REMOVAL

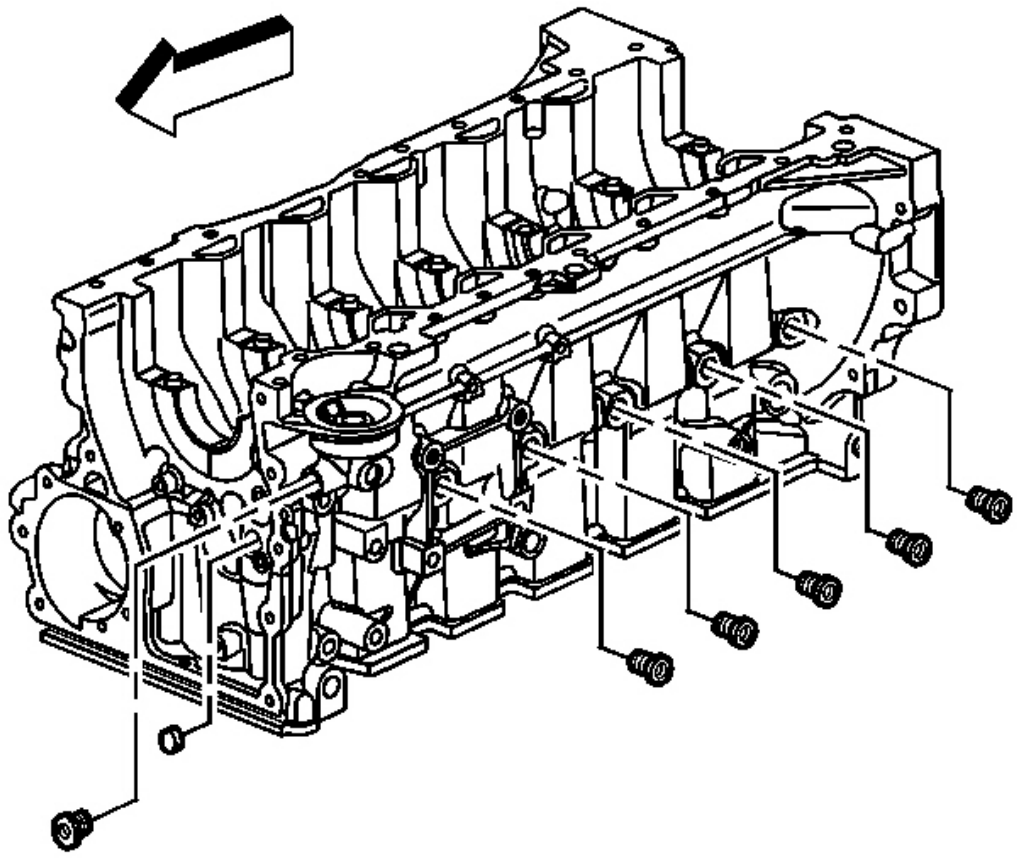


Fig. 312: View Of Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block oil gallery plugs.

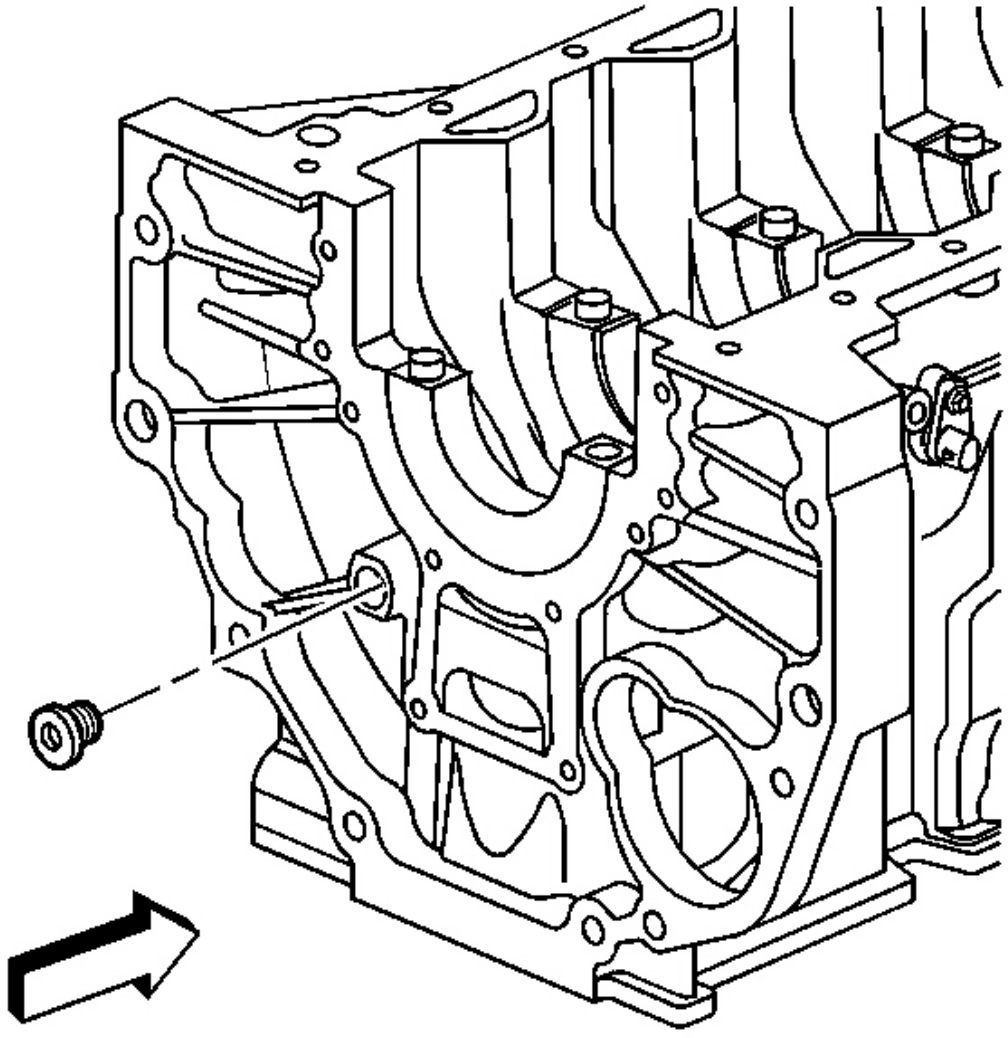


Fig. 313: View Of Oil Gallery Plug From Rear Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block oil gallery plug from rear of block.

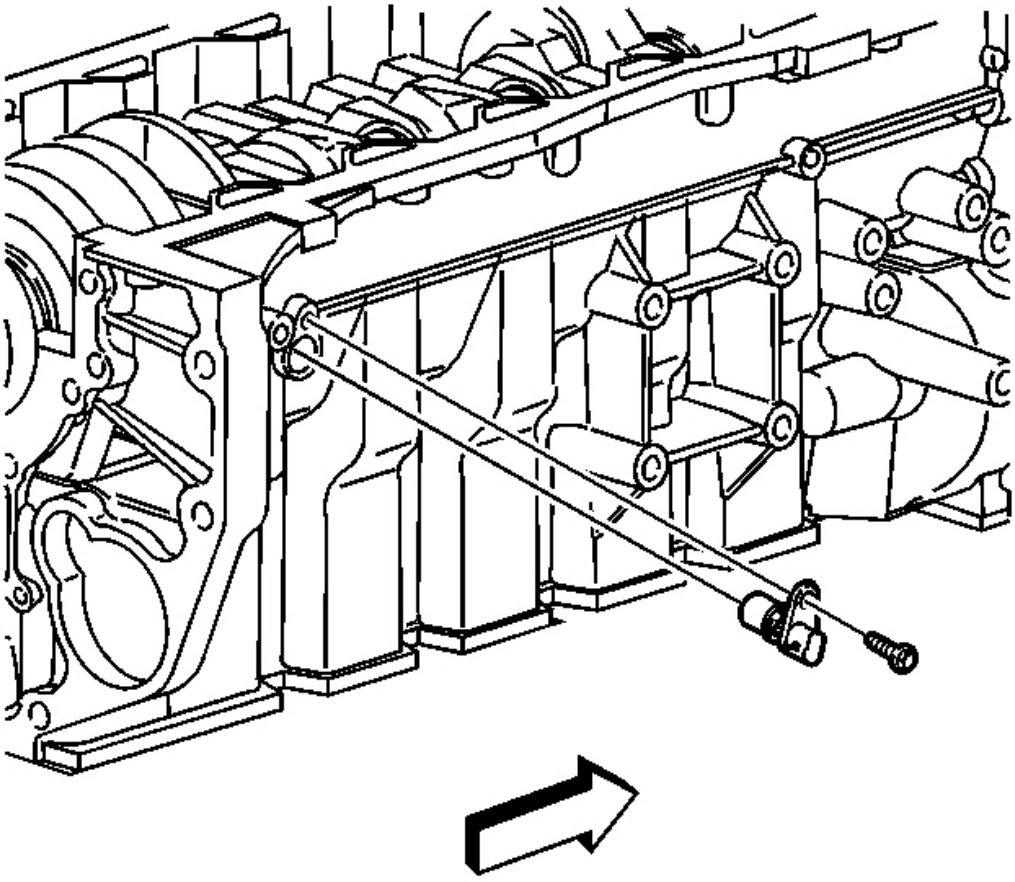


Fig. 314: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft position sensor.

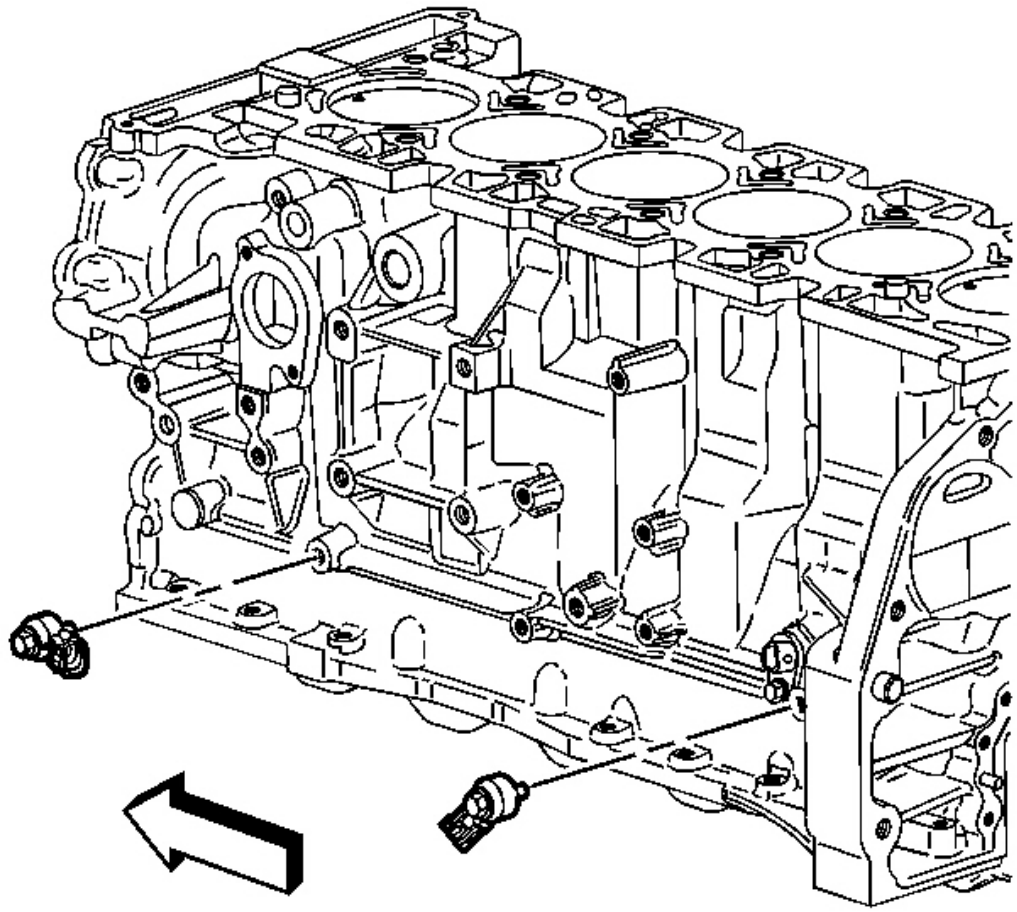


Fig. 315: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

4. Remove the knock sensors.

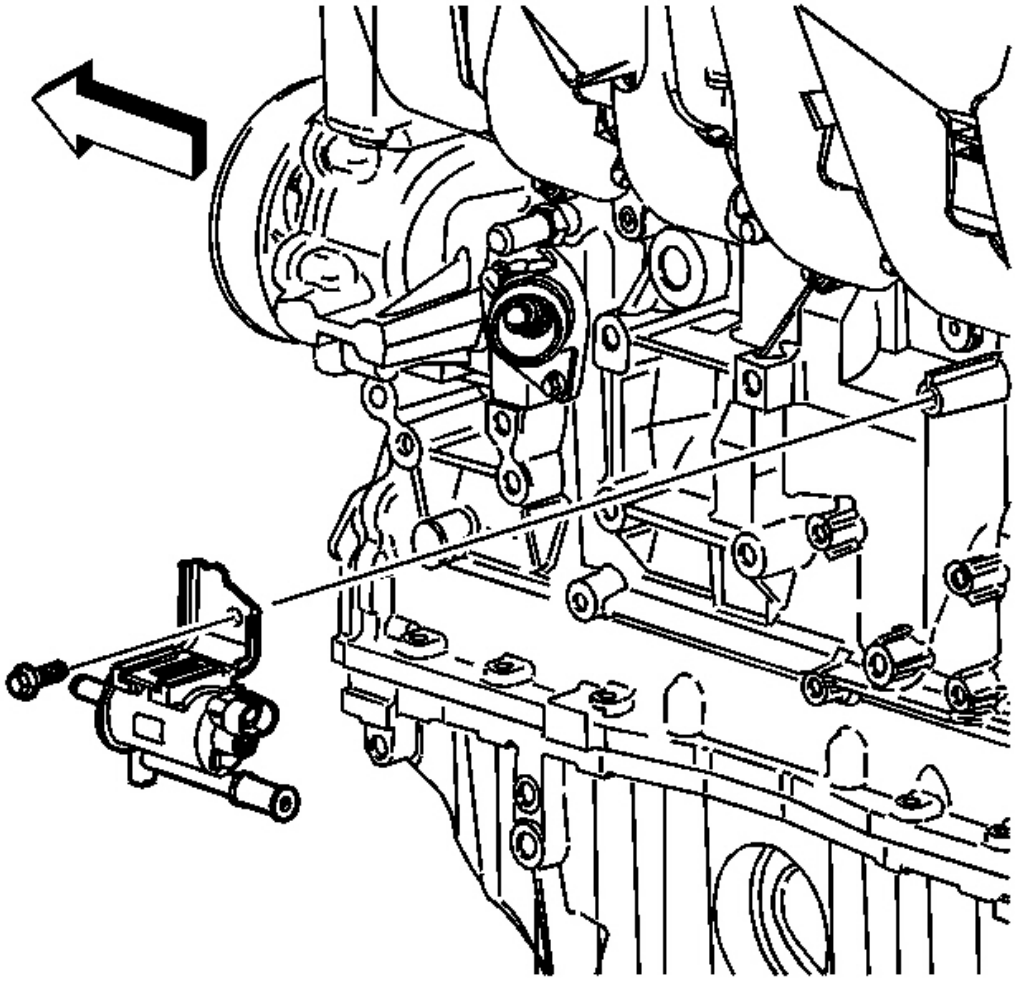


Fig. 316: View Of EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

5. Remove the EVAP solenoid.

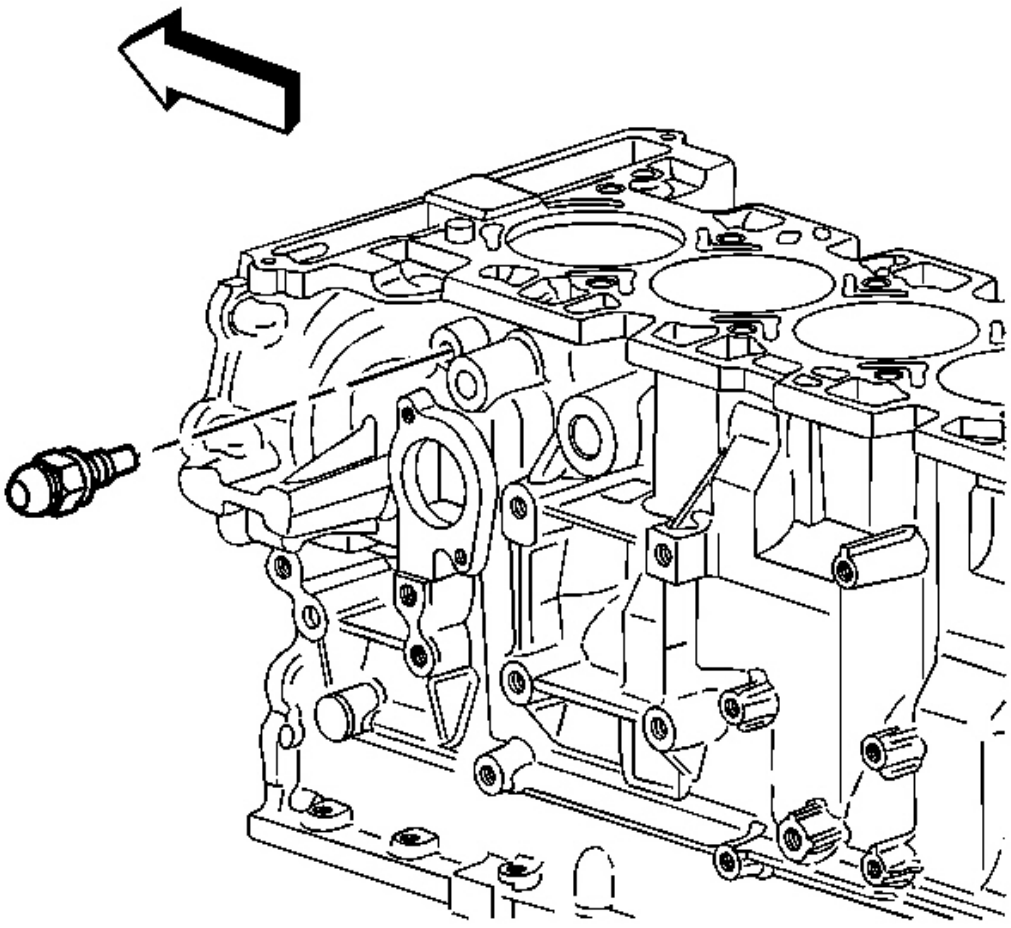


Fig. 317: View Of Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the coolant temperature sensor.

ENGINE BLOCK CLEANING & INSPECTION

Tools Required

- **J 8001** Dial Indicator Set
- **J 8087** Cylinder Bore Gage. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Cleaning & Inspection Procedure

1. Clean the sealing material from all gasket mating surfaces.
2. Clean the engine block with a cleaning solution.
3. Flush the engine block with clean water.
4. Clean the oil passages.
5. Coat the cylinder bores and the machined surfaces with engine oil.
6. Inspect the threaded holes. Clean the holes with a tap, if needed.
7. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully remove any minor irregularities. Replace the block if there is more than 0.08 mm (0.003 in) gap.

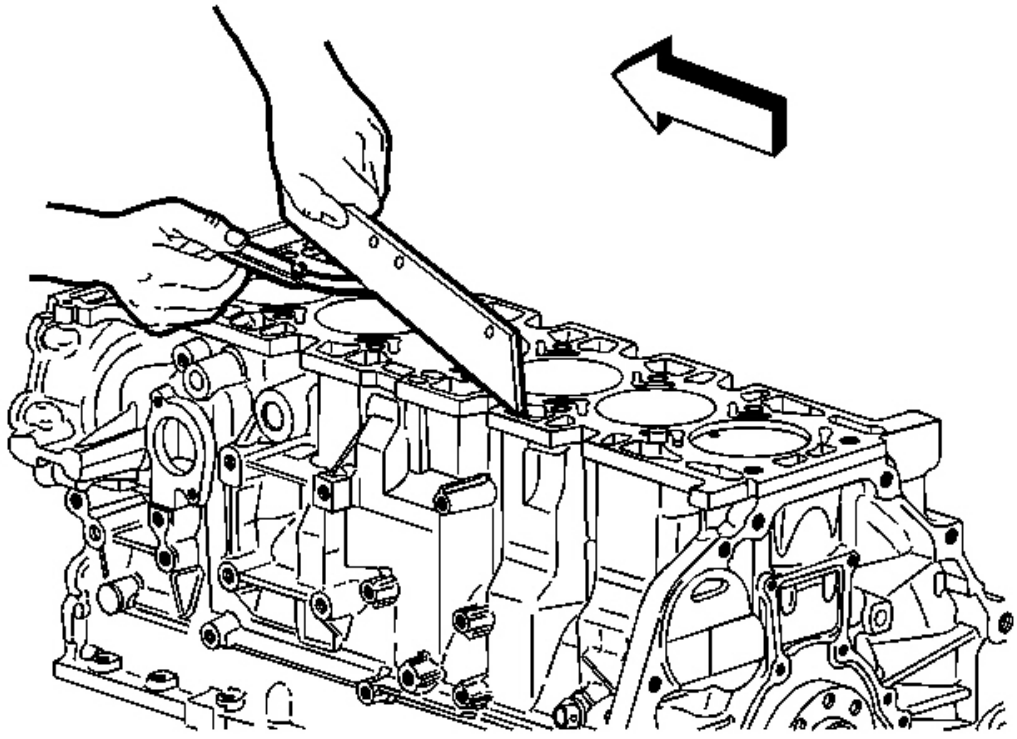


Fig. 318: Checking Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

8. Inspect the cylinder bores. Use **J 8087** to measure the cylinder bore. See **Special Tools**. Inspect the bores for the following conditions:
   - Wear
   - Taper
   - Runout

- Ridging

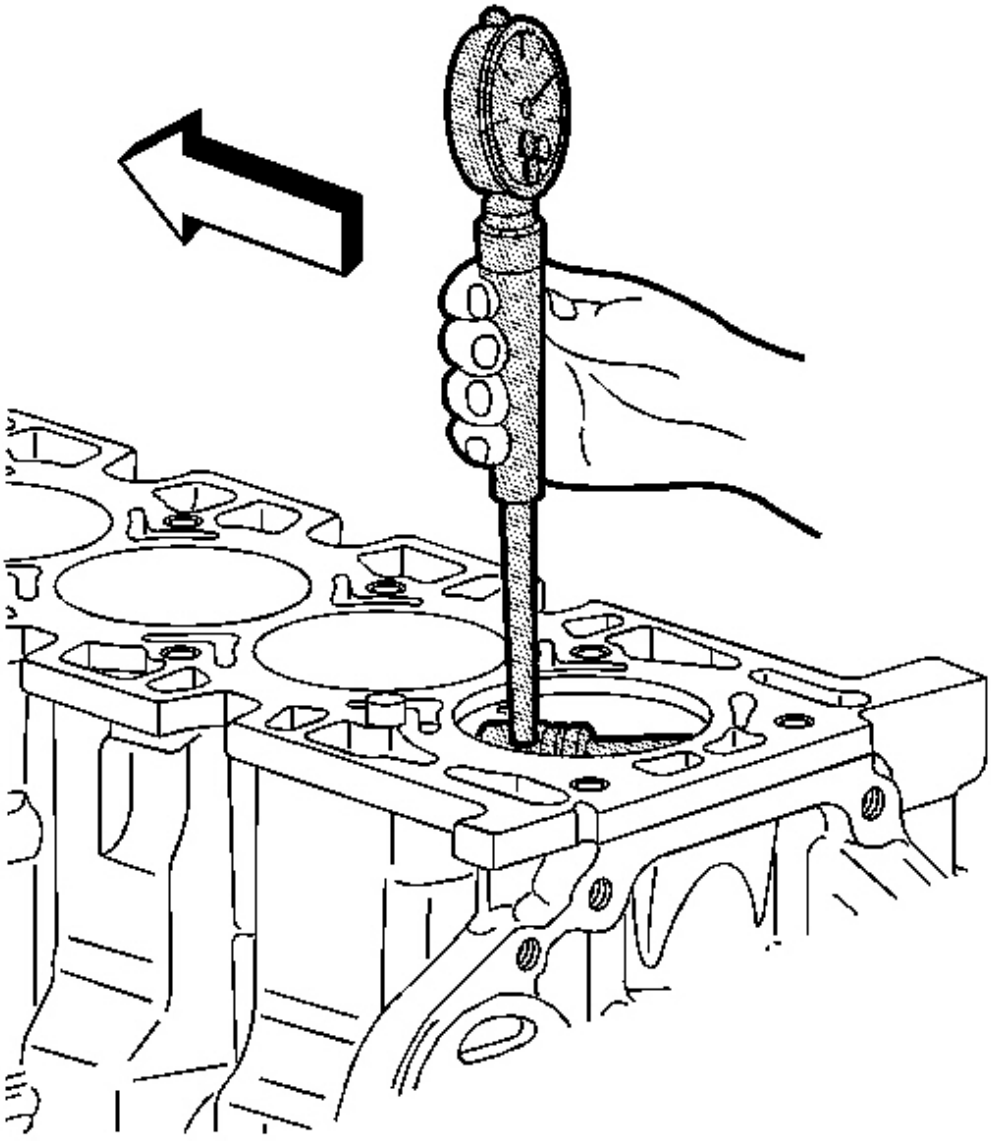


Fig. 319: Measuring Cylinder Bores With J 8087
Courtesy of GENERAL MOTORS CORP.

9. Replace the cylinder sleeve if the bore is out of specification.

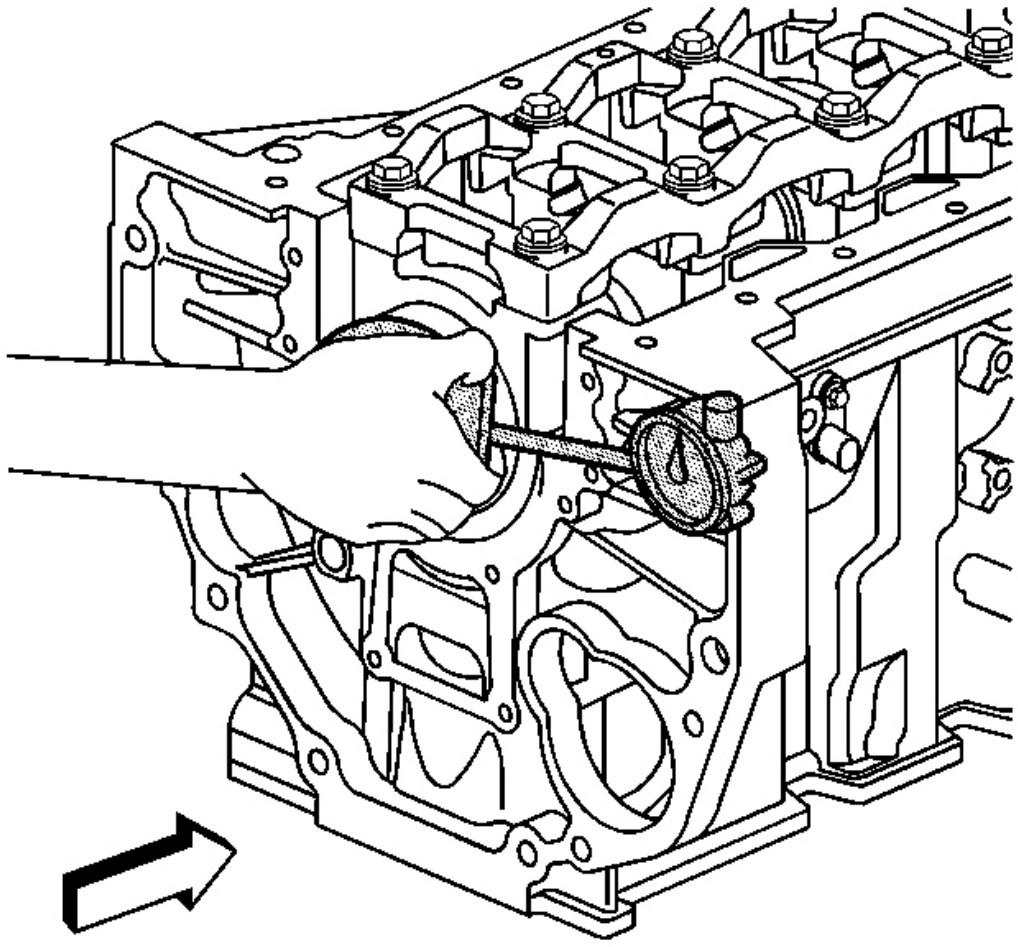


Fig. 320: Measuring Bolt Hole Bosses
Courtesy of GENERAL MOTORS CORP.

10. Inspect the oil pan rail for nicks. Use a flat file to remove an nicks.
11. Inspect the front cover attaching area for nicks. Use a flat file to remove any nicks.
12. Inspect the mating surfaces of the transmission case.
13. Use the following procedure to measure the engine block flange runout at the mounting bolt hole bosses:
    1. Temporarily install the crankshaft. Measure the crankshaft flange runout.
    2. Hold a gauge plate flat against the crankshaft flange.
    3. Place **J 8001** (dial indicator stem) on the transmission mounting bolt hole boss. Set the indicator to zero.
    4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary

more than 0.25 mm (0.010 in).

5. Recheck the crankshaft flange runout if the readings vary more than 0.25 mm (0.010 in). If the crankshaft flange runout is within the specification, replace the engine block.

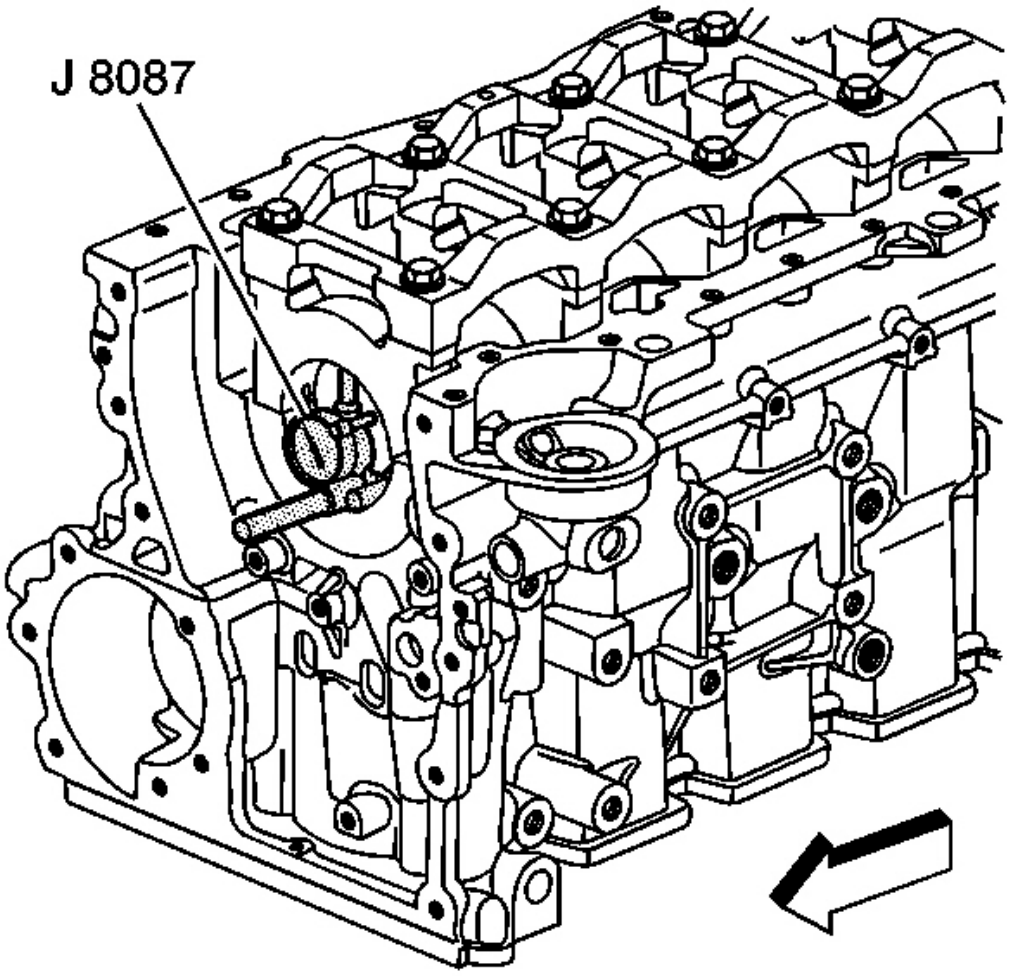


Fig. 321: Inspecting Crankshaft Main Bearing Bores With J 8087
Courtesy of GENERAL MOTORS CORP.

14. Remove the crankshaft.

NOTE: **Refer to Fastener Notice .**

15. Re-install the crankshaft bearing caps, stiffener, and bolts.

Tighten:

1. Tighten the crankshaft bearing cap bolts to 25 N.m (18 lb ft).
2. Use **J 45059** to tighten the crankshaft bearing cap bolts an additional 180 degrees. See **Special Tools**.

IMPORTANT: Perform the following inspections, and reconditioning (if necessary), with the crankshaft main bearing caps installed and tightened to specification.

16. Inspect the crankshaft main bearing bores. Use **J 8087** to measure the bearing bore concentricity and alignment. See **Special Tools**.
17. Remove the crankshaft main bearing cap stiffener and main bearing caps with bearings.

CYLINDER HONING

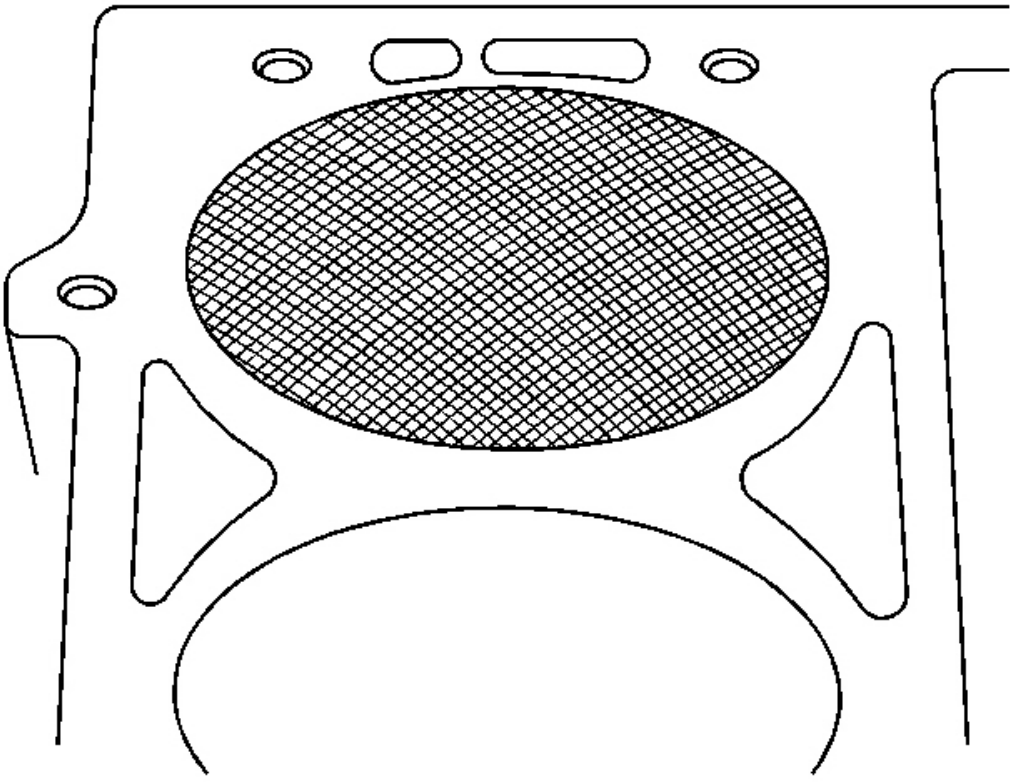


Fig. 322: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
   - Use only clean sharp stones of the proper grade for the amount of material to be removed.
   - Dull, dirty stones cut unevenly and generate excessive heat.
   - DO NOT hone to a final grade with a coarse or medium-grade stone.
   - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
   - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45-65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
   - Repeatedly check the cylinder bore fit with the selected piston.
   - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.

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

   - The finish marks should be clean but not sharp.
   - The finish marks should be free from imbedded particles or torn or folded metal.
4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
5. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
   1. Scrub the cylinder bores with a stiff bristle brush.
   2. Rinse the cylinder bores thoroughly with clean hot water.
   3. Dry the cylinder bores with a clean rag.
   4. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
6. Perform final measurements of the piston and the cylinder bore.
7. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

CRANKSHAFT & BEARING CLEANING & INSPECTION

Tools Required

- **J 45059** Angle Meter. See **Special Tools**.
- **J 8087** Cylinder Bore Gage. See **Special Tools**.

Cleaning & Inspection Procedure

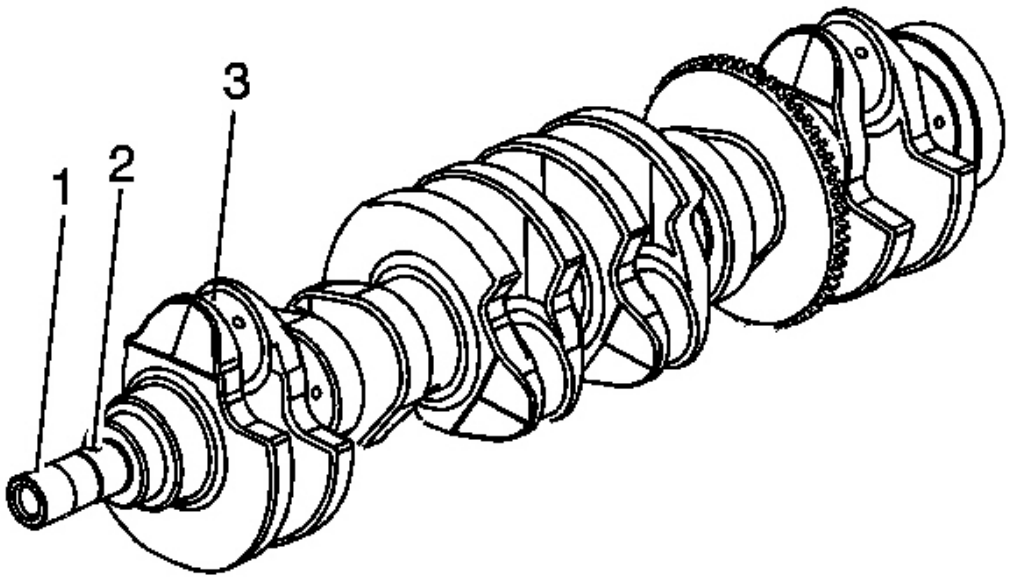


Fig. 323: Crankshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the crankshaft of all elements.
2. Inspect the crankshaft oil passages for obstructions.
3. Inspect the crankshaft for the following conditions:
   - Damaged threads (1)
   - Damaged mounting faces
   - Worn crankshaft pin (2)
   - Wear without any grooves or scratches (3)
   - Grooves or scoring (3)
   - Scratches (3)

- Pitting or embedded bearing material (3)
- Overheating (discoloration) (3)

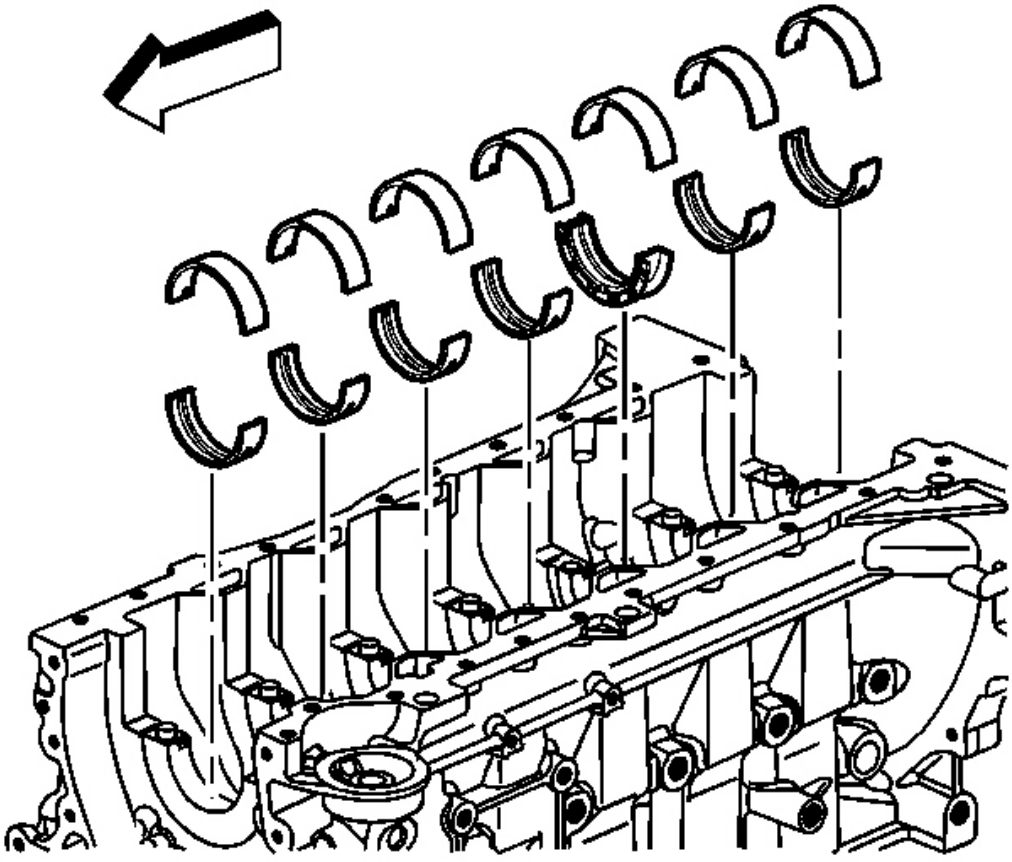


Fig. 324: Inspecting Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

4. Inspect the corresponding crankshaft bearing inserts for embedded material and determine the source of the material.

IMPORTANT: If cracks, severe gouges or burned spots are found, replace the crankshaft. Remove slight roughness using a fine polishing cloth soaked in clean engine oil. Remove any burrs using a fine oil stone.

5. Inspect the outer surfaces of the crankshaft bearings for the following conditions:
   - Wear - surface wear indicates either movement of the insert or high spots in the surrounding

material (spot wear)

- Overheating or discoloration
- Looseness or rotation indicated by flattened tangs and wear grooves

IMPORTANT: Note the location of the crankshaft main bearing high spots. If the spots are not in line, the crankshaft is bent. Replace the crankshaft.

6. Inspect the crankshaft main bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.
7. Inspect the thrust surfaces of the main thrust bearing for the following conditions:
   - Wear
   - Grooving - Grooves are caused by irregularities of the crankshaft thrust surface.
8. Inspect the crankshaft bearings for excessive scoring or discoloration.
9. Inspect the crankshaft bearings for dirt or imbedded debris.
10. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections.
11. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

IMPORTANT: If crankshaft bearing failure is due to conditions other than normal wear, investigate the cause of the condition. Inspect the crankshaft or connecting rod bearing bores.

12. Inspect the connecting rod bearing bores using the following procedure:
    1. Tighten the connecting rod bearing cap to specification.
    2. Use **J 8087** to measure the bearing bore for taper and out-of-round. See **Special Tools**. Record the readings.
    3. No taper or out-of-round should exist.

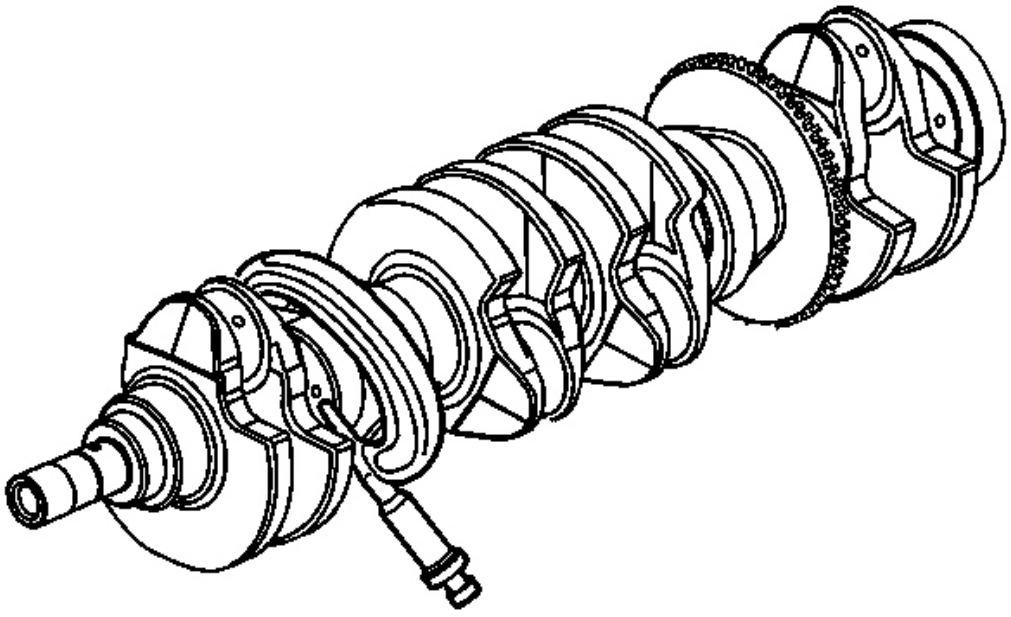


Fig. 325: Measuring Crankshaft Bearing Journal Diameter With Micrometer
Courtesy of GENERAL MOTORS CORP.

13. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.

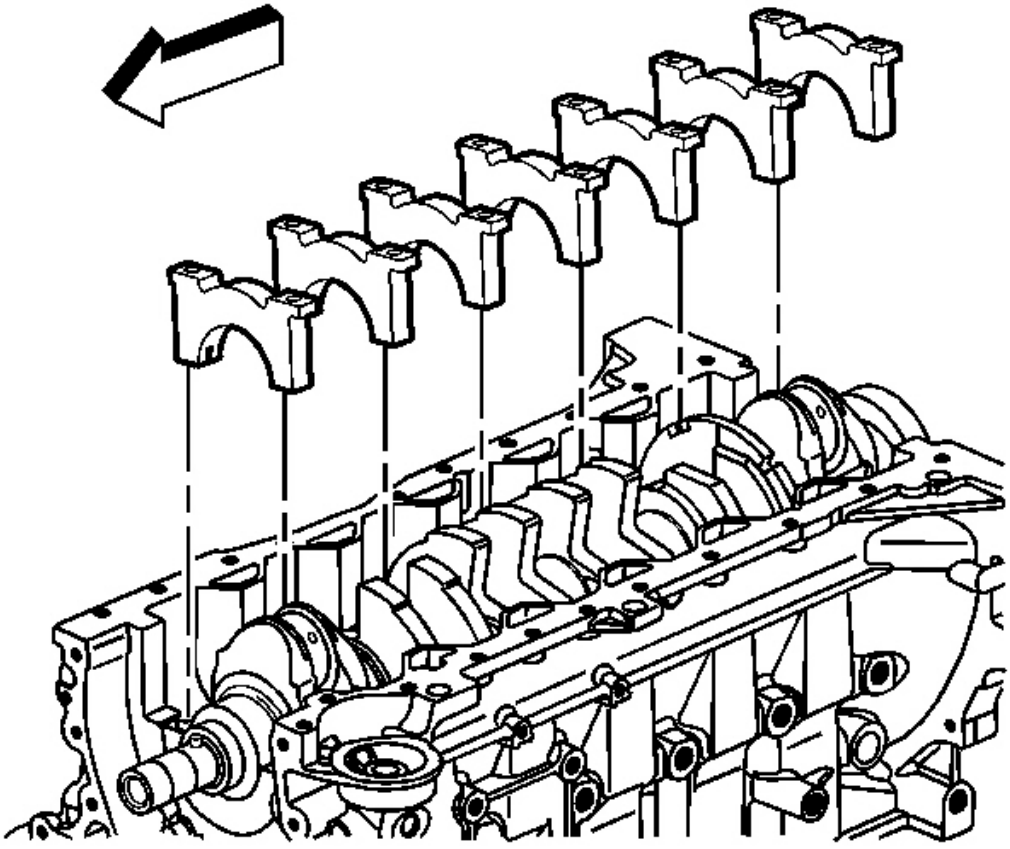


Fig. 326: View Of Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

14. Measure the crankshaft bearing journal taper and runout.

IMPORTANT: Refer to the pin stamp on the crankshaft main bearing caps for sequence and direction of installation. The pin stamp arrow points to the front of the engine.

15. Install the crankshaft bearing caps.
16. Install the crankshaft main bearing cap stiffener.

NOTE: Refer to Fastener Notice .

17. Install the crankshaft bearing cap bolts.

Tighten:

1. Tighten the crankshaft bearing cap bolts to 25 N.m (18 lb ft).
2. Use **J 45059** to tighten the crankshaft bearing cap bolts an additional 180 degrees. See **Special Tools**.

18. Measure the crankshaft main bearing inside diameter with an inside micrometer.
19. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
20. If the specified clearances cannot be met, the crankshaft, connecting rods, or block may need to be replaced.

CRANKSHAFT BALANCER CLEANING & INSPECTION

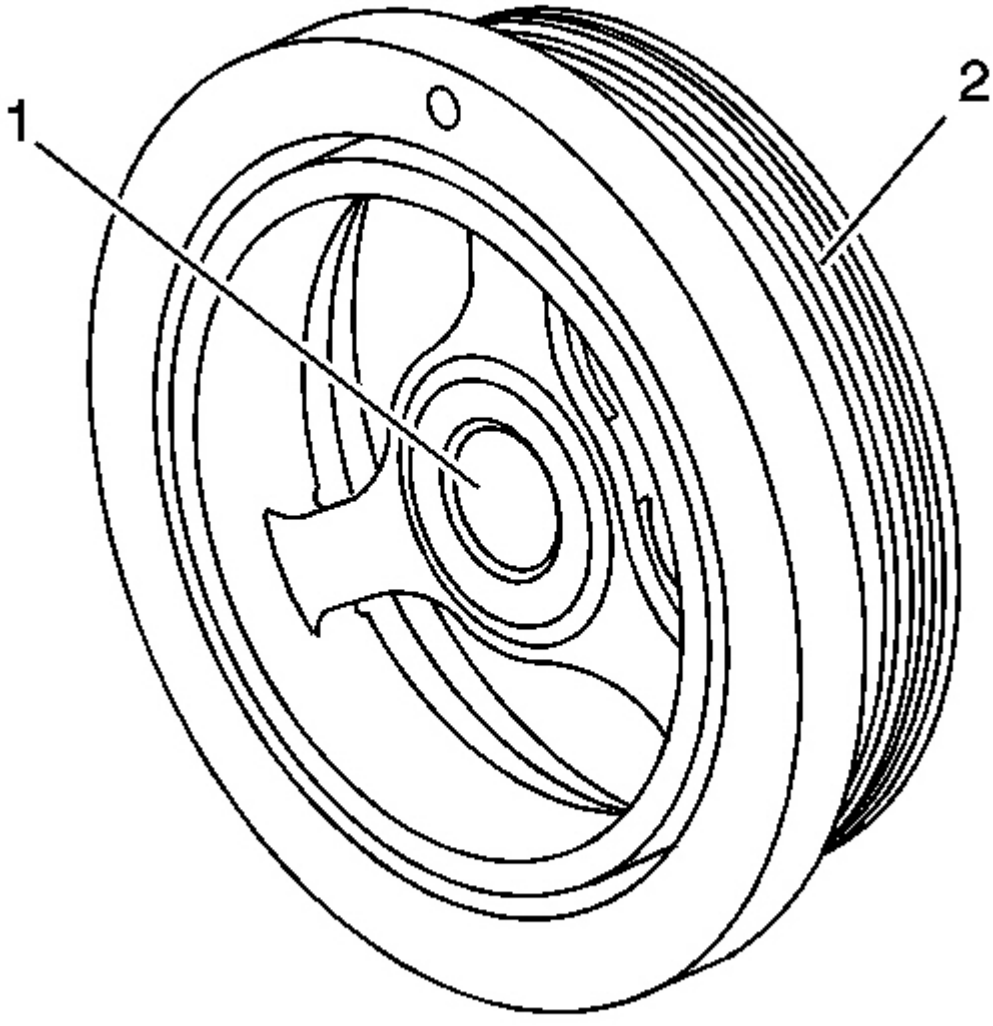


Fig. 327: View Of Crankshaft Balancer Sealing Area & Belt Ribs
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft balancer sealing area for grooves, nicks, or burs (1).
2. Inspect the crankshaft balancer belt ribs for dents or damage (2).
3. Replace the crankshaft balancer if damage is present.

ENGINE FLYWHEEL CLEANING & INSPECTION

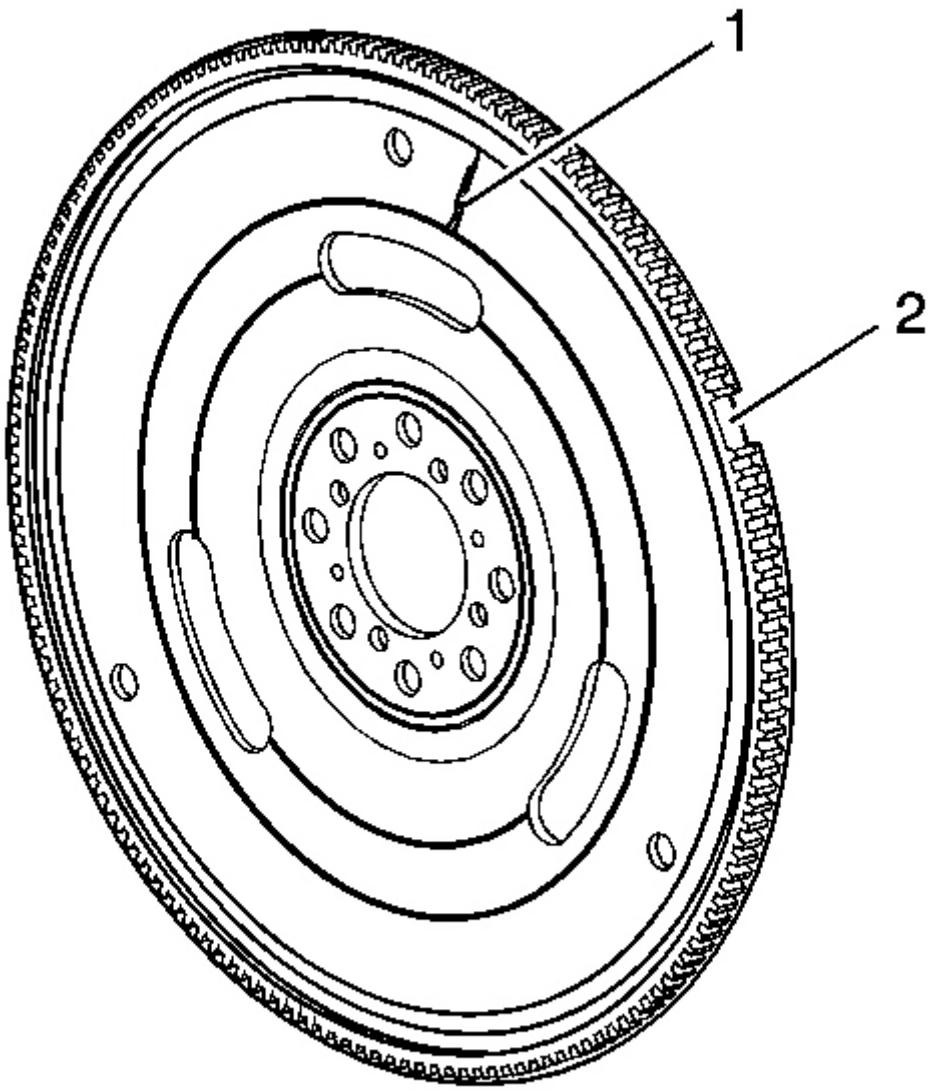


Fig. 328: Inspecting Engine Flywheel & Teeth
Courtesy of GENERAL MOTORS CORP.

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

1. Inspect the engine flywheel for cracks (1).

2. Inspect the engine flywheel teeth for damage (2).
3. Replace the engine flywheel if damage is present.

PISTON & CONNECTING ROD DISASSEMBLE

Tools Required

EN-46745 Piston Pin Retainer Remover and Installer. See **Special Tools**.

Disassembly Procedure

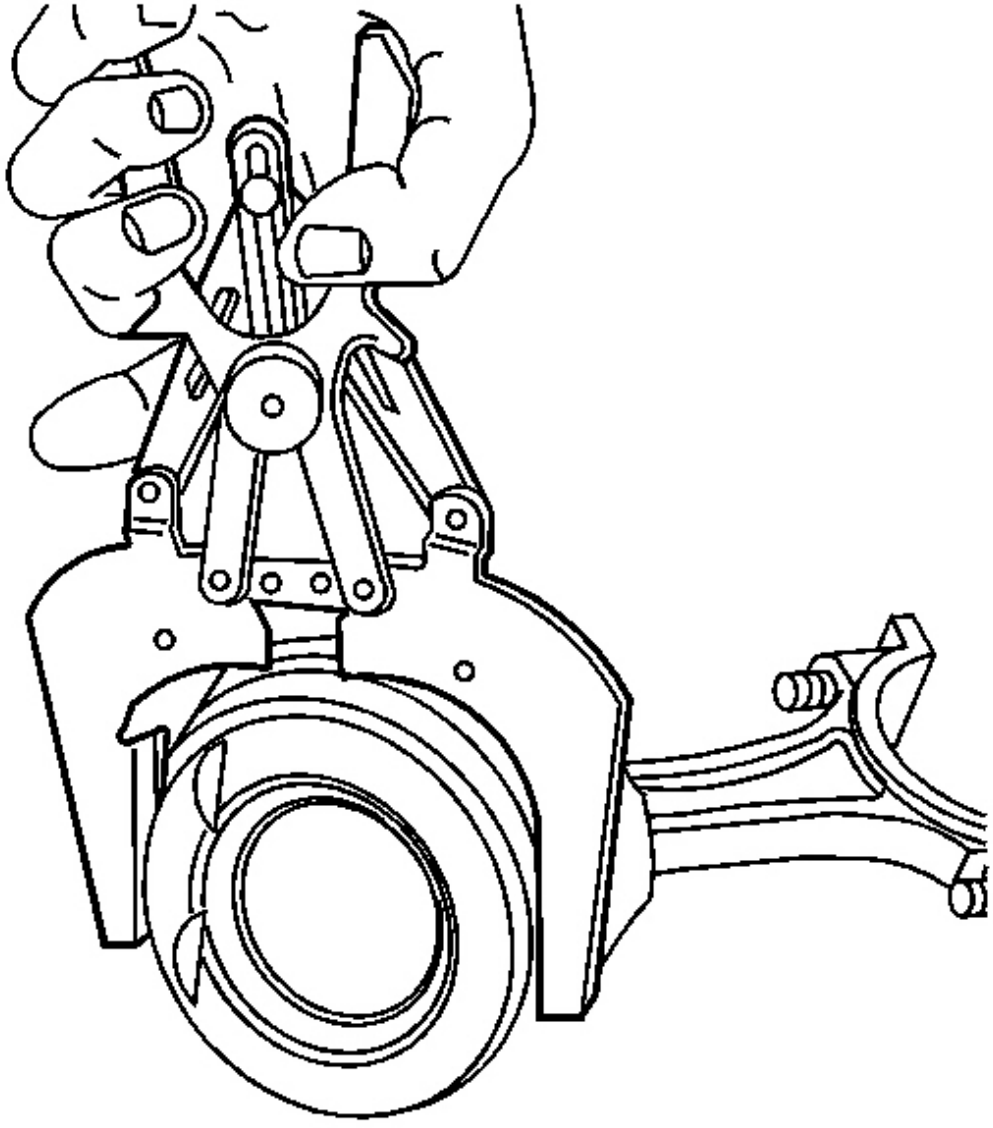


Fig. 329: View Of Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

IMPORTANT: Do not reuse the piston rings.

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

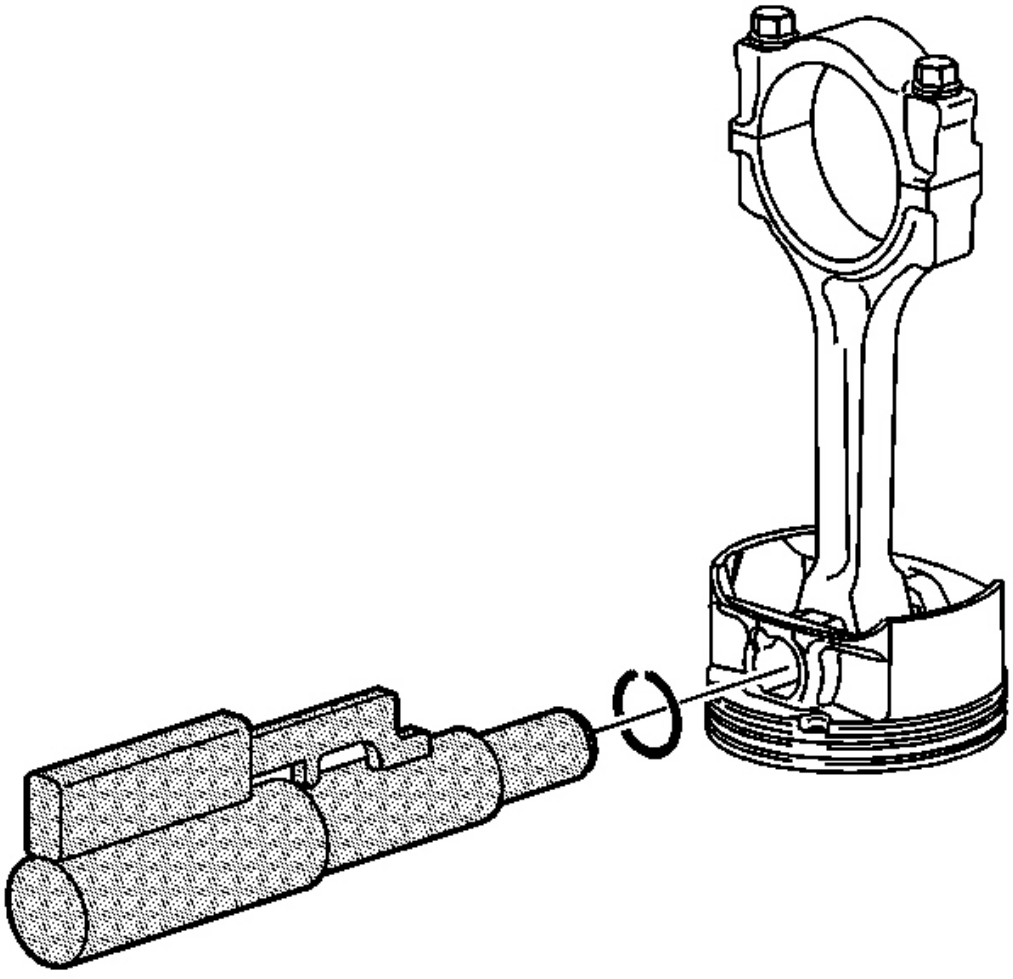


Fig. 330: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Two retainers hold the piston pins in place. Reuse the retainers if they are not damaged during removal.

2. Remove the piston pin retainers using **EN-46745** . See **Special Tools**.

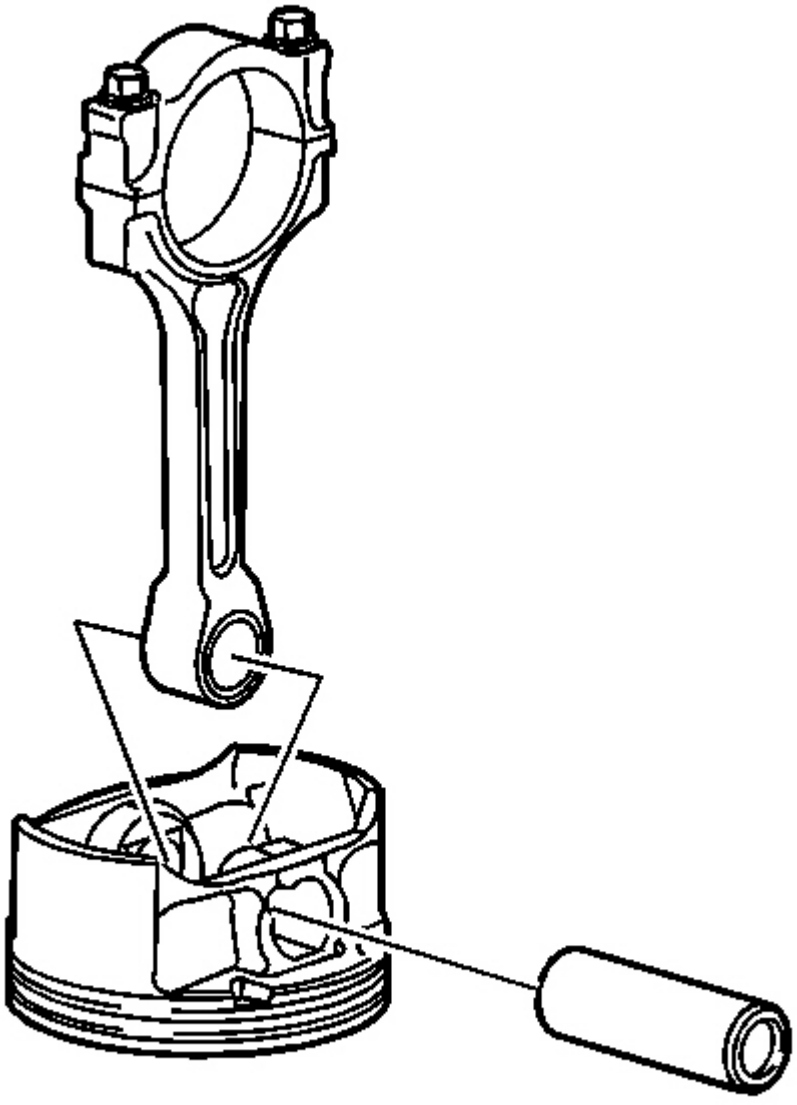


Fig. 331: View Of Piston Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin.

PISTON, CONNECTING ROD & BEARING CLEANING & INSPECTION

Tools Required

J 8087 Cylinder Bore Gage. See **Special Tools**.

Cleaning & Inspection Procedure

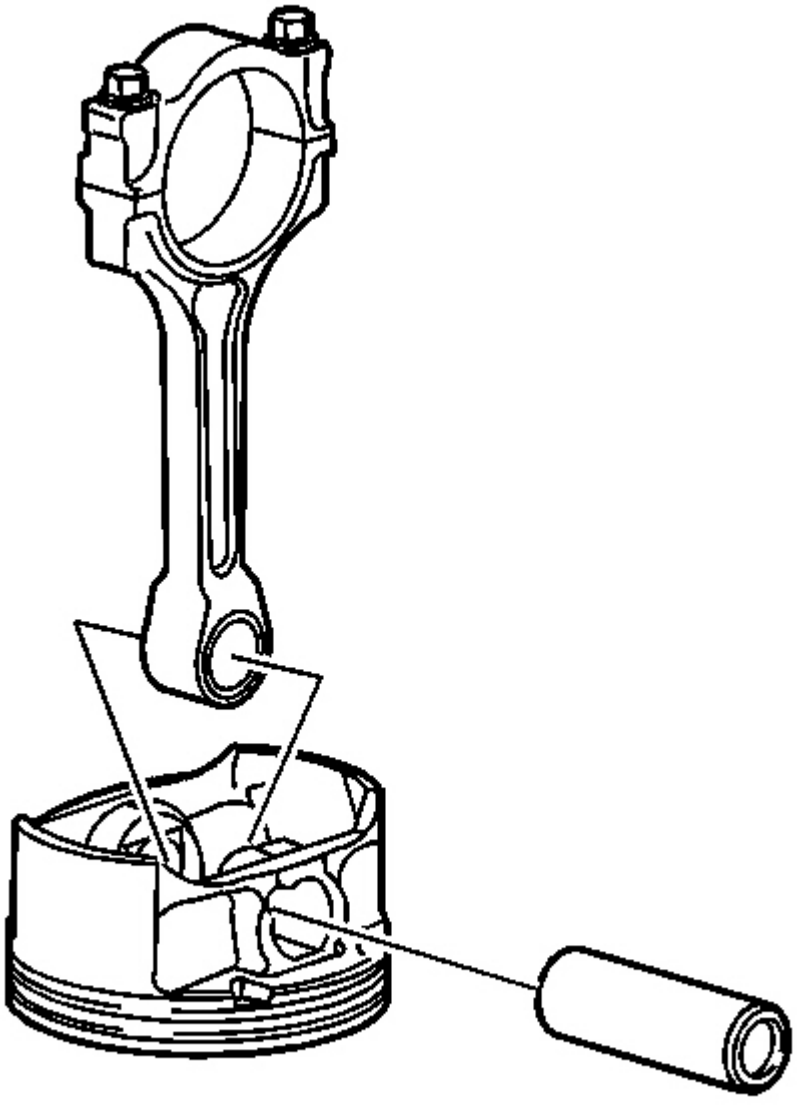


Fig. 332: View Of Piston Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean and soak the following components in a carburetor cleaning solution to remove carbon, sludge, and

varnish:

- Piston
- Piston pin
- Connecting rod

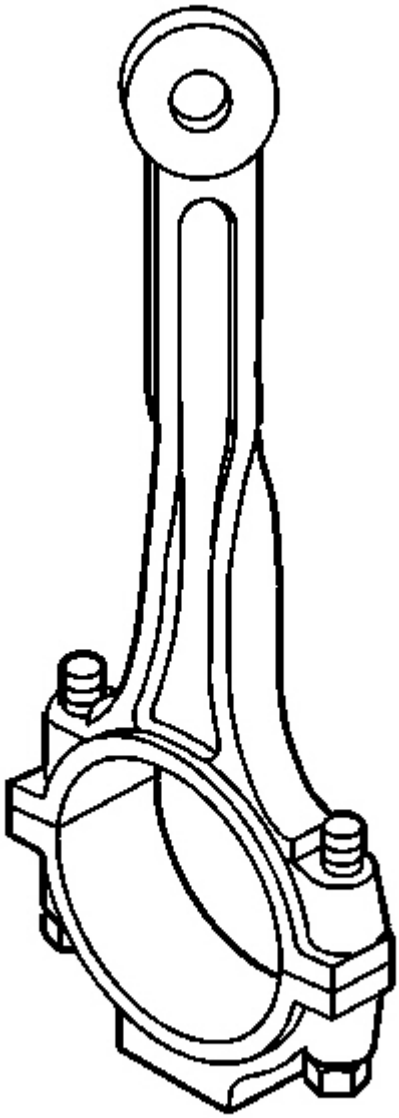


Fig. 333: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

2. Install the connecting rod cap.
3. Place the connecting rod assembly on a checking fixture.
4. Inspect the connecting rod assembly for bending or twisting.
5. Replace any bent or twisted connecting rods.
6. If the connecting rod large bore contains minor scratches or abrasions, clean the bore in a circular direction with light emery paper. DO NOT scrape the connecting rod or cap.
7. Measure the piston pin to connecting rod bore using the following procedure:
   - Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
   - Using an inside micrometer, measure the connecting rod piston pin bore.
   - Subtract the piston pin diameter from the piston pin bore diameter.
   - The clearance should not be more than 0.018 mm (0.0007 in).
8. If there is excessive clearance, replace the piston pin.
9. If there is still excessive clearance, replace the connecting rod.
10. If there is evidence of pin bore or pin scoring, replace the rod and pin assembly.

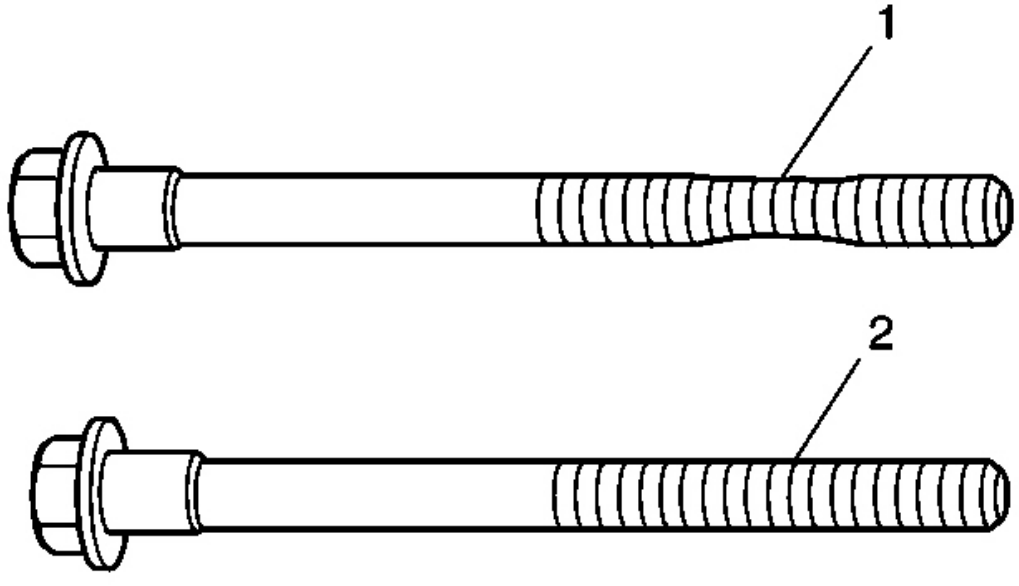


Fig. 334: Inspecting Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod bearings for the following conditions:

- Craters or pockets
- Flattened sections
- Excessive scoring or discoloration.
- Imbedded debris
- Bright, polished sections

12. Inspect the inside of the connecting rod bearing and outside diameter of the connecting rod bearing journal for wear. This indicates high spots.
13. Inspect the connecting rod bearing bore for taper and out-of-round.
14. Inspect the connecting rod bolts for stretching (compare to new or known good bolt). The callout (1) is a stretched bolt, (2) is a new or good bolt.
15. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
16. Clean the piston ring grooves. Ensure that the oil ring holes and slots are clean.
17. Inspect the pistons for the following conditions:
    - Cracked ring lands, skirts, or pin bosses
    - Ring grooves for nicks, burrs that may cause binding
    - Warped or worn ring lands
    - Eroded areas at the top of the piston
    - Scuffed or damaged skirts
    - Worn piston pin bores
18. Replace pistons that show any signs or damage or excessive wear.

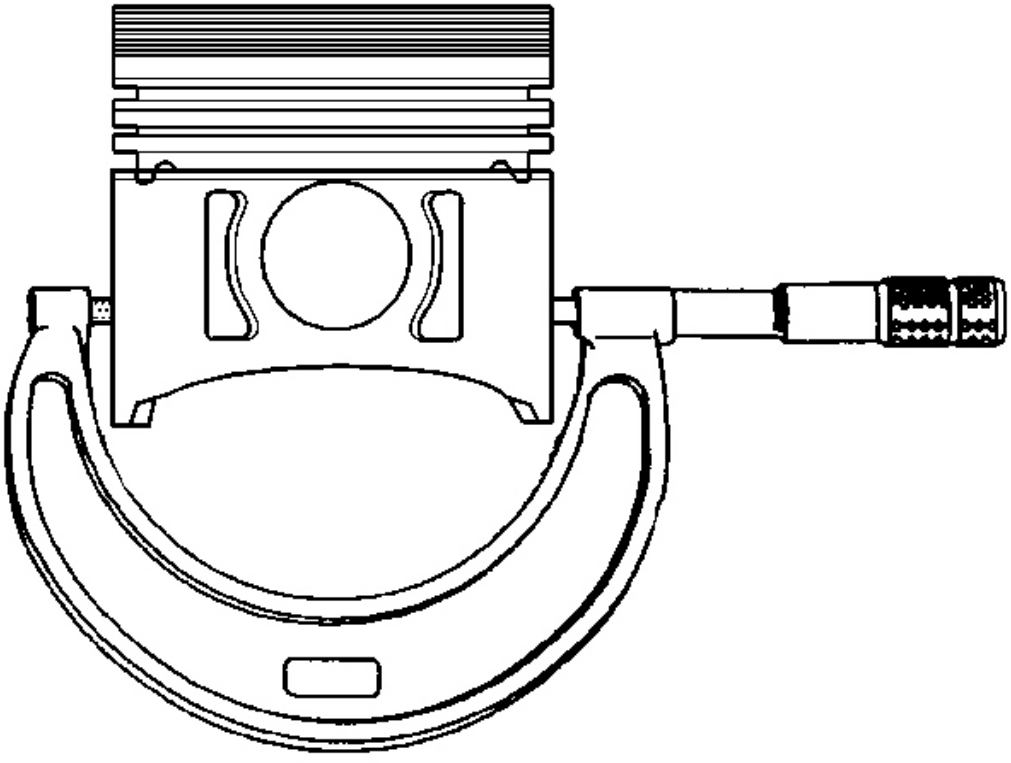


Fig. 335: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When fitting pistons, consider both the piston and the cylinder bore conditions together. Production and service pistons have the same nominal weight and may be intermixed without affecting engine balance. If necessary, used pistons may be fitted selectively to any cylinder of the engine, providing the pistons are in good condition and the same weight. Do not cut oversize pistons down or the engine balance may be affected. Finish hone when selecting the piston.

19. Measure the piston diameter for size with a micrometer or caliper at a right angle to the pin center line, across the skirts, 38 mm (1.50 in) from the top of the piston.

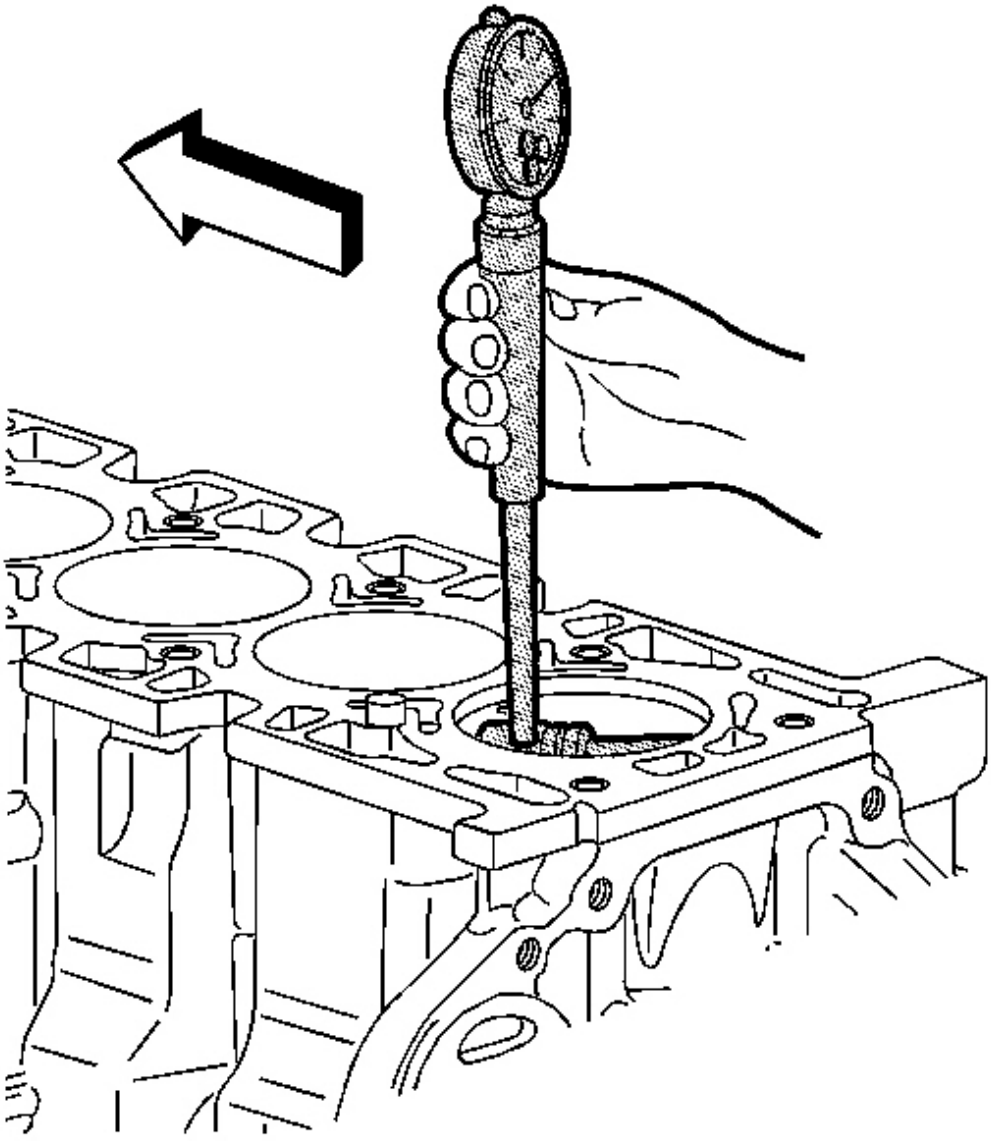


Fig. 336: Measuring Cylinder Bores With J 8087
Courtesy of GENERAL MOTORS CORP.

20. Replace the piston if worn beyond specifications or if damaged.
21. Use **J 8087** to measure the cylinder bore. See **Special Tools**.
22. Hone to size if necessary. Use the following procedure to hone the cylinder bore to the correct size.

1. Select a piston.
2. Hone the cylinder bore to obtain the recommended clearance.
3. Clean the piston and cylinder bore with soap and water. Dry the cylinder bore and piston. Lubricate the cylinder bore with clean engine oil.

23. Use the following procedure to measure the piston-to-cylinder bore clearance.
    1. Subtract the piston diameter from the cylinder bore diameter to determine the piston-to-bore clearance.
    2. Compare the piston-to-bore clearance using the specifications to determine if the clearance is in the acceptable range.
    3. If the used piston is not acceptable, a new service piston may be selected.
24. When a piston has been selected, mark the piston to identify the cylinder for which the piston was fitted.
25. Select a set of new piston rings.
26. Install each ring, one at a time, into the corresponding cylinder.
27. Install the piston for that cylinder, upside down (top of piston pushing on the ring) and push the ring to approximately 25 mm (1 in) down from the deck surface.
28. Remove the piston.
29. Measure the ring end gap with a feeler gage.

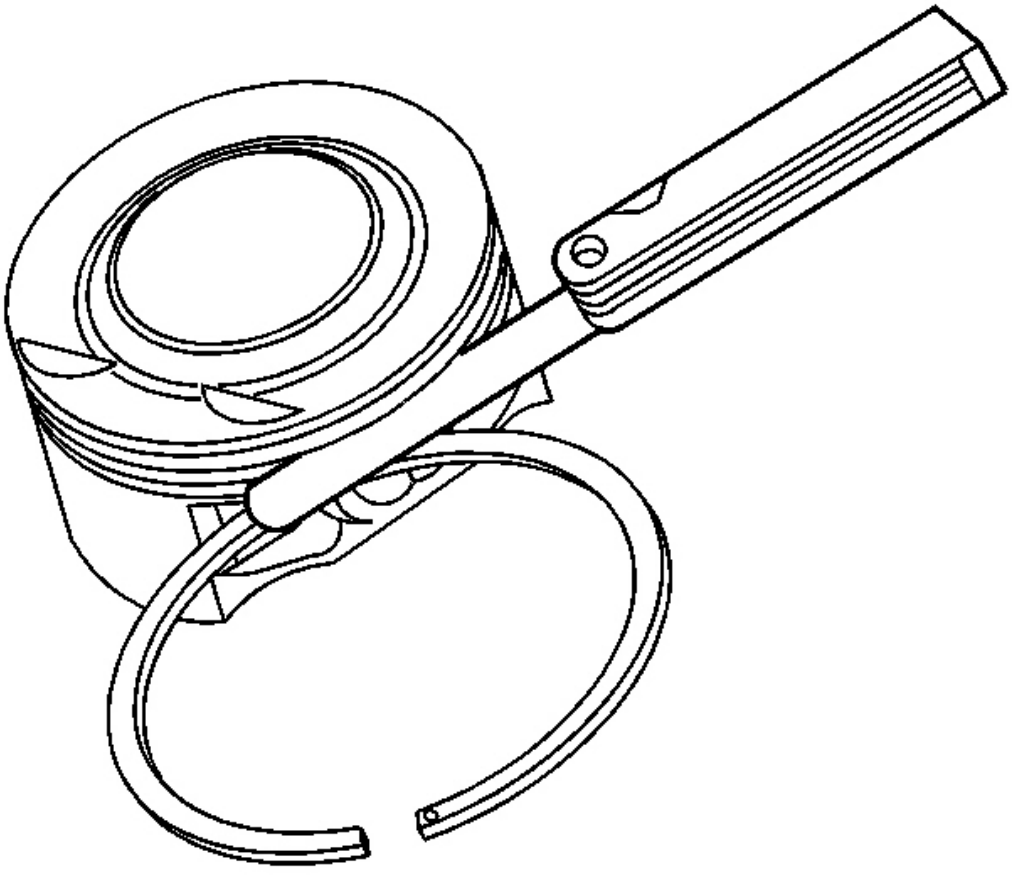


Fig. 337: Measuring Ring End Gap
Courtesy of GENERAL MOTORS CORP.

30. If the ring gap is not within the specification range, replace the rings.
31. Measure the piston ring side clearance - compression rings.

NOTE: The piston ring groove must only be cleaned with a ring groove cleaning tool. Proper engine performance and durability depends on the straightness and smoothness of the ring groove. Cleaning the piston ring groove with an improper tool can damage the piston ring groove and effect the performance and durability of the engine.

32. Use the following procedure to measure the compression ring side clearance.
    1. Roll the piston ring around the groove.
    2. Measure the side clearance with a feeler gage.

3. If the ring is too tight, inspect the piston ring groove for nicks, burrs, or damage. Use emery cloth to remove any minor burrs.
4. If the ring side clearance is greater than the specification, replace the piston.

CYLINDER SLEEVE REMOVAL

Tools Required

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See **Special Tools**.

Removal Procedure

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

NOTE: Do not damage the crankshaft connecting rod journals or reluctor ring or engine damage will occur.

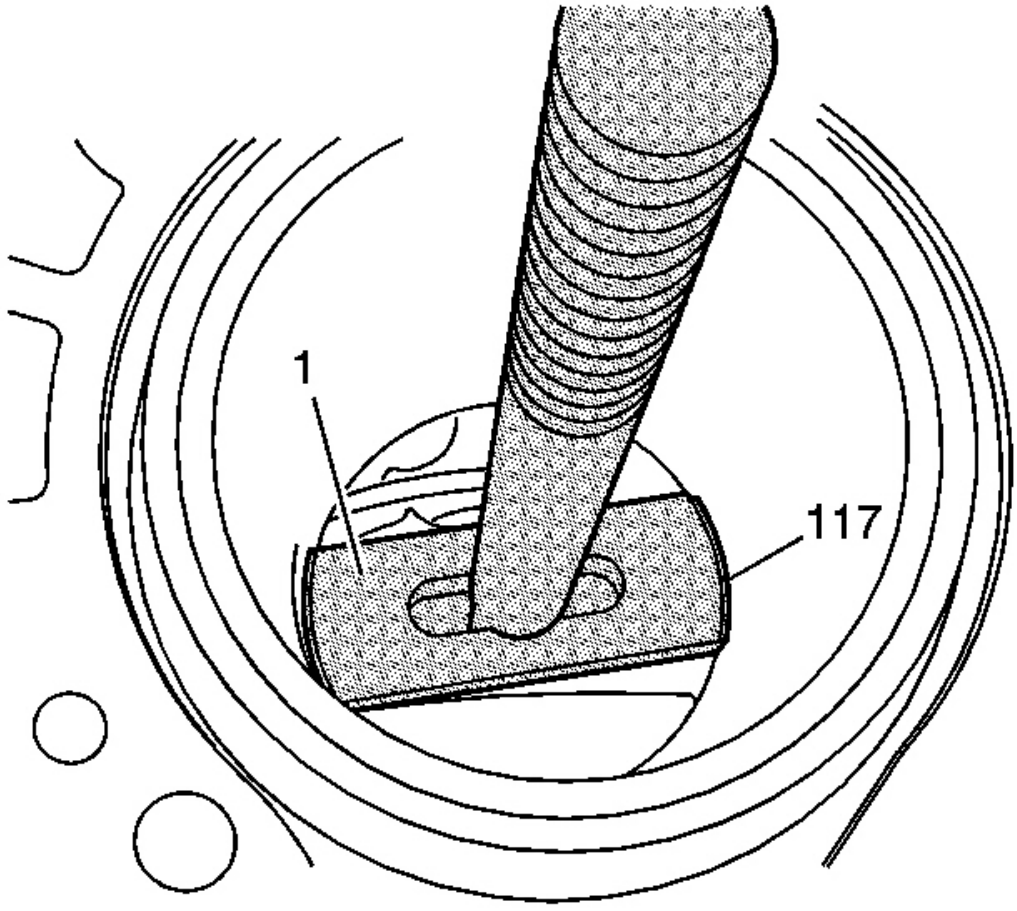


Fig. 338: View Of Cylinder Bore Liner Puller
Courtesy of GENERAL MOTORS CORP.

1. If the crankshaft is still installed, rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
2. Install the cylinder bore sleeve puller EN 45680-402 (1) which is part of **EN-45680-400** , through the cylinder bore. See **Special Tools**.

NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore sleeve or damage to the cylinder bore sleeve puller will occur.

3. Align the shoe (1) of the cylinder bore sleeve puller EN 45680-402 to the bottom of the cylinder bore sleeve (117).

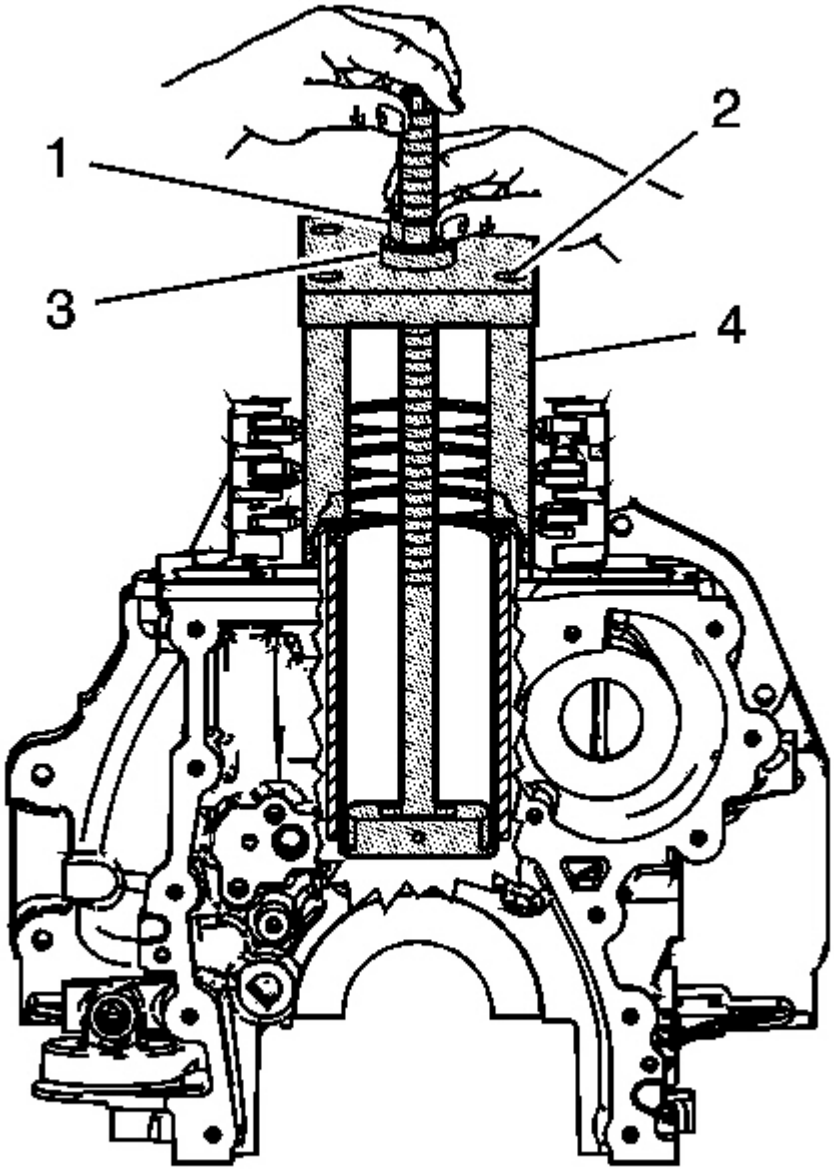


Fig. 339: View Of Cylinder Bore Sleeve Puller EN 45680-402 & Components
Courtesy of GENERAL MOTORS CORP.

4. Hold the threaded shaft of the cylinder bore sleeve puller EN 45680-402 upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.
5. Install the fixture EN 456850-401 (4) onto the threaded shaft of the cylinder bore sleeve puller EN

456850-402 and the engine block.

6. Install the bearing (3) and the nut (1).
7. Tighten the nut (1) to the bearing (3).

NOTE: **Refer to Fastener Notice .**

IMPORTANT: Use four old cylinder head bolts for the attaching bolts.

8. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block.

Tighten: Tighten the bolts to 15 N.m (11 lb ft).

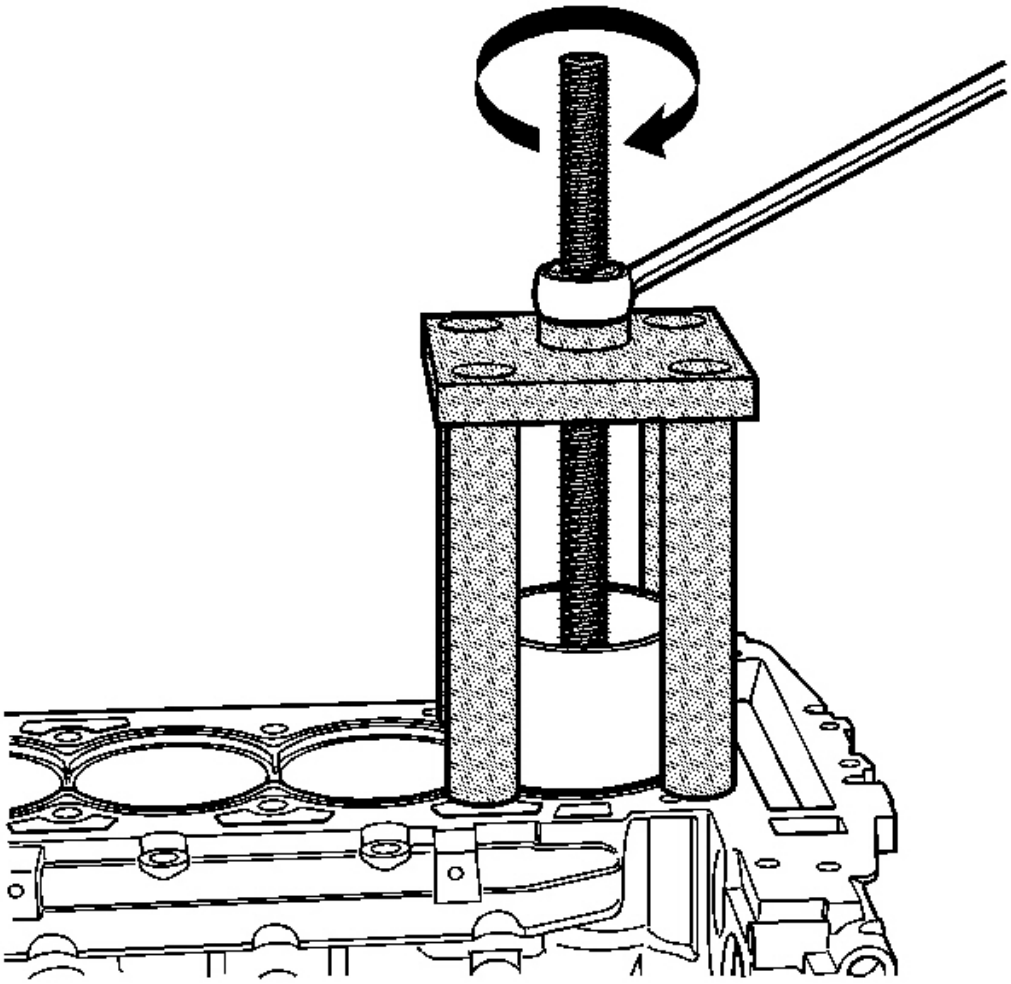


Fig. 340: Removing Cylinder Bore Sleeve By Rotating Nut
Courtesy of GENERAL MOTORS CORP.

9. Rotate the nut clockwise in order to remove the cylinder bore sleeve.

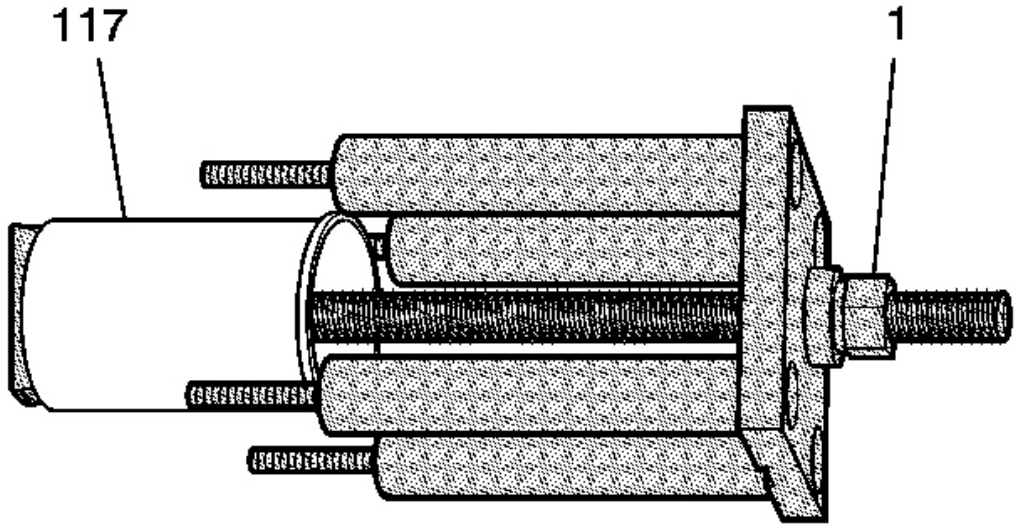


Fig. 341: View Of Cylinder Bore Sleeve & Removal Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the cylinder block surface. Damage to the cylinder block surface can cause engine failure.

10. Remove fixture EN 45680-401, cylinder bore sleeve puller EN 45680-402, and the cylinder bore sleeve (117) from the engine block.
11. Loosen the nut (1) in order to remove the cylinder bore sleeve (117).
12. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.
13. Inspect the piston, piston rings, and connecting rod for damage. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection**.

CYLINDER SLEEVE INSTALLATION

Tools Required

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See **Special Tools**.

Installation Procedure

NOTE: **Do not use assembly aids or lubricants on the cylinder bore sleeve or the cylinder bore block when installing a new cylinder bore sleeve, or engine damage will occur. These items will not aid in the installation of the new cylinder bore sleeve.**

NOTE: **Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.**

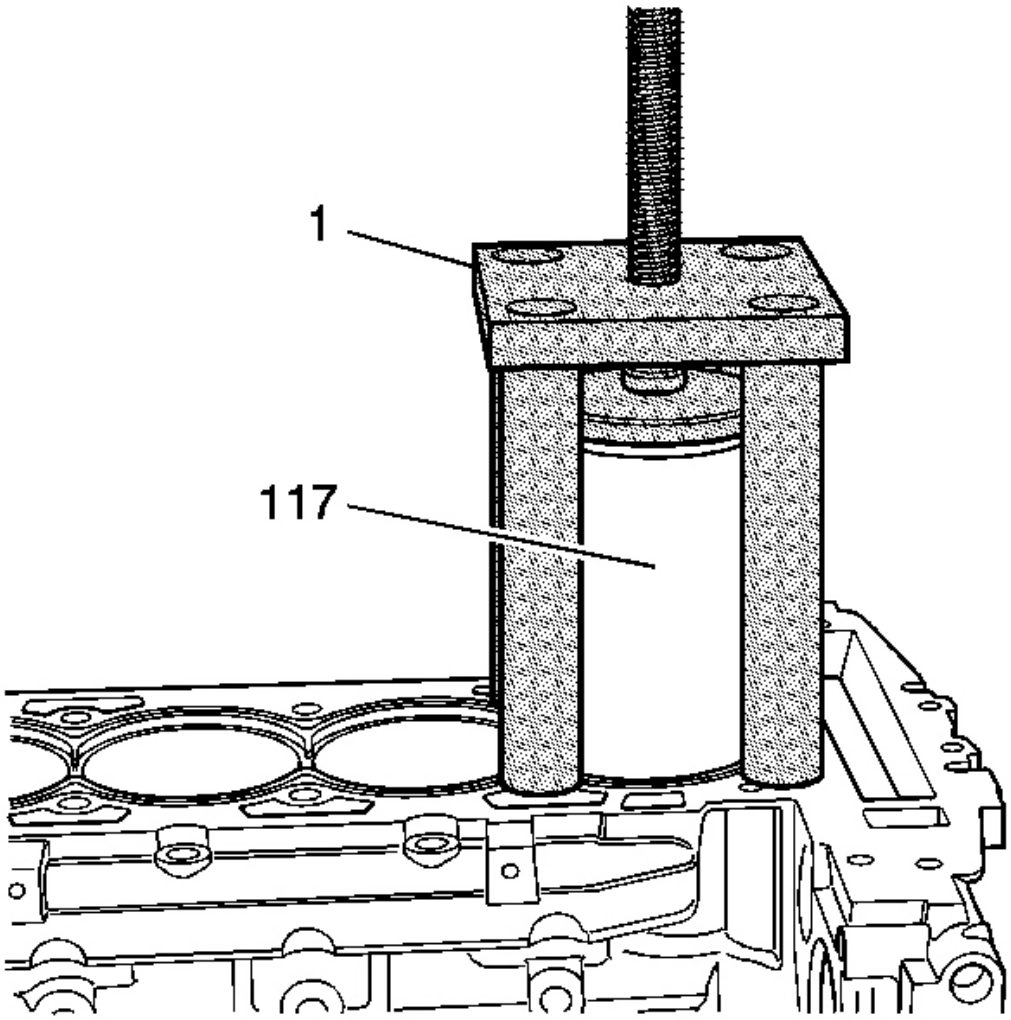


Fig. 342: View Of Cylinder Bore Sleeve Fixture
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) which is part of **EN-45680-400** , over the cylinder bore sleeve (117) and onto the cylinder block. See **Special Tools**. Do not apply downward pressure to the cylinder bore sleeve (117).

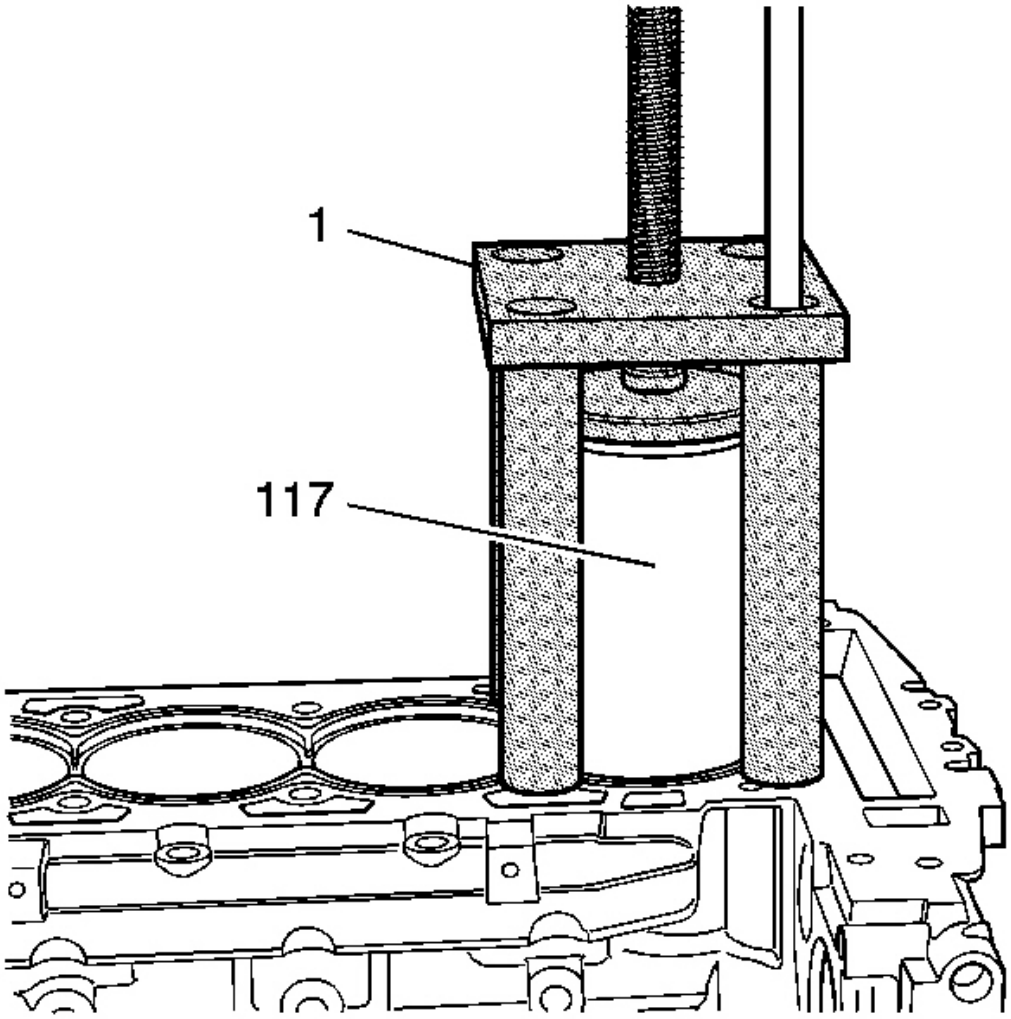


Fig. 343: View Of Cylinder Bore Sleeve Puller & Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

3. Insert the 4 attachment bolts into the legs of the fixture EN 45680-401 (1).

NOTE: Refer to Fastener Notice .

4. Tighten the 4 attachment bolts. Do not apply downward pressure to the cylinder bore sleeve (117).

Tighten: Tighten the 4 attachment bolts to 15 N.m (11 lb ft).

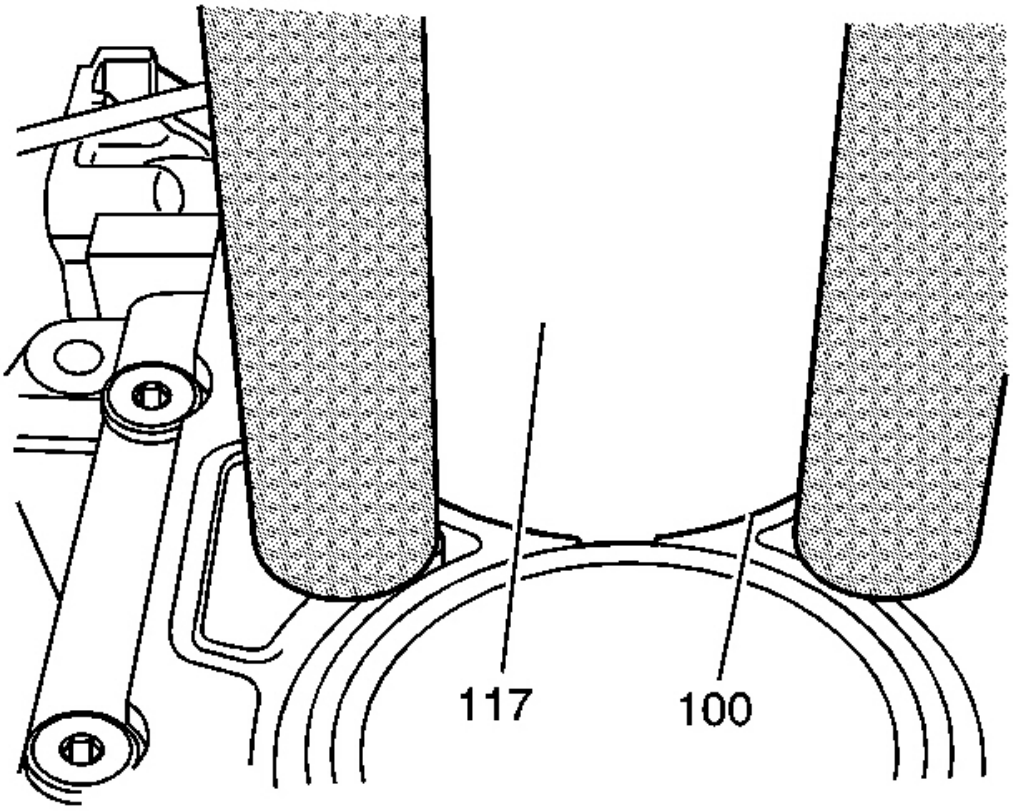


Fig. 344: View Of Proper Liner Alignment
Courtesy of GENERAL MOTORS CORP.

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).

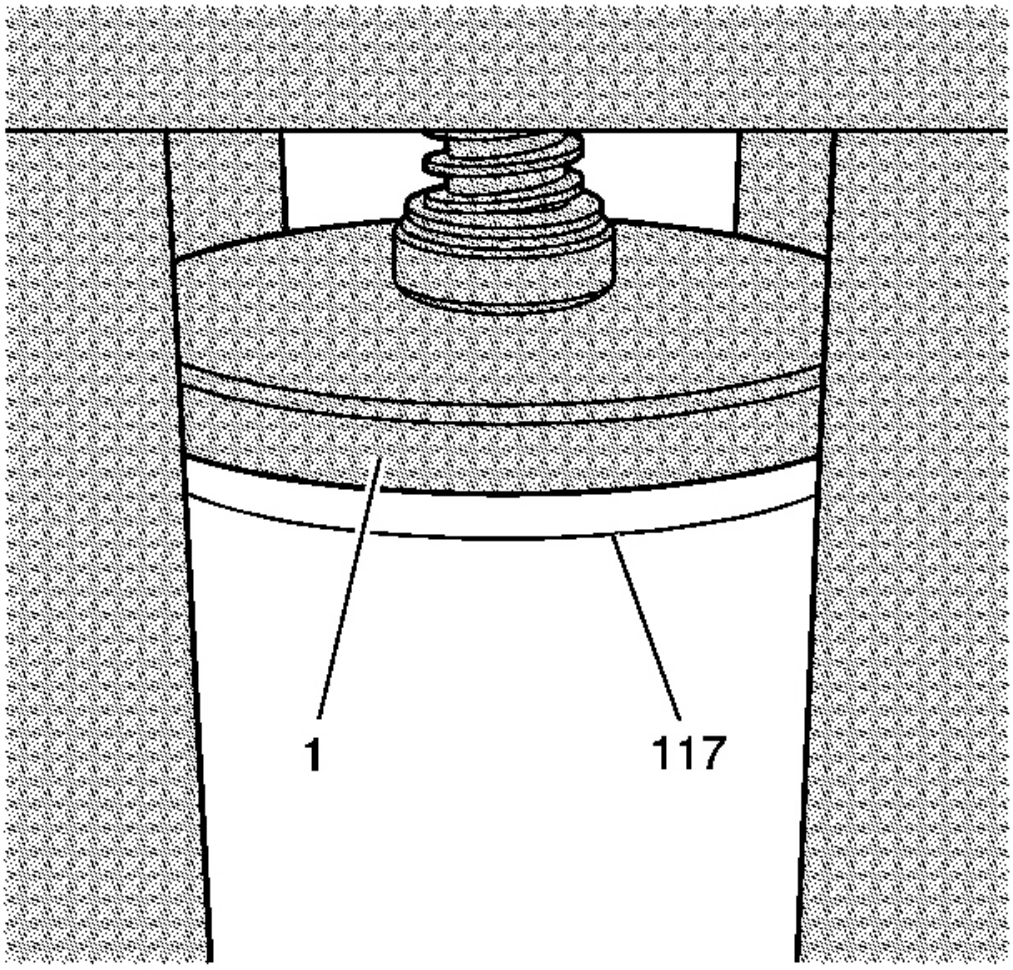


Fig. 345: View Of Installation Arbor
Courtesy of GENERAL MOTORS CORP.

6. Align the installation arbor (1) onto the top of the cylinder bore sleeve (117).

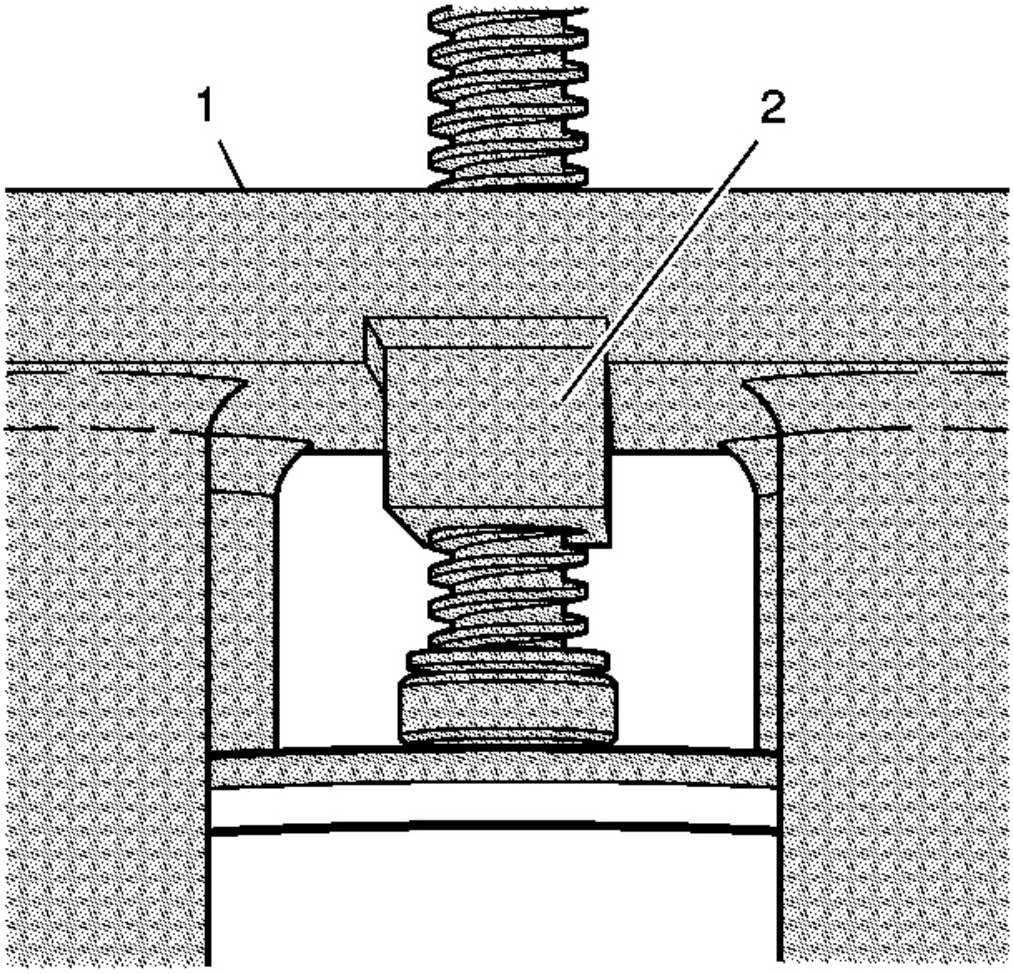


Fig. 346: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

7. Align the pusher block (2) of cylinder bore sleeve installer EN 45680-403 into the groove of fixture EN 45680-401 (1).

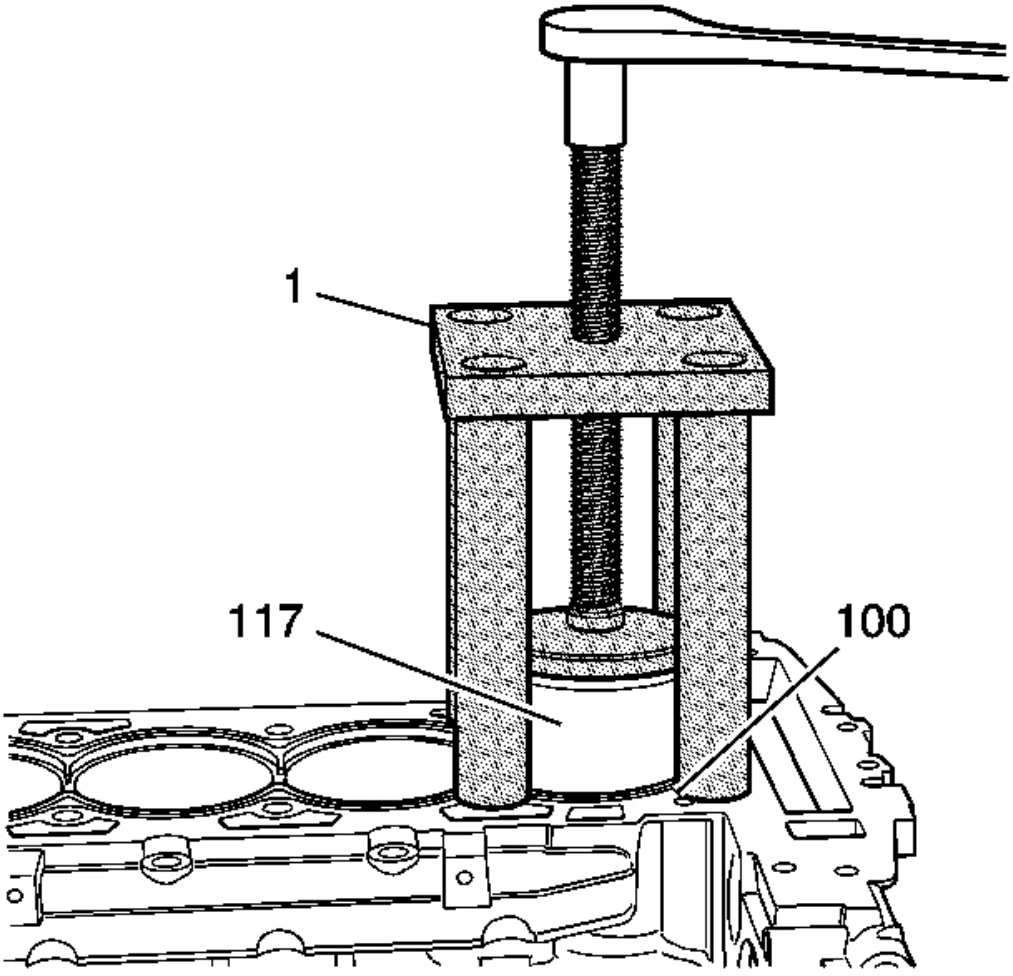


Fig. 347: Installing Cylinder Bore Sleeve Into Engine Block Using Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any air powered or electric tools to rotate the threaded shaft of the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly or damage to the cylinder bore sleeve will occur.

8. Using a ratchet, rotate the threaded shaft of fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) in order to install the cylinder bore sleeve (117) into the engine block (100).
9. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

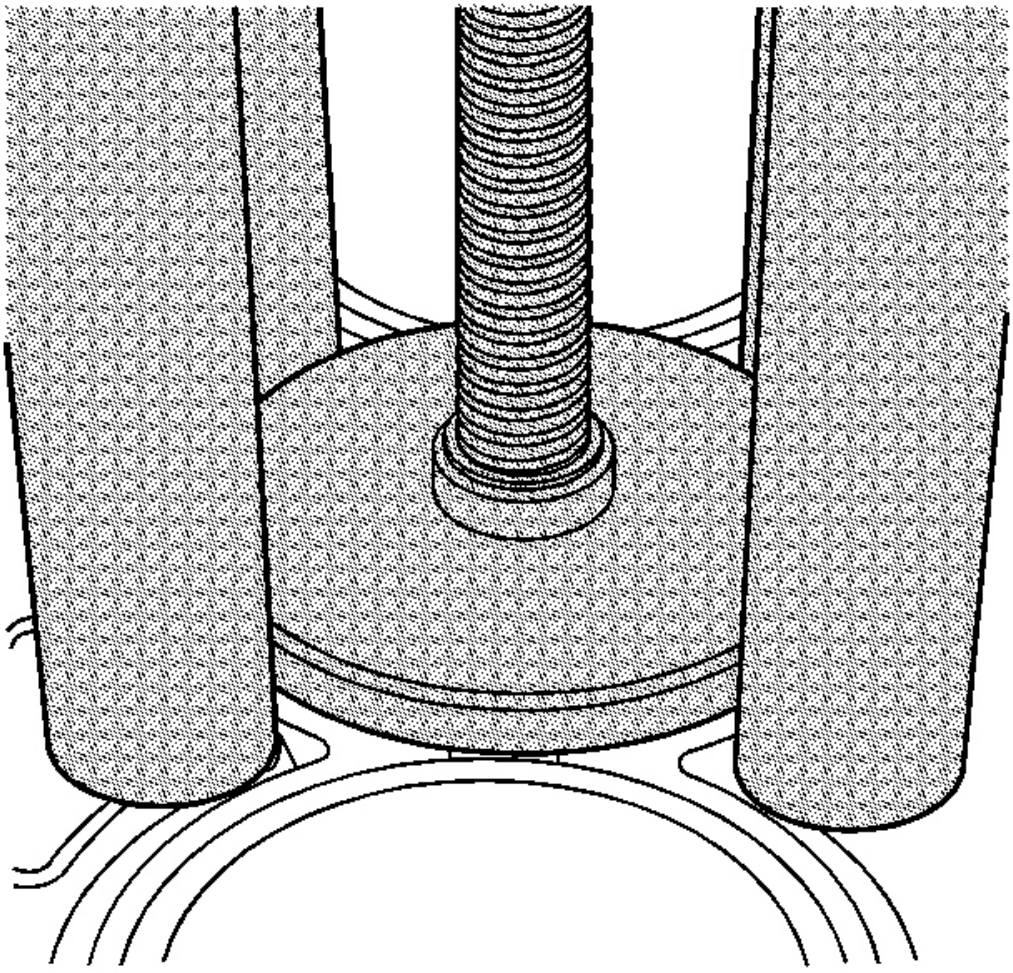


Fig. 348: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

10. Using a torque wrench, torque the threaded shaft of the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly to 102 N.m (75 lb ft) in order to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore sleeve flange will protrude above the block deck surface.

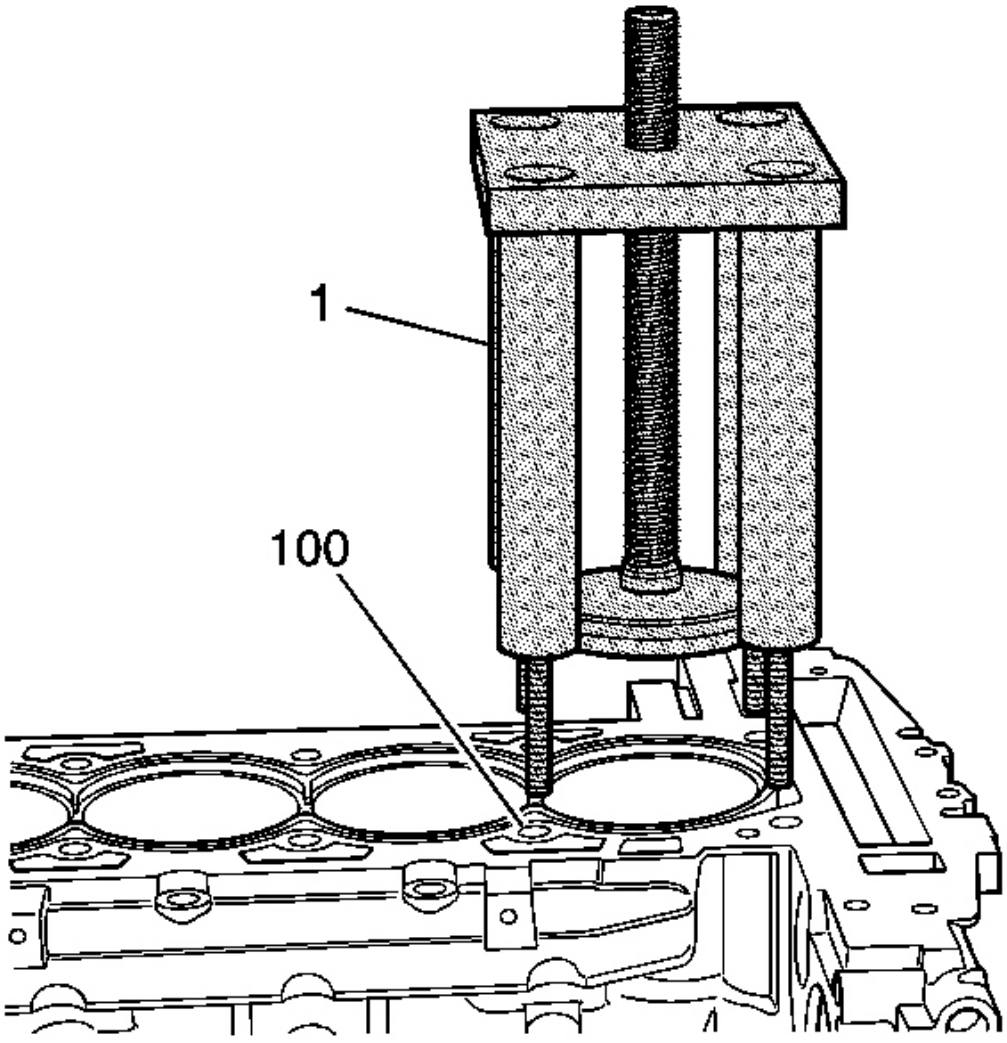


Fig. 349: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) from the cylinder block (100).

Cylinder Sleeve Trimming

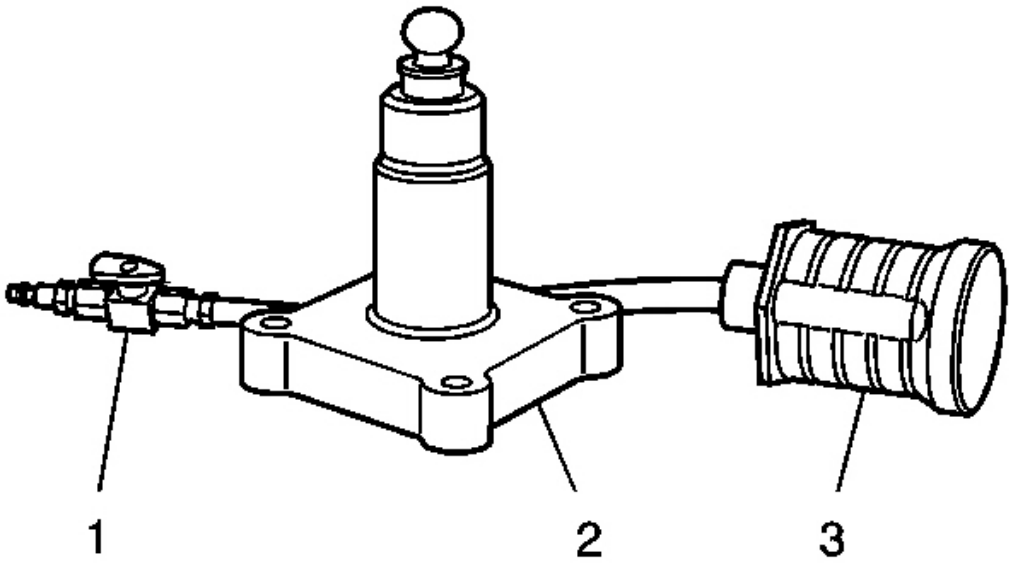


Fig. 350: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- EN 45680-865 Debris Collector (3)
- EN 45680-411 Trim Tool Assembly (2)
- EN 45680-499 Updated Trimmer Pilot (white in color)
- Air Control Valve (1 - Part of EN 45680-411)
- Drill Motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction

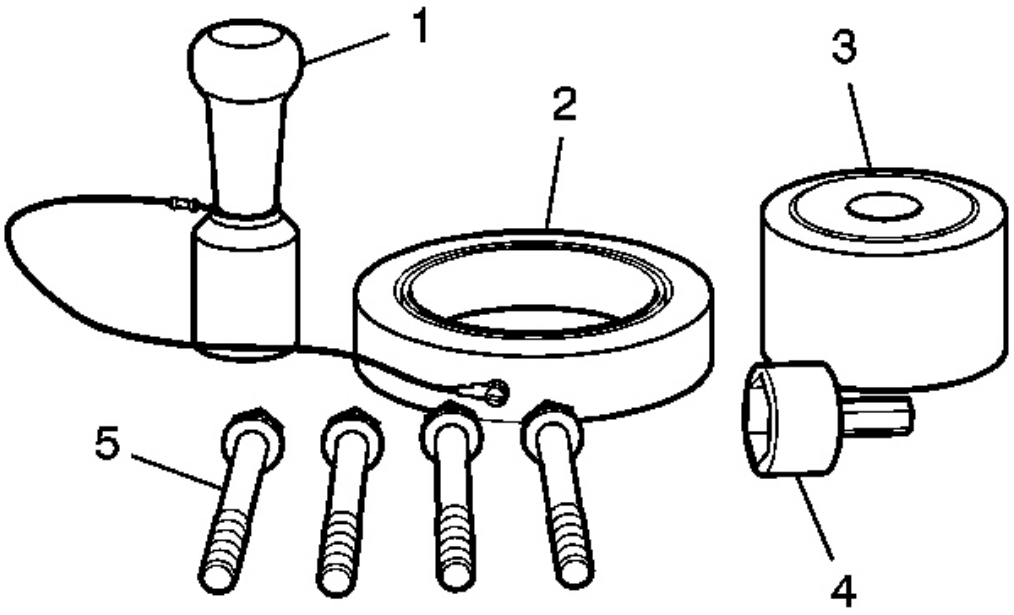


Fig. 351: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- Trim Tool Preloader (1)
- EN 45680-412 Set Gage Ring (2)
- EN 45680-413 Metal Shavings Catch Plug (3)
- EN 45680-866 Drive Adapter (4)
- EN 45680-414 Bolts (5)

NOTE: **Do not bore or hone the cylinder bore sleeve. The cylinder bore sleeve inside diameter (I.D) is fully machined and honed to size and is optimally finished as shipped. Any attempt to modify this factory-produced sizing and finish with additional boring and honing will lead to engine damage, excessive noise or abnormal oil consumption.**

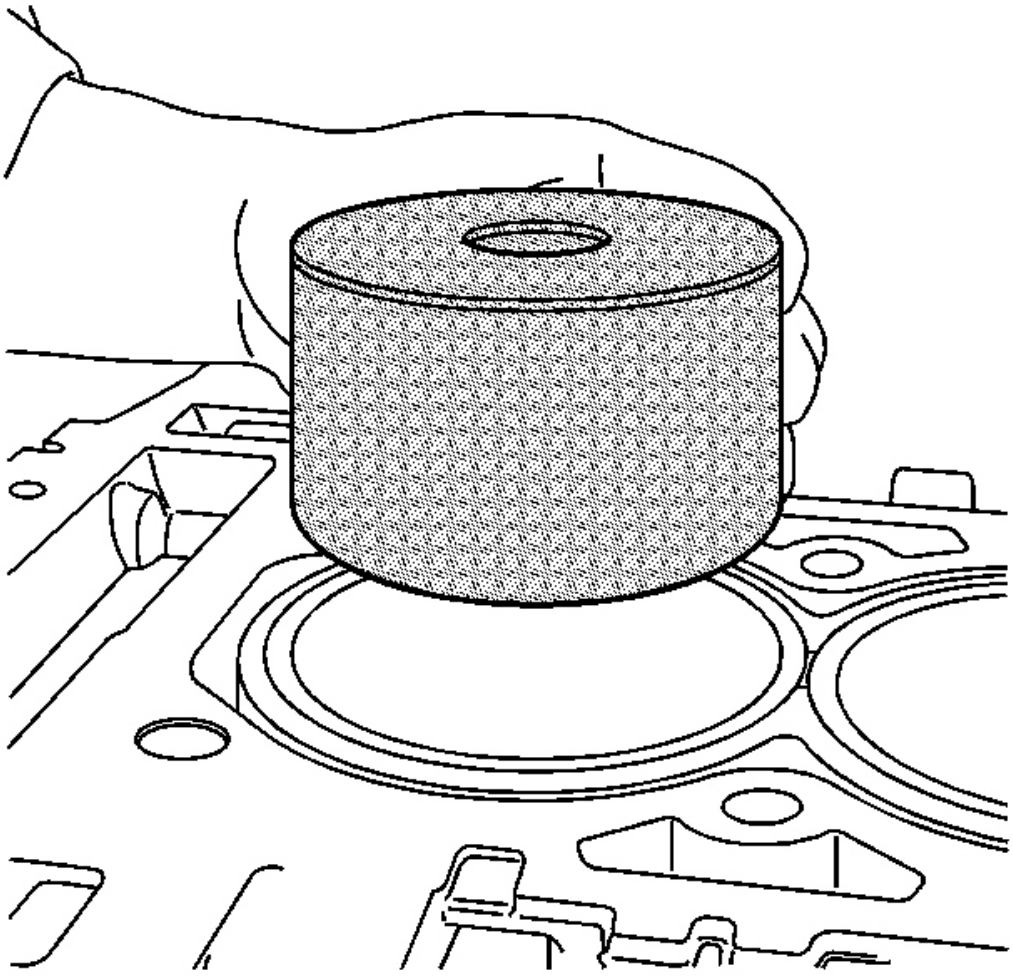


Fig. 352: Placing Metal Shaving Catch Plug Into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

1. After installing the NEW cylinder bore sleeve(s) into the engine block, trim the excess material from the cylinder bore sleeve flange.

NOTE: Ensure that all the metal particles are collected in order to prevent internal damage to the transaxle or bearings.

2. Place metal shaving catch plug EN 45680-413 into the cylinder bore sleeve to be trimmed. Position the top of the EN 45680-413 approximately 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.

3. Place additional metal shaving catch plugs EN 45680-413 into all remaining cylinder bore sleeves.

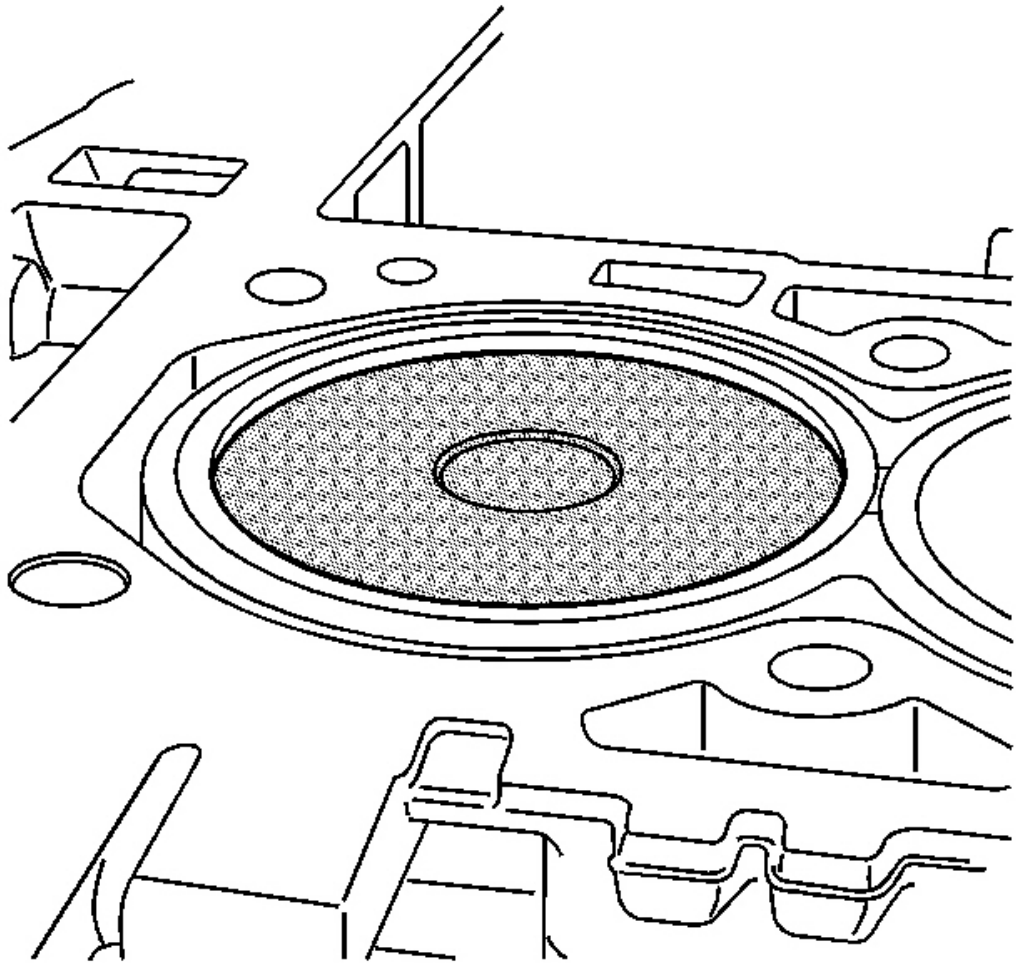


Fig. 353: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Installing the metal shaving catch plug deeper than the recommended depth will create a decrease in vacuum system performance. A decrease in vacuum system performance will cause metal shavings to enter the engine and cause engine failure.

NOTE: Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.

4. Ensure that the metal shaving catch plug EN 45680-413 is 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.

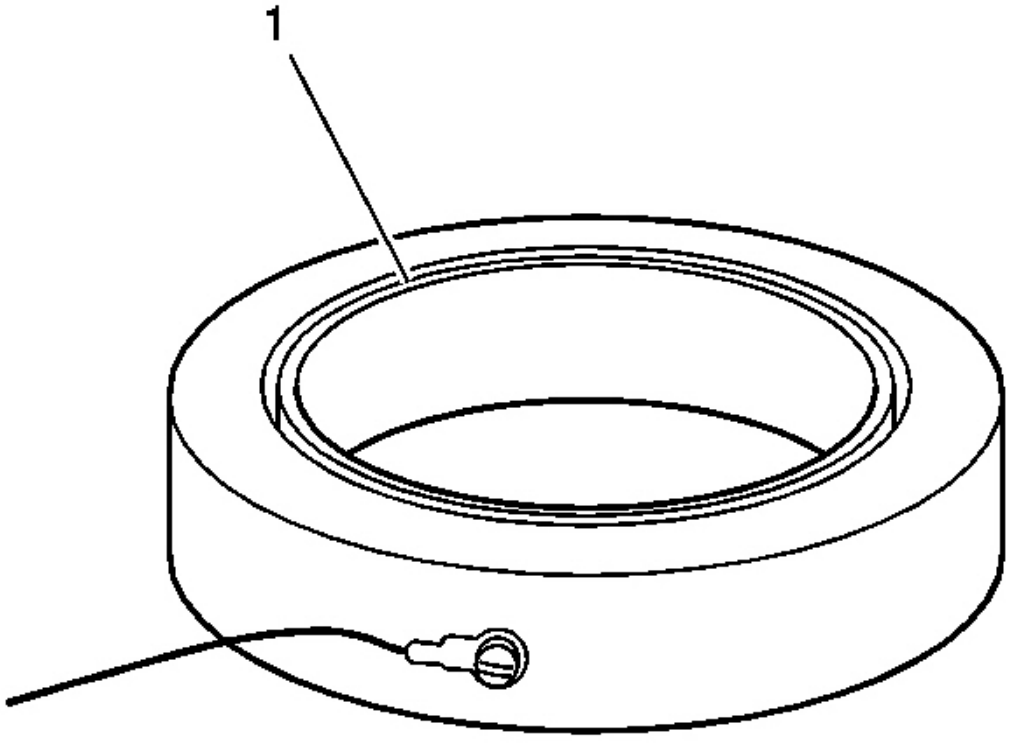


Fig. 354: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Before using trim tool assembly EN 45680-411, the height of the cutting blades must be set to the proper specification. The proper specification is that the cylinder bore sleeve flange must be flush to +0.02 mm (0.0008 in) above the block deck surface.

5. The groove side of the set gage ring EN 45680-412 (1) should be positioned upward on a flat surface.

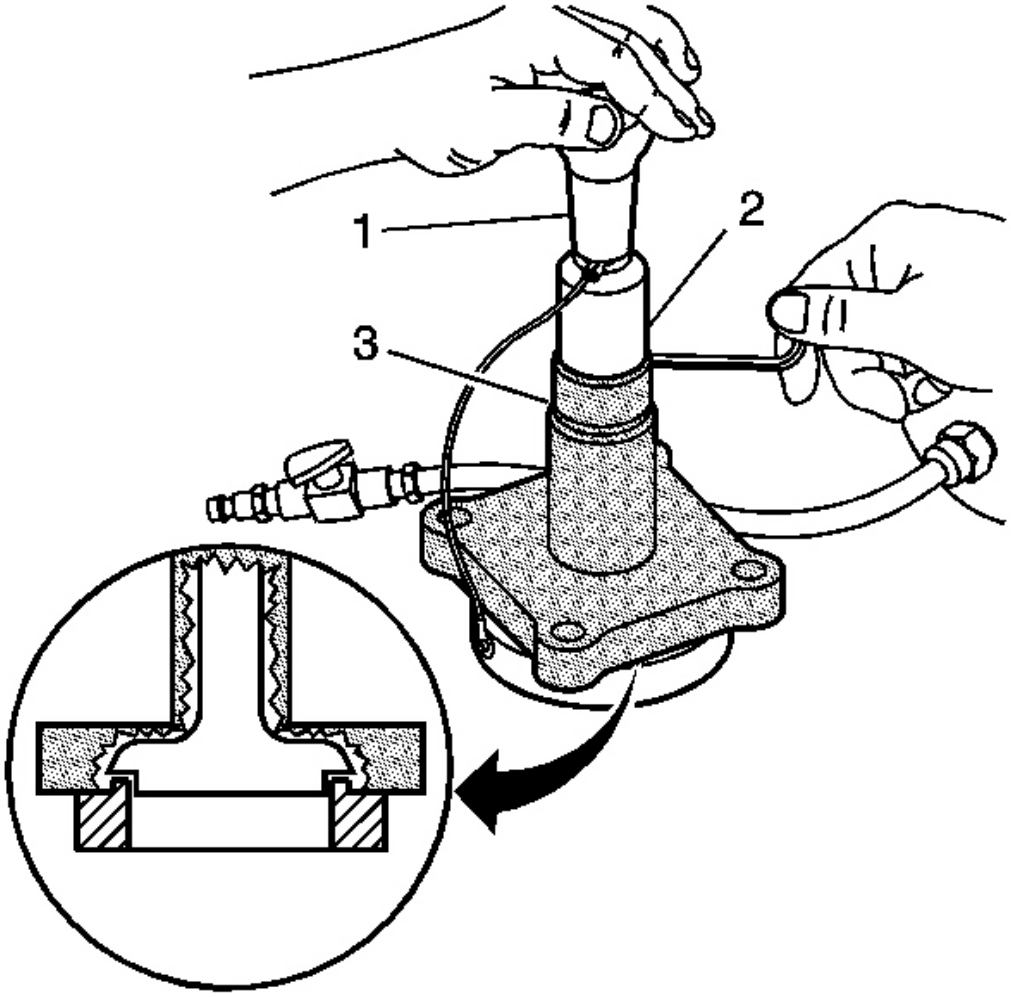


Fig. 355: View Of Trim Tool Assembly Components & Positioning
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the set gage ring EN 45680-412 surfaces are clean.

6. Carefully position trim tool assembly EN 45680-411 onto the set gage ring EN 45680-412.
7. Loosen the shaft collar screw (2).
8. Push the shaft collar (2) downward using the trim tool preloader (1) until the shaft collar is positioned against the top of the flange bearing (3).

IMPORTANT: Once this procedure is done, it is not necessary to reset the trim tool

assembly EN 45680-411 height until the blades are worn or damaged.

9. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw.

   Tighten: Tighten the shaft collar screw to 19 N.m (14 lb ft).

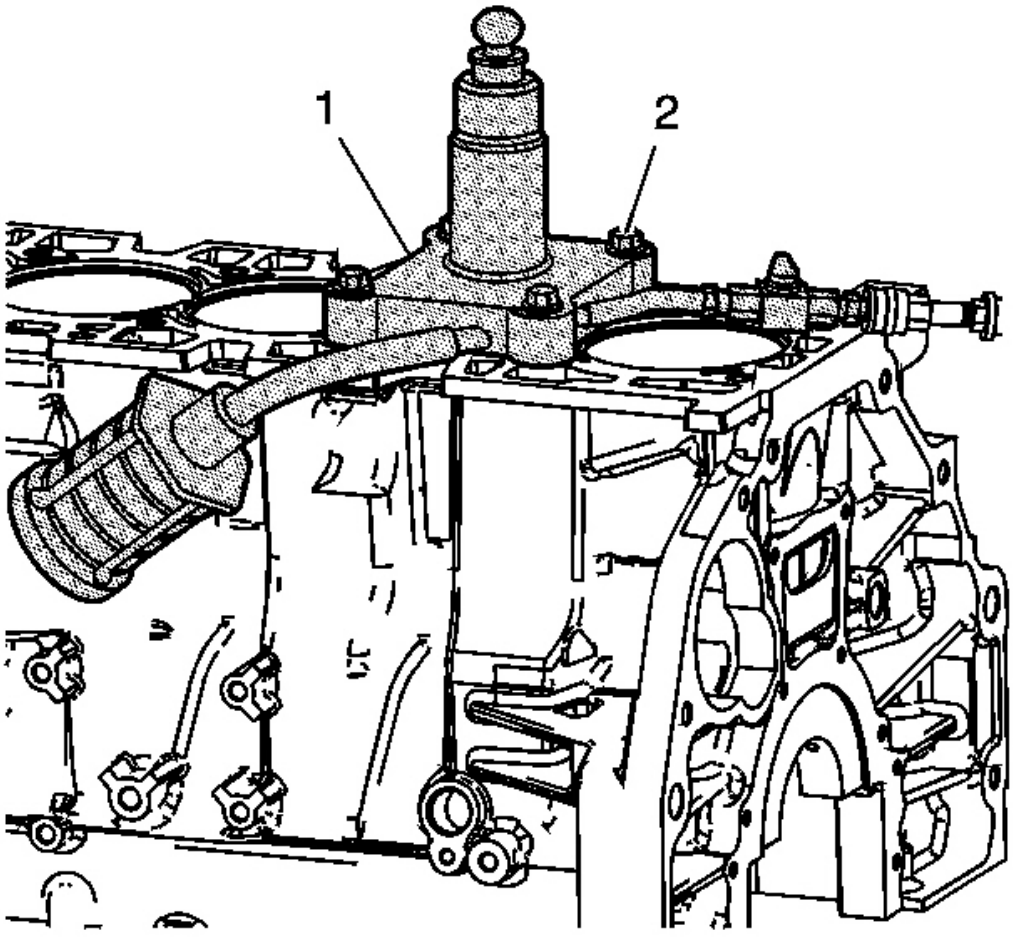


Fig. 356: View Of Trim Tool Assembly Alignment
Courtesy of GENERAL MOTORS CORP.

10. Place trim tool assembly EN 45680-411 onto the cylinder to be trimmed with the directional arrow (1) pointing in line with the crankshaft centerline and the front of the block.
11. Install the 4 bolts EN 45680-414 (2) into the cylinder head bolt holes in the block.

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

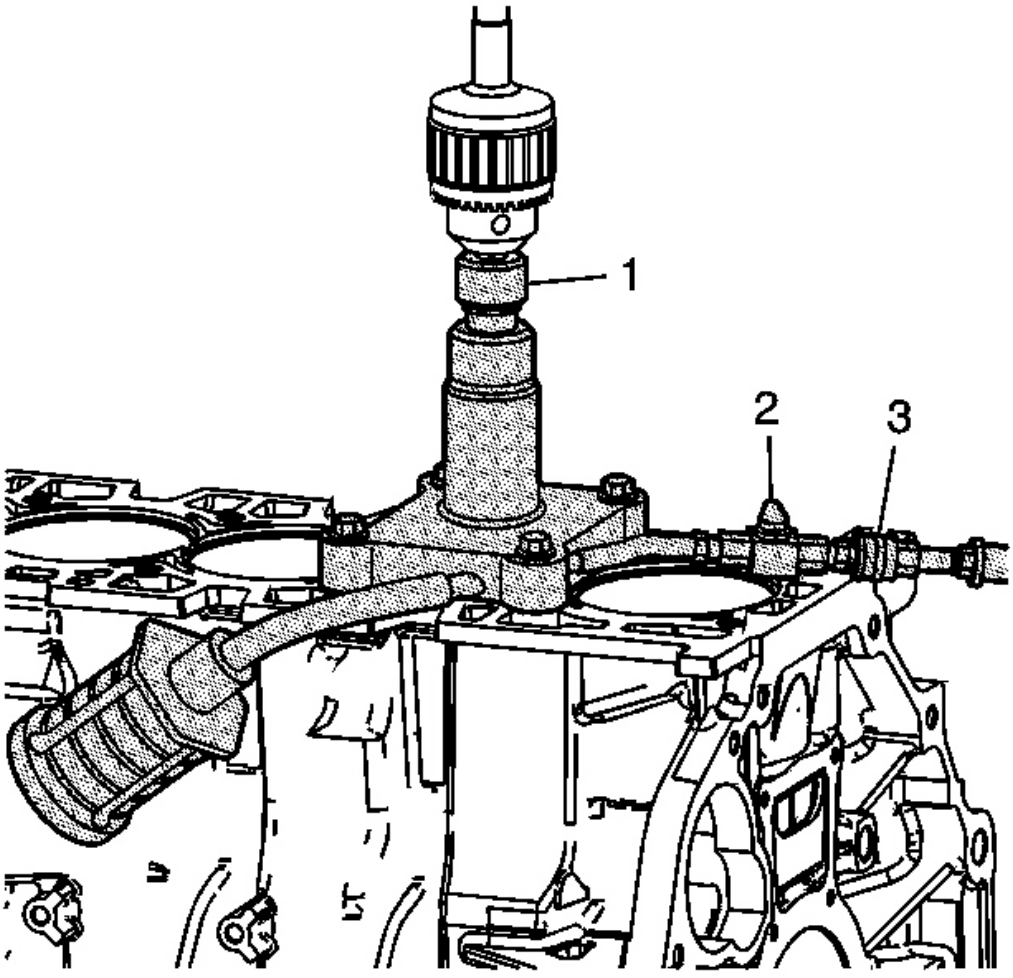


Fig. 357: View Of Drive Adapter, Compressed Air Valve & Male Quick Connect
Courtesy of GENERAL MOTORS CORP.

NOTE: **For proper tool operation, a drill motor with a 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction must be used. If the proper drill motor is not used, damage to the cylinder bore sleeve will occur.**

12. Fasten drive adapter EN 45680-866 (1) into the drill chuck.

NOTE: Ensure that there are no crimps in the air feed hose or the vacuum hose. Crimps in the hose may cause metal shavings to exit the cutting tool in any direction, causing engine damage.

13. Connect a compressed air supply (75-125 psi) to the male quick connect (3) located on trim tool assembly EN 45680-411. Turn the compressed air valve (2) to the open position. This starts the venturi vacuum system that will catch the metal shavings.

IMPORTANT: It should not take longer than 15 seconds to complete the trimming procedure. If it does, the trimming bits must be repositioned to a new cutting surface.

14. Place drive adapter EN 45680-866 and drill assembly (1) vertically onto the drive adapter end of trim tool assembly EN 45680-411. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, apply firm downward force until the cutting action is complete.
15. Remove drive adapter EN 45680-866 (1) and drill assembly from the trim tool assembly EN 45680-411.
16. Turn off the compressed air valve (2).
17. Remove trim tool assembly EN 45680-411 from the engine block.
18. Remove any material shavings that may be found on the metal shaving catch plug EN 45680-413.
19. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug EN 45680-413.

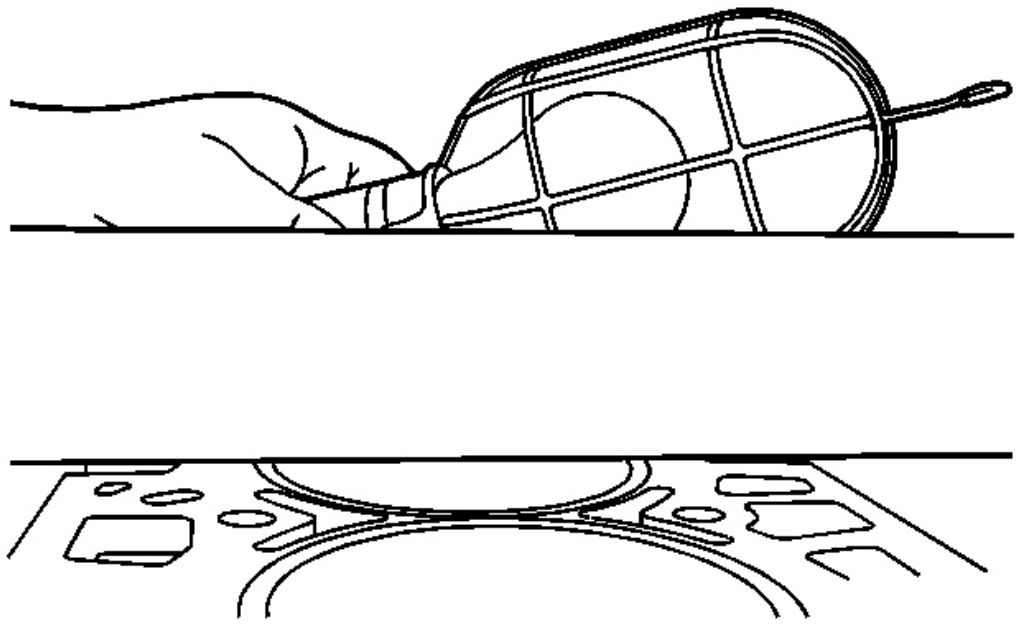


Fig. 358: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

20. Install a straight edge on the cylinder block perpendicular to the crankshaft center line.
21. Using a light, illuminate the backside of the straight edge.

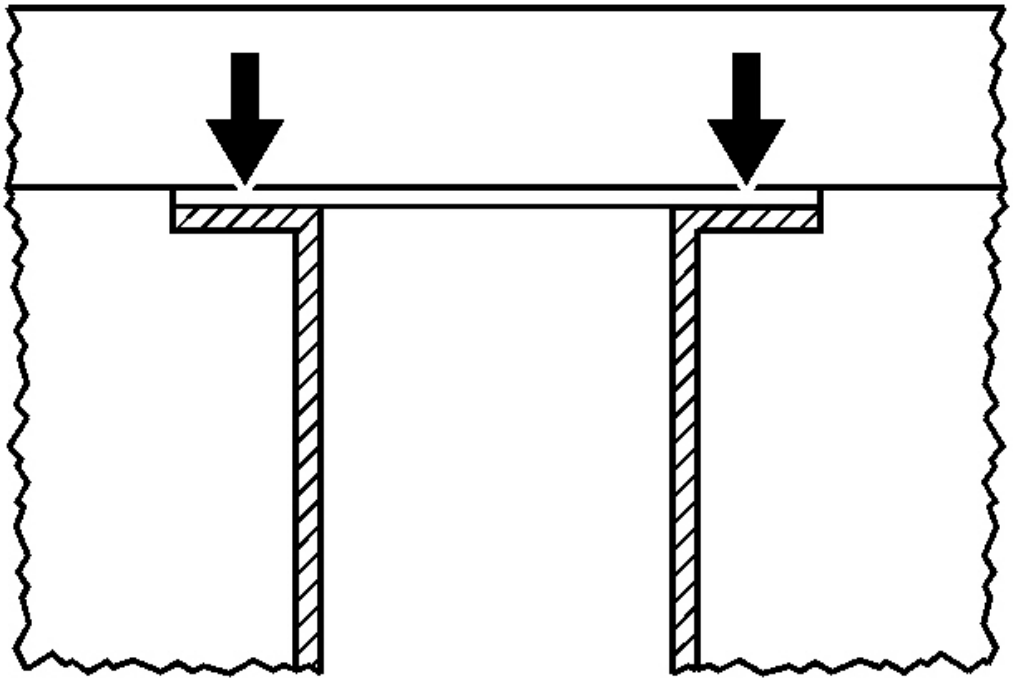


Fig. 359: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

22. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder bore sleeve flange. If light is present on either side or both sides of the cylinder bore sleeve, the cylinder bore sleeve is cut incorrectly and a new cylinder bore sleeve needs to be installed.

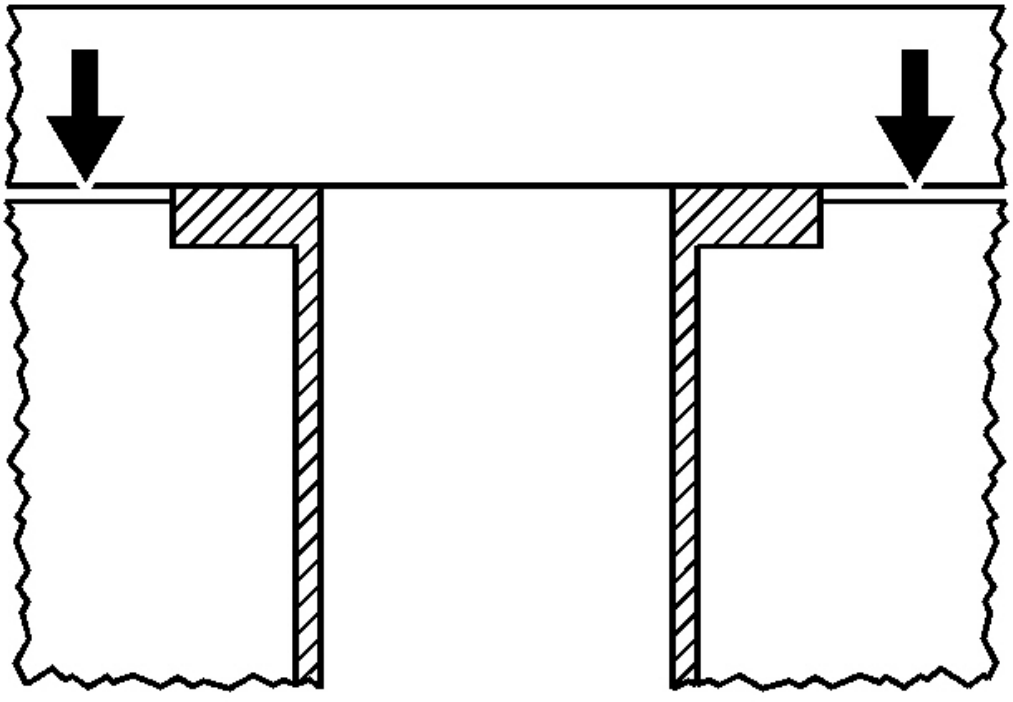


Fig. 360: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

23. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.
24. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

PISTON & CONNECTING ROD ASSEMBLE

Tools Required

EN-46745 Piston Pin Retainer Remover and Installer. See **Special Tools**.

Assembly Procedure

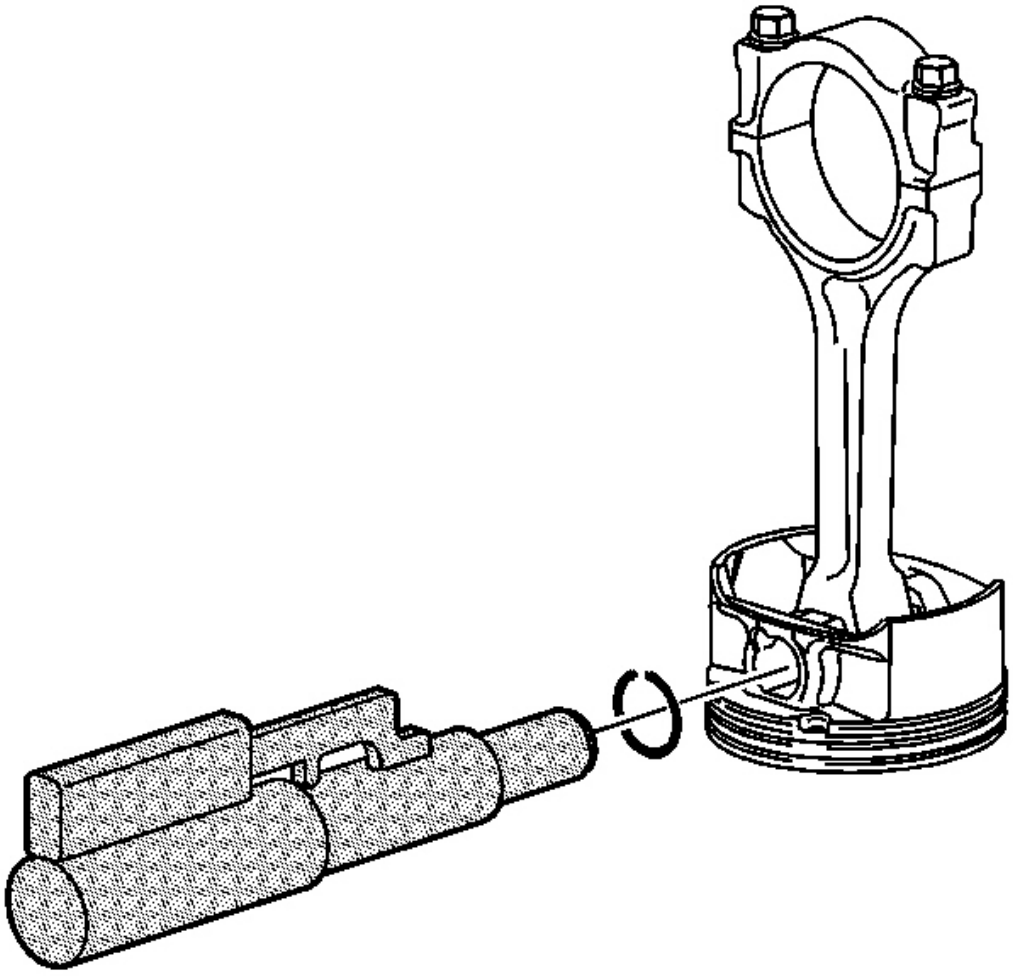


Fig. 361: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the piston pin with clean engine oil.

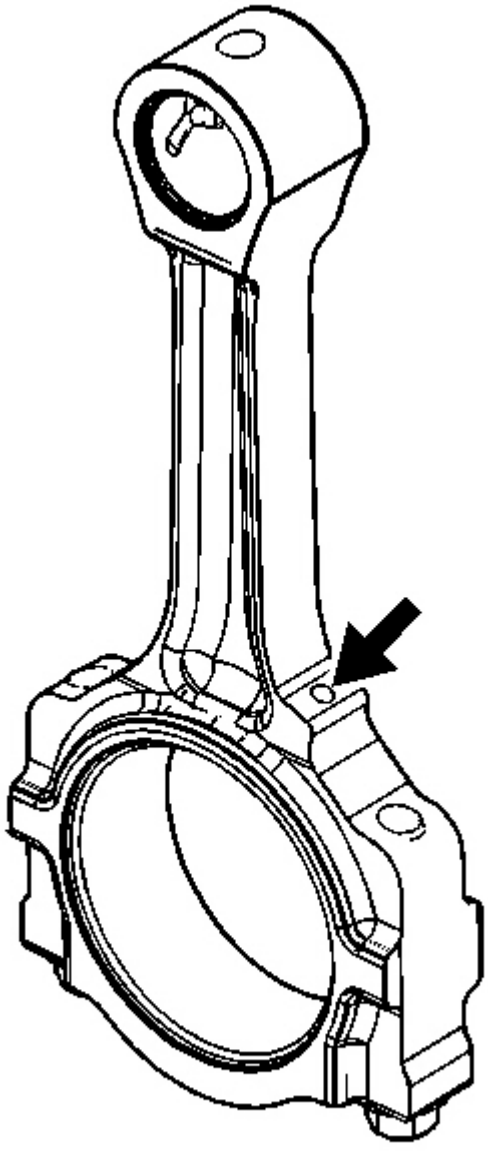


Fig. 362: Identifying Connecting Rod Oil Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil hole, in the connecting rod, should be facing the exhaust side of the block.

2. Install one of the piston pin retainers into the retainer groove using **EN-46745**. See **Special Tools**

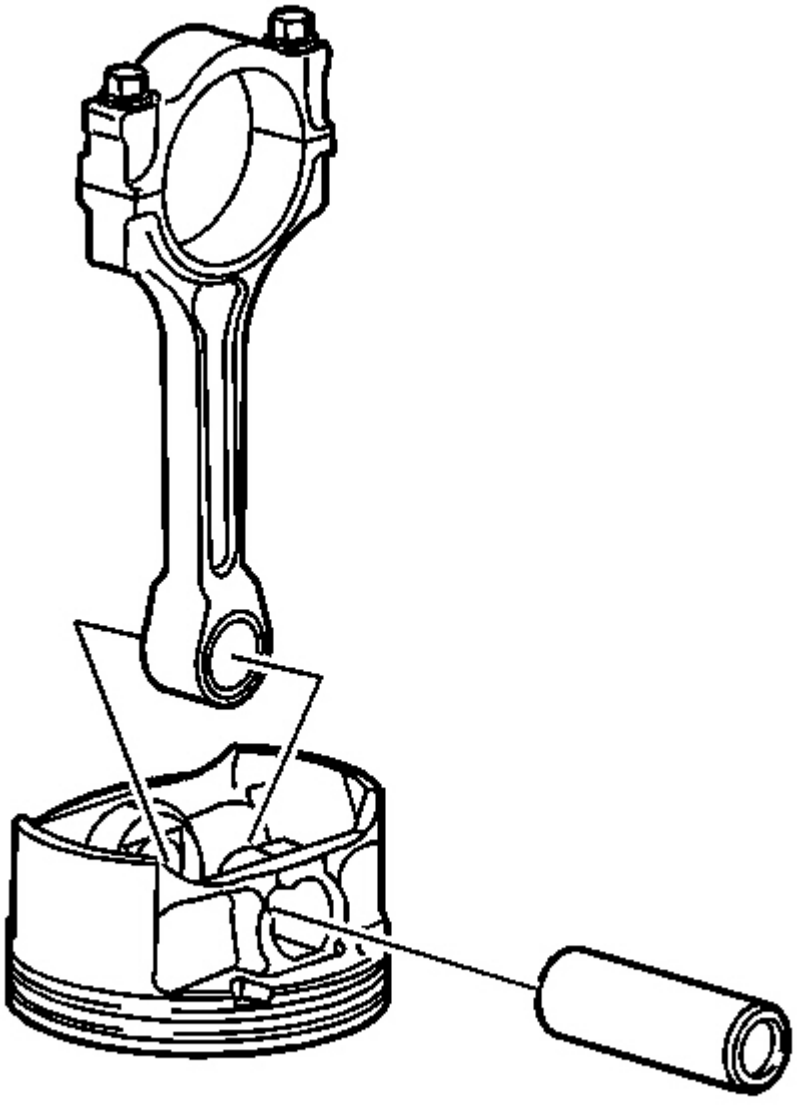


Fig. 363: View Of Piston Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Install the connecting rod and piston pin. Push the piston pin in until it bottoms against the installed piston pin retainer.

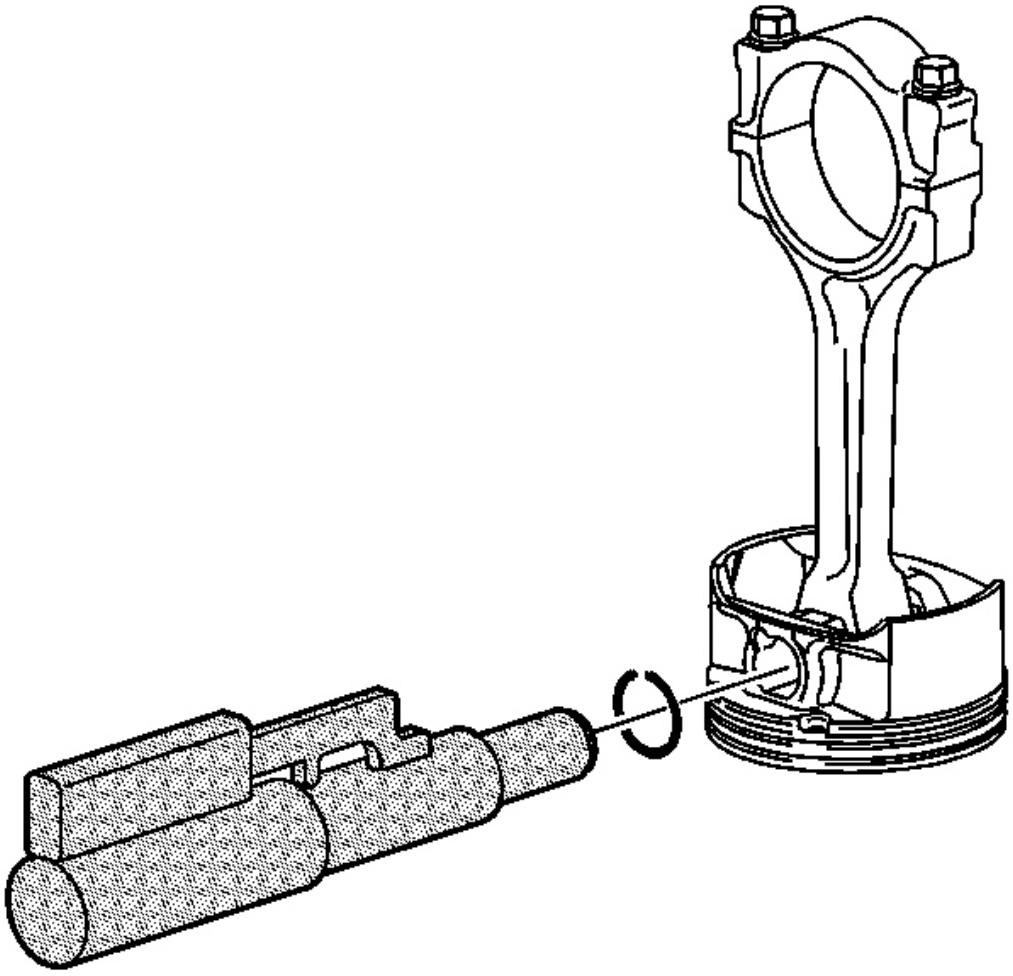


Fig. 364: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

4. Install the second piston pin retainer.

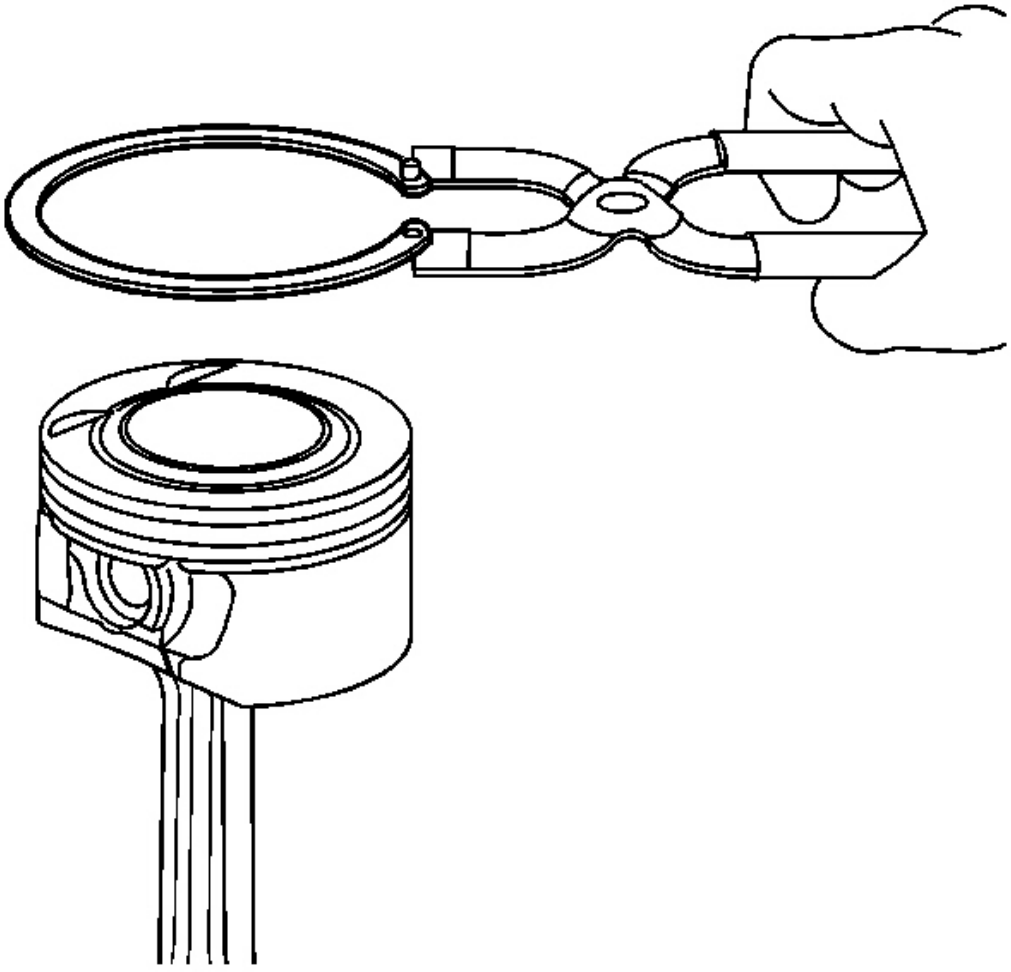


Fig. 365: Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

IMPORTANT: The piston ring end gaps must be staggered 90 degrees apart.

5. Install the following components of the bottom ring assembly (oil control ring).
    1. The expander
    2. The lower oil control ring

3. The upper oil control ring

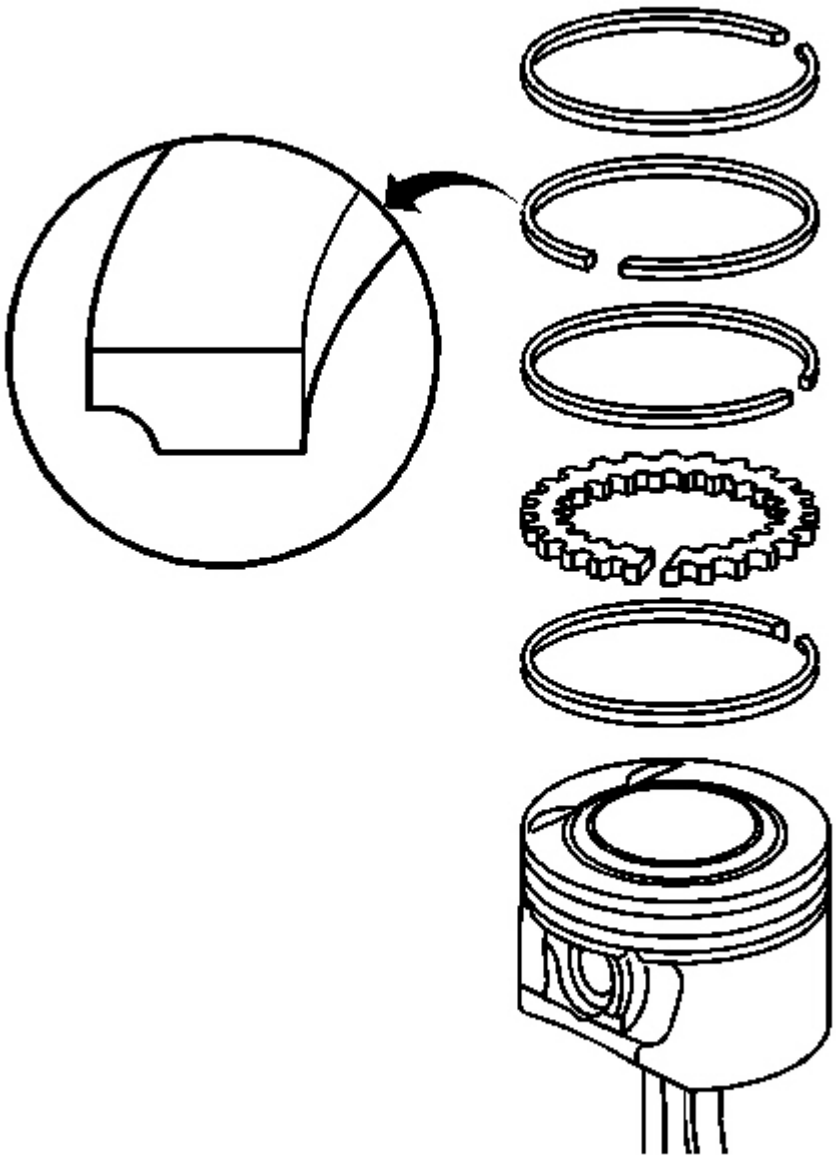


Fig. 366: Identifying Middle Ring
Courtesy of GENERAL MOTORS CORP.

6. Install the middle ring (compression ring) with the napier groove facing down.

7. Install the top ring.

CAMSHAFTS CLEANING & INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator Set

Cleaning & Inspection Procedure

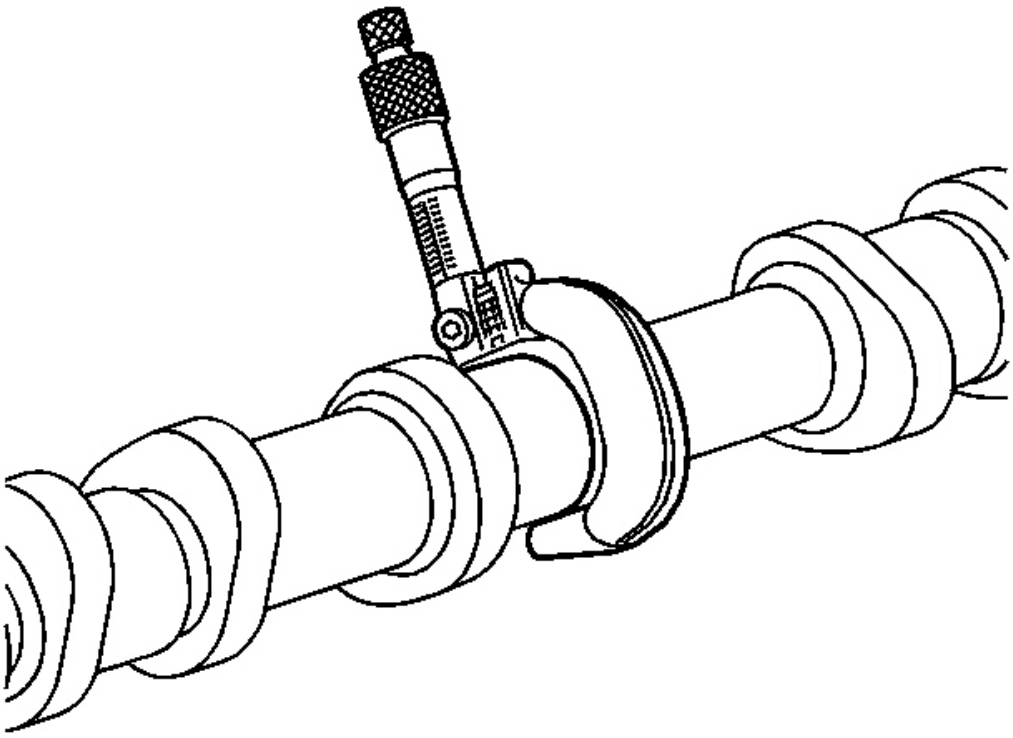


Fig. 367: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

1. Clean the camshafts with cleaning solvent.
2. Inspect the camshafts for the following conditions:
   - Scored camshaft journals
   - Damaged camshaft lobes
   - Damaged camshaft sprocket locator pin slots

- Damaged threads

3. Measure the camshaft lobes using a micrometer. The intake camshaft lobes should be a minimum of 41.5 mm (1.635 in). The exhaust camshaft lobes should be a minimum of 41 mm (1.615 in).

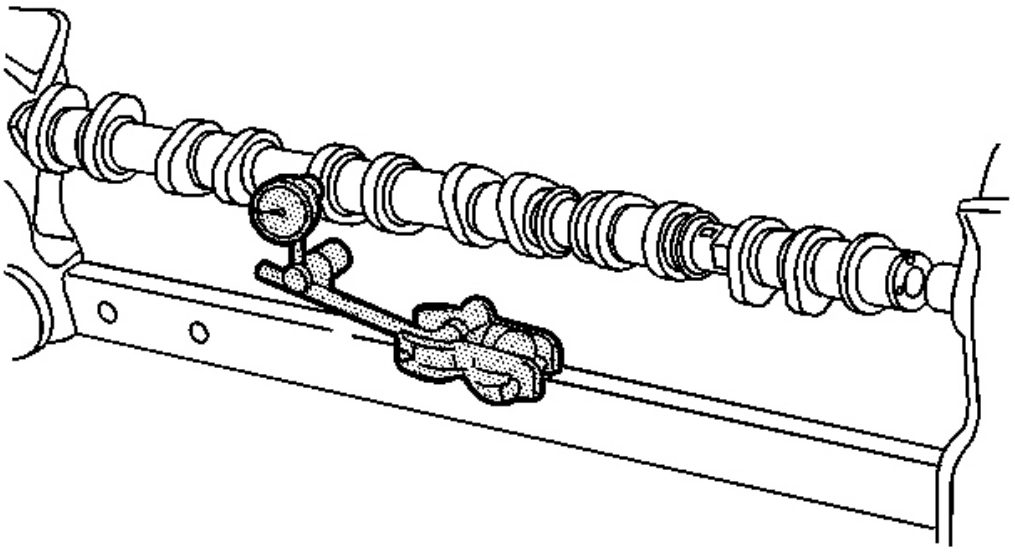


Fig. 368: Measuring Camshaft Runout & Lobe Lift
Courtesy of GENERAL MOTORS CORP.

4. Use **J 7872** to measure the camshaft runout.
    1. Set the camshaft in V-blocks between the centers.
    2. Measure the intermediate camshaft journal.
5. Use **J 7872** to measure the camshaft lobe lift.
    1. Lubricate the camshaft to V-block contact areas with engine oil.
    2. Set the camshaft on V-blocks.
    3. Measure the camshaft lobe lift.
6. If the runout or camshaft lobe lift is not within specifications, replace the camshaft.

CAMSHAFT TIMING CHAIN & SPROCKET CLEANING & INSPECTION

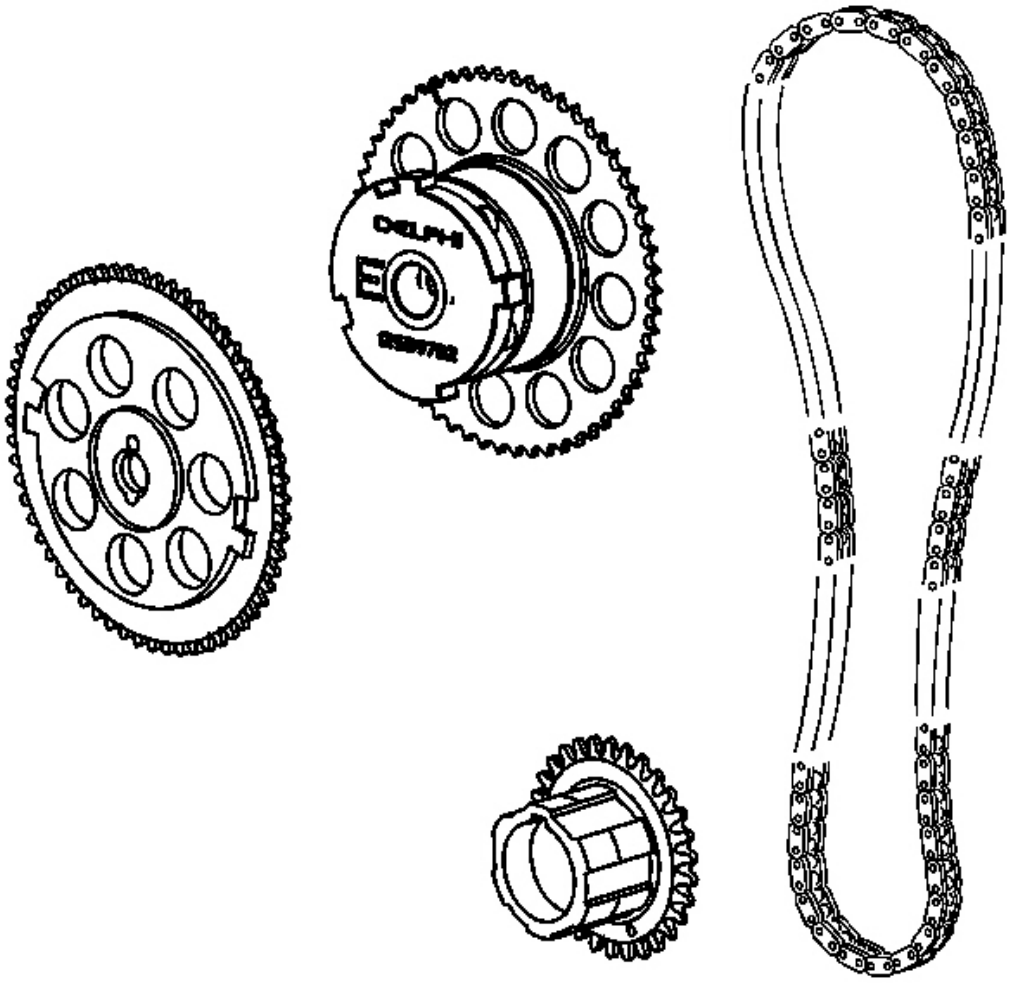


Fig. 369: View Of Camshaft Timing Chain & Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain sprockets for cracks or teeth that are worn, broken, or chipped.
2. Inspect the timing chain for binding or stretching.
3. Inspect the dowel pins for wear or damage.
4. Inspect the crankshaft sprocket keyway and the locating dowel pins in the crankshaft for damage.
5. Inspect the timing chain shoe and guide for excessive wear or cracks.
6. Inspect the timing chain tensioner for damage.
7. Replace the timing chain and sprockets if damaged.

VALVE ROCKER ARM & VALVE LASH ADJUSTER CLEANING & INSPECTION

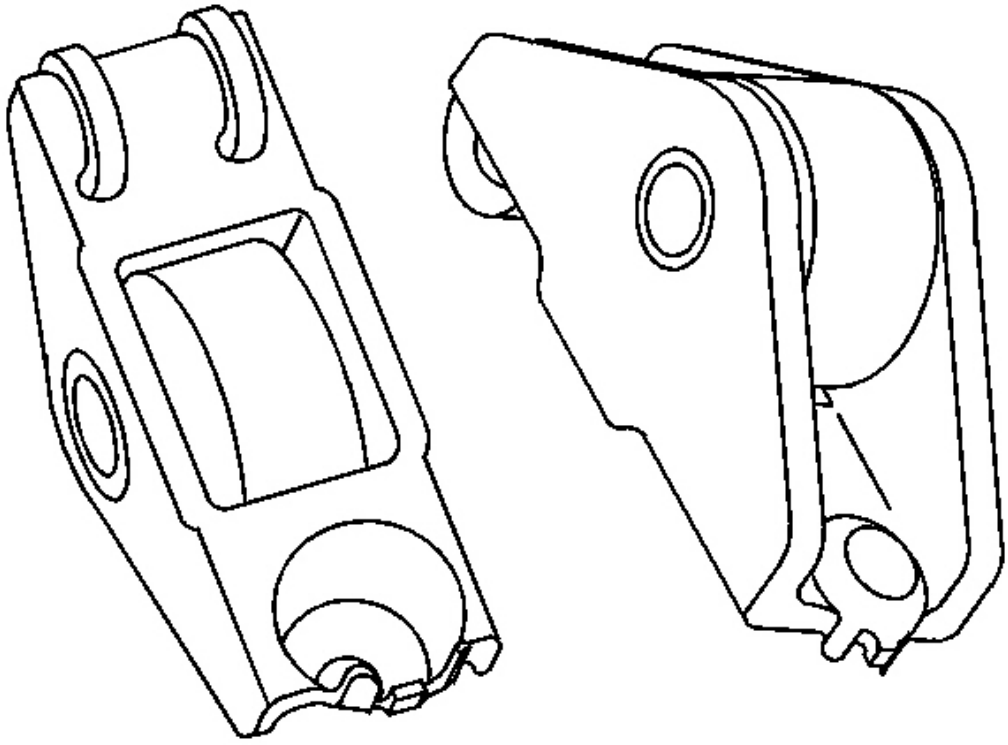


Fig. 370: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Clean the valve rocker arms and valve lash adjusters in cleaning solvent.
2. Dry the valve rocker arms and valve lash adjusters with compressed air.
3. Inspect the valve rocker arms for the following conditions:
    - Excessive wear at the valve contact or valve lash adjuster socket area
    - A loose or damaged pin
    - A worn or damaged roller. The roller should rotate freely with no binding or roughness.

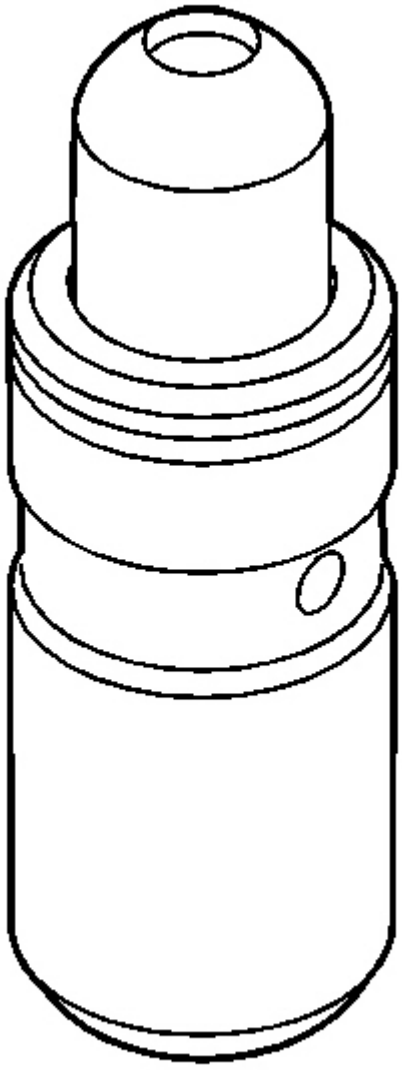


Fig. 371: View Of Valve Lash Adjuster
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep the valve rocker arms and valve lash adjusters in the order from where they where removed.

4. Inspect the valve lash adjusters for the following conditions:
   - Excessive wear

- Clogging of the oil passage
- Damage
- Collapsed or spongy

CYLINDER HEAD DISASSEMBLE

Tools Required

- **EN 46119** Valve Spring Compressor Adapter. See **Special Tools**.
- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 38820** Valve Stem Seal Remover/Installer. See **Special Tools**.

Disassembly Procedure

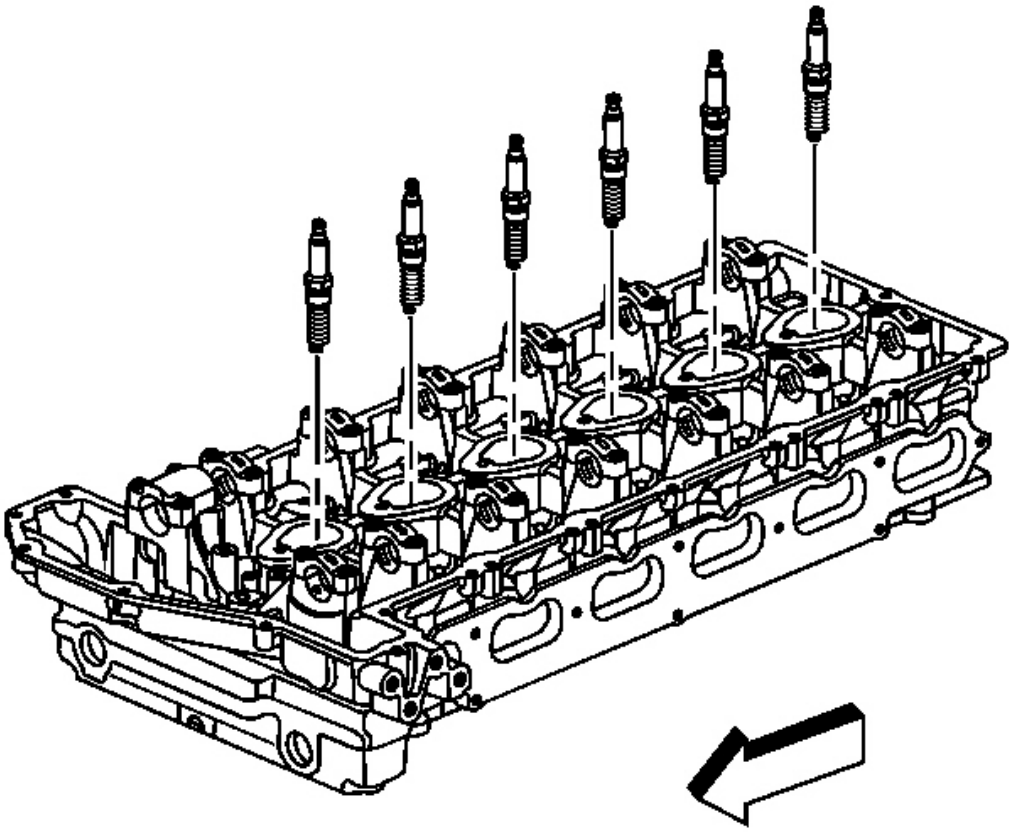


Fig. 372: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.

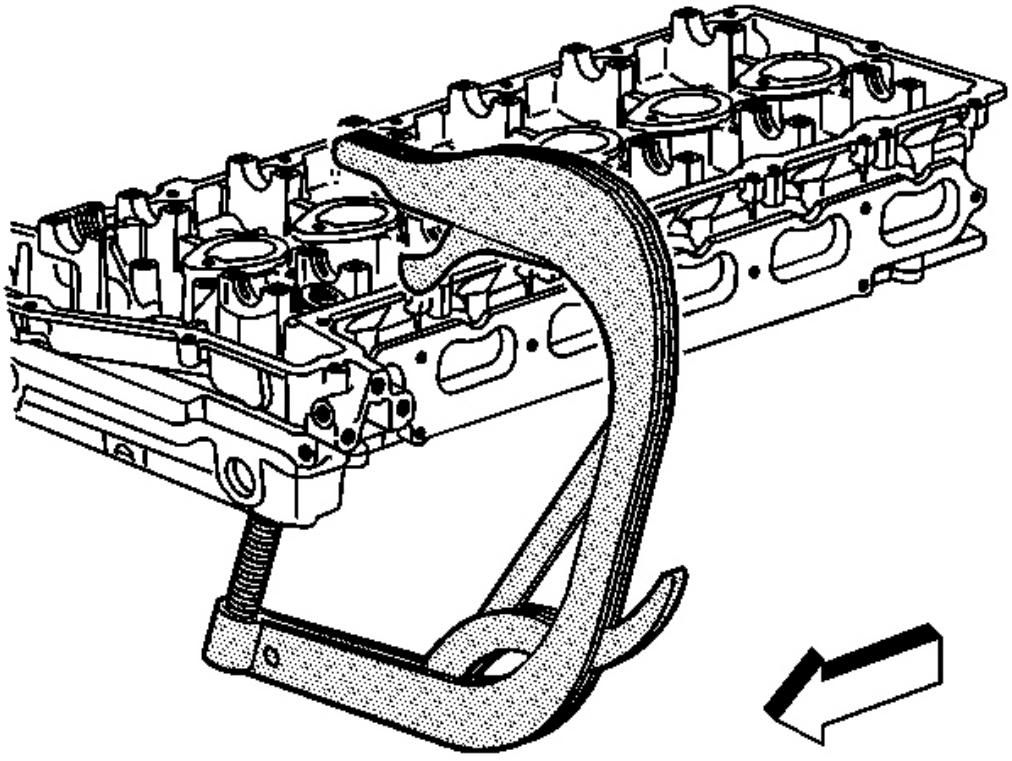


Fig. 373: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Organize the valve train components when disassembling so they can be reassembled in the same location and matched up with the same components as previously installed.

2. Use **J 8062** and **EN 46119** to compress the valve spring. See **Special Tools**.

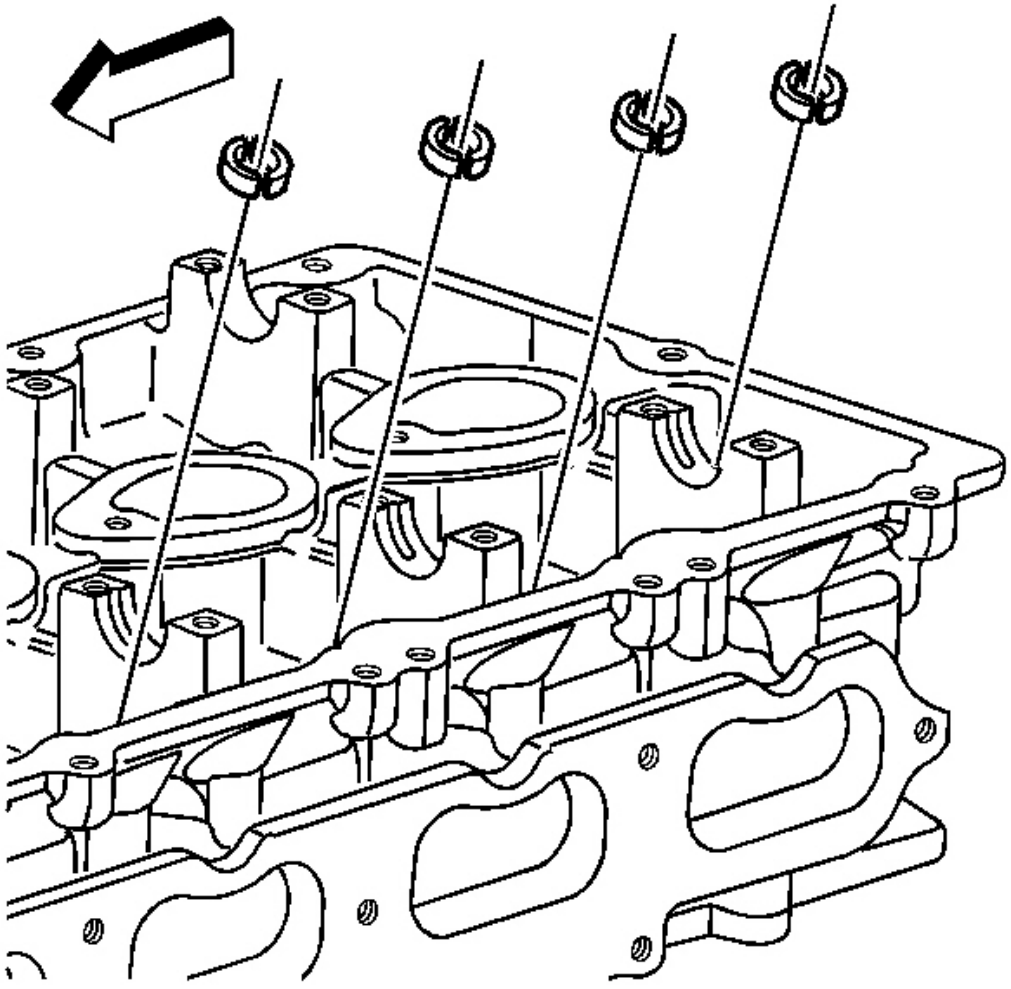


Fig. 374: View Of Valve Keys
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve keys.

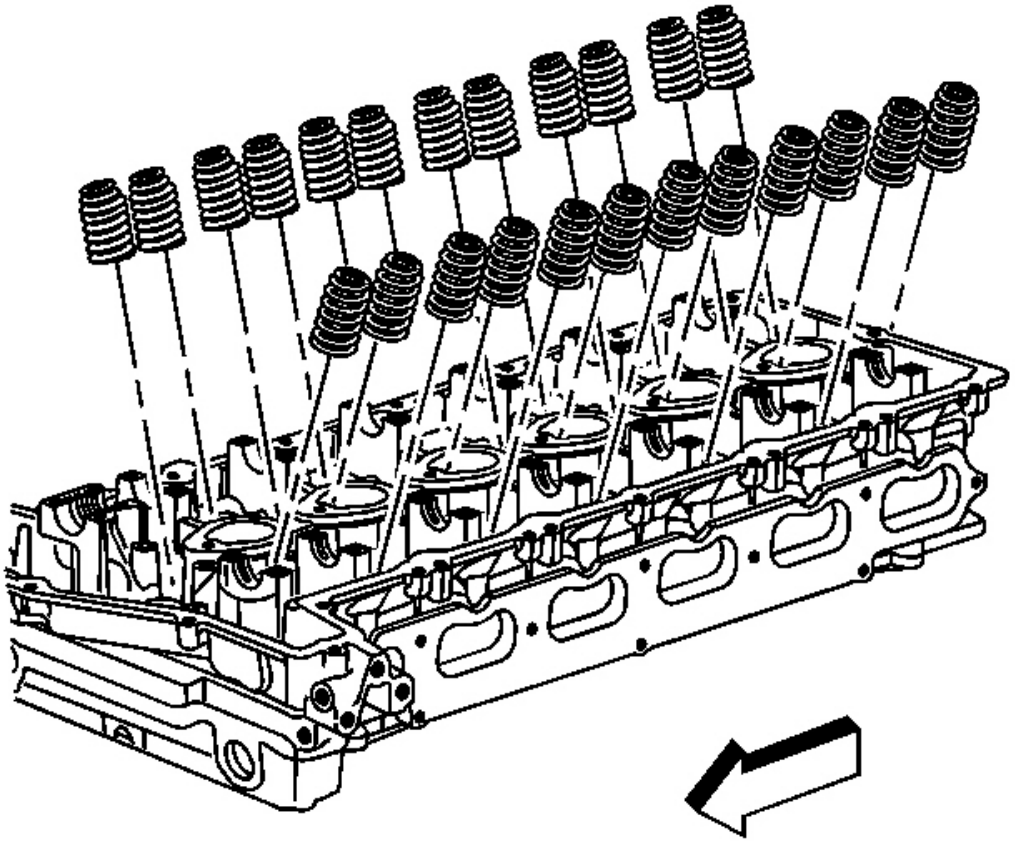


Fig. 375: Identifying Valve Springs
Courtesy of GENERAL MOTORS CORP.

4. Remove **J 8062** and **EN 46119** . See **Special Tools**.
5. Remove the valve spring retainer and valve spring.

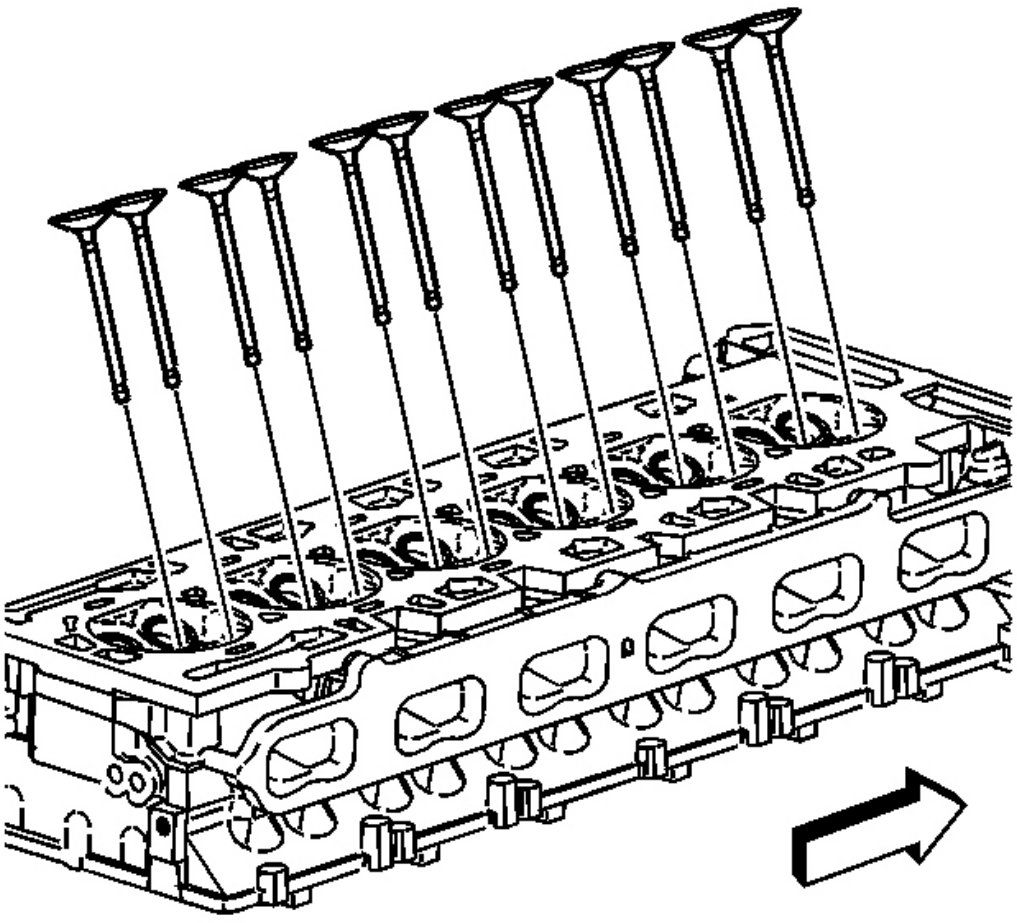


Fig. 376: View Of Valves
Courtesy of GENERAL MOTORS CORP.

6. Remove the valves.

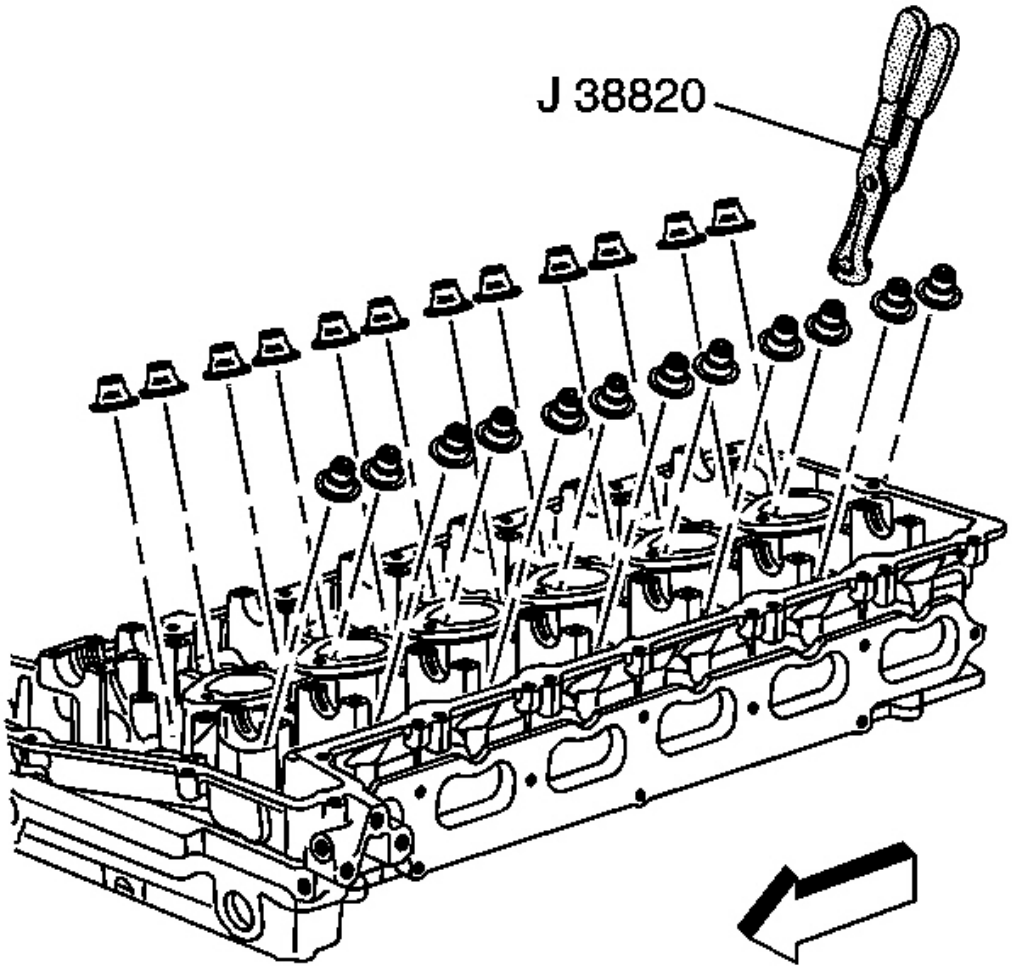


Fig. 377: View Of J 38820 & Valve Seals
Courtesy of GENERAL MOTORS CORP.

7. Use **J 38820** to remove the valve seals. See **Special Tools**.

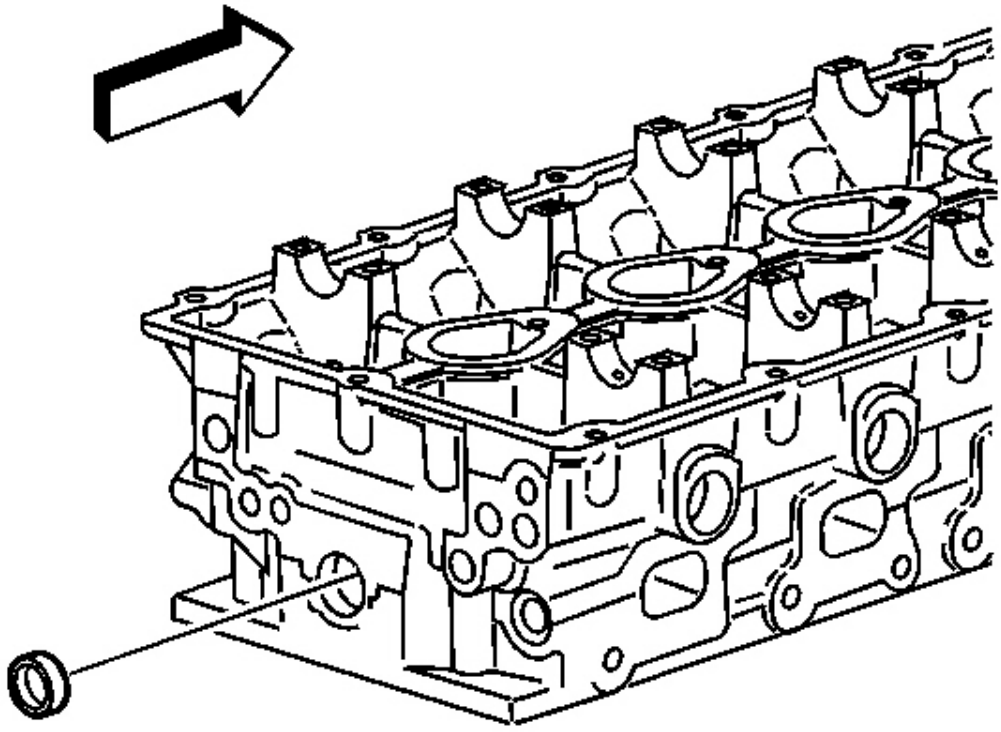


Fig. 378: View Of Water Jacket Plug
Courtesy of GENERAL MOTORS CORP.

8. Inspect the water jacket plug, for leakage. Replace if necessary.

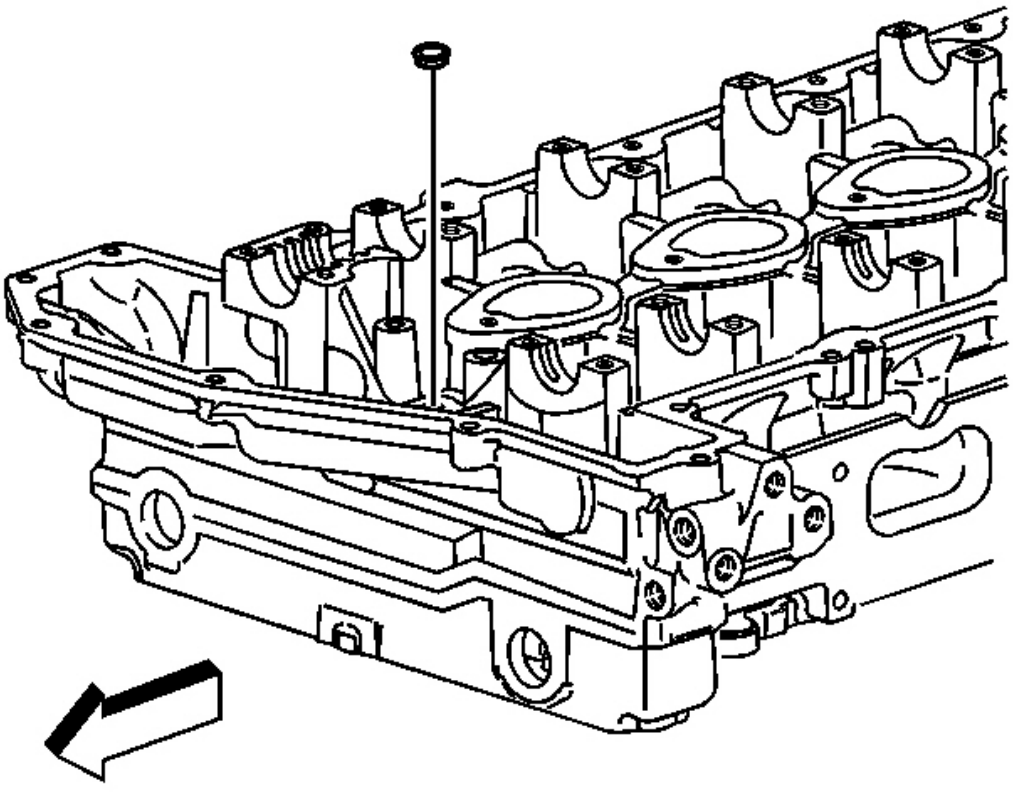


Fig. 379: View Of Inner Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

9. Inspect the (inner) oil gallery plug, for leakage. Replace if necessary.

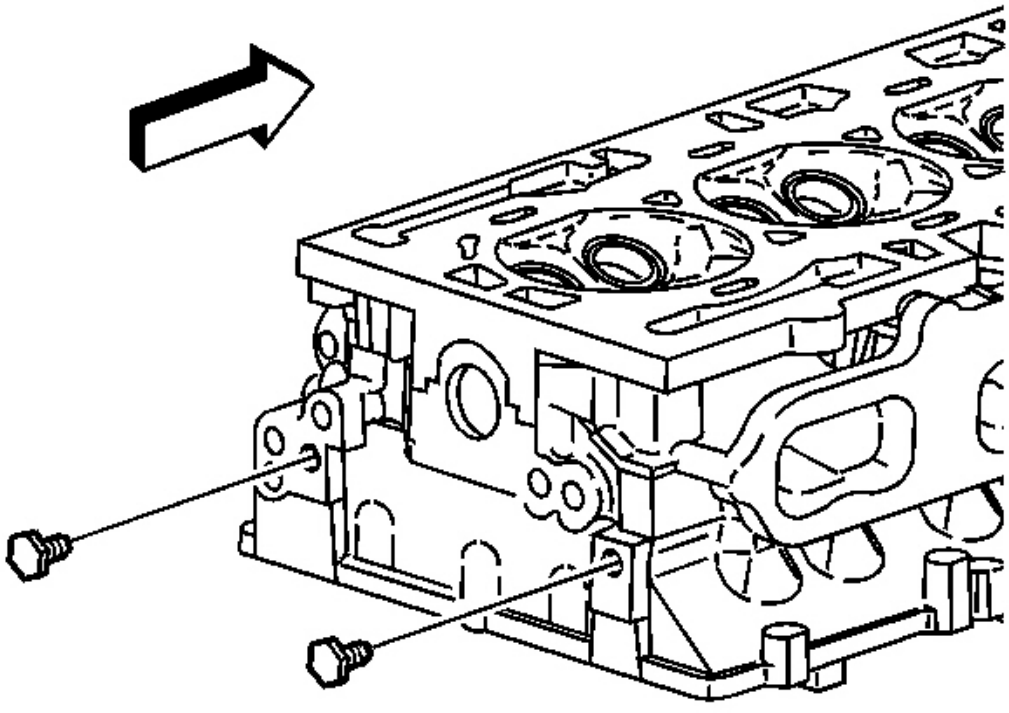


Fig. 380: View Of End Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

10. Inspect the (end) oil gallery plugs, for leakage. Replace if necessary.

CYLINDER HEAD CLEANING & INSPECTION

Tools Required

J 9666 Valve Spring Tester

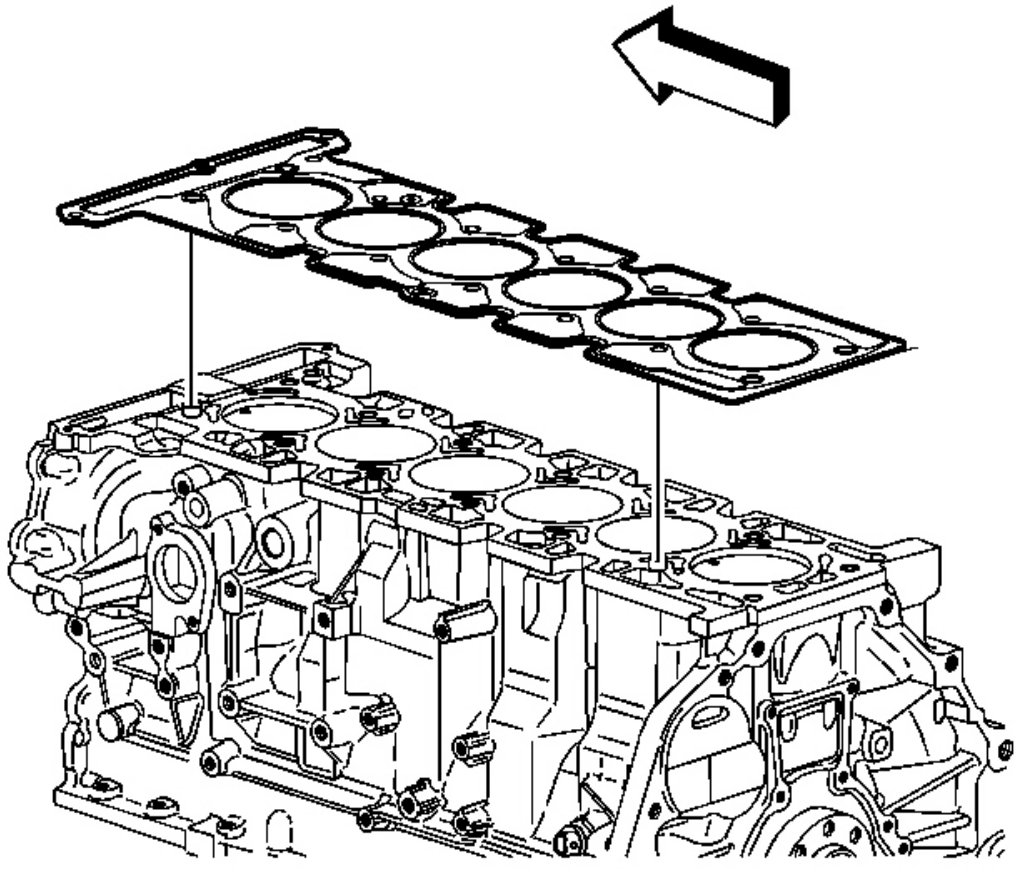


Fig. 381: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surface. Inspect for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. The following conditions may cause gasket failure:
    - Improper installation
    - Warped cylinder head
    - Missing or not fully seated dowel pins
    - Low torque on the cylinder head bolts
    - Incorrect length cylinder head bolts
    - A warped engine block surface
    - Scratched surfaces
    - Foreign material
    - Cracked engine block threaded holes

3. Clean the following components:
   - The gasket surfaces

     Do not use a motorized brush on the head gasket sealing surface.

   - Valve stems and valve heads
   - The bolt hole threads

     Remove all dirt, debris, or threadlocking material from the bolt holes.

4. Inspect the cylinder head mating surfaces for flatness. Use a feeler gauge and a straight edge.

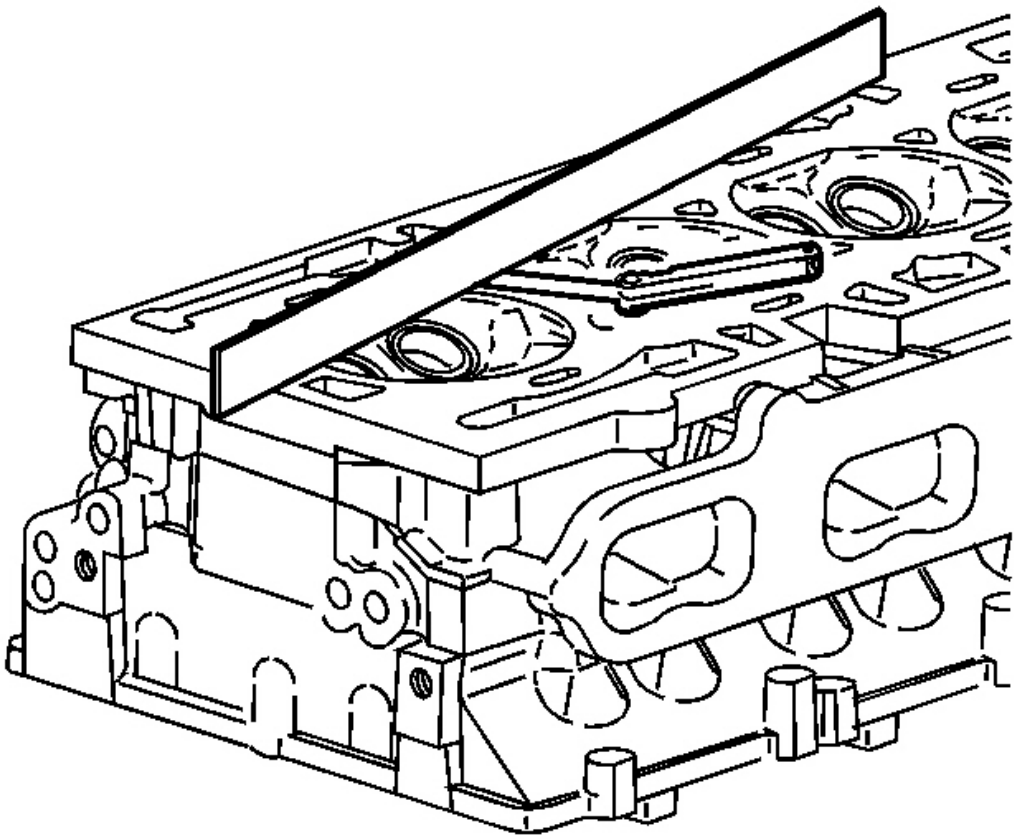


Fig. 382: Checking For Cylinder Head Warpage
Courtesy of GENERAL MOTORS CORP.

5. Replace the cylinder head if warped more than 0.08 mm (0.003 in).

6. Inspect the cylinder head for cracks.

IMPORTANT: Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head. Minor nicks may be repaired with a fine flat file or emery cloth.

7. Inspect the cylinder head deck for corrosion.

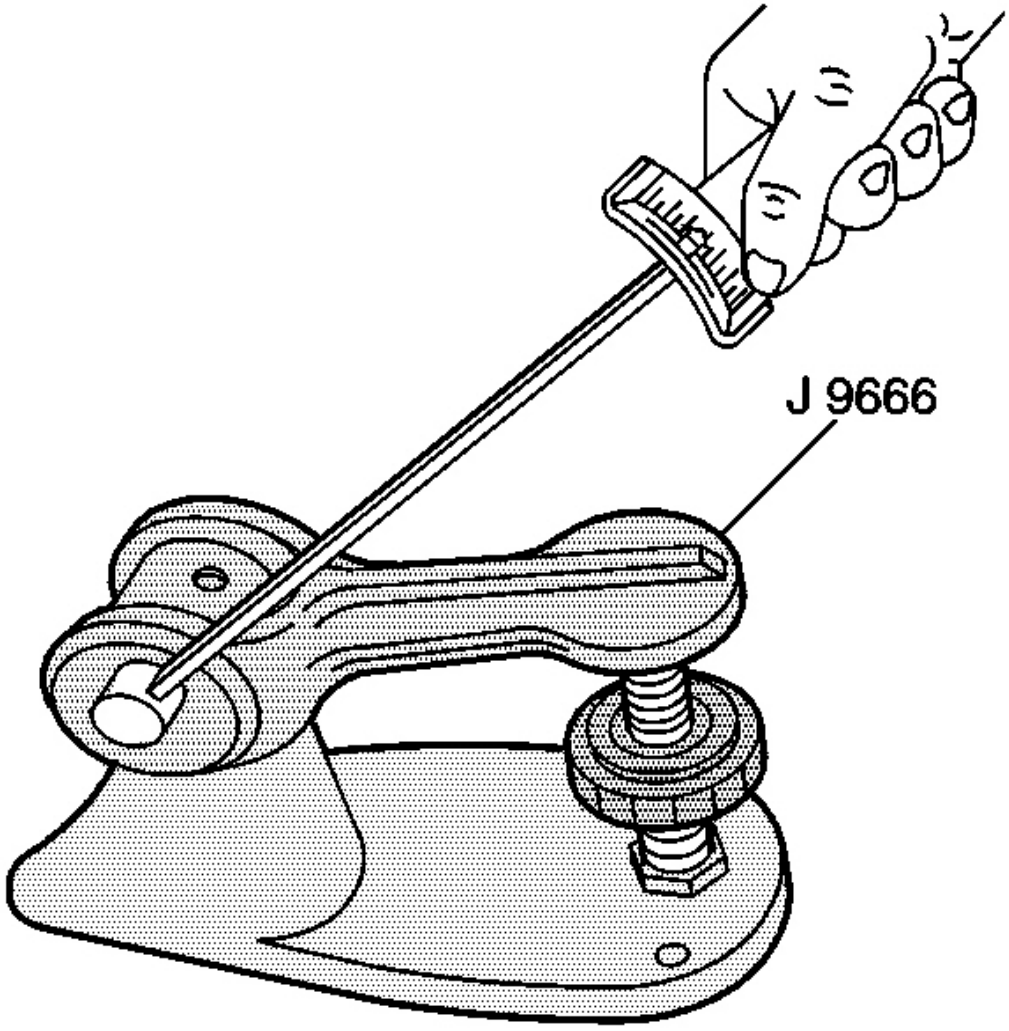


Fig. 383: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

8. Inspect the valve springs for squareness.
9. Use **J 9666** to measure the valve spring tension. Replace the valve spring if the tension is not within specification.

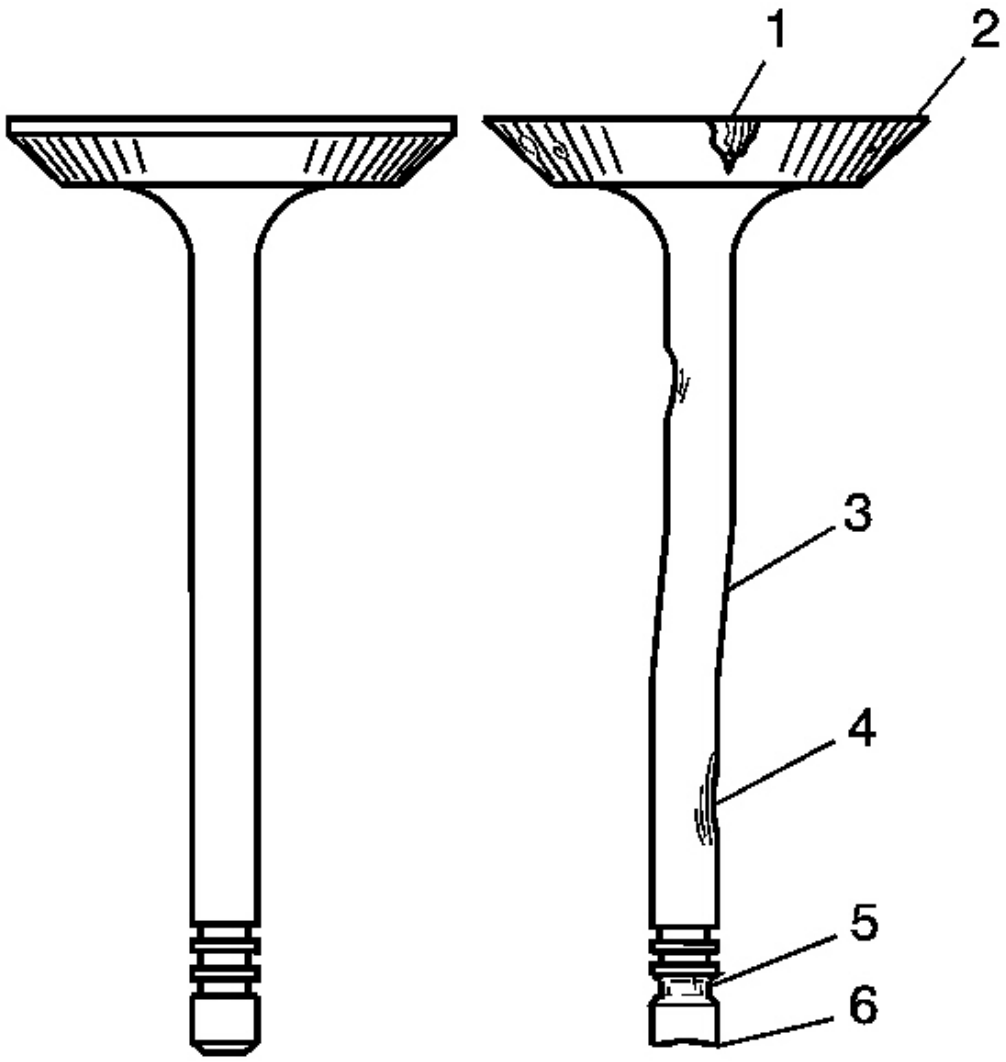


Fig. 384: Inspecting Valve Guides
Courtesy of GENERAL MOTORS CORP.

10. Inspect the valve guides for wear. The valve guides may be reamed oversized 0.075 mm (0.003 in) and oversized stemed valves may be installed. The same size valve seal should be used.

11. Inspect the valve seats for excessive wear, damage, or hot spots.
12. Use the following procedure to measure the valve seat concentricity:
    1. Lift the valve off the valve seat.
    2. Apply a dab of blue dye to the valve face.
    3. Seat and rotate the valve. The blue dye traces transferred to the valve seat are an indication of concentricity of the valve seat.
13. Use the following procedure to measure the valve runout:
    1. Clean off the blue dye.
    2. Apply blue dye to the valve seat.
    3. Seat and rotate the valve.
    4. The traces of blue dye transferred to the valve indicates valve runout.
14. Replace the head if the valve seats are damaged.
15. Inspect the valves for the following damage:
    - Grooving (1, 2)
    - Bent valve stem (3). Replace any bent valve.
    - Burrs or scratches (4). Minor burrs or scratches may be removed with a fine oil stone.
    - Chipped or worn key grooves (5). Replace if damaged.
    - Valve tip wear (6). Replace if worn.

Cleaning & Inspection Procedure

CYLINDER HEAD ASSEMBLE

Tools Required

- **EN 46119** Valve Spring Compressor Adapter. See **Special Tools**.
- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 38820** Valve Stem Seal Remover/Installer. See **Special Tools**.

Assembly Procedure

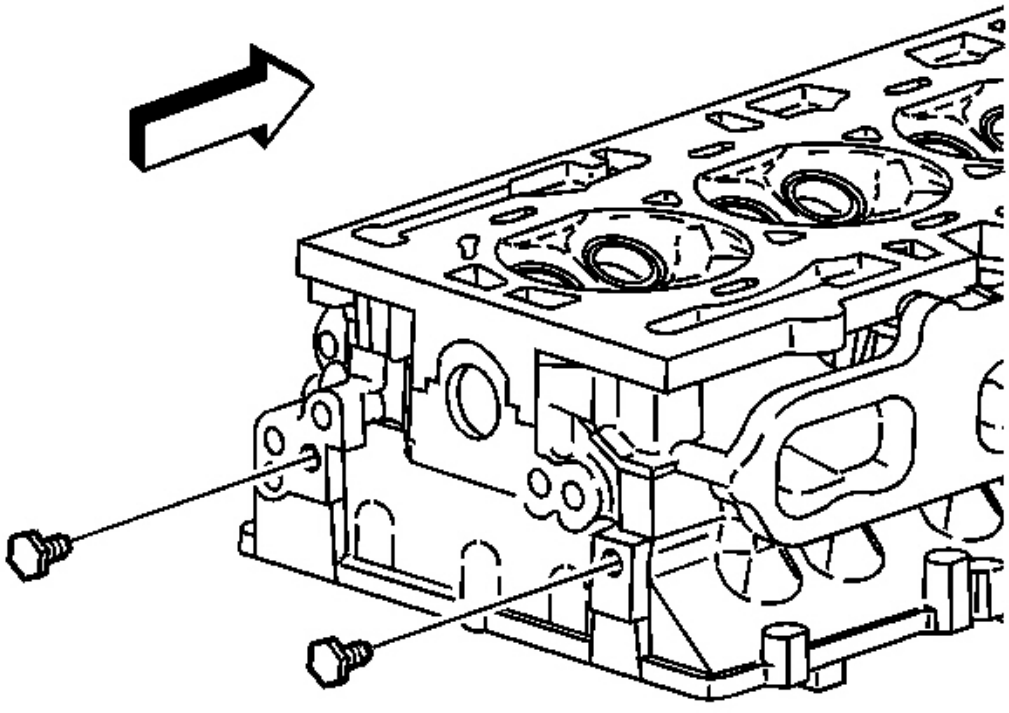


Fig. 385: View Of End Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the threads.

   NOTE: Refer to Fastener Notice .

2. Install the (end) oil gallery plugs.

   Tighten: Tighten the oil gallery plugs to 38 N.m (28 lb ft).

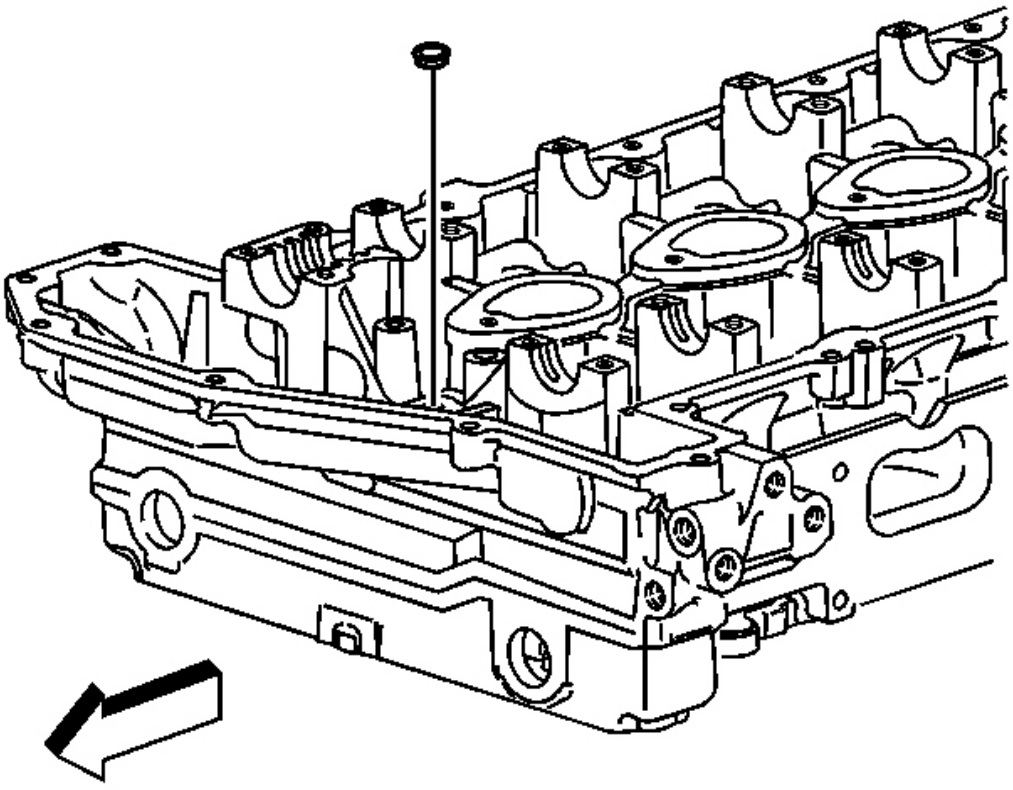


Fig. 386: View Of Inner Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

3. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the plugs.
4. Install the (inner) oil gallery plugs.

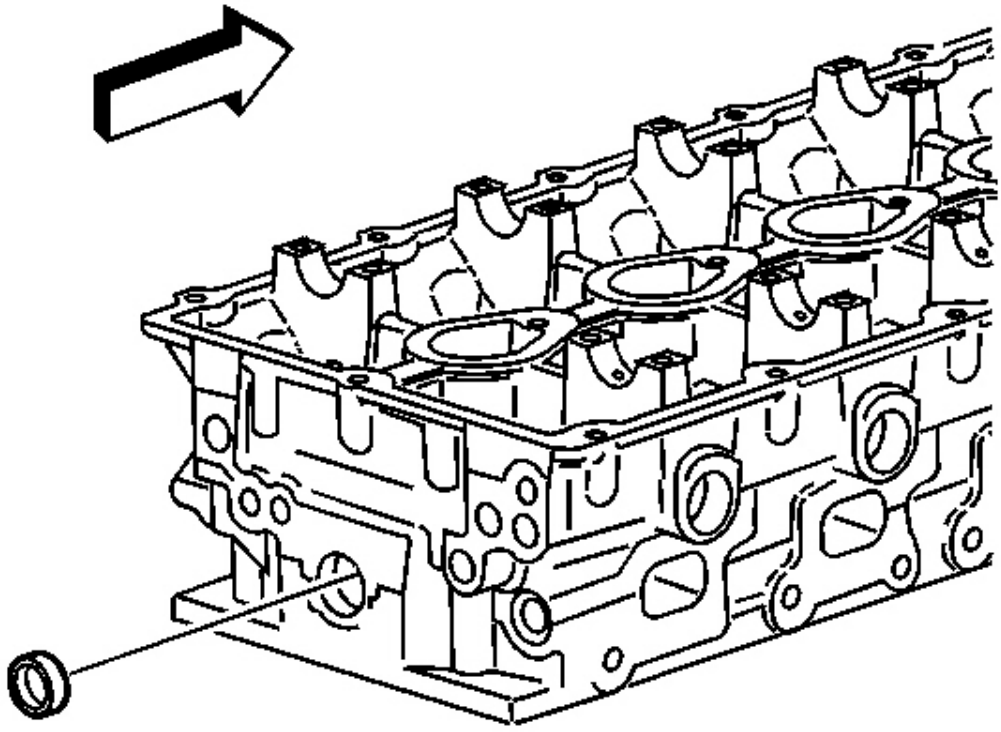


Fig. 387: View Of Water Jacket Plug
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the plug.
6. Install the water jacket plug.

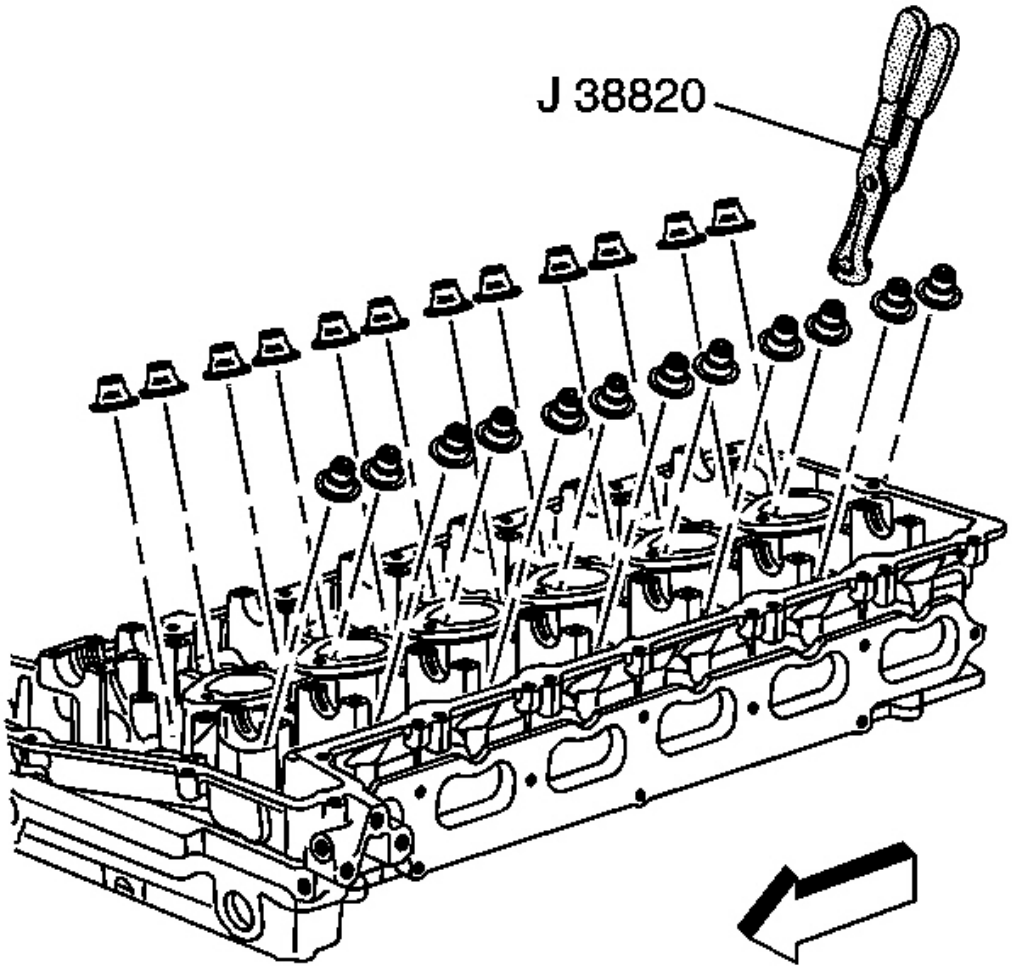


Fig. 388: View Of J 38820 & Valve Seals
Courtesy of GENERAL MOTORS CORP.

7. Use **J 38820** to install the valve seals. See **Special Tools**. There is only one size valve seal.

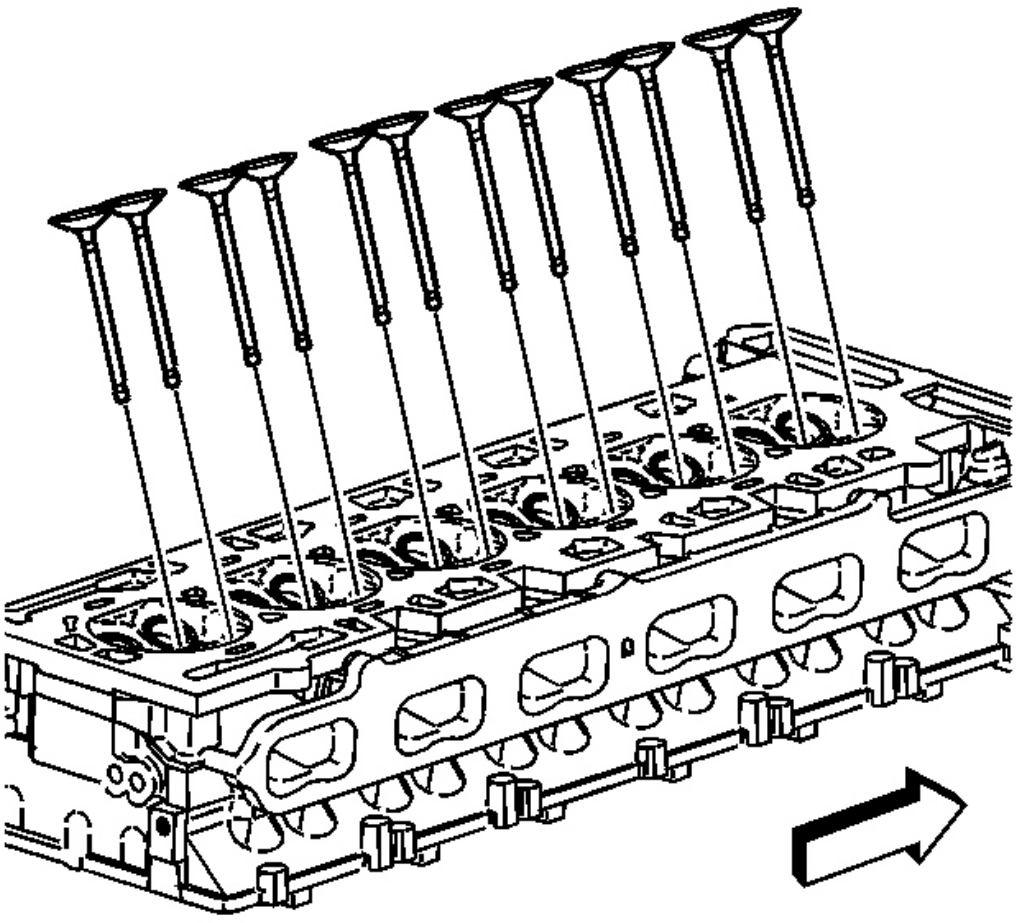


Fig. 389: View Of Valves
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lubricate the valve stems with clean engine oil before installing.

8. Install the valves. 0.075 mm (0.003 in) oversized valves are available if the valve guides needed to be reamed. Use the same (original size) valve seal.

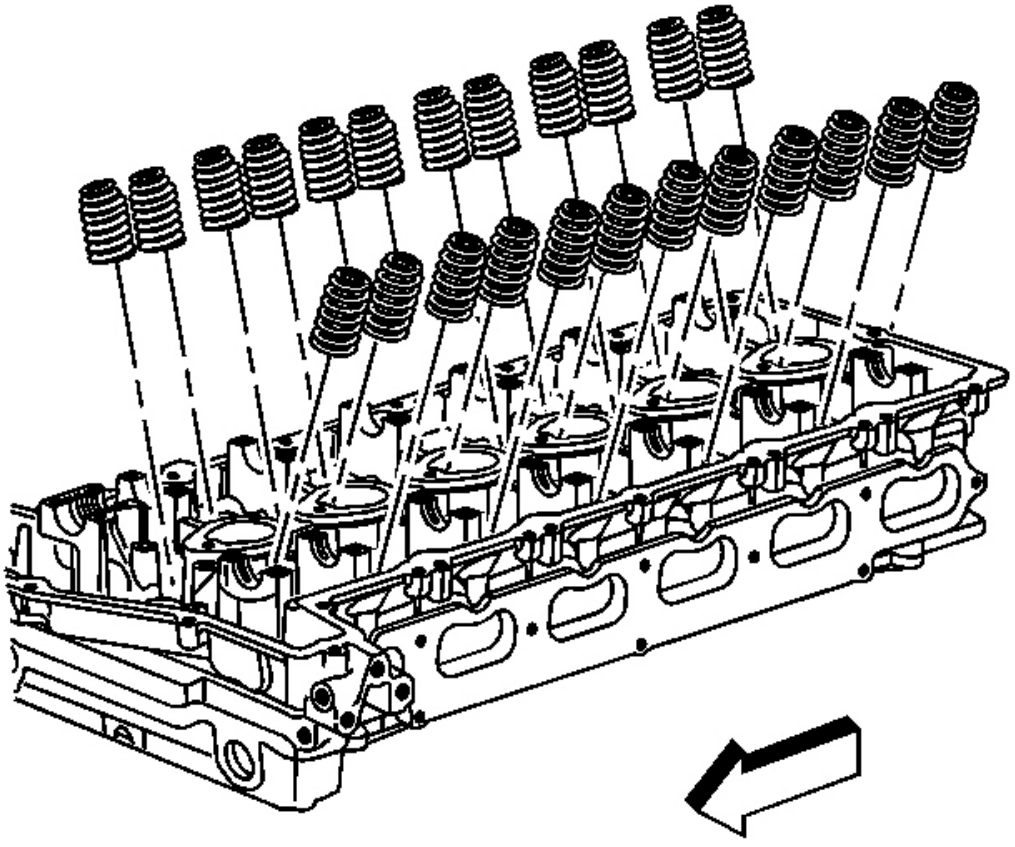


Fig. 390: Identifying Valve Springs
Courtesy of GENERAL MOTORS CORP.

9. Install the valve spring and the valve spring retainer.

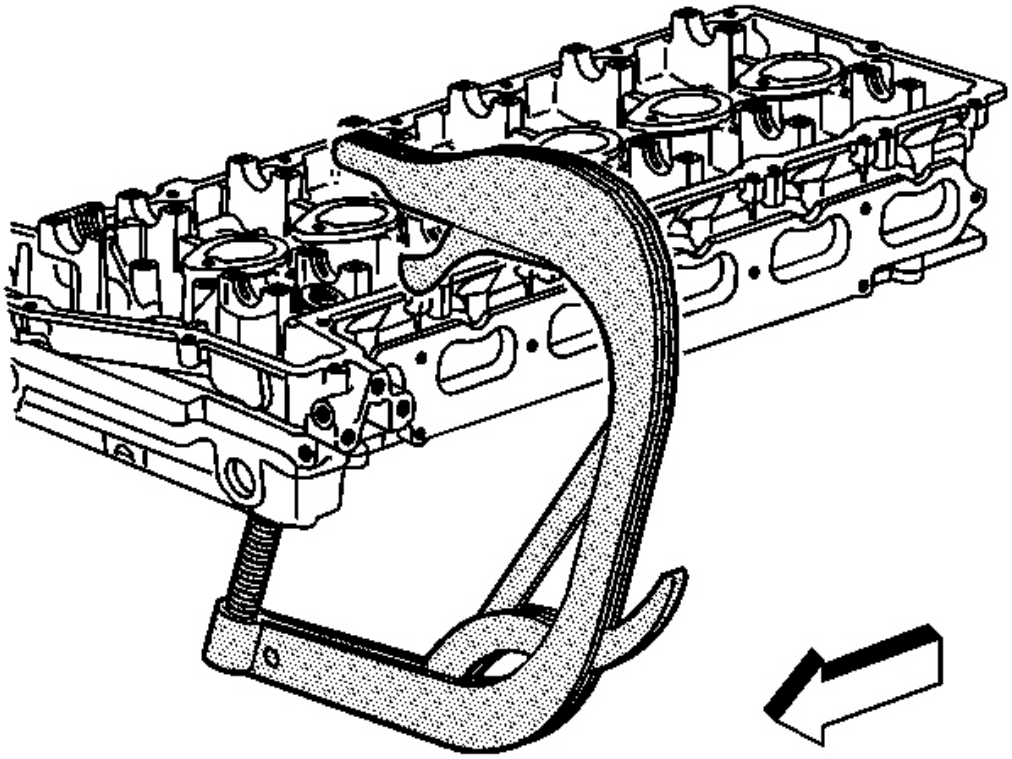


Fig. 391: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

10. Use **J 8062** and **EN 46119** to compress the valve spring. See **Special Tools**.

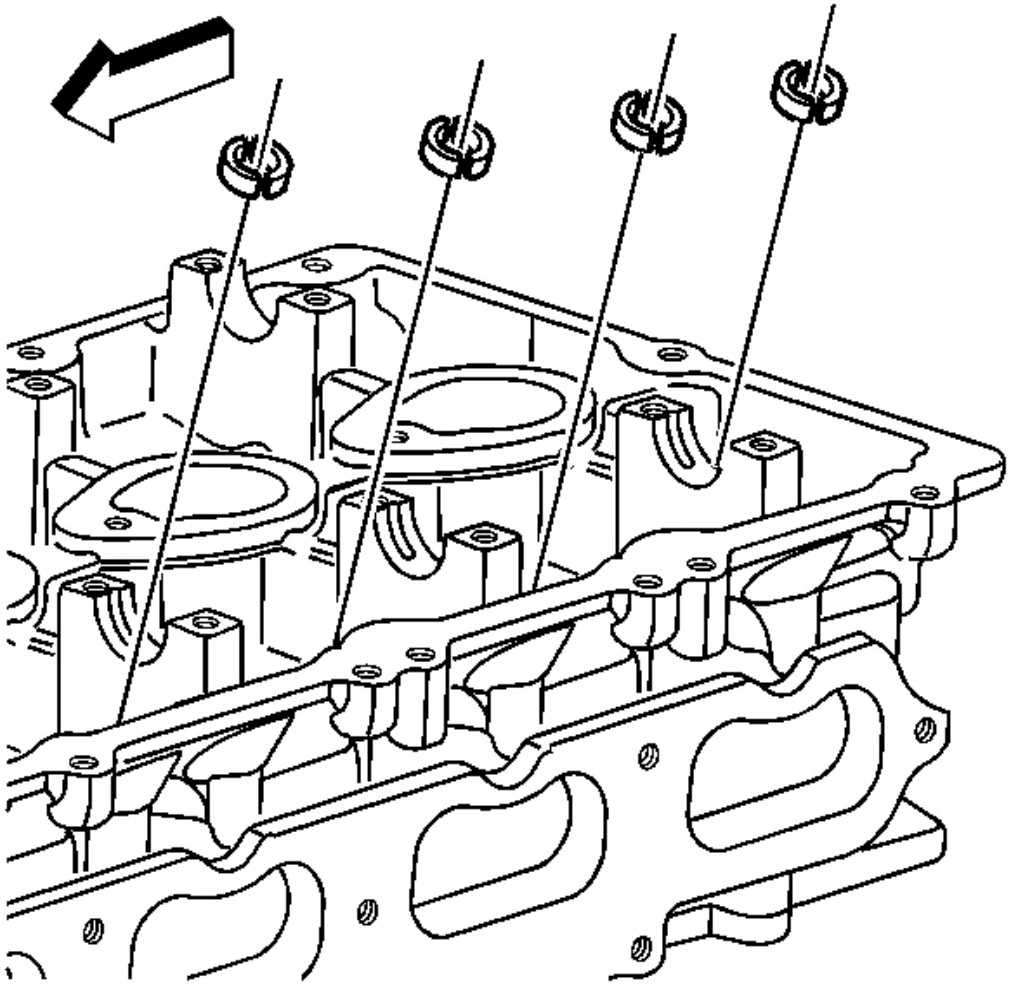


Fig. 392: View Of Valve Keys
Courtesy of GENERAL MOTORS CORP.

11. Install the valve keys.
12. Remove **J 8062** and **EN 46119** . See **Special Tools**.

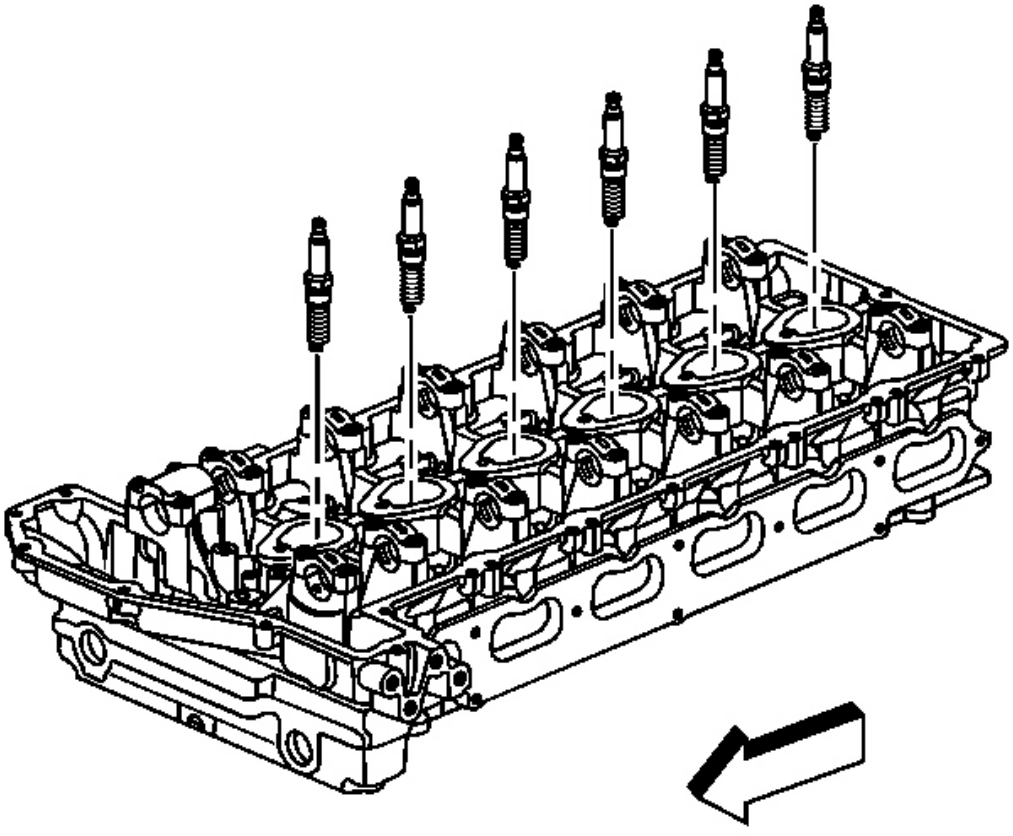


Fig. 393: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not try to centralize the electrode on the spark plug. The electrode is offset by design.

13. Install the spark plugs.

CAMSHAFT COVER CLEANING & INSPECTION

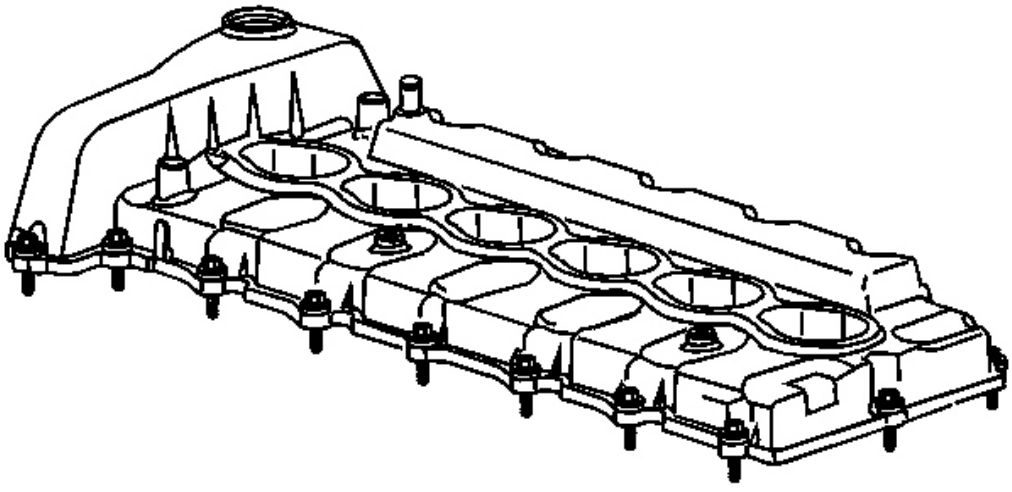


Fig. 394: View Of Camshaft & Cover Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the rubber ignition coil seals, and the camshaft cover seal.
2. Clean the camshaft cover with a suitable cleaning solvent.
3. Inspect the camshaft cover for cracks or damage.
4. Inspect the bolt threads for damage.
5. Replace the camshaft cover if necessary.

OIL PUMP CLEANING & INSPECTION

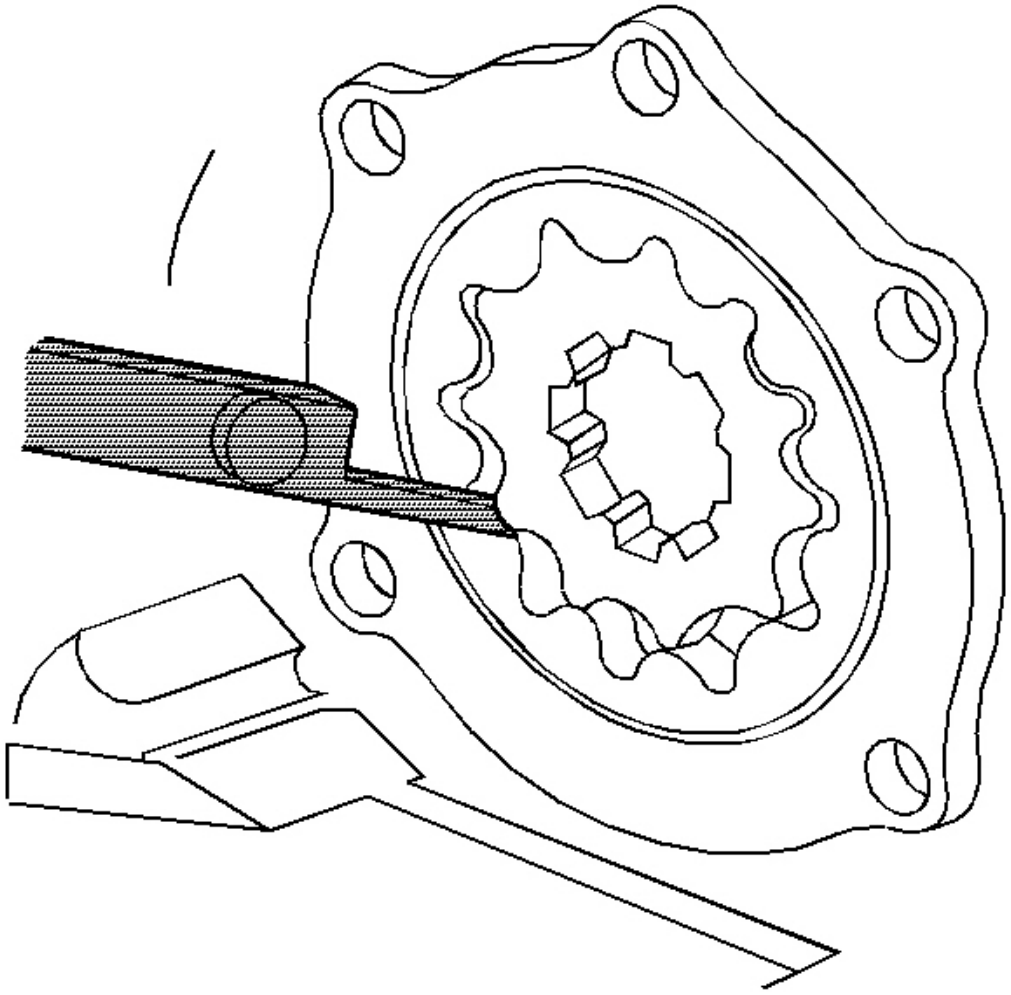


Fig. 395: Measuring Inner Oil Pump Gear Tip Clearance
Courtesy of GENERAL MOTORS CORP.

1. Clean all parts of sludge, oil, and varnish by soaking in carburetor cleaner or cleaning solvent.
2. Inspect for foreign material and determine the source of the foreign material.
3. Inspect the oil pump housing and engine front cover for the following conditions:
    - Cracks or casting imperfections
    - Scoring
    - Damaged threads
4. Do not attempt to repair the oil pump housing. Replace the oil pump housing if damage is found.

5. Inspect the oil pump gears for damage.
6. Measure the inner oil pump gear tip clearance in several places.

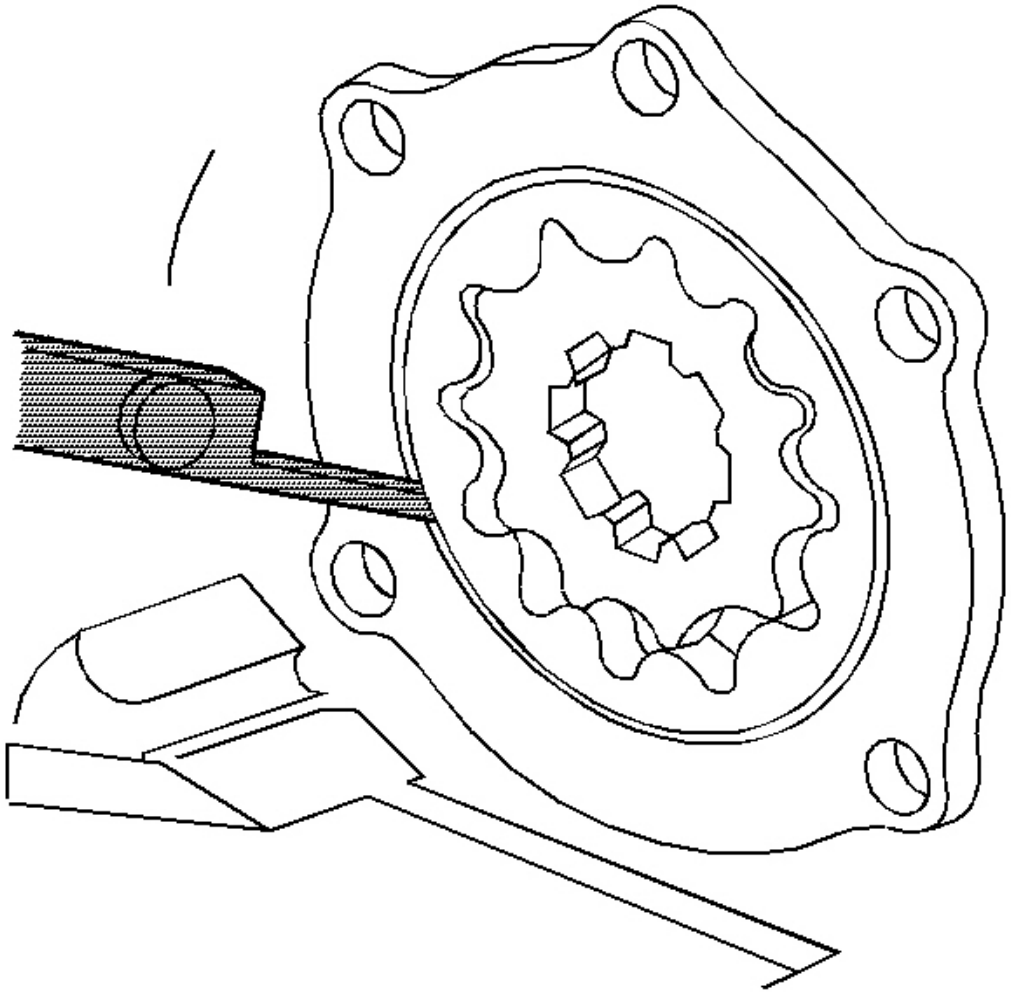


Fig. 396: Measuring Outer Oil Pump Gear Diameter Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the outer oil pump gear tip clearance in several places.

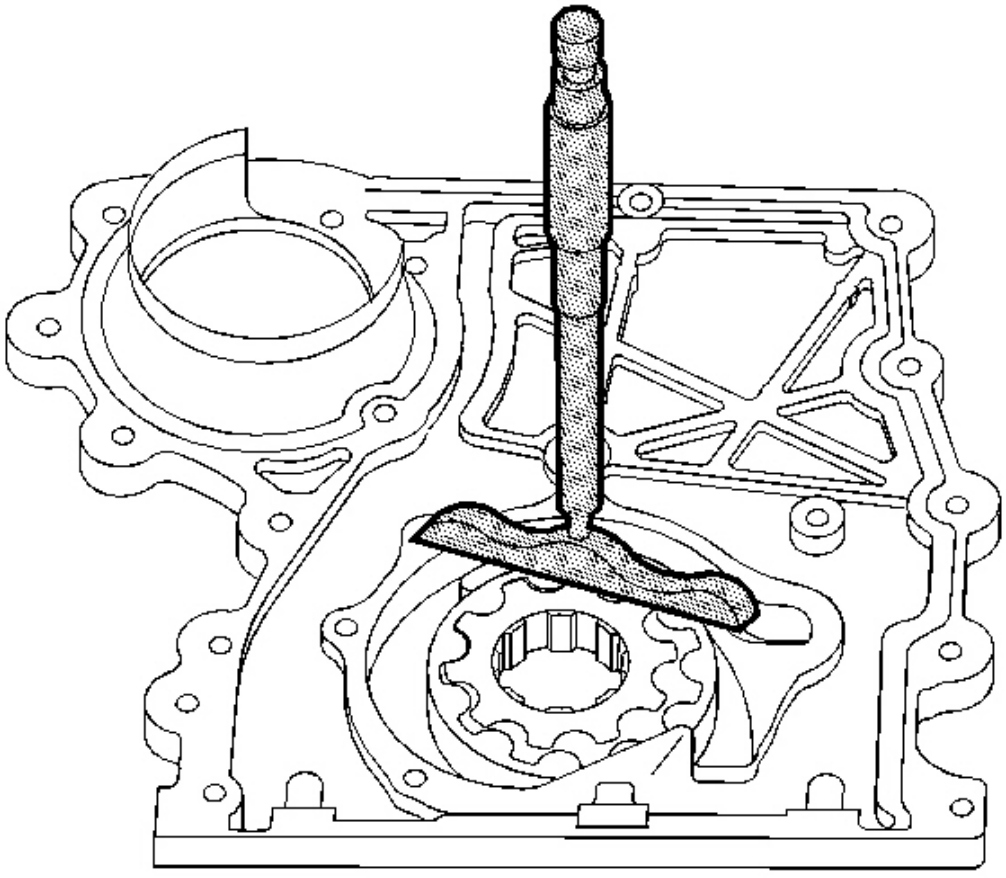


Fig. 397: Measuring Clearance Of Oil Pump Gear Side
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When deciding oil pump serviceability based on end clearance, consider depth of the wear pattern in the pump cover.

8. Measure the oil pump gear side clearance.
9. Inspect the pressure regulator valve for the following conditions:
   - Scoring
   - Sticking
   - Burrs - Burrs may be removed using a fine oil stone.
10. Inspect the pressure regulator valve spring for loss of tension or bending. Replace the pressure regulator spring if damaged.

11. Inspect the oil pump pipe pickup tube and screen assembly for the following conditions:
    - Looseness - If the oil pump pipe pickup tube is loose or bent, replace the oil pump pipe pickup tube.
    - Broken wire mesh or screen
    - Inspect the O-ring seal at the base of the oil pump pickup tube for damage.

OIL PAN CLEANING & INSPECTION

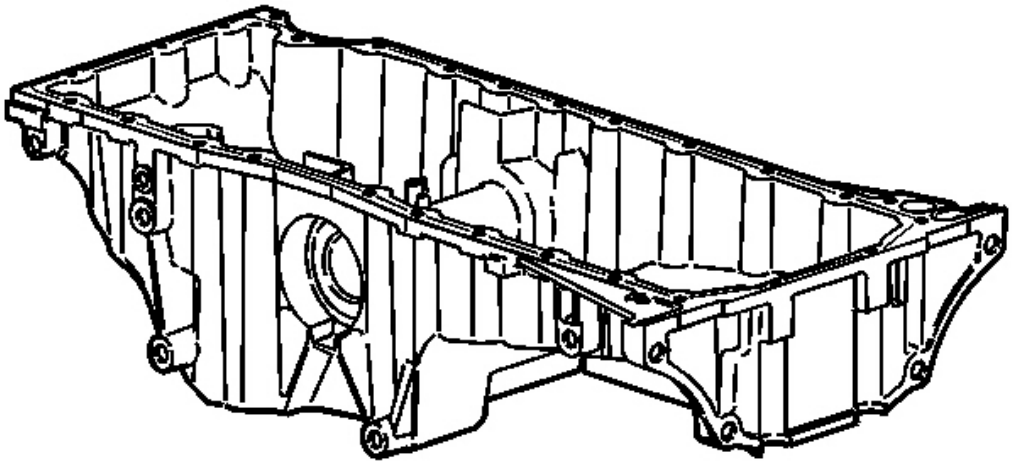


Fig. 398: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pan in solvent. Remove all sludge and debris from the oil pan.

IMPORTANT: Do not use a motorized tool or bristle disc to clean this component.

2. Remove all sealing material from the oil pan rails.
3. Inspect the oil pan sealing surfaces for nicks or damage. Remove any minor nicks with a fine flat file.
4. Inspect the threads in the oil drain plug hole.
5. Replace the oil pan if necessary.

ENGINE FRONT COVER CLEANING & INSPECTION

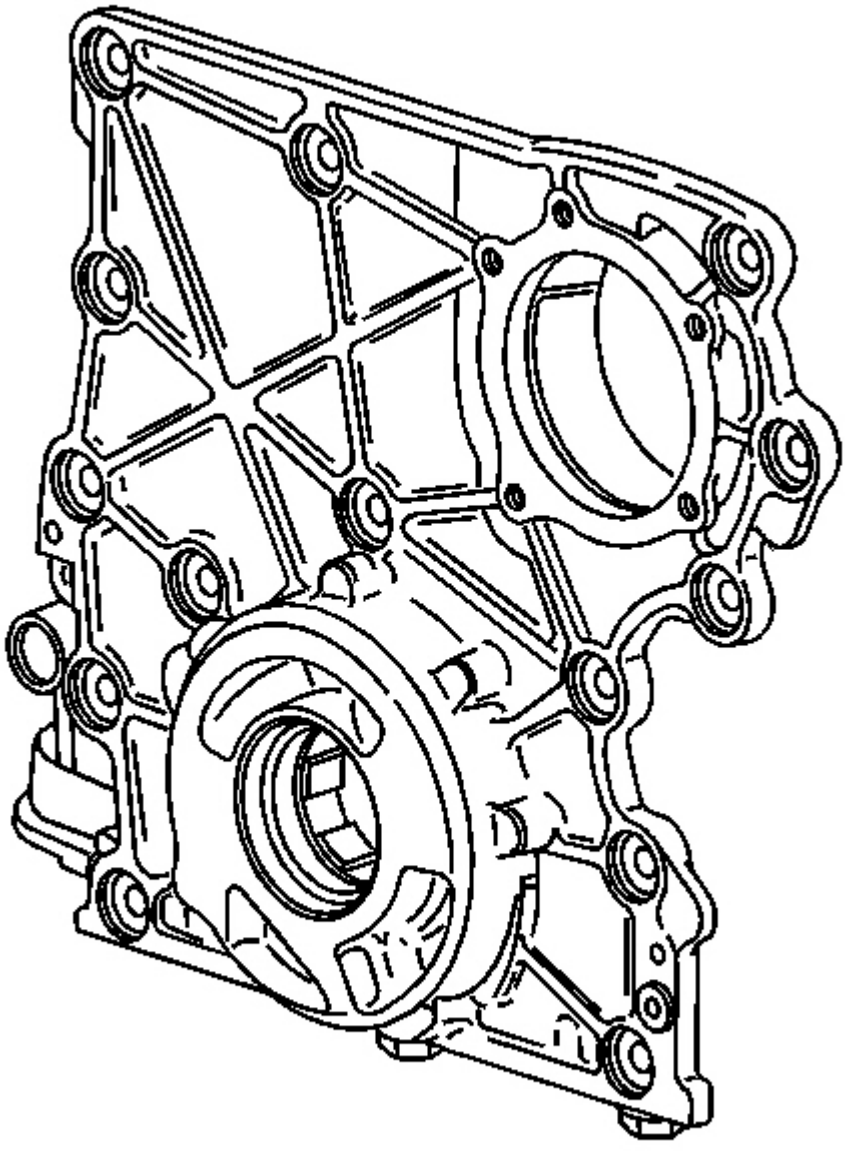


Fig. 399: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine front cover with cleaning solvent.

IMPORTANT: Do not use a motorized tool or bristle disc to clean this component.

2. Remove all sealing material.
3. Inspect the engine front cover sealing surfaces for nicks or damage. Use a fine flat file to remove any minor nicks.
4. Inspect the engine front cover threaded holes for damage.
5. Repair or replace the engine front cover as necessary.

INTAKE MANIFOLD CLEANING & INSPECTION

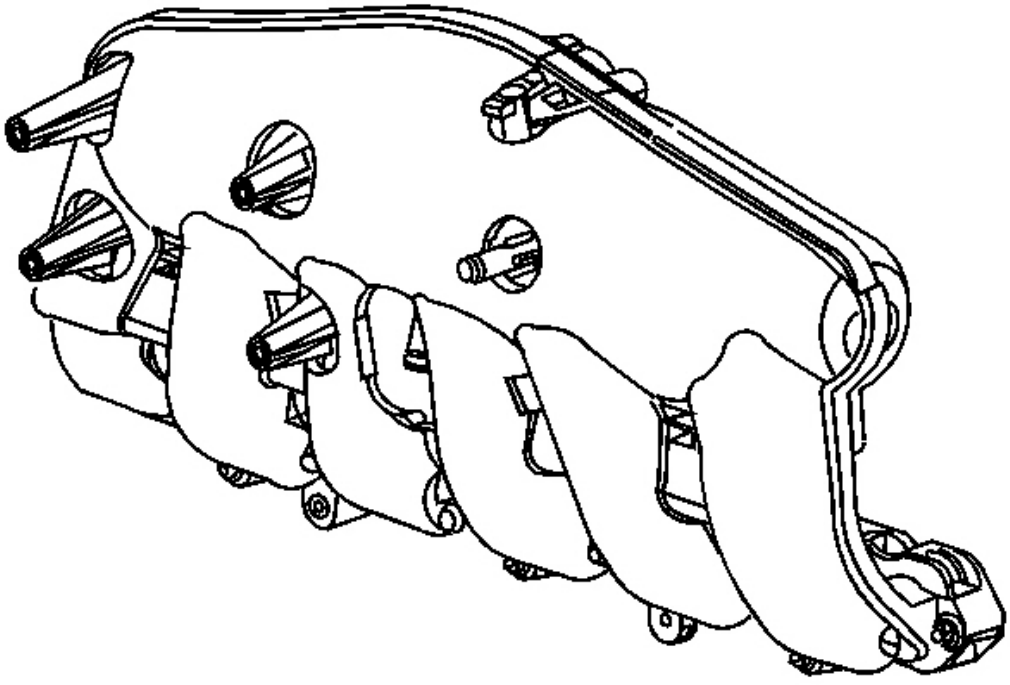


Fig. 400: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the intake manifold gasket mating surface.
2. Inspect the threads on the retaining bolts.
3. Inspect the intake manifold for cracks.
4. Clean the internal ports of all debris.
5. Replace the intake manifold if necessary.

EXHAUST MANIFOLD CLEANING & INSPECTION

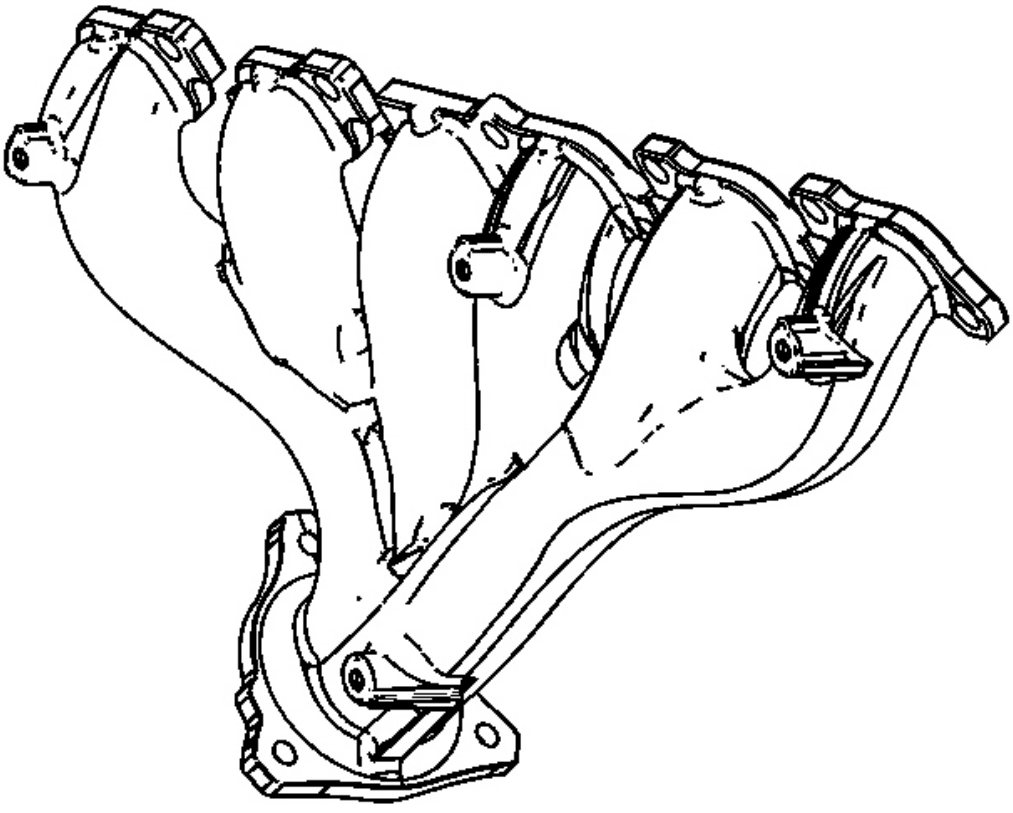


Fig. 401: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the exhaust manifold.
2. Inspect the exhaust manifold for cracks or damage.
3. Inspect the exhaust manifold threads and studs (if necessary).

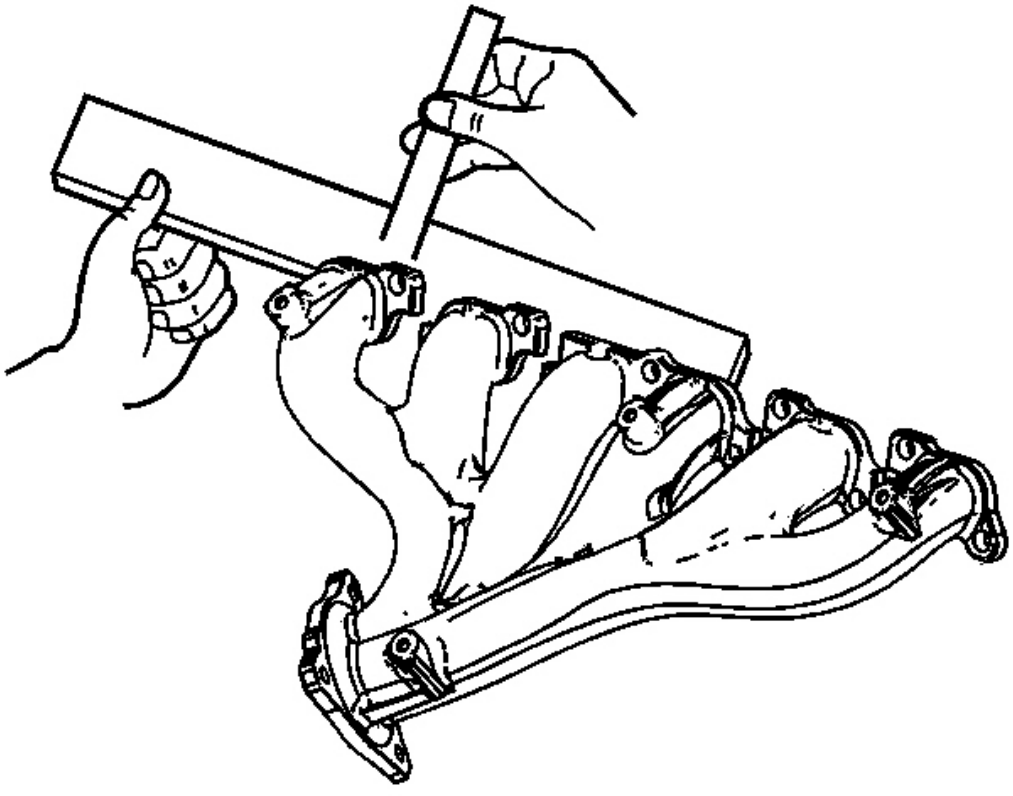


Fig. 402: Checking Exhaust Manifold Mating Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

4. Check the exhaust manifold mating surface for flatness. Use a straight edge and a feeler gauge.
5. Replace the exhaust manifold if necessary.

WATER PUMP CLEANING & INSPECTION

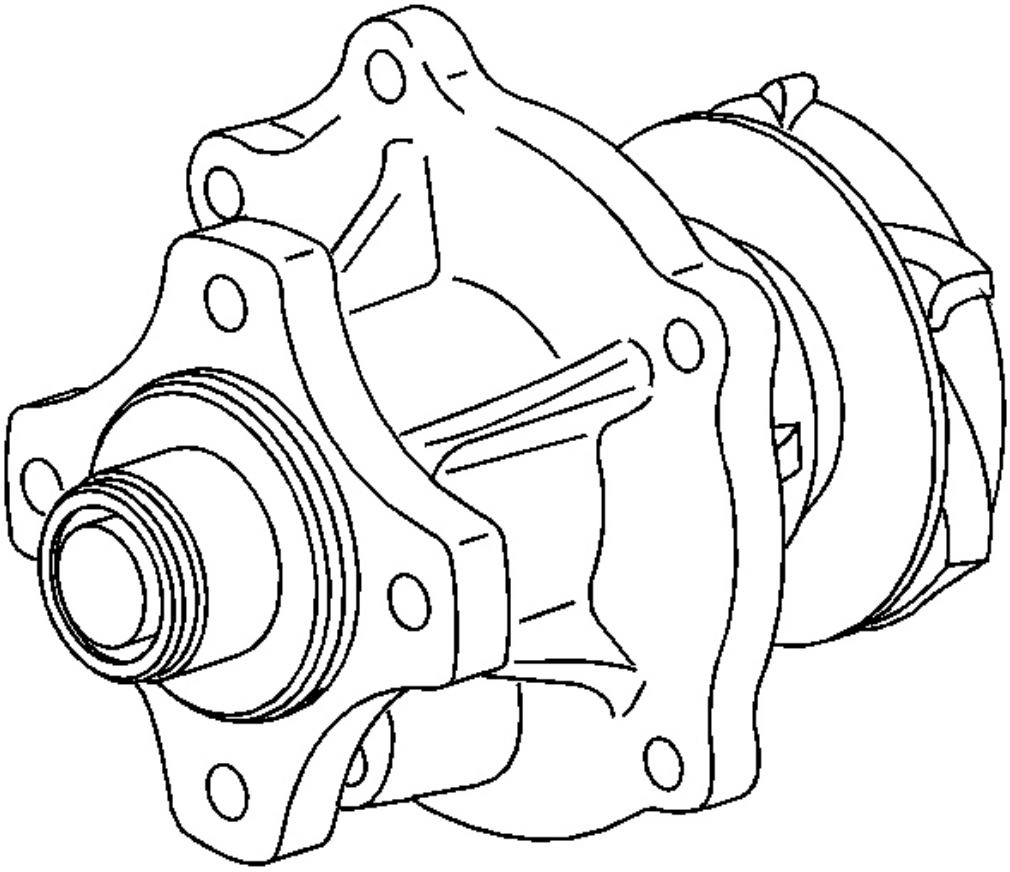


Fig. 403: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove all sealing material from the sealing surface.
2. Inspect the water pump impeller for damage.
3. Inspect the water pump shaft for looseness.
4. Inspect the threads for damage.
5. Replace the water pump if necessary.

THREAD REPAIR

Tools Required

- **J 42385-400** Thread Repair Kit. See **Special Tools**.

- **J 43965** Extension Kit. See **Special Tools**.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.

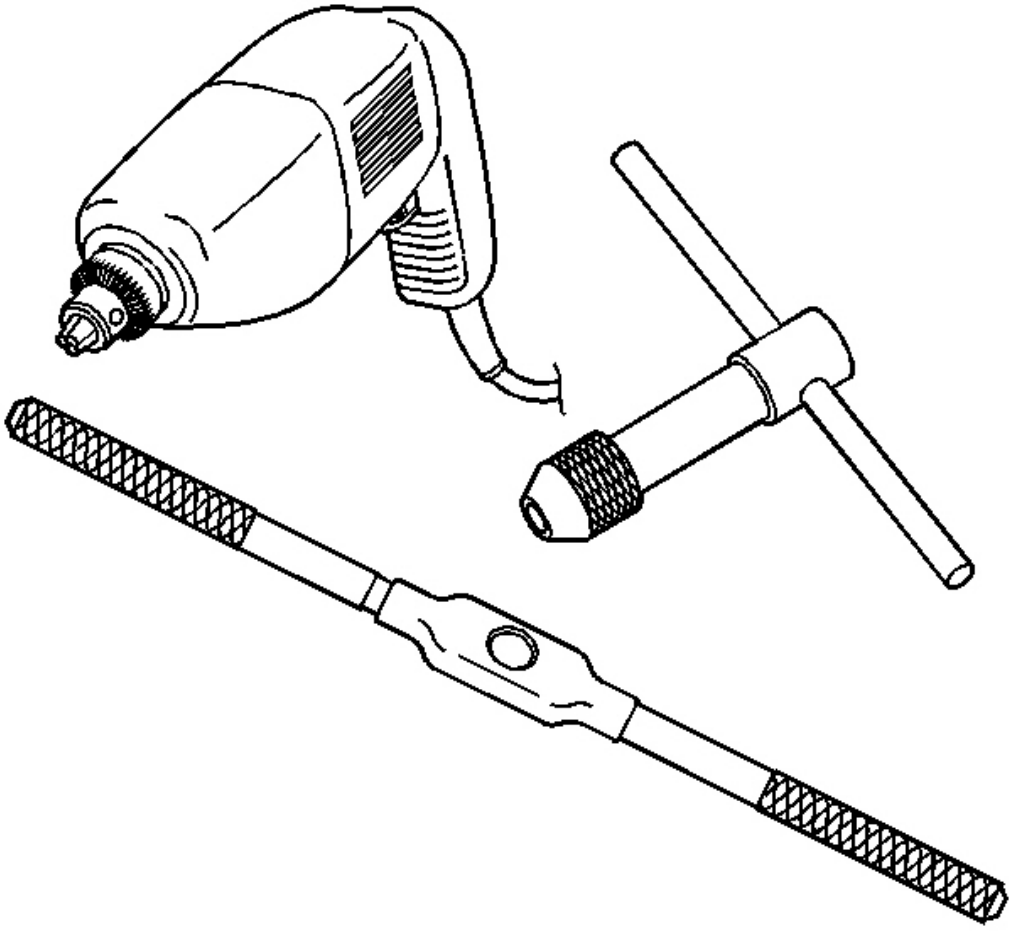


Fig. 404: View Of J 42385-400 Tool Kit
Courtesy of GENERAL MOTORS CORP.

The tool kit **J 42385-400** is designed for use with either a suitable tap wrench or drill motor. See **Special Tools**. Limited access and larger hole repair may process better using a tap wrench. An extension **J 43965** may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. See **Special Tools**.

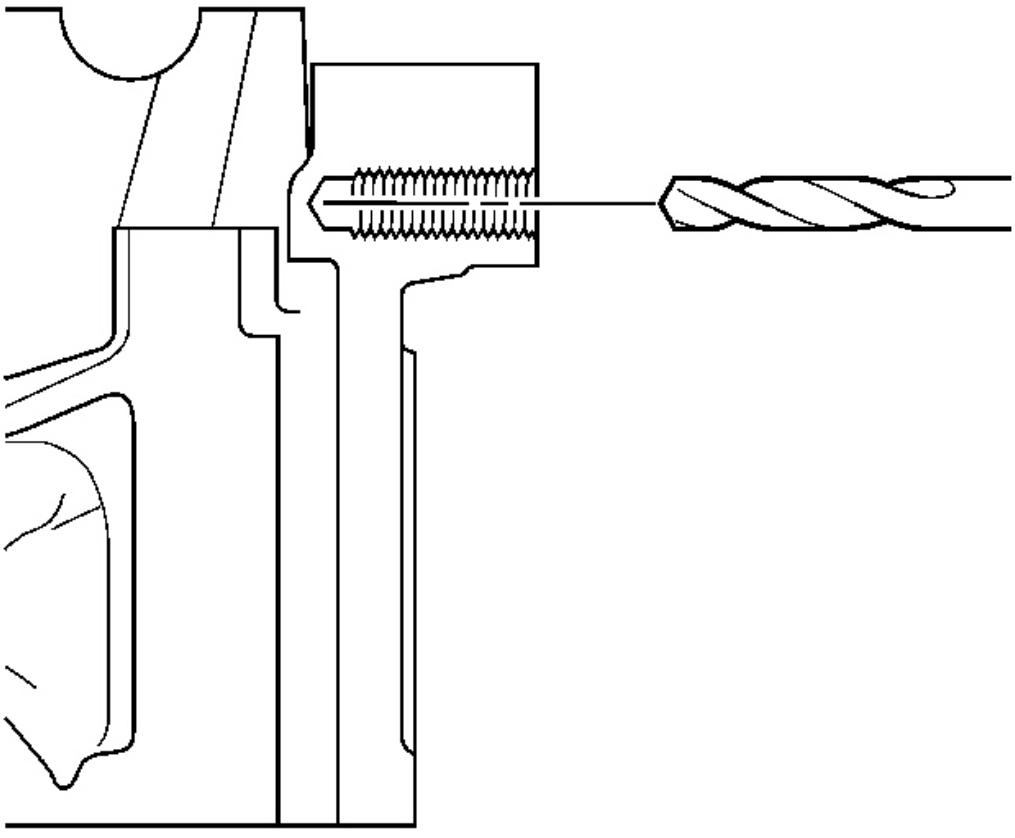


Fig. 405: View Of Drilled Hole Centerline
Courtesy of GENERAL MOTORS CORP.

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

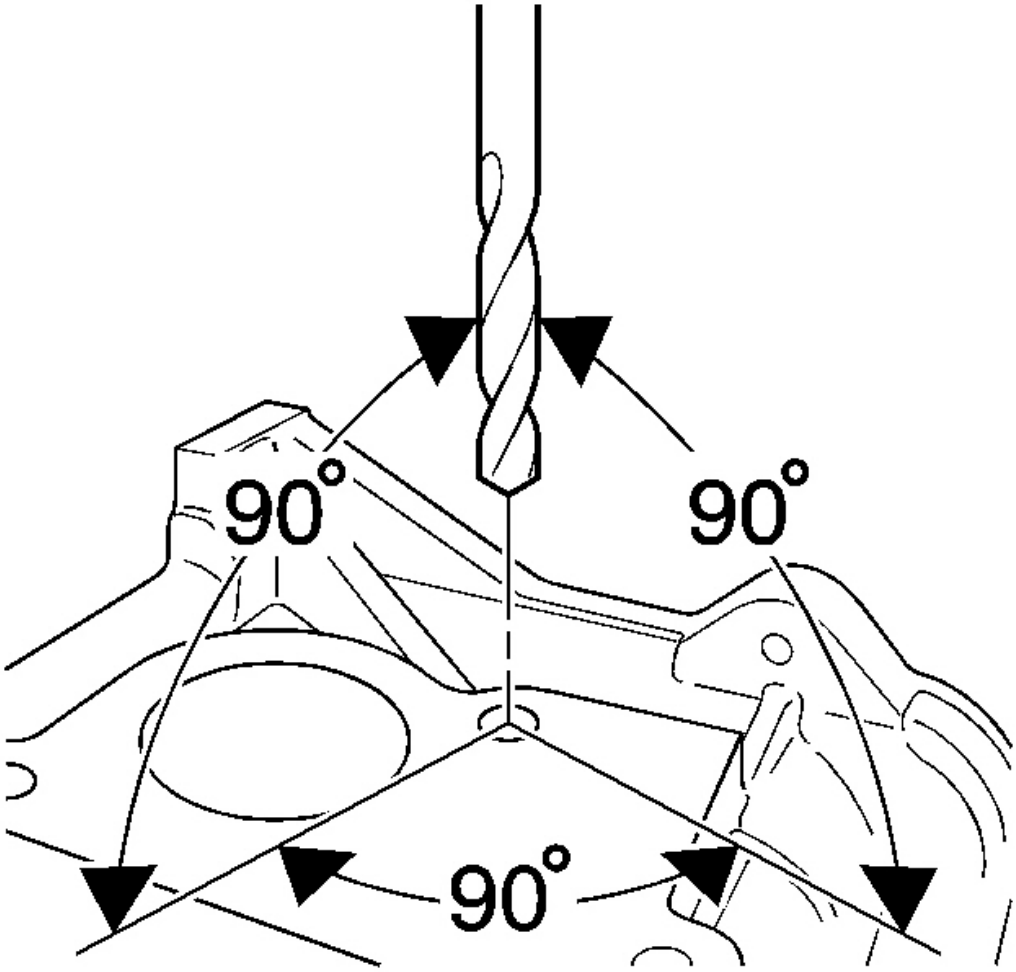


Fig. 406: Identifying Proper Drilling Angle
Courtesy of GENERAL MOTORS CORP.

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

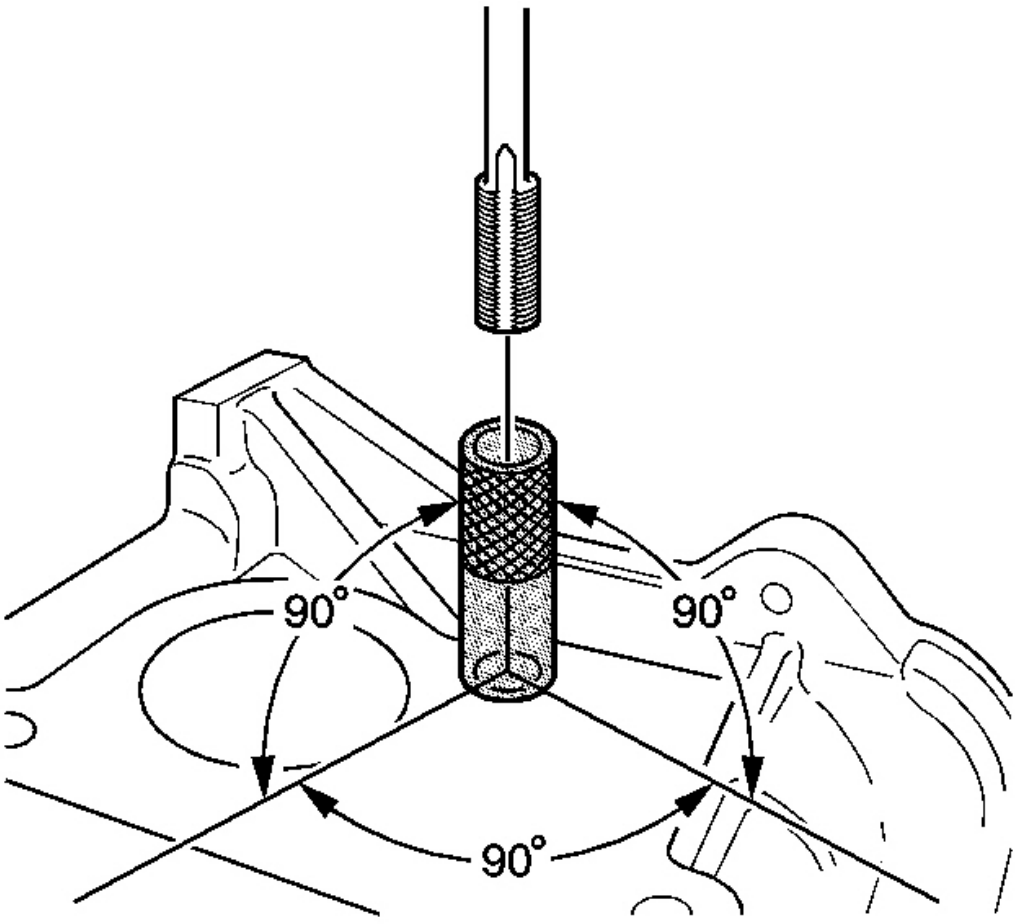


Fig. 407: View Of Tapping Guide
Courtesy of GENERAL MOTORS CORP.

If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Tap Size	Tap Guide	Tap Size	Tap Guide	Tap Size	Tap Guide
-	J 42385-	-	J 42385-	-	J 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

Standard Thread Repair - Flush Hole

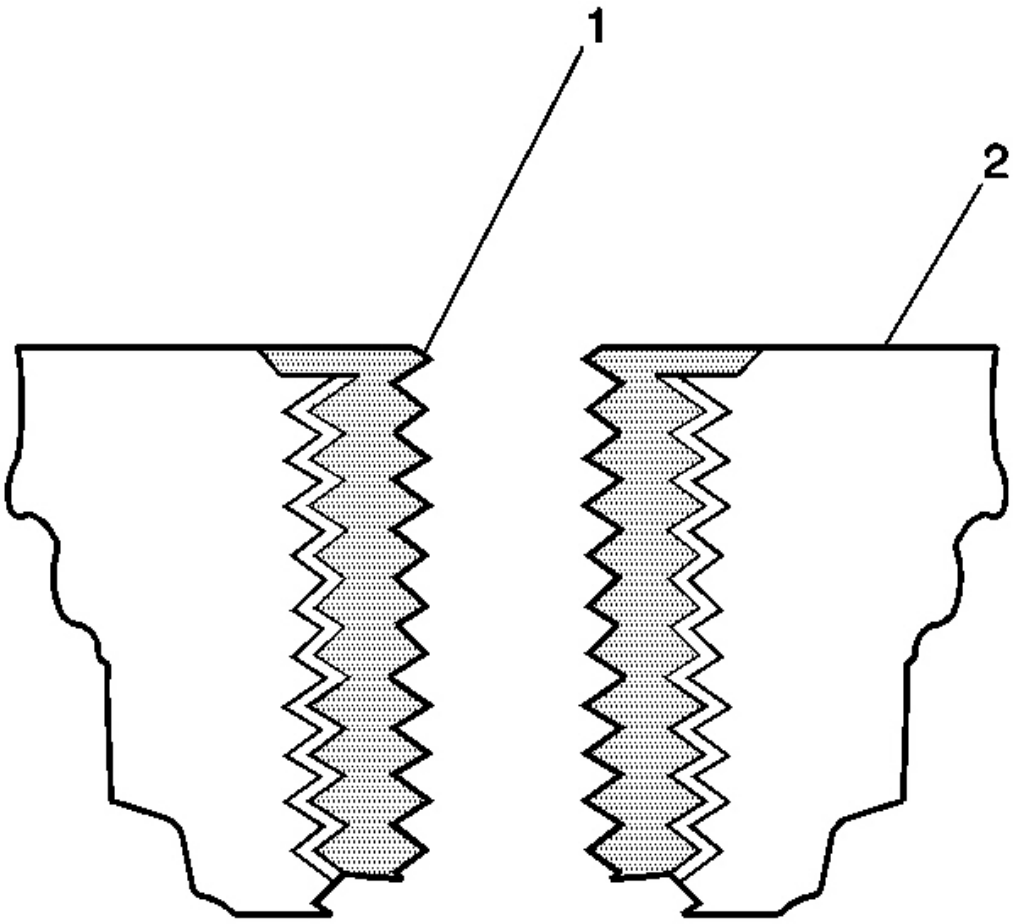


Fig. 408: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, Canadian P/N 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

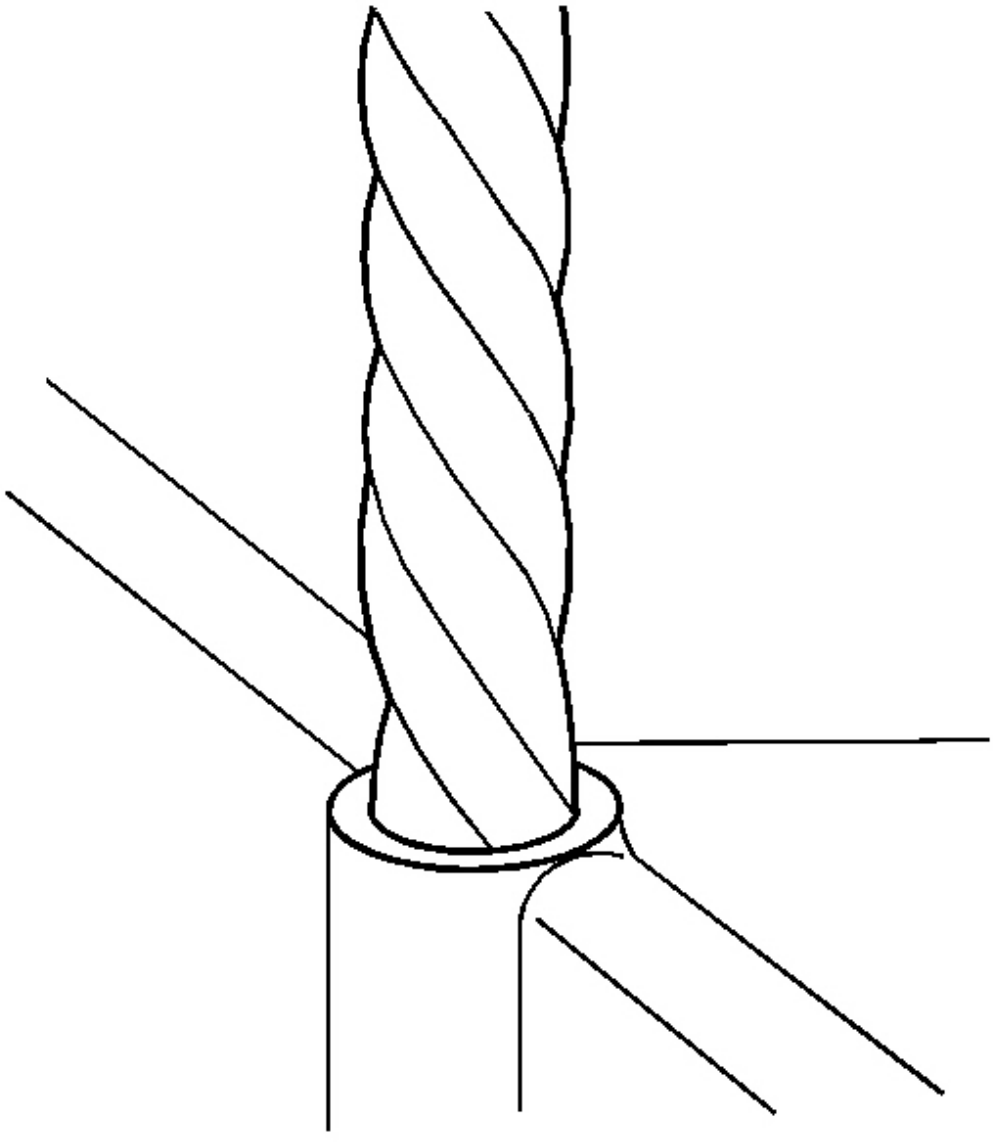


Fig. 409: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Do NOT drill any further than the original hole depth.**

1. Drill out the threads of the damaged hole.
    - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
    - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
    - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

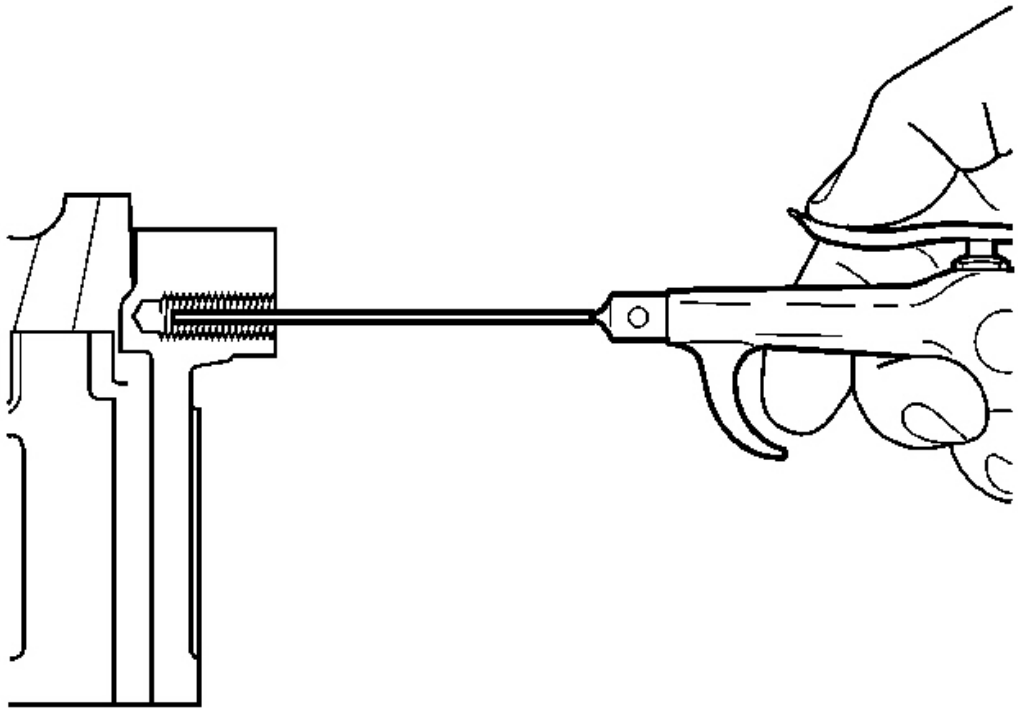


Fig. 410: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

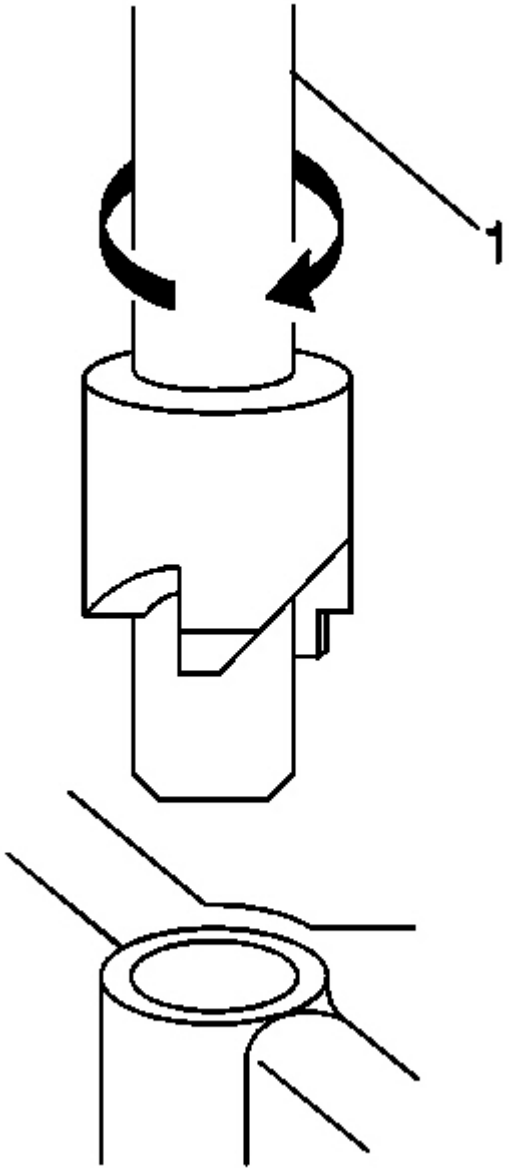


Fig. 411: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

3. Counterbore the drilled hole to the full depth permitted by the tool (1).

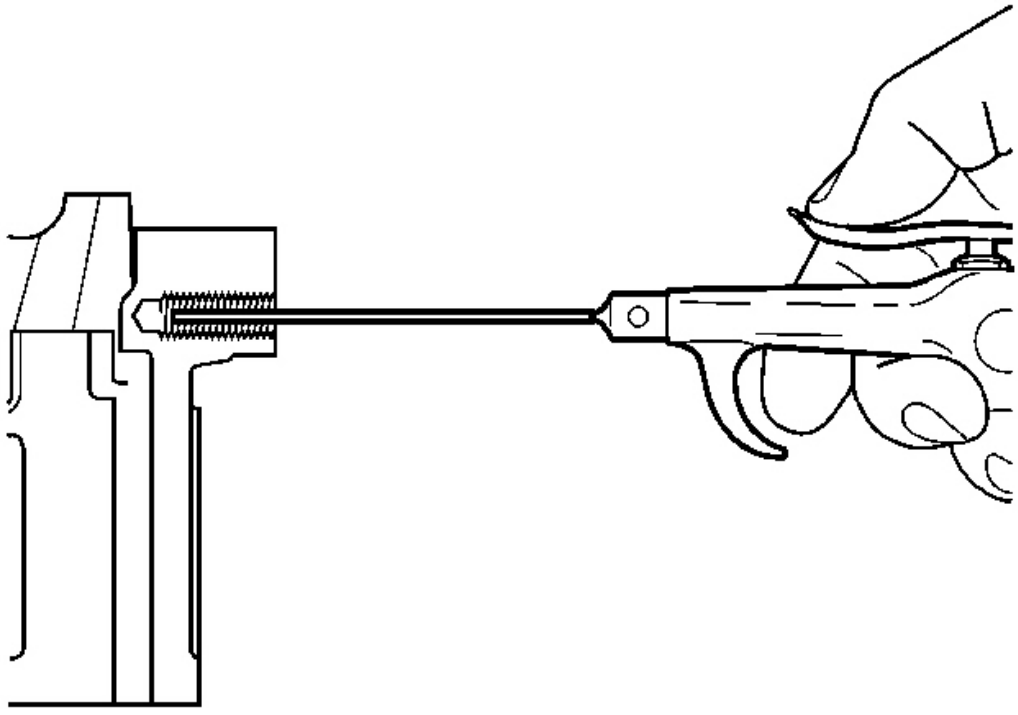


Fig. 412: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

4. Using compressed air, clean out any chips.

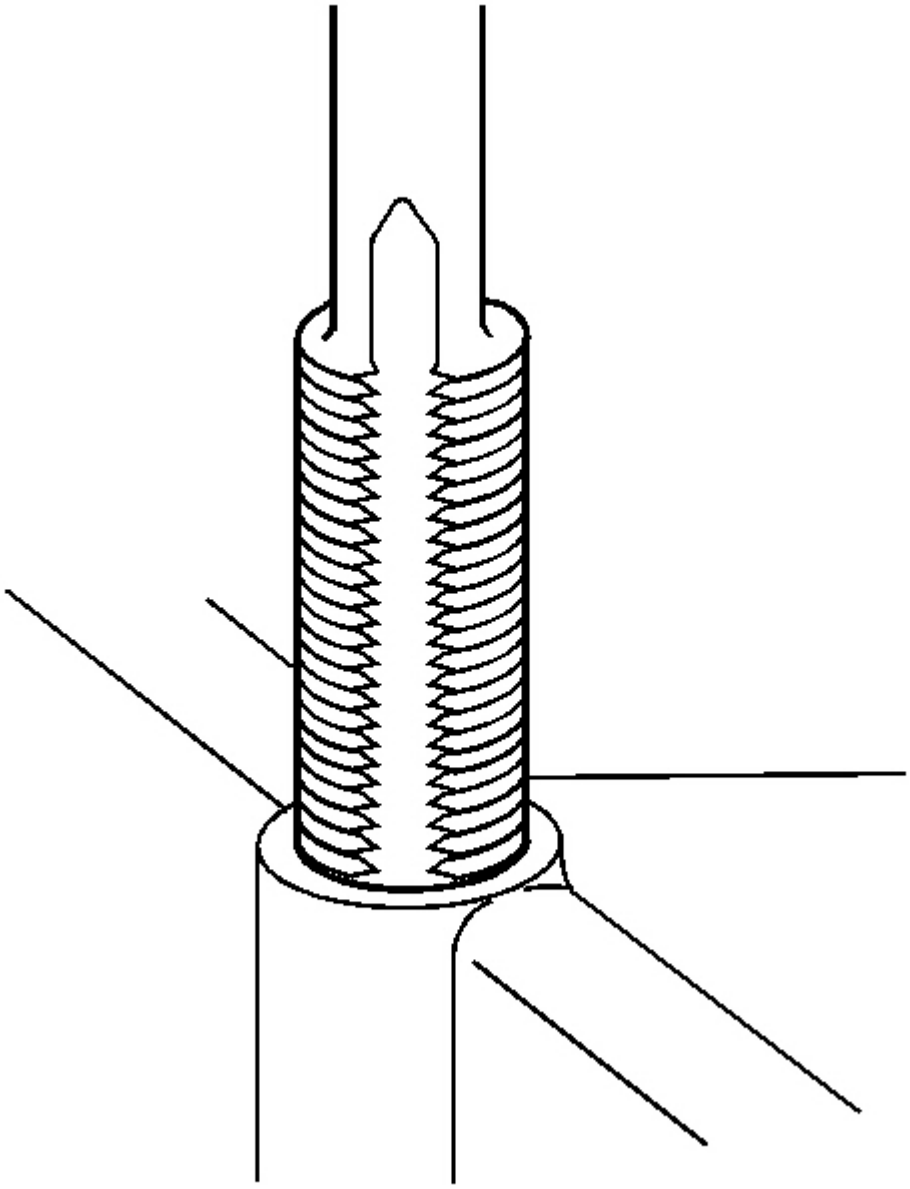


Fig. 413: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

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

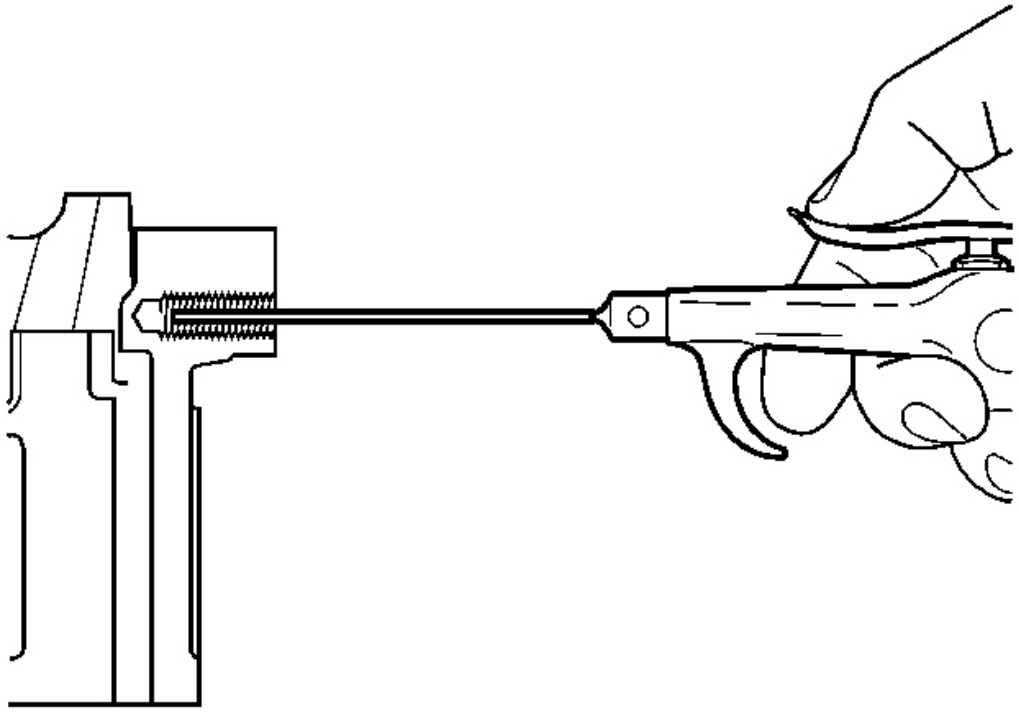


Fig. 414: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.

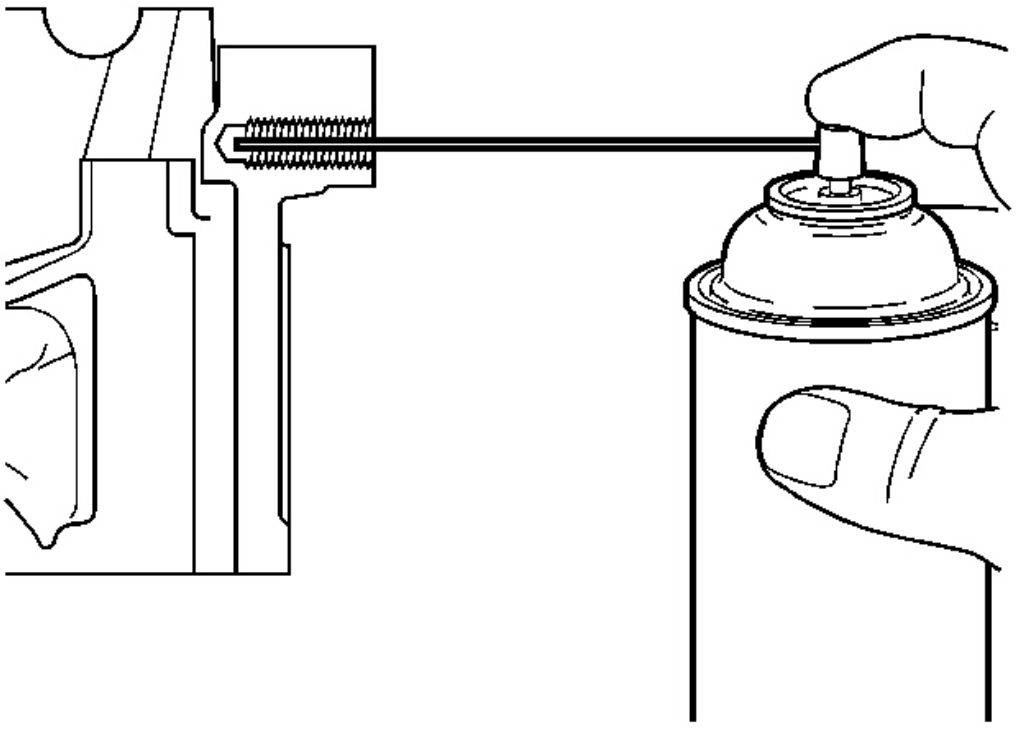


Fig. 415: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

7. Spray cleaner GM P/N 12377981, Canadian P/N 10953463 or equivalent into the tapped hole.

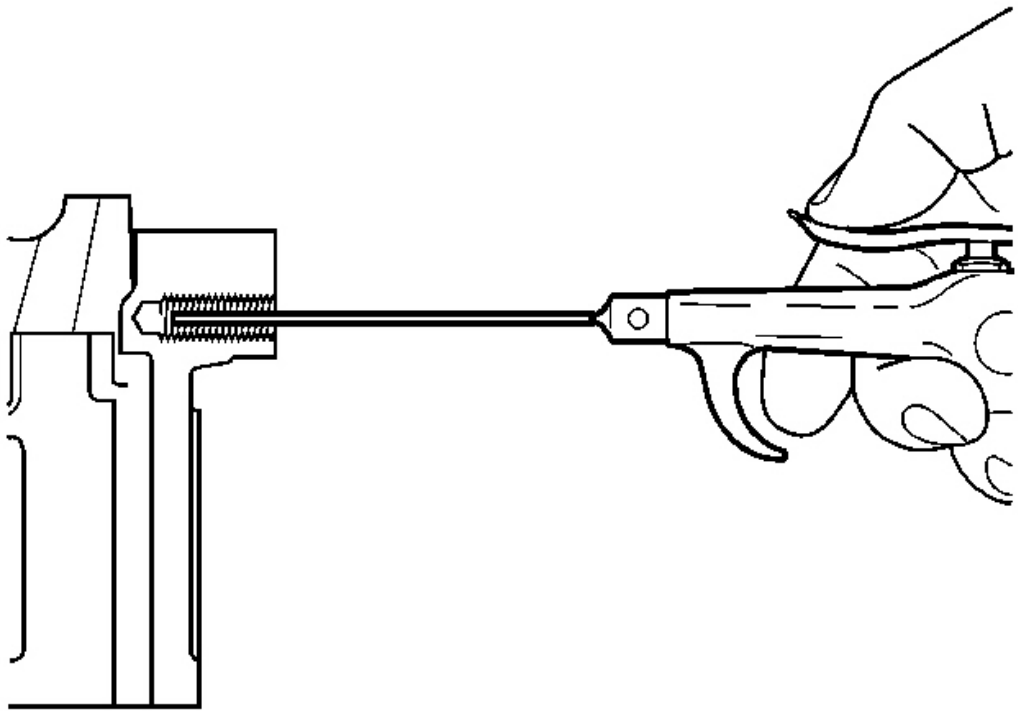


Fig. 416: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.

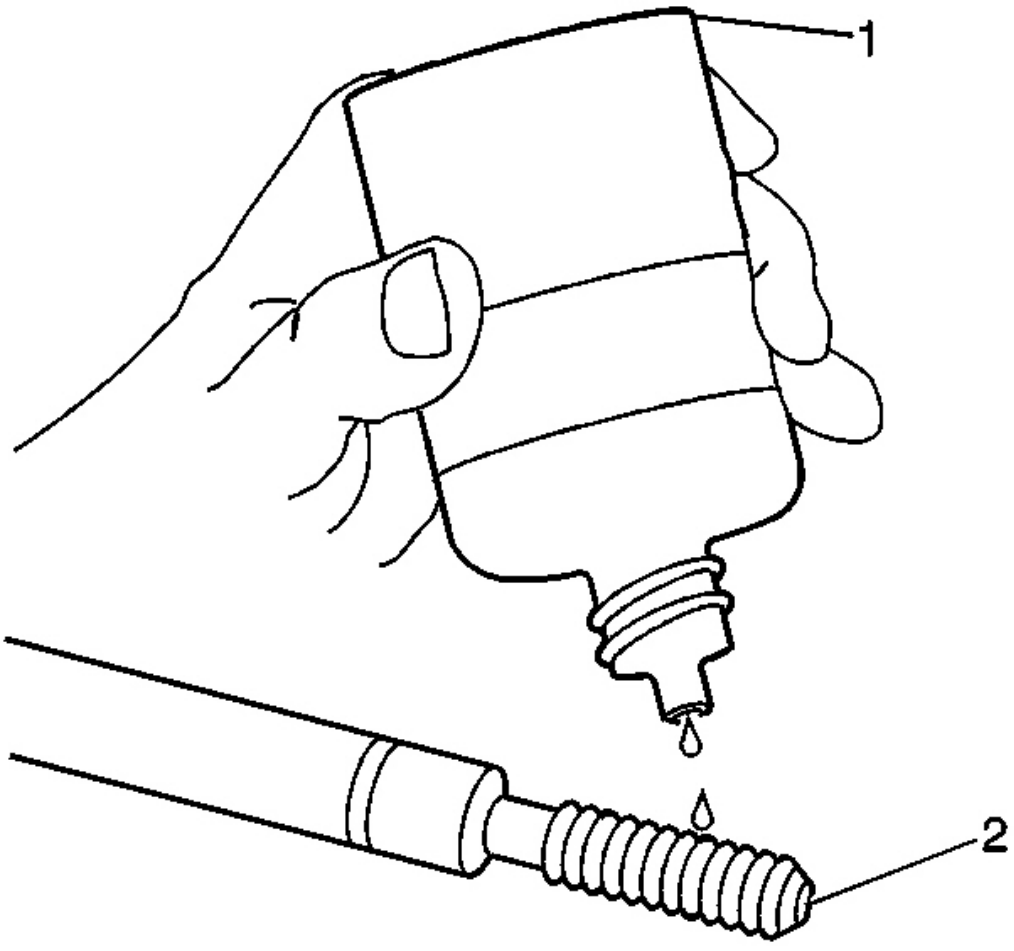


Fig. 417: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

9. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

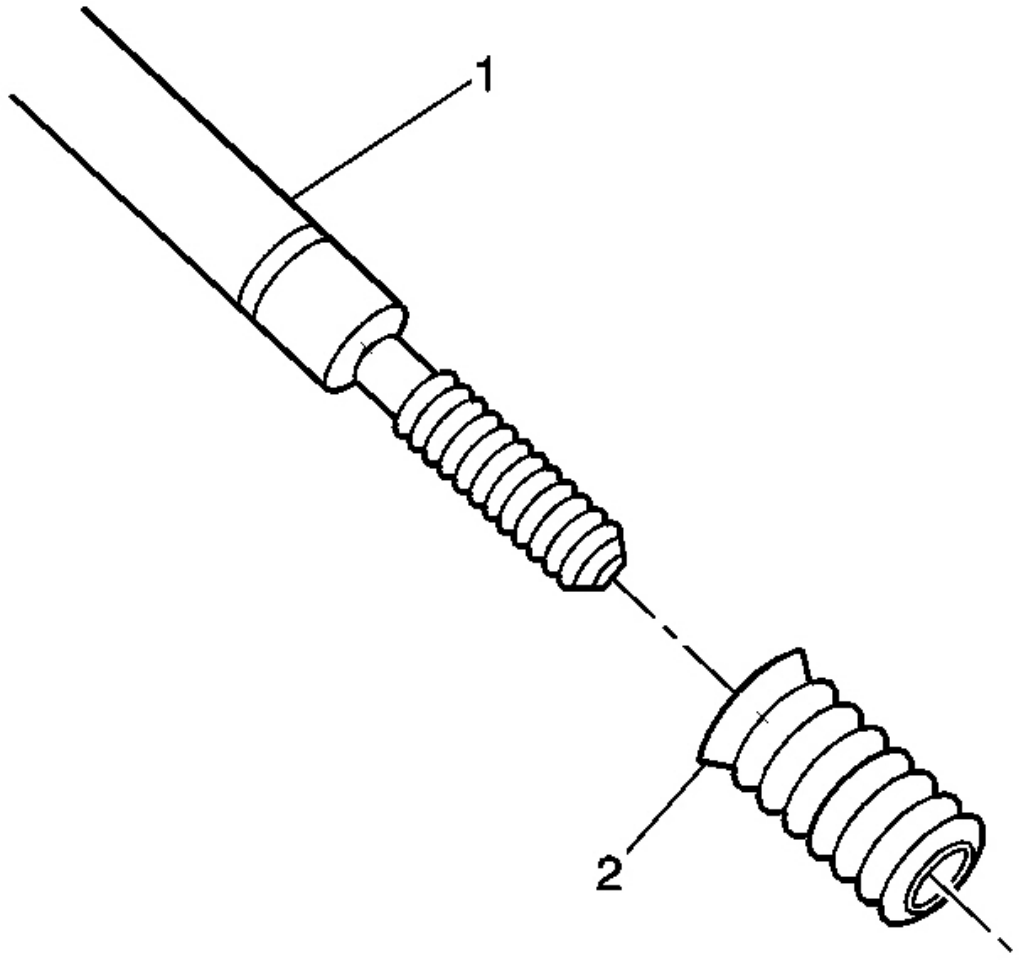


Fig. 418: View Of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

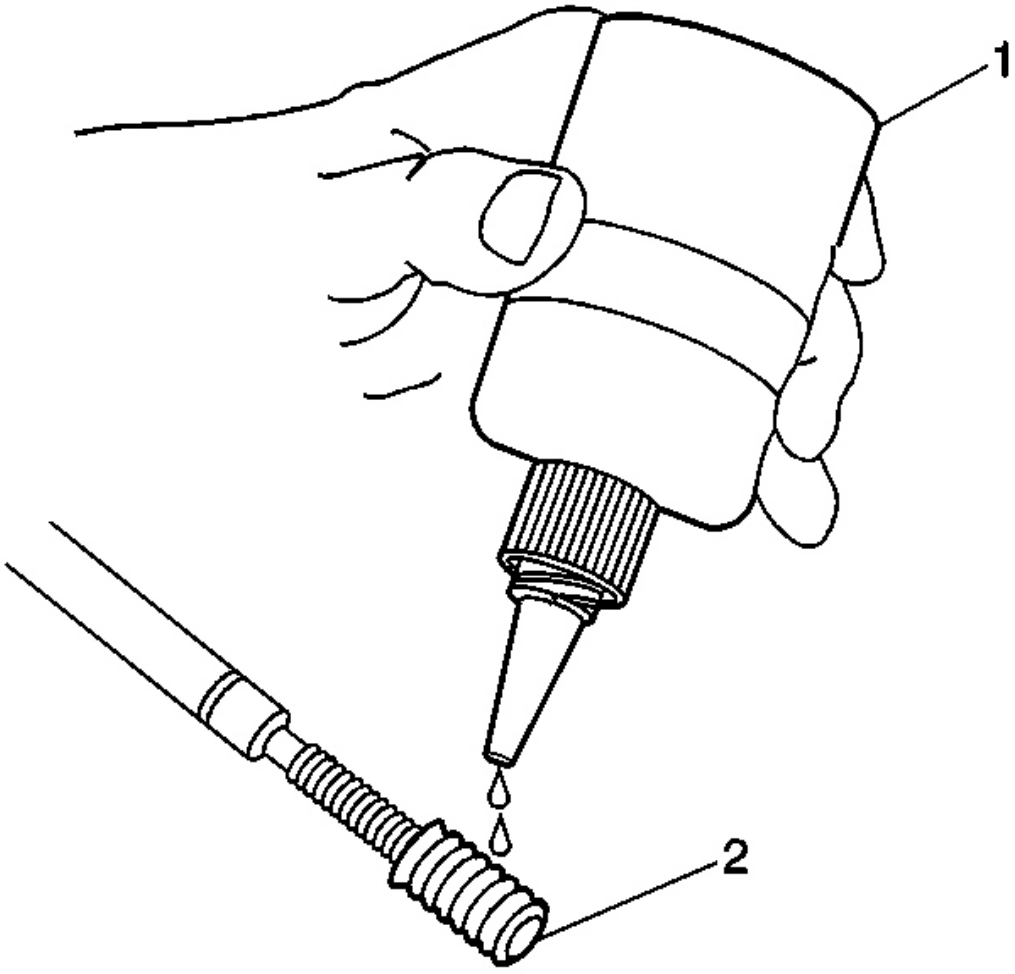


Fig. 419: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock sealant GM P/N 12345493, Canadian P/N 10953488, J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

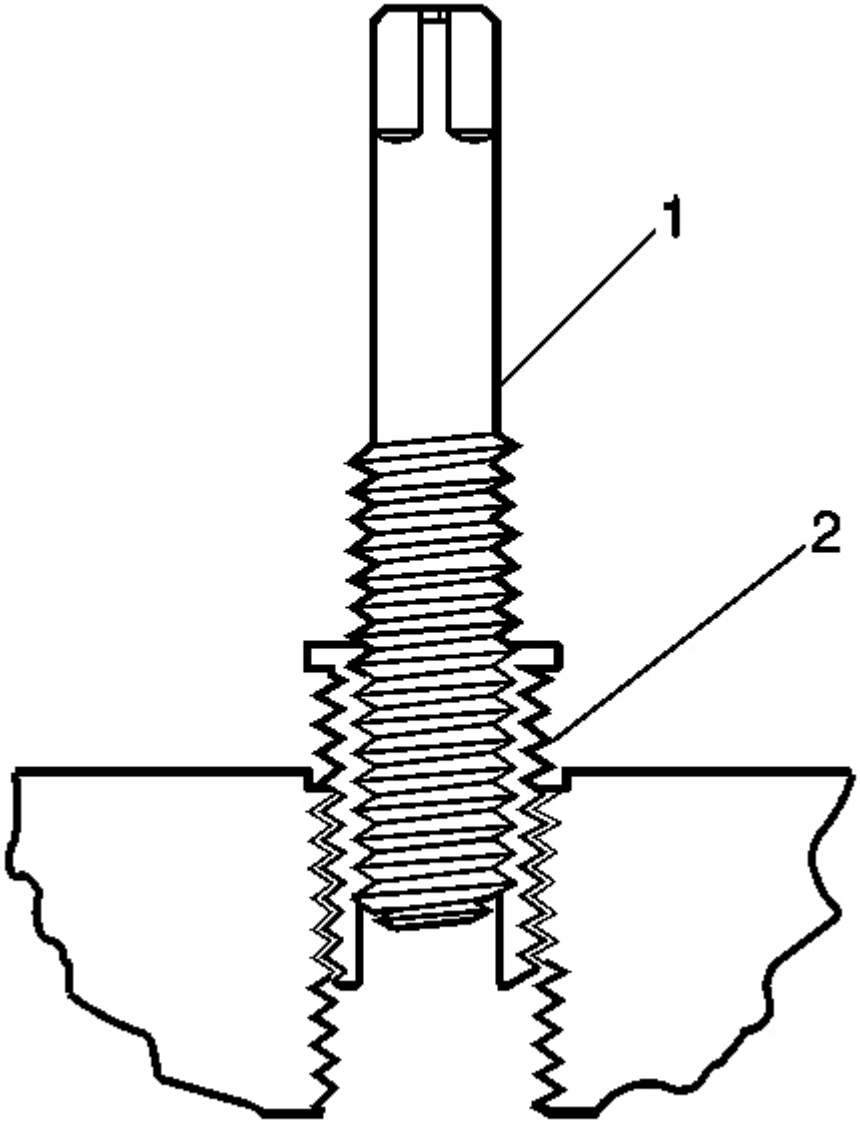


Fig. 420: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the tapped hole.

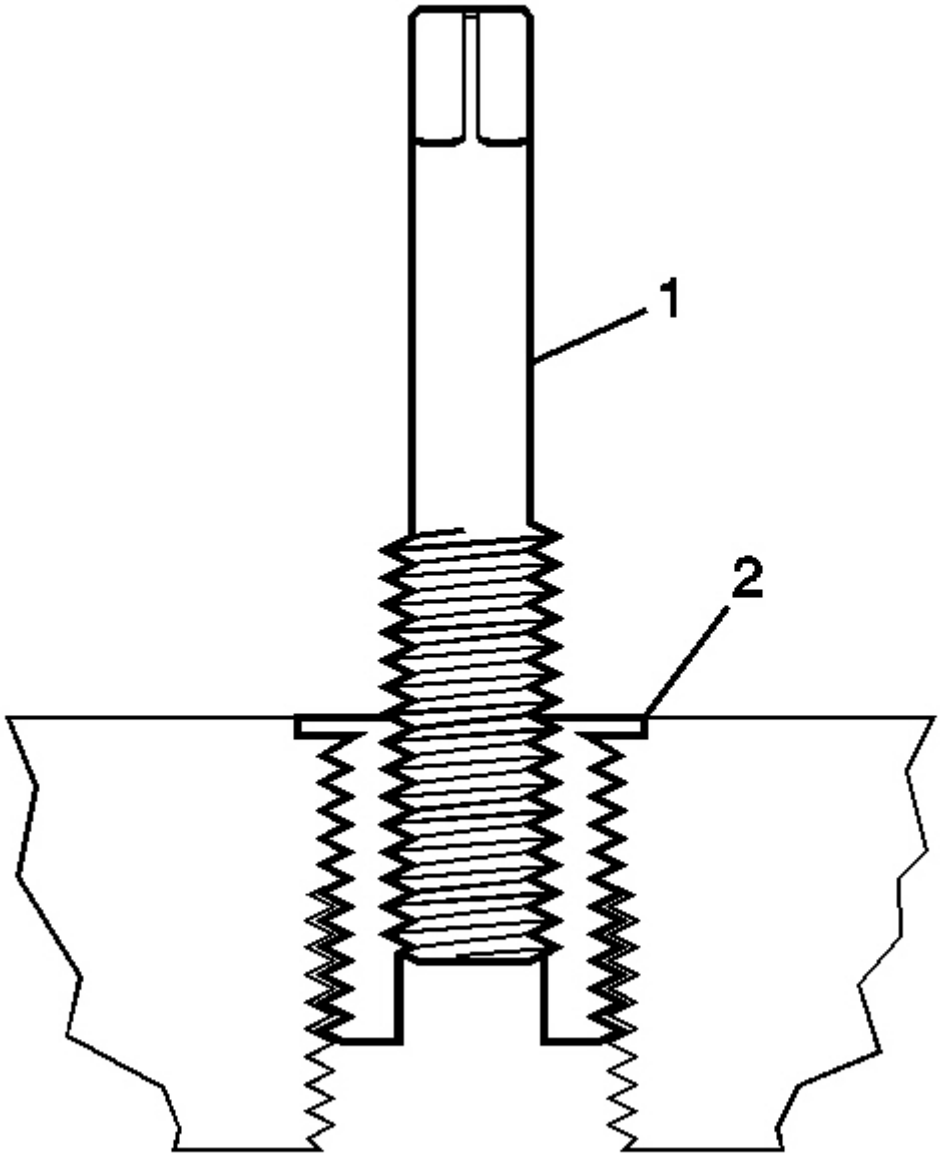


Fig. 421: Installing Insert - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or

improper tapping.

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

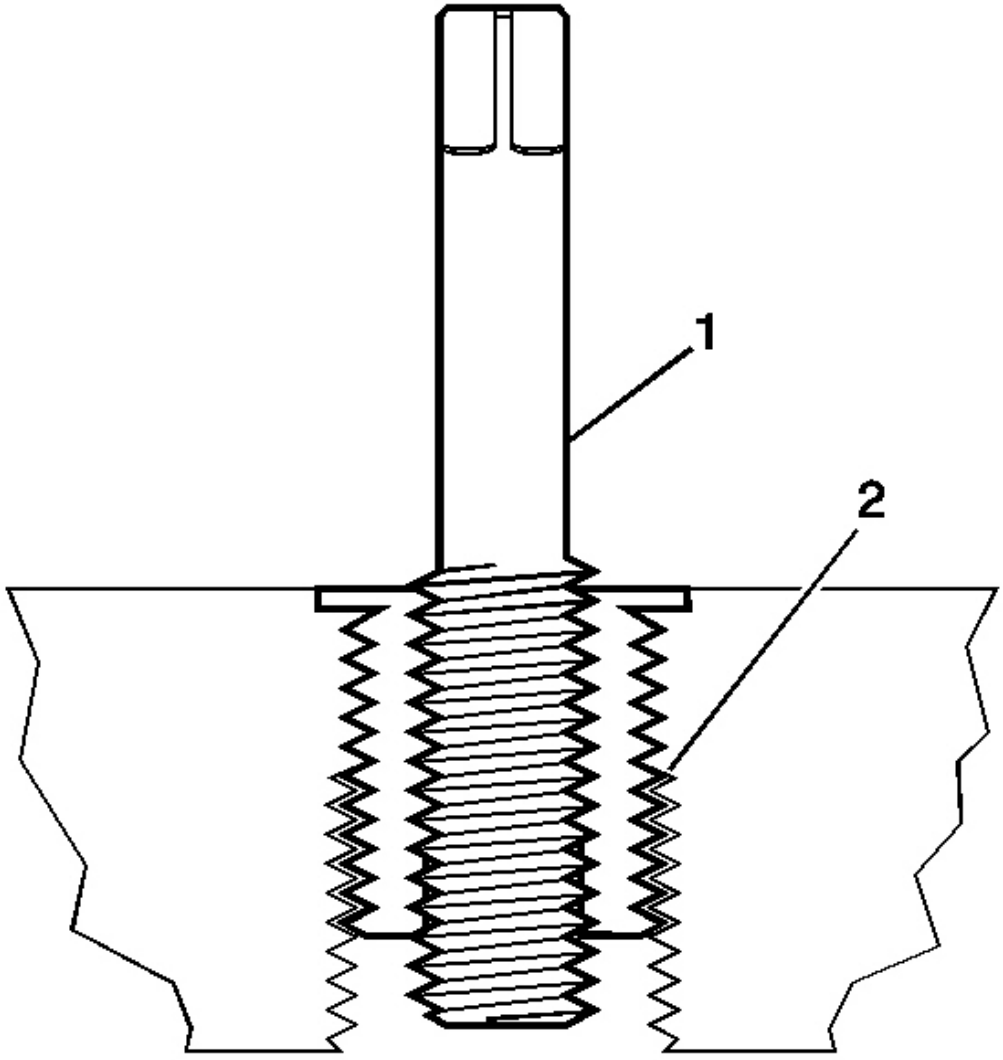


Fig. 422: View Of Insert & Tool - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

insert are being formed and the insert is mechanically locking the insert into the base material threads.

14. Continue to rotate the driver installation tool (1) through the insert (2).

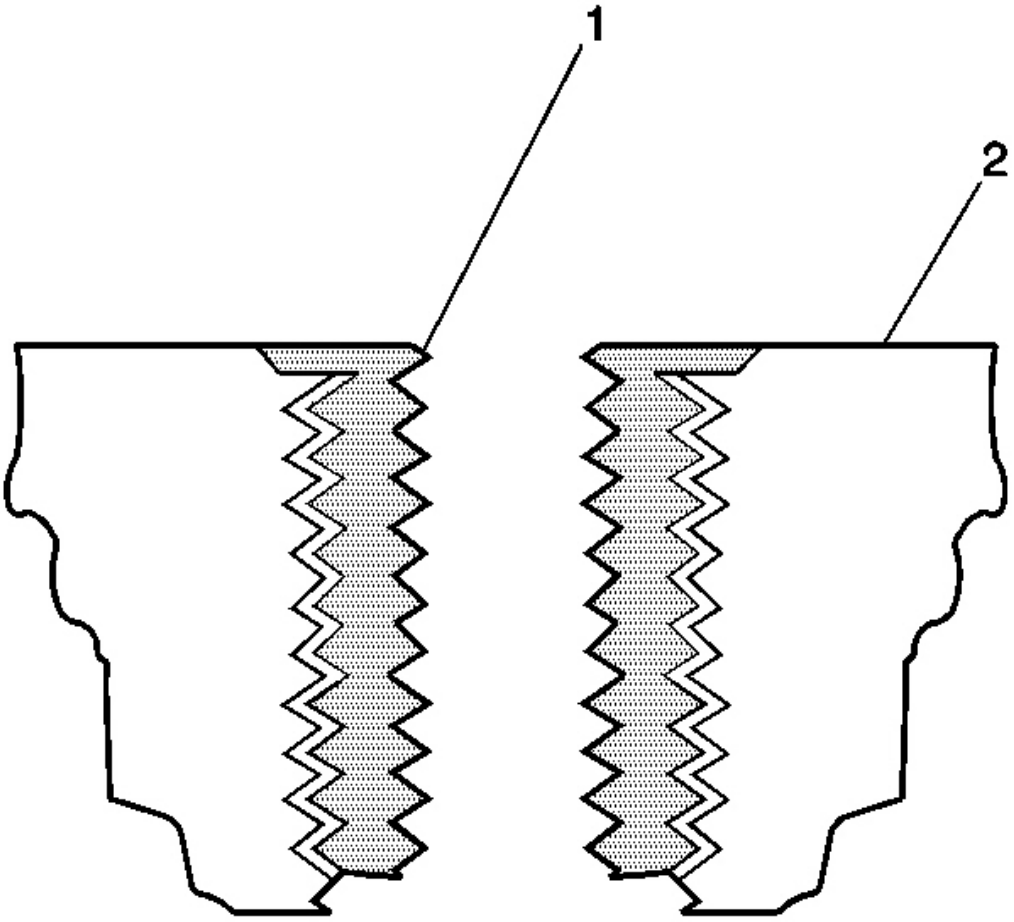


Fig. 423: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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

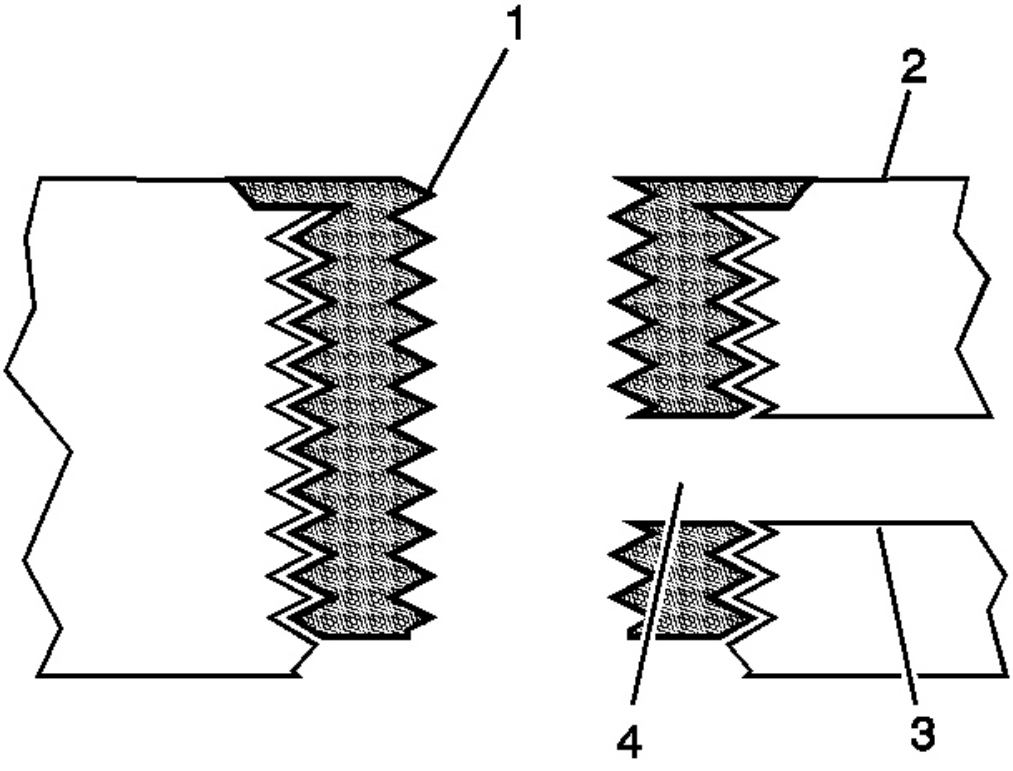


Fig. 424: View Of Restricted Engine Coolant Passages - Standard Thread Repair
Courtesy of GENERAL MOTORS CORP.

16. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Recessed Thread Repair

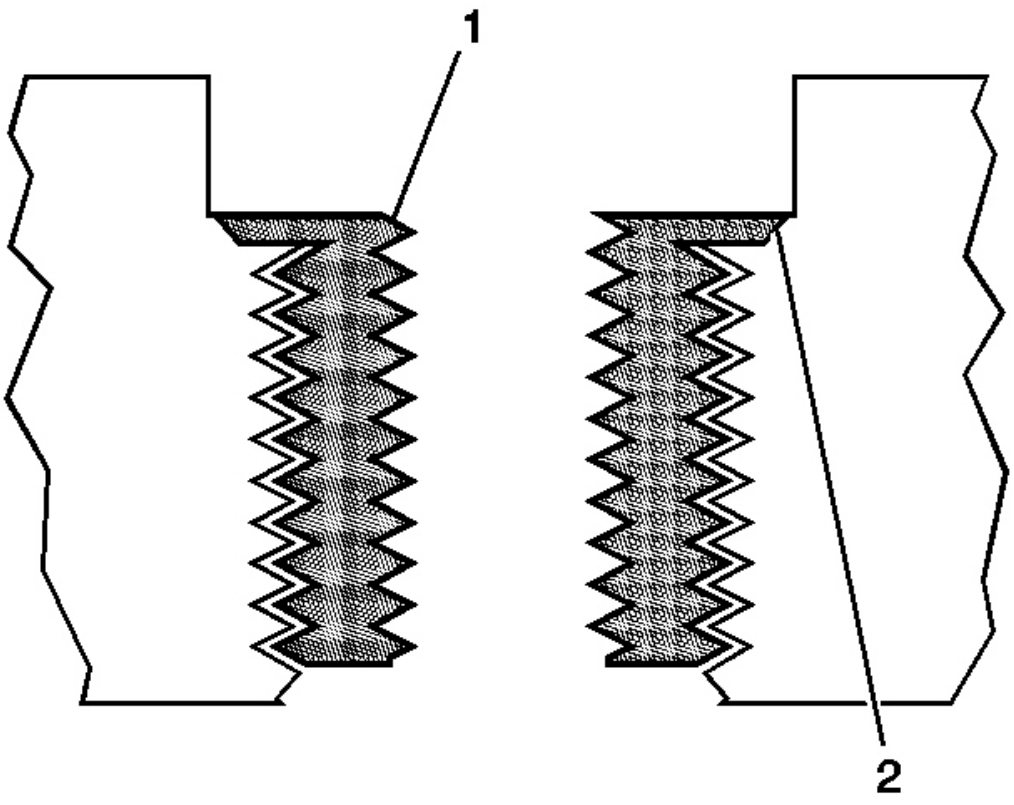


Fig. 425: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **The use of a cutting type fluid GM P/N 1052864, Canadian P/N 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**
- **Do NOT remove the original stop collar from a counterbore drill.**

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

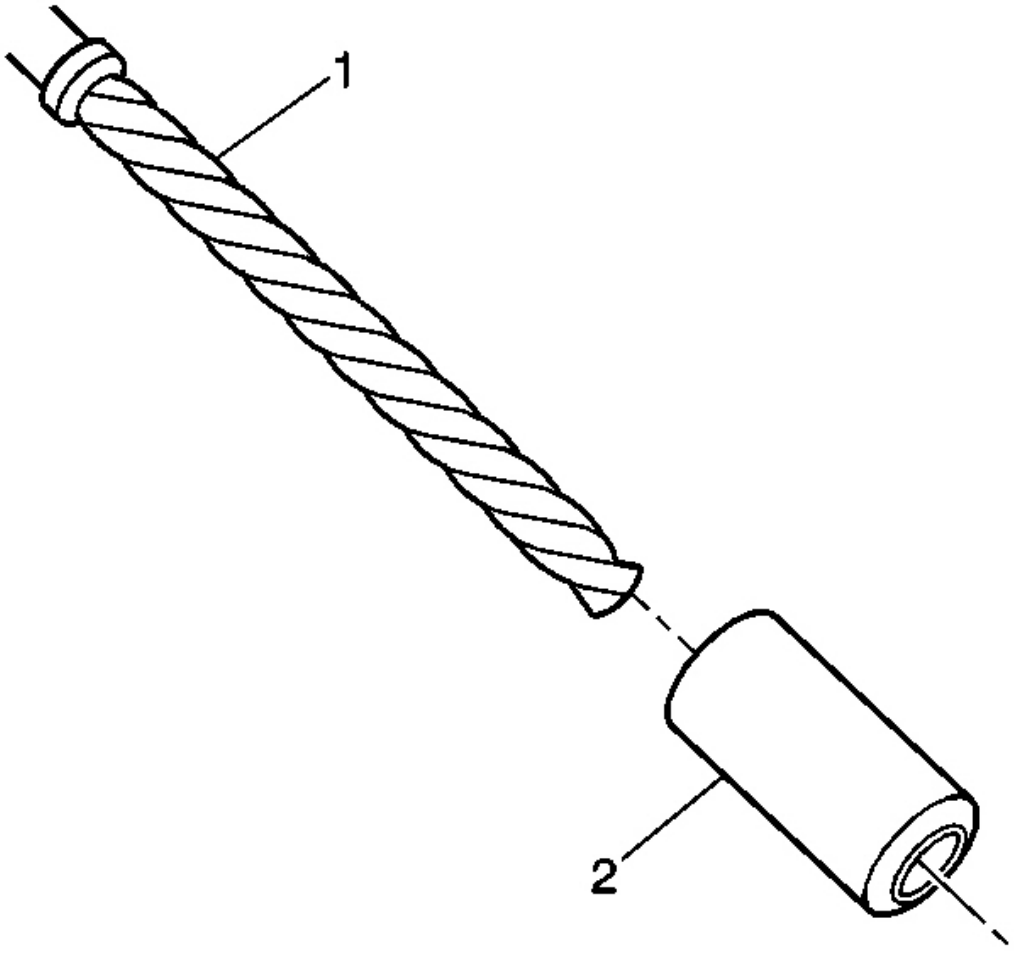


Fig. 426: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

1. Install a stop collar (2) on the counterbore drill (1), if required.

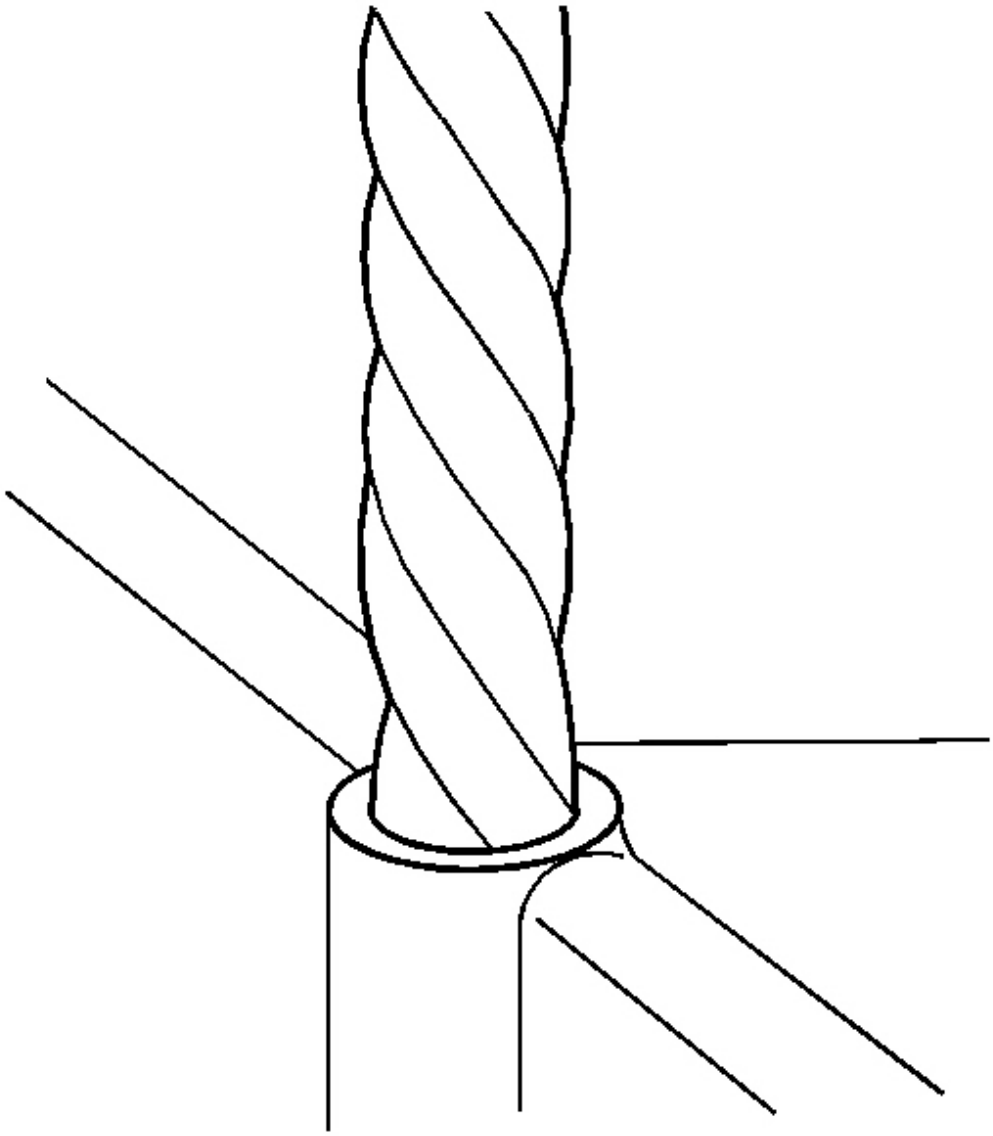


Fig. 427: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base material.**

2. Drill out the threads of the damaged hole.

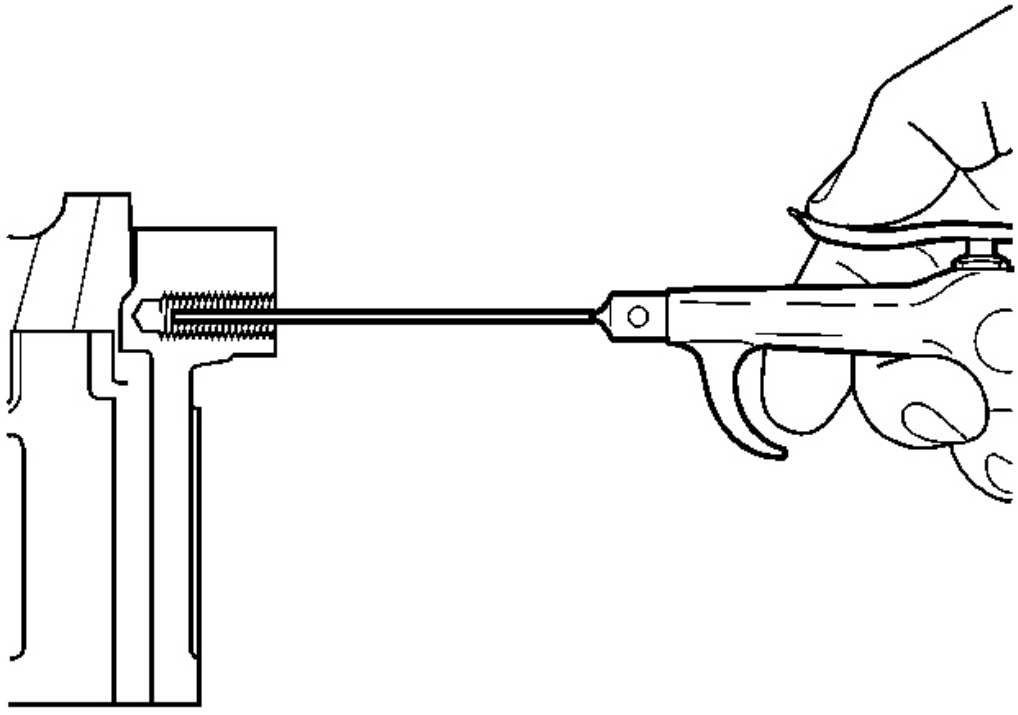


Fig. 428: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.

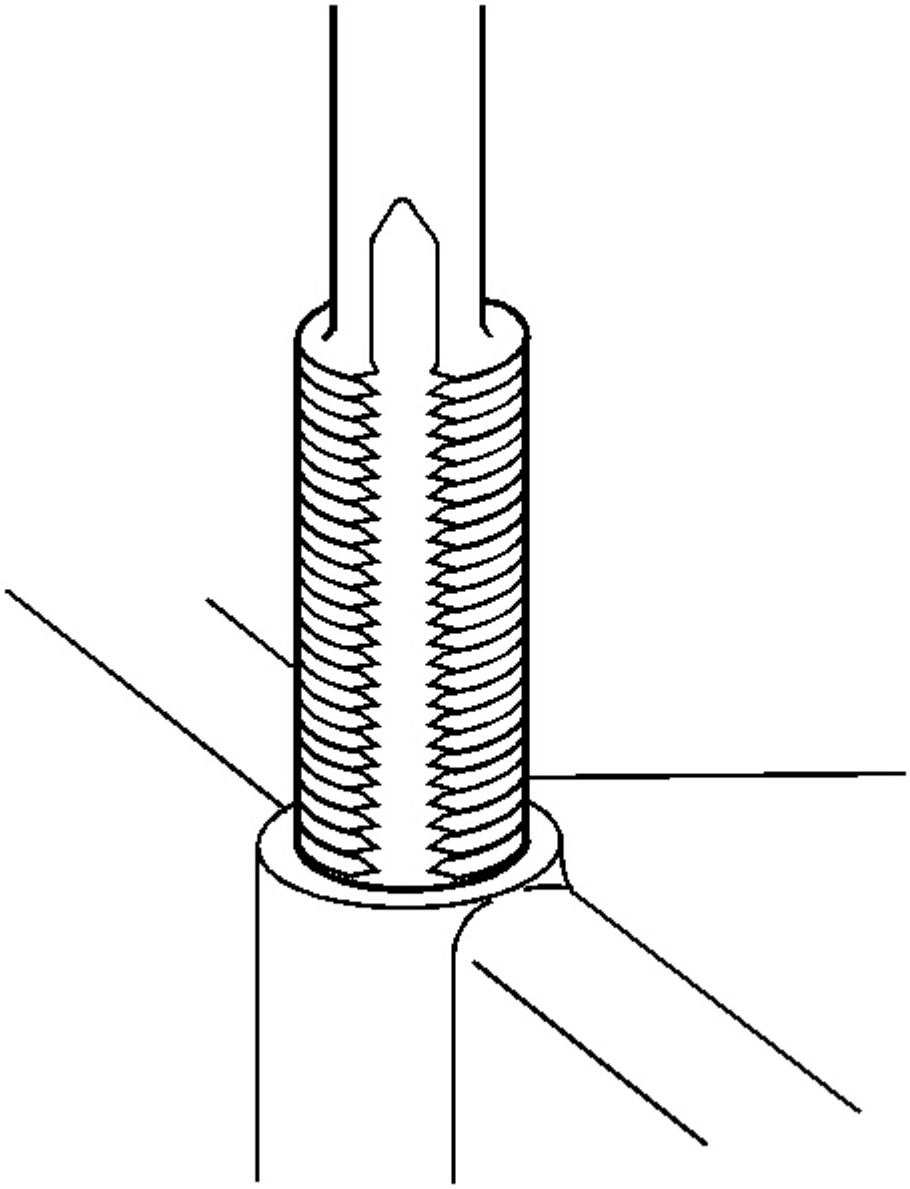


Fig. 429: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

4. Using a suitable tapping wrench, tap the threads of the drilled hole.

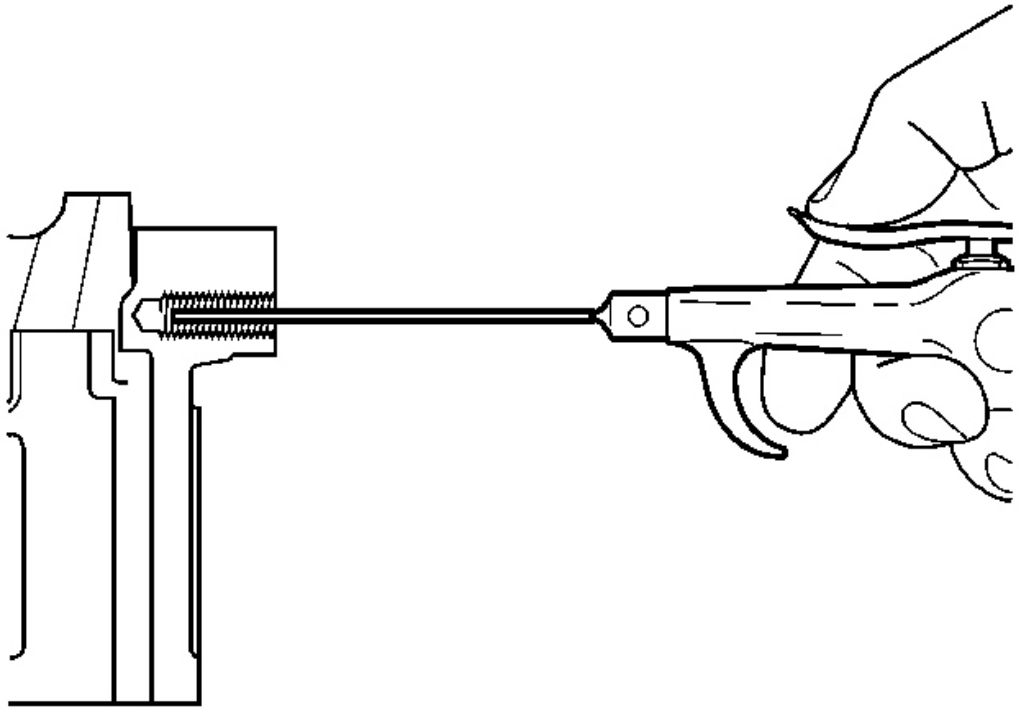


Fig. 430: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

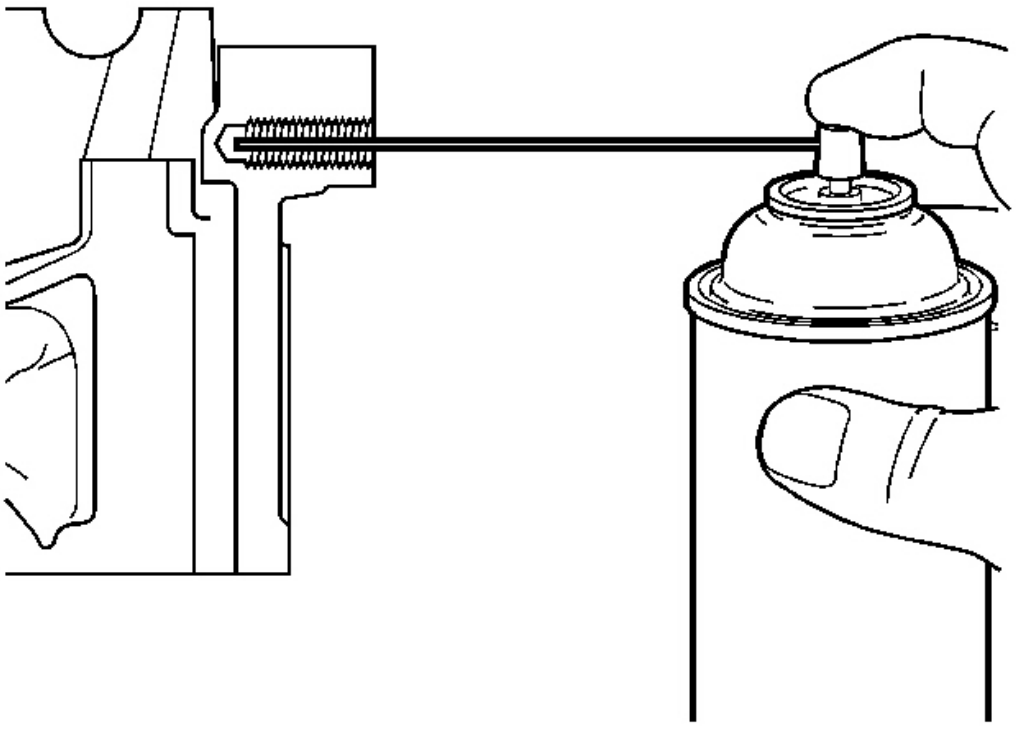


Fig. 431: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12377981, Canadian P/ N 10953463 or equivalent into the tapped hole.

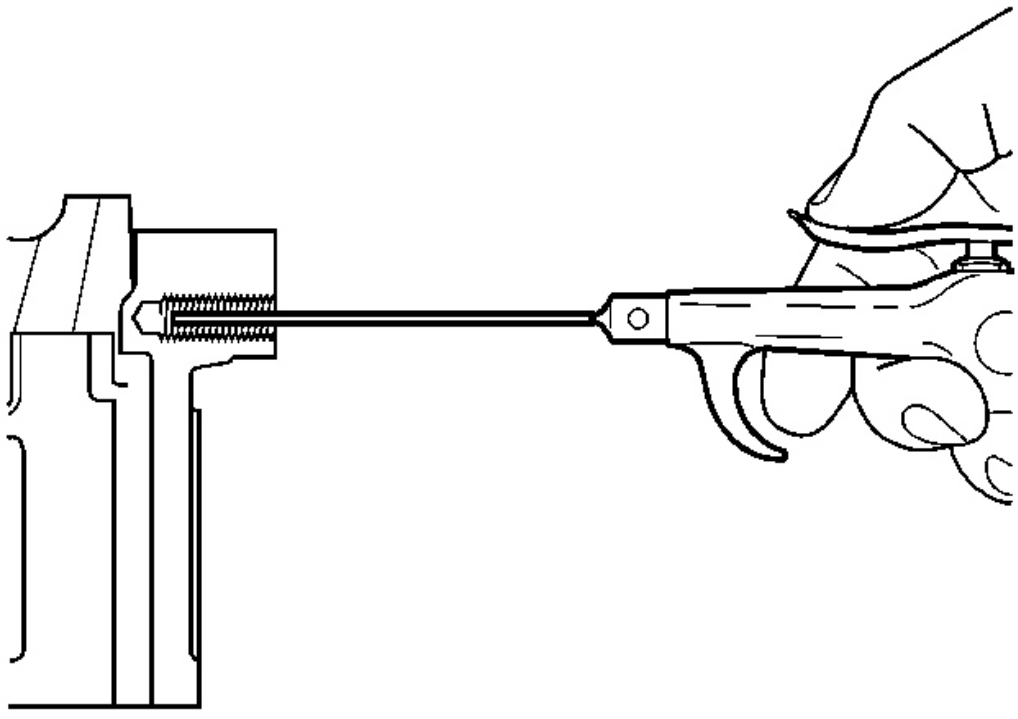


Fig. 432: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

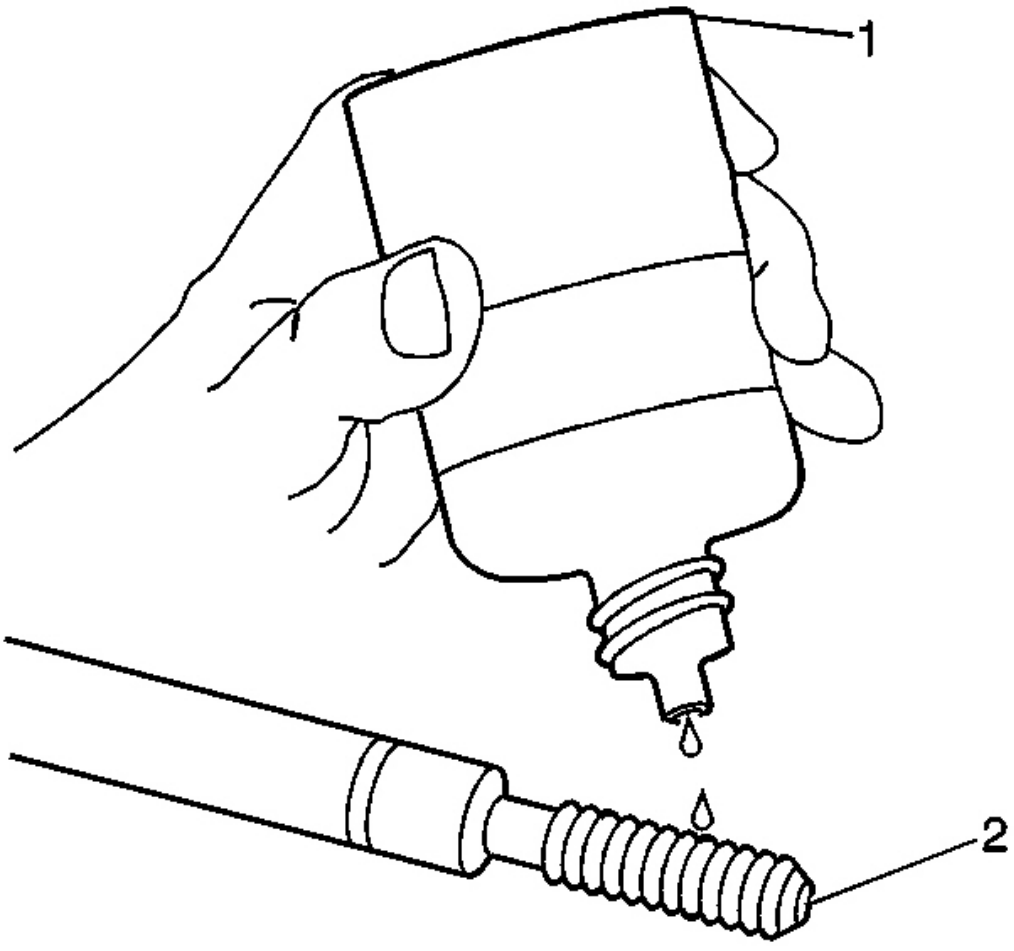


Fig. 433: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

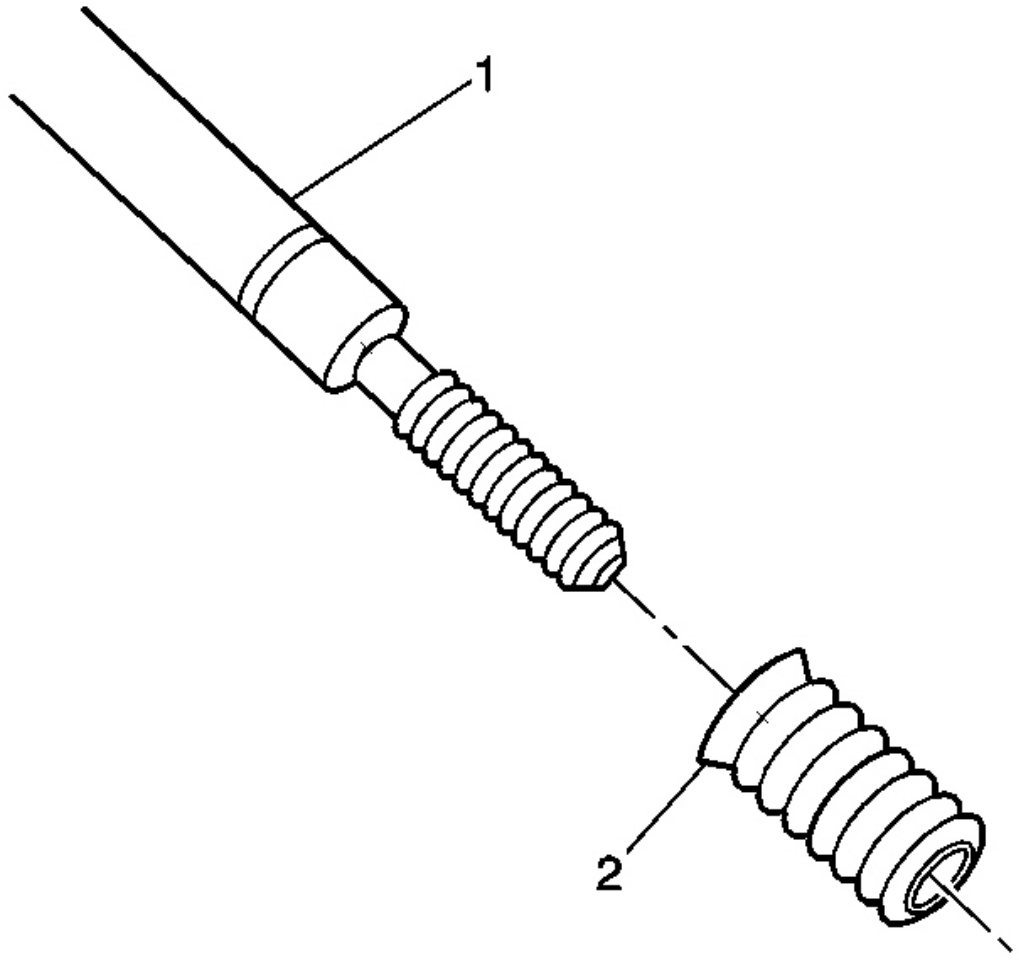


Fig. 434: View Of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

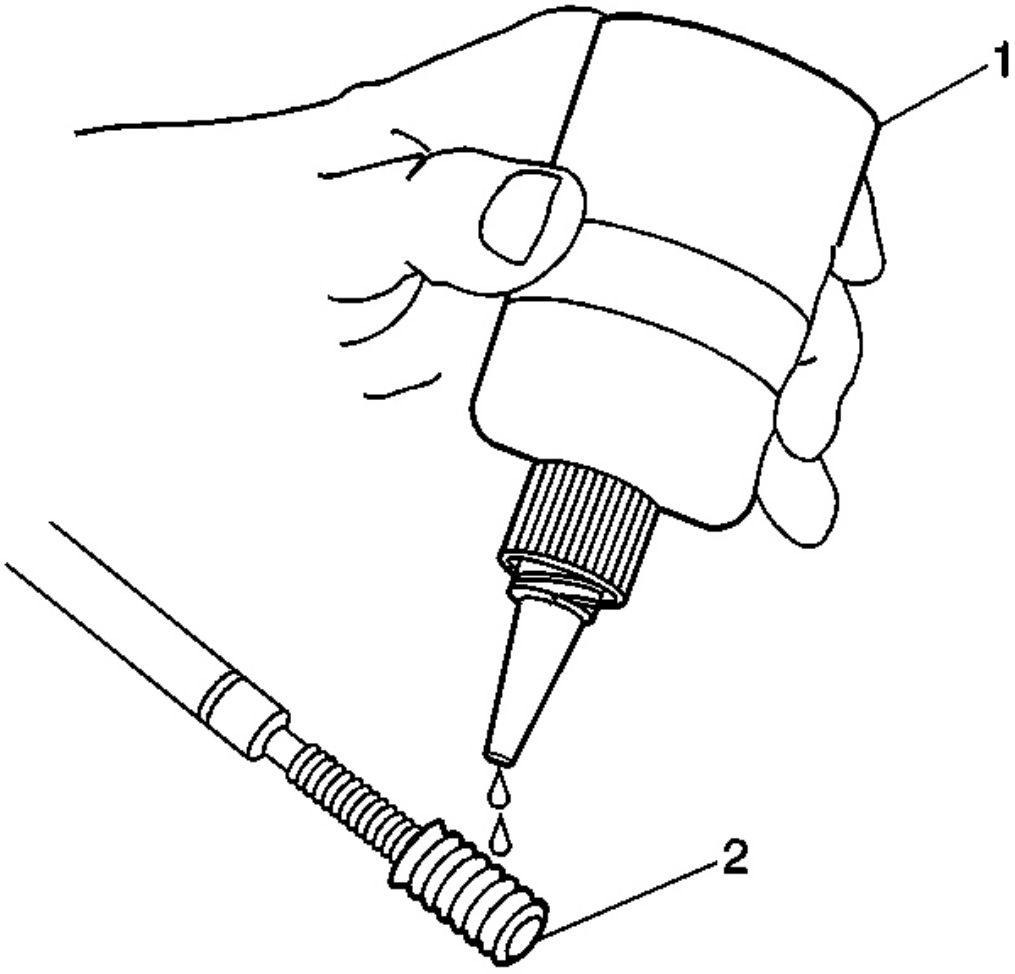


Fig. 435: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, Canadian P/N 10953488, J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

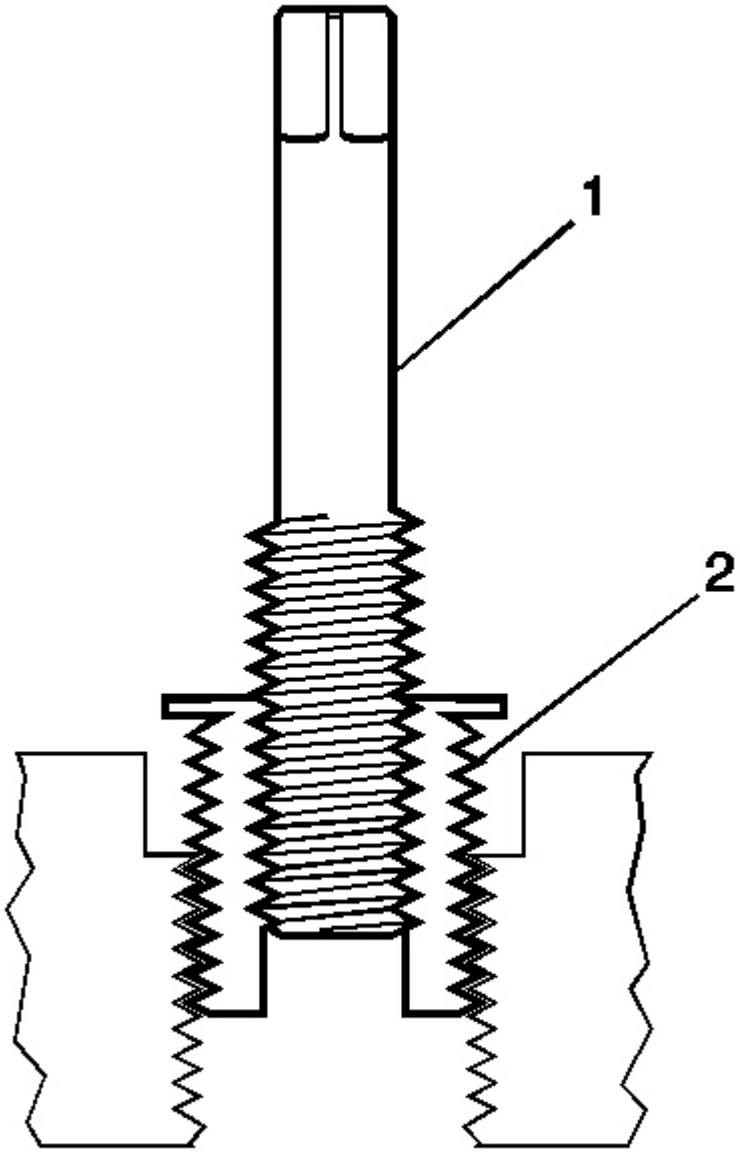


Fig. 436: Identifying Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole.

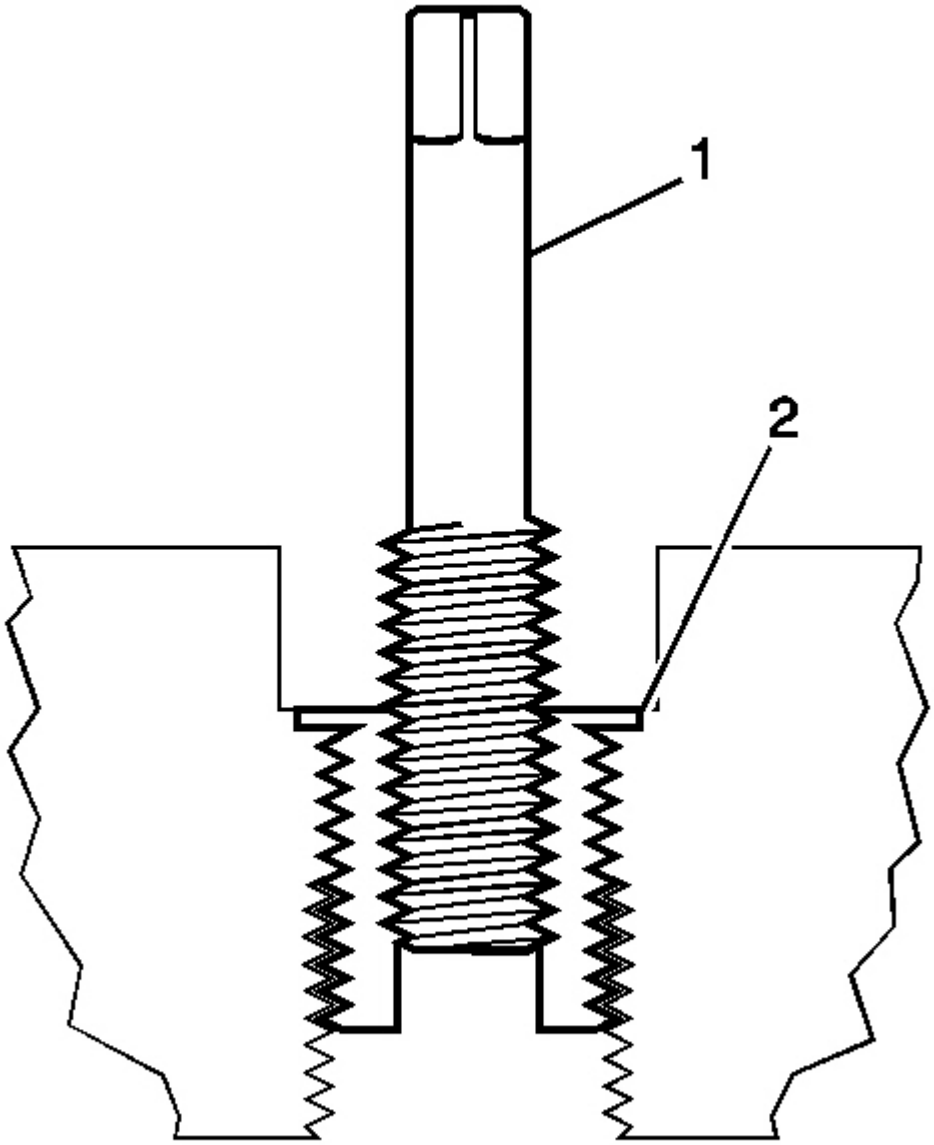


Fig. 437: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

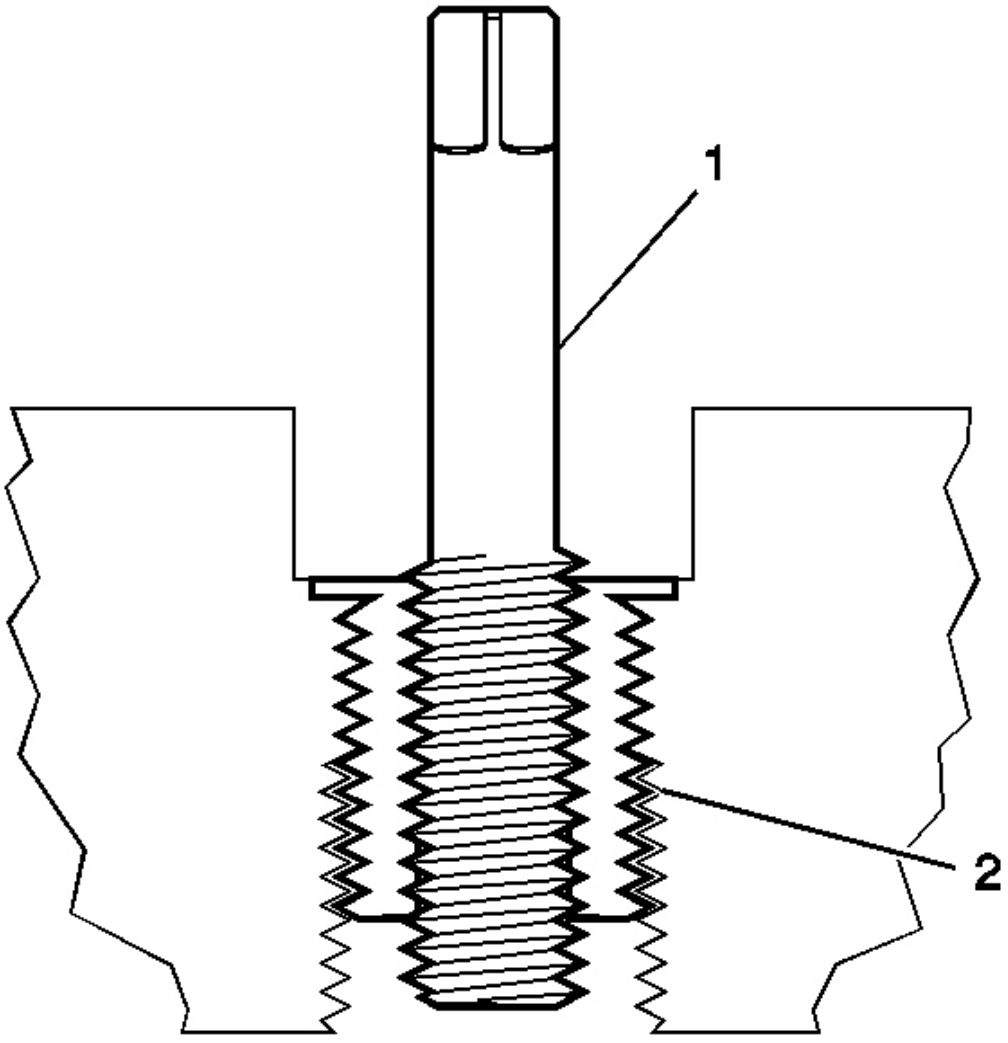


Fig. 438: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) through the insert (2).

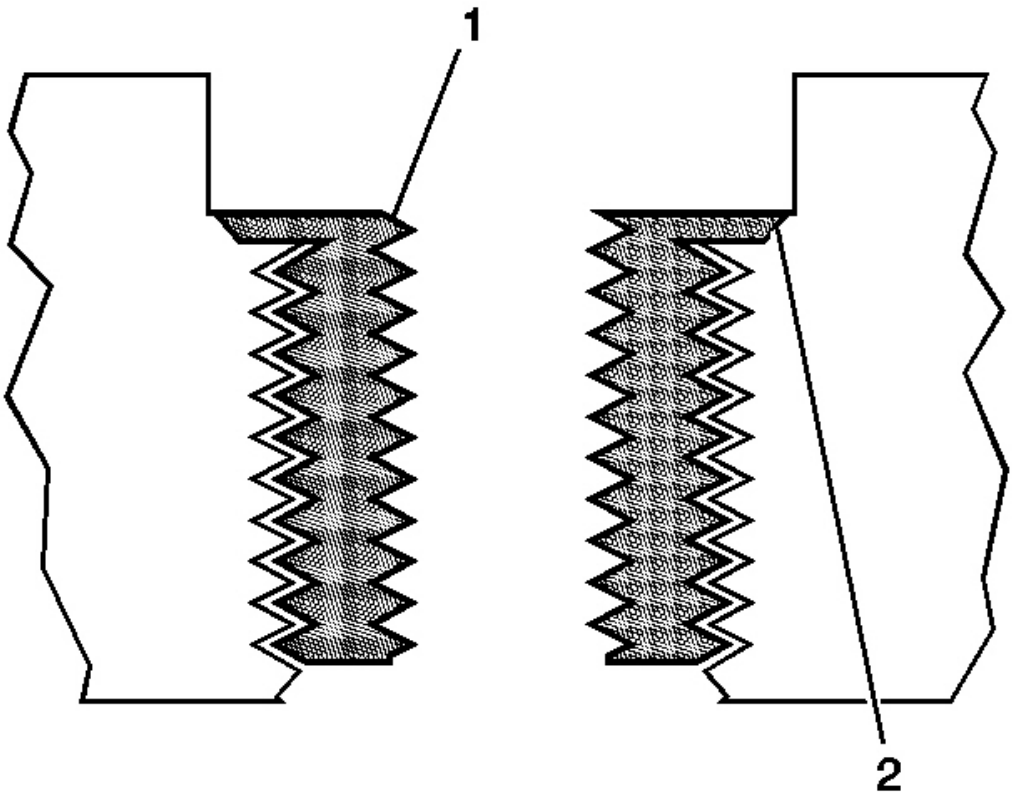


Fig. 439: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

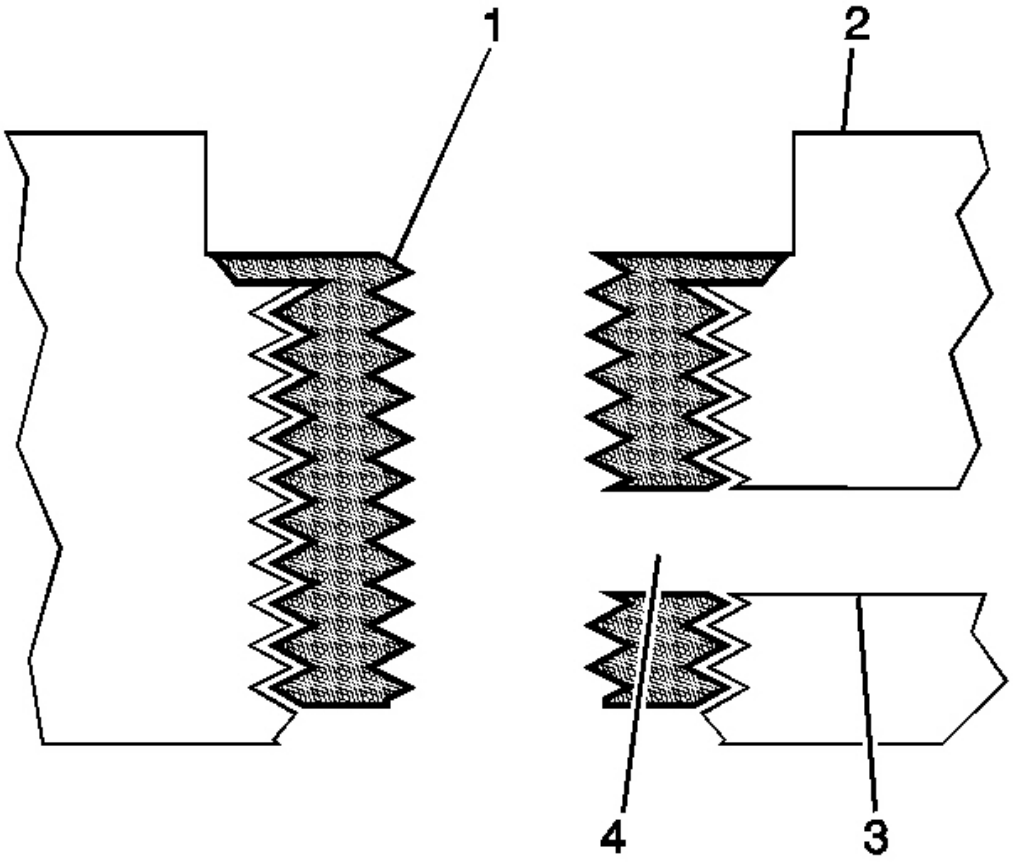


Fig. 440: View Of Restricted Engine Coolant Passage - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Tapered Pipe Thread Repair

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

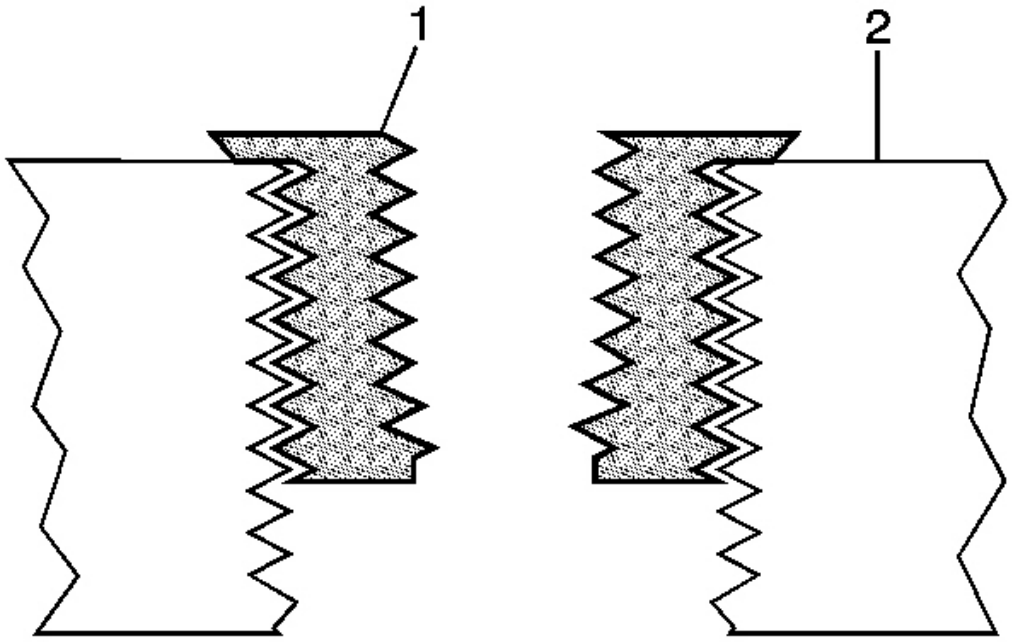


Fig. 441: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, Canadian P/N 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

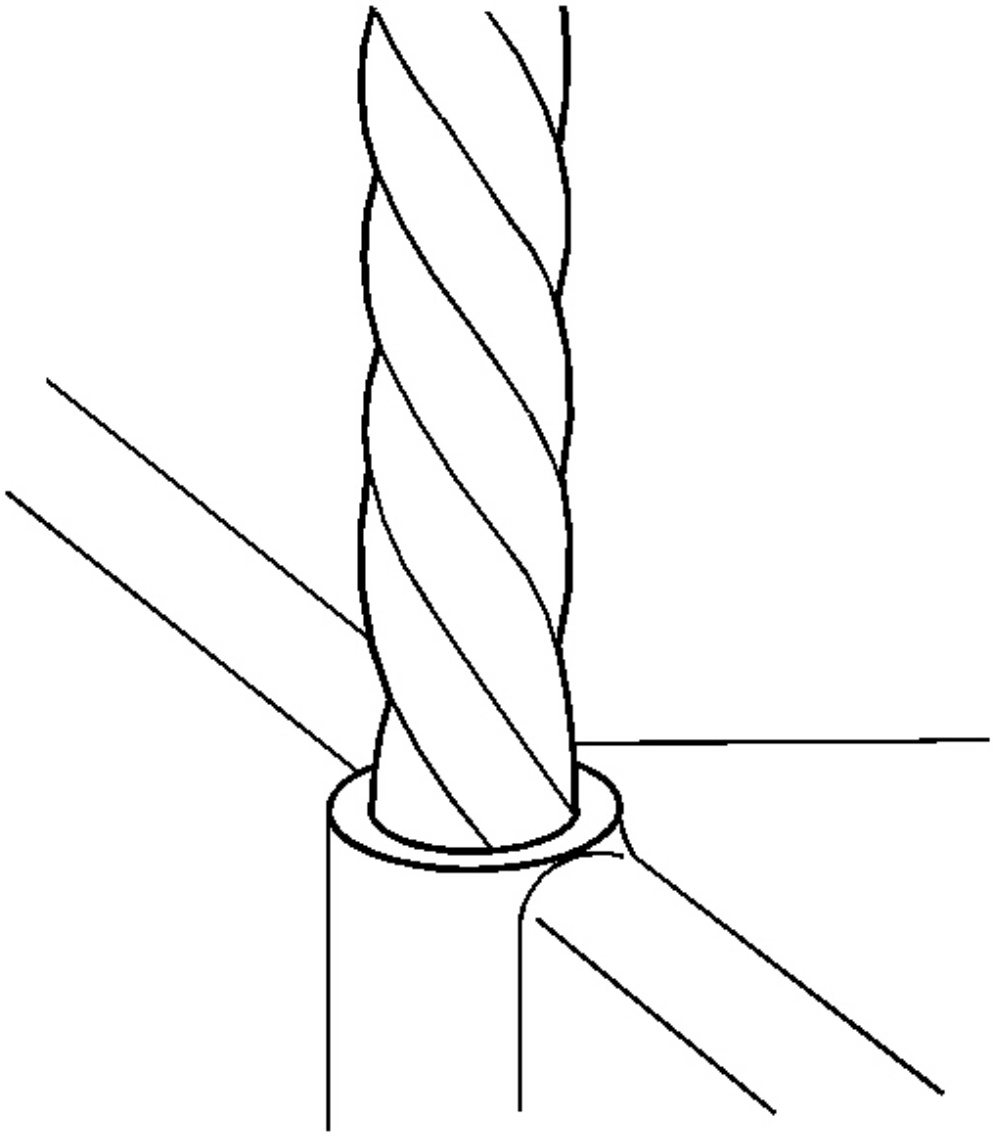


Fig. 442: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the hole until the stop collar contacts the surface of the base material.**

1. Drill out the threads of the damaged hole.

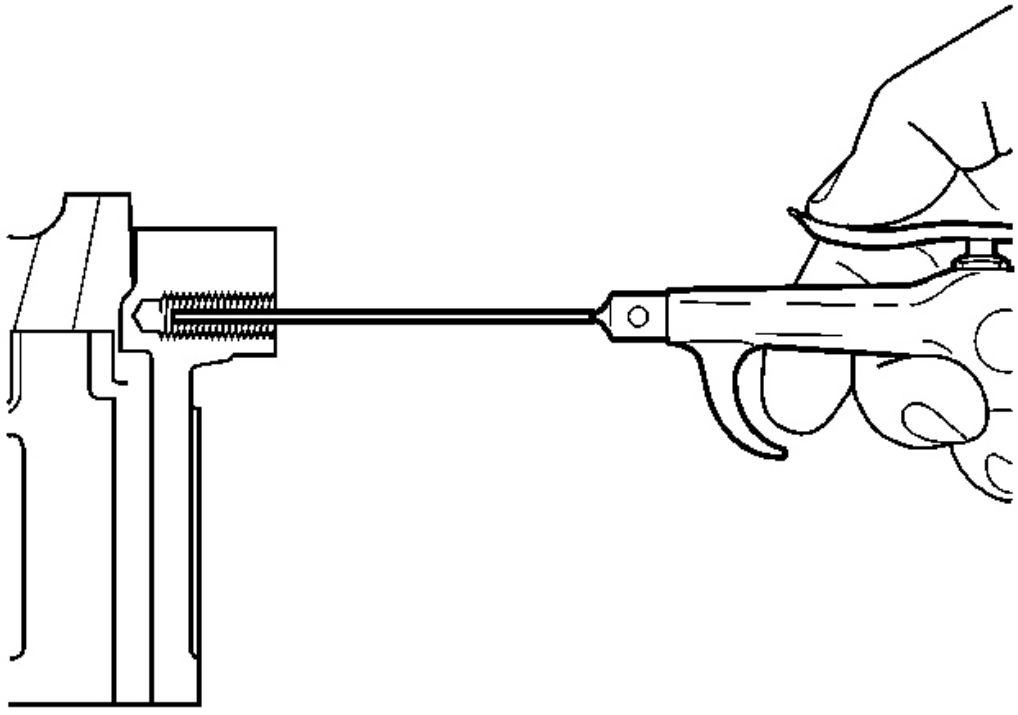


Fig. 443: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

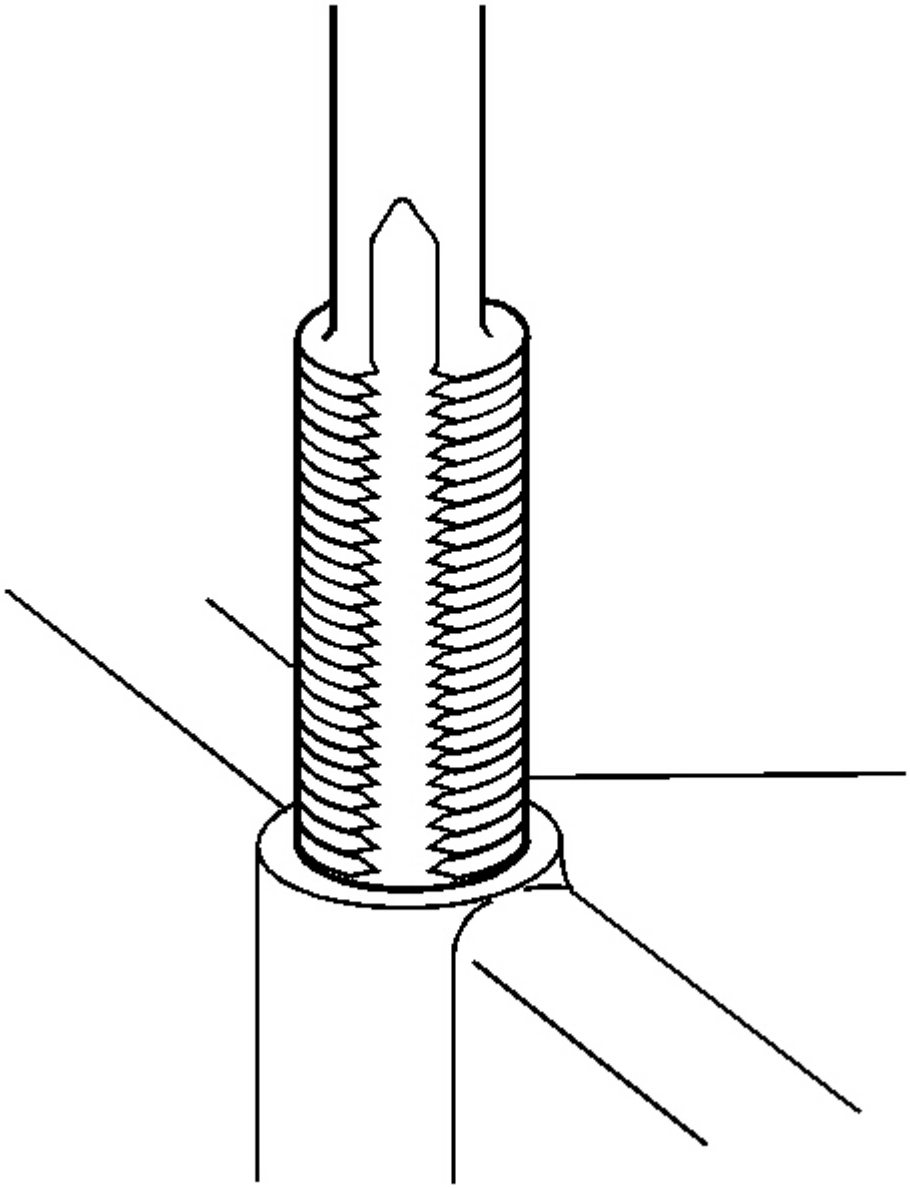


Fig. 444: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**

- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

3. Using a suitable tapping wrench, tap the threads of the drilled hole.

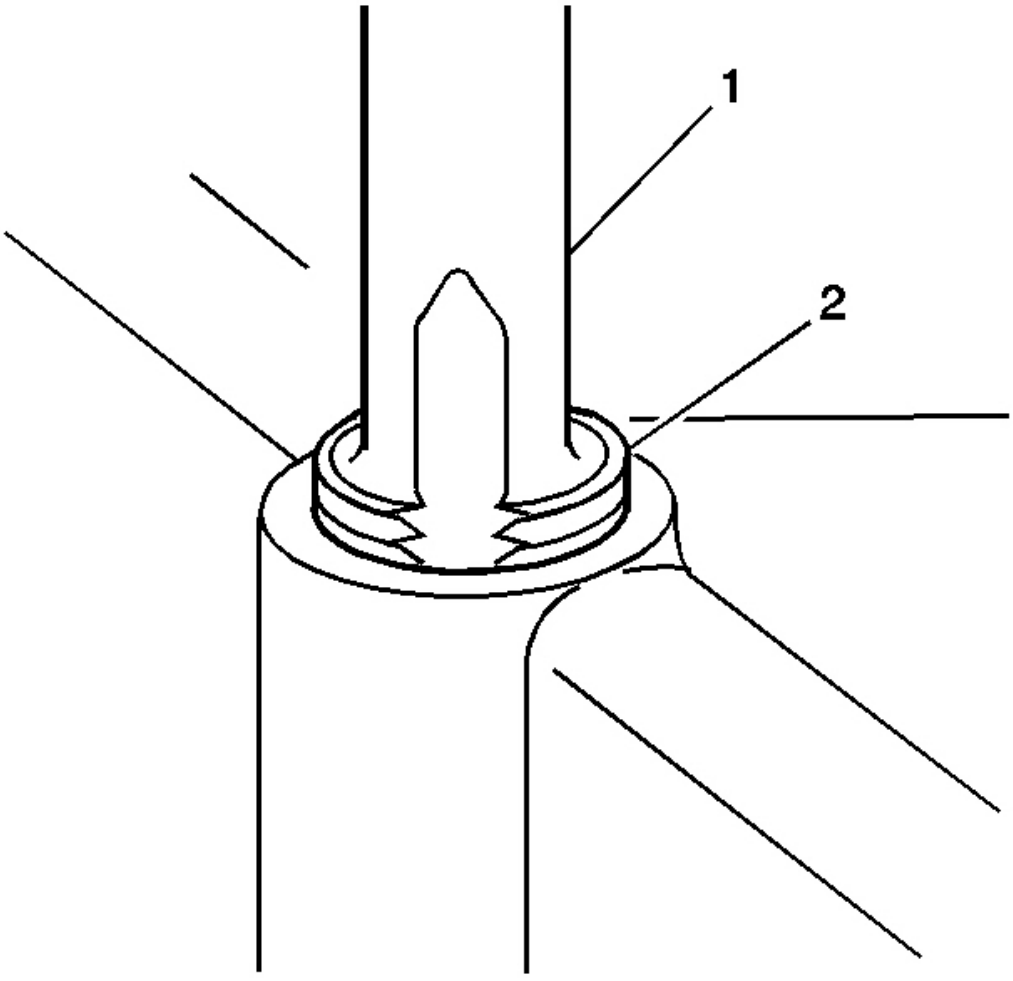


Fig. 445: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

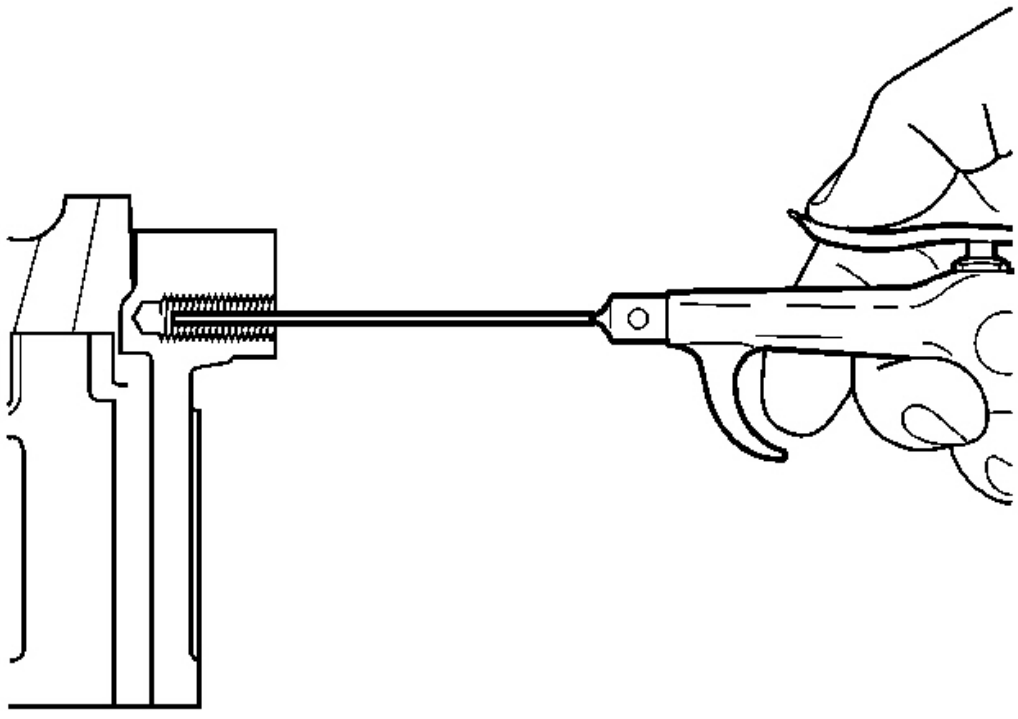


Fig. 446: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

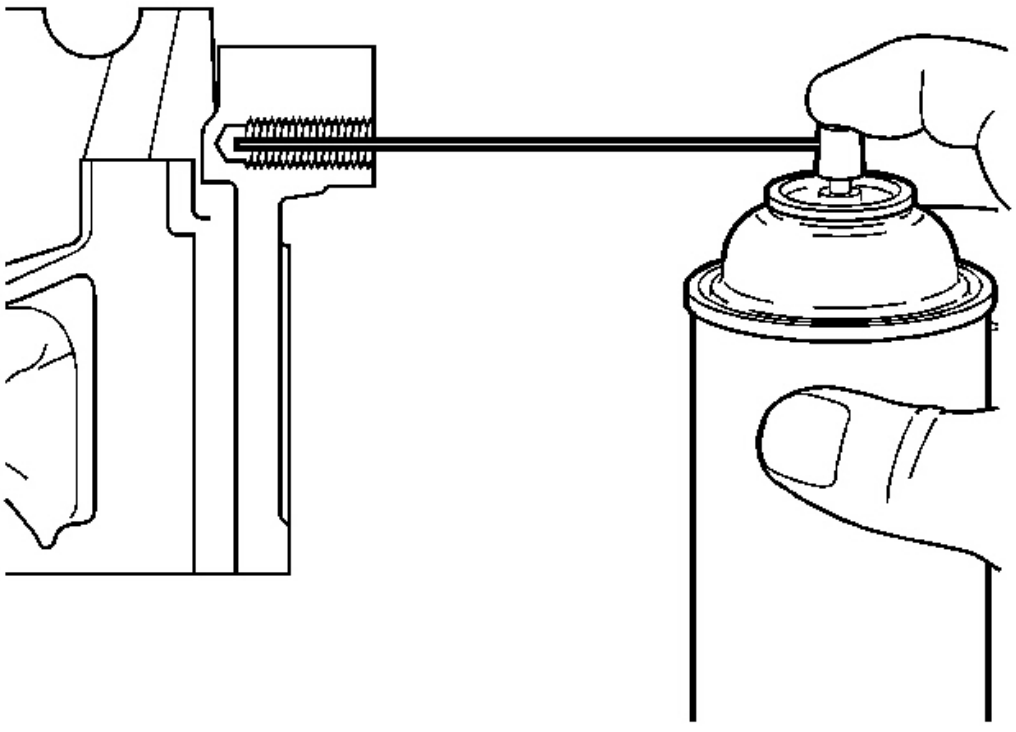


Fig. 447: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12377981, Canadian P/N 10953463 or equivalent into the tapped hole.

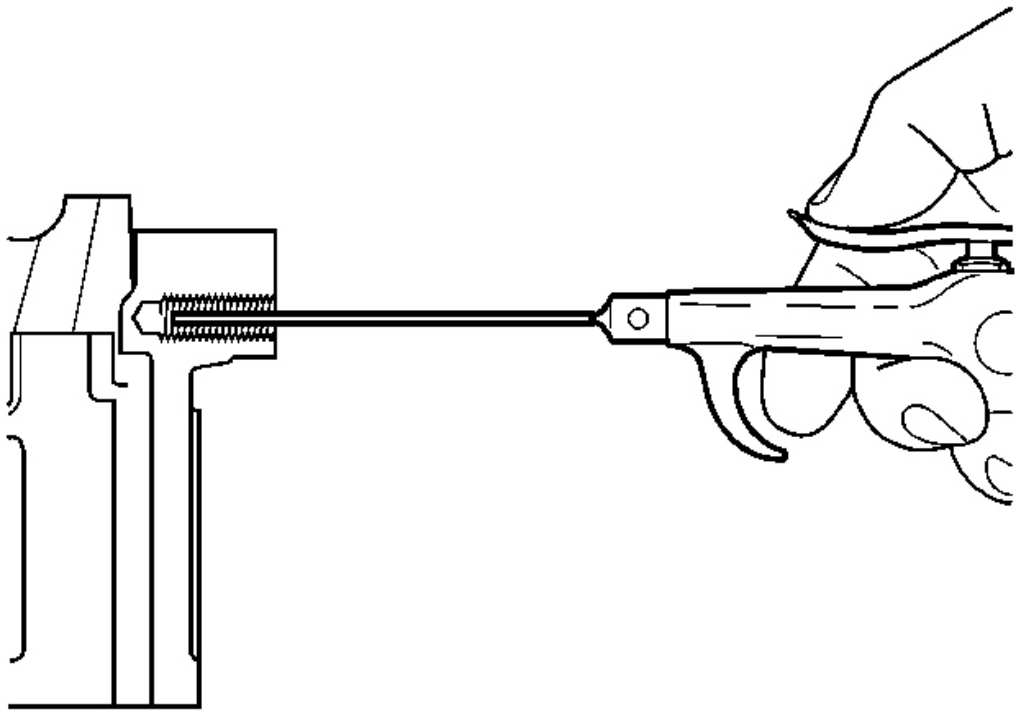


Fig. 448: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

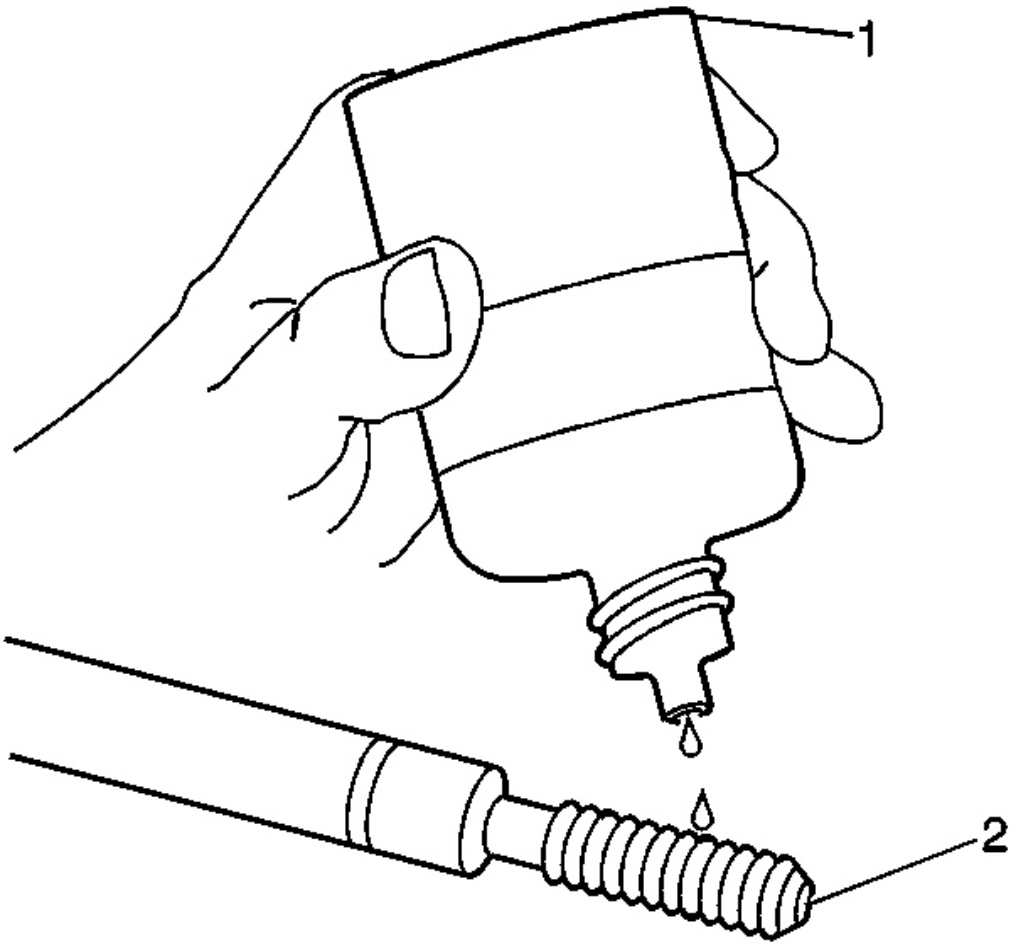


Fig. 449: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

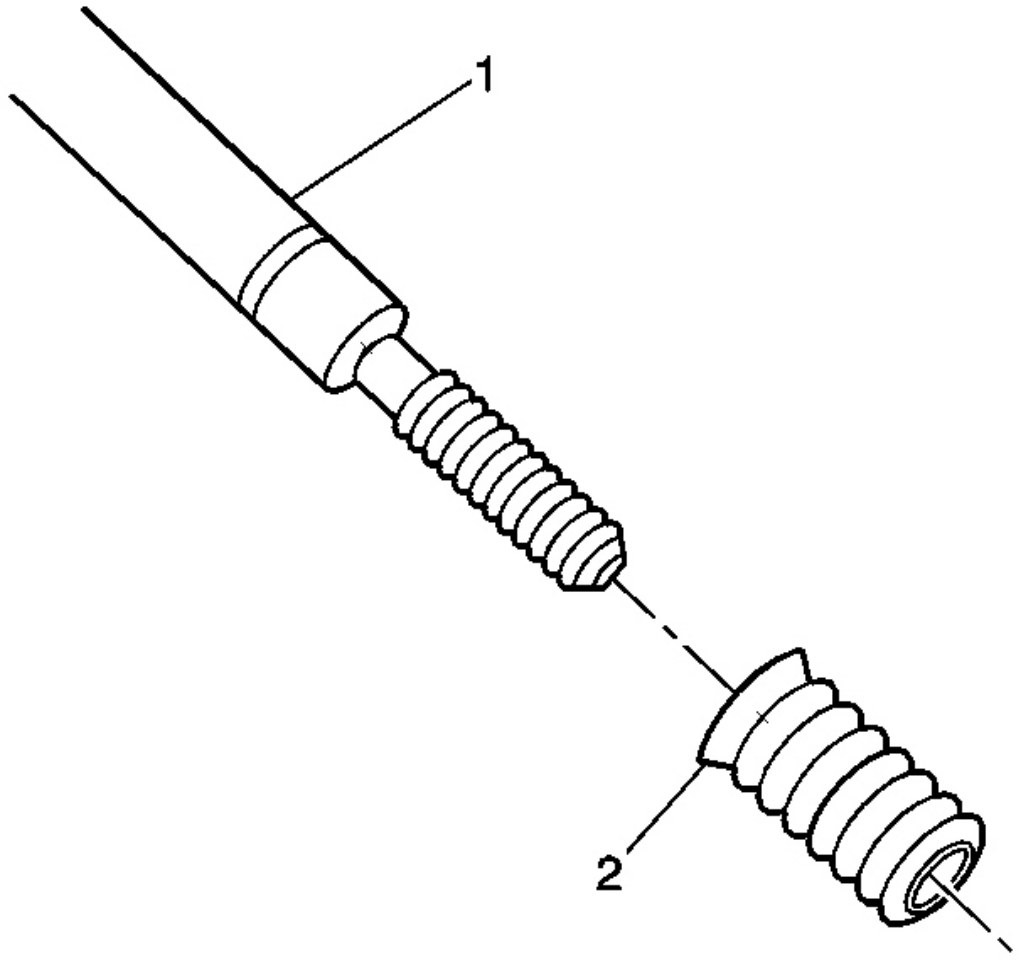


Fig. 450: View Of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

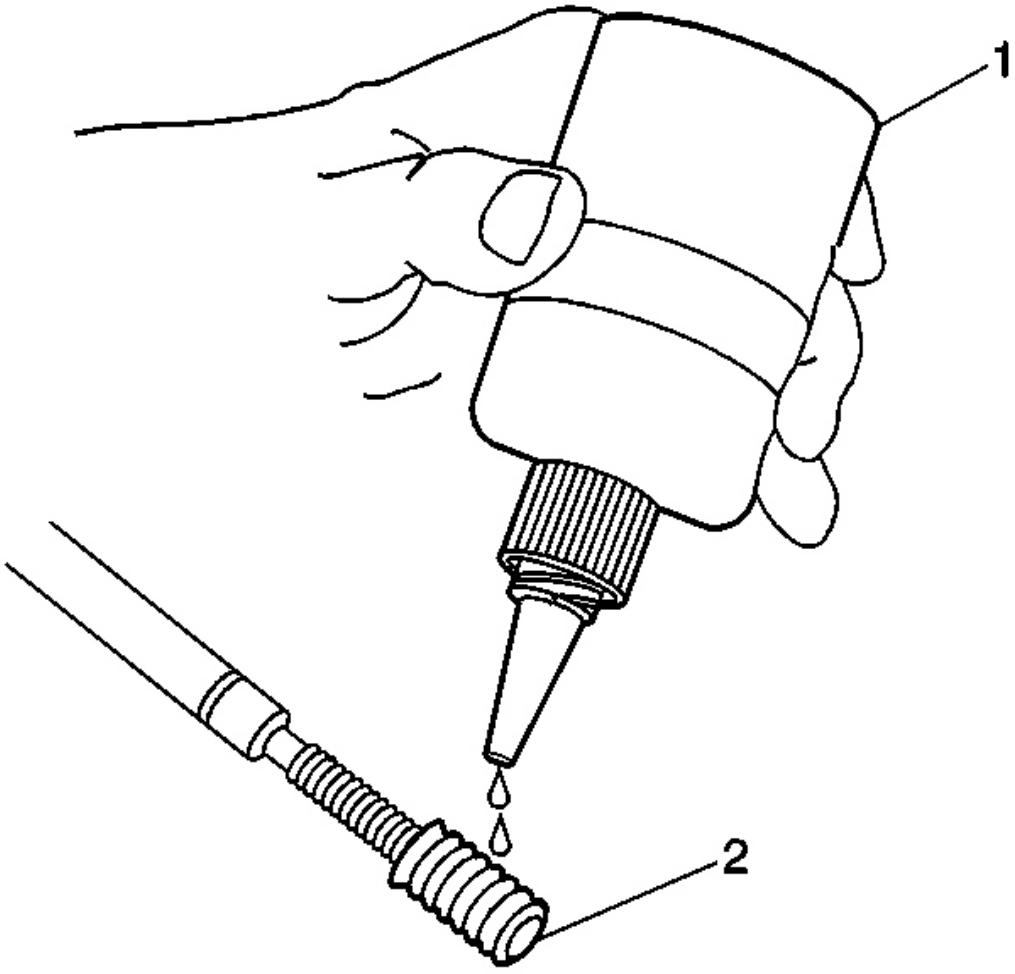


Fig. 451: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, Canadian P/N 10953488, J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

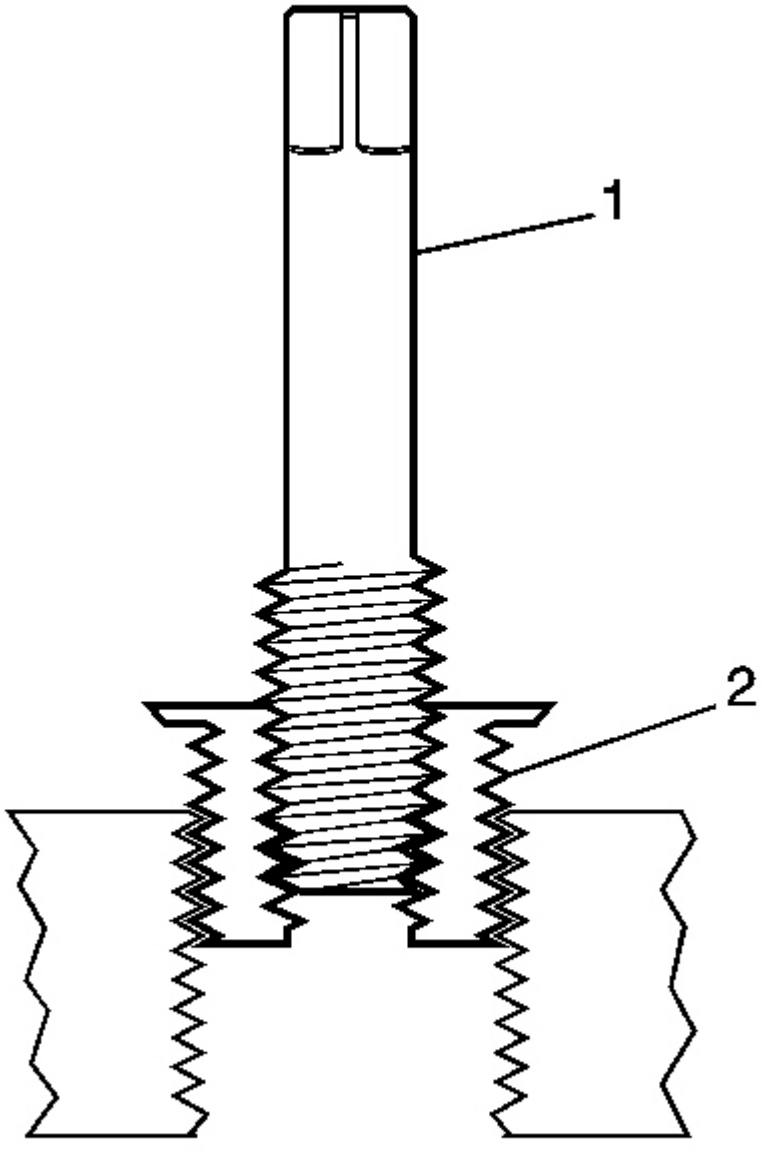


Fig. 452: View Of Insert - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole.

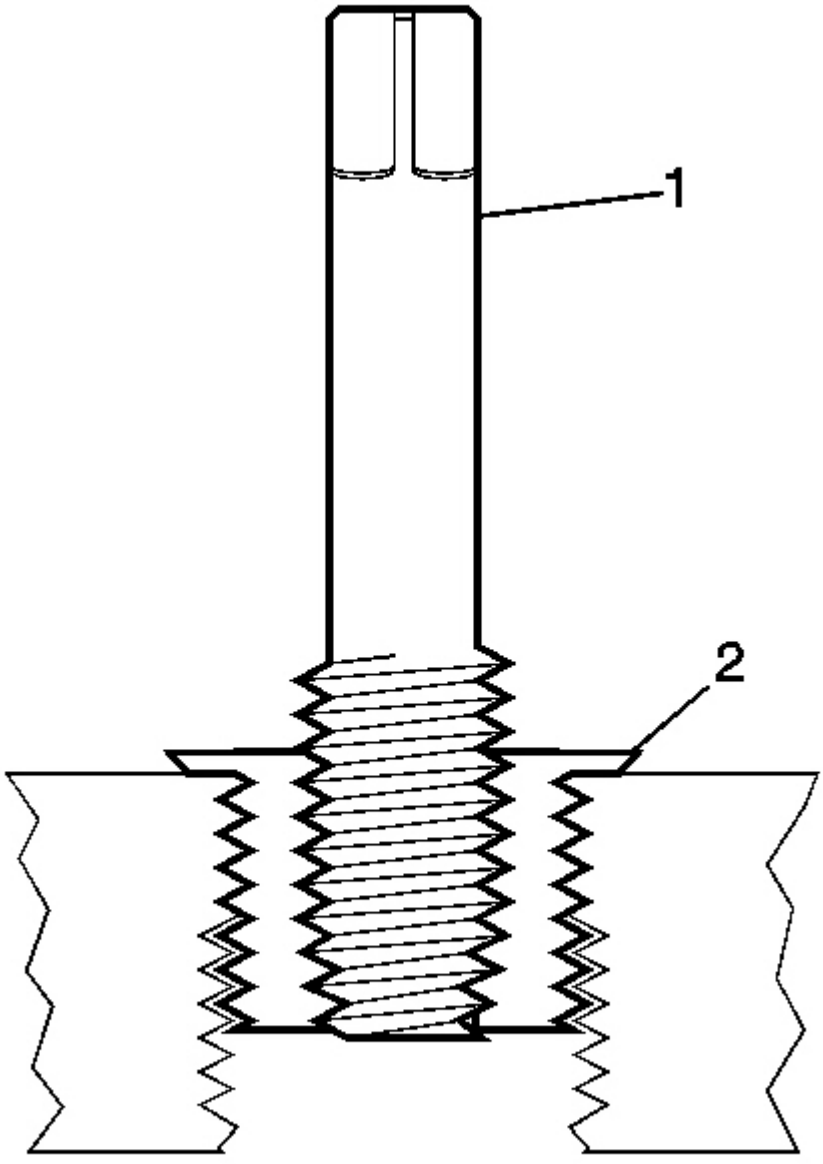


Fig. 453: View Of Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper

tapping.

12. Install the insert until the flange (2) of the insert contacts the surface of the base material.

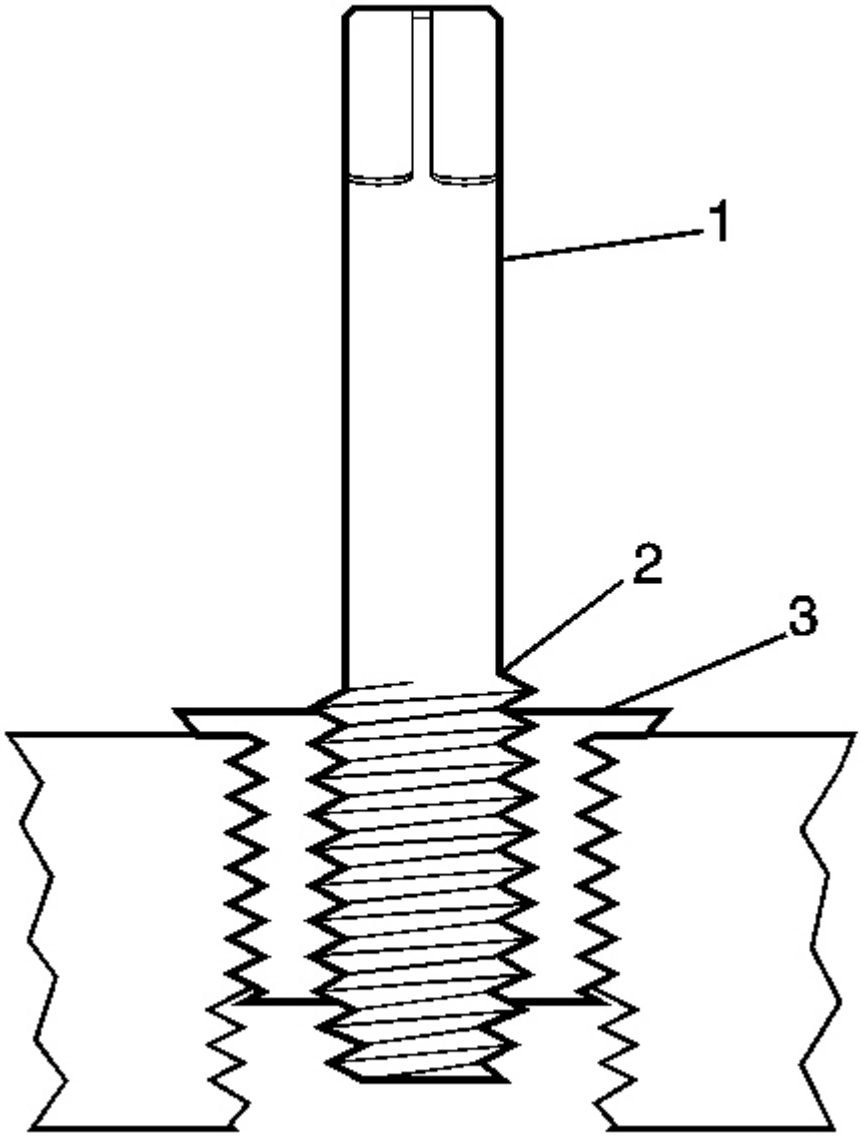


Fig. 454: View Of Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).

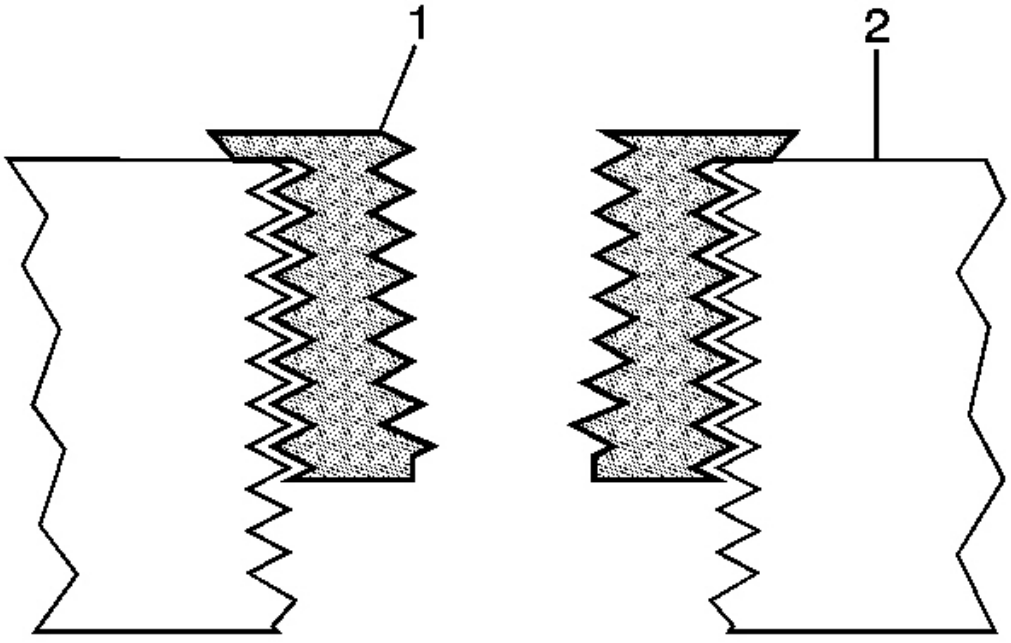


Fig. 455: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

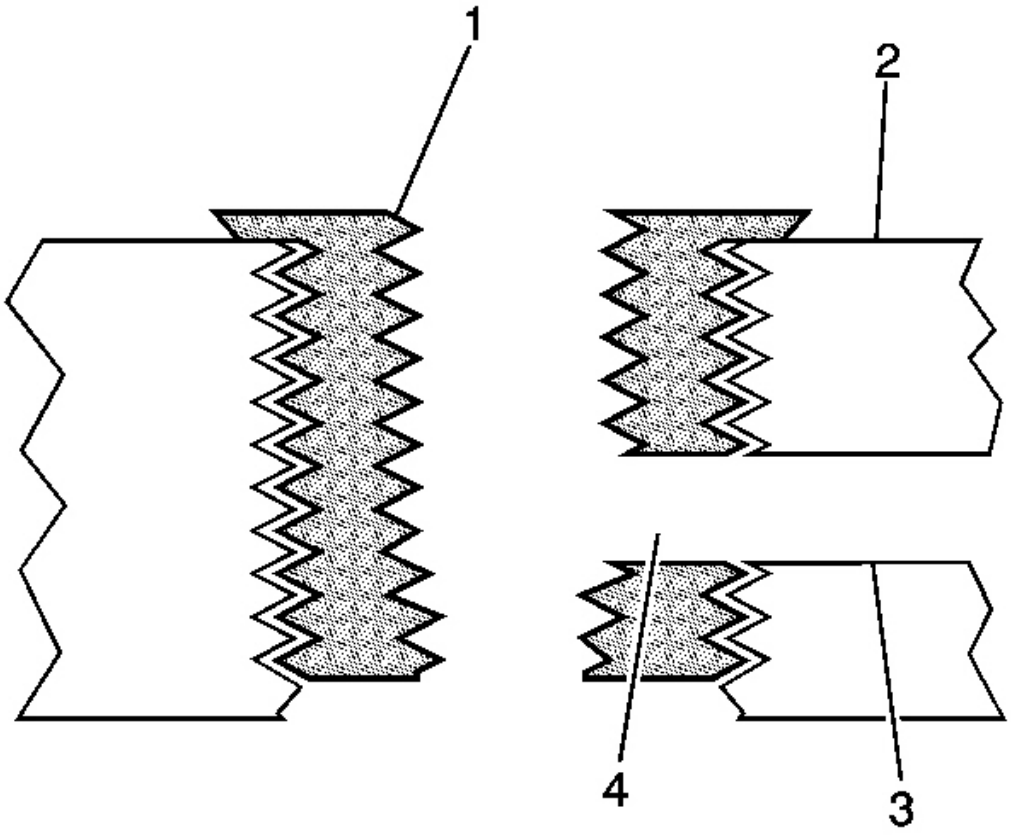


Fig. 456: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Cylinder Head Bolt Hole Thread Repair

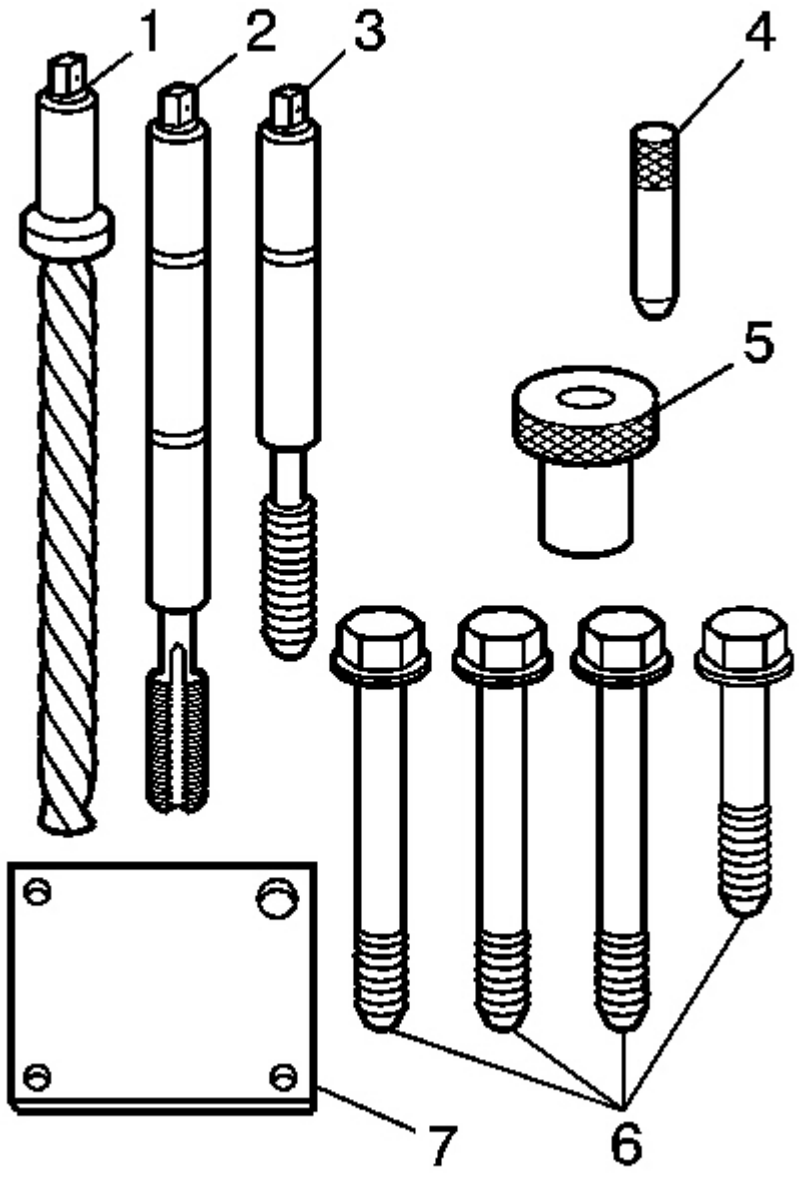


Fig. 457: View Of Cylinder Head Bolt Hole Required Tools
Courtesy of GENERAL MOTORS CORP.

The cylinder head bolt hole required tools consist of the following:

- Drill (1) J 42385-402

- Tap (2) J 42385-403
- Installation driver (3) J 42385-404
- Alignment pin (4) J 42385-303
- Bushing (5) J 42385-302
- Bolts (6) J 42385-421
- Fixture plate (7) J 42385-401

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **Remove the fixture plate prior to installing the insert with the installer tool.**
- **The use of a cutting type fluid GM P/N 1052864, Canadian P/N 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

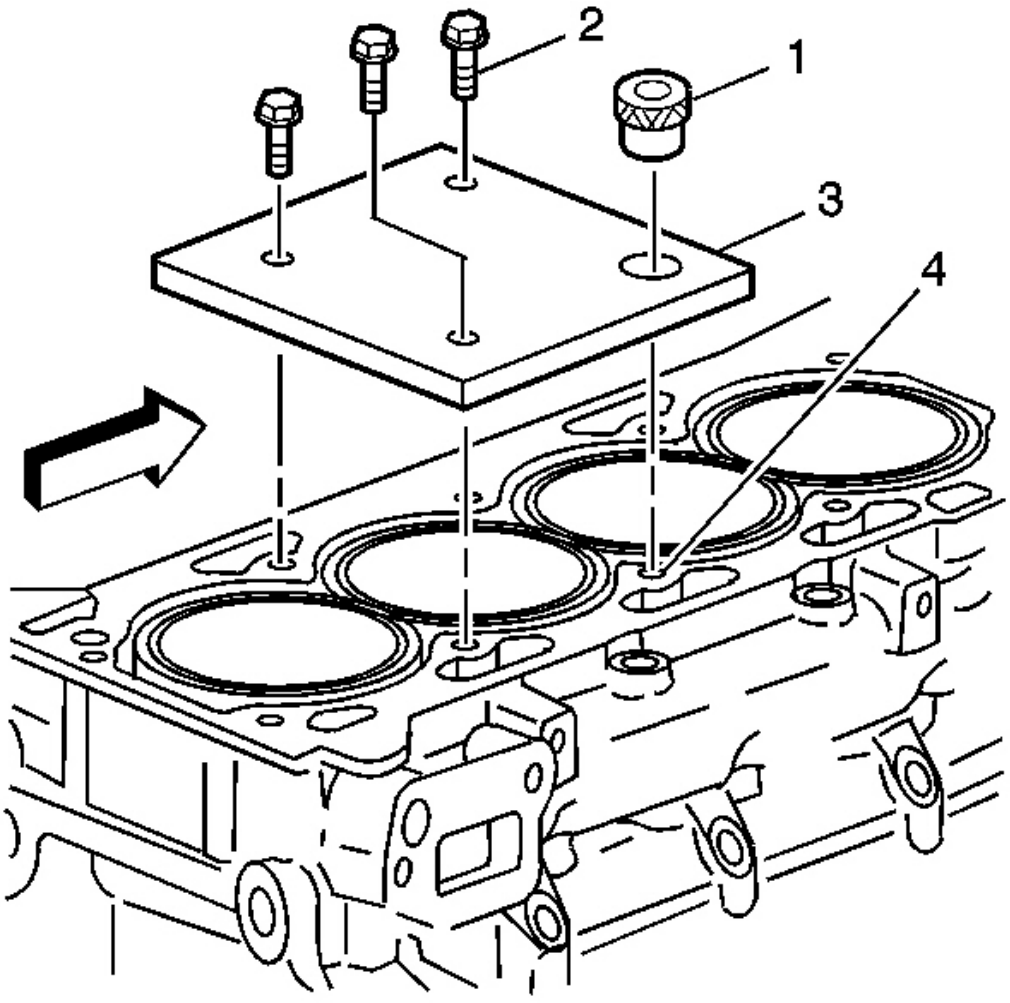


Fig. 458: View Of Bushing, Fixture Plate, Bolts & Bolt Hole
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.

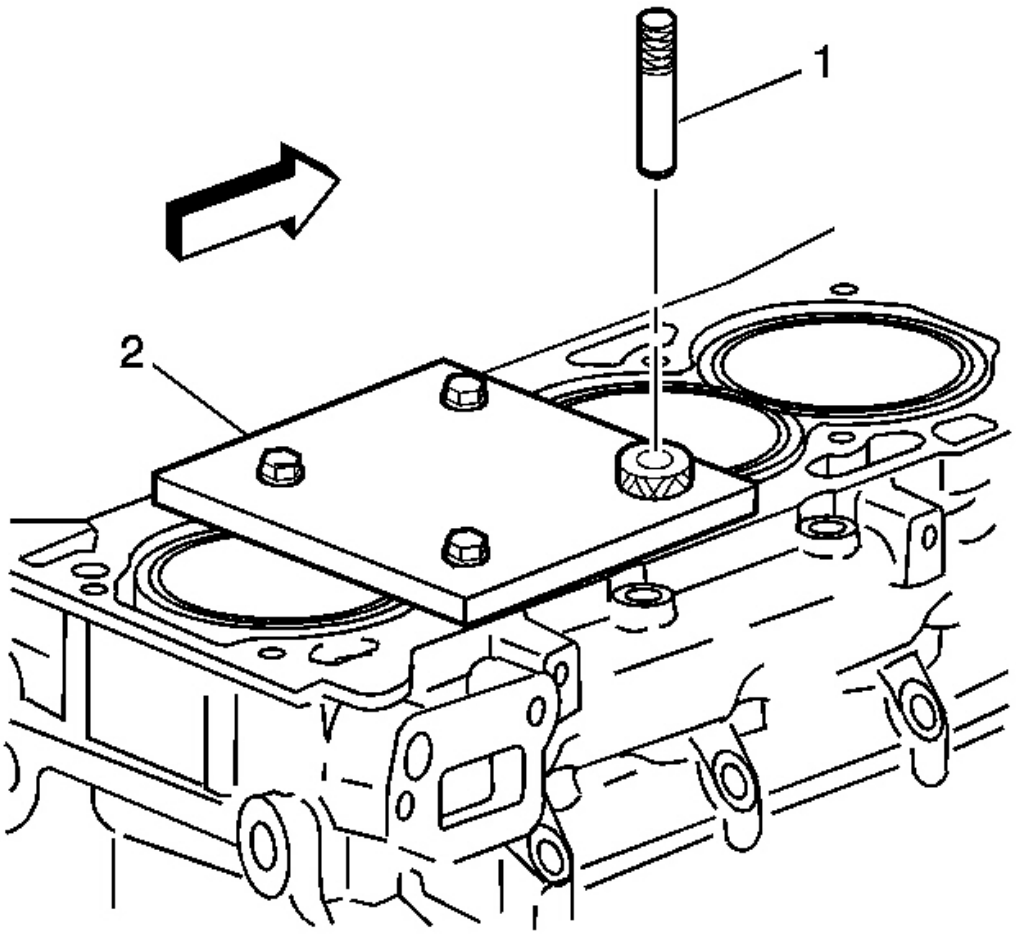


Fig. 459: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

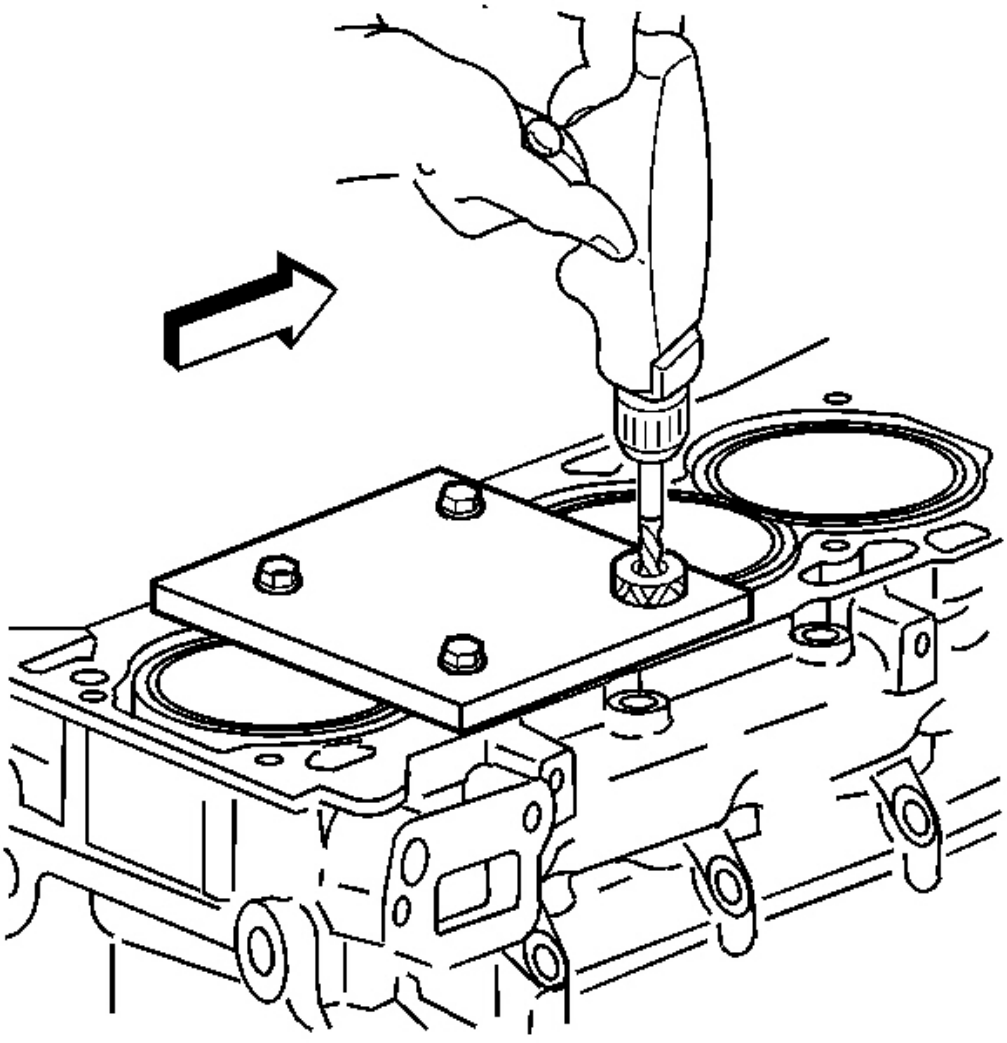


Fig. 460: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.

6. Drill out the threads of the damaged hole.

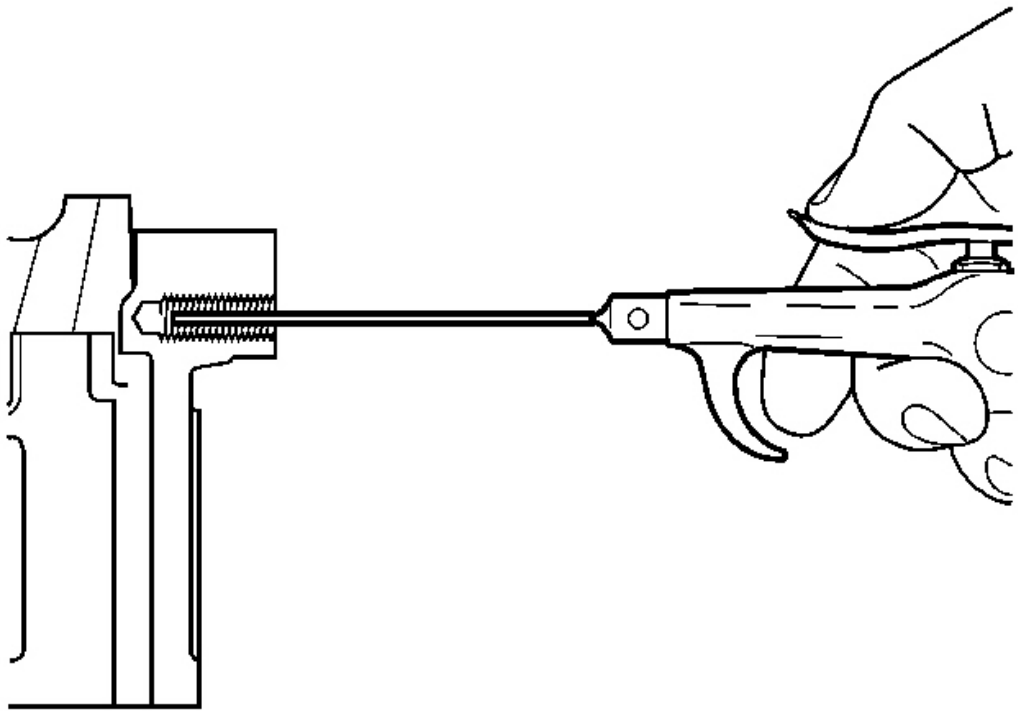


Fig. 461: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

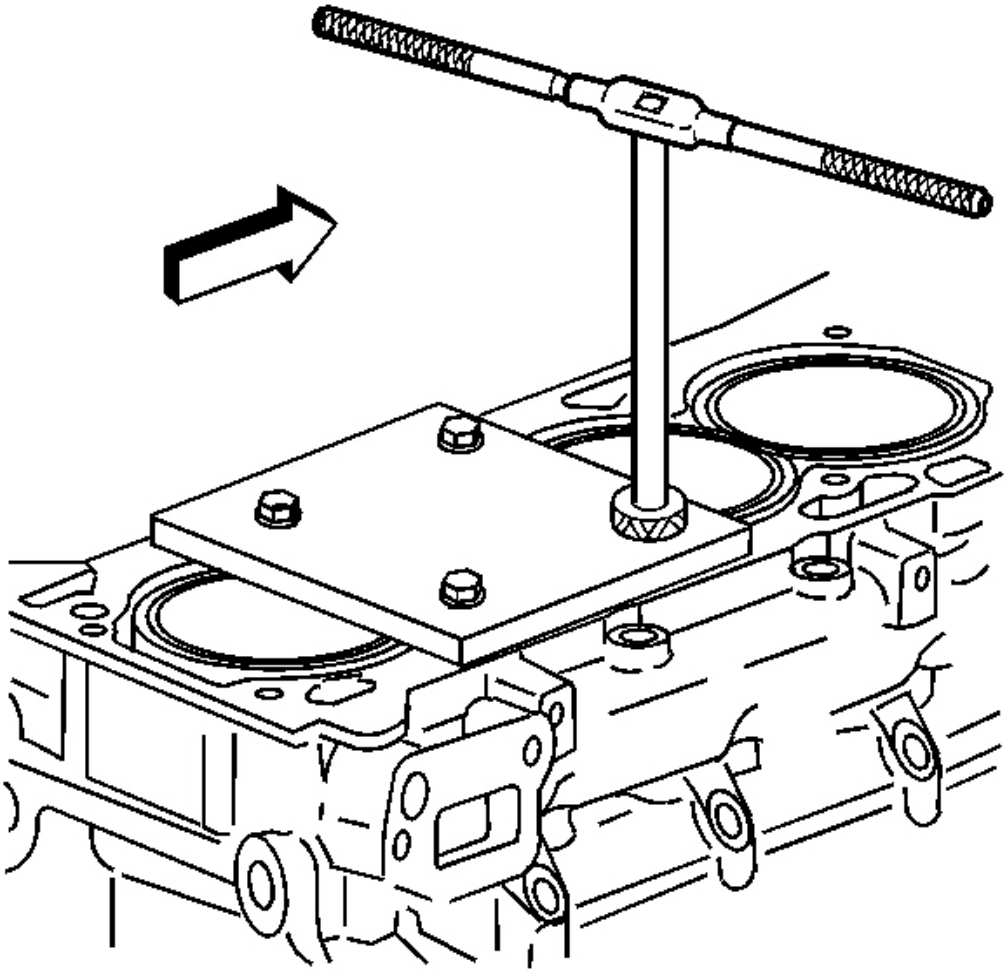


Fig. 462: Tapping Out Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole.

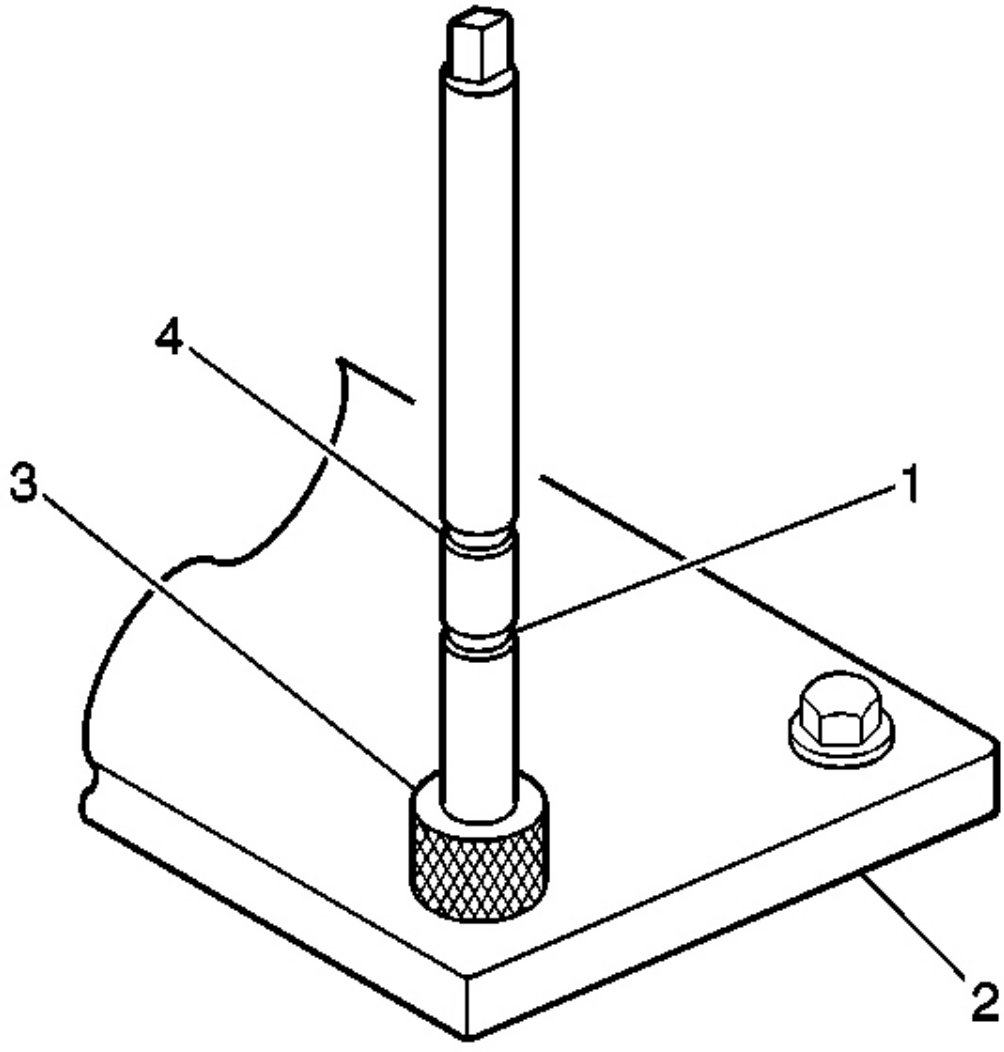


Fig. 463: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the first mark (1) on the tap aligns with the top of the drill bushing (3).

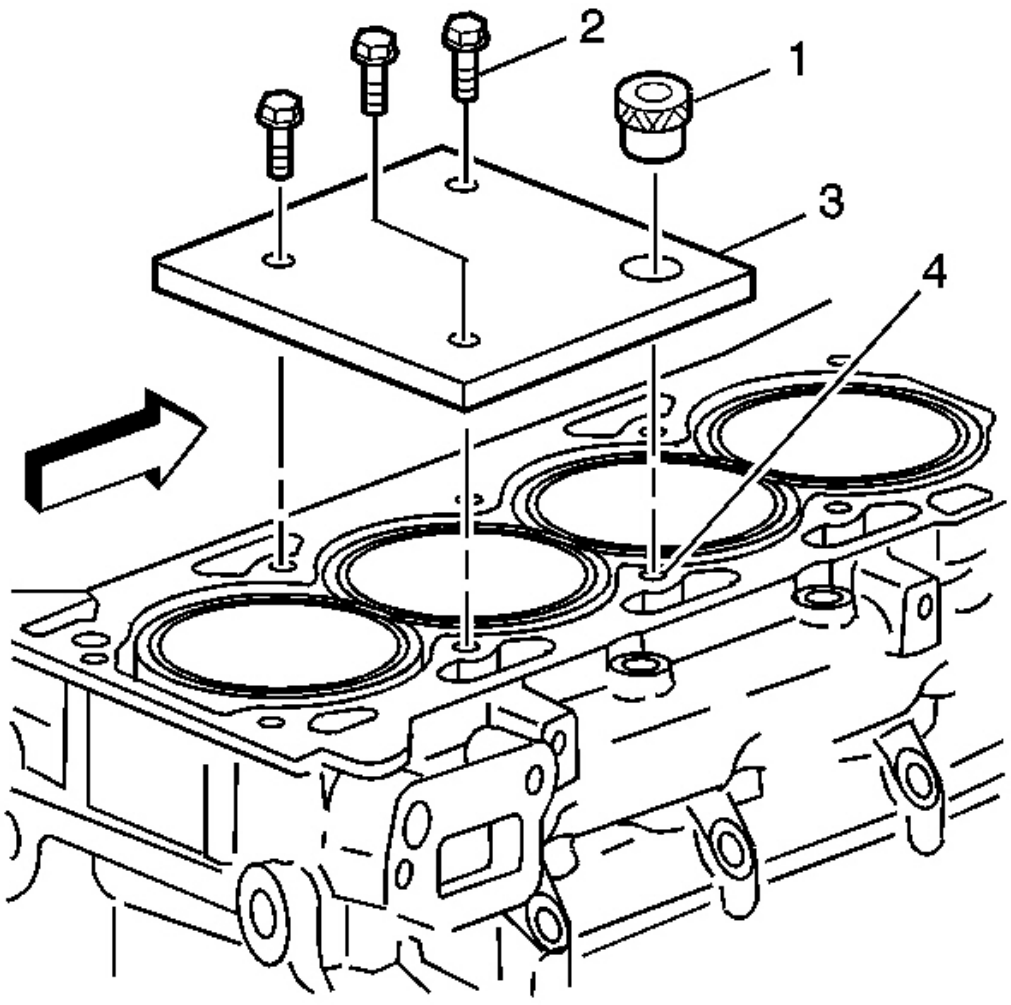


Fig. 464: View Of Bushing, Fixture Plate, Bolts & Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the fixture plate prior to installing the insert with the installer tool.

10. Remove the fixture plate bolts (2).
11. Remove the fixture plate (3) and bushing (1).

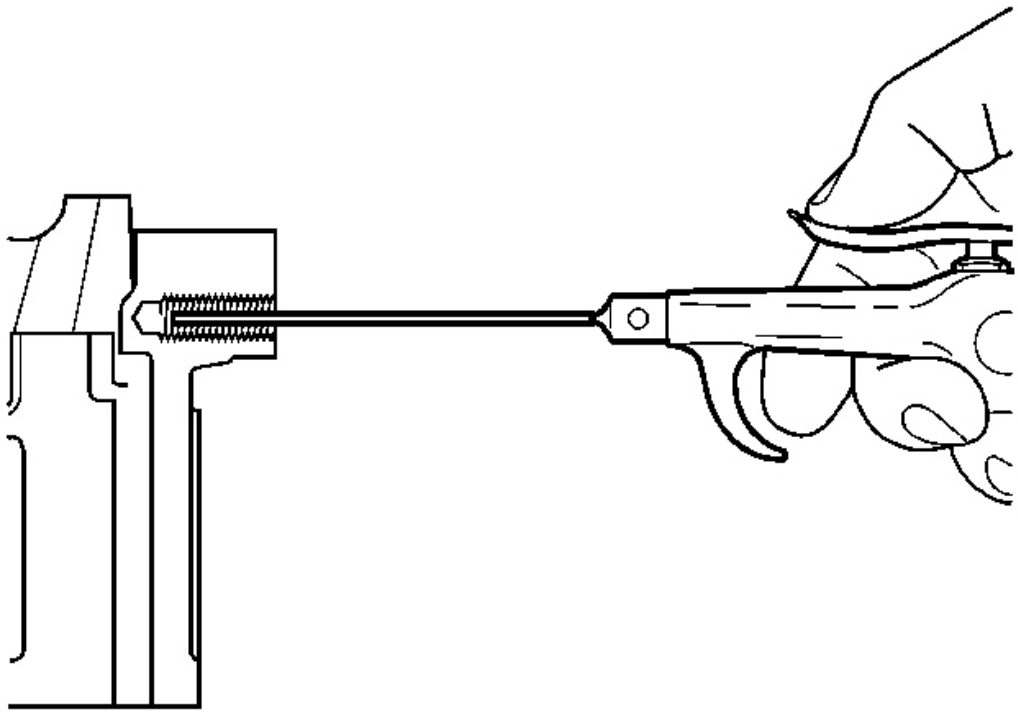


Fig. 465: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

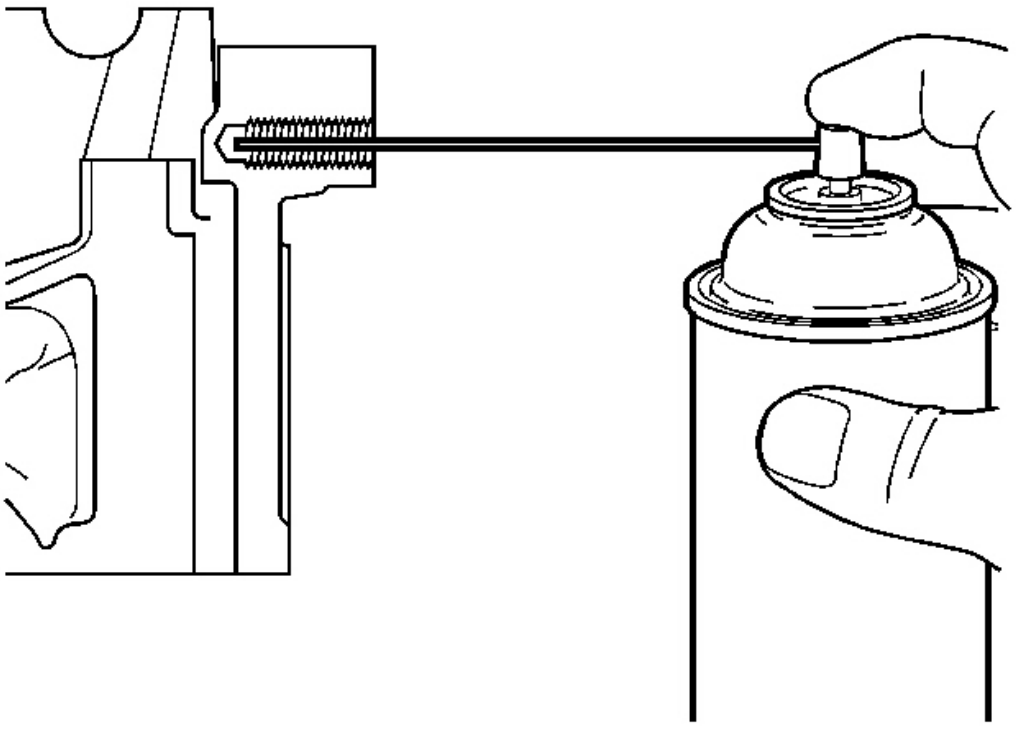


Fig. 466: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

13. Spray cleaner GM P/N 12377981, Canadian P/N 10953463 or equivalent into the tapped hole.

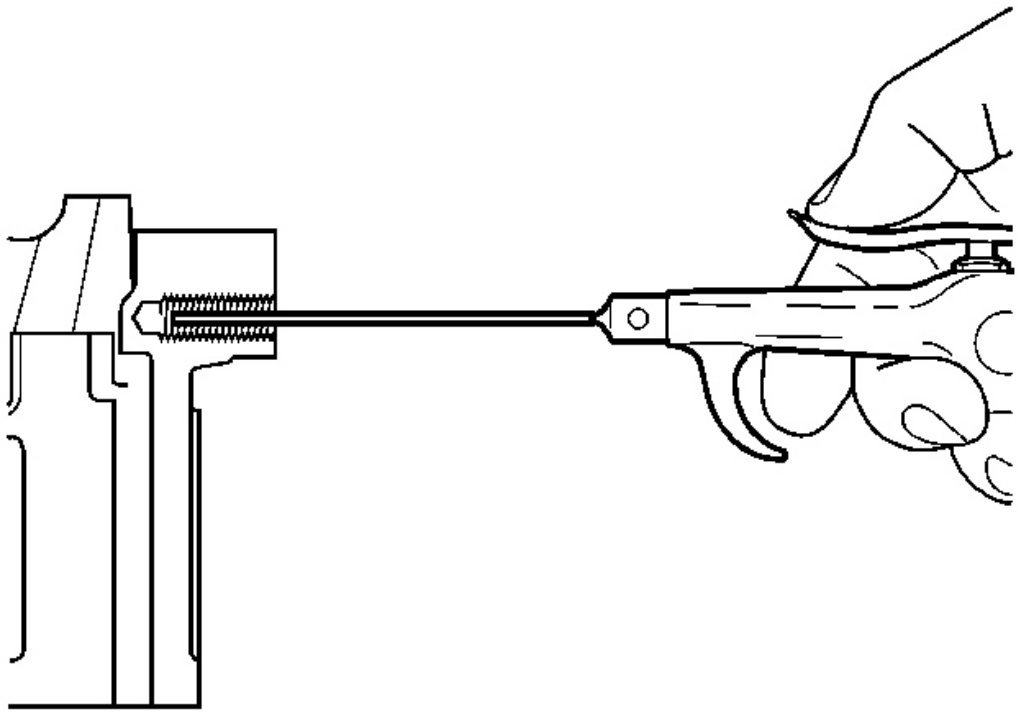


Fig. 467: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

14. Using compressed air, clean out any chips.

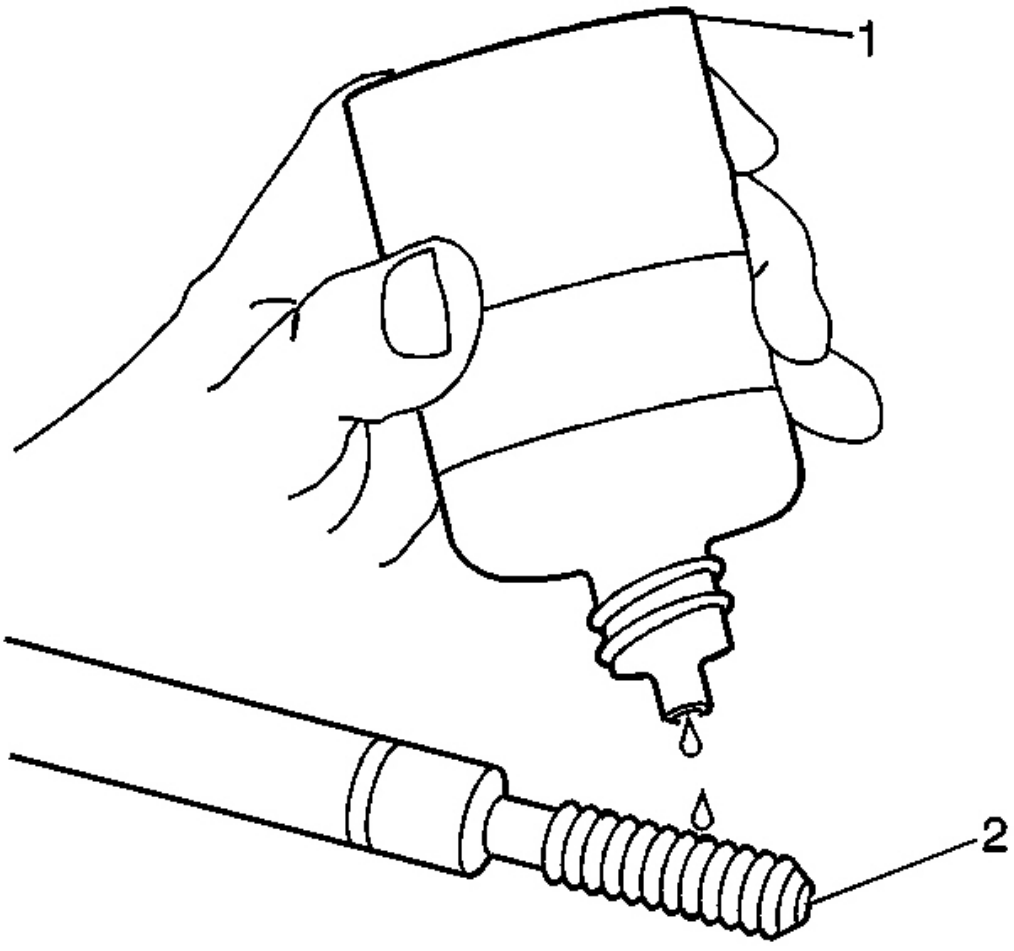


Fig. 468: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

15. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

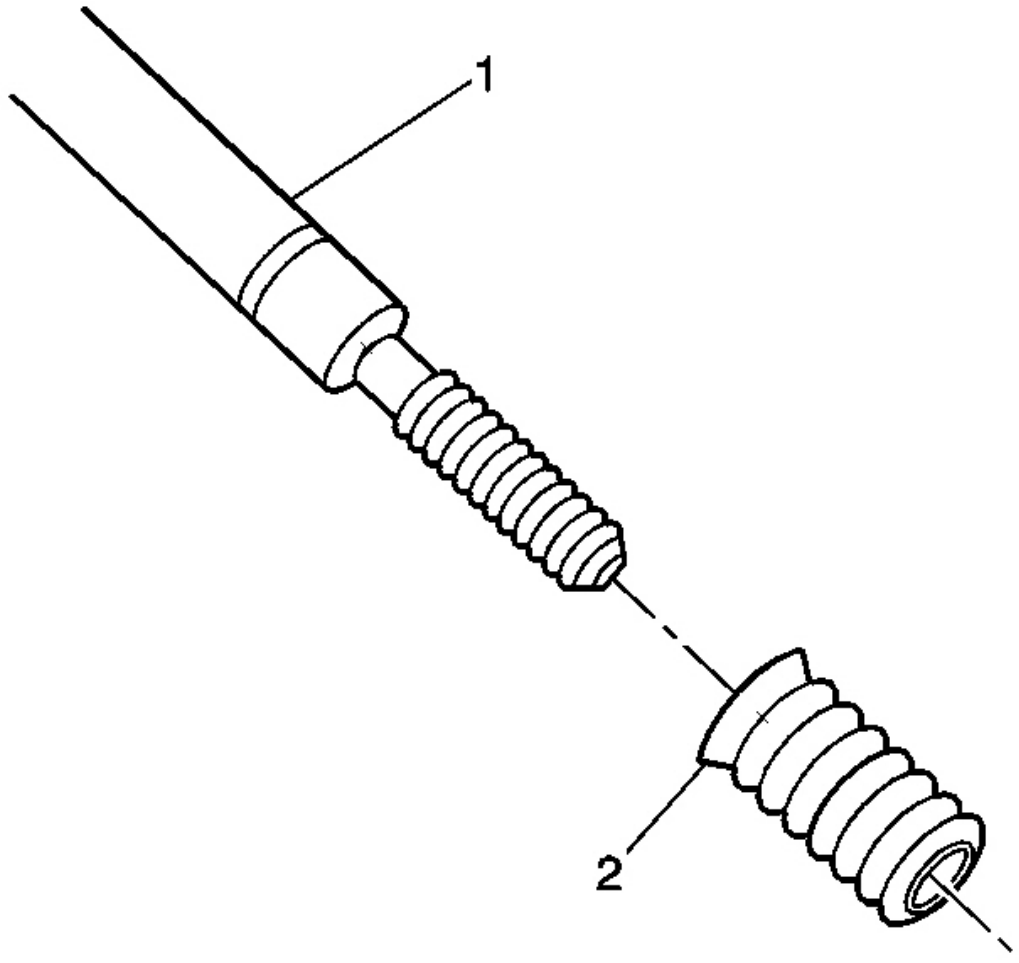


Fig. 469: View Of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver installation tool (1).

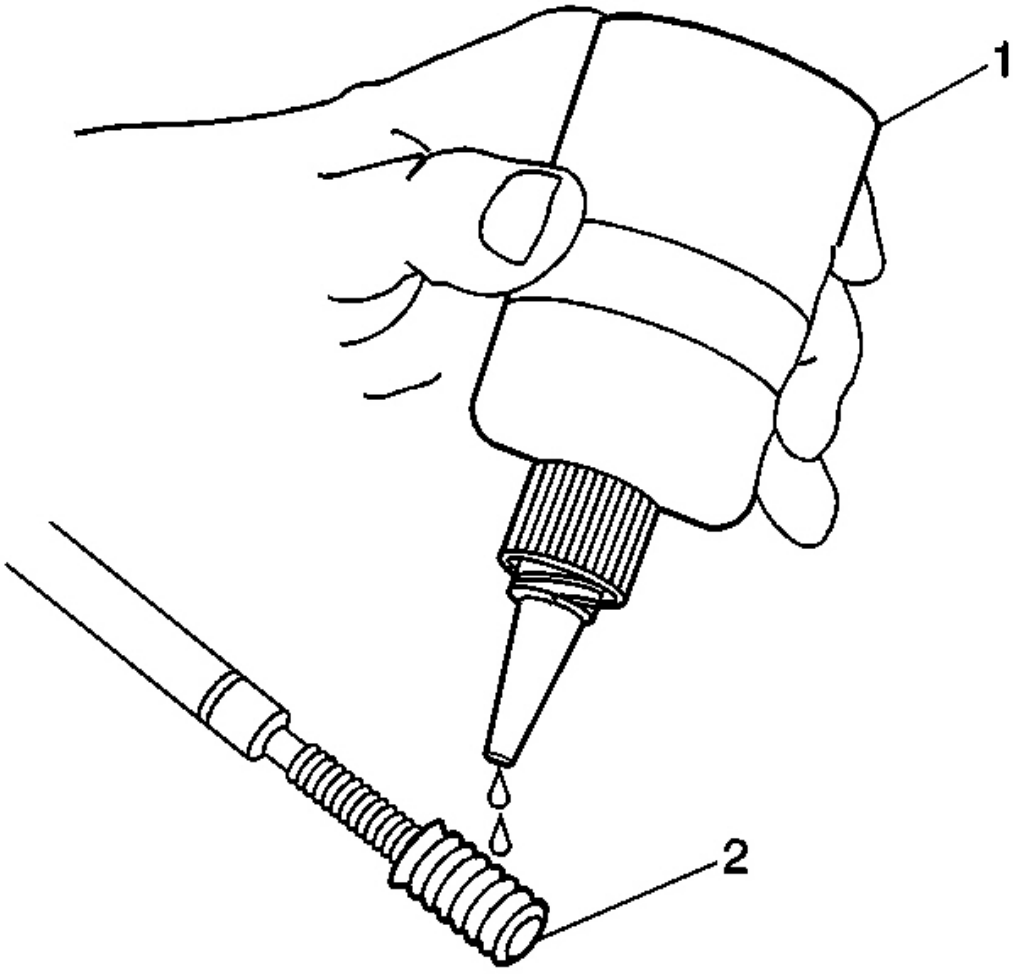


Fig. 470: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock sealant GM P/N 12345493, Canadian P/N 10953488, J 42385-109, LOCTITE 277®, or equivalent (1) to the insert OD threads (2).

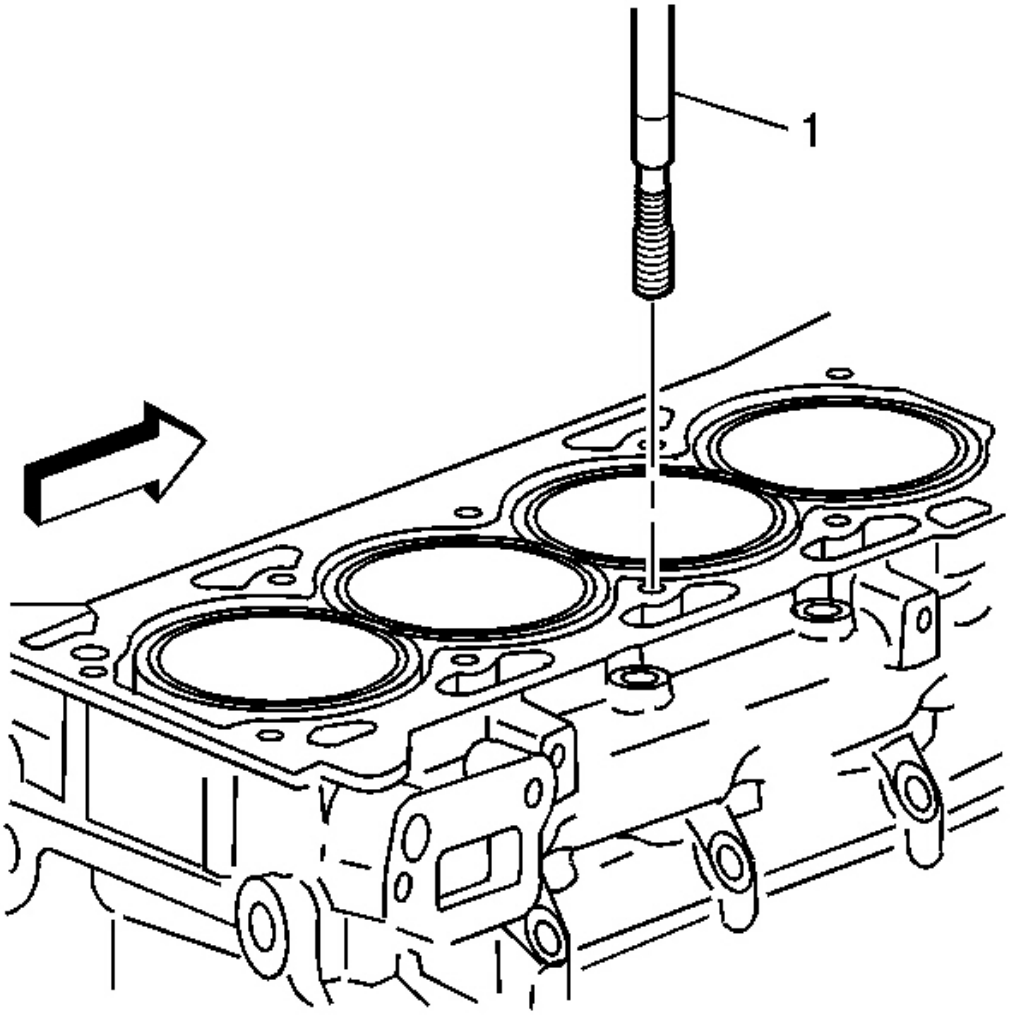


Fig. 471: View Of Installation Driver
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and installation driver (1) into the tapped hole.
19. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.
22. Inspect the insert for proper installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair

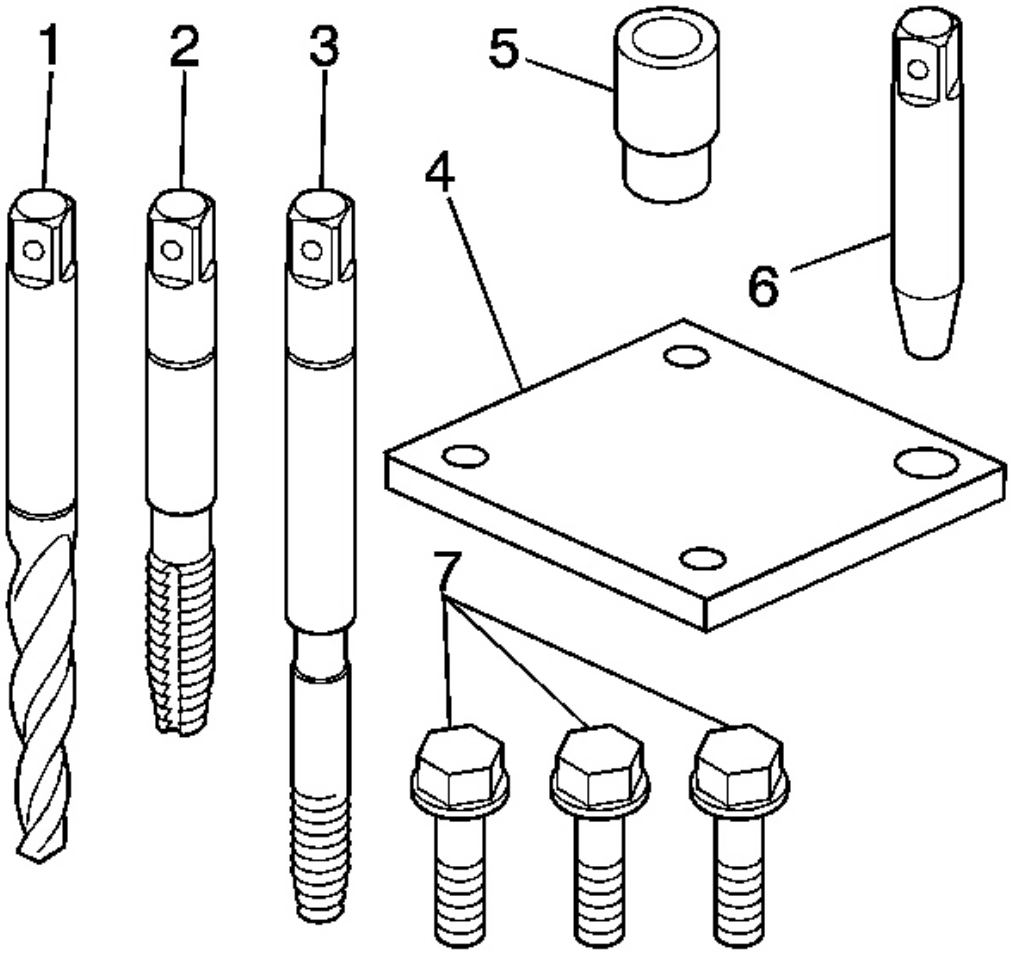


Fig. 472: View Of Crankshaft Main Bearing Bolt Hole Required Tools

Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.**
- **Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.**

The crankshaft main bearing bolt hole required tools consist of the following:

- Drill (1) J 42385-417
- Tap (2) J 42385-418
- Installation driver (3) J 42385-419
- Fixture plate (4) J 42385-401
- Bushing (5) J 42385-307
- Alignment pin (6) J 42385-308
- Bolts (7) J 42385-510

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **Ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **The use of a cutting type fluid GM P/N 1052864, Canadian P/N 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

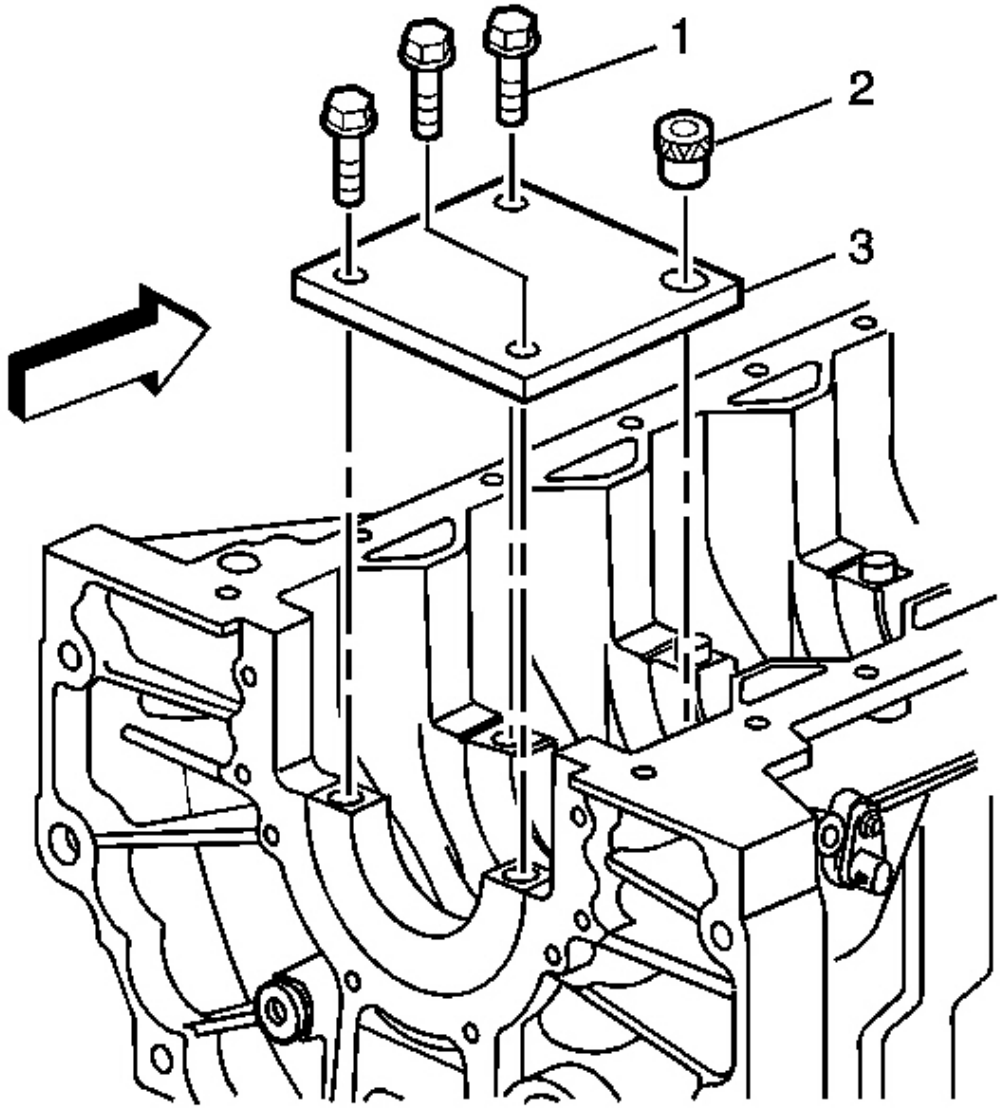


Fig. 473: View Of Fixture Plate, Bolts & Bushing
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (2), installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.

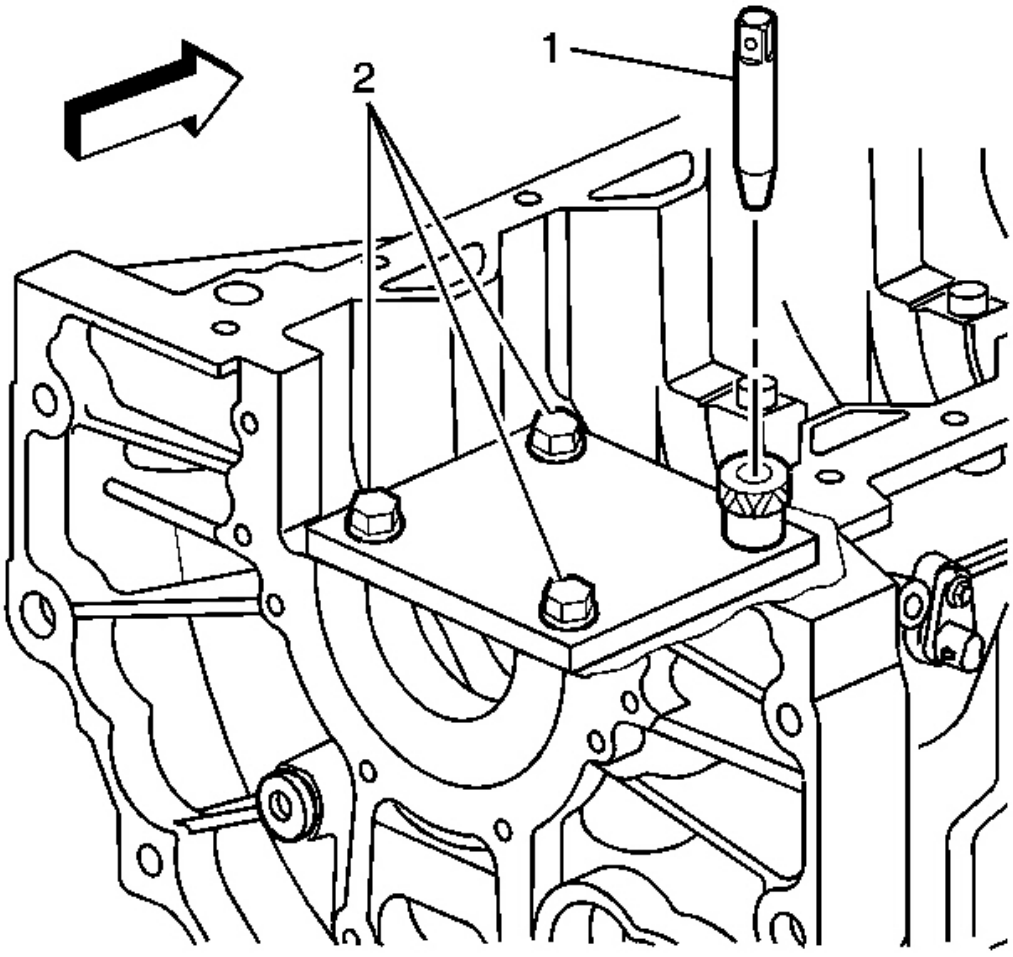


Fig. 474: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

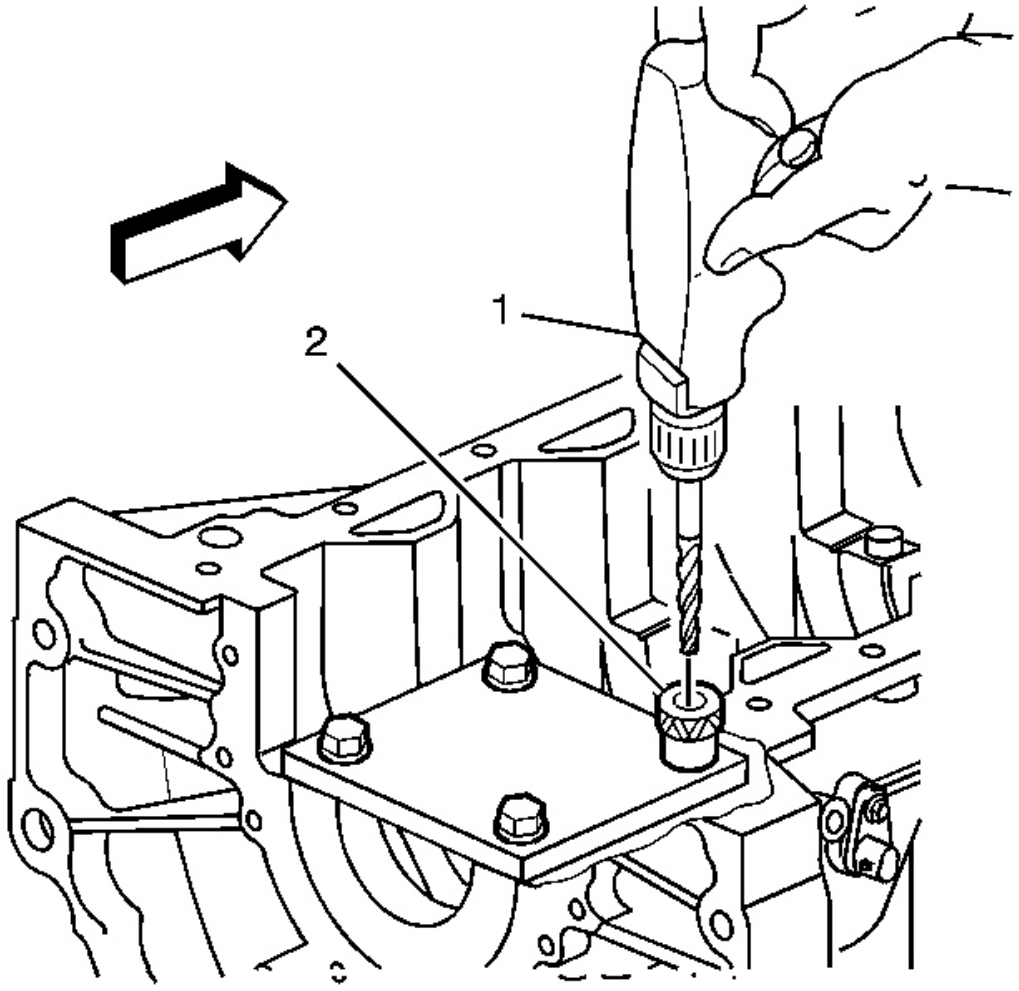


Fig. 475: Drilling Bushing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.**
- **Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).**

6. Drill out the threads of the damaged hole.

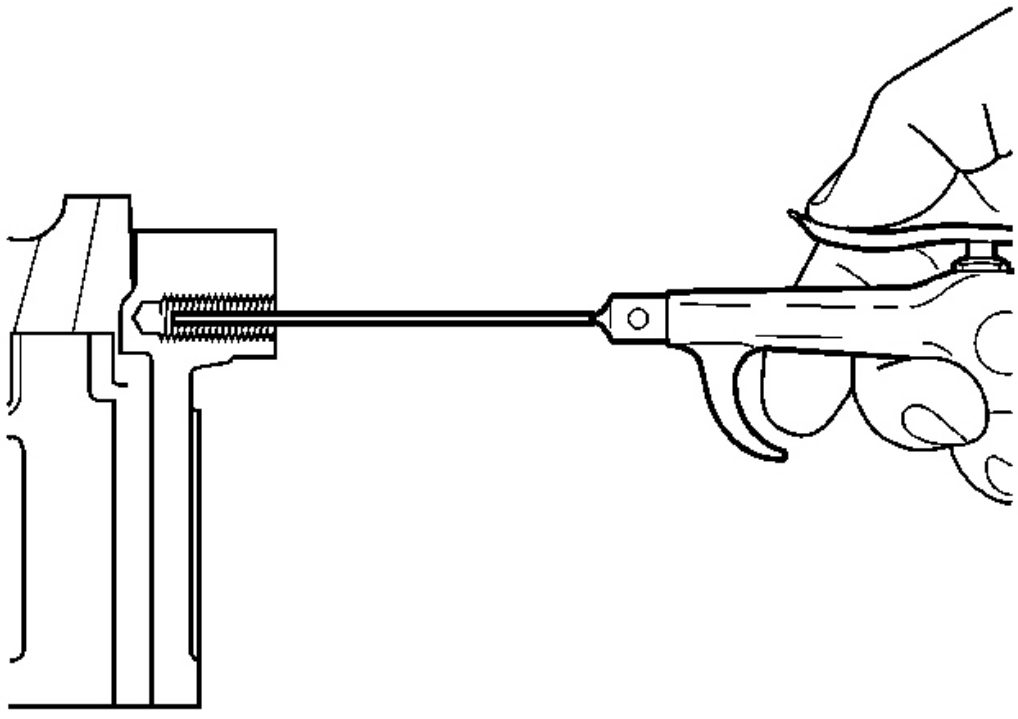


Fig. 476: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

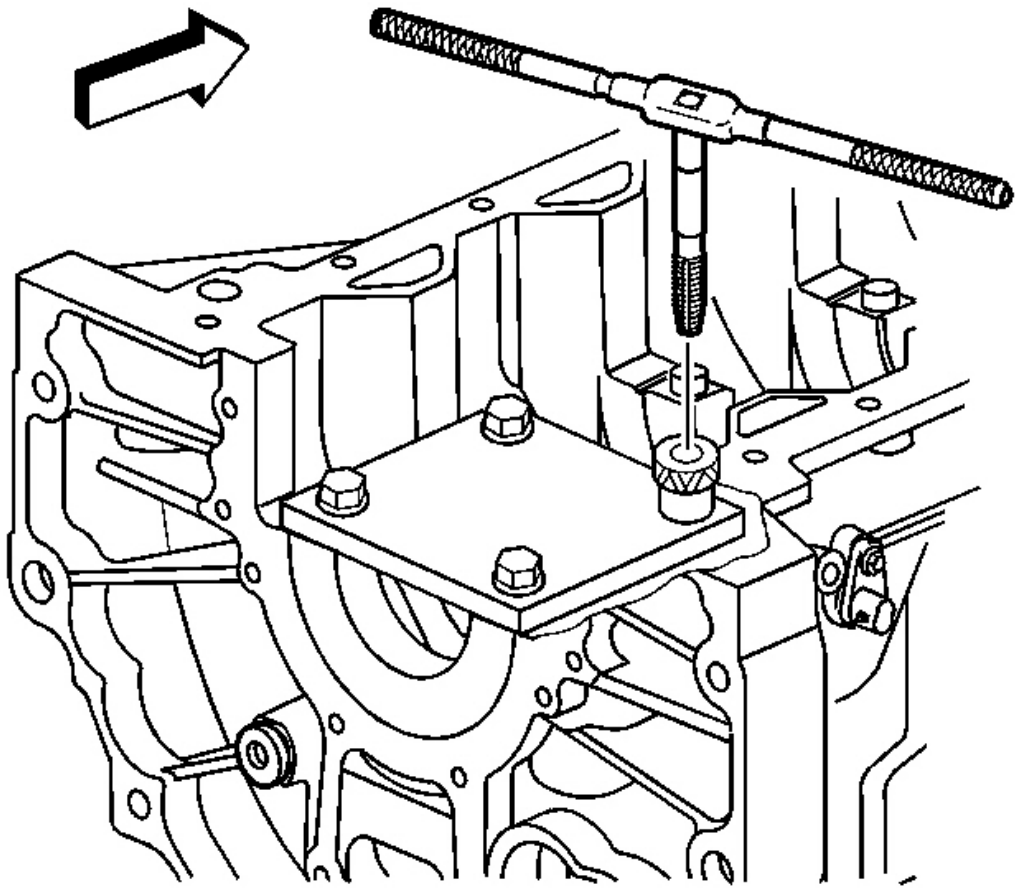


Fig. 477: Tapping Out Threads Of Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.**
- **Ensure the tap has created full threads at least to the depth equal to the insert length.**

8. Using a suitable tapping wrench, tap the threads of the drilled hole.

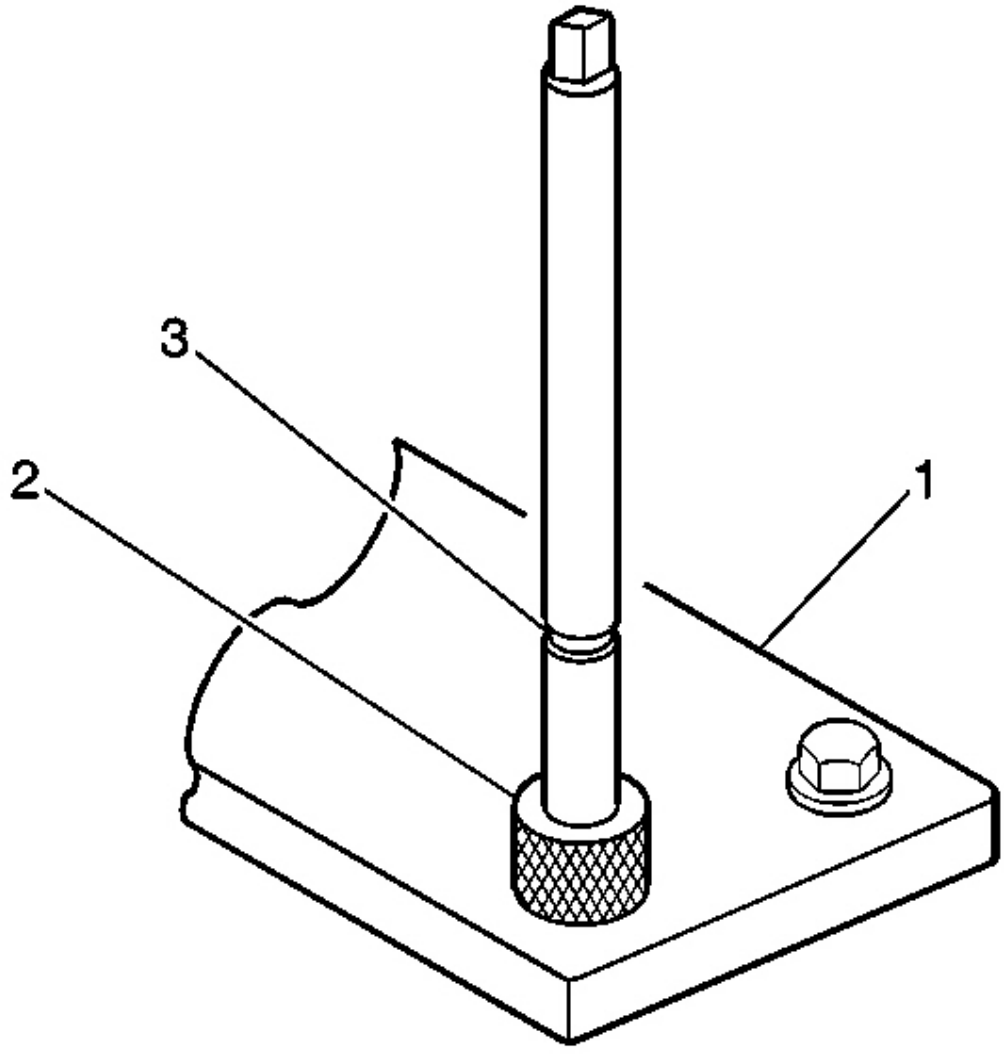


Fig. 478: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

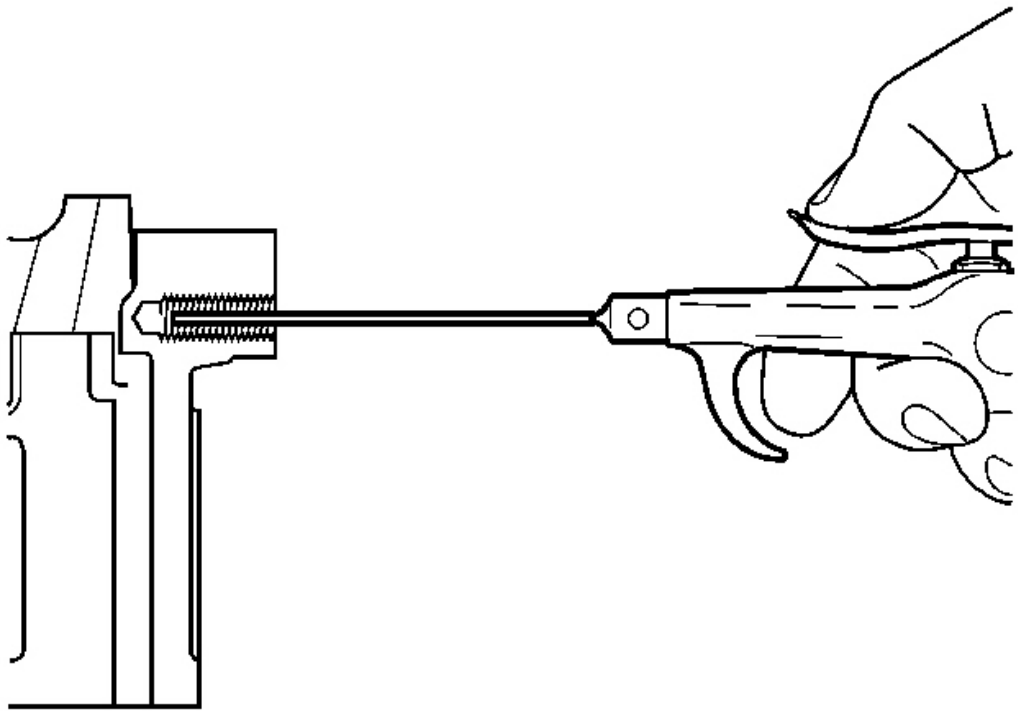


Fig. 479: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.

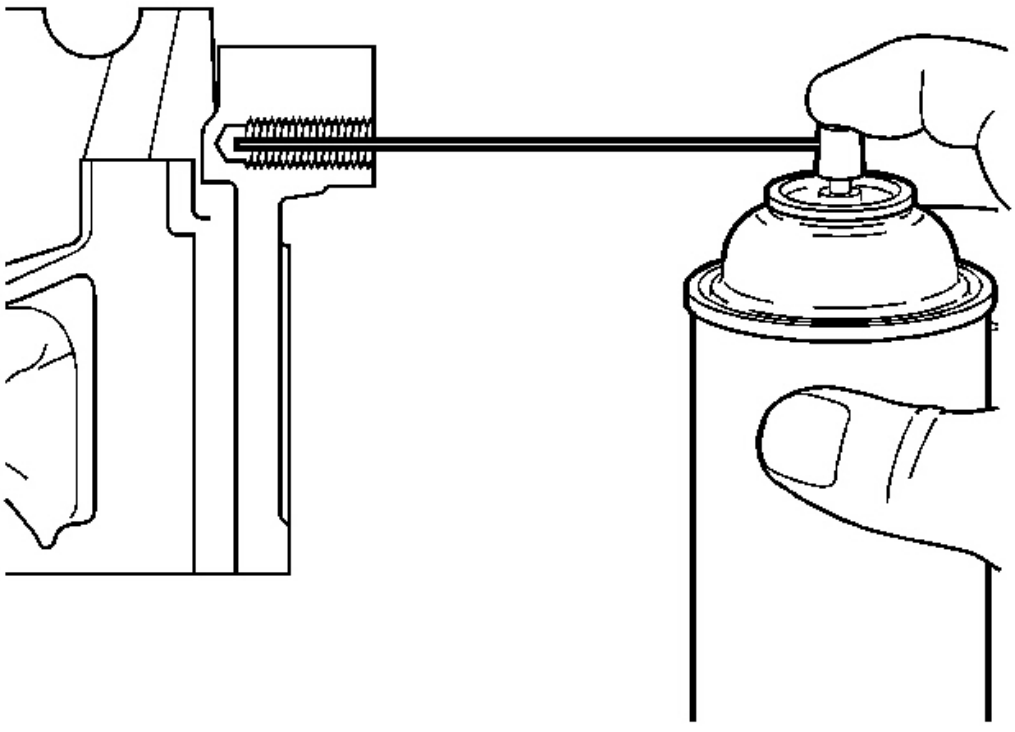


Fig. 480: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

11. Spray cleaner GM P/N 12377981, Canadian P/N 10953463 or equivalent into the tapped hole.

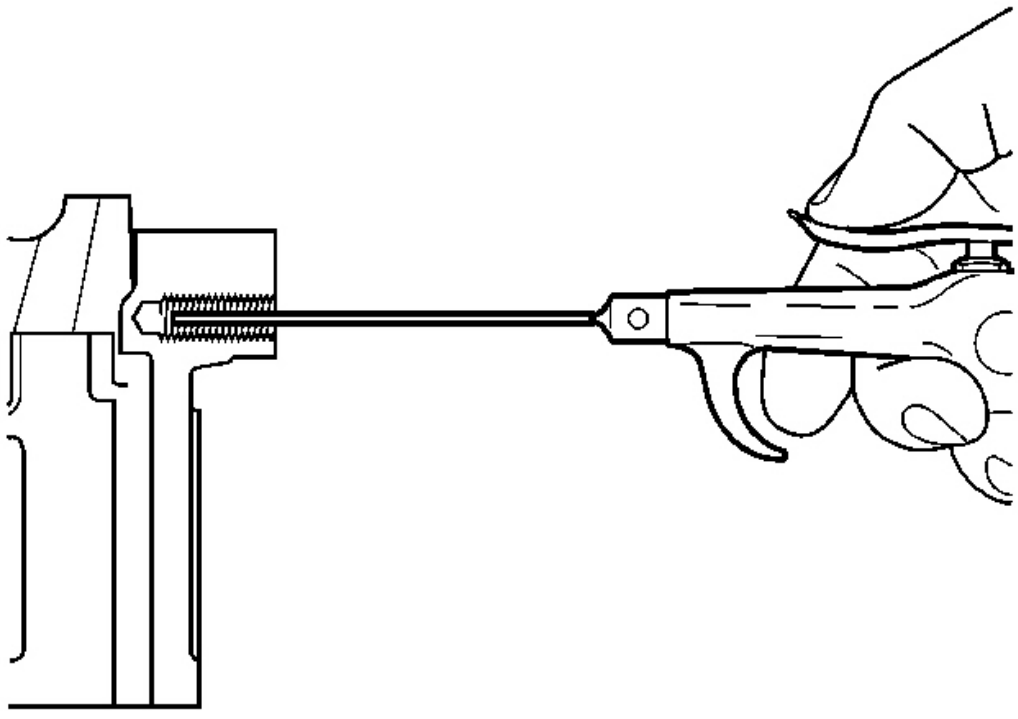


Fig. 481: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

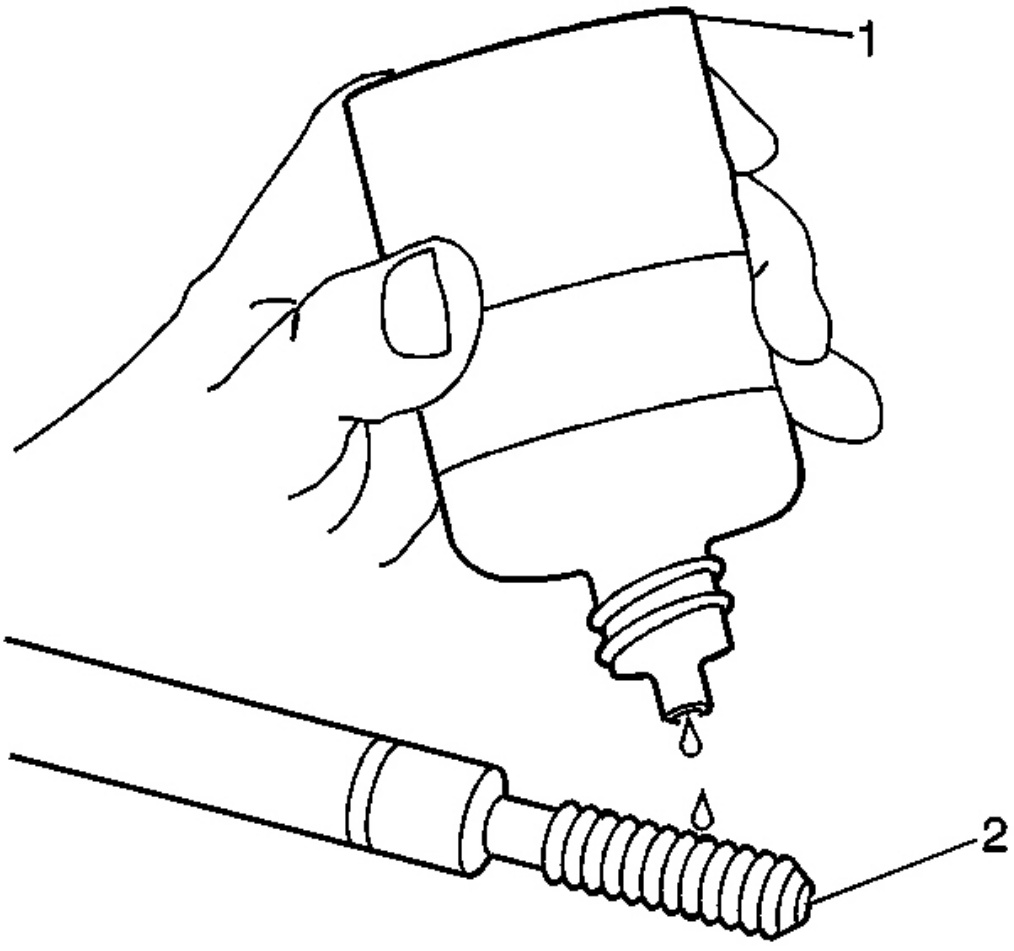


Fig. 482: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.**
- **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

13. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

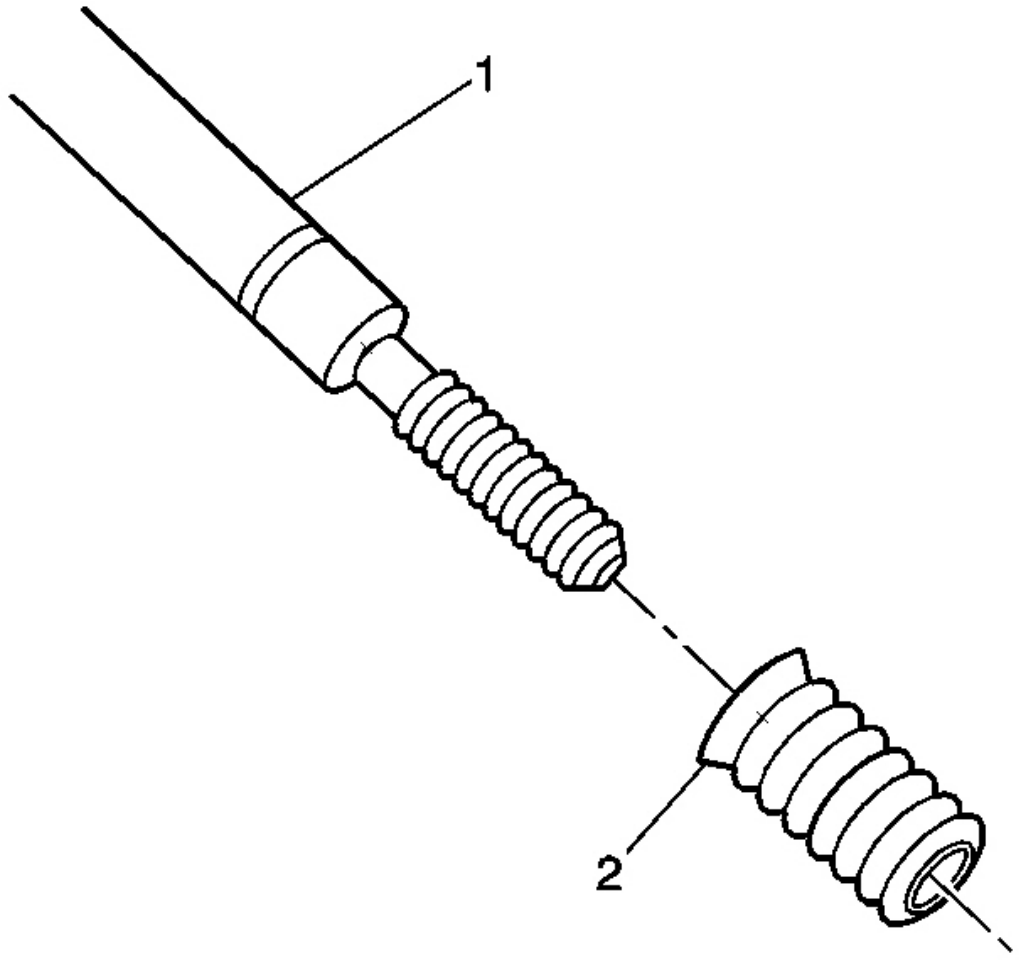


Fig. 483: View Of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

14. Install the insert (2) onto the driver installation tool (1).

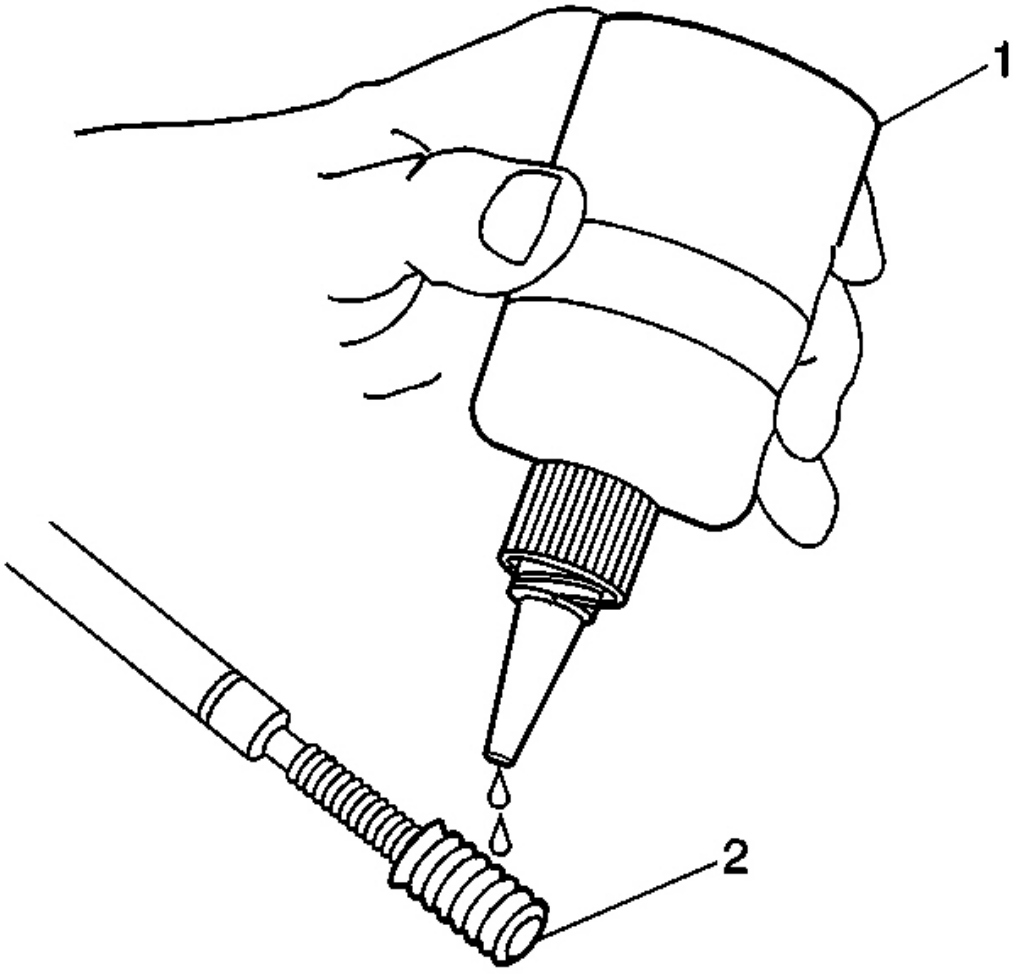


Fig. 484: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

15. Apply threadlock sealant GM P/N 12345493, Canadian P/N 10953488, J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

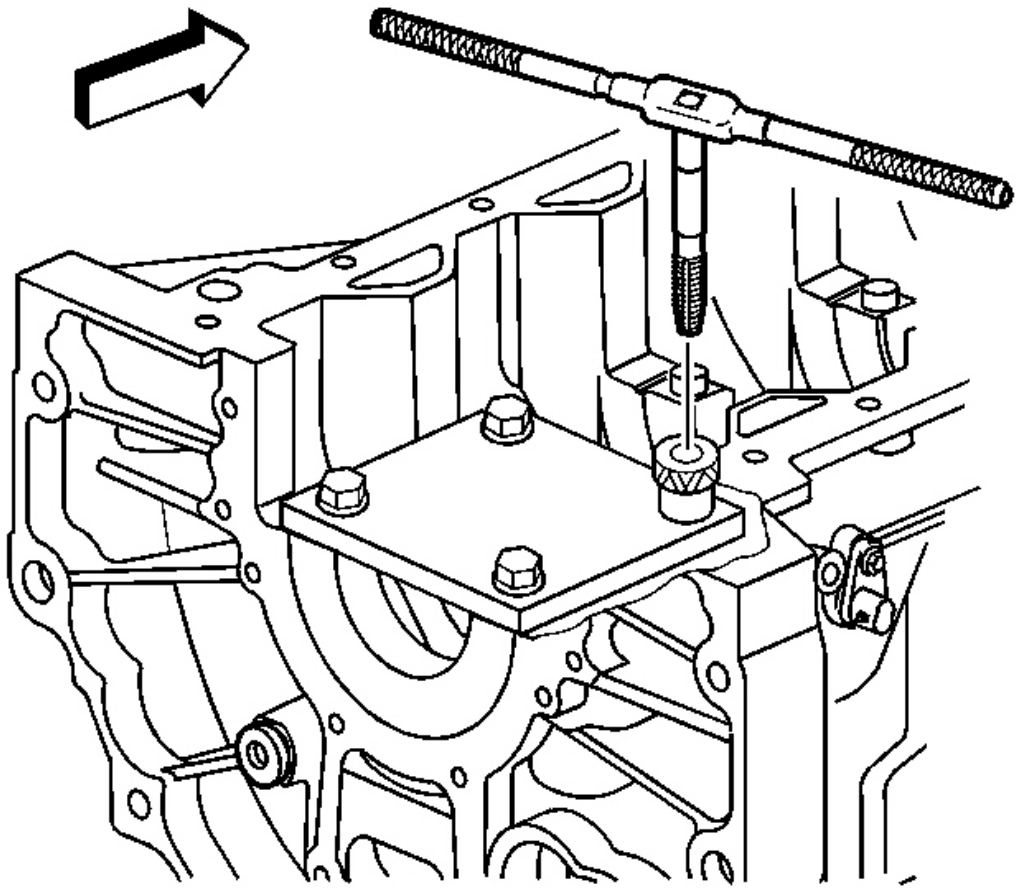


Fig. 485: Tapping Out Threads Of Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

16. Install the insert and installation driver (1) into the tapped hole.
17. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

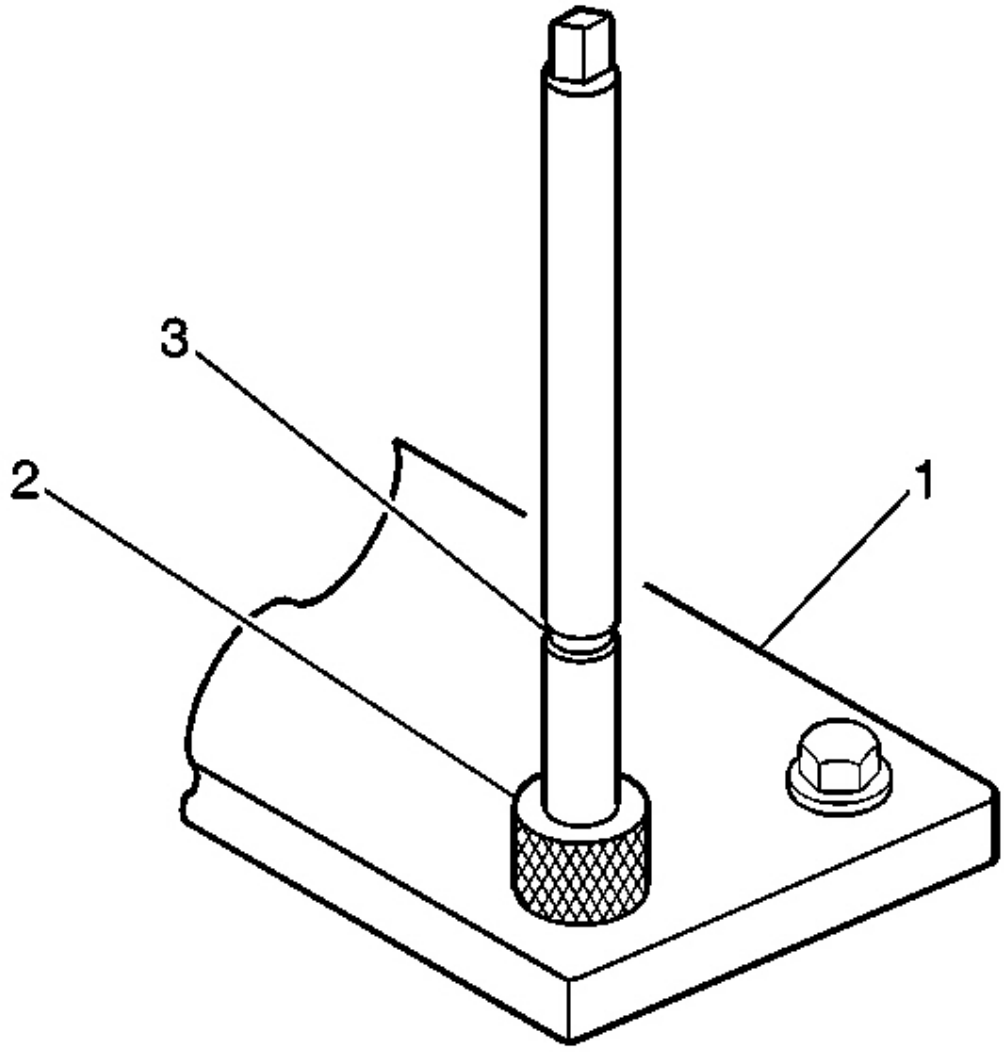


Fig. 486: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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

21. Inspect the insert for proper installation into the tapped hole.

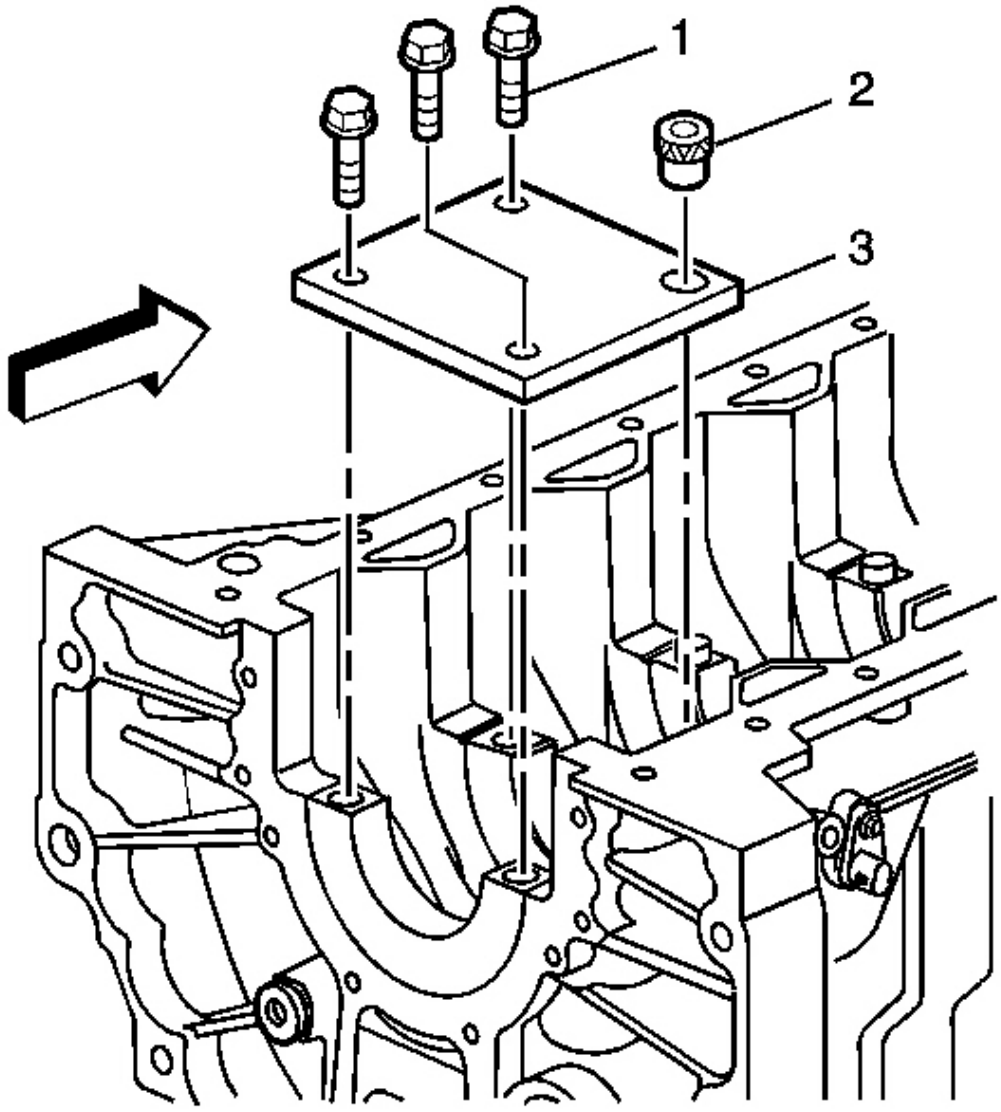


Fig. 487: View Of Fixture Plate, Bolts & Bushing
Courtesy of GENERAL MOTORS CORP.

22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

SERVICE PRIOR TO ASSEMBLY

Dirt will cause premature wear of the rebuilt engine. Clean all of the components. Use the proper tools in order to measure components when inspecting for excessive wear. Repair or replace the components that are not within the manufacturers specification. When components are reinstalled into an engine, return the components to their original location, position, and direction. During assembly, lubricate all of the moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started.

ENGINE BLOCK PLUG INSTALLATION

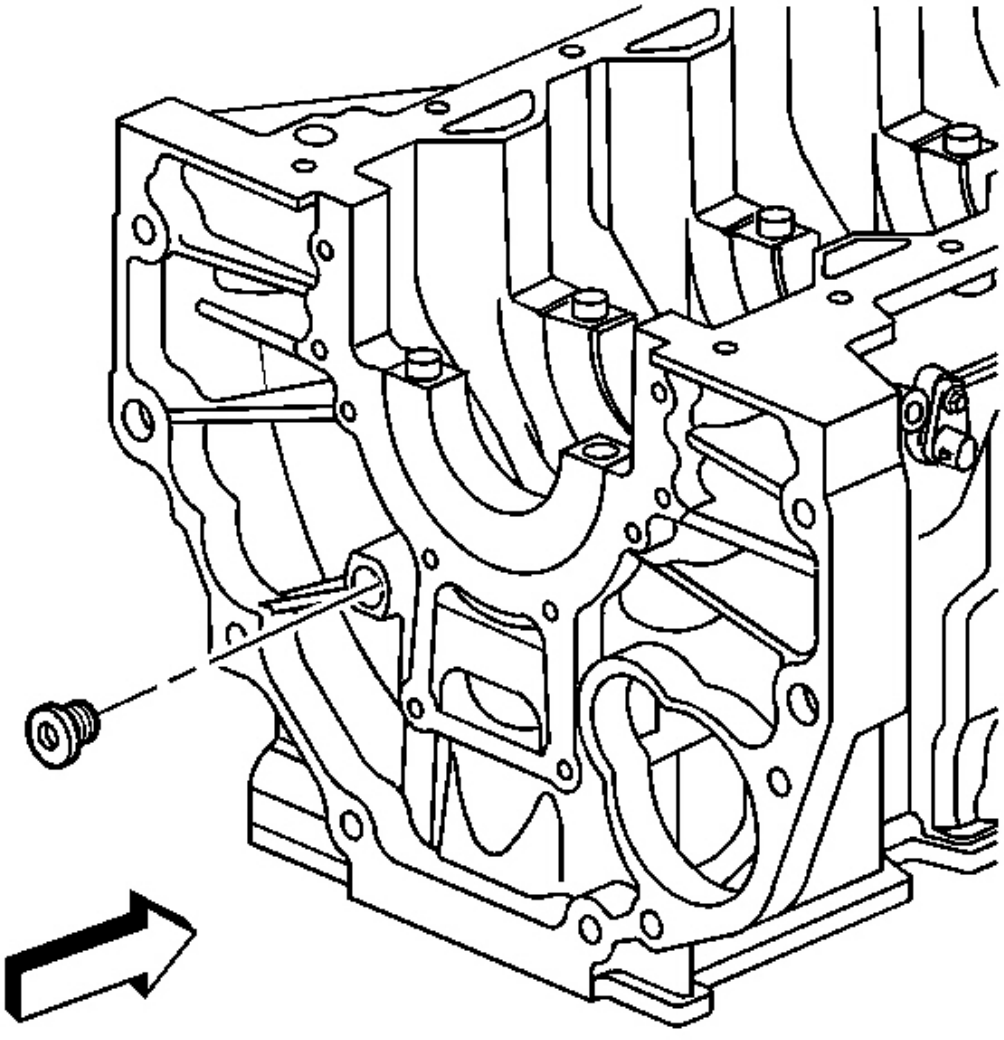


Fig. 488: View Of Oil Gallery Plug From Rear Of Block
Courtesy of GENERAL MOTORS CORP.

1. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the plug threads.

   NOTE: Refer to Fastener Notice .

2. Install the engine block oil gallery plug to rear of block.

   Tighten: Tighten the engine block oil gallery plug to 80 N.m (40 lb ft).

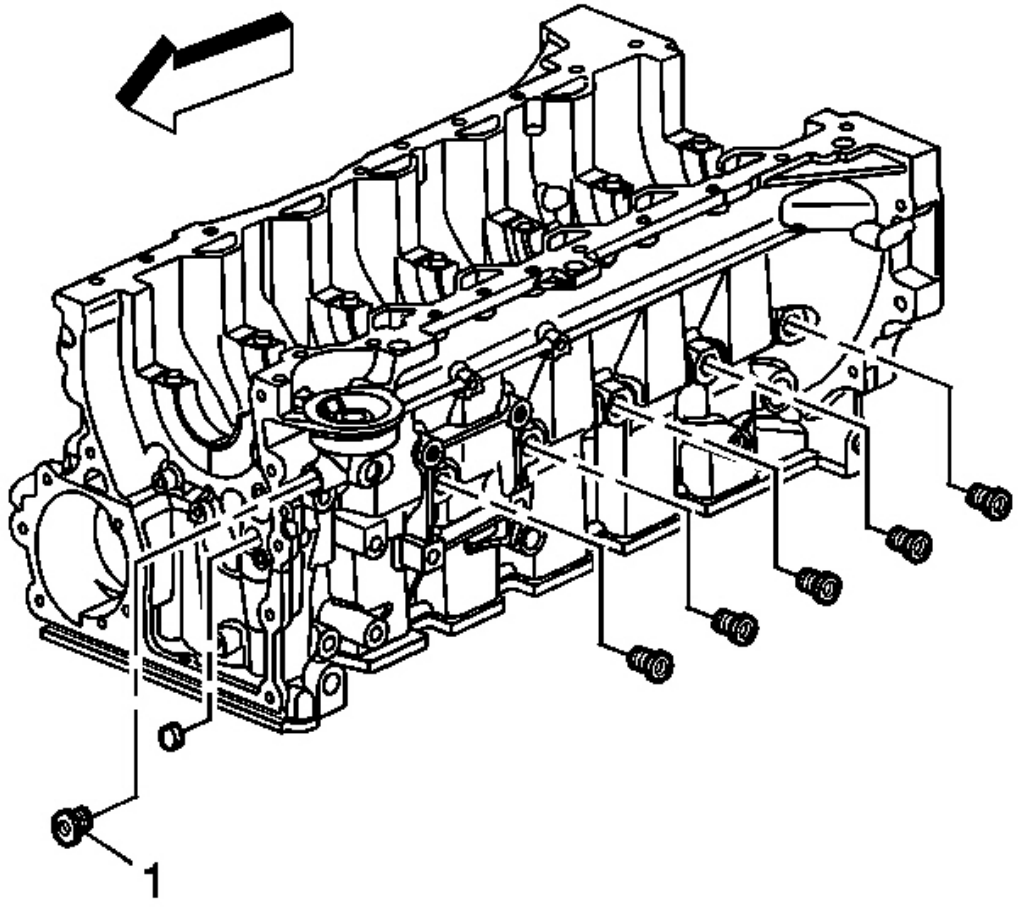


Fig. 489: View Of Front Engine Block Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

3. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the plug threads.
4. Install the engine block oil gallery plugs to front and left of block.

Tighten:

- Tighten the side engine block oil gallery plugs to 35 N.m (26 lb ft).
- Tighten the front (1) engine block oil gallery plug to 80 N.m (40 lb ft).

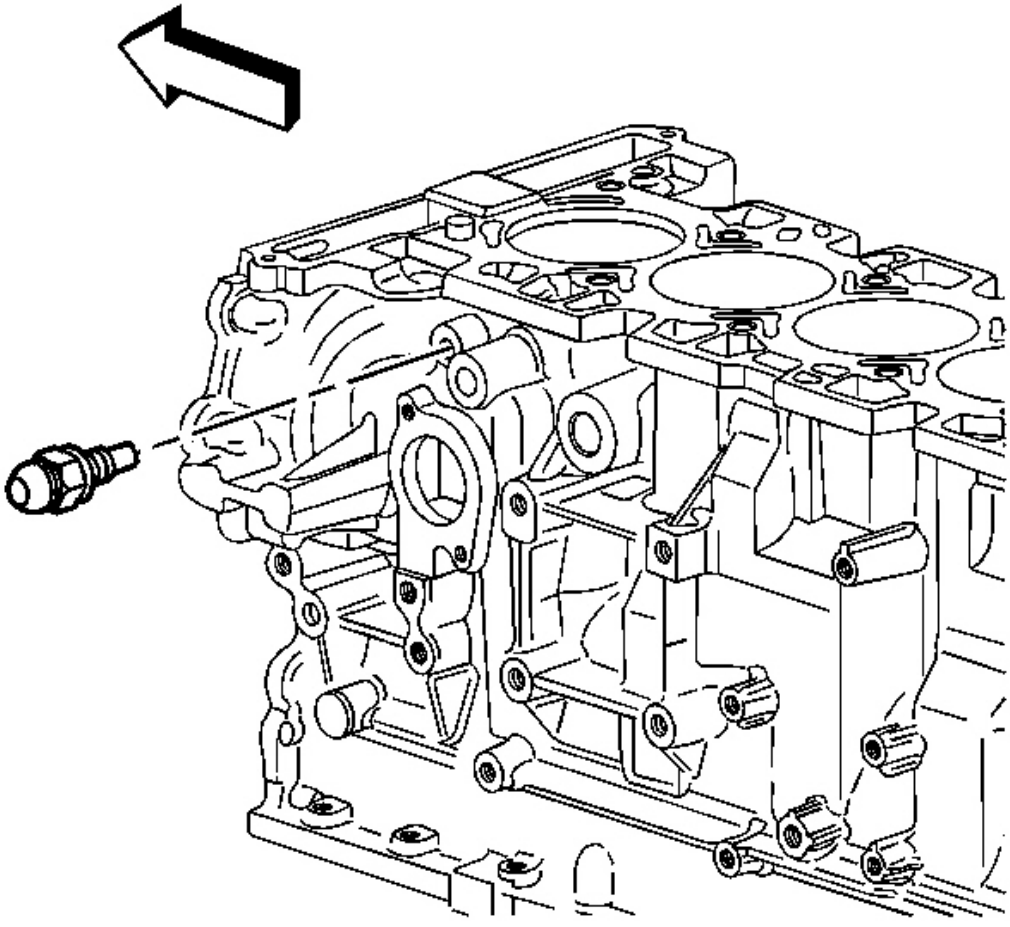


Fig. 490: View Of Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

5. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the coolant temperature sensor threads.
6. Install the coolant temperature sensor.

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

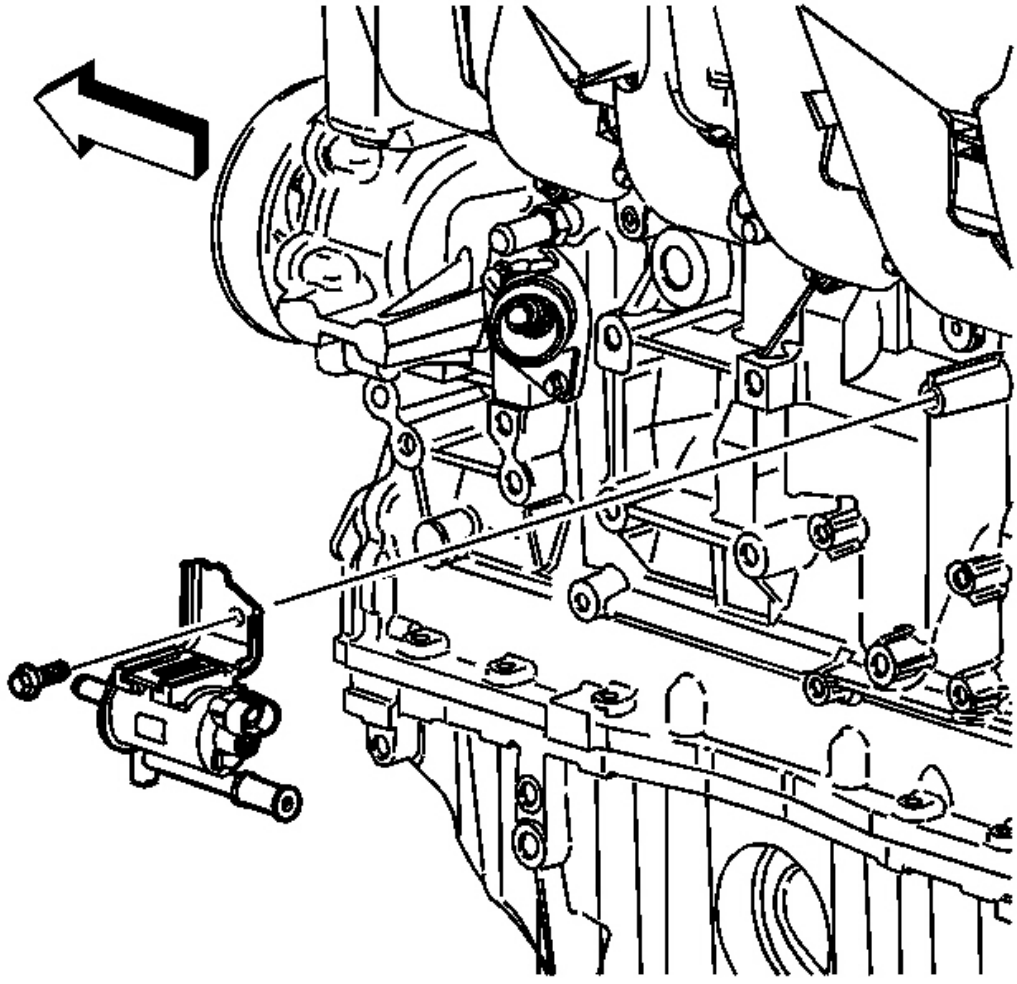


Fig. 491: View Of EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

7. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the EVAP solenoid bolt threads.

   Tighten: Tighten the EVAP solenoid bolt to 10 N.m (89 lb in).

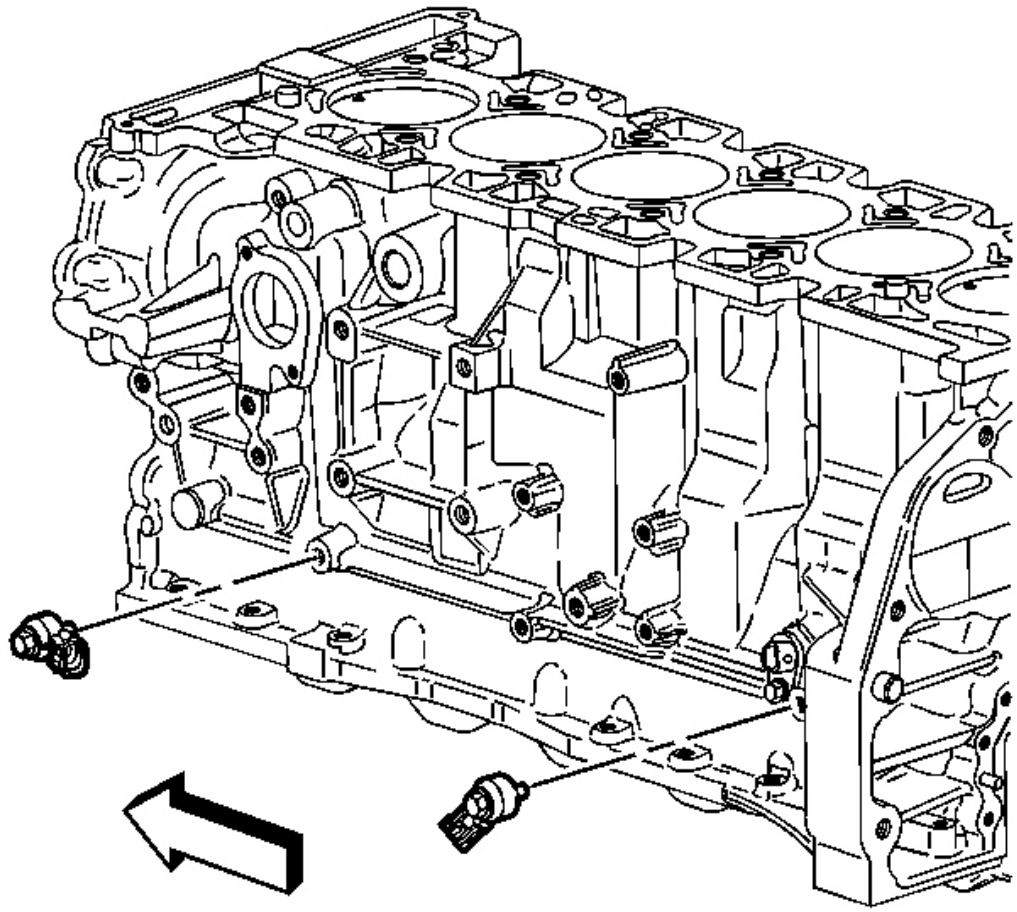


Fig. 492: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

8. Install the knock sensors.

   Tighten: Tighten the knock sensors to 25 N.m (18 lb ft).

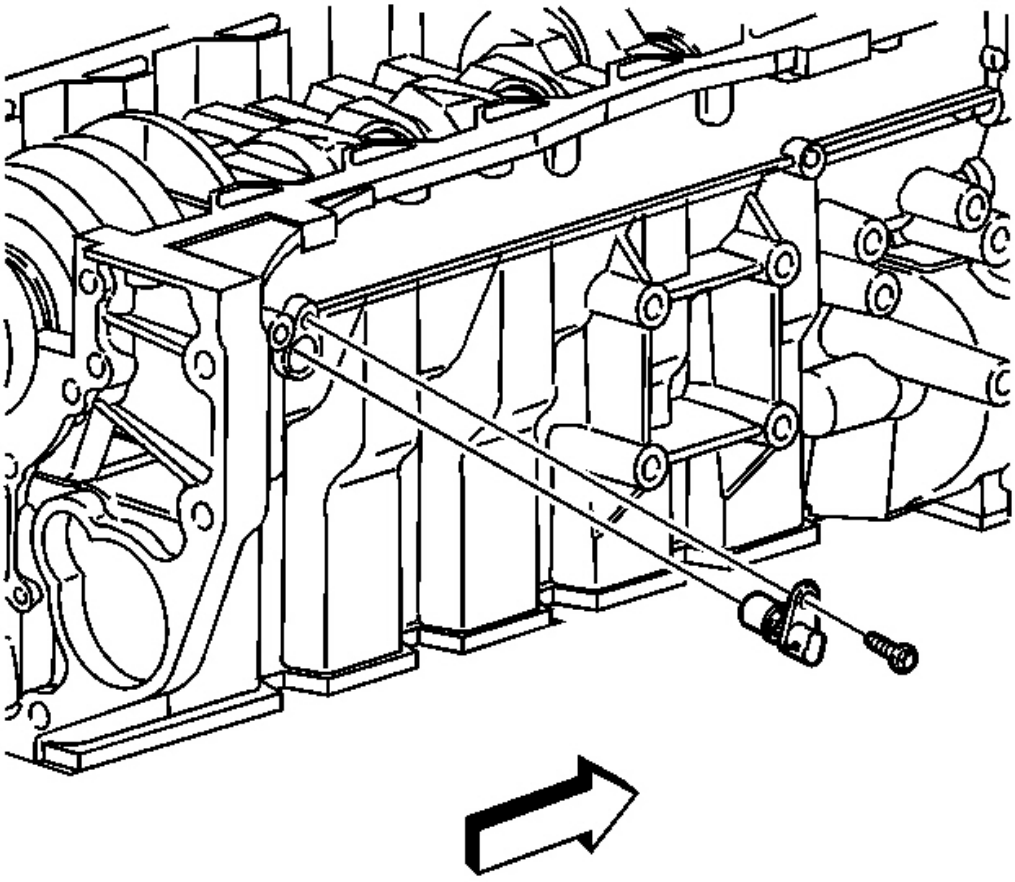


Fig. 493: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

9. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the crankshaft position sensor bolt.
10. Install the crankshaft position sensor and bolt.

Tighten: Tighten the crankshaft position sensor bolt to 10 N.m (89 lb in).

CRANKSHAFT & BEARING INSTALLATION

Tools Required

J 45059 Angle Meter. See **Special Tools**.

Installation Procedure

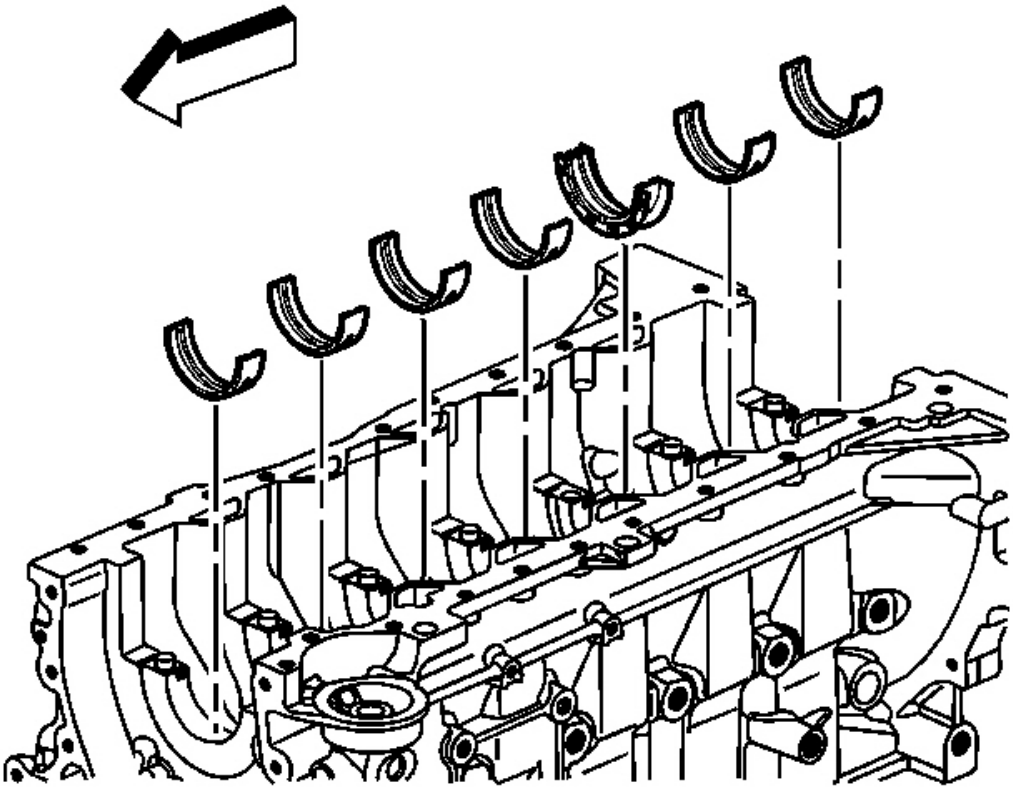


Fig. 494: View Of Upper Crankshaft Main Bearing Halves
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft main bearings into the block.

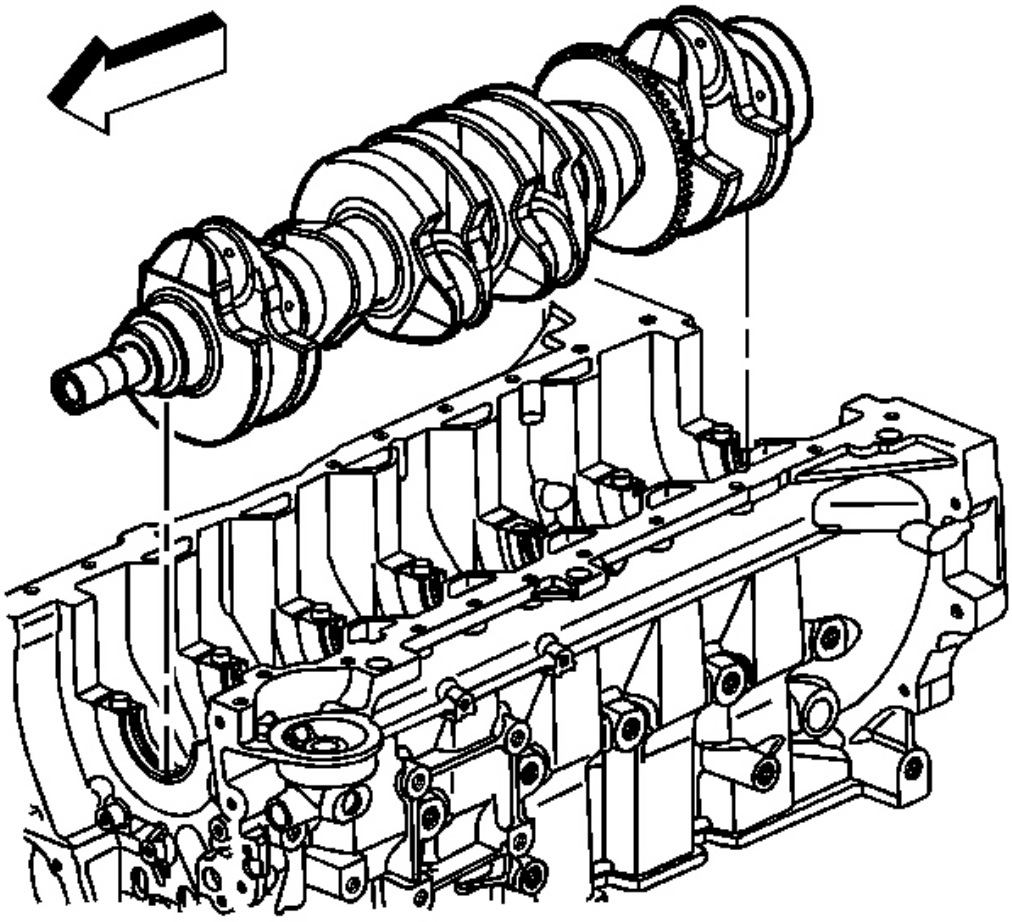


Fig. 495: View Of crankshaft & Block
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the upper crankshaft main bearing surface with clean engine oil.
3. Install the crankshaft.

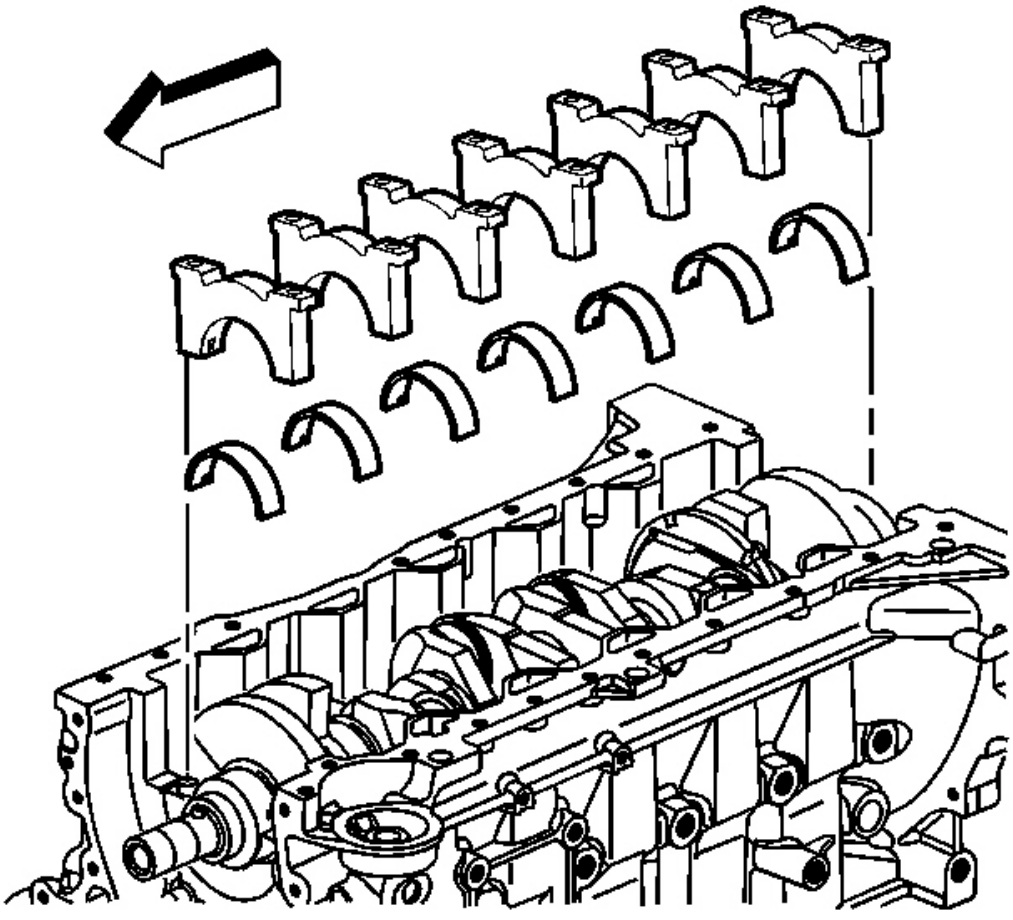


Fig. 496: View Of Crankshaft Main Bearing Caps & Lower Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Refer to the pin stamp on the crankshaft main bearing caps for sequence and direction of installation. The pin stamp arrow points to the front of the engine.

4. Install the lower crankshaft main bearings into the main bearing caps.
5. Lubricate the lower crankshaft main bearing surface with clean engine oil.
6. Install the crankshaft main bearing caps.

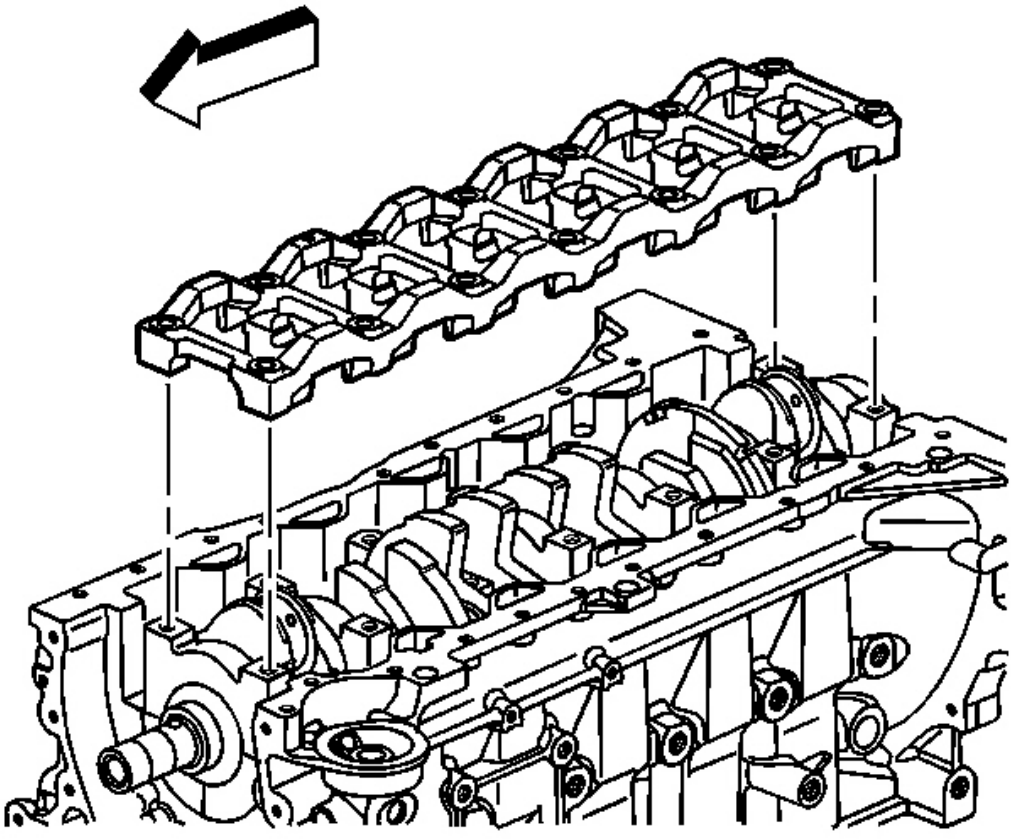


Fig. 497: View Of Crankshaft Main Bearing Cap Stiffener
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft main bearing cap stiffener is directional. The end marked front goes to the front.

7. Install the crankshaft main bearing cap stiffener.

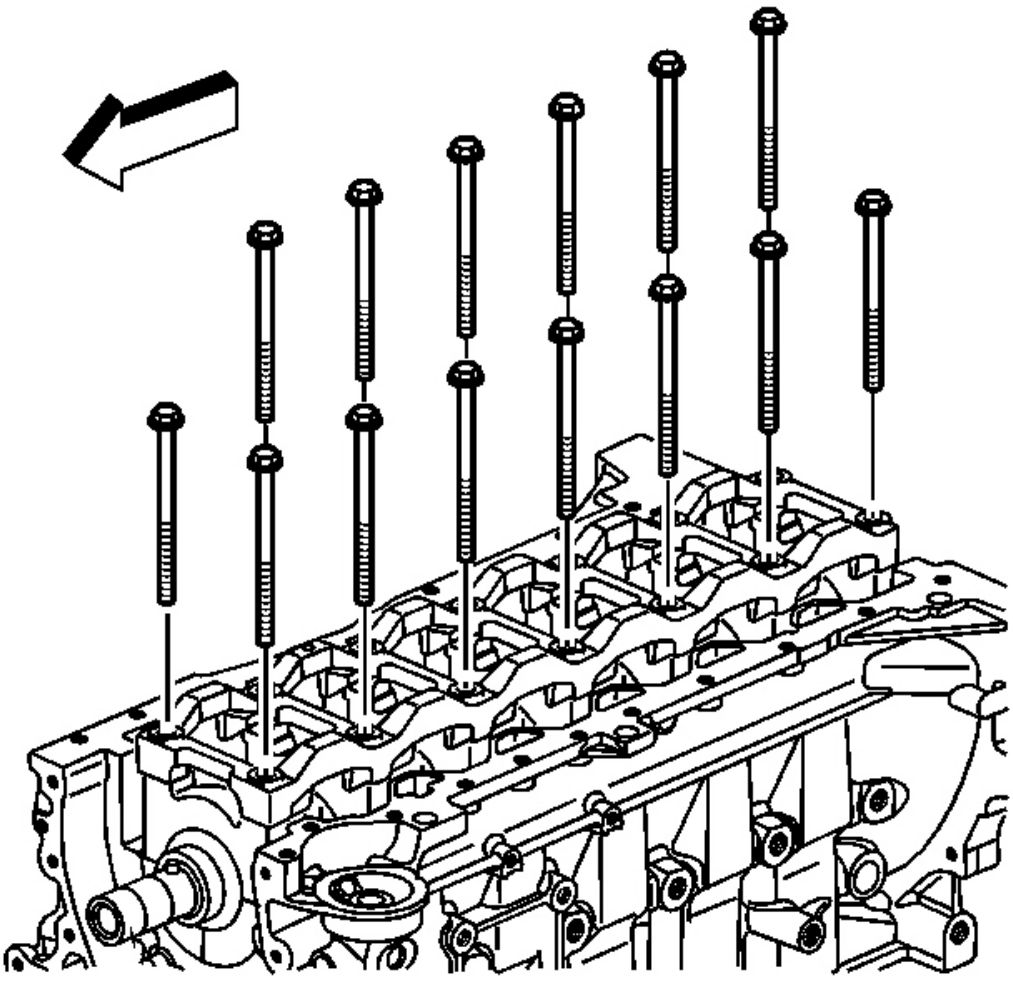


Fig. 498: View Of Crankshaft Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install new crankshaft main bearing bolts. Start the crankshaft main bearing cap bolts by hand. Ensure the bottom of the crankshaft main bearing cap is parallel to the block surface.

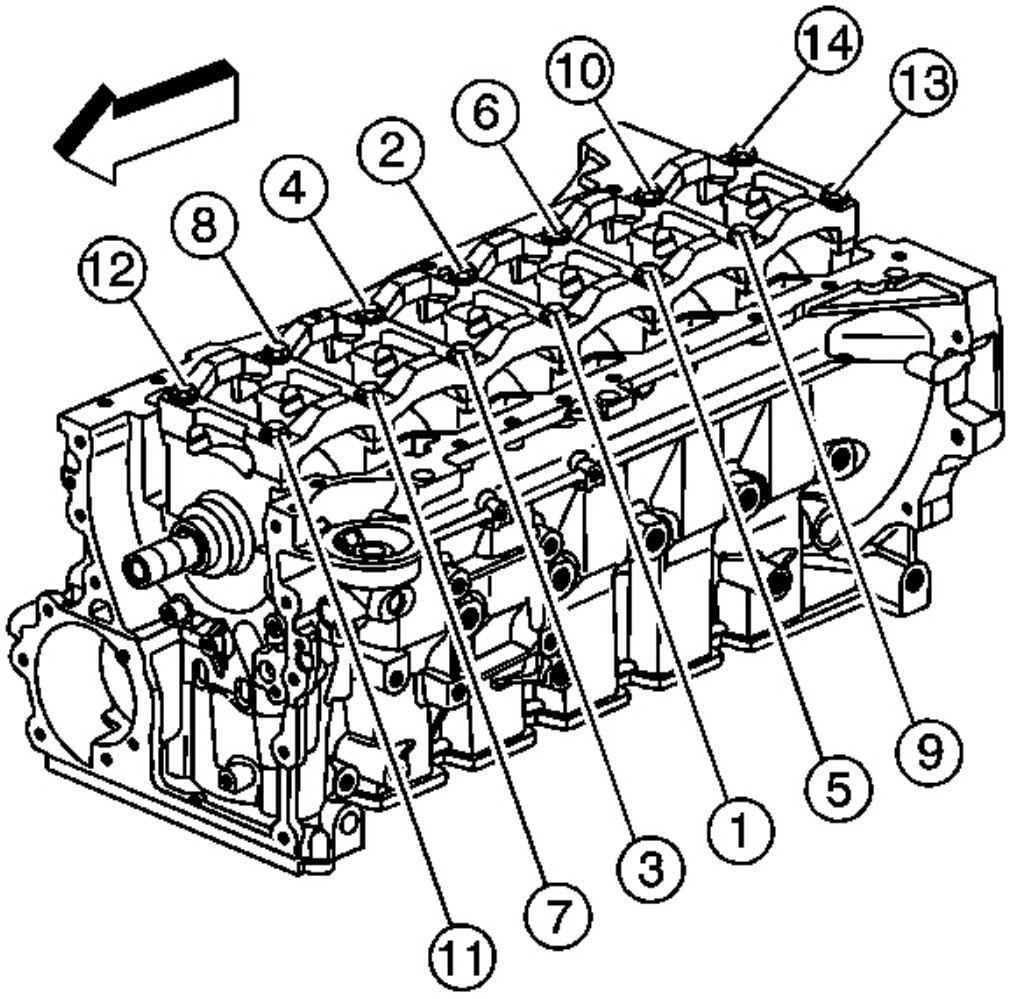


Fig. 499: Tightening Sequence For Crankshaft Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Tighten the crankshaft main bearing cap bolts in equal increments.

Tighten:

1. Tighten the crankshaft main bearing cap bolts to 25 N.m (18 lb ft) in sequence.
2. Use **J 45059** to tighten the crankshaft main bearing cap bolts an additional 180 degrees. See **Special Tools**.

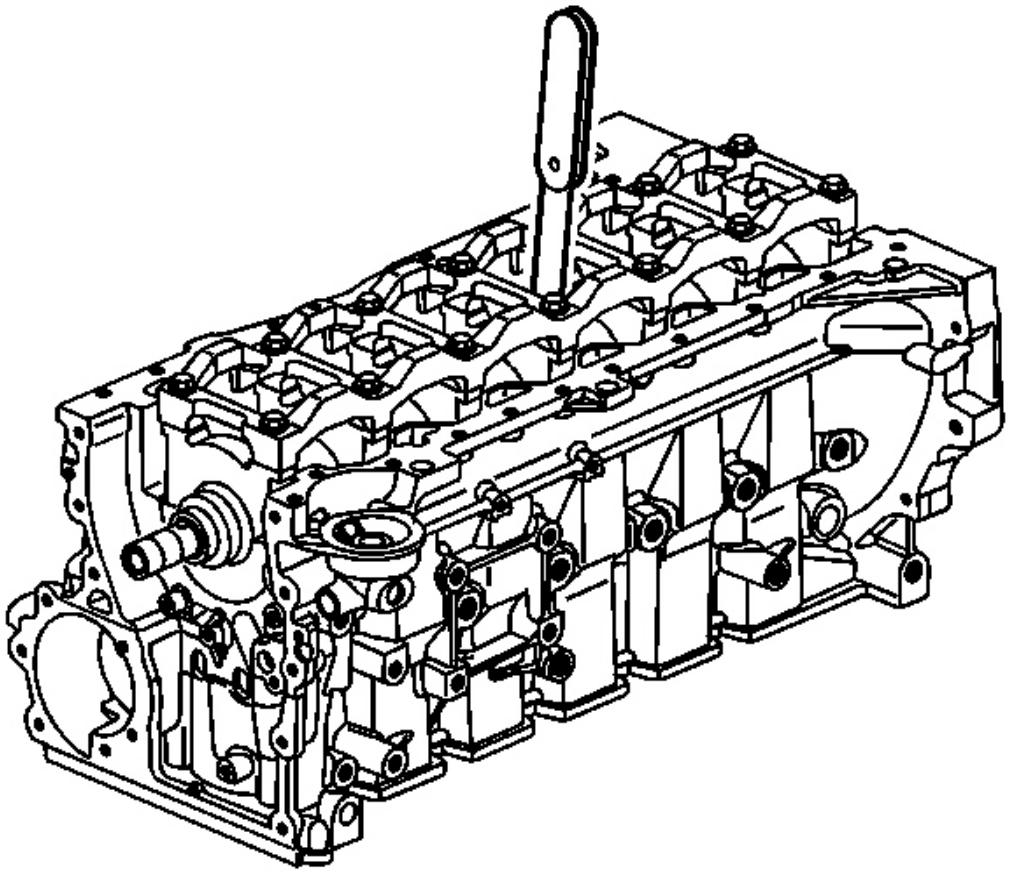


Fig. 500: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gage between the thrust crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance. Refer to **Engine Mechanical Specifications** for the proper clearance.
    3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

PISTON, CONNECTING ROD & BEARING INSTALLATION

Tools Required

- **EN-47701** Piston Ring Compressor. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.

Installation Procedure

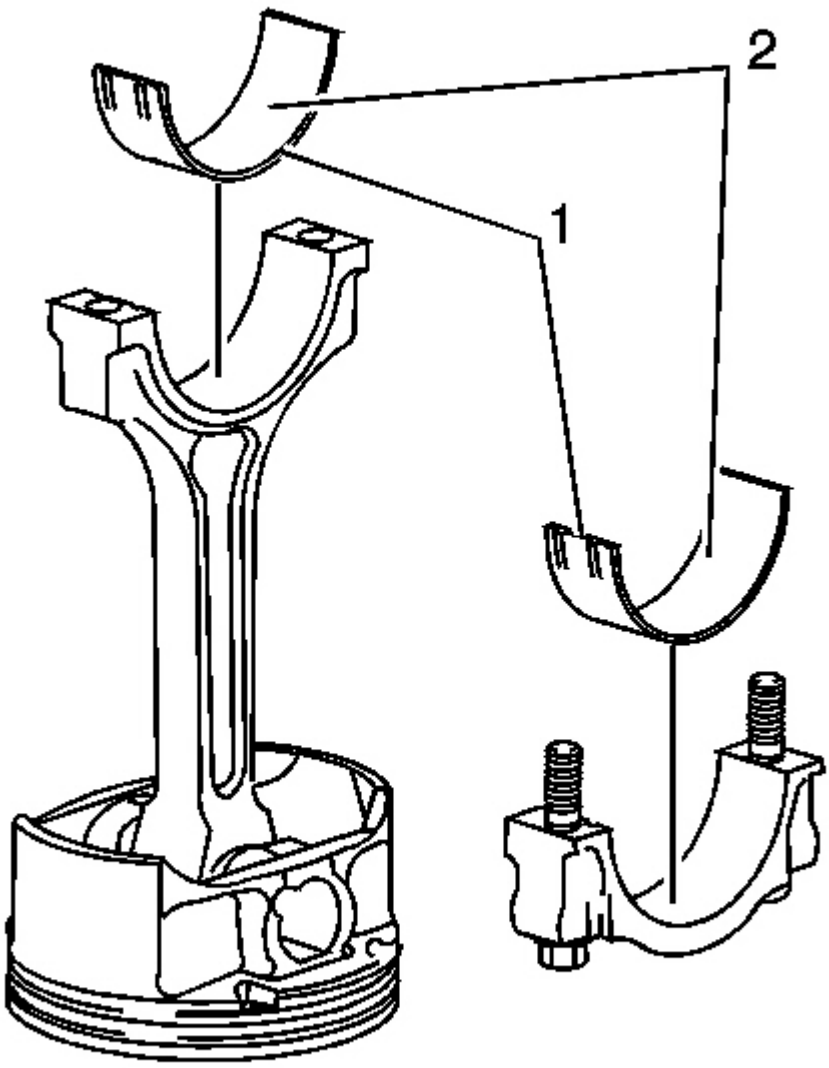


Fig. 501: View Of Connecting Rods & Caps
Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft so the connecting rod journal for the piston being installed is at bottom dead center.
2. Lubricate the cylinder wall with engine oil.
3. Lubricate the piston and rings with engine oil.
4. Stagger the ring end gaps 90 degrees apart.
5. Install **EN-47701** onto the piston and ring assembly to compress the rings. See **Special Tools**.
6. Install the connecting rod bearings into the connecting rods and caps (1).

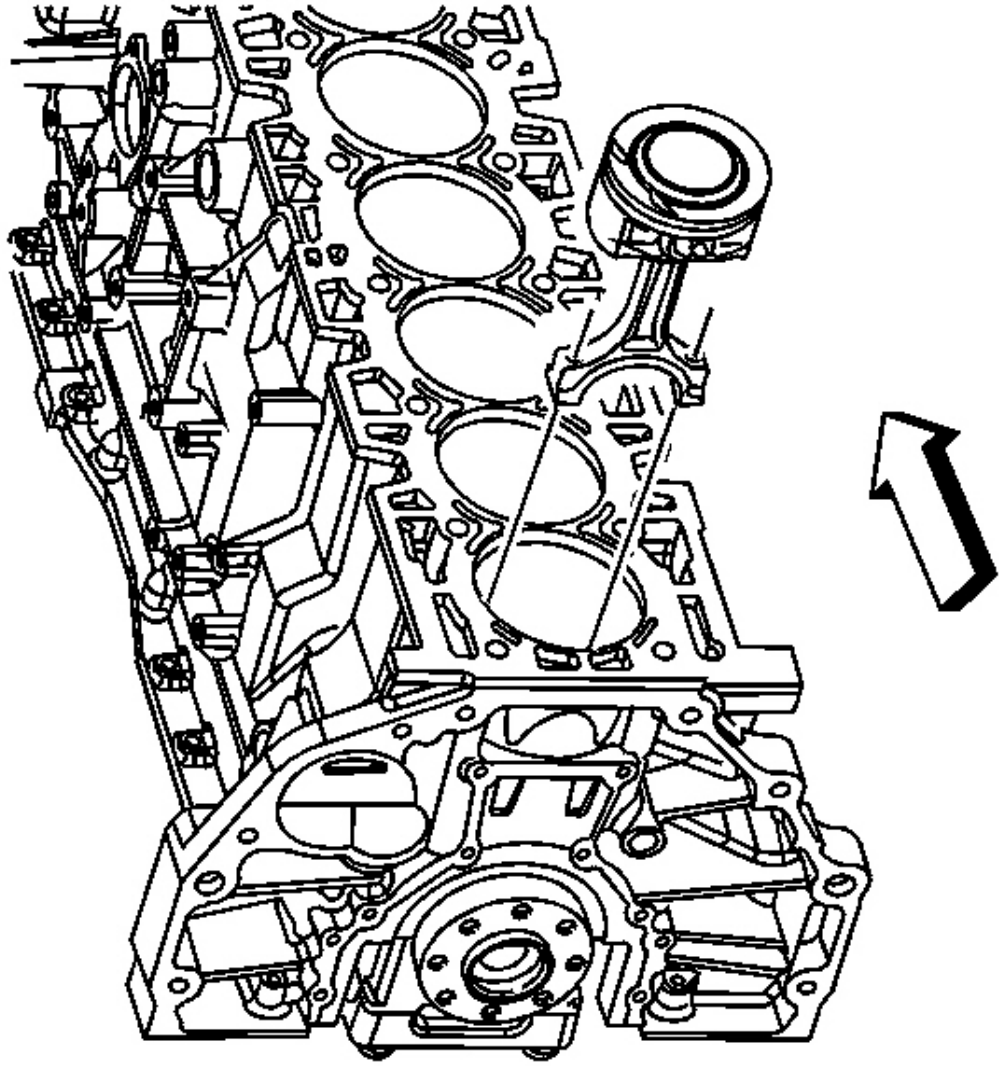


Fig. 502: View Of Piston

Courtesy of GENERAL MOTORS CORP.

7. Lubricate the connecting rod bearing contact surfaces with engine oil.
8. Install the **J 41556** into the connecting rod. See **Special Tools**.

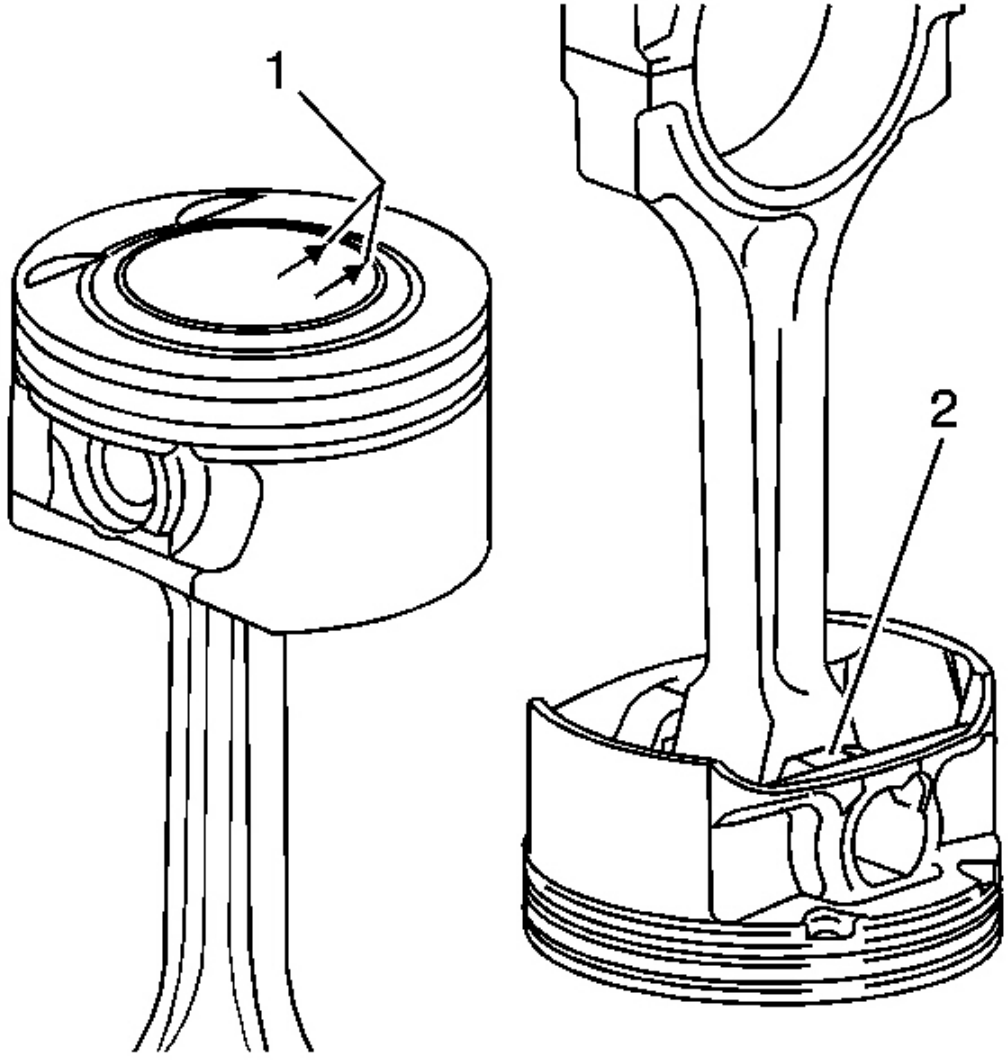


Fig. 503: Piston Alignment Mark
Courtesy of GENERAL MOTORS CORP.

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

assembly into the proper cylinder bore. The piston alignment mark MUST face the front of the engine block (1) or the flat casting boss (2).

9. Install the connecting rod and piston into the proper cylinder bore.

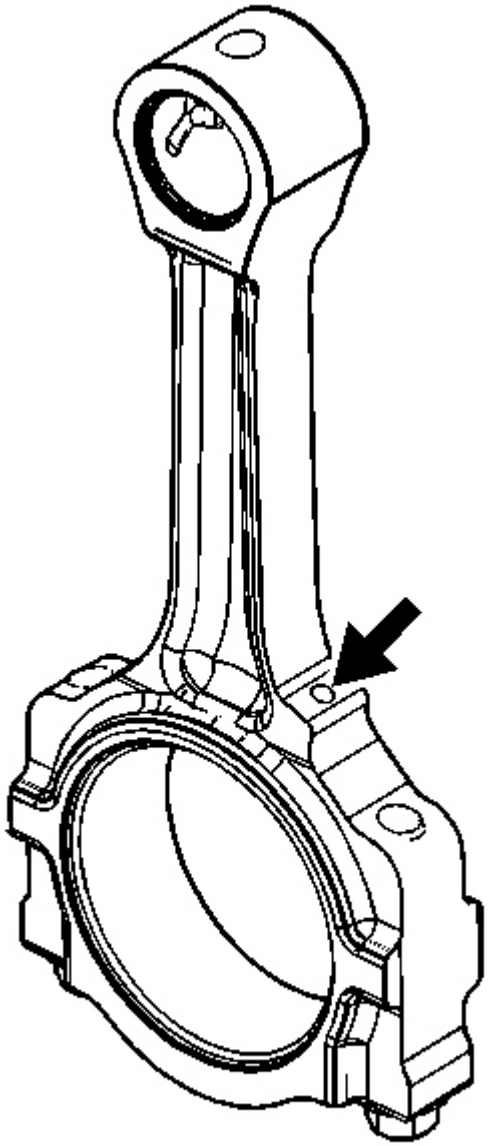


Fig. 504: Identifying Connecting Rod Oil Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil hole, in the connecting rod, should be facing the exhaust side of the block.

10. Make sure to install the connecting rod facing the right direction.

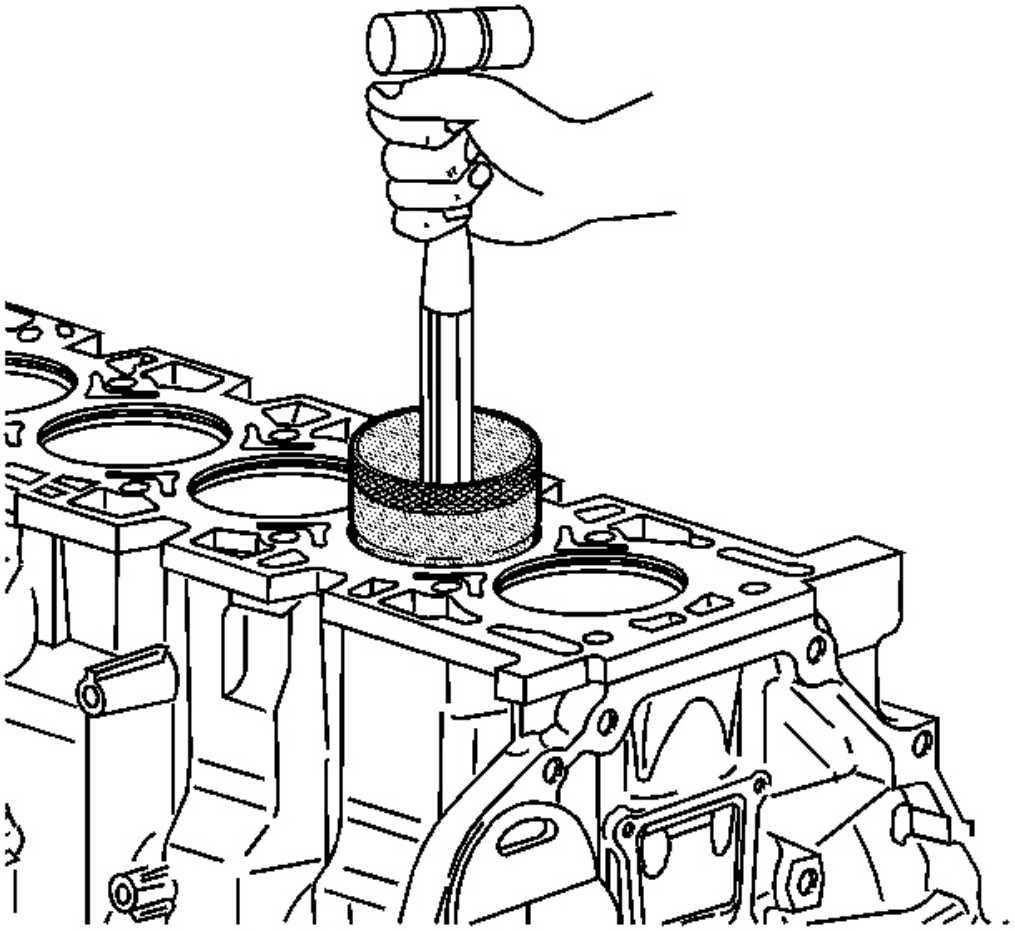


Fig. 505: Using Wooden Hammer To Tap Piston Into Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

11. Hold the **EN-47701** firmly against the engine block. See **Special Tools**. Using a wooden hammer handle, lightly tap the top of the piston until all of the piston rings enter the cylinder bore.

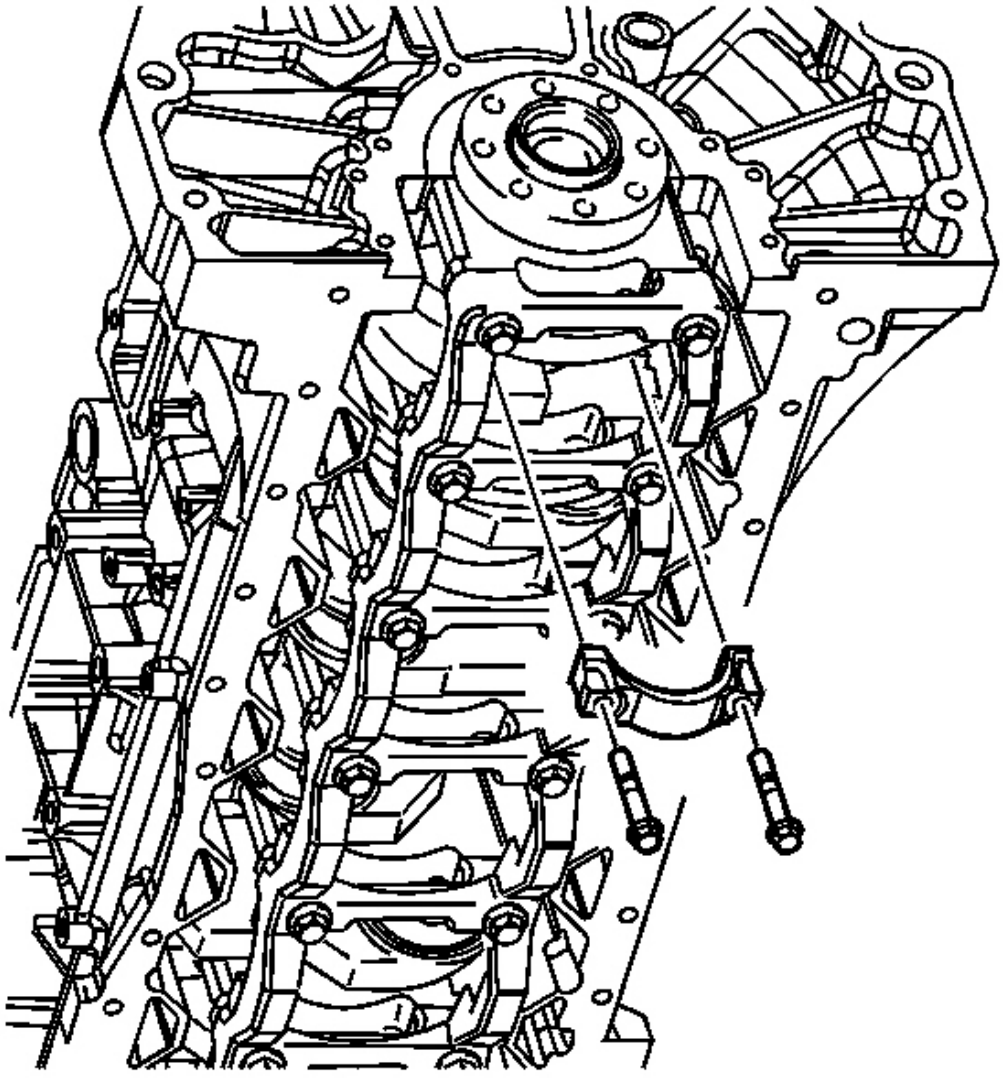


Fig. 506: View Of Connecting Rod, Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Guide the connecting rod end onto the crankshaft journal.

    Use **J 41556** to pull the connecting rod into place. See **Special Tools**.

    NOTE: Refer to Fastener Notice .

13. Install the connecting rod bearing, cap, and bolts.

    Tighten:

    1. Tighten the connecting rod bearing cap bolts on the first pass to 25 N.m (18 lb ft).
    2. Use **J 45059** to tighten the connecting rod bearing cap bolts on the second pass an additional 110 degrees. See **Special Tools**.

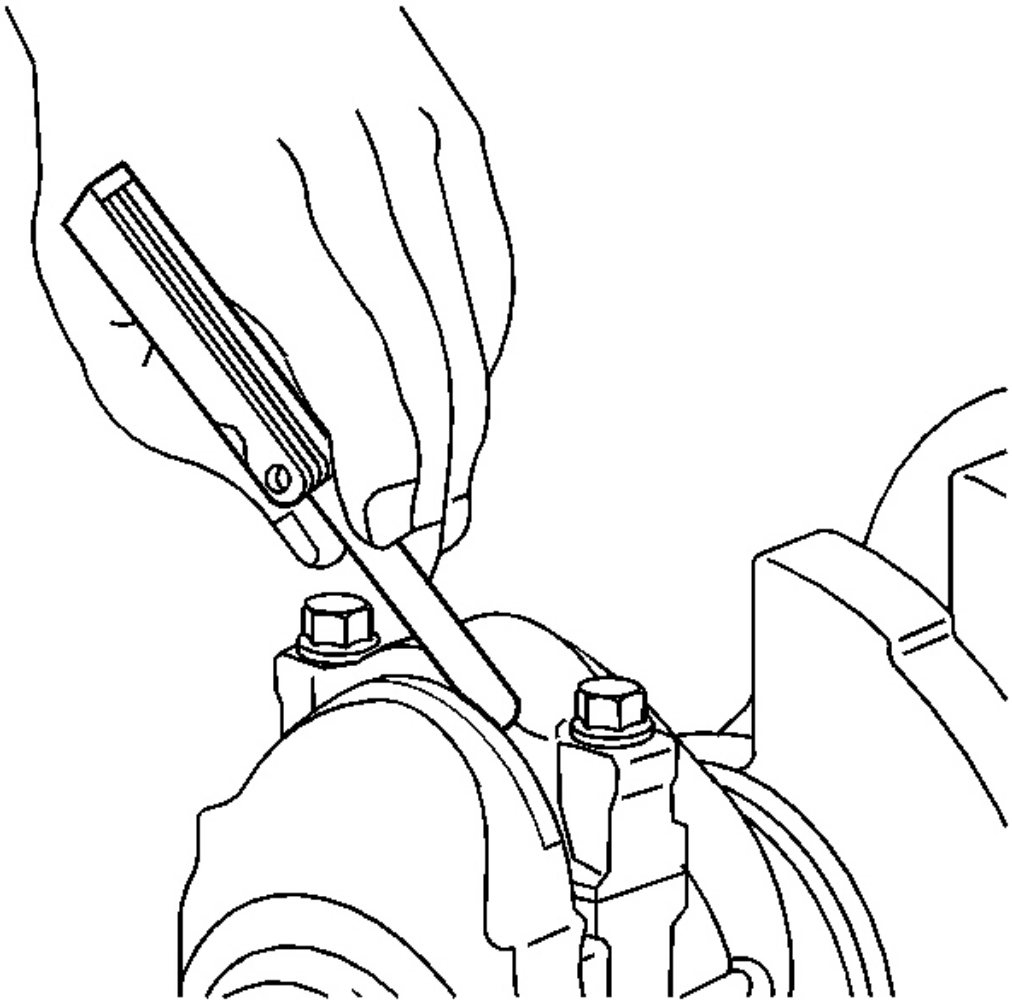


Fig. 507: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

14. With the pistons and connecting rods installed, use a soft faced mallet and lightly tap each connecting rod

assembly parallel to the crankshaft.

15. Measure the connecting rod side clearance using a feeler gauge. Connecting rod side clearance should be between 0.05-0.35 mm (0.0019-0.0137 in).

CYLINDER HEAD INSTALLATION

Tools Required

J 45059 Angle Meter. See **Special Tools**.

Installation Procedure

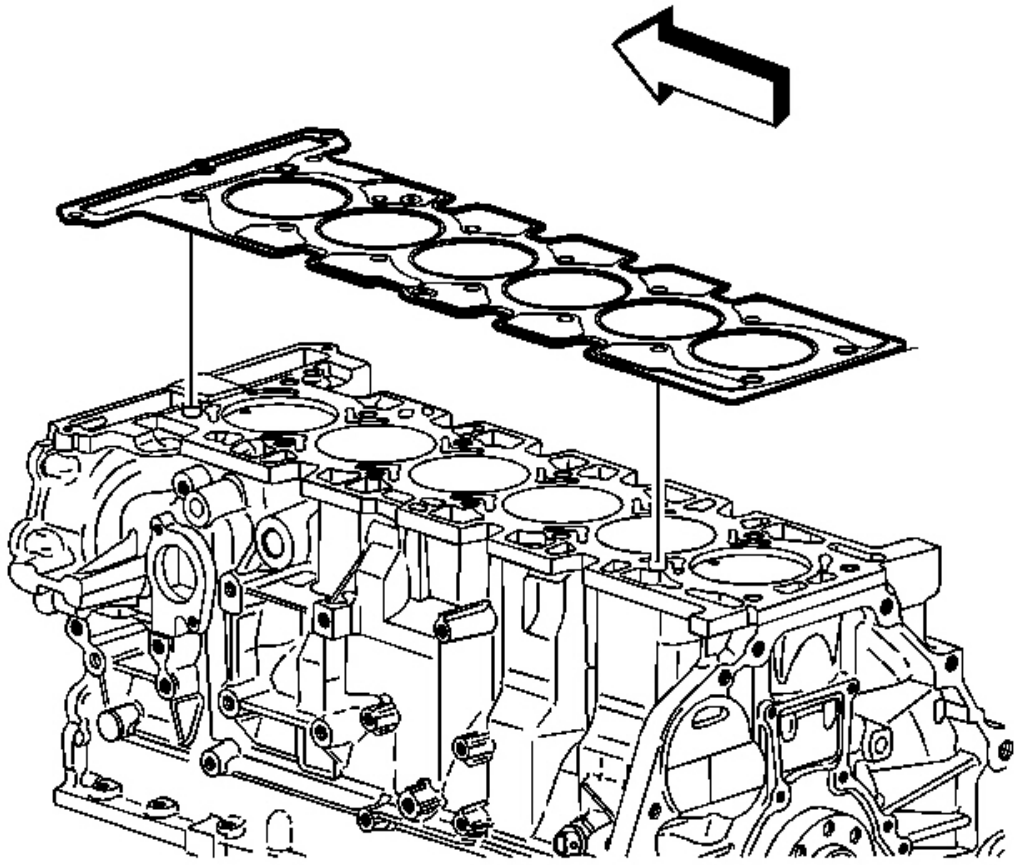


Fig. 508: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the dowel pins - cylinder head locator, if necessary.

2. Install a new cylinder head gasket.

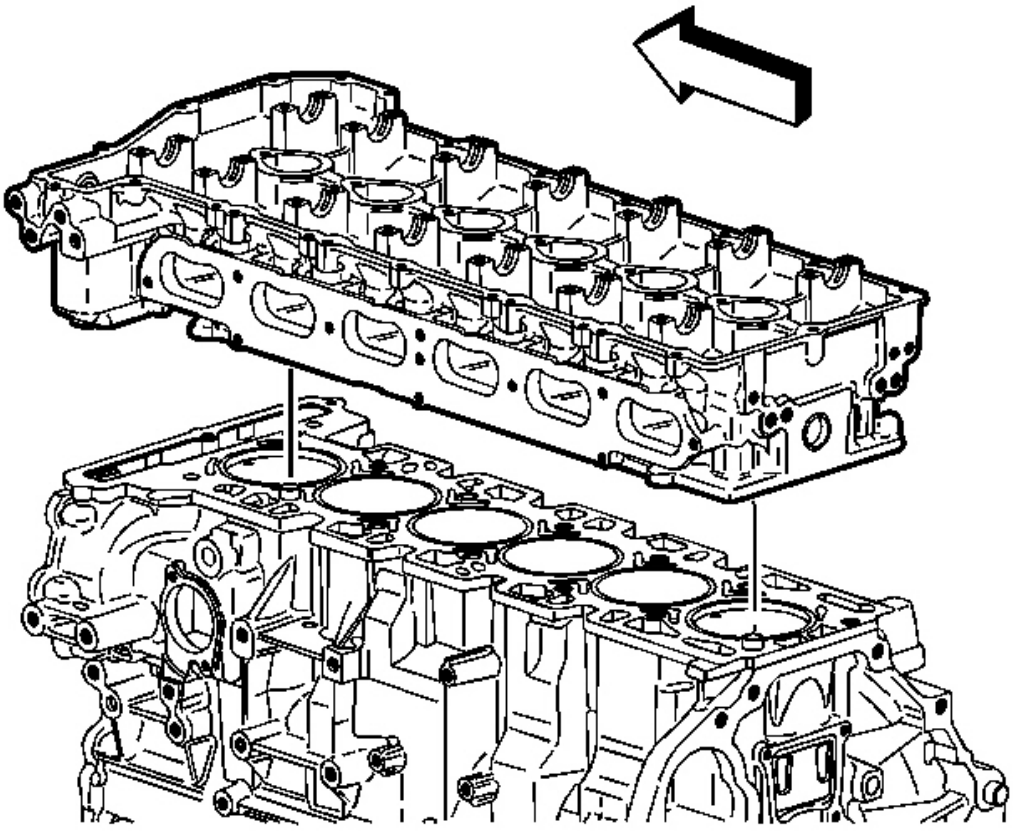


Fig. 509: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head.

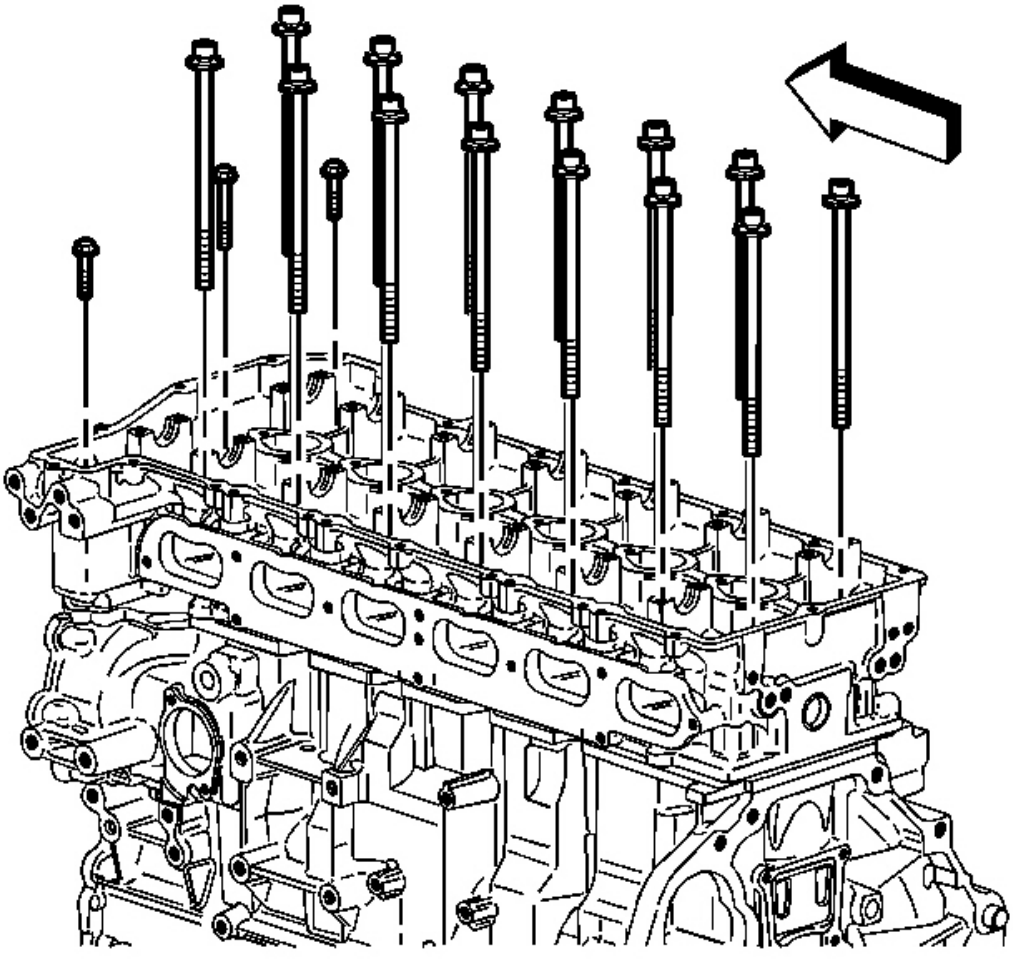


Fig. 510: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install new cylinder head bolts.

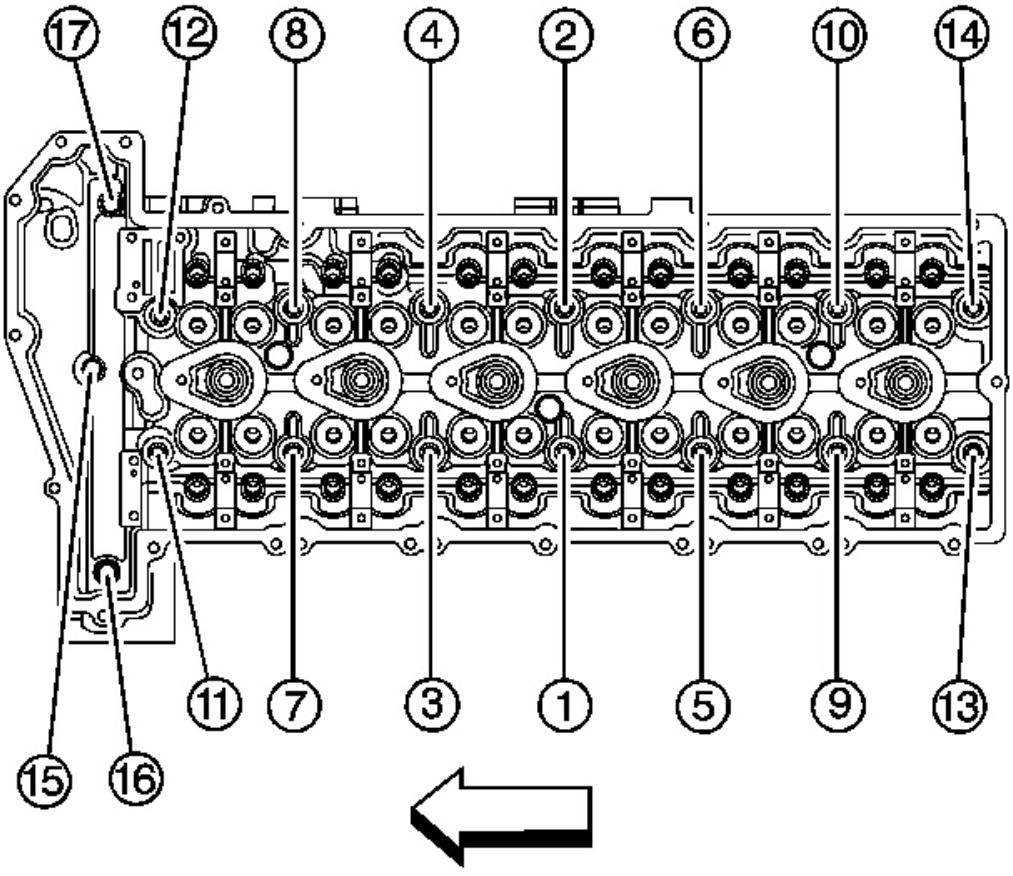


Fig. 511: Tightening Sequence For Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Tighten the new cylinder head bolts in the following sequence:

Tighten:

1. Tighten the (14) long cylinder head bolts in sequence to 30 N.m (22 lb ft).
2. Use **J 45059** to tighten the cylinder head bolts in sequence an additional 155 degrees. See **Special Tools**.
3. Tighten the (2 Short) end bolts to 7 N.m (62 lb in).

   Use **J 45059** to tighten the short cylinder head end bolts an additional 60 degrees. See **Special Tools**.

4. Tighten the (1 Long) end bolt to 7 N.m (62 lb in).

   Use **J 45059** to tighten the long cylinder head end bolt an additional 120 degrees. See **Special Tools**.

VALVE ROCKER ARM & VALVE LASH ADJUSTER INSTALLATION

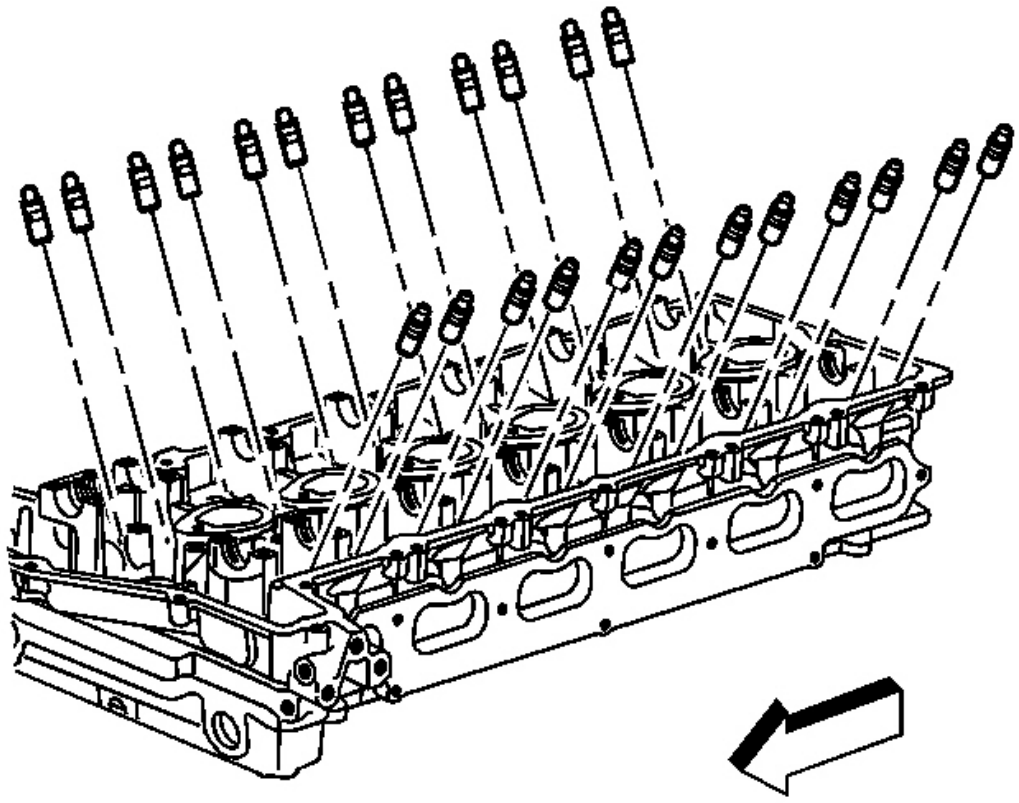


Fig. 512: View Of Valve Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Lubricate and fill the valve lash adjusters with engine oil.
2. Install the valve lash adjusters in their original locations.

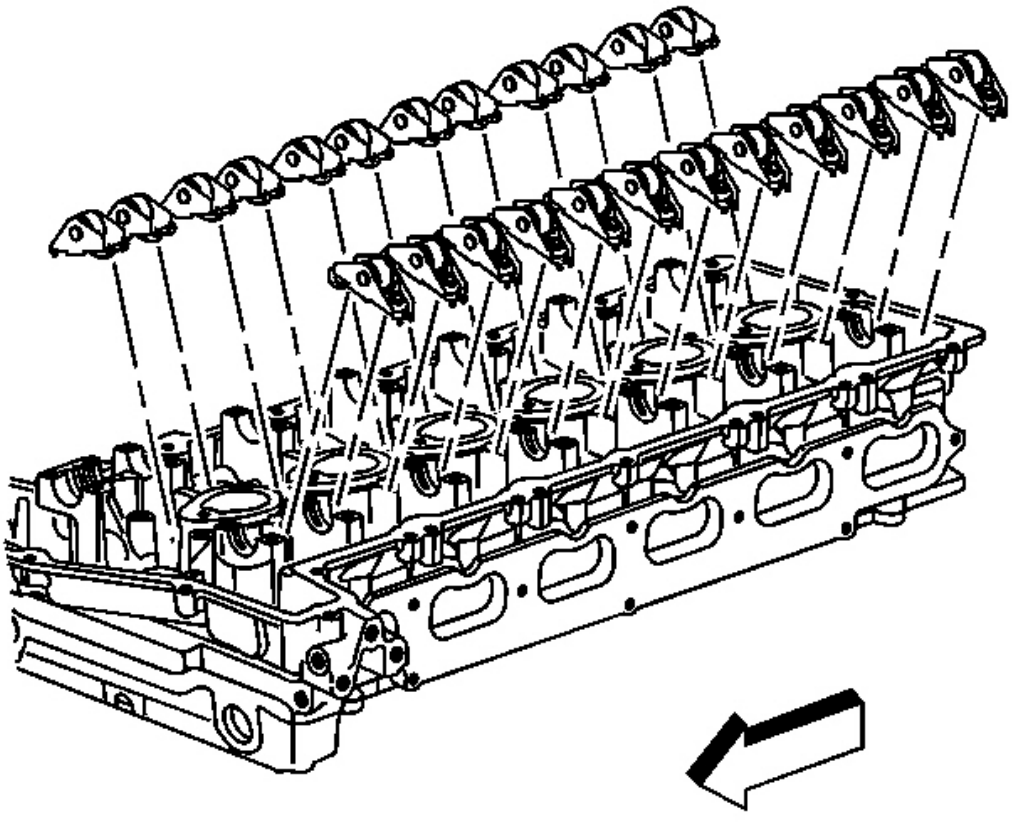


Fig. 513: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve rocker arm roller, needle bearings, valve pallet, and lash adjuster pocket.
4. Install the valve rocker arms in their original locations.

CAMSHAFT INSTALLATION

Tools Required

J 44221 Camshaft Holding Tool. See **Special Tools**.

Installation Procedure

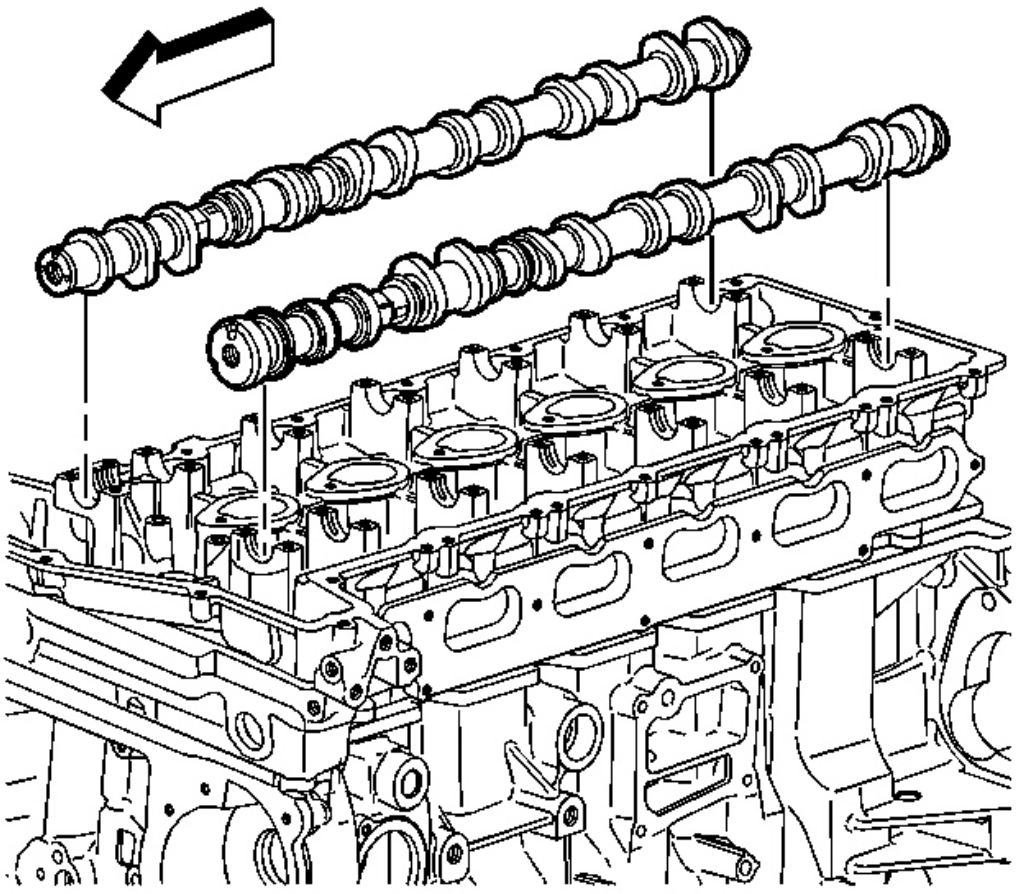


Fig. 514: Identifying Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Coat the camshaft journals, camshaft journal thrust face, and camshaft lobes with clean engine oil.
2. Install the exhaust camshaft.
3. Install the intake camshaft.

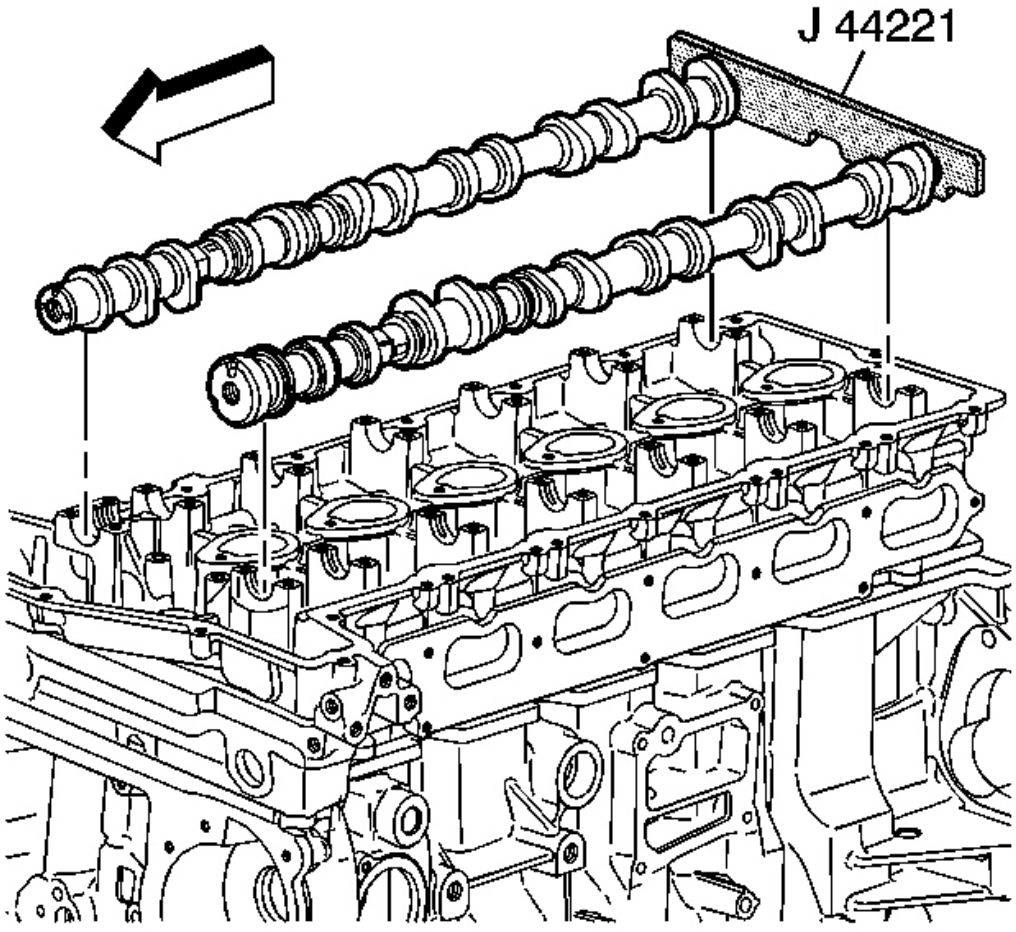


Fig. 515: Identifying J 44221 Installed Onto Camshafts
Courtesy of GENERAL MOTORS CORP.

4. Install **J 44221** with the camshaft flats up and the number 1 cylinder at top dead center. See **Special Tools**.

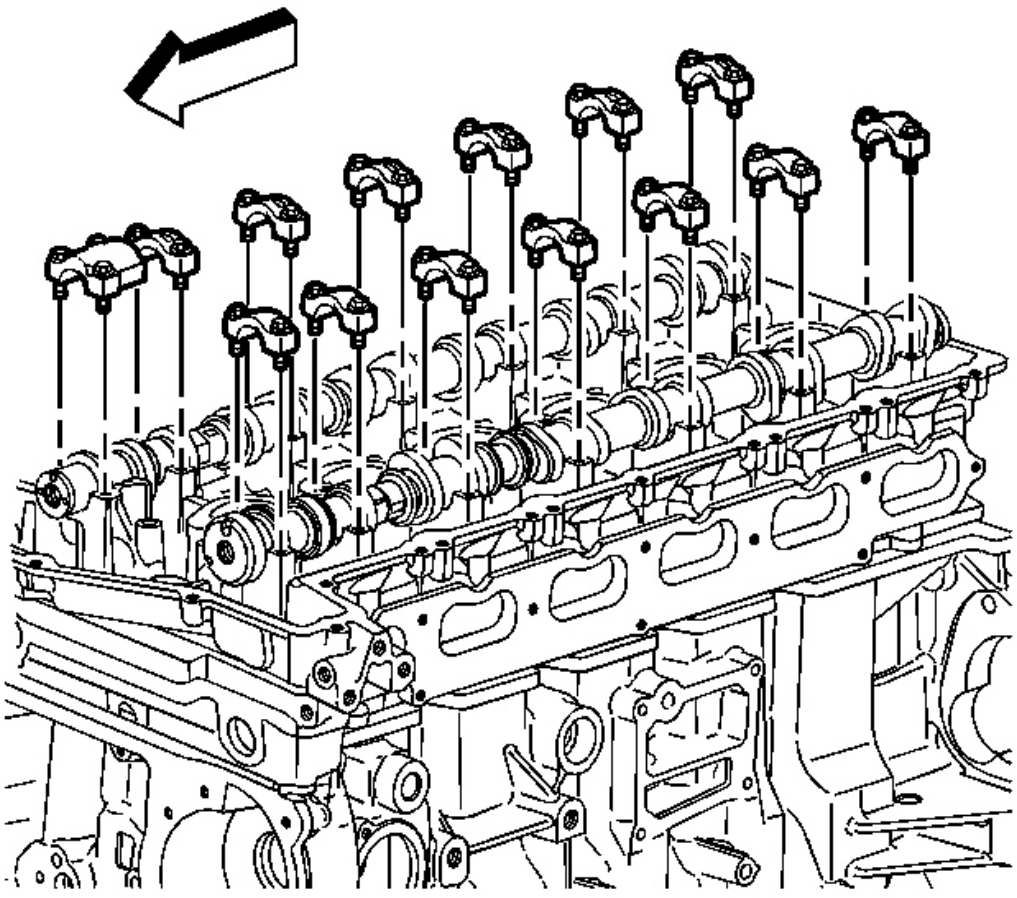


Fig. 516: View Of Camshaft Retainer Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the same camshaft cap onto the same camshaft journal from which it was removed. The camshaft caps are pin stamped for direction and numerical order.

5. Install the exhaust camshaft caps.
6. Install the intake camshaft caps.

NOTE: Refer to Fastener Notice .

7. Install the camshaft cap bolts.

Tighten: Tighten the camshaft cap bolts to 12 N.m (106 lb in).

8. Remove **J 44221** . See **Special Tools**.

ENGINE LIFT BRACKET INSTALLATION

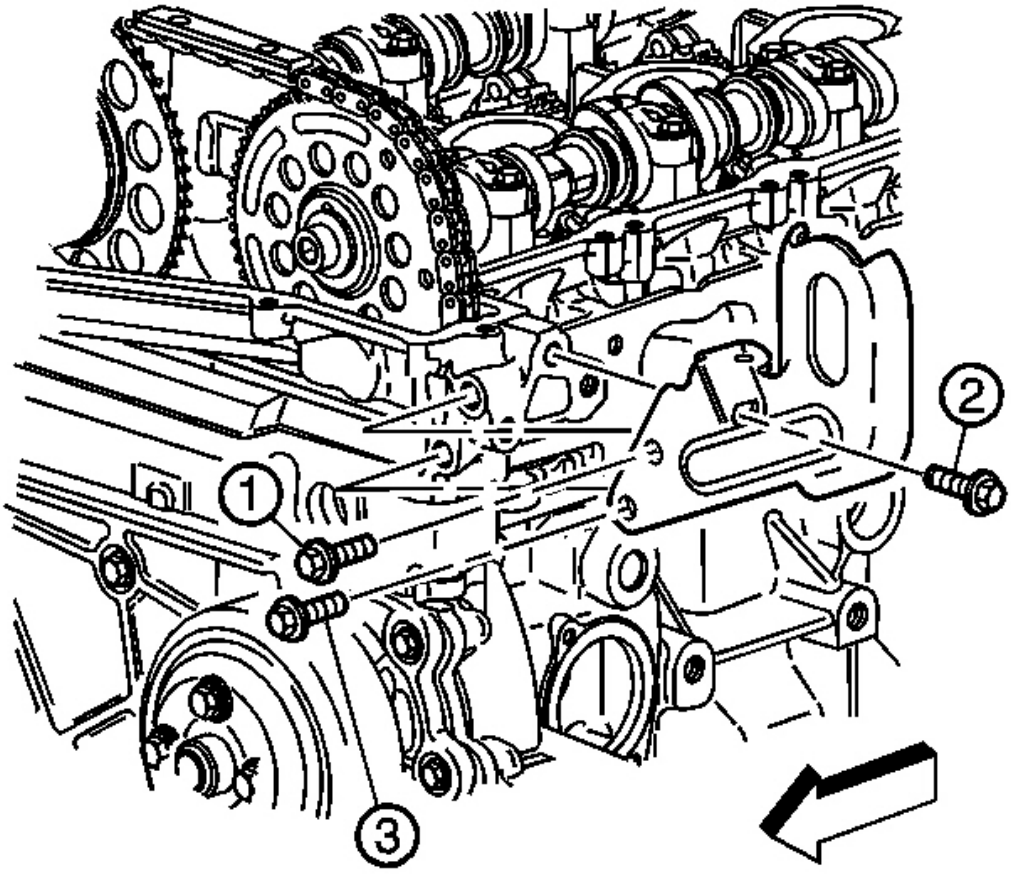


Fig. 517: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine lift bracket.

NOTE: Refer to Fastener Notice .

2. Install the engine lift bracket bolts in sequence.

Tighten: Tighten the engine lift bracket bolts in sequence to 50 N.m (37 lb ft)

TIMING CHAIN TENSIONER INSTALLATION

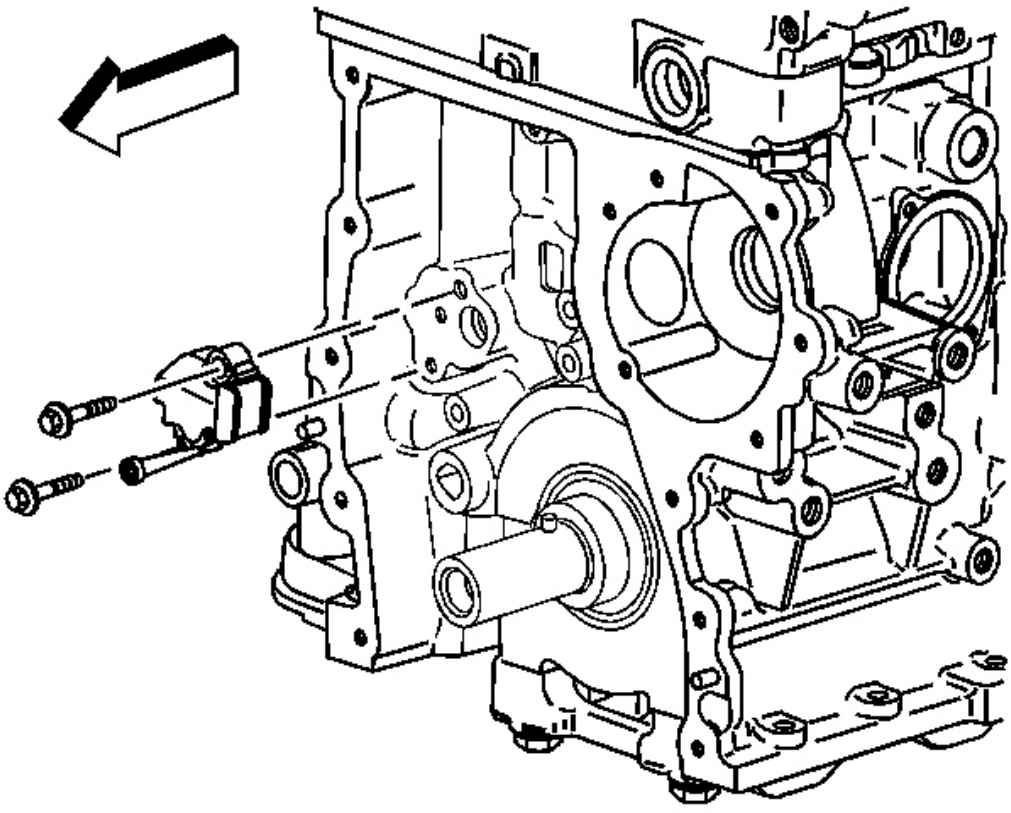


Fig. 518: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the timing chain tensioner.

   NOTE: Refer to Fastener Notice .

2. Install the timing chain tensioner bolts.

   Tighten: Tighten the timing chain tensioner bolts to 25 N.m (18 lb ft).

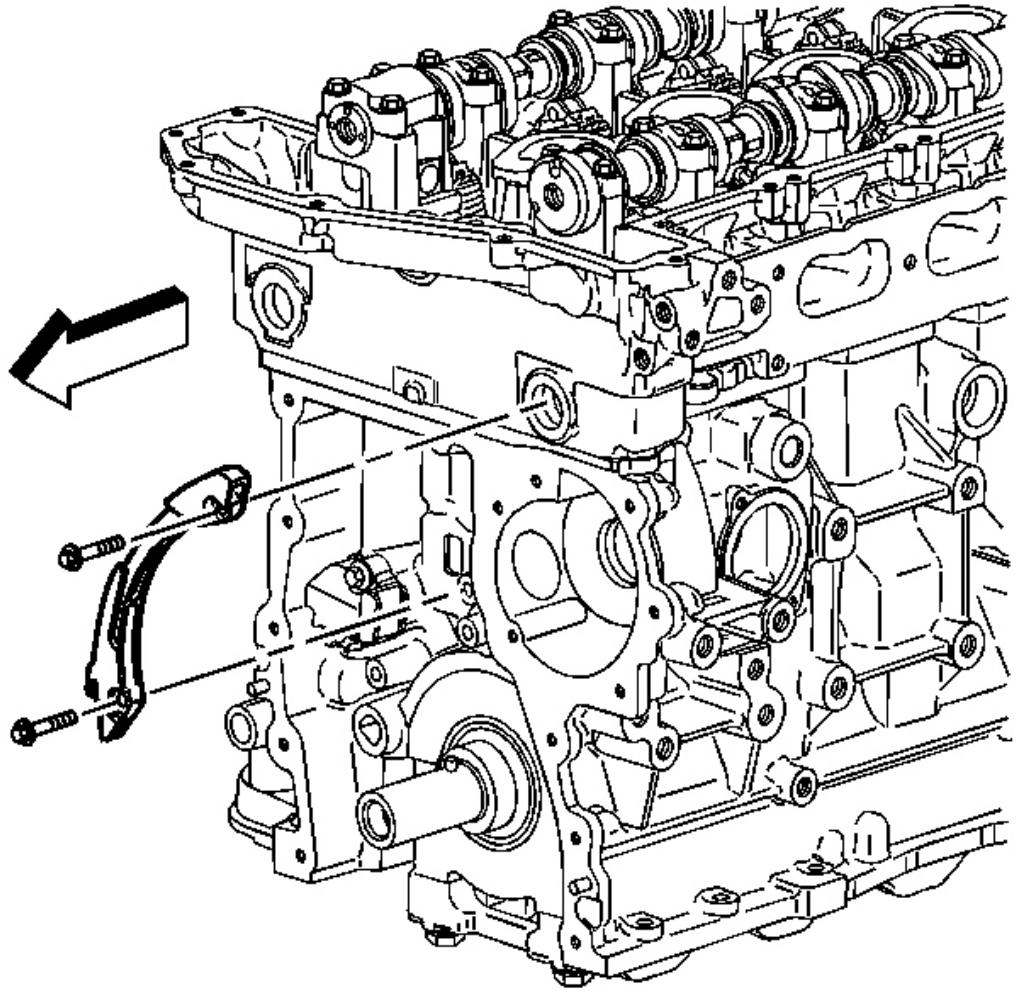


Fig. 519: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain tensioner guide.
4. Install the timing chain tensioner guide bolts.

Tighten: Tighten the timing chain tensioner guide bolts to 12 N.m (107 lb in).

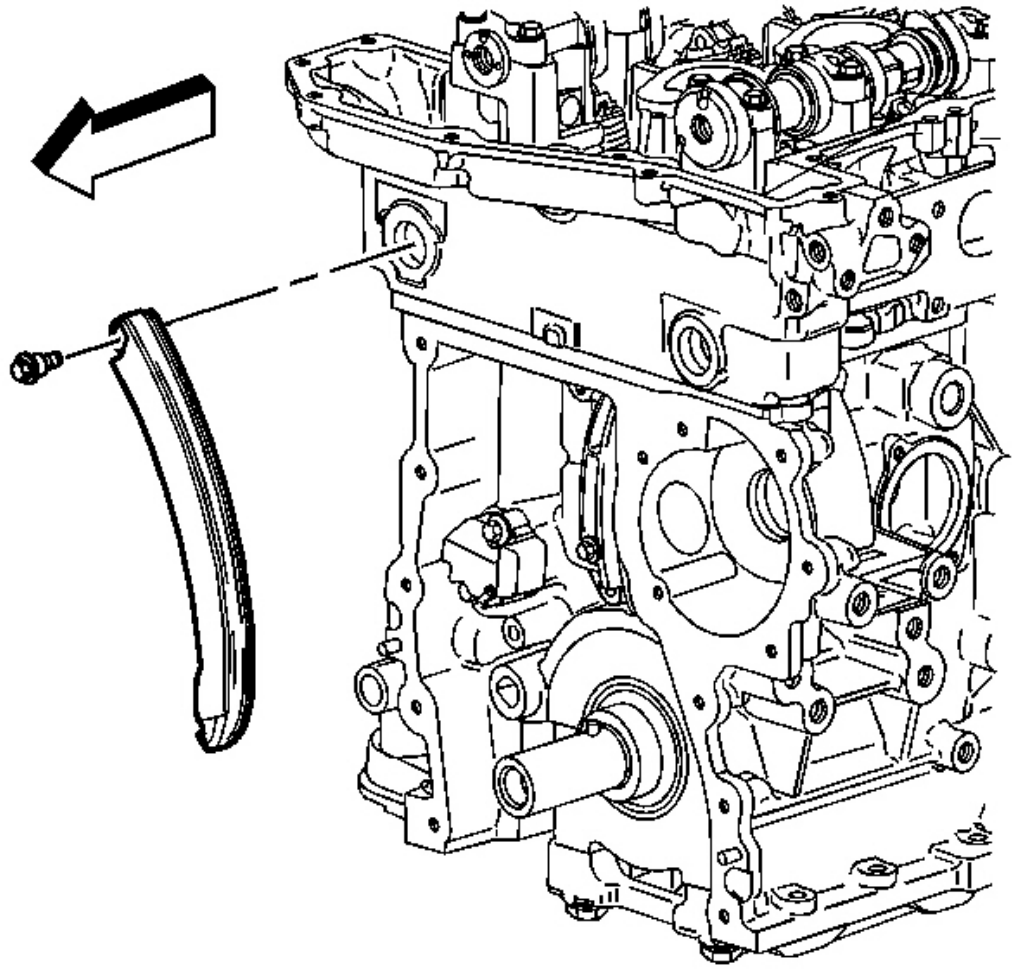


Fig. 520: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain tensioner shoe.
6. Install the timing chain tensioner shoe bolt.

Tighten: Tighten the timing chain tension shoe bolt to 25 N.m (18 lb ft).

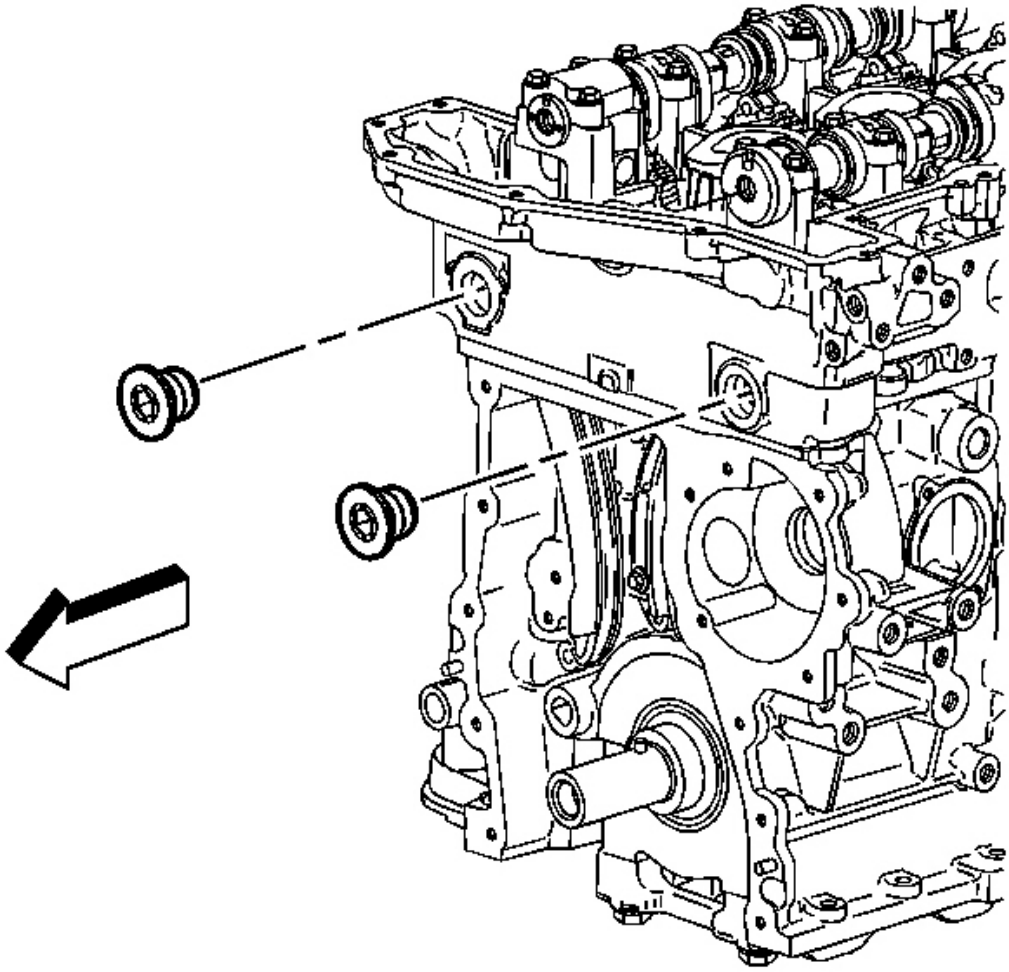


Fig. 521: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the cylinder head access hole plugs.

   Tighten: Tighten the cylinder head access hole plugs to 5 N.m (44 lb in).

TIMING CHAIN & SPROCKETS INSTALLATION

Tools Required

- **J 44221** Camshaft Holding Tool. See **Special Tools**.

- **J 45059** Angle Meter. See **Special Tools**.

Installation Procedure

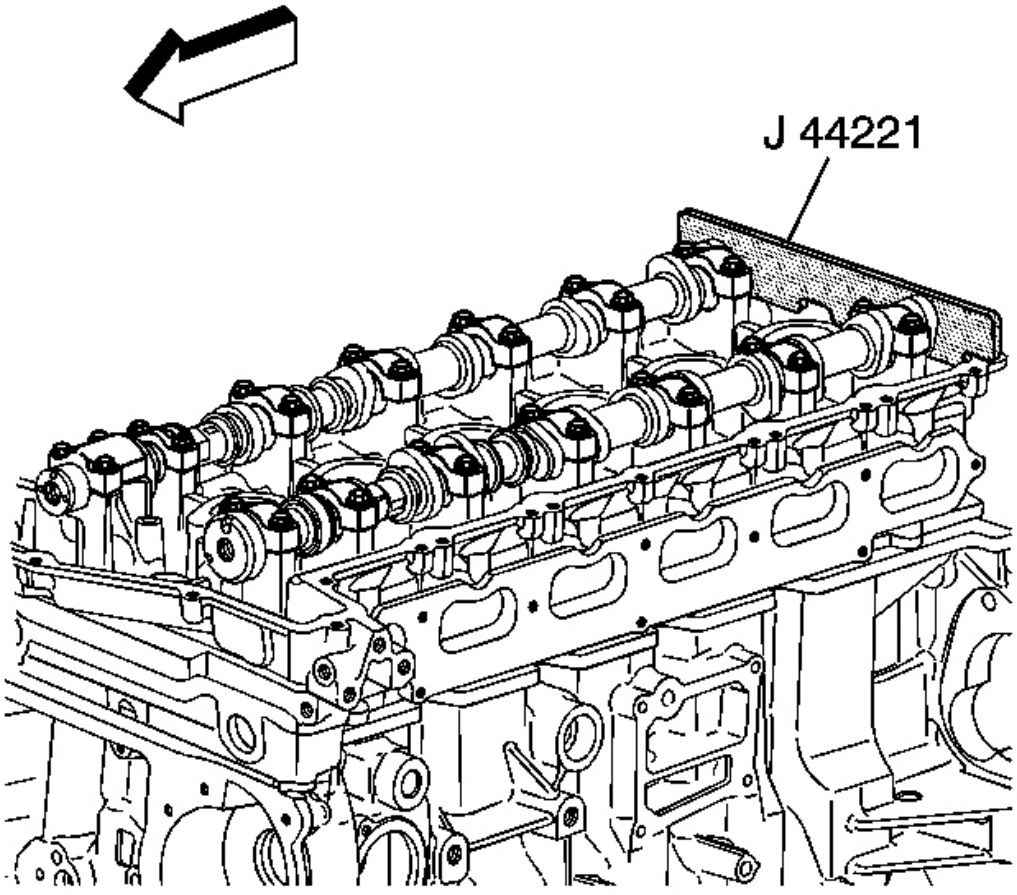


Fig. 522: View Of J 44221 Installed To Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Install **J 44221** with the camshaft flats up and the number 1 cylinder at top dead center. See **Special Tools**. The crankshaft pin should be at 12 o'clock when the number 1 piston is at top dead center.

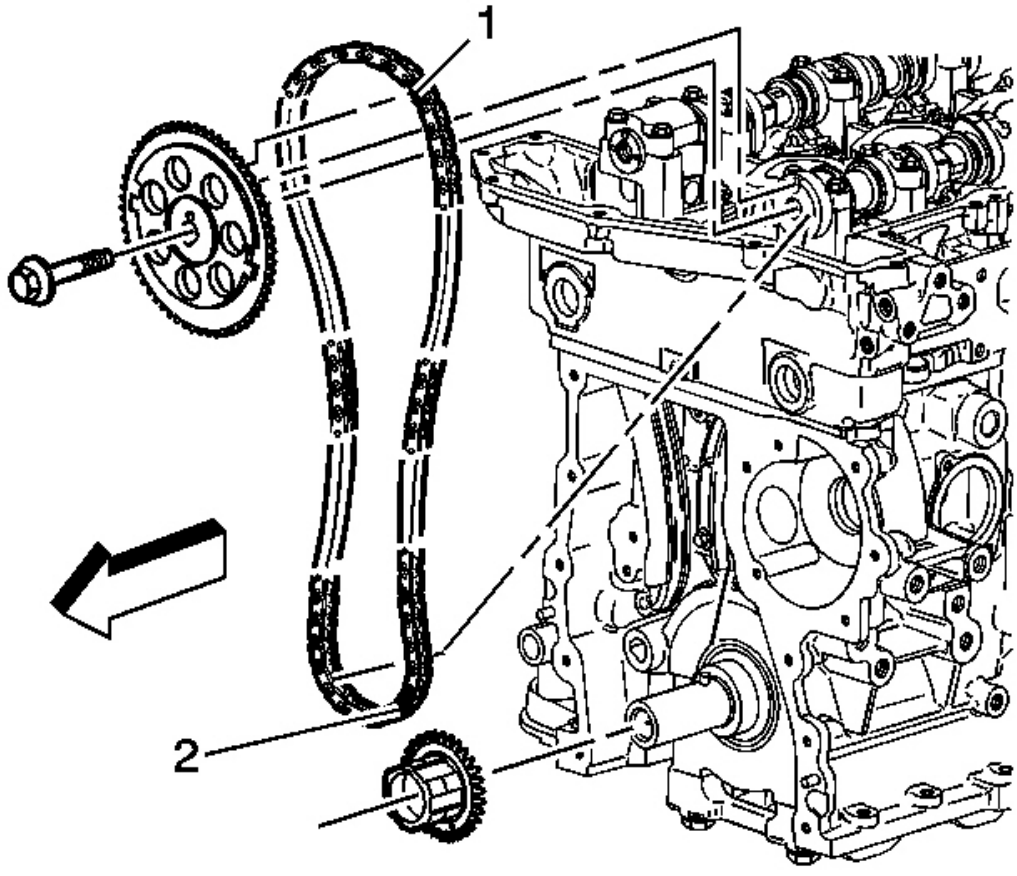


Fig. 523: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

2. Compress the tensioner and lock in place.
3. Install the crankshaft sprocket.
4. Install the intake camshaft sprocket into the timing chain.
5. Align the - dark link of the timing chain with the timing mark on the intake camshaft sprocket (1).
6. Feed the timing chain down through the opening in the head.
7. Install the timing chain onto the crankshaft sprocket. Align the - dark link of the timing chain with the timing mark on the crankshaft sprocket (2).

IMPORTANT: It may be necessary to temporarily remove J 44221 to rotate and hold the camshaft (hex) to align the pin to the camshaft sprocket. See Special Tools.

8. Install the intake camshaft sprocket onto the intake camshaft.

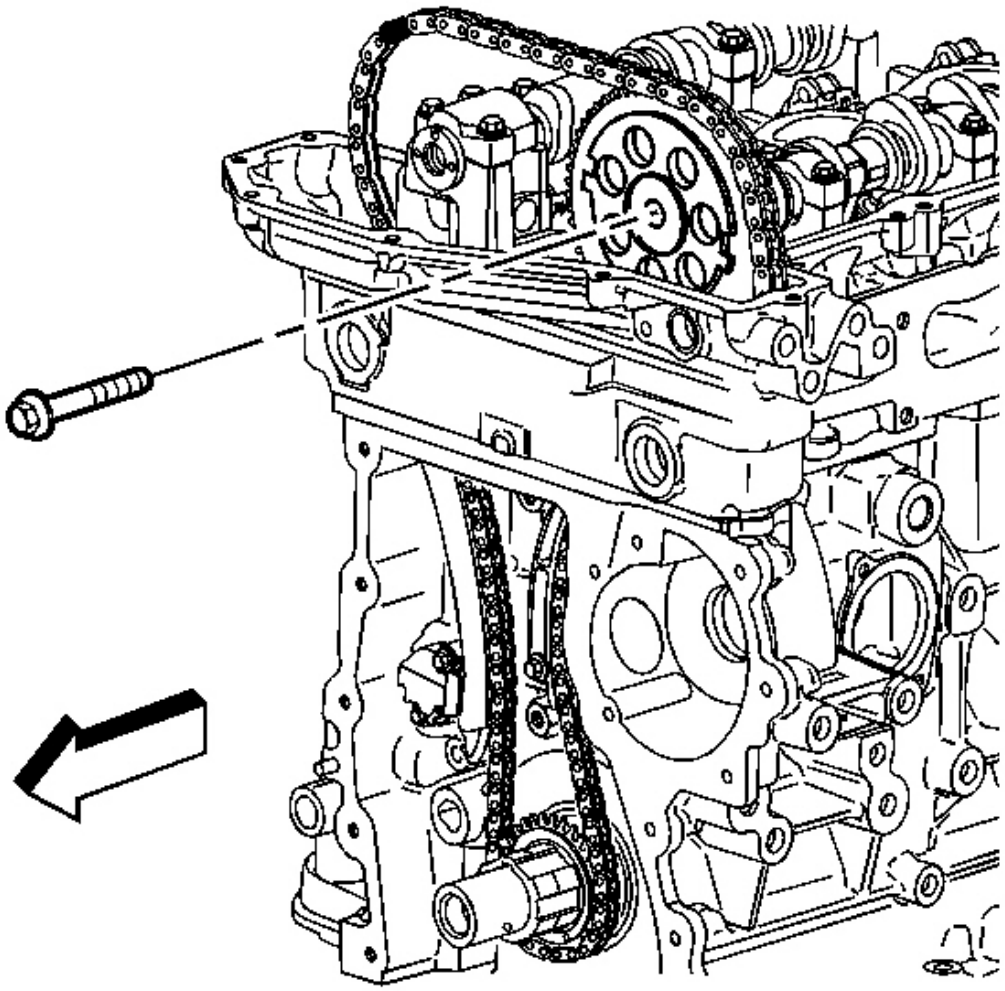


Fig. 524: View Of Intake Camshaft Sprocket Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Install the intake camshaft sprocket washer and new bolt.

Tighten:

- Tighten the new intake camshaft sprocket bolt the first pass to 20 N.m (15 lb ft).

- Use **J 45059** to tighten the intake camshaft sprocket bolt the final pass an additional 100 degrees. See **Special Tools**.

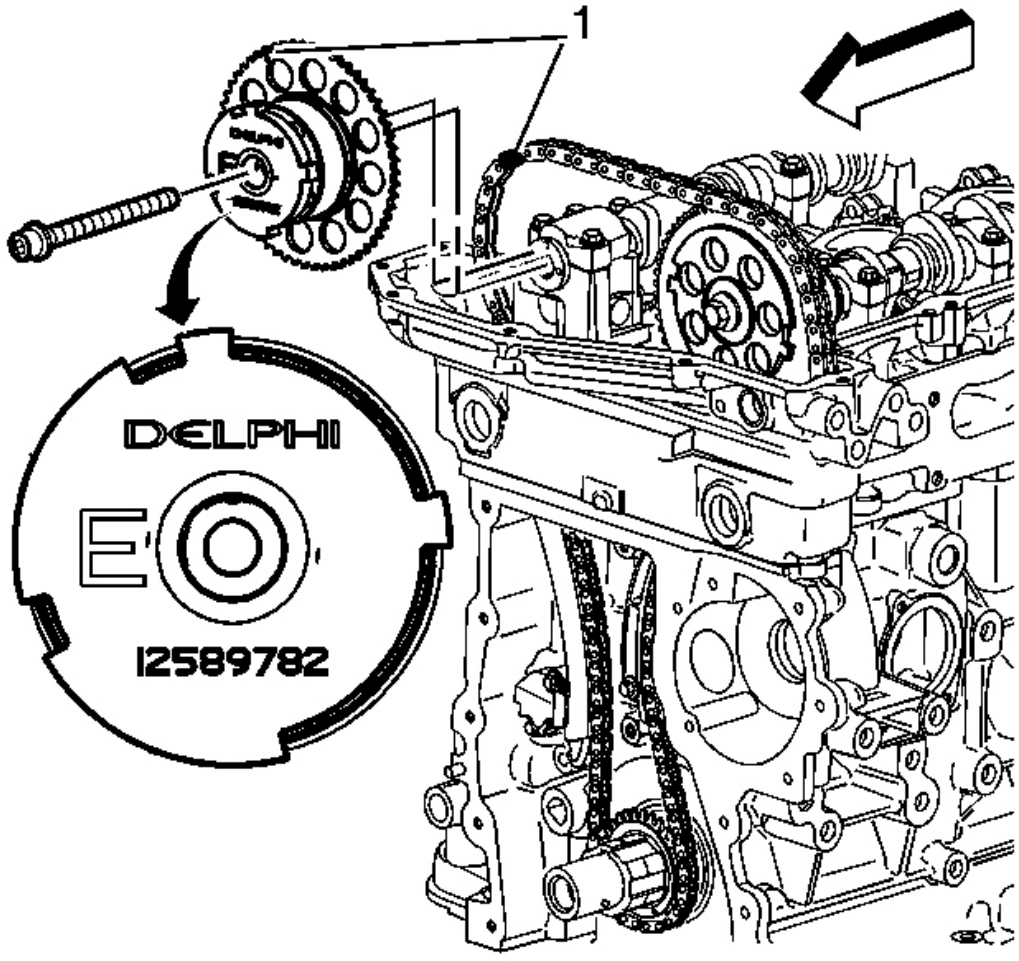


Fig. 525: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

10. Install the exhaust camshaft actuator into the timing chain.
11. Align the - dark link of the timing chain with the timing mark on the exhaust camshaft actuator (1).

IMPORTANT: It may be necessary to temporarily remove J 44221 to rotate and hold the camshaft (hex) to align the pin to the camshaft sprocket. See Special Tools.

12. Install the exhaust camshaft actuator onto the exhaust camshaft.
13. Install the new exhaust camshaft actuator bolt.

    Tighten:

    - Tighten the exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
    - Use **J 45059** to tighten the exhaust camshaft actuator bolt the final pass an additional 135 degrees. See **Special Tools**.

14. Unlock the tensioner.
15. Remove **J 44221** . See **Special Tools**.

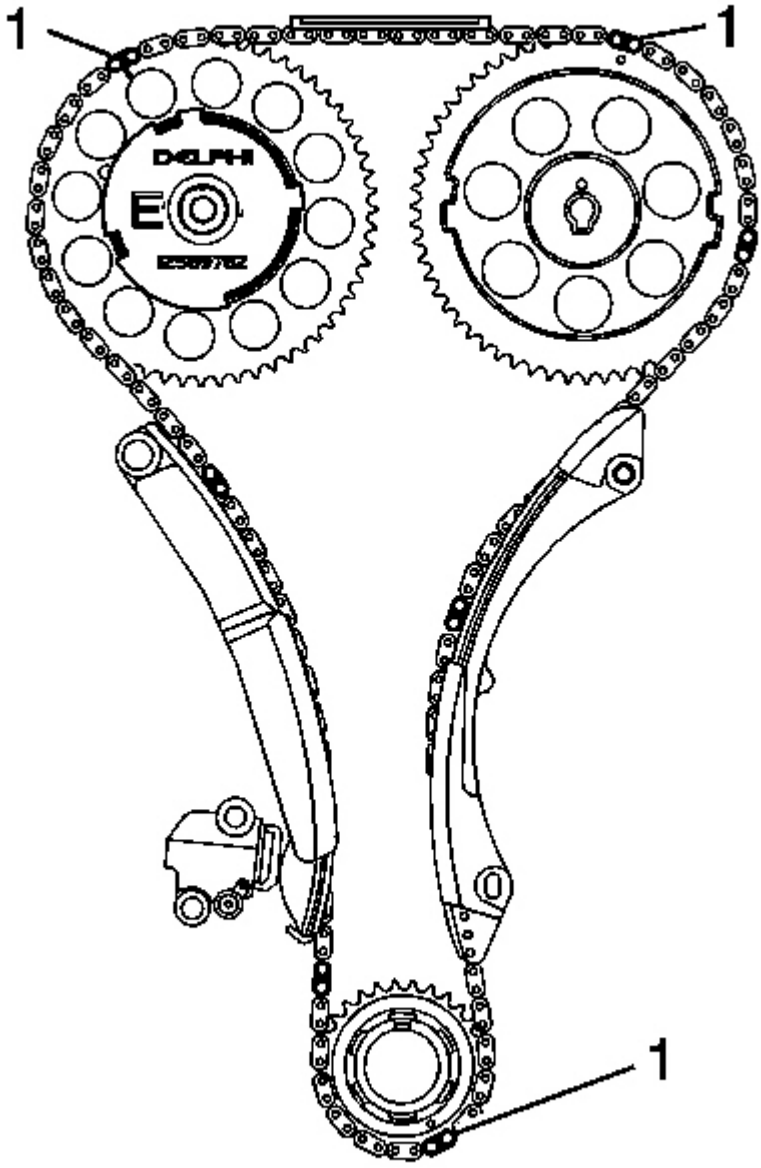


Fig. 526: Identifying Timing Chain/Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

16. The dark links (1) on the chain should be aligned with marks on sprockets as shown.

CAMSHAFT COVER INSTALLATION

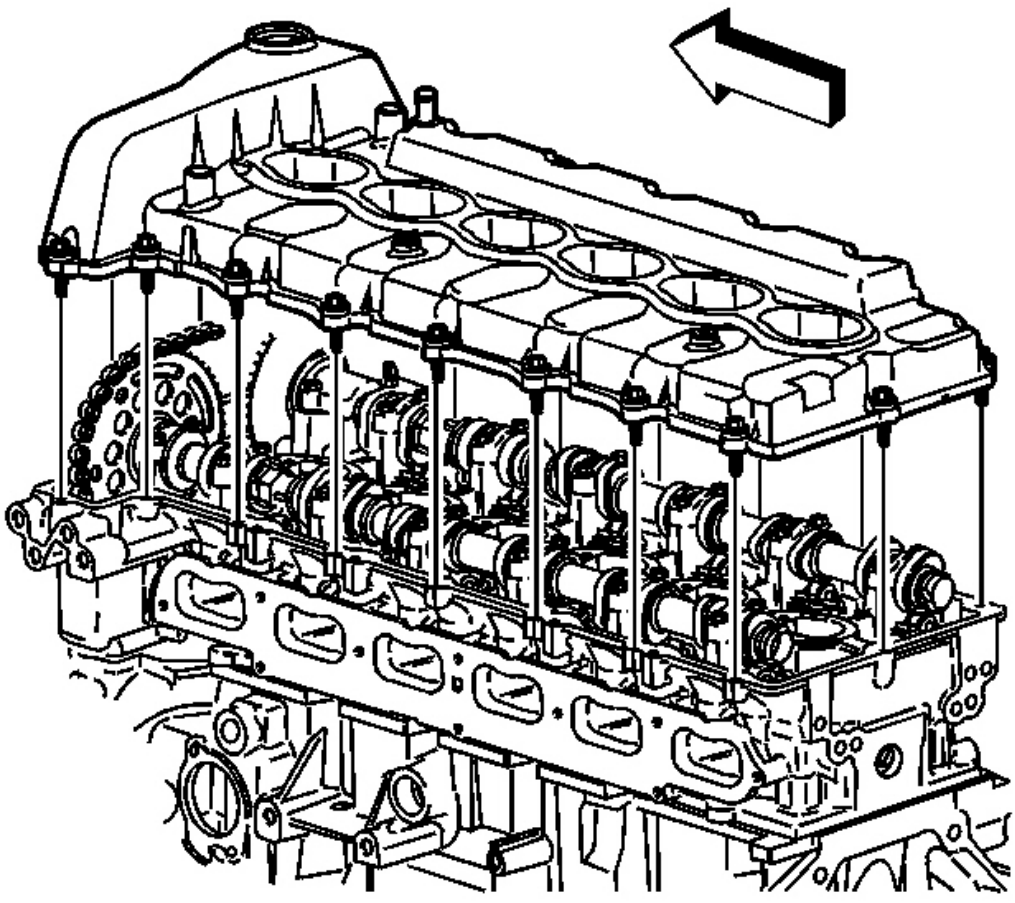


Fig. 527: View Of Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a new camshaft cover seal.

   NOTE: Refer to Fastener Notice .

2. Install the camshaft cover and bolts.

   Tighten: Tighten the camshaft cover bolts to 10 N.m (89 lb in).

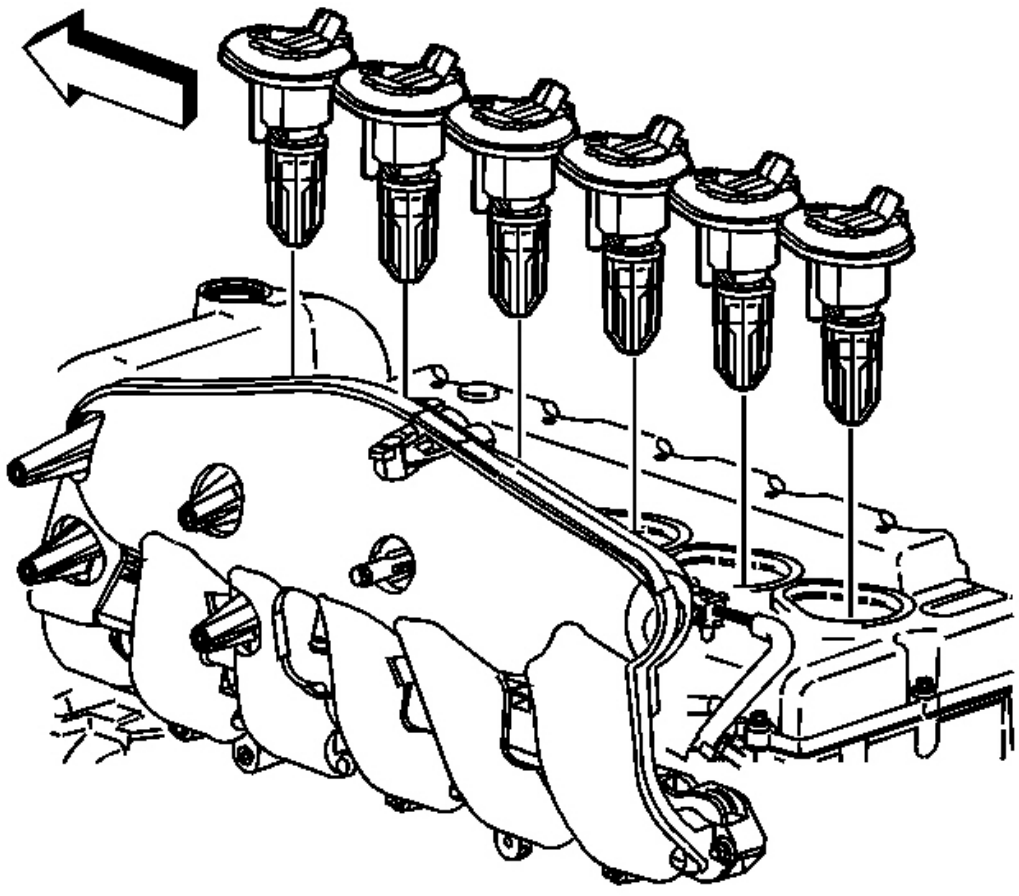


Fig. 528: View Of Ignition Control Modules & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install new ignition control module seals.
4. Install the ignition control modules and bolts.

Tighten: Tighten the ignition control module bolts to 10 N.m (89 lb in).

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSTALLATION

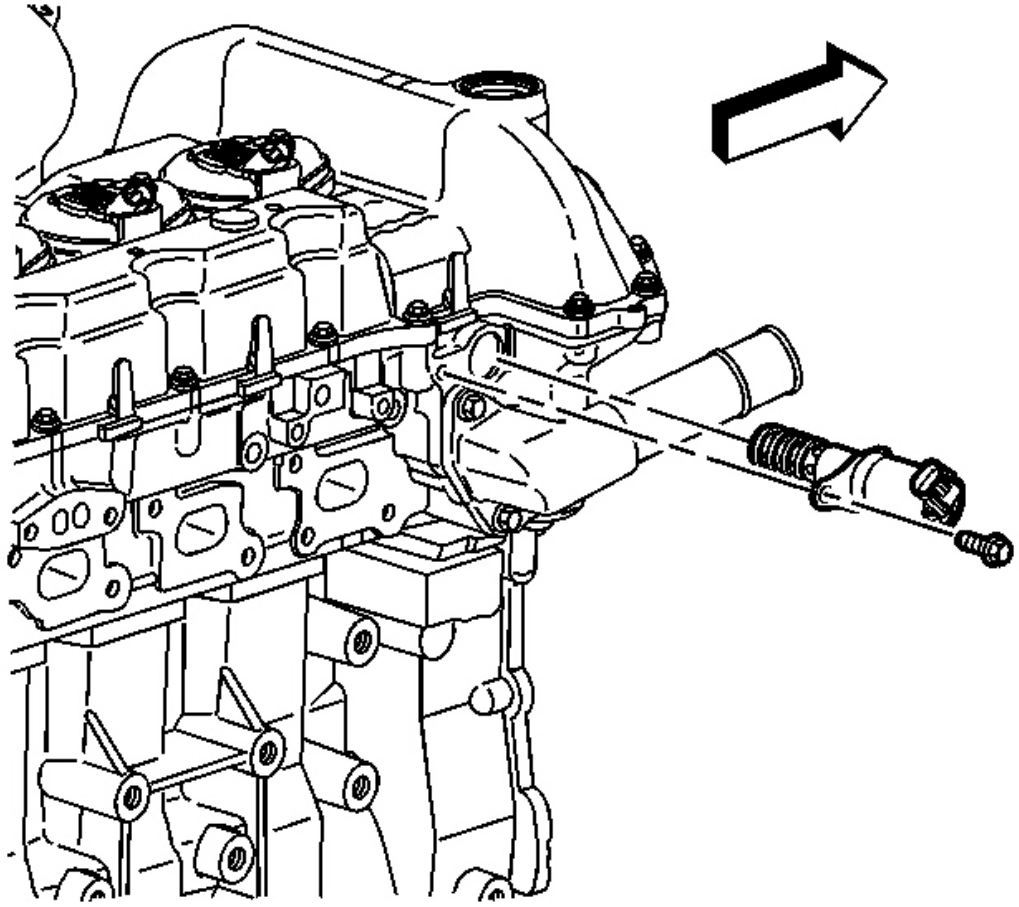


Fig. 529: View Of Camshaft Position Actuator Valve & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the camshaft position actuator valve hole.
2. Install the camshaft position actuator valve.
3. Add sealant GM P/N 12346004 (Canadian P/N 10953480) to the camshaft position actuator valve bolt threads.

NOTE: **Refer to Fastener Notice .**

4. Install the camshaft position actuator valve bolt.

Tighten: Tighten the camshaft position actuator valve bolt to 10 N.m (89 lb in).

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

J 44218 Seal Installer. See **Special Tools**.

Installation Procedure

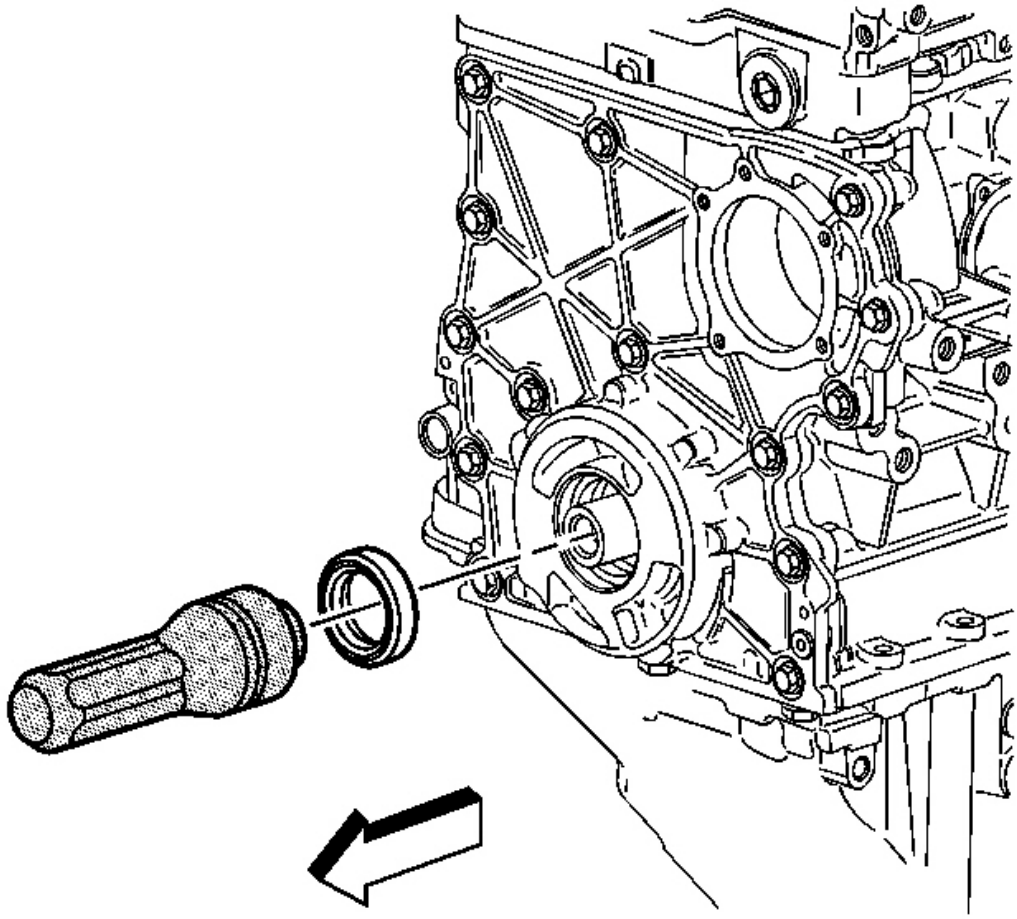


Fig. 530: View Of Installing Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Apply engine oil to the outside diameter of the crankshaft front oil seal.
2. Use **J 44218** to install the crankshaft front oil seal. See **Special Tools**.
3. Remove **J 44218** . See **Special Tools**.

OIL PUMP INSTALLATION

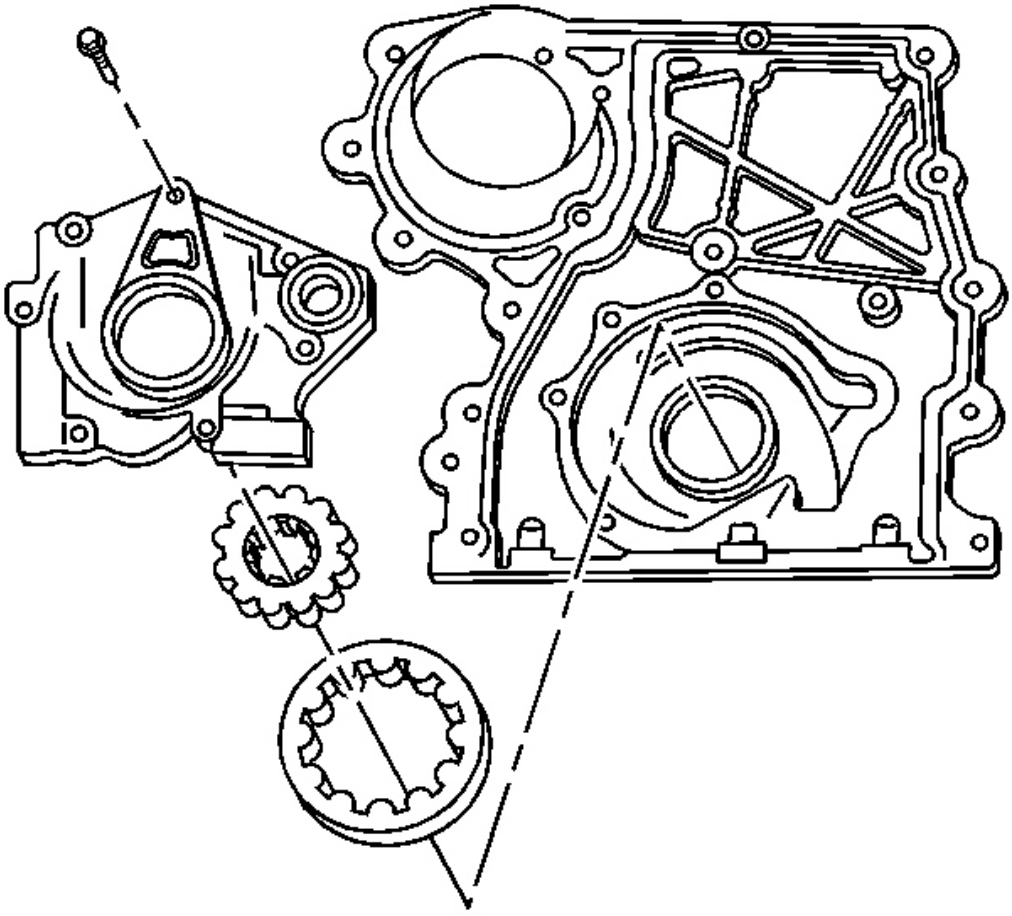


Fig. 531: View Of Oil Pump Outer & Inner Gears, Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump pressure relief valve and spring.

   NOTE: Refer to Fastener Notice .

2. Install the oil pump pressure relief valve plug.

   Tighten: Tighten the oil pump pressure relief valve plug to 14 N.m (124 lb in).

3. Install the oil pump outer and inner gears as removed.

4. Install the oil pump cover.
5. Install the oil pump cover bolts.

   Tighten: Tighten the oil pump cover bolts to 10 N.m (89 lb in).

ENGINE FRONT COVER INSTALLATION

Tools Required

J 44219 Engine Cover Alignment Pins. See **Special Tools**.

Installation Procedure

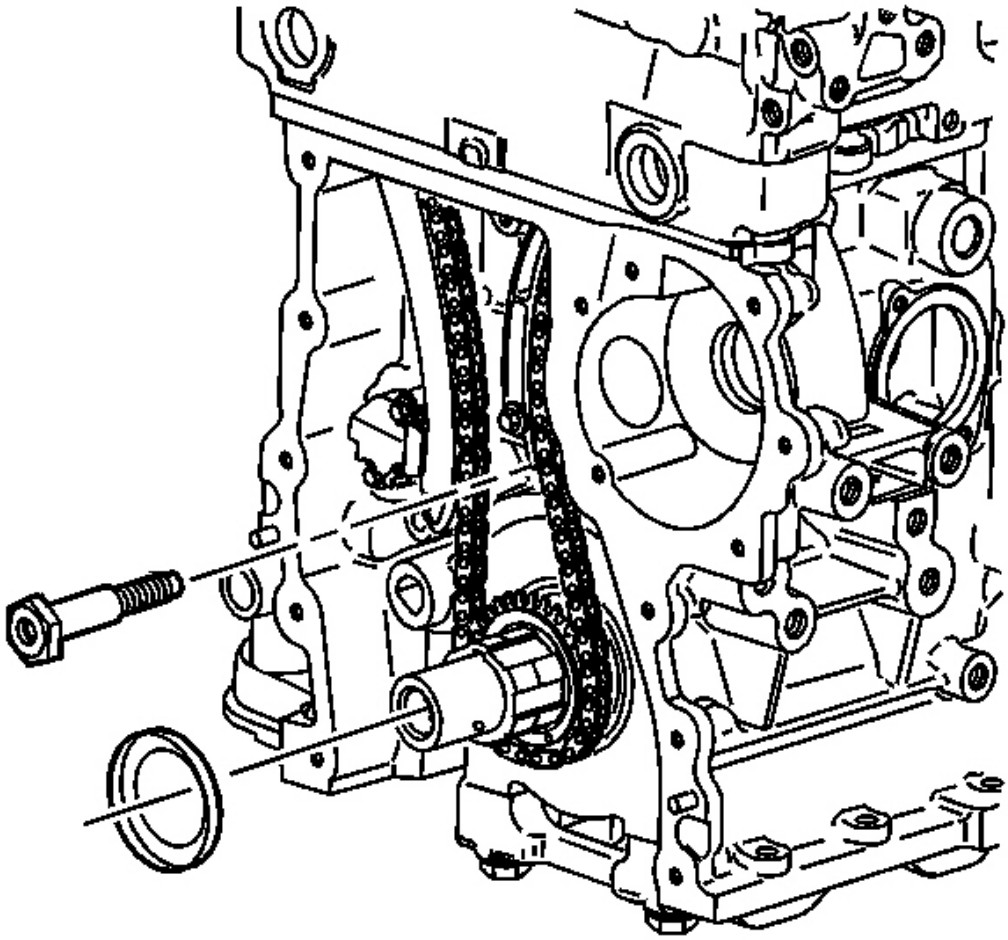


Fig. 532: View Of Spacer Bolt & Crankshaft Balancer Friction Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the engine front cover spacer bolt.

   Tighten: Tighten the engine front cover spacer bolt to 10 N.m (89 lb in).

2. Install the crankshaft balancer friction washer GM P/N 12573950 over the crankshaft snout, up against the crankshaft gear.

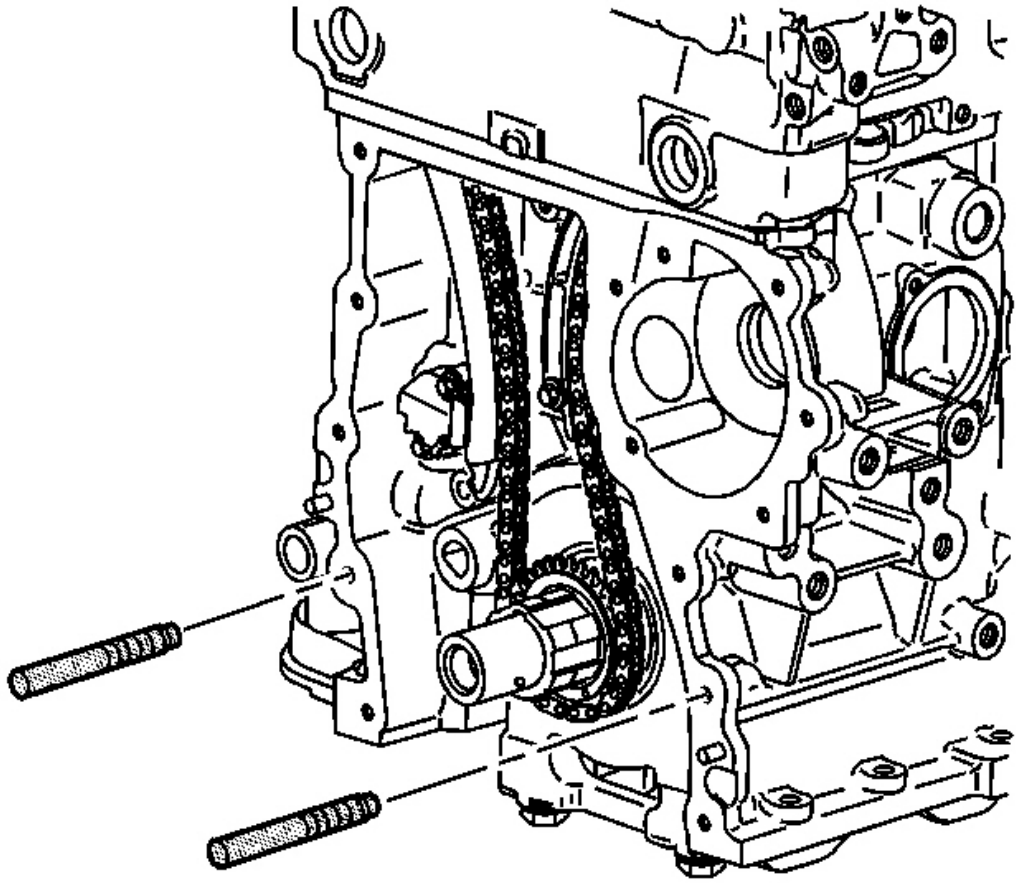


Fig. 533: Installing J 44219 Into Engine Block
Courtesy of GENERAL MOTORS CORP.

3. Install **J 44219** . See **Special Tools**.

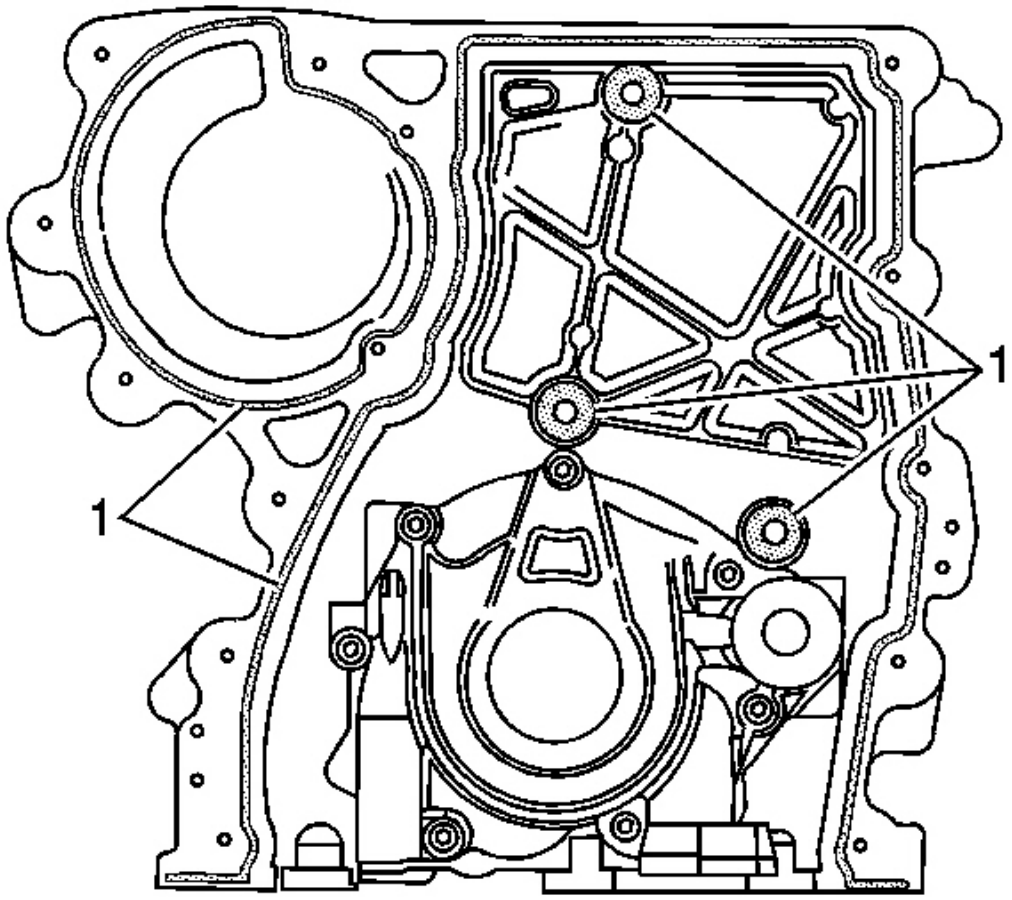


Fig. 534: Locating Sealer Application Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine front cover must be installed within 10 minutes from when the sealer was applied.

4. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521, Canadian P/N 88901148 to the back side of the engine front cover (1).

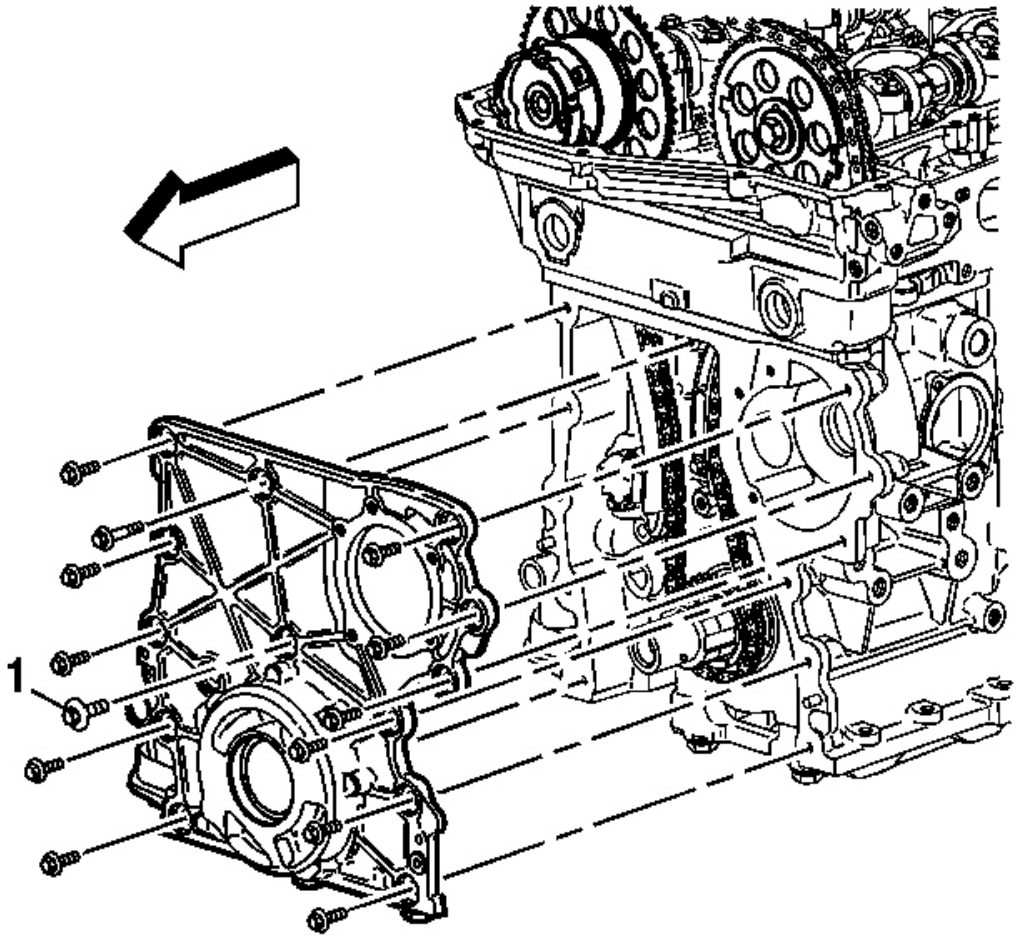


Fig. 535: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Align the oil pump to the crankshaft sprocket splines.
6. Install the engine front cover.
7. Remove **J 44219** . See **Special Tools**.
8. Install the engine front cover bolts.

Tighten:

1. Tighten the engine front cover bolts to 10 N.m (89 lb in).
2. Tighten the small center bolt (1) last to 10 N.m (89 lb in).

WATER PUMP INSTALLATION

Tool Required

J 41240 Fan Clutch Remover and Installer

Installation Procedure

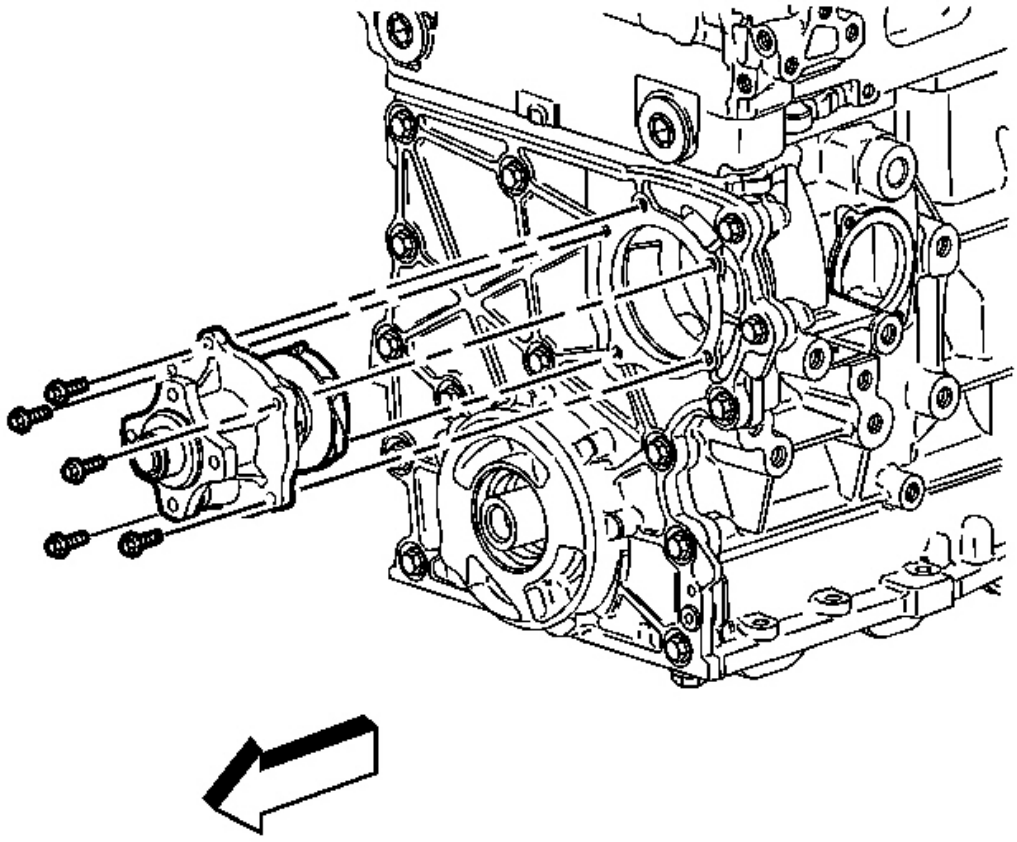


Fig. 536: View Of Water Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump gasket.
2. Install the water pump.

NOTE: Refer to Fastener Notice .

3. Install the water pump bolts.

Tighten: Tighten the water pump bolts to 10 N.m (89 lb in).

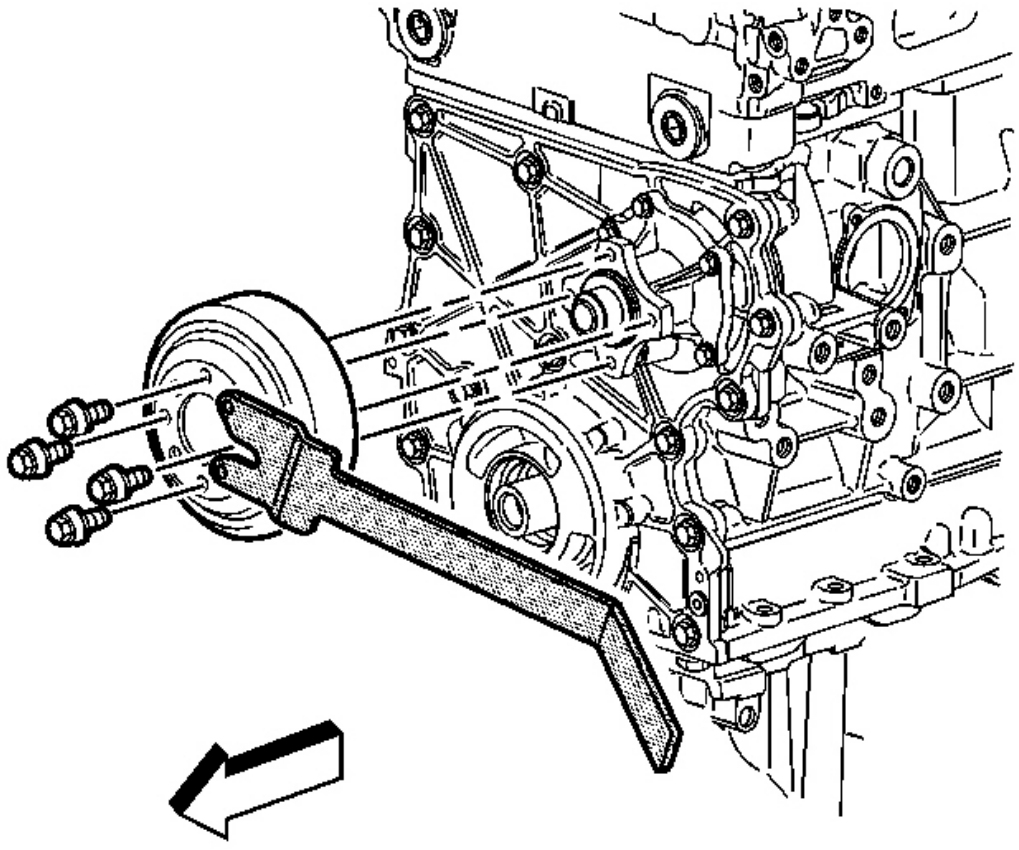


Fig. 537: Tightening Water Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the water pump pulley.
5. Install the water pump pulley bolts.
6. Install **J 41240** to hold pulley.
7. Tighten the water pump pulley bolts.

   Tighten: Tighten the water pump pulley bolts to 25 N.m (18 lb ft).

8. Remove **J 41240** .

CRANKSHAFT REAR OIL SEAL & HOUSING INSTALLATION

Tools Required

J 44219 Cover Alignment Pins. See **Special Tools**.

Installation Procedure

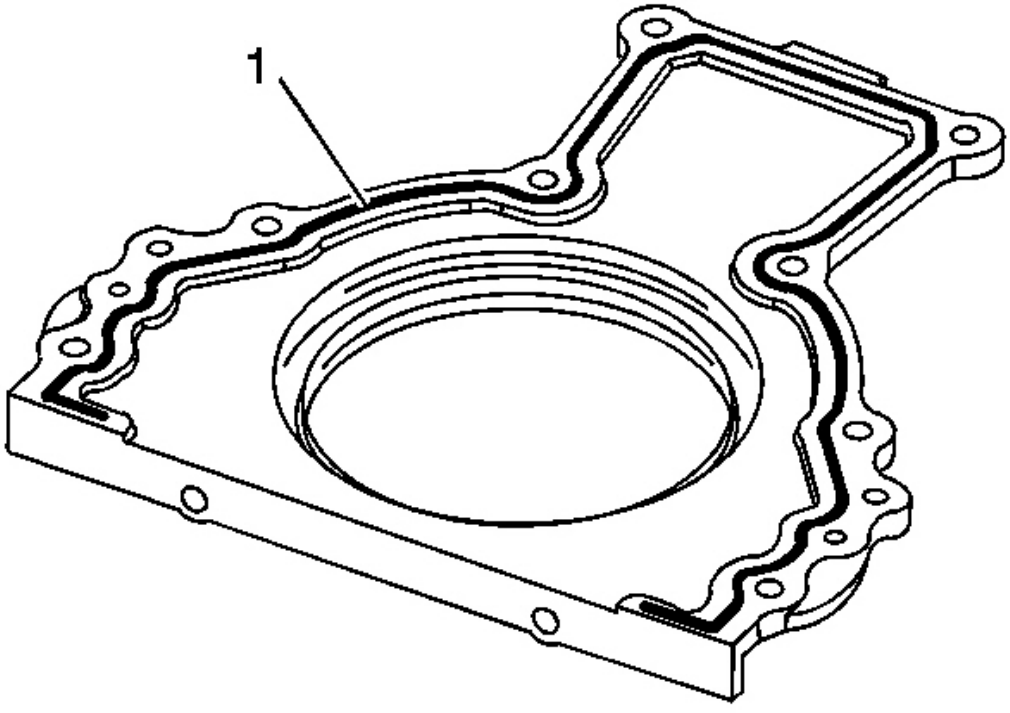


Fig. 538: Applying Sealant To Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

1. Apply a 3 mm (0.12 in) bead of GM P/N 12378521, Canadian P/N 88901148 to the rear oil seal housing (1).

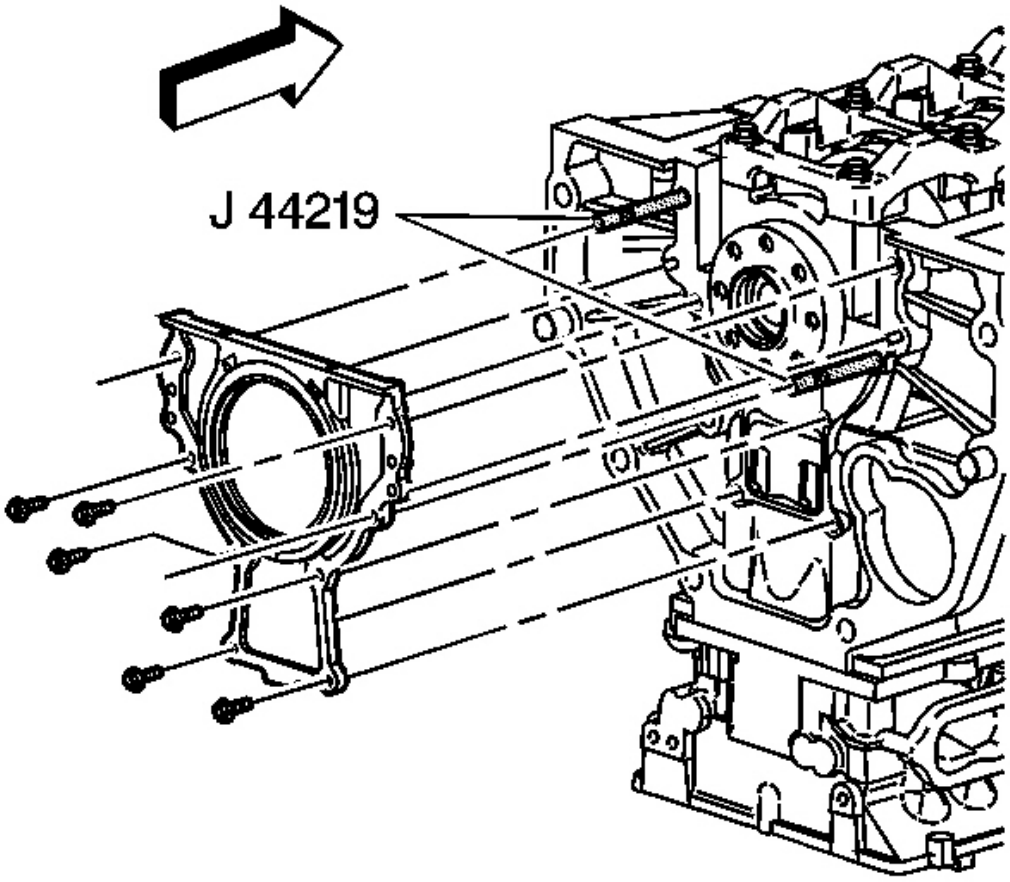


Fig. 539: View Of J 44219 Installed In Engine Block
Courtesy of GENERAL MOTORS CORP.

2. Install **J 44219** into the block. See **Special Tools**.

IMPORTANT: With the help of the plastic installation aid (supplied with the new seal), be sure the lip of the seal faces inward.

3. Slide the crankshaft rear oil seal housing over the **J 44219** and crankshaft. See **Special Tools**.

NOTE: Refer to Fastener Notice .

4. Install the crankshaft rear oil seal housing bolts (except the two in place of the guide pins).
5. Remove **J 44219** . See **Special Tools**.

6. Install the remaining two crankshaft rear oil seal housing bolts.

   Tighten: Tighten the crankshaft rear oil seal housing bolts to 10 N.m (89 lb in).

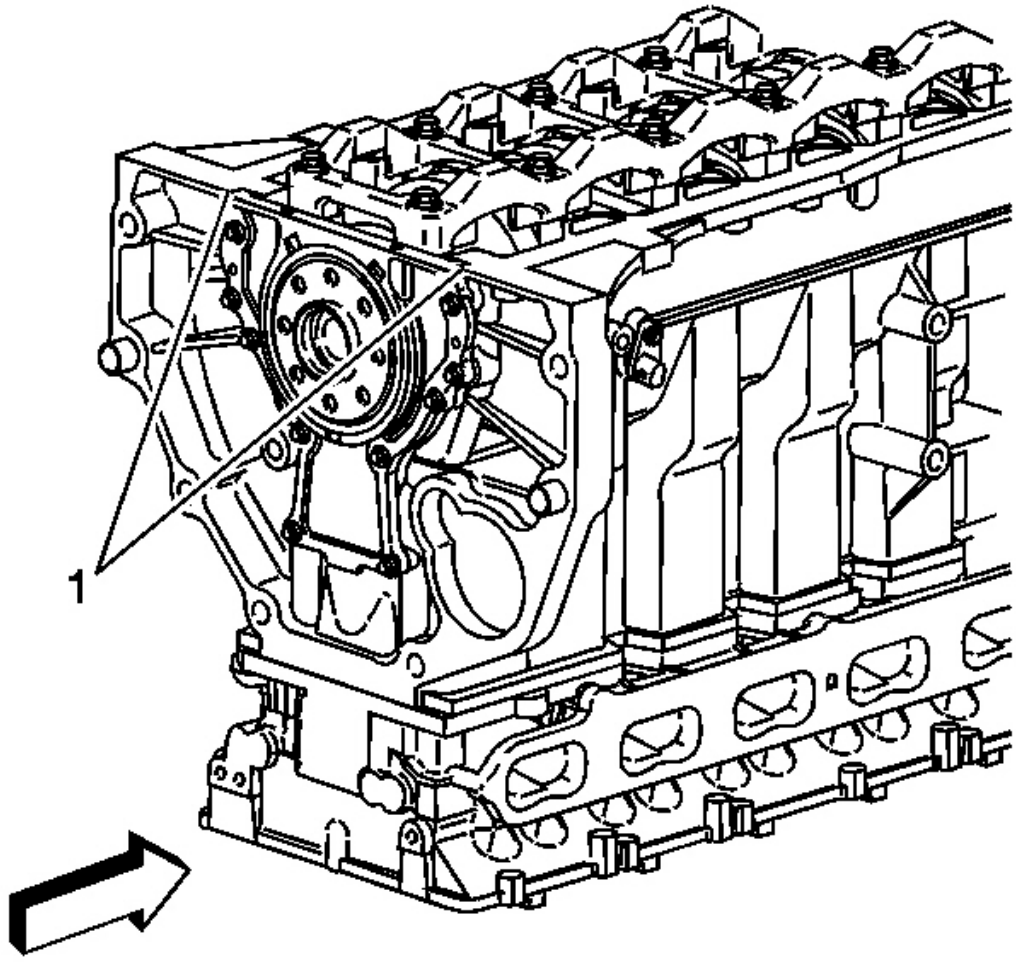


Fig. 540: View Of Oil Pan Sealing Area With Engine Inverted
Courtesy of GENERAL MOTORS CORP.

7. Wipe off any excess material from the bottom of the oil pan sealing area (1).

OIL PUMP SUCTION PIPE & SCREEN ASSEMBLY INSTALLATION

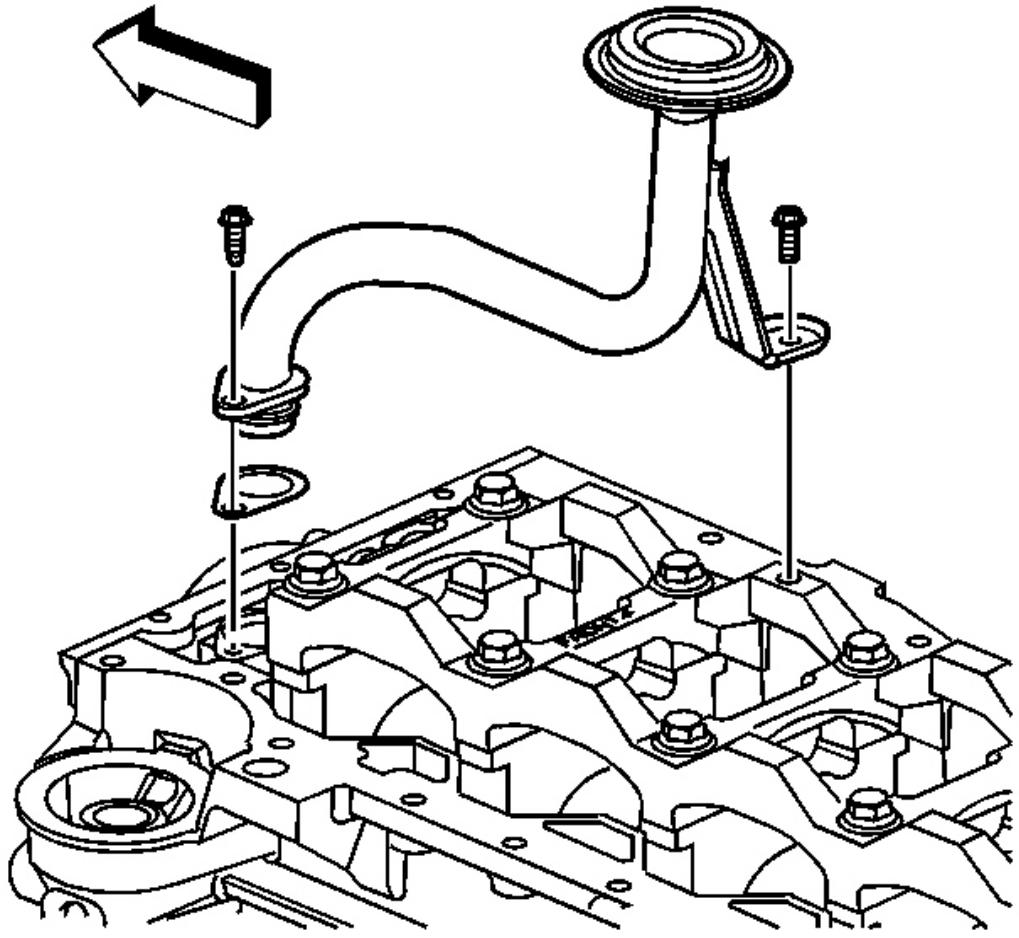


Fig. 541: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil pump pipe gasket.
2. Install the oil pump pipe and screen assembly.
3. Add sealant GM P/N 12346004 (Canadian P/N 10953480) to the oil pump pipe bolt threads.

NOTE: Refer to Fastener Notice .

4. Install the oil pump pipe and screen assembly bolts.

Tighten: Tighten the oil pump pipe and screen assembly bolts to 10 N.m (89 lb in).

OIL PAN INSTALLATION

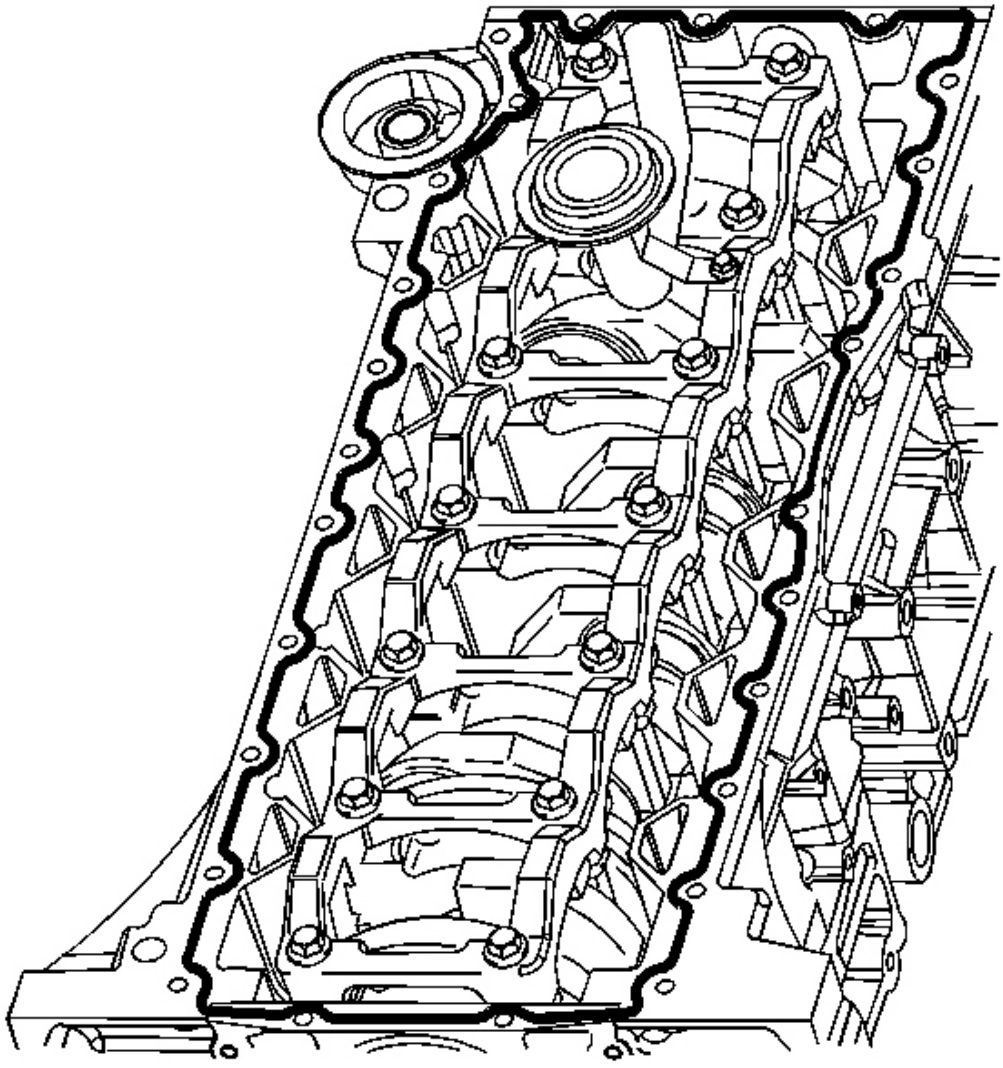


Fig. 542: Applying Sealant To Block
Courtesy of GENERAL MOTORS CORP.

1. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521, Canadian P/N 88901148 to the block.

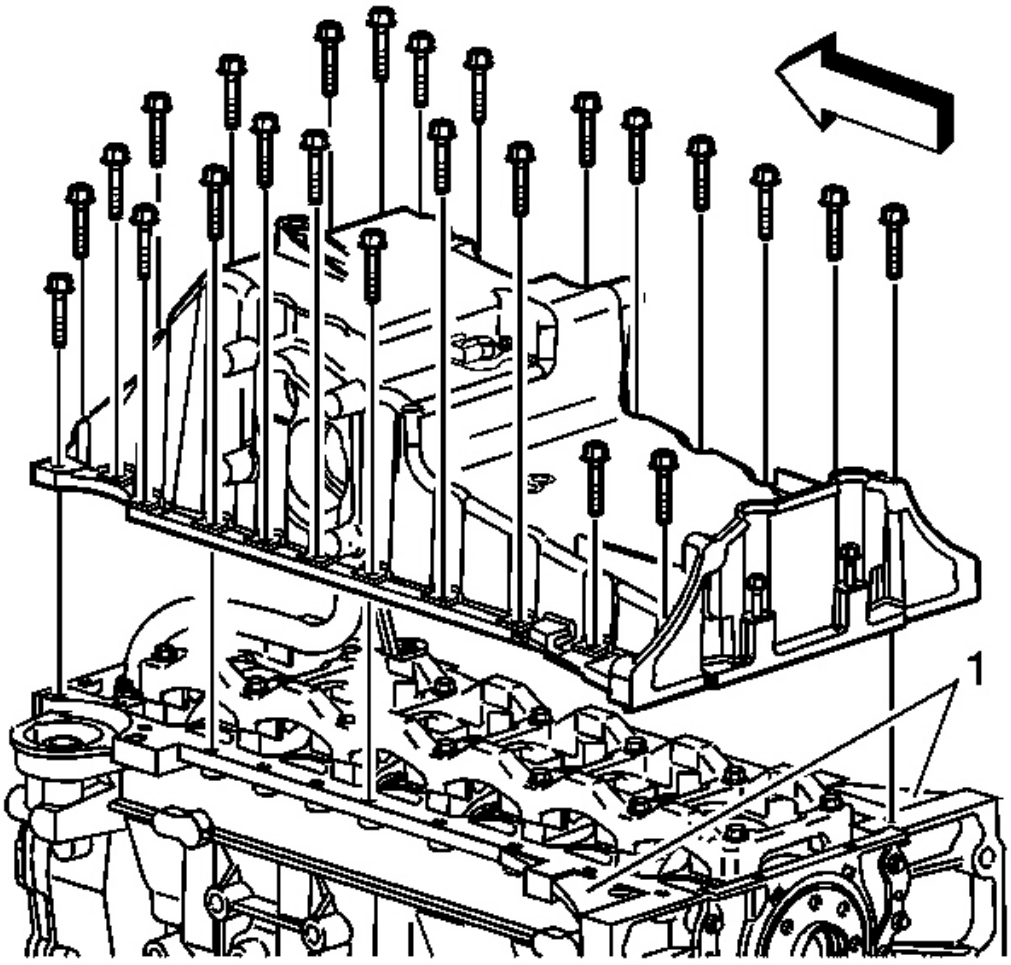


Fig. 543: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan must be installed within 10 minutes from when the sealer was applied.

2. Install the oil pan.
3. Install the oil pan bolts.

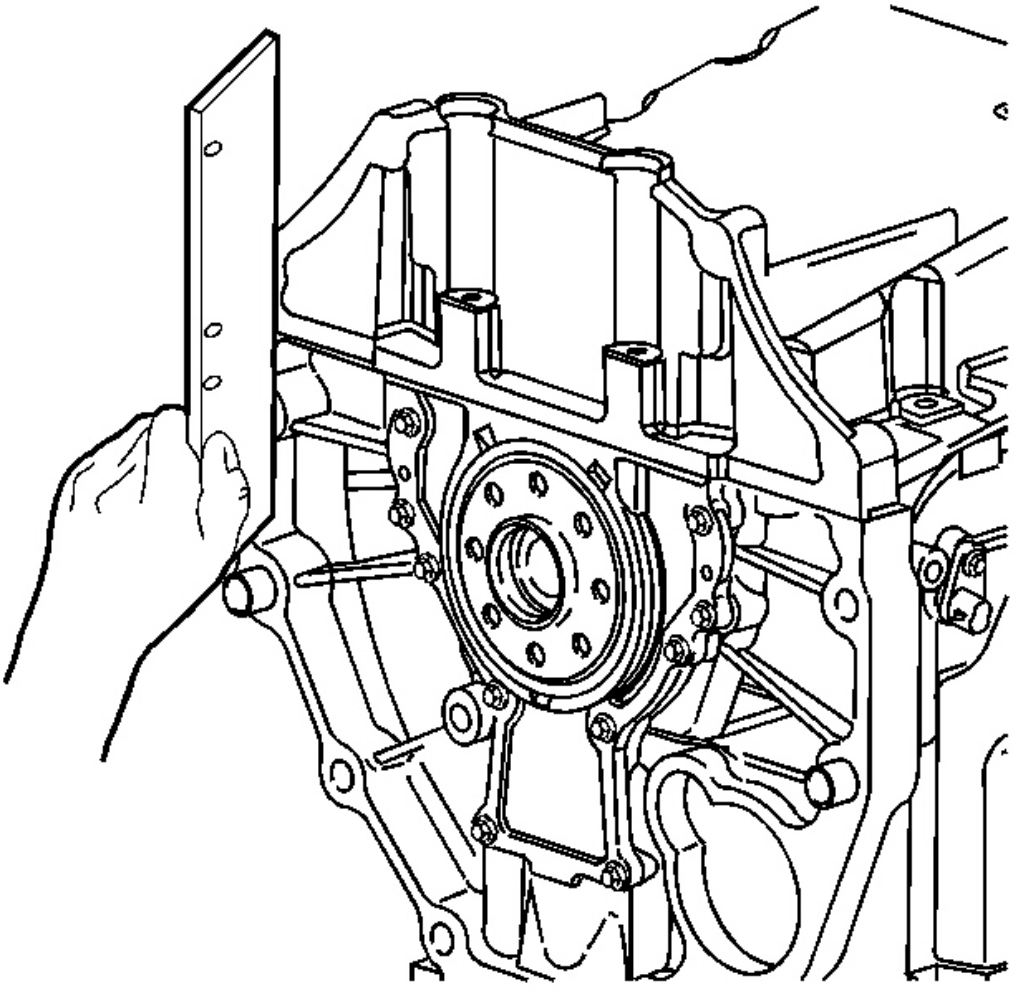


Fig. 544: Inspecting Oil Pan Alignment
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing the oil pan, it could be shifted front or back a little which could cause a transmission alignment problem. The back of the oil pan needs to be flush with the block.

4. Check the oil pan alignment. Use a straight edge on the back of the block and oil pan - transmission mounting surface.

NOTE: Refer to Fastener Notice .

5. Tighten the oil pan bolts.

   Tighten:
   - Tighten the - side oil pan bolts to 25 N.m (18 lb ft).
   - Tighten the - end oil pan bolts to 10 N.m (89 lb in).

6. Install the oil level sensor.
7. Install the oil level sensor bolt.

   Tighten: Tighten the oil level sensor bolt to 10 N.m (89 lb in).

CRANKSHAFT BALANCER INSTALLATION

Tools Required

- **J 45059** Angle Meter. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.

Installation Procedure

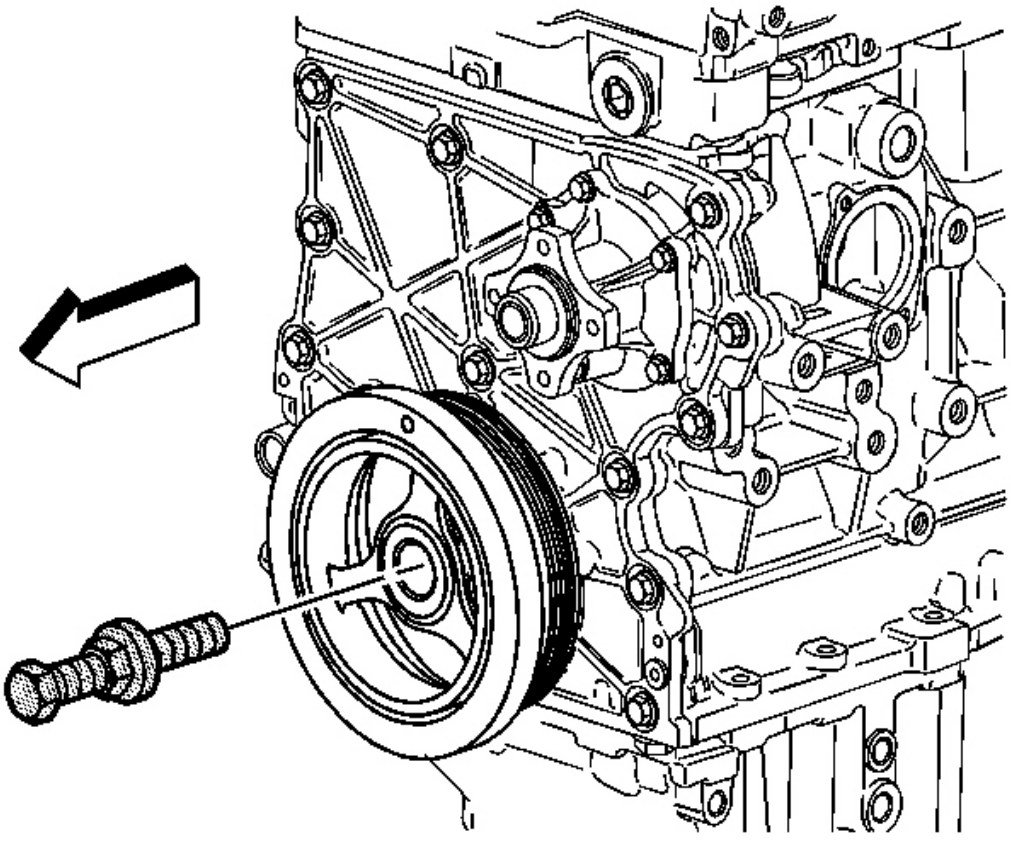


Fig. 545: Installing Crankshaft Balancer Using The J 41478
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft balancer using **J 41478** . See **Special Tools**.
2. Remove **J 41478** . See **Special Tools**.
3. Hold the flywheel or back of the crankshaft. The crankshaft balancer does not have a keyway so the crankshaft could turn when tightening, causing an improper torque.

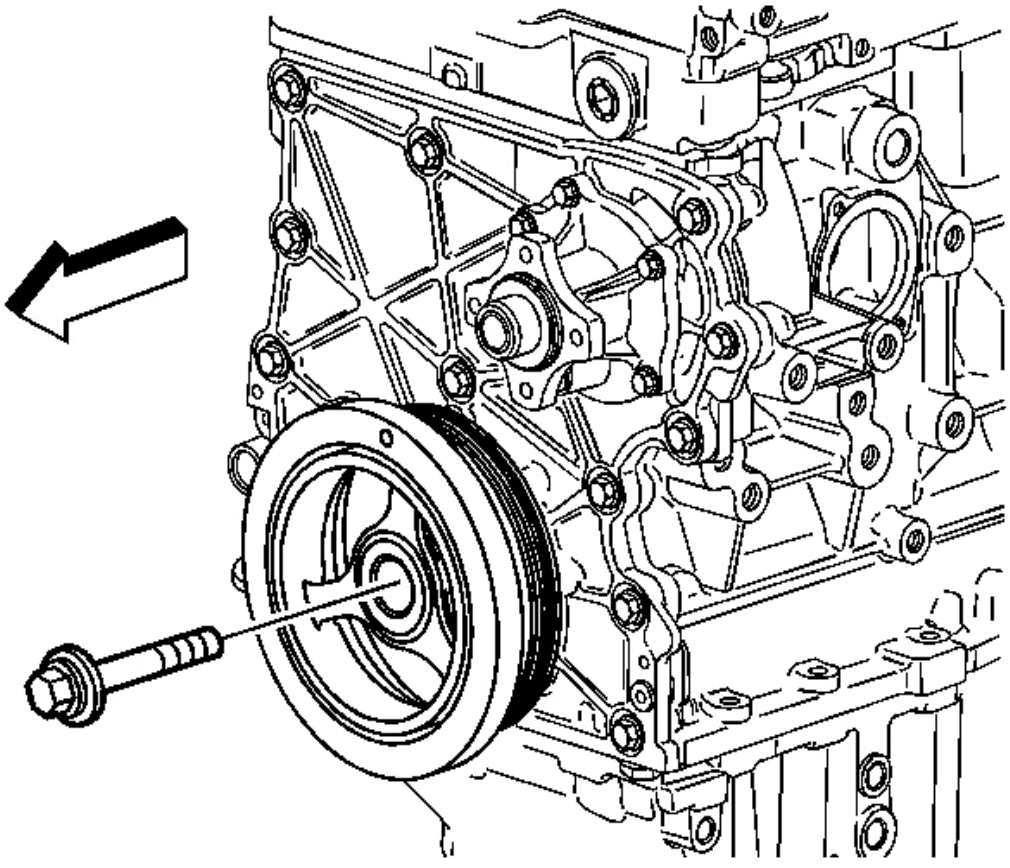


Fig. 546: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Be sure the crankshaft balancer friction washer, GM P/N 12573950, was installed prior to the engine front cover installation.

4. Install the crankshaft balancer washer and new bolt.

Tighten:

1. Tighten the new crankshaft balancer bolt while holding the back to 150 N.m (110 lb ft).
2. Use **J 45059** to tighten the crankshaft balancer bolt an additional 180 degrees. See **Special Tools**.

FUEL RAIL & INJECTORS INSTALLATION

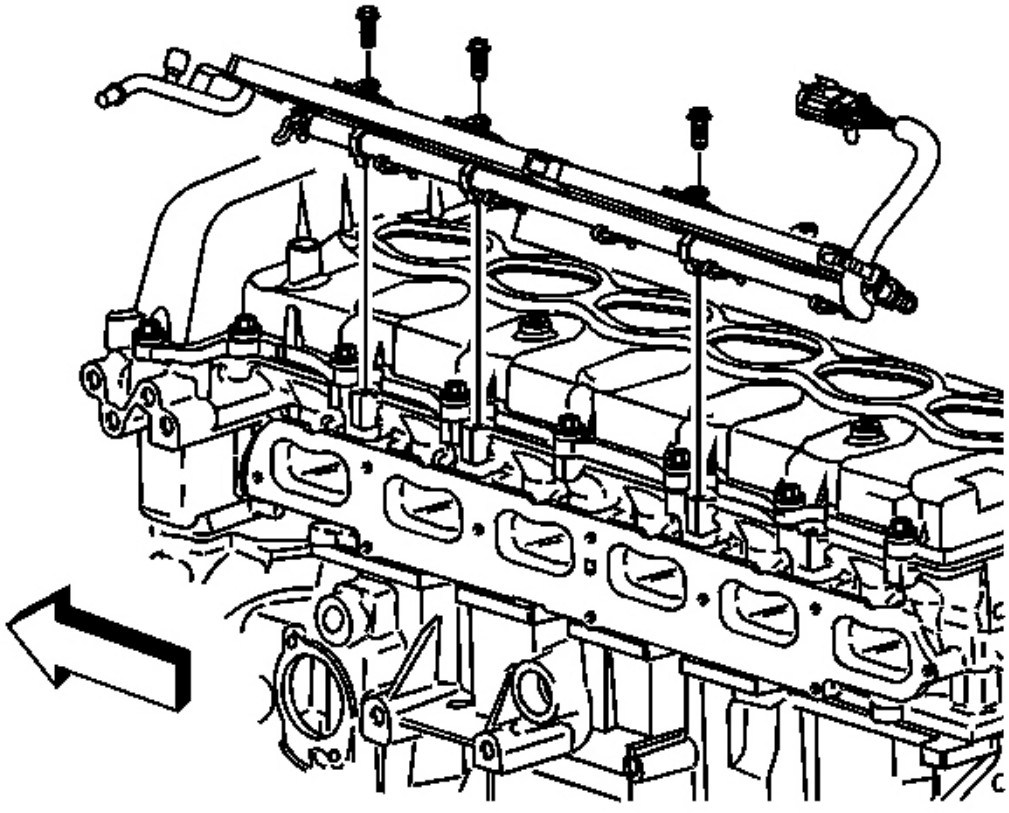


Fig. 547: View Of Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the lower injector O-rings with mineral oil GM P/N 9981704.
2. Install the fuel injector rail.

NOTE: Refer to Fastener Notice .

3. Install the fuel injector rail bolts.

Tighten: Tighten the fuel injector rail bolts to 10 N.m (89 lb in).

INTAKE MANIFOLD INSTALLATION

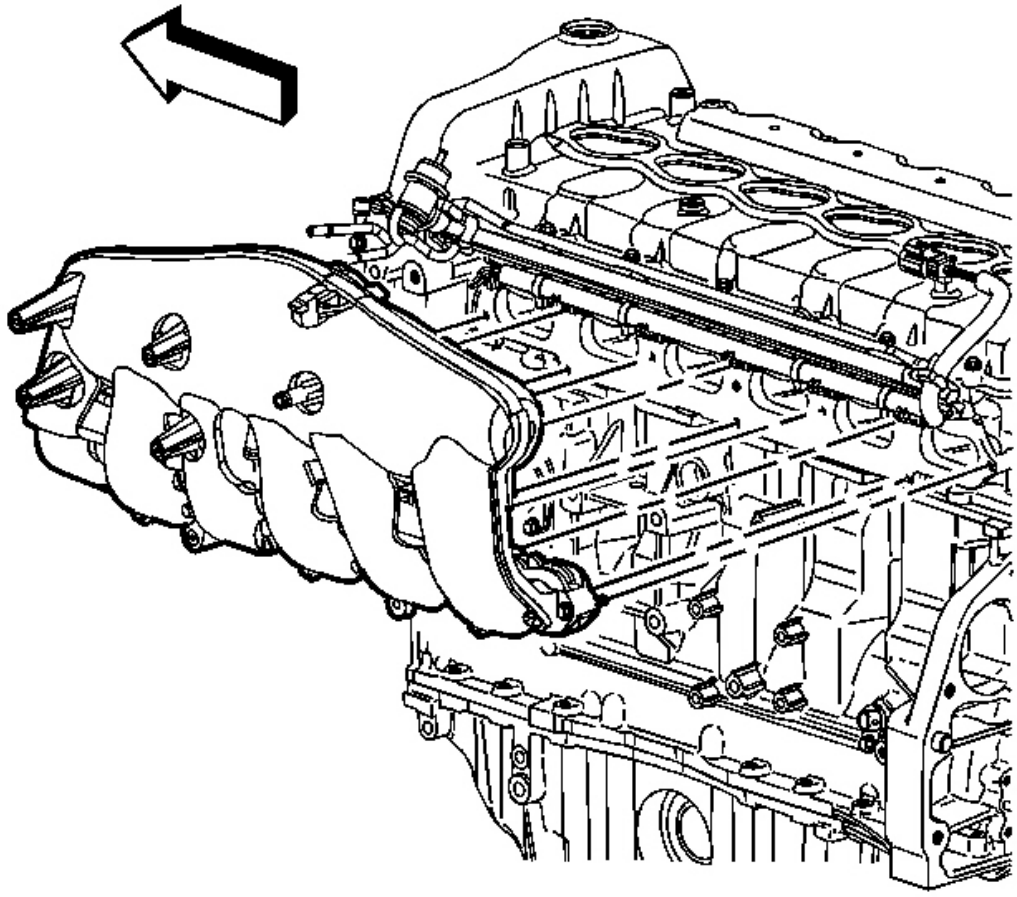


Fig. 548: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a new intake manifold gasket.

NOTE: **Refer to Fastener Notice .**

2. Install the intake manifold and bolts.

Tighten: Tighten the intake manifold bolts from the inside out to 10 N.m (89 lb in).

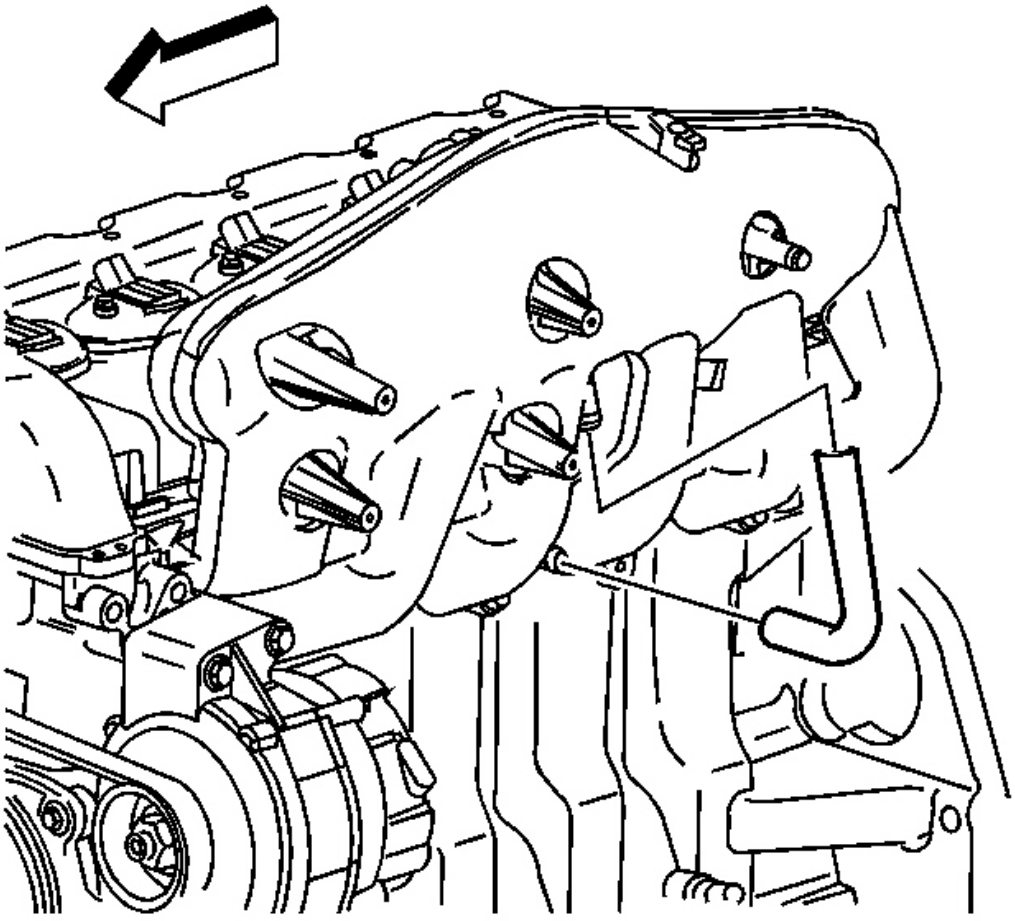


Fig. 549: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the inner diameter of the ends of PCV hose with GM P/N 12345884, (Canadian P/N 5728223) or equivalent.
4. Install the PCV hose.

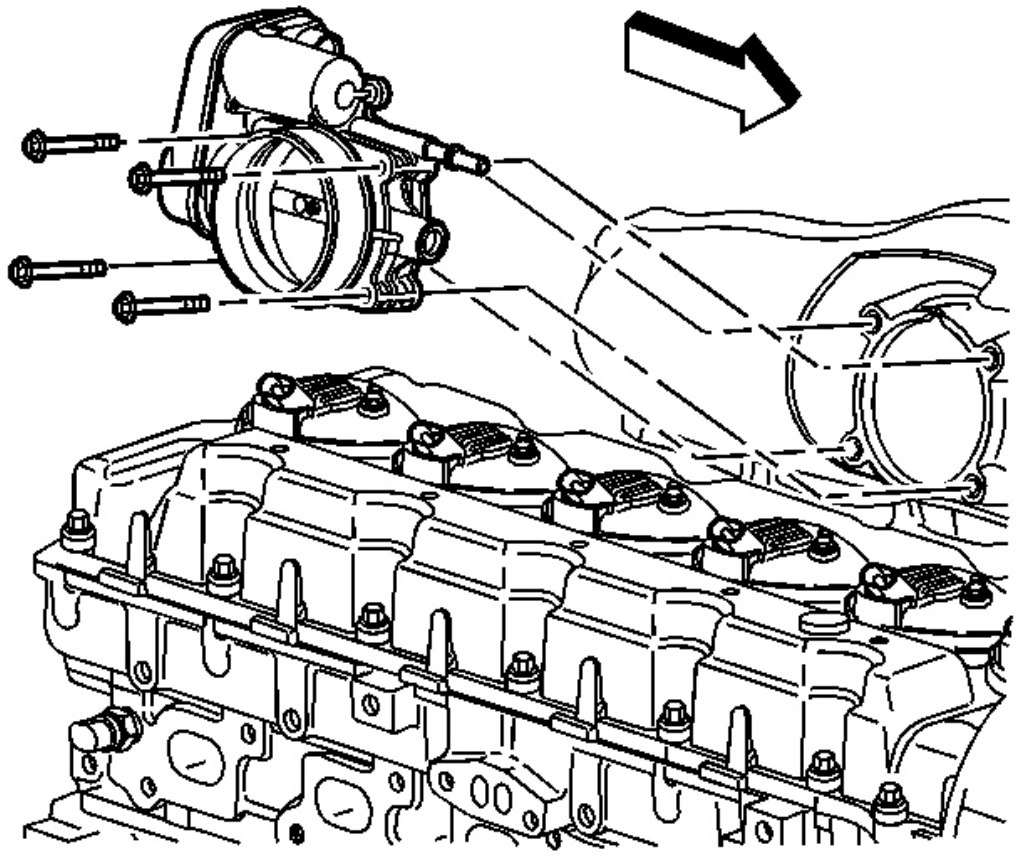


Fig. 550: View Of Throttle Control Module & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install a new throttle control module gasket.
6. Install the throttle control module.
7. Add sealer GM P/N 12346004 (Canadian P/N 10953480) to the throttle control module bolt threads.
8. Install the throttle control module bolts.

Tighten: Tighten the throttle control module bolts to 10 N.m (89 lb in).

ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION

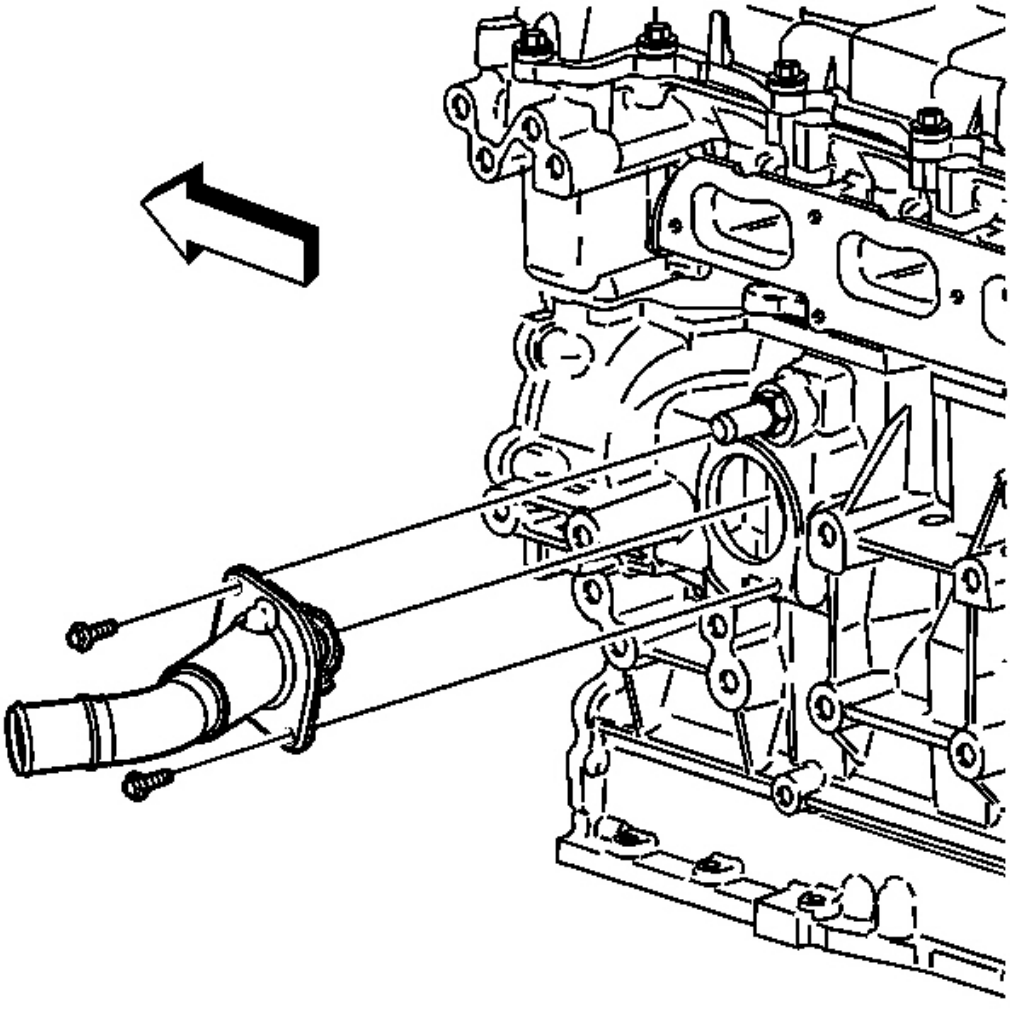


Fig. 551: View Of Thermostat Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat housing.

NOTE: **Refer to Fastener Notice .**

2. Install the thermostat housing bolts.

Tighten: Tighten the thermostat housing bolts to 10 N.m (89 lb in).

HEATER INLET PIPE INSTALLATION

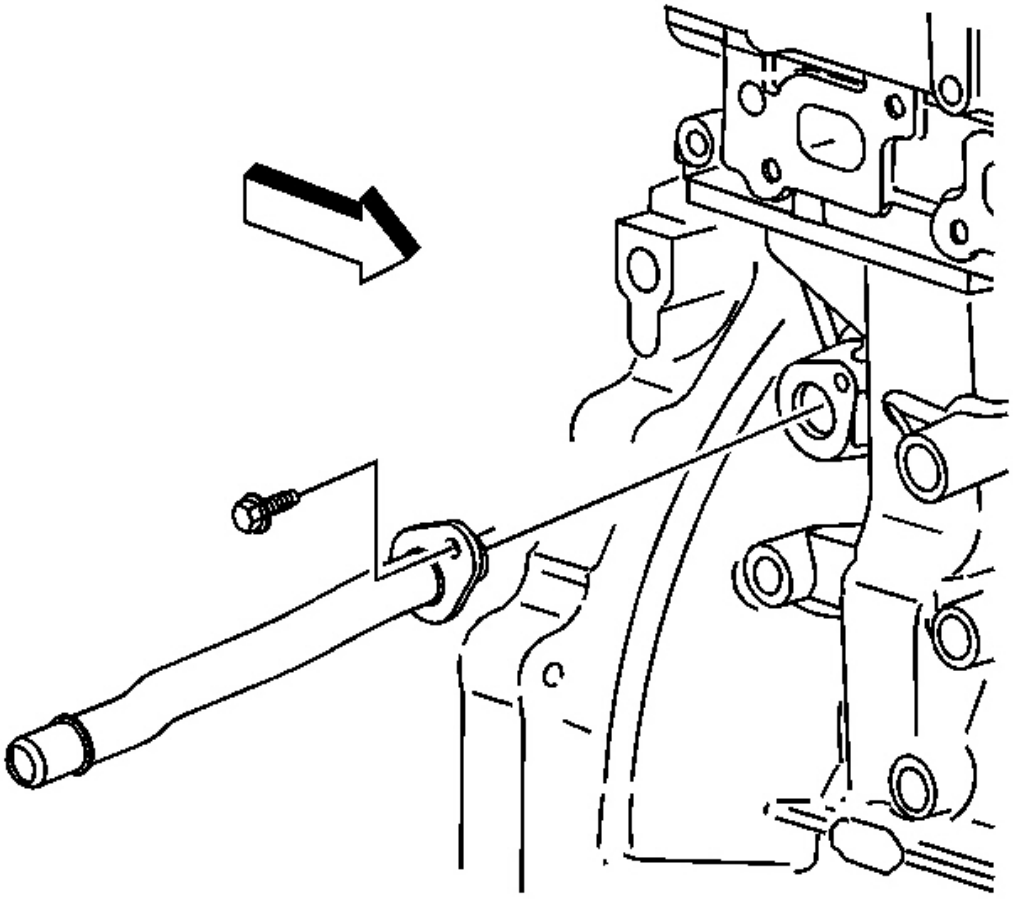


Fig. 552: View Of Heater Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the heater inlet pipe.

   NOTE: Refer to Fastener Notice .

2. Install the heater inlet pipe bolt.

   Tighten: Tighten the heater inlet pipe bolt to 10 N.m (89 lb in).

HEATER OUTLET HOSE FITTING INSTALLATION

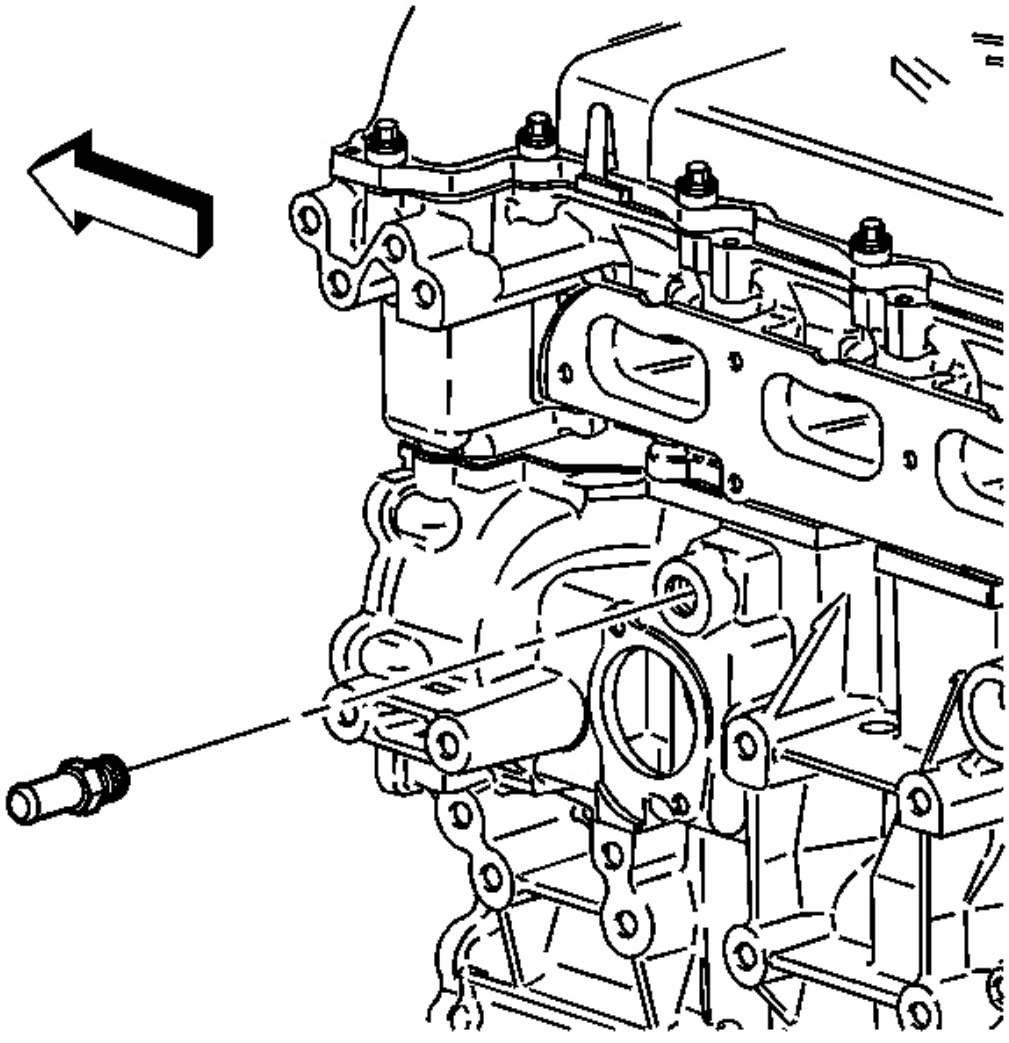


Fig. 553: View Of Heater Outlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the heater outlet hose fitting threads.

NOTE: **Refer to Fastener Notice .**

2. Install the heater outlet hose fitting.

Tighten: Tighten the heater outlet hose fitting to 45 N.m (33 lb ft).

WATER OUTLET INSTALLATION

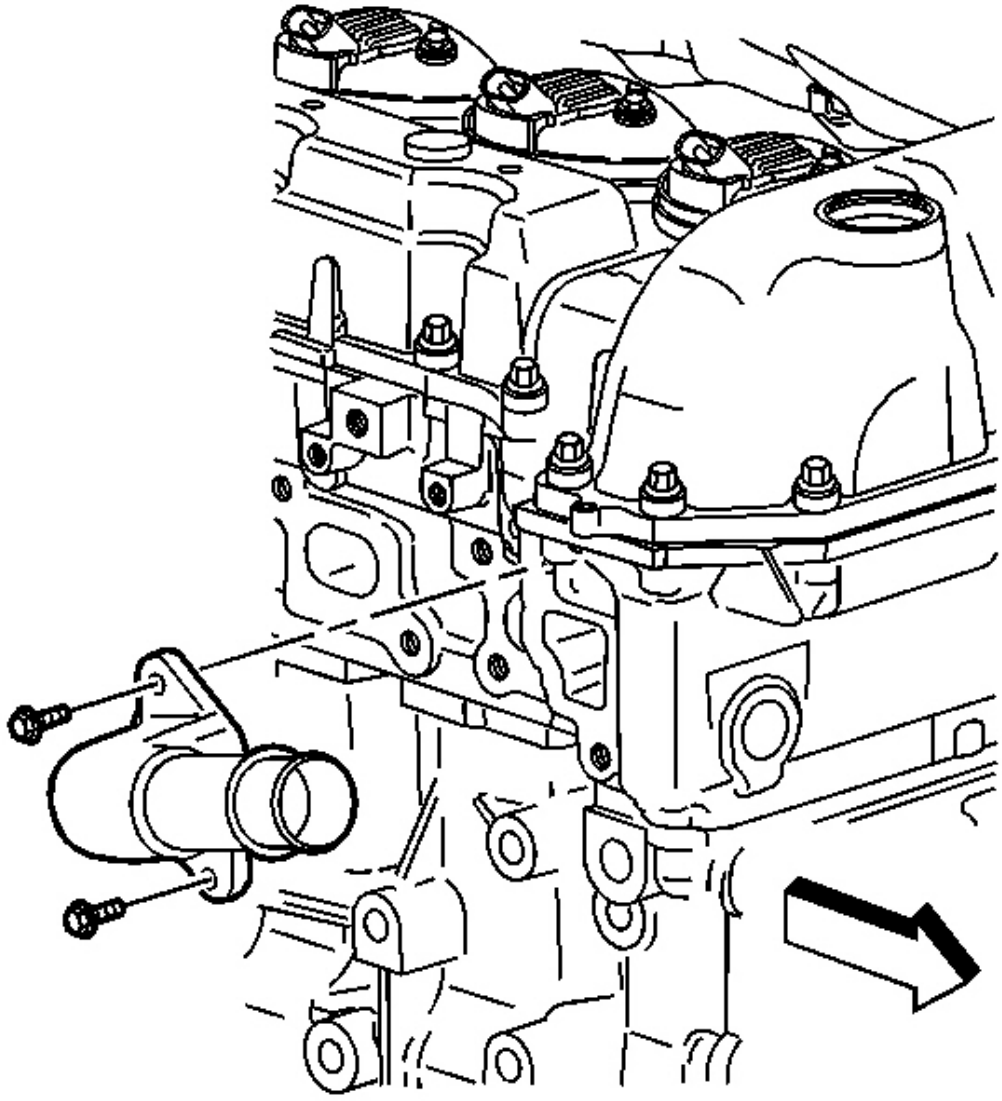


Fig. 554: View Of Water Outlet
Courtesy of GENERAL MOTORS CORP.

1. Install the water outlet.

NOTE: **Refer to Fastener Notice .**

2. Install the water outlet bolts.

   Tighten: Tighten the water outlet bolts to 10 N.m (89 lb in).

OIL FILTER ADAPTER INSTALLATION

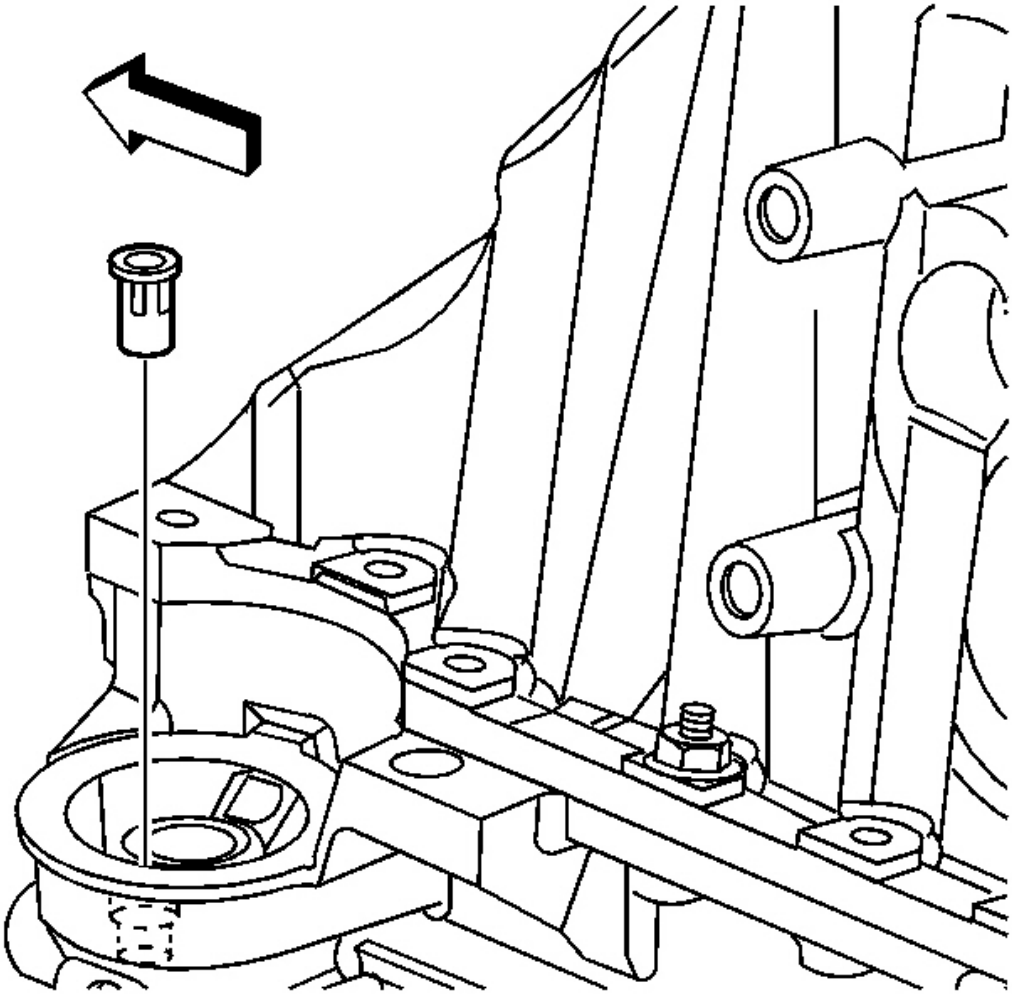


Fig. 555: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil filter bypass valve.

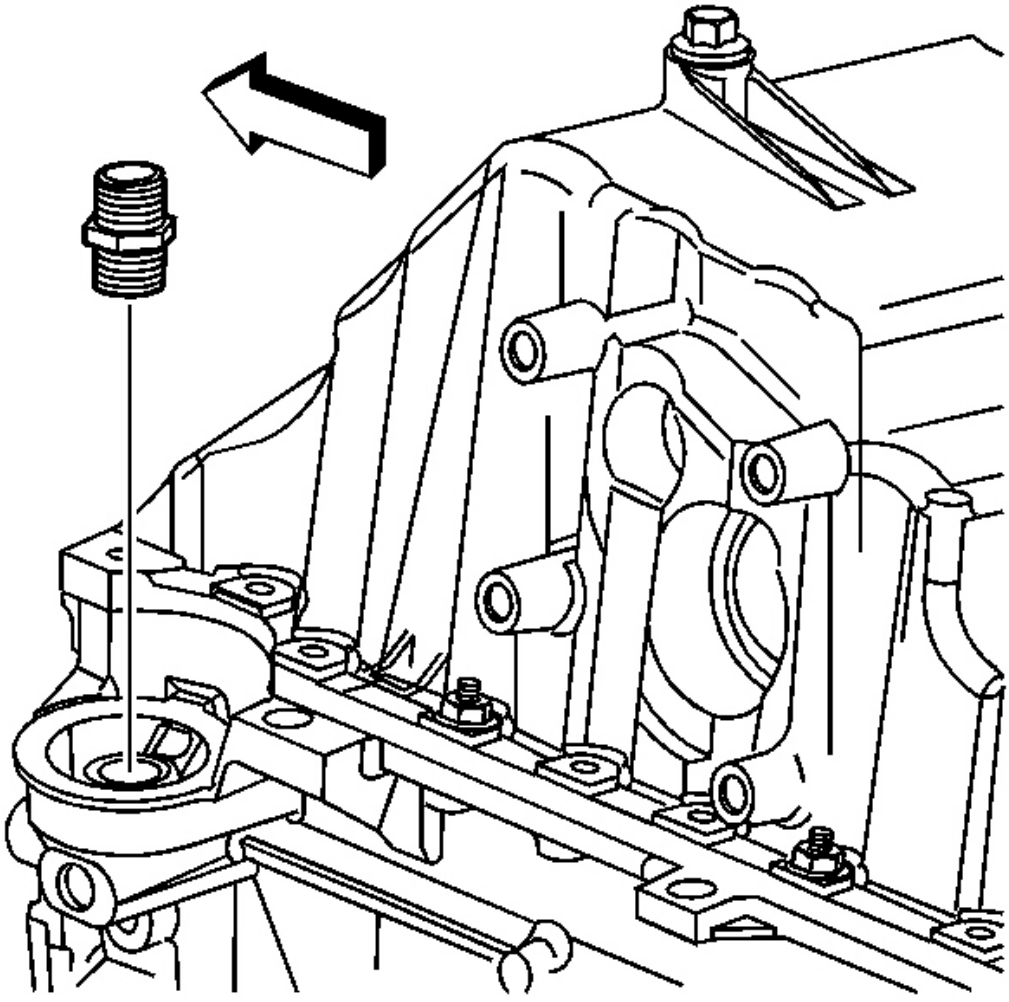


Fig. 556: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the oil filter adapter.

Tighten: Tighten the oil filter adapter to 50 N.m (37 lb ft).

EXHAUST MANIFOLD INSTALLATION

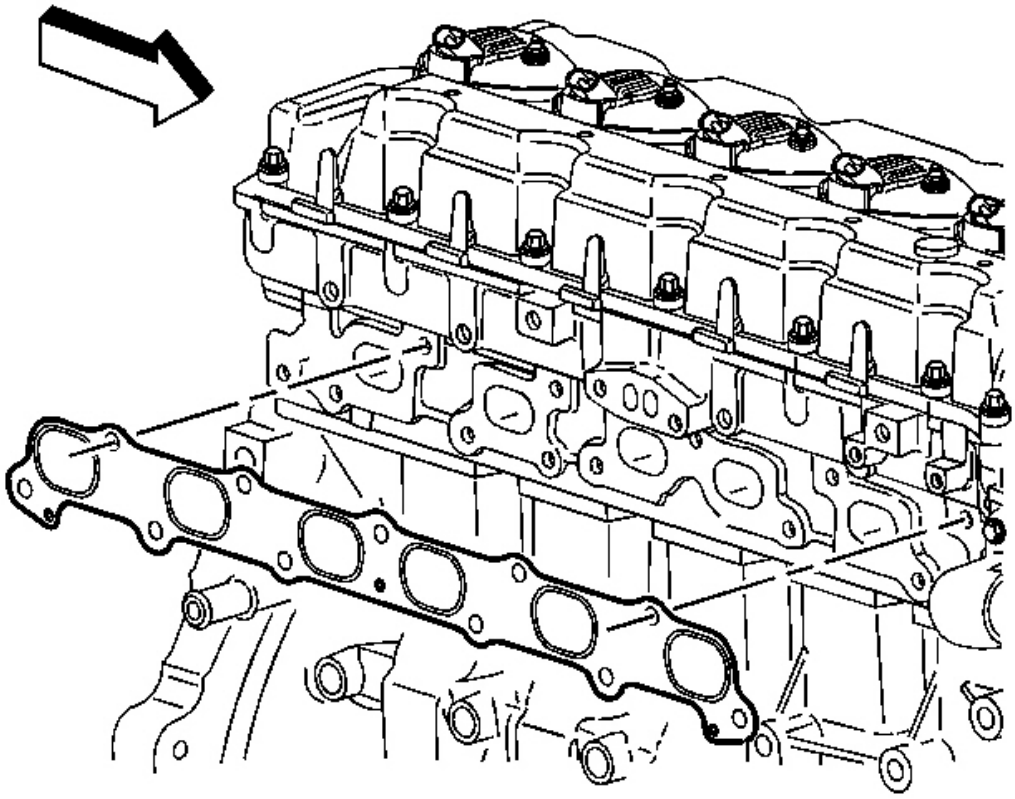


Fig. 557: View Of Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.

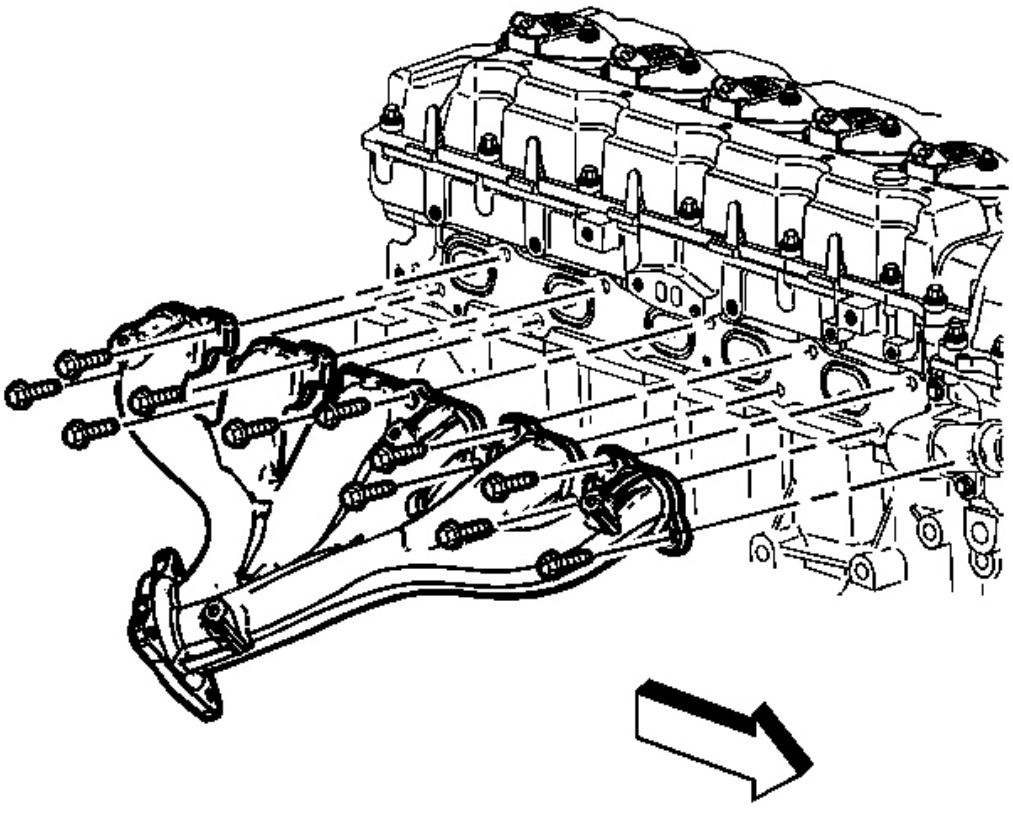


Fig. 558: View Of Exhaust Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold.
3. Add threadlock GM P/N 12345493, Canadian P/N 10953488 to the exhaust manifold bolt threads.
4. Install the exhaust manifold bolts.

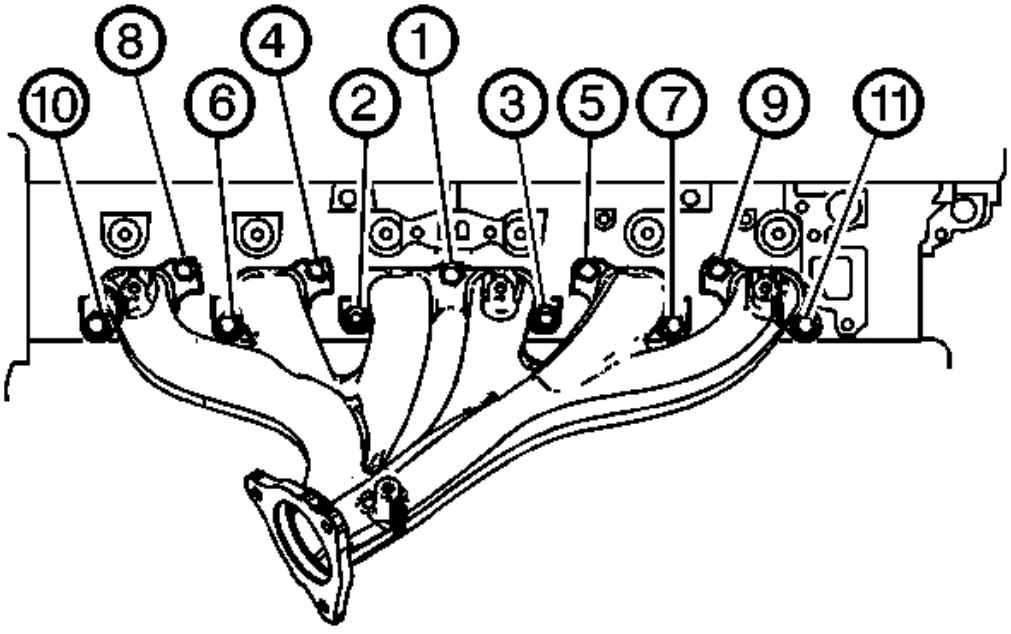


Fig. 559: Exhaust Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Tighten the exhaust manifold bolts.

Tighten:

1. Tighten the exhaust manifold bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the exhaust manifold bolts a second pass in sequence to 20 N.m (15 lb ft).
3. Tighten the exhaust manifold bolts a final pass in sequence to 20 N.m (15 lb ft).

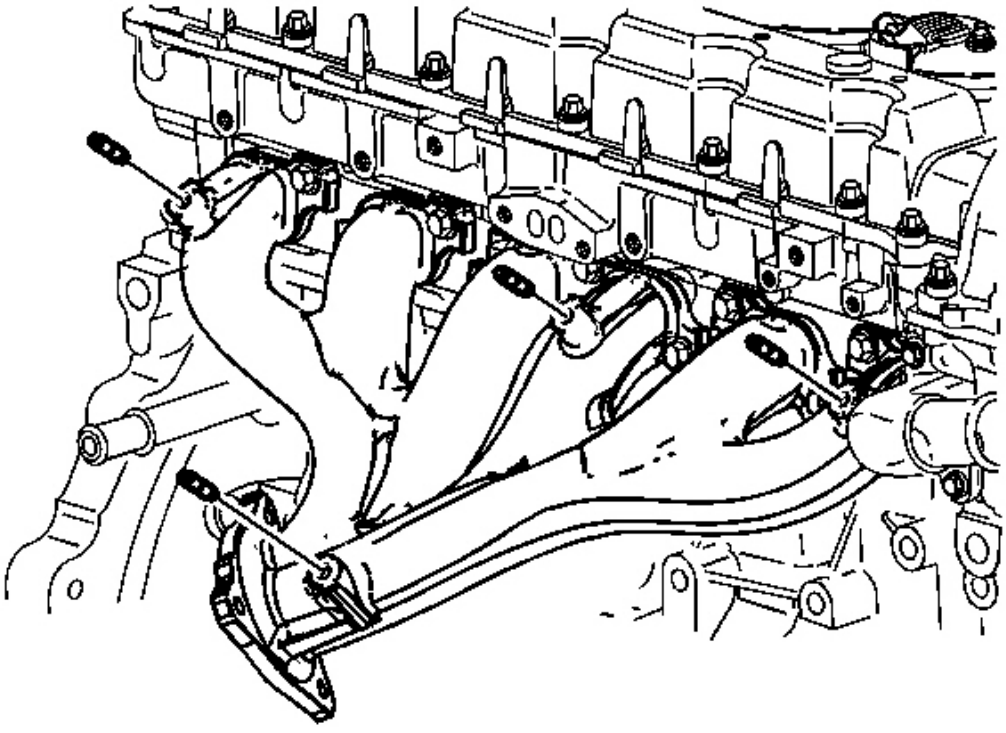


Fig. 560: Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

6. Install the exhaust manifold heat shield studs (if required).

   Tighten: Tighten the exhaust manifold heat shield studs to 10 N.m (89 lb in).

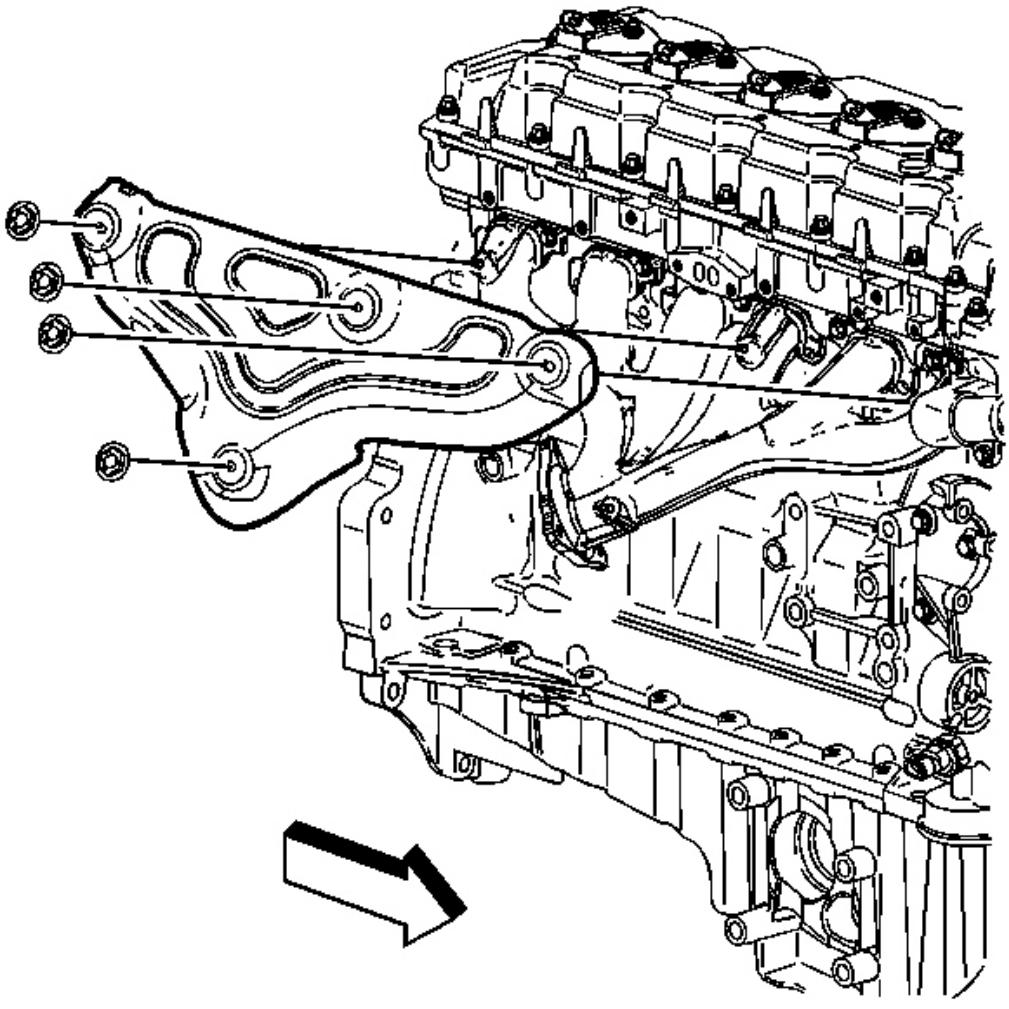


Fig. 561: View Of Exhaust Manifold Heat Shield & Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust manifold heat shield.
8. Add anti-seize GM P/N 12371386, Canadian P/N 993128 to the exhaust manifold heat shield nuts.
9. Install the exhaust manifold heat shield nuts.

Tighten: Tighten the exhaust manifold heat shield nuts to 10 N.m (89 lb in).

OIL LEVEL INDICATOR & TUBE INSTALLATION

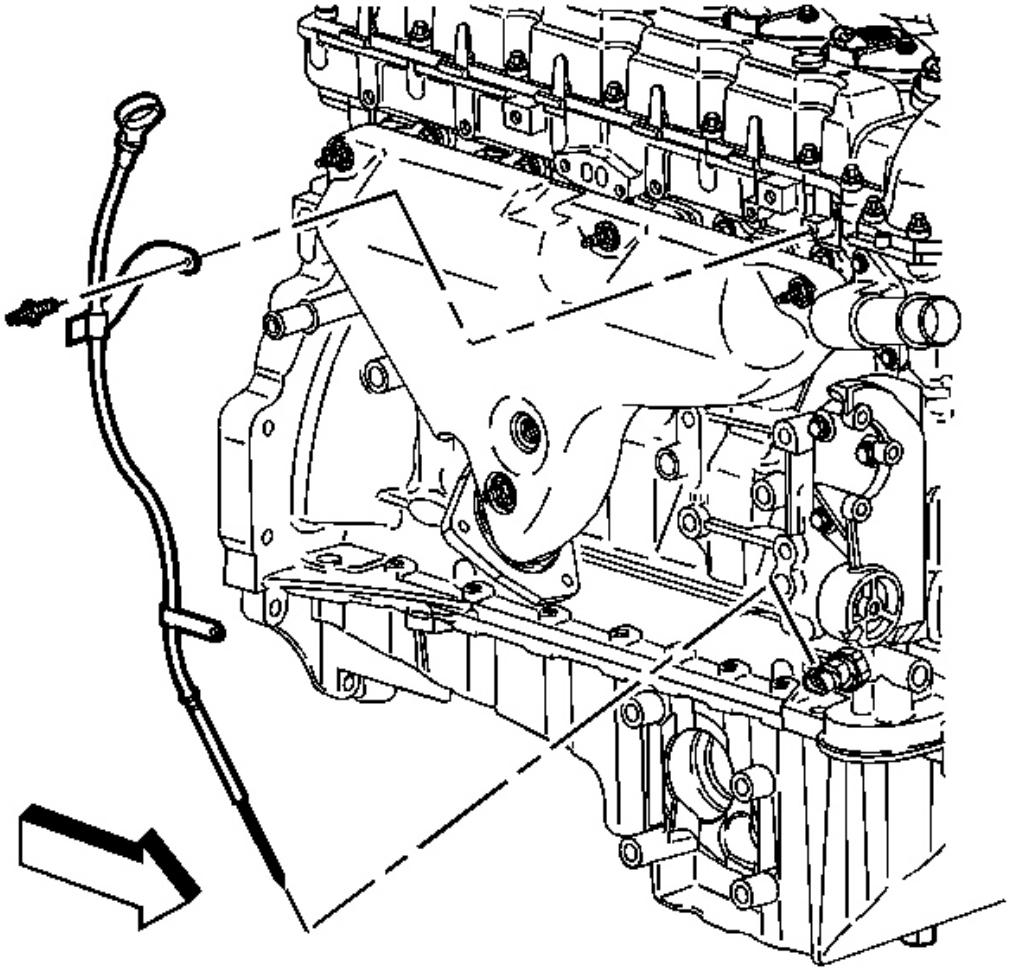


Fig. 562: View Of Oil Level Indicator Tube Stud
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube.
2. Add sealant GM P/N 12346004 (Canadian P/N 10953480) to the oil level indicator tube stud threads.

NOTE: **Refer to Fastener Notice .**

3. Install the oil level indicator tube stud.

Tighten: Tighten the oil level indicator tube stud to 10 N.m (89 lb in).

4. Install the oil level indicator.

POWER STEERING PUMP BRACKET INSTALLATION

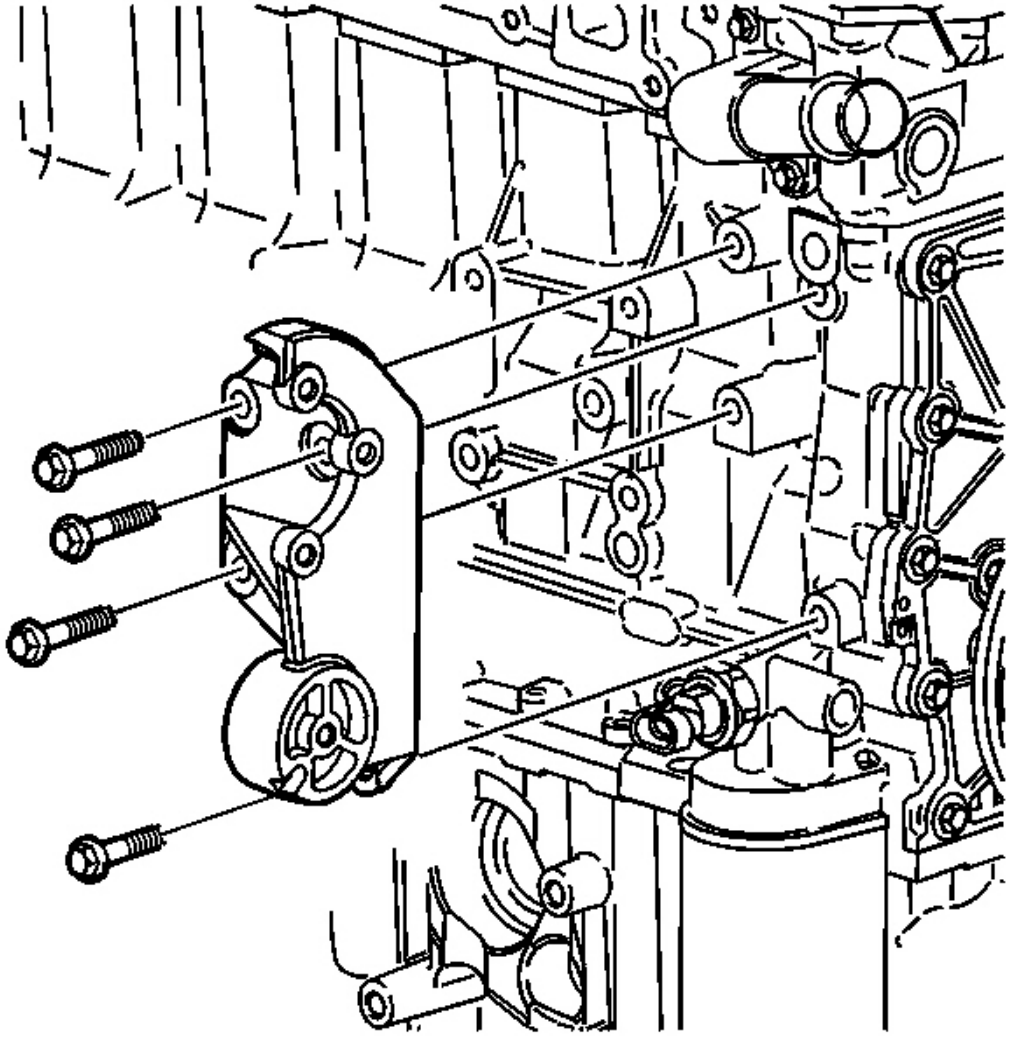


Fig. 563: View Of Power Steering Pump Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the power steering pump bracket.

NOTE: **Refer to Fastener Notice .**

2. Install the power steering pump bracket bolts.

   Tighten: Tighten the power steering pump bracket bolts to 50 N.m (37 lb ft).

DRIVE BELT TENSIONER INSTALLATION

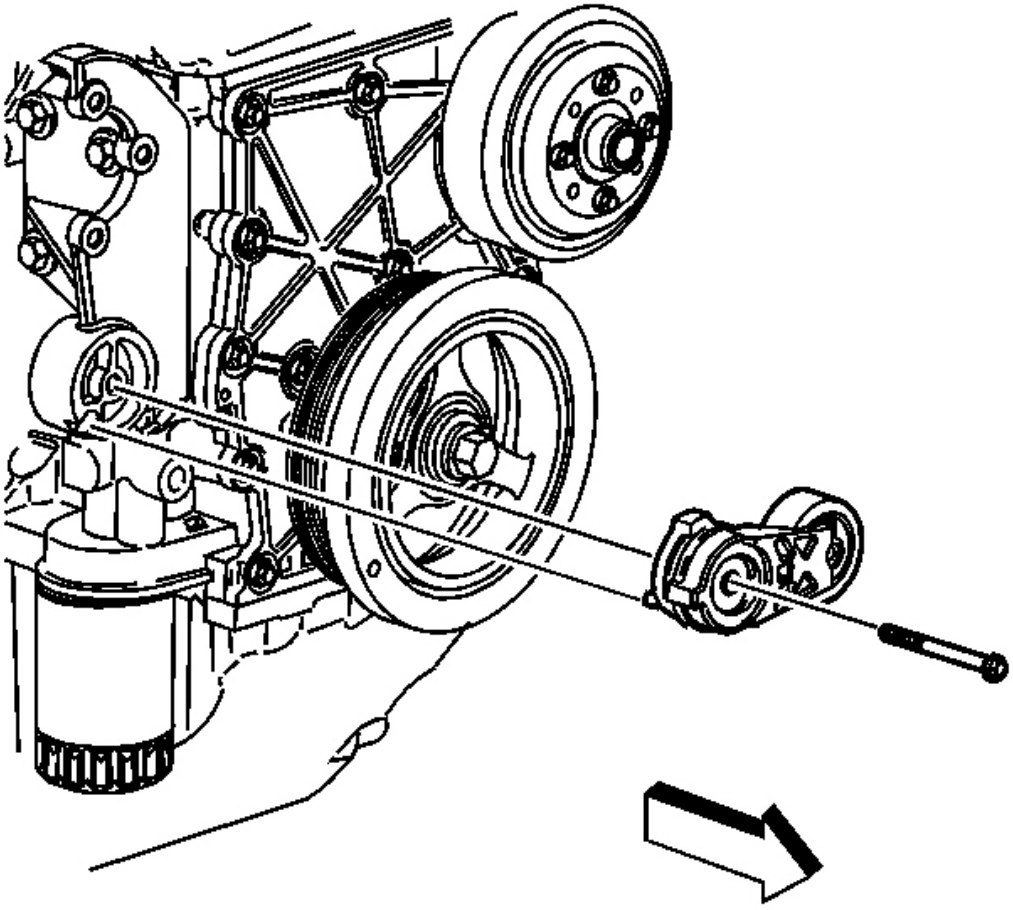


Fig. 564: View Of Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

   NOTE: Refer to Fastener Notice .

2. Install the drive belt tensioner bolt.

Tighten: Tighten the drive belt tensioner bolt to 50 N.m (37 lb ft).

DRIVE BELT IDLER PULLEY INSTALLATION

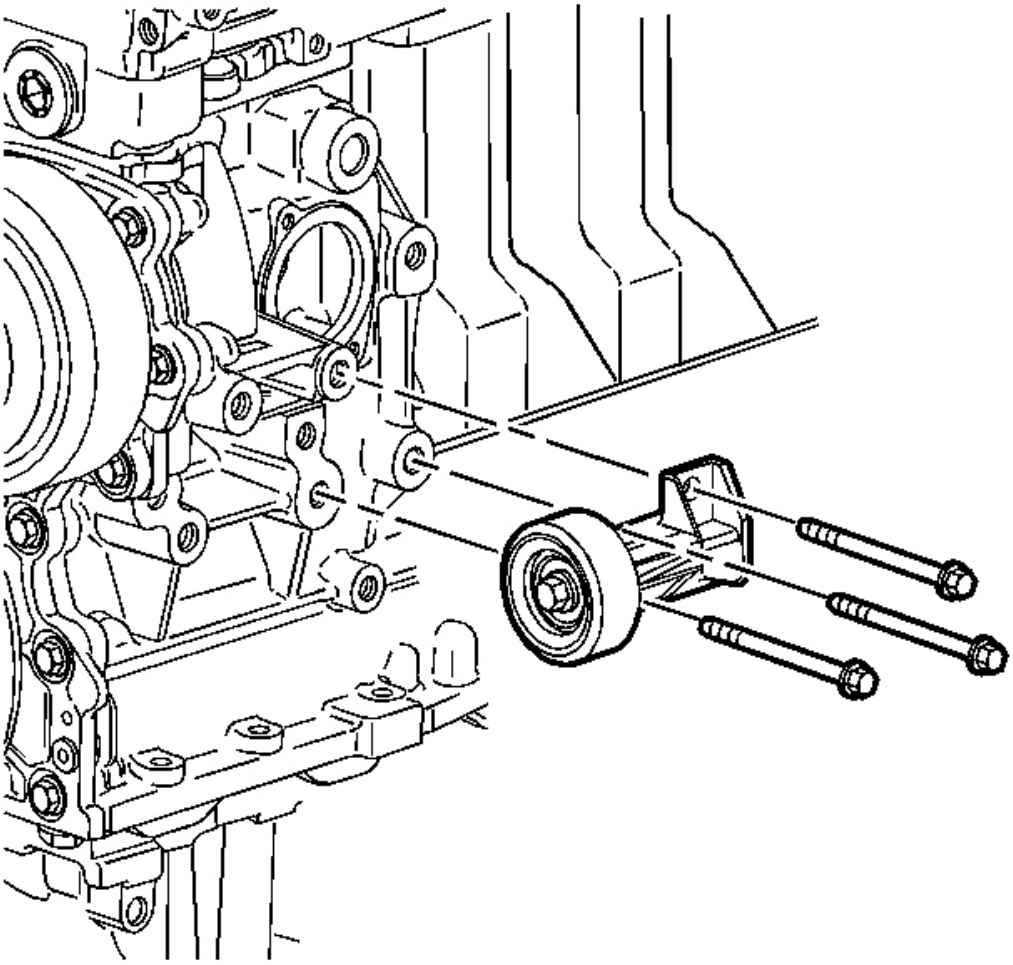


Fig. 565: View Of Drive Belt Idler Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley.

NOTE: **Refer to Fastener Notice .**

2. Install the drive belt idler pulley bolts.

Tighten: Tighten the drive belt idler pulley bolts to 50 N.m (37 lb ft).

CRANKSHAFT REAR OIL SEAL INSTALLATION

Tools Required

J 44227 Rear Seal Installer. See **Special Tools**.

Installation Procedure

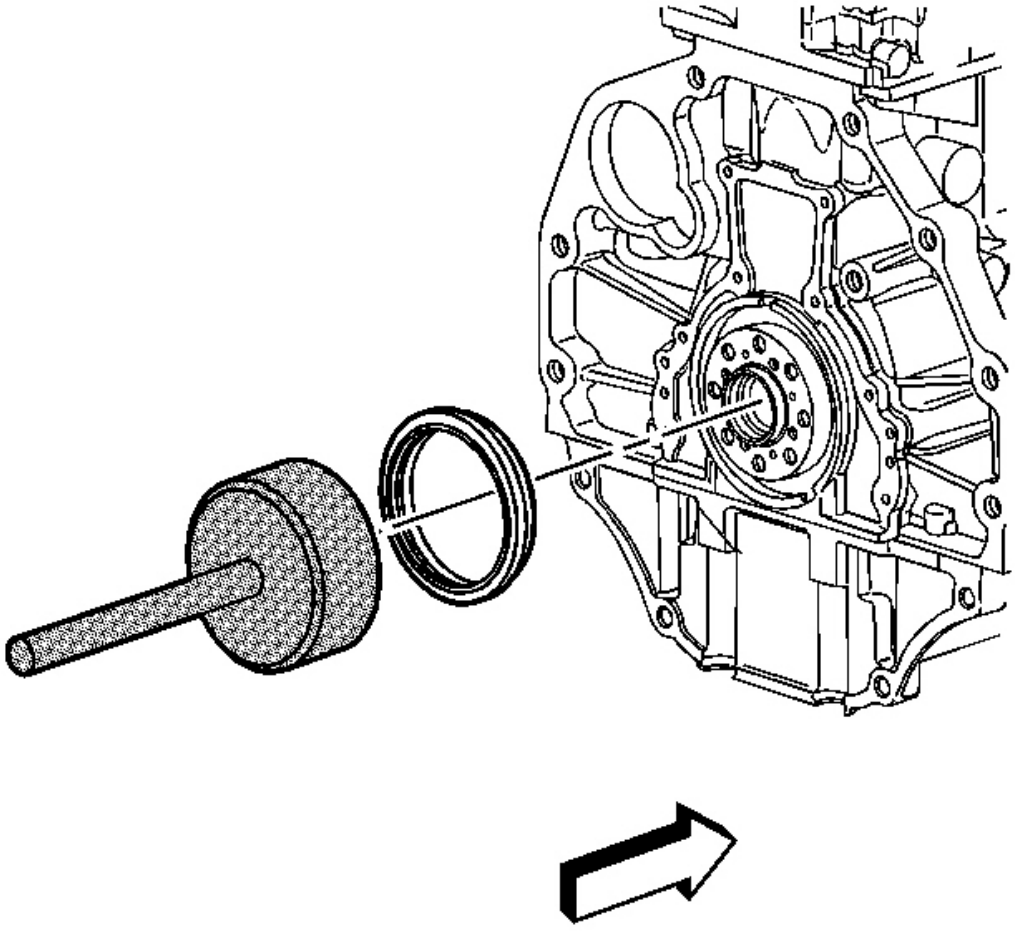


Fig. 566: View Of Crankshaft Rear Oil Seal & J 44227
Courtesy of GENERAL MOTORS CORP.

1. Use the plastic installation sleeve supplied with the new seal when installing a new seal.

Use **J 44227** to install the crankshaft rear oil seal. See **Special Tools**.

2. Remove **J 44227** . See **Special Tools**.

ENGINE FLYWHEEL INSTALLATION

Tools Required

J 45059 Angle Meter. See **Special Tools**.

Installation Procedure

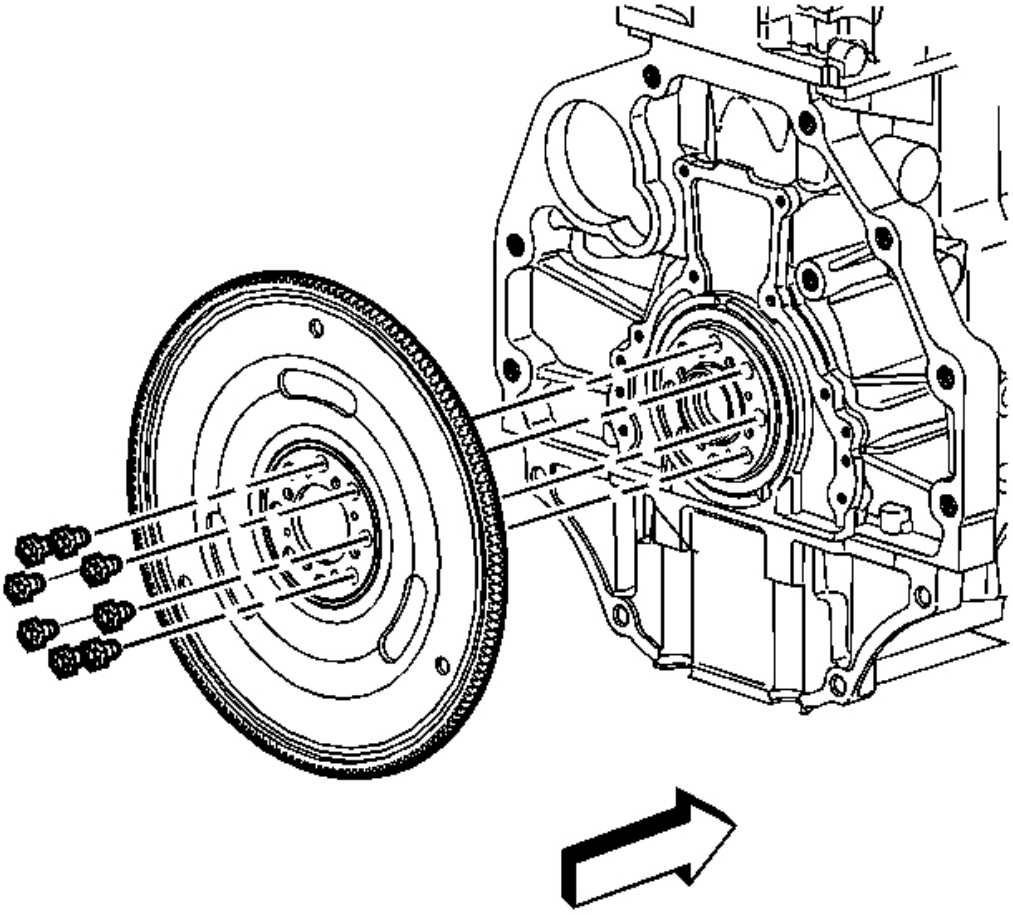


Fig. 567: View Of Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

NOTE: Refer to Fastener Notice .

2. Install new flywheel bolts.

Tighten:

1. Tighten the new flywheel bolts to 25 N.m (18 lb ft).
2. Use **J 45059** to tighten the flywheel bolts an additional 50 degrees. See **Special Tools**.

ENGINE PRELUBING

Tools Required

J 45299 Engine Preluber. See **Special Tools**.

Prelubing Procedure

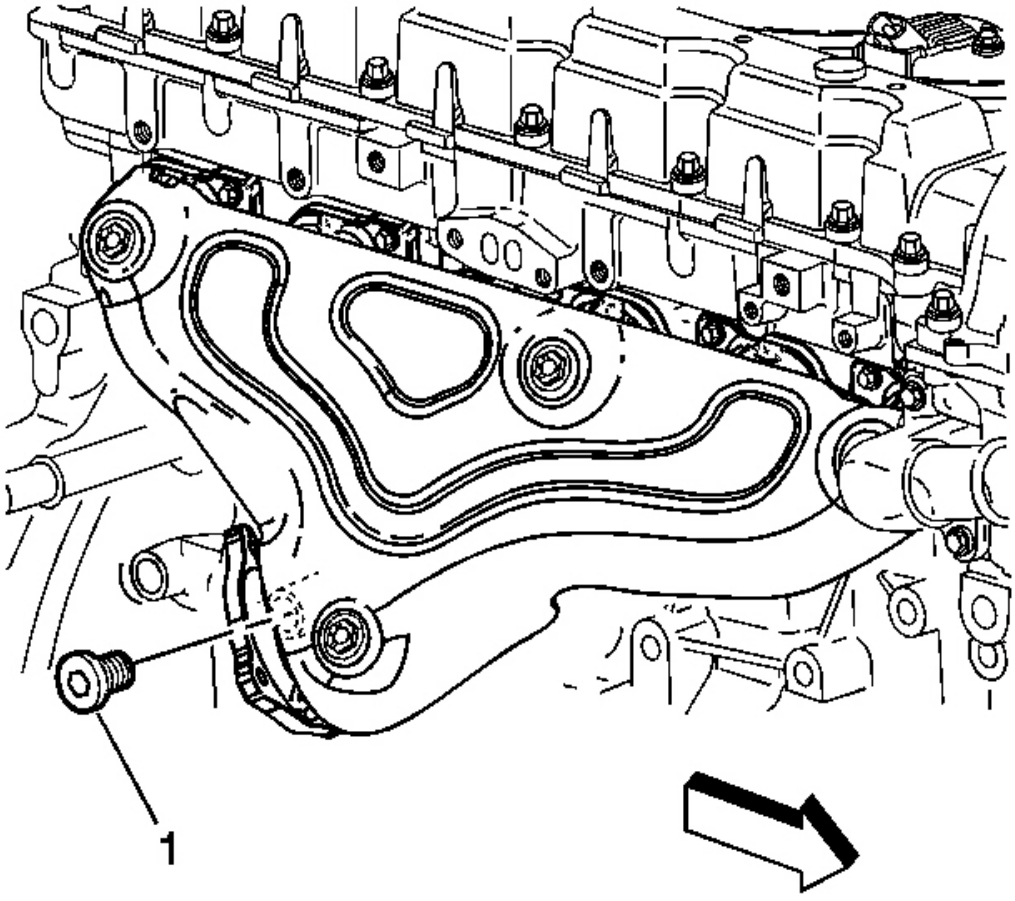


Fig. 568: Engine Block Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant/continuous flow of clean engine oil is required to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

NOTE: Refer to Fastener Notice .

1. Remove the engine oil filter, fill with clean engine oil, and reinstall.

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

2. Remove the engine block oil gallery plug (1).

3. Install the M16 x 1.5 adapter P/N 509375.

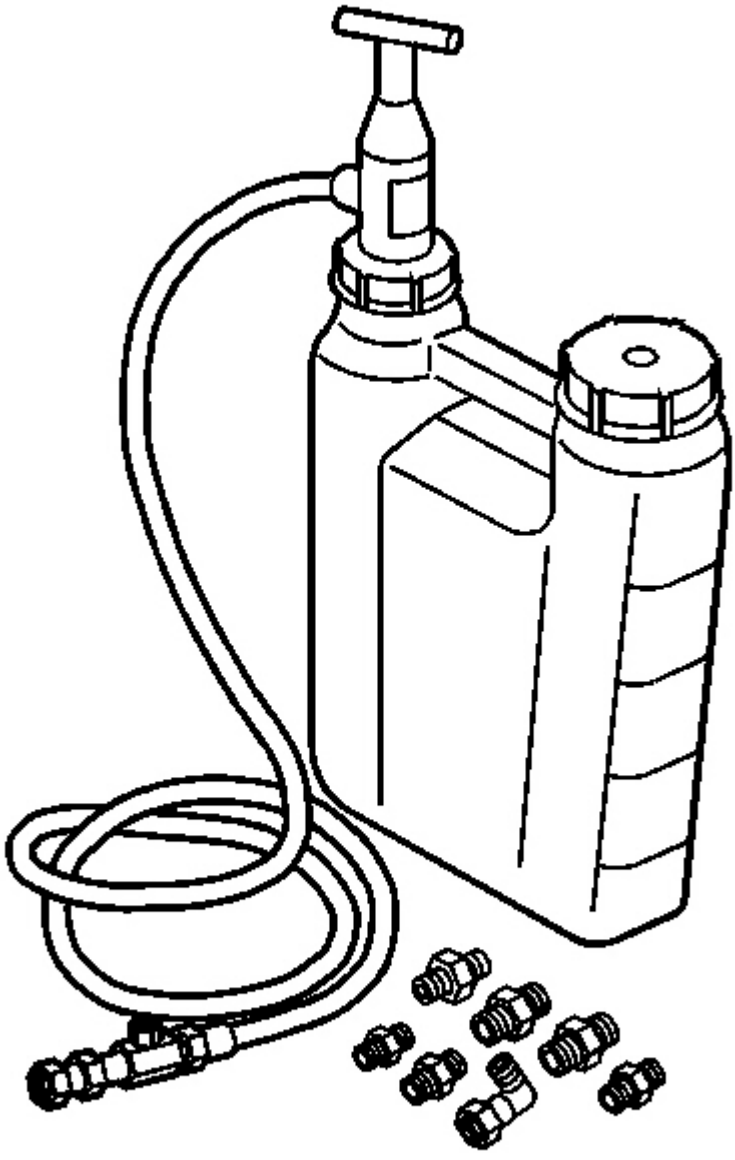


Fig. 569: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

4. Install the flexible hose to the adapter and open the valve.

5. Pump the handle on **J 45299** to flow a minimum of 1-2 quarts of engine oil. See **Special Tools**. Observe the flow of engine oil through the flexible hose and into the engine assembly.
6. Close the valve and remove the flexible hose and adapter from the engine.
7. Install the engine block oil gallery plug (1).

   Tighten: Tighten the oil pressure sensor to 35 N.m (26 lb ft).

8. Top off the engine oil to the proper level.

DESCRIPTION & OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

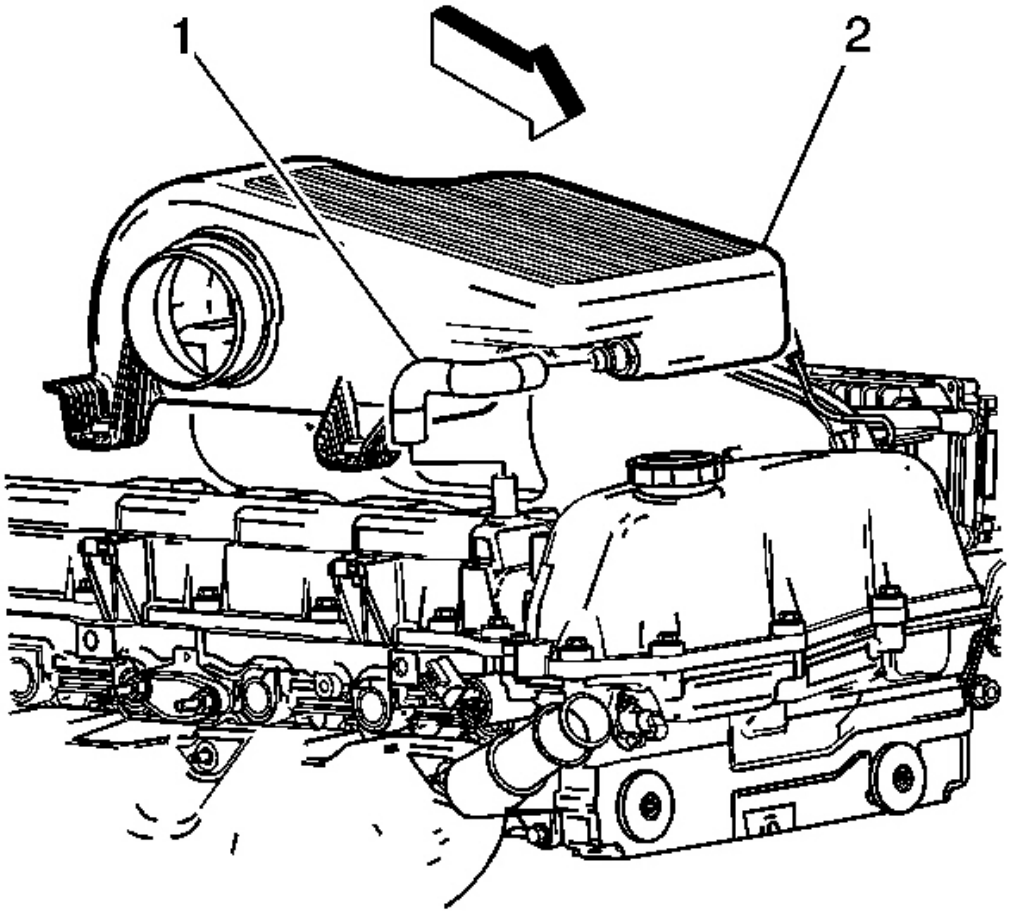


Fig. 570: View Of Crankcase Clean Air Hose & Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to the atmosphere. Fresh air from the intake system (1) is supplied to the crankcase, mixed with blow by gases and then passes through a calibrated orifice in the cylinder head gasket.

Operation

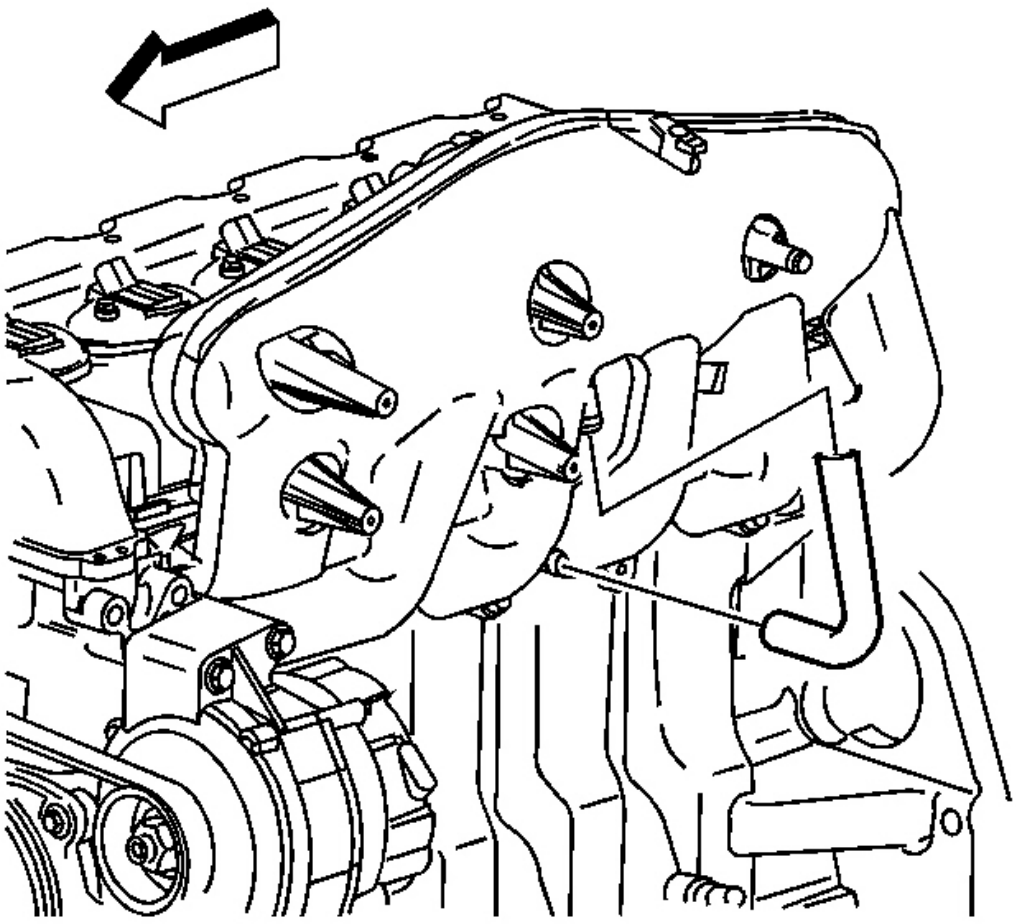


Fig. 571: View Of Crankcase Ventilation Hose Location
Courtesy of GENERAL MOTORS CORP.

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on the inlet vacuum. The PCV orifice is an integral part of the cylinder head gasket.

Results of Incorrect Operation

A plugged PCV pipe/passage way may cause:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

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 one belt or two belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

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

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

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Block

The lost foam all aluminum engine block utilizes a deep skirt design for increased rigidity. The cylinders are positioned in a straight in-line 6 cylinder orientation. The crankshaft bearing caps have a bearing beam or "ladder" for enhanced structural rigidity and vibration reduction.

Oil Pan

A single piece cast aluminum oil pan contributes to crankshaft and block rigidity while reducing overall weight. The oil pan bolts to the bell housing as well as the block. This eliminates points of vibration and makes the complete powertrain act as a single casting. Jack screws are used to remove the oil pan.

Crankshaft

The crankshaft is a nodular iron design with seven main bearings.

Connecting Rods

The connecting rods are forged powdered metal. The connecting rods and caps are of a fractured split design to improve durability and reduce internal friction. Care must be taken to ensure the mating surfaces are not damaged during service procedures.

Pistons

The pistons are a full-floating design. The piston pins are a slip fit in the bronze bushed connecting rod and are retained in the piston by round wire retainers. There are two compression rings and one oil control ring.

Cylinder Head

The cylinder head is also made of the lost foam aluminum for lighter weight and rapid heat dissipation. There are 4 valves per cylinder and the ports are of a high swirl design for improved combustion. The cylinder head gasket consist of a steel laminated construction.

Valve Train

The engine utilizes dual overhead camshafts and roller followers for reduced friction, which results in improved gas mileage.

Fuel System

A new electronic throttle control system is used on the engine. A throttle actuator control or TAC system eliminates cable linkage from the pedal to the throttle control module. All throttle movements are controlled by the PCM.

Oil Pump

The oil pump is gear driven directly from the crankshaft. The oil pump drive gear is a slip fit to the crankshaft.

Engine Covers

There is a front engine cover and a rear engine cover, both are made of aluminum. The front engine cover and rear engine cover have "T" sealing joints and need to be removed after the oil pan. The front and rear covers need to be installed before the oil pan. Jack screws are used to remove the covers. Guide pins are used to aid in the installation of both covers.

EXHAUST CAMSHAFT POSITION ACTUATOR DESCRIPTION

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, the camshaft is at the default or "home" position. At this position, the exhaust camshaft is fully advanced to minimize valve overlap for smooth idle. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor to accurately determine the position of the camshaft.

The camshaft position actuator control valve directs oil from the oil feed in the head to the camshaft position actuator. A filter screen protects each oil port from any contamination in the oil supply. During start-up, when little oil pressure is available, an internal spring loaded locking pin keeps the rotor and stator locked together in the home position. When phasing is desired oil pressure is applied to the phaser unlocking the pin.

The camshaft front journal has a drilled oil hole to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position. The camshaft position actuator is mounted to the front end of the 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.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important new features for the service community.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- Special tools required

New Sealants & Adhesives

- U.S. and Canadian SPO part numbers
- 3-Bond sealant P/N 12378521 (Canadian P/N 88901148)

New Features

- 10.3:1 Compression

- Vane style camshaft position actuator
- "Bee Hive" valve springs

Engine Features

- Powder metal connecting rods
- Full floating piston pins
- Lost foam casted aluminum block and head
- Composite plastic camshaft cover
- Electronic Throttle Control - ETC
- Bridge/bearing beam - stiffener ladder
- Stainless steel fuel rail
- Coil-on-plug ignition system
- Inlet side thermostat
- No EGR
- No AIR

New Special Tools Required

No change from previous year.

LUBRICATION DESCRIPTION

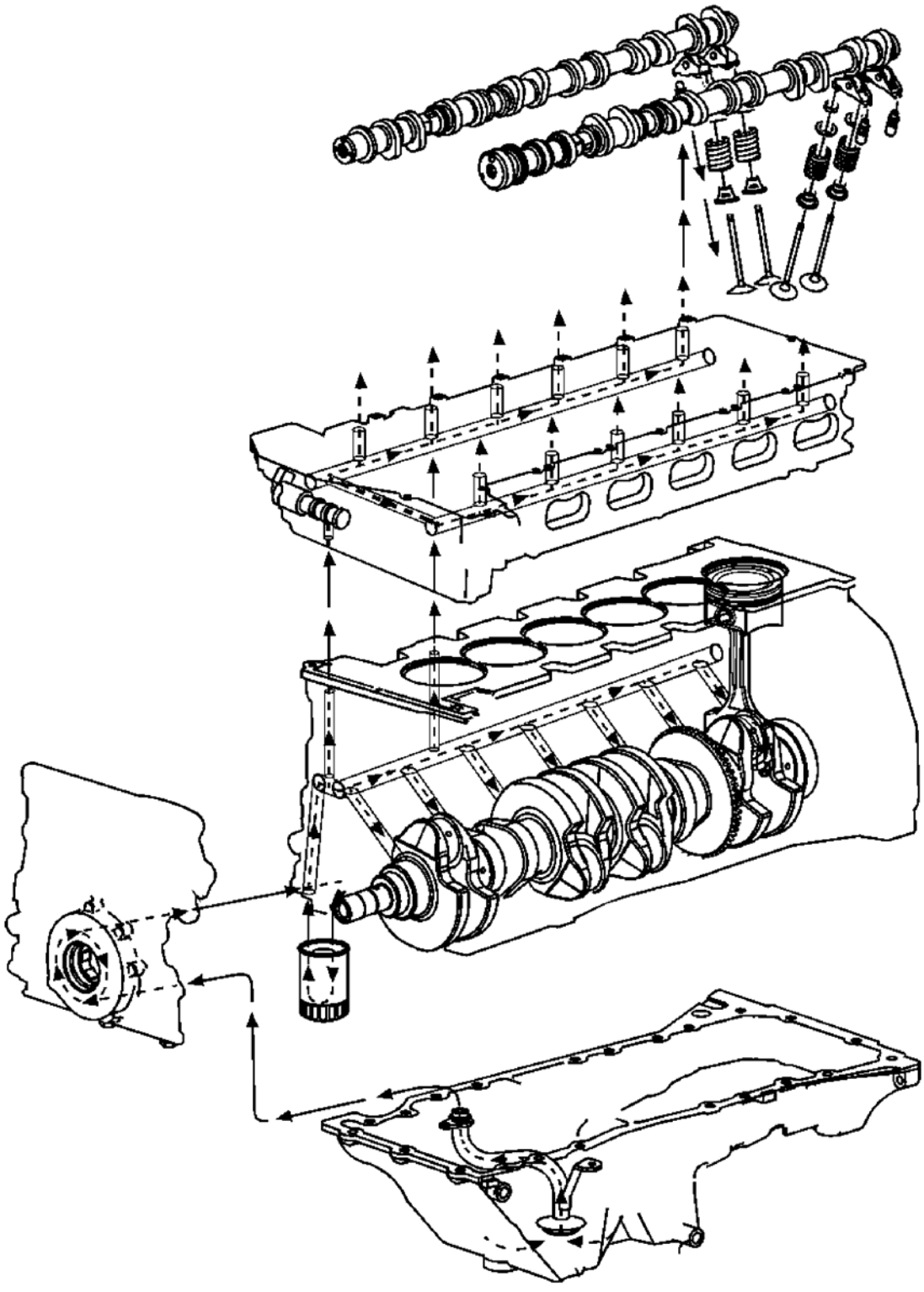


Fig. 572: Cutaway View Of Lubrication System
Courtesy of GENERAL MOTORS CORP.

The engine lubrication system is of the force-feed type. The oil is supplied under full pressure to the crankshaft, connecting rods, valve lash adjusters, and cam phasing system. A controlled volume of oil is supplied to the camshaft and valve rocker arms. Gravity flow or splash lubricates all other parts. The engine oil is stored in the oil pan, which is filled through a fill cap in the camshaft cover. A removable oil level indicator, on the right side of the engine block, is provided to check the oil level. The oil pump is located in the engine front cover and is driven by the crankshaft. It is a gerotor-style pump, which is a combination of a gear, and a rotor pump. It is connected by a passage in the cylinder block to an oil screen and pipe assembly. The screen is submerged in the oil supply and has ample volume for all operating conditions. Oil is drawn into the pump through the screen and pipe assembly, and a passage in the crankcase, connecting to the passages in the engine front cover. Oil is discharged from the oil pump to the oil filter. The oil pressure relief valve limits the oil pressure. The oil filter bypass valve opens when the oil filter is restricted to approximately 68.95 kPa (10 psi) of pressure difference between the oil filter inlet and discharge. The oil will then bypass the oil filter and channel unfiltered oil directly to the main oil galleries of the engine. A full-flow oil filter is mounted to the oil filter adapter on the lower right front side of the engine. The main oil galleries run the full length of the engine block and cut into the valve lash adjuster holes to supply oil at full pressure to the valve lash adjusters. Holes are drilled from the crankshaft bearings to the main oil gallery. Oil is transferred from the crankshaft bearings to the connecting rod bearings through holes drilled in the crankshaft. Pistons, piston pins, and cylinder walls are lubricated by oil splash from the crankshaft and connecting rods. The camshafts and valve rocker arms are supplied with oil from the oil passages drilled into the camshaft mounting areas.

CLEANLINESS & 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

The components of an internal combustion engine develop wear patterns with their mating components. During disassembly of the engine, parts should be separated and kept in order so they may be reinstalled in the same location from which they were removed.

REPLACING ENGINE GASKETS

1. Do not reuse any gasket unless otherwise specified. Reusable gaskets will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service procedure.
2. Use jack screws to separate components.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a components.
Do not use the following items in order to clean the gasket surfaces:

- **Abrasive pads**
- **Sand paper**
- **Power tools**

These methods of cleaning may damage the component.
Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

3. Remove all of the gasket and the sealing material from the component using a plastic or a wood scraper. Do not gouge or scrape the sealing surfaces.

IMPORTANT: Do not allow the sealant to enter any blind threaded holes. The sealant may cause the following conditions:

- **Prevent you from properly seating the bolt**
- **Cause damage when you tighten the bolt**

4. When assembling components, use only the sealant specified in the service procedure. Ensure that the sealing surfaces are clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure.
5. Tighten the bolts to the specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) & 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:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

IMPORTANT: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch. Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

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 five minutes, may result in incorrect clamp load of assembled components.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

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

Use the following information when using pipe sealant:

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

IMPORTANT: Do not allow the pipe sealant to enter any of the blind threaded holes, as the pipe sealant may prevent the fastener from clamping properly, or cause component damage when the fastener is tightened.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

TOOLS & EQUIPMENT

Work in a clean and well-lit area. Have the following components available before you begin to work:

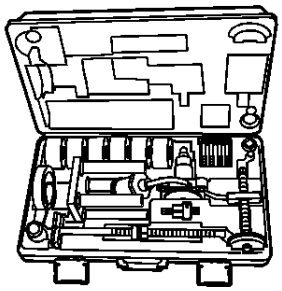
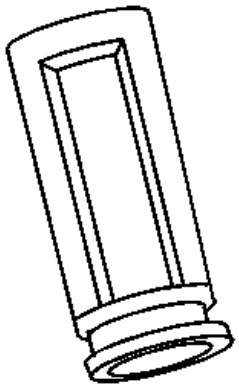
- A suitable parts cleaning tank
- A compressed air supply

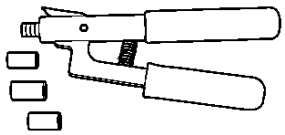
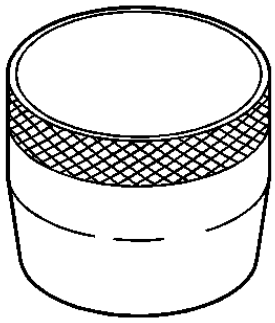
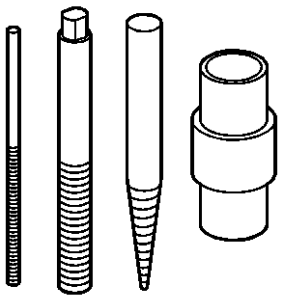
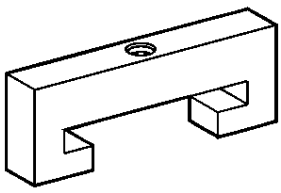
- Trays, in order to keep the parts and the fasteners organized
- An adequate set of hand tools

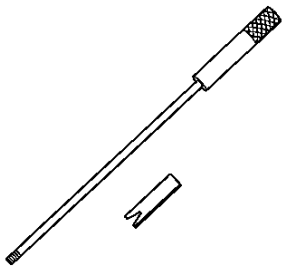
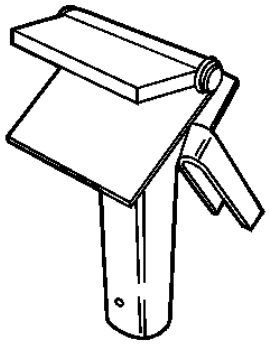
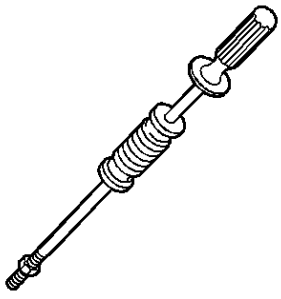
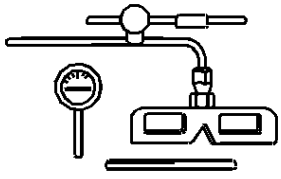
An approved engine repair stand will prevent personal injury or damage to the engine components. The special tools are designed in order to quickly and safely accomplish the operations for which the tools are intended. Using the tools will minimize possible damage to the engine components. Precision measuring tools are required for the inspection of certain critical components. Torque wrenches are needed for the correct assembly of various parts.

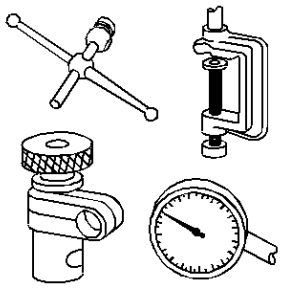
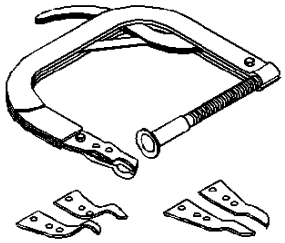
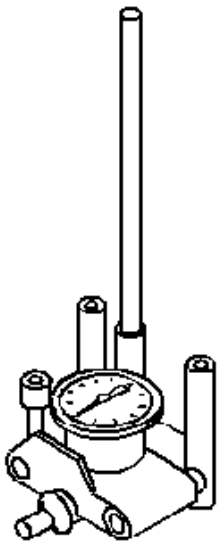
SPECIAL TOOLS & EQUIPMENT

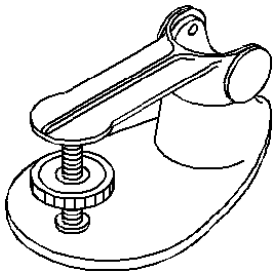
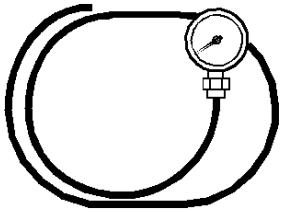
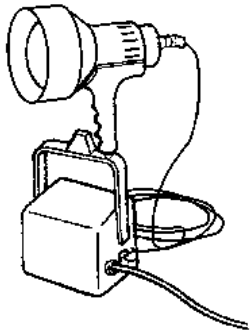
SPECIAL TOOLS

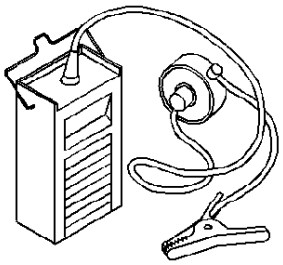
Illustration	Tool Number/Description
	EN 45680-400 Cylinder Sleeve Removal and Installation Kit
	EN 46119 Valve Spring Compressor Adapter

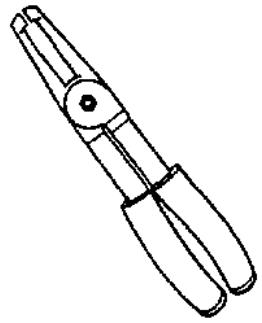
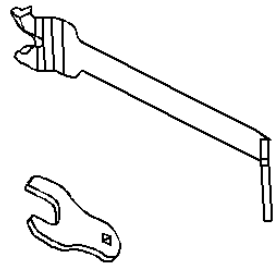
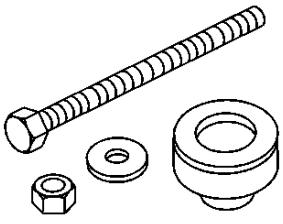
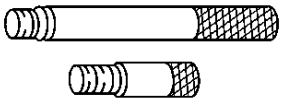
	EN 46745 Piston Pin Retainer Remover and Installer
	EN 47701 Piston Ring Compressor
	EN 47702 Bolt Extractor Kit
	EN 48268 Main Bearing Cap Remover

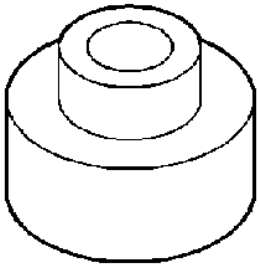
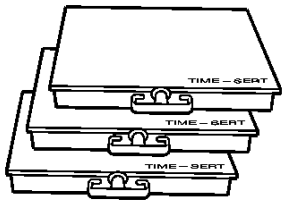
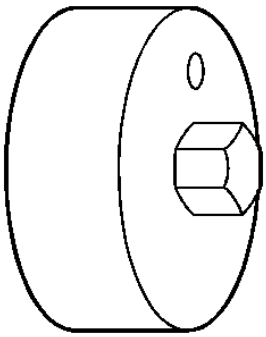
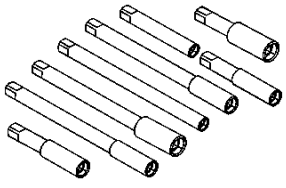
	EN 48464 Lower Timing Gear Tensioner Holding Tool
	GE-48326 Sealant Dispenser
	J 6125-1B Slide Hammer with Adapter
	J 7872 Magnetic Base Dial Indicator Set

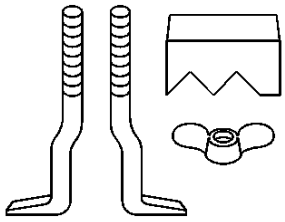
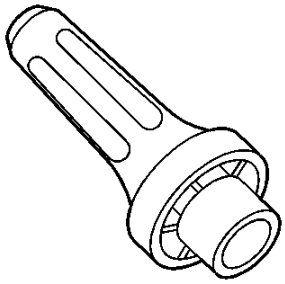
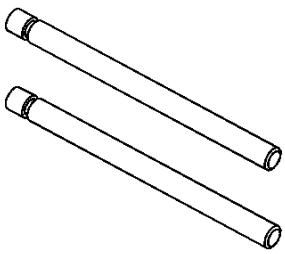
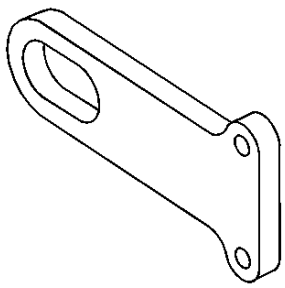
	J 8001 Dial Indicator Set
	J 8062 Valve Spring Compressor (Head-Off)
	J 8087 Cylinder Bore Gage

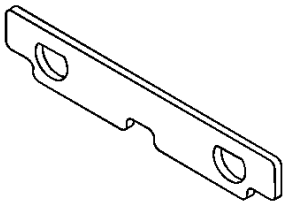
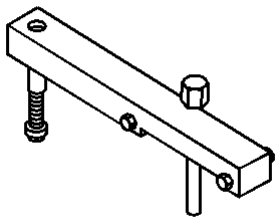
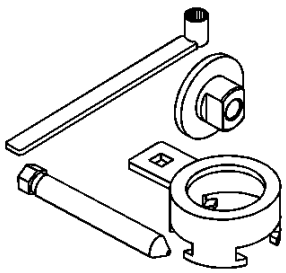
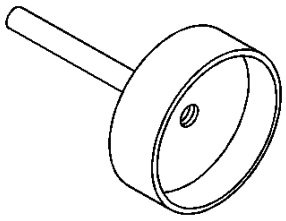
	J 9666 Valve Spring Tester
	J 21867 Pressure Gage
	J 28428-E High Intensity Black Light
	J 35667-A Cylinder Head Leakdown Tester

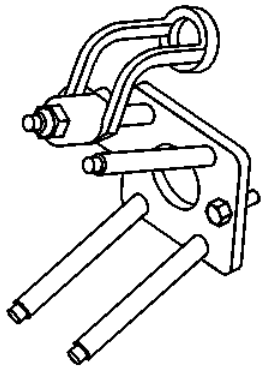
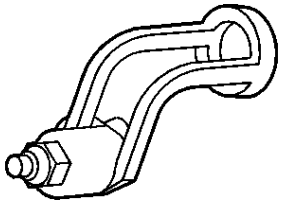
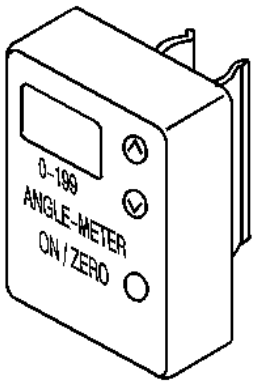
	
	J 36660-A Torque Angle Meter
	J 38722 Compression Tester
	J 38820 Valve Stem Seal Remover/Installer

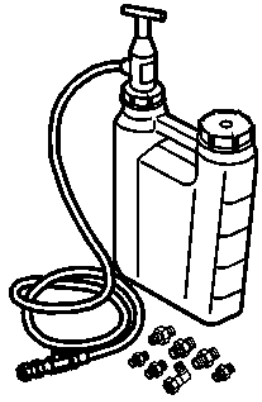
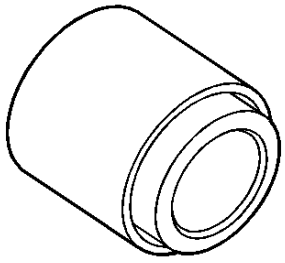
	
	J 41240 Fan Clutch Remover and Installer
	J 41478 Crankshaft Front Oil Seal Installer
	J 41556 Connecting Rod Guides

	J 41816-2 Crankshaft End Protector
	J 42385-400 Thread Repair Kit
	J 42907 Oil Pressure Tester
	J 43965 Thread Repair Extension Kit

	J 44217 Timing Chain Retention Tool
	J 44218 Seal Installer
	J 44219 Cover Alignment Pins
	J 44220 Engine Lift Bracket

	J 44221 Camshaft Holding Tool
	J 44222 Camshaft Sprocket Holding Tool
	J 44226 Crankshaft Balancer Remover
	J 44227 Rear Seal Installer

	J 44228-A Valve Spring Compressor
	J 44228-3 Valve Spring Compressor Adapter
	J 45059 Angle Meter

	J 45299 Engine Pre-Luber
	J 45951 Seal Installer