

2021 ENGINE

Engine Mechanical - 2.5L (LCV) - Canyon, Colorado

SPECIFICATIONS

FASTENER SPECIFICATIONS

Single Use Non-Threaded Fasteners/Components

NOTE:

***All
fasteners/components
listed in this table
MUST BE
DISCARDED and
replaced with NEW
after removal.***

Application
Camshaft Cover Gasket
Connecting Rod Bearing
Crankshaft Front Oil Seal
Crankshaft Rear Oil Seal
Cylinder Head Gasket
Cylinder Head Oil Gallery Plug
Engine Coolant Thermostat Housing Gasket
Exhaust Manifold Gasket
Fuel Injection Fuel Rail Seal
Fuel Injector Nozzle Housing Seal
Fuel Injector Seal Spacer
Fuel Pump Gasket
Fuel Pump Housing Seal
Intake Manifold Gasket
Oil Pan Gasket
Piston Pin Retainer
Thermostat Bypass Pipe Gasket
Throttle Body Gasket
Timing Chain Tensioner Seal
Vacuum Pump Gasket
Vacuum Pump Seal
Valve Stem Oil Seal
Water Outlet Gasket
Water Pump Gasket

Single Use Threaded Fastener/Component Tightening Specifications

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Automatic Transmission Flex Plate Bolt [8x]	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	40 degrees
Balance Shaft Sprocket Bolt	
• First Pass:	40 N.m (30 lb ft)
• Final Pass:	50 degrees
Camshaft Position Actuator Bolt	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	100 degrees
Connecting Rod Bolt	
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	110 degrees
Crankshaft Balancer Bolt	
• First Pass:	150 N.m (111 lb ft)
• Final Pass:	140 degrees
Cylinder Head Bolt [10x]	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	190 degrees
Cylinder Head Core Hole Plug	
	50 N.m (37 lb ft)
Engine Flywheel Bolt [8x]	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	80 degrees
Engine Front Cover Bolt - M10 [3x]	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	130 degrees

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Engine Mount Bracket Fastener	
• First Pass:	60 N.m (44 lb ft)
• Final Pass:	75 degrees
Engine Mount Fastener	
• First Pass:	60 N.m (44 lb ft)
• Final Pass:	75 degrees
Exhaust Manifold Bolt [5x]	20 N.m (15 lb ft)
Fuel Feed Intermediate Pipe	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	30 N.m (22 lb ft)
Fuel Pump Bolt [2x]	
• First Pass:	8 N.m (71 lb in)
• Final Pass:	50 degrees
Lower Crankcase Bolt [10x]	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	140 degrees
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange

Reusable Threaded Fastener Tightening Specifications**NOTE:**

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Air Conditioning Compressor Bolt	25 N.m (18 lb ft)
Balance Chain Guide Bolt [2x]	10 N.m (89 lb in)
Balancer Chain Tensioner Bolt	10 N.m (89 lb in)
Balancer Shaft with Oil Pump Bolt [8x]	

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
• First Pass:	58 N.m (43 lb ft)
• Final Pass:	58 N.m (43 lb ft)
Camshaft Bearing Cap Bolt [18x]	10 N.m (89 lb in)
Camshaft Bearing Cap Bolt- Front [4x]	10 N.m (89 lb in)
Camshaft Cover Bolt [23x]	10 N.m (89 lb in)
Camshaft Cover Heat Shield Bolt [4x]	10 N.m (89 lb in)
Camshaft Cover Opening Plug	35 N.m (26 lb ft)
Camshaft Cover Stud	10 N.m (89 lb in)
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m (89 lb in)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Cylinder Head Oil Gallery Plug	40 N.m (30 lb ft)
Drive Belt Tensioner Bolt	58 N.m (43 lb ft)
Engine Block Oil Gallery Plug	65 N.m (48 lb ft)
Engine Block Oil Gallery Plug	40 N.m (30 lb ft)
Engine Coolant Air Bleed Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Heater	50 N.m (37 lb ft)
Engine Coolant Heater Hole Plug	60 N.m (44 lb ft)
Engine Coolant Thermostat Housing Bolt [2x]	10 N.m (89 lb in)
Engine Front Cover Bolt - M6 [4x]	10 N.m (89 lb in)
Engine Front Cover Bolt - M8 [13x]	25 N.m (18 lb ft)
Engine Lift Front Bracket Bolt [2x]	25 N.m (18 lb ft)
Engine Lift Rear Bracket Bolt [2x]	25 N.m (18 lb ft)
Engine Mount Bracket Fastener	58 N.m (43 lb ft)
Engine Mount Bracket Fastener	60 N.m (44 lb ft)
Engine Mount Bracket Fastener	100 N.m (74 lb ft)
Engine Mount Fastener	58 N.m (43 lb ft)
Engine Mount Fastener	60 N.m (44 lb ft)
Engine Mount Heat Shield Fastener	9 N.m (80 lb in)
Engine Oil Level Indicator Switch Bolt [2x]	10 N.m (89 lb in)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Exhaust Manifold Heat Shield Bolt [3x]	14 N.m (124 lb in)
Fuel Injection Fuel Rail Bolt [4x]	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m (24 lb ft)
Fuel Pump Shield Bolt [3x]	10 N.m (89 lb in)
Ignition Coil Bolt [4x]	10 N.m (89 lb in)
Intake Manifold Bolt [6x]	12 N.m (106 lb in)
Intake Manifold Bracket Bolt - Upper	10 N.m (89 lb in)
Intake Manifold Cover Bolt	9 N.m (80 lb in)
Knock Sensor Bolt [2x]	25 N.m (18 lb ft)
Lower Crankcase Bolt [11x]	25 N.m (18 lb ft)
Manifold Absolute Pressure Sensor Bolt	5 N.m (44 lb in)

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Oil Filter Fitting	50 N.m (37 lb ft)
Oil Pan Bolt [2x]	10 N.m (89 lb in)
Oil Pan Bolt [12x]	25 N.m (18 lb ft)
Oil Pan Bolt @ Transmission	58 N.m (43 lb ft)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pump Flow Control Valve Bolt	10 N.m (89 lb in)
Piston Oil Nozzle Bolt [4x]	10 N.m (89 lb in)
Positive Crankcase Ventilation Valve Bolt	10 N.m (89 lb in)
Radiator Inlet Pipe Bolt	9 N.m (80 lb in)
Radiator Inlet Pipe Nut	9 N.m (80 lb in)
Thermostat Bypass Pipe Bolt [2x]	10 N.m (89 lb in)
Throttle Body Bolt [4x]	10 N.m (89 lb in)
Timing Chain Guide Bolt [2x]	25 N.m (18 lb ft)
Timing Chain Tensioner Bolt [2x]	25 N.m (18 lb ft)
Timing Chain Tensioner Shoe Bolt	25 N.m (18 lb ft)
Transmission Bolt @ Oil Pan	58 N.m (43 lb ft)
Vacuum Pump Bolt [3x]	10 N.m (89 lb in)
Water Outlet Bolt [2x]	10 N.m (89 lb in)
Water Pump Bolt [3x]	25 N.m (18 lb ft)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
LCV		
Oil Capacity	4.7L	5.0 quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.5 L	152 CID
• RPO	LCV	
• VIN	-	
• Bore	87.992 - 88.008 mm	3.4642 - 3.4649 in
• Stroke	101 mm	3.976 in
• Compression Ratio	11.20	
• Spark Plug Gap	0.95 - 1.10 mm	0.037 - 0.043 in
Block		
• Crankshaft Main Bearing Bore Diameter	60.862 - 60.876 mm	2.3961 - 2.3967 in
• Cylinder Bore Diameter	87.992 - 88.008 mm	3.4642 - 3.4649 in
• Cylinder Bore Out-of-Round - Maximum	0.013 mm	0.0005 in
• Cylinder Head Deck Surface Flatness - over 25 mm length	0.025 mm	0.001 in
• Cylinder Head Deck Surface Flatness - over 150 mm length	0.050 mm	0.002 in
Engine Block to Bedplate Flatness - overall	0.1 mm	0.0039 in
Engine Block to Bedplate Flatness - straightness	0.050 mm within every 100 mm	0.002 in within every 3.937 in
Piston Deck Height - Below Deck	1.105 - 1.675 mm	0.0435 - 0.0659 in
Camshaft		
• Camshaft End Play	0.040 - 0.307 mm	0.0016 - 0.0121 in
• Camshaft Journal Diameter - Journal 1	34.935 - 34.960 mm	1.3754 - 1.3764 in
• Camshaft Journal Diameter - Journal 2 thro 5	26.935 - 26.960 mm	1.0604 - 1.0614 in
• Camshaft Thrust Width - Camshaft with Phaser installed	30.025 - 30.175 mm	1.1821 - 1.1880 in
• Camshaft Thrust Width - Cylinder Head	29.868 - 29.890 mm	1.1759 - 1.1768 in
Connecting Rod		
• Connecting Rod Bearing to Crankpin Clearance	0.030 - 0.065 mm	0.0012 - 0.0026 in
• Connecting Rod Bore Diameter - Bearing End	52.118 - 52.134 mm	2.0519 - 2.05252 in

Application	Specification	
	Metric	English
• Connecting Rod Bore Diameter - Pin End	20.007 - 20.017 mm	0.7877 - 0.7881 in
• Connecting Rod Side Clearance	0.070 - 0.370 mm	0.0028 - 0.0146 in
• Connecting Rod Straightness - Bend - Maximum	0.017 mm	0.0007 in
• Connecting Rod Straightness - Twist - Maximum	0.040 mm	0.0016 in
Crankshaft		
• Connecting Rod Pin Diameter	48.999 - 49.015 mm	1.9291 - 1.9297 in
• Crankshaft End Play	0.040 - 0.270 mm	0.0016 - 0.0106 in
• Crankshaft Main Bearing Clearance	0.020 - 0.048 mm	0.0008 - 0.0019 in
• Crankshaft Main Journal Diameter	55.993 - 56.009 mm	2.2044 - 2.2051 in
• Crankshaft Thrust Bearing Width	20.30 - 20.45 mm	0.799 - 0.805 in
Cylinder Head		
• Surface Flatness - Block Deck - in 25 mm	0.025 mm	0.0001 in
• Surface Flatness - Block Deck - in 150 mm	0.050 mm	0.0019 in
• Surface Flatness - Block Deck - between bolts	0.030 mm	0.0012 in
• Surface Flatness - Block Deck - Overall	0.100 mm	0.0039 in
• Valve Guide Bore - Exhaust	6.000 - 6.020 mm	0.2362 - 0.2370 in
• Valve Guide Bore - Intake	6.000 - 6.020 mm	0.2362 - 0.2370 in
• Valve Lifter Bore Diameter - Stationary Lash Adjusters	12.008 - 12.030 mm	0.4728 - 0.4736 in
• Valve Seat Angle - Relief Surface	30 Degrees	
• Valve Seat Angle - Seating Surface	45 Degrees	
• Valve Seat Angle - Undercut Surface	60 Degrees	
• Valve Seat Runout - Maximum	0.080 mm	0.0031 in
Lubrication System		
• Oil Pressure - @ 700 RPM 100B°C	154 - 220 kPa	22 - 32 psi
Oil Pan		
• Upper Oil Pan Sealing Surface Flatness	0.07 mm	0.0028 in
Piston Rings		

Application	Specification	
	Metric	English
• Piston Ring End Gap - Top	0.15 - 0.25 mm	0.006 - 0.010 in
• Piston Ring End Gap - Second	0.20 - 0.45 mm	0.008 - 0.018 in
• Piston Ring End Gap - Oil Control	0.15 - 0.65 mm	0.006 - 0.026 in
• Piston Ring to Groove Clearance - Top	0.04 - 0.08 mm	0.0015 - 0.0031 in
• Piston Ring to Groove Clearance - Second	0.030 - 0.070 mm	0.0012 - 0.0030 in
• Piston Ring to Groove Clearance - Oil Control	0.058 - 0.207 mm	0.0023 - 0.0081 in
• Piston Ring Thickness - Top	1.170 - 1.190 mm	0.0461 - 0.0469 in
• Piston Ring Thickness - Second	1.470 - 1.490 mm	0.0579 - 0.0587 in
• Piston Ring Thickness - Oil Control - Maximum	0.490 mm	0.0193 in
• Piston Ring Thickness - Oil Control - Spacer	0.929 - 1.006 mm	0.0366 - 0.0396 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.007 - 0.020 mm	0.0003 - 0.0008 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.002 - 0.010 mm	0.0001 - 0.0004 in
• Pin - Piston Pin Diameter	21.997 - 22.000 mm	0.8660 - 0.8661 in
• Pin - Piston Pin End Play	0.413 - 1.269 mm	0.0163 - 0.0500 in
• Piston - Piston Diameter - @ 14.8 mm up	87.968 - 87.982 mm	3.4633 - 3.4638 in
• Piston - Piston Pin Bore Diameter	22.002 - 22.007 mm	0.8662 - 0.8664 in
• Piston - Piston Ring Groove Width - Top	1.23 - 1.25 mm	0.0484 - 0.0492 in
• Piston - Piston Ring Groove Width - Second	1.52 - 1.54 mm	0.0598 - 0.0606 in
• Piston - Piston Ring Groove Width - Oil Control	2.01 - 2.03 mm	0.0791 - 0.0799 in
• Piston - Piston to Bore Clearance - w/o polymer	0.010 - 0.041 mm	0.0004 - 0.0016 in
Valve System		
• Valves - Valve Face Angle	45 Degrees	
• Valves - Valve Face Runout - Maximum	0.040 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valves - Valve Seat Gauge Ball Height - Exhaust	10.885 - 11.115 mm	0.4285 - 0.4376 in

Application	Specification	
	Metric	English
• Valves - Valve Seat Gauge Ball Height - Intake	9.086 - 9.314 mm	0.3577 - 0.3667 in
• Valves - Valve Stem Diameter - Exhaust	5.945 - 5.965	0.2341 - 0.2348 in
• Valves - Valve Stem Diameter - Intake	5.955 - 5.975 mm	0.2344 - 0.2352 in
• Valves - Valve Stem Installed Height	Check and Record	
• Valves - Valve Stem to Guide Clearance - Exhaust	0.035 - 0.075 mm	0.0013 - 0.0030 in
• Valves - Valve Stem to Guide Clearance - Intake	0.025 - 0.065 mm	0.0010 - 0.0026 in
• Valve Lash Adjusters - Valve Lash Adjuster Diameter - Stationary Lash Adjuster	11.986 - 12.000 mm	0.0005 - 0.0020 in
• Valve Lash Adjusters - Valve Lash-Adjuster-to-Bore Clearance - Stationary Lash Adjuster	0.013 - 0.051 mm	3.2210 - 3.2299 in
• Valve Springs - Valve Spring Installed Height	35.0 mm	1.3779 in
• Valve Springs - Valve Spring Load - Closed - @ 35 mm	247 - 273 N	56 - 61 lb
• Valve Springs - Valve Spring Load - Open - @ 24 mm	598 - 662 N	134 - 149 lb

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Balance Shaft Bearings	5W-20*	19259486	88863951
Cam Lobes	5W-20*	19259486	88863951
Camshaft Cover ¹	Sealant	19369831	19369832
Crank Sensor O-ring	5W-20*	19259486	88863951
Cylinder Bores	5W-20*	19259486	88863951
Cylinder Head Plugs	Threadlocker	12345382	10953489
Engine Block Threaded Plugs	Sealant	12346004	10953480
Engine Block to Bedplate ¹	Sealant	19369831	19369832
Engine Front Cover ¹	Sealant	19369831	19369832
Engine Oil	5W-20*	19259486	88863951
Engine Oil - Alternate	0W-20	19259487	19259784
Fuel Injection Pump Bolt	Threadlocker	12345382	10953489
Fuel Injector O-rings	5W-20*	19259486	88863951
Fuel Injector Tip Insulators, for Multiple Port Injection Only	5W-20*	19259486	88863951
Hydraulic Lash Adjusters	5W-20*	19259486	88863951
Ignition Coils	Lubricant	19260901	19260902
Intake and Exhaust Valve Stems	5W-20*	19259486	88863951
Lower Oil Pan ¹	Sealant	19369831	19369832
Main Bearings	5W-20*	19259486	88863951

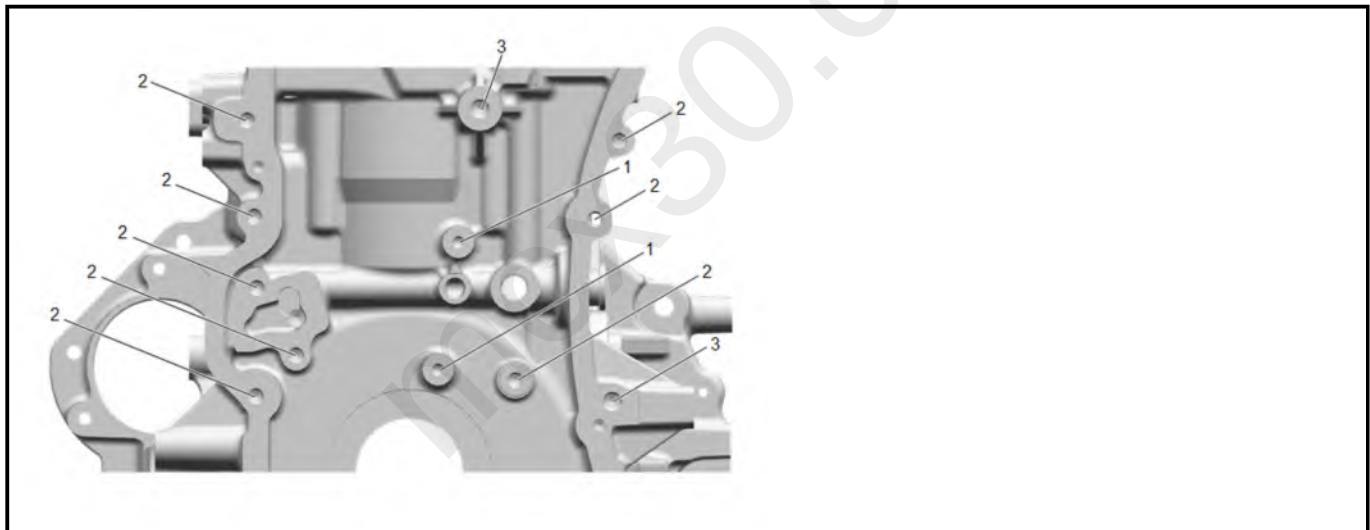
Application	Type of Material	GM Part Number	
		United States	Canada
Oil Filter - Threads and O-ring Lead-in Chambers	5W-20*	19259486	88863951
Oil Level Indicator Tube O-ring	Lubricant	88862586	88862827
Oil Pan to Bedplate Joint ¹	Sealant	19369831	19369832
Oil Pump - Pump Elements	5W-20*	19259486	88863951
Oxygen Sensor Threads	Anti-seize	88862477	88862478
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	5W-20*	19259486	88863951
Rod Bearings - Rod Pins of Crankshaft	5W-20*	19259486	88863951
Thread Repair Cutting Oil	Lubricant	1052864	992881
Thread Repair	Cleaner	88862650	88901247
Timing Chain Tensioner Cover	Sealant	19369831	19369832
Valves	Parts Immersion Solvent	12345368	10953514
Valve Rocker Arm/Valve Tip	5W-20*	19259486	88863951
Water Feed Tube O-rings	Lubricant	19260901	19260902

*0W-20 is an approved alternate engine oil for 5W-20, see Engine Oil - Alternate

¹ Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

THREAD REPAIR SPECIFICATIONS

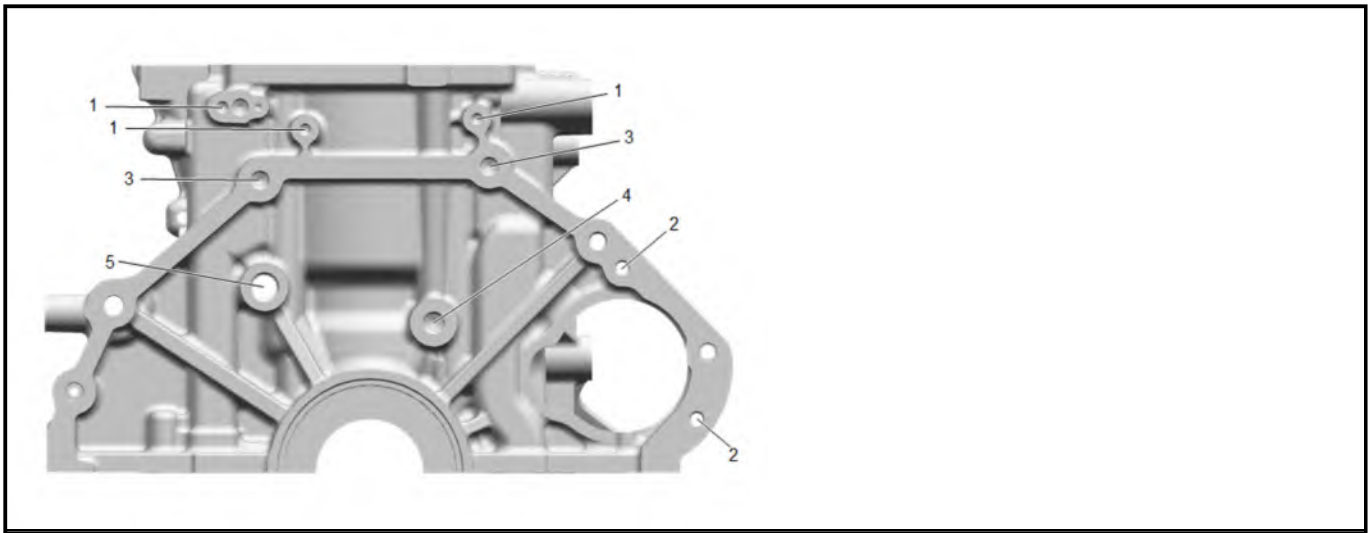
Engine Block - Front View



Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

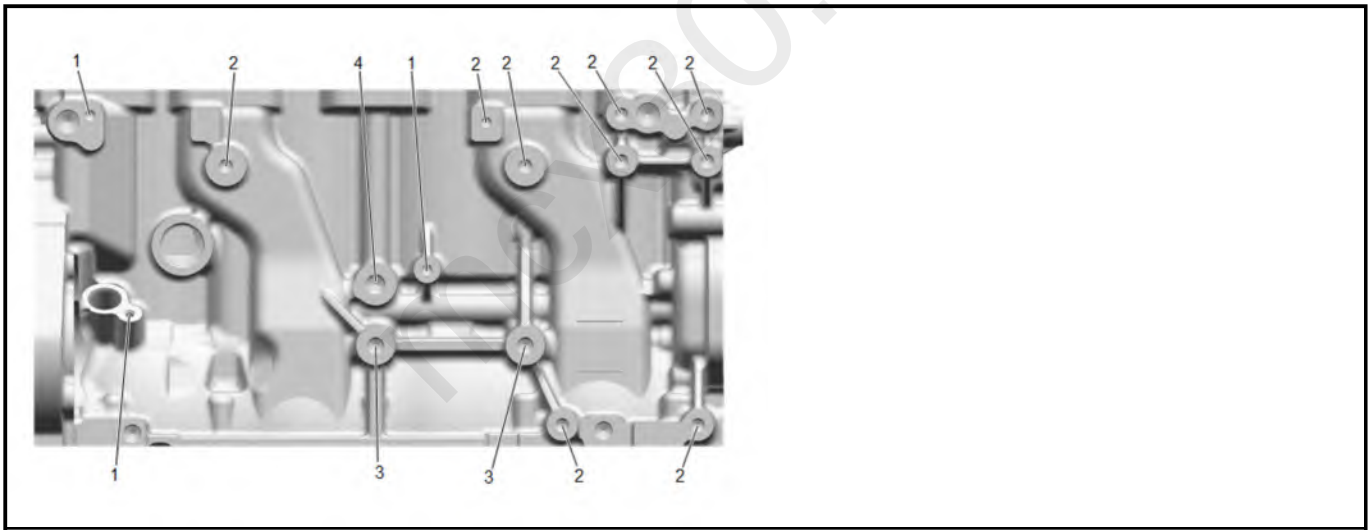
Engine Block - Back View



Engine Block - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	24.0	1.35
4	M12x1.75	865	856	857	858	859	27.5	1.08	27.5	1.08
5	M16x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

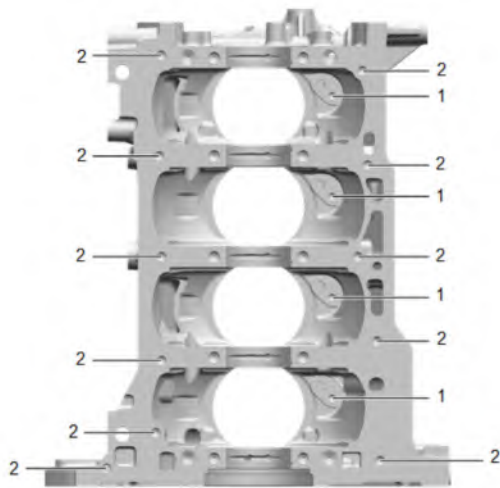
Engine Block - Right Side View



Engine Block - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	m10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M12x1.75	865	856	857	858	859	27.5	1.08	27.5	1.08

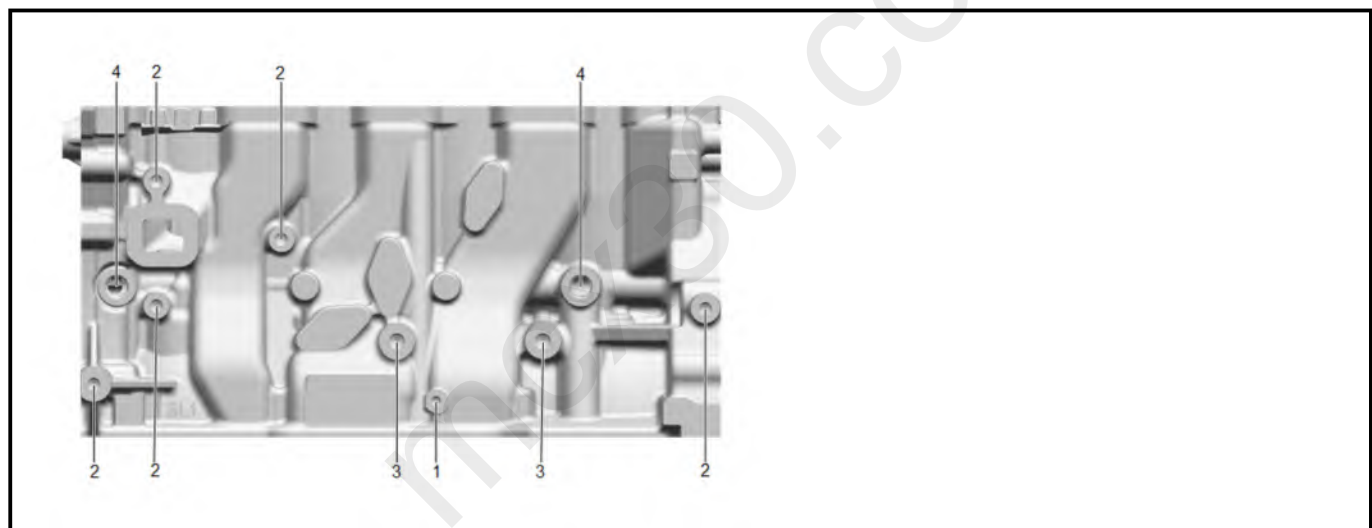
Engine Block - Bottom View



Engine Block - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

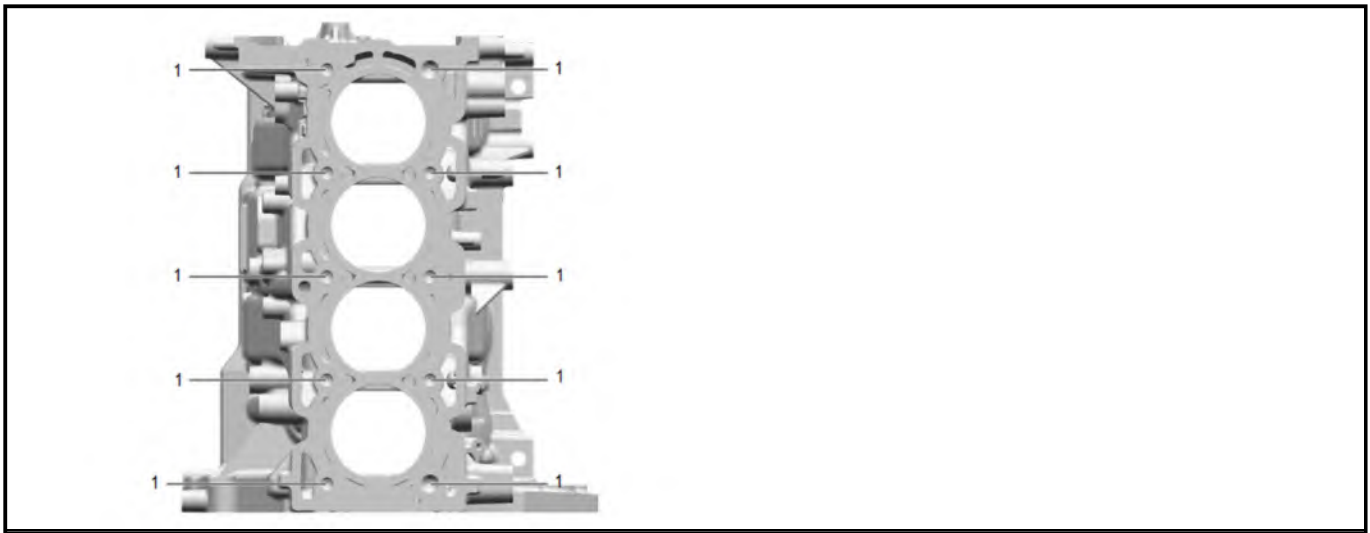
Engine Block - Left Side View



Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M16x1.5	420	211	212	213	214	22.0	0.866	22.0	0.866

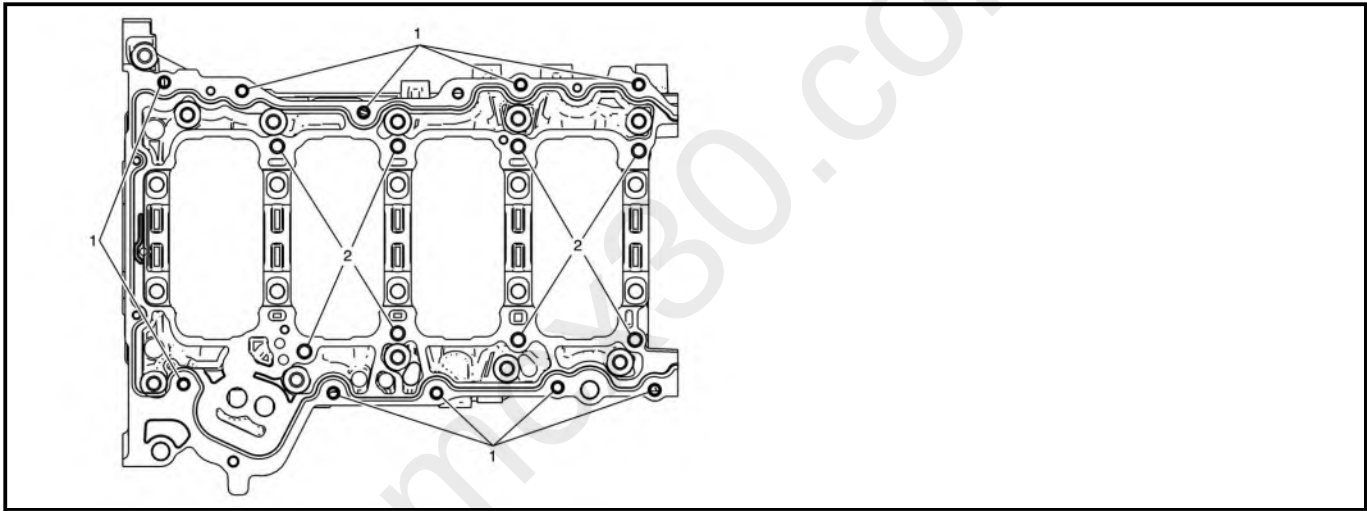
Engine Block - Top View



Engine Block - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M11x2.0	108	723	one	724	725	88.0	3.46	80.0	3.15

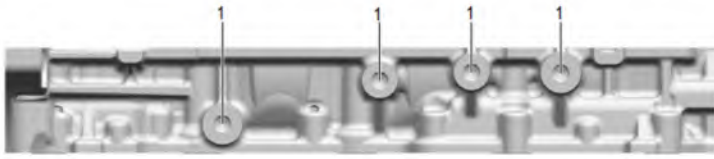
Lower Crankcase - Bottom View



Lower Crankcase - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
2	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

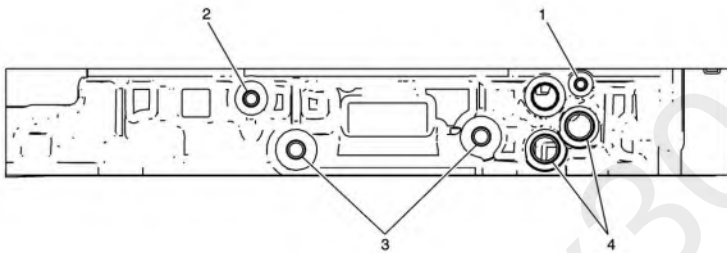
Lower Crankcase - Right Side View



Lower Crankcase - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

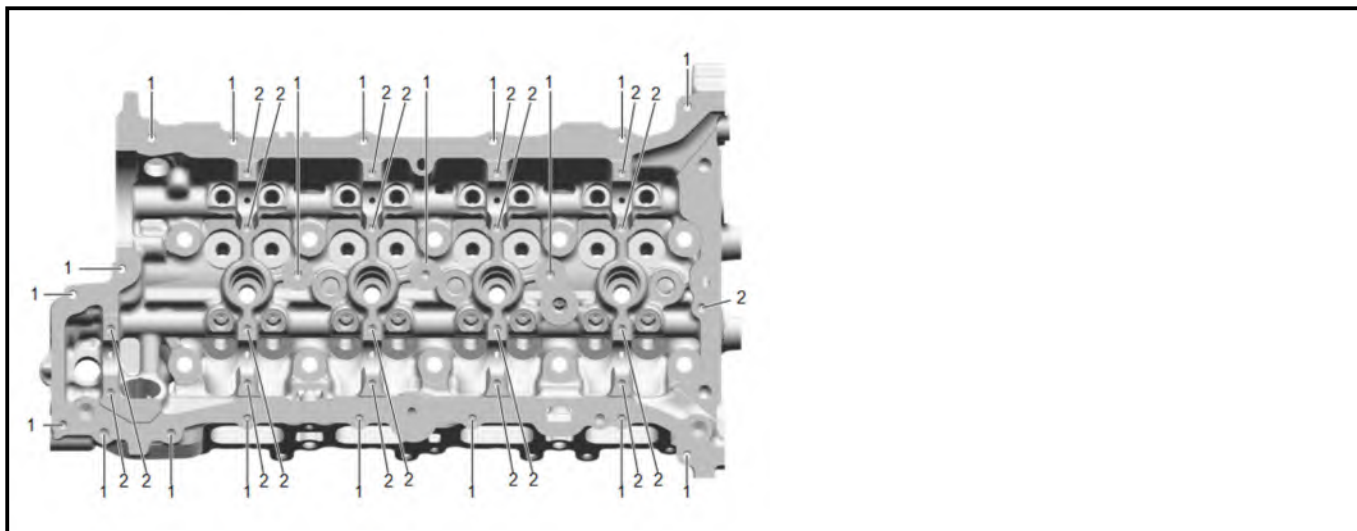
Lower Crankcase - Left Side View



Lower Crankcase - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M16x1.5	420	211	212	213	214	22.0	0.866	22.0	0.866

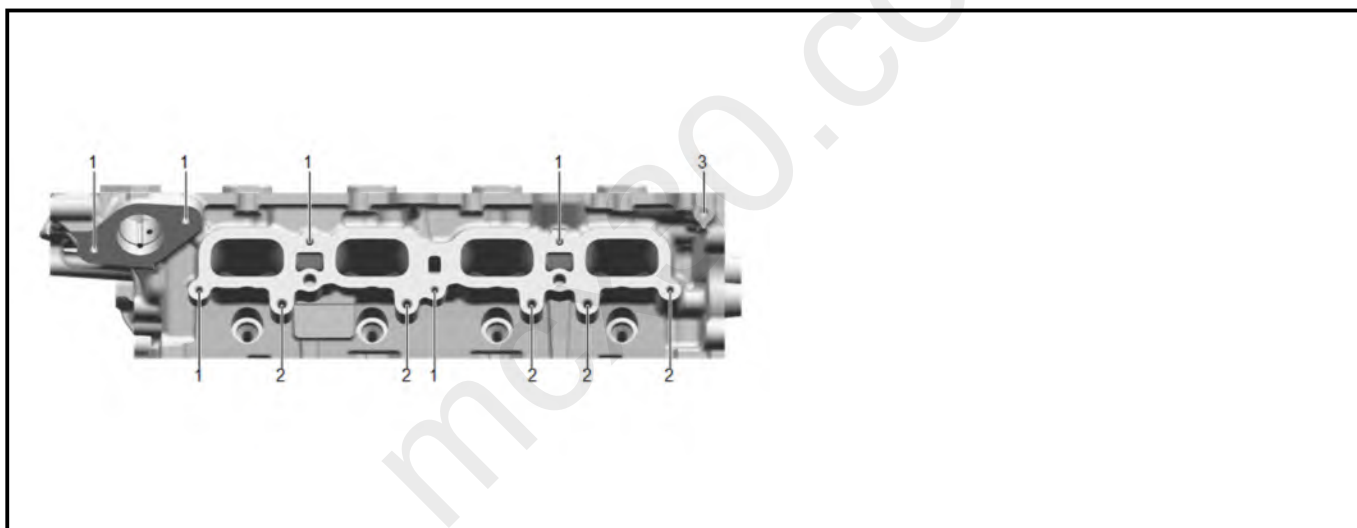
Cylinder Head - Top View



Cylinder Head - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
2	M6x1.0	205	701	one	203	204	23.0	0.907	23.0	0.907

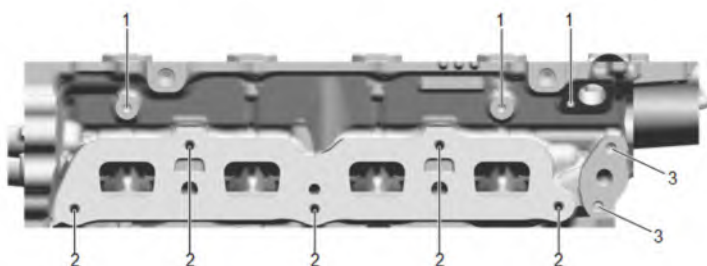
Cylinder Head Right Side View - Intake Manifold Deck Face



Cylinder Head Right Side View - Intake Manifold Deck Face

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
EN 42385							MM	IN	MM	IN
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
3	M6x1.0	205	701	one	203	204	23.0	0.907	23.0	0.907

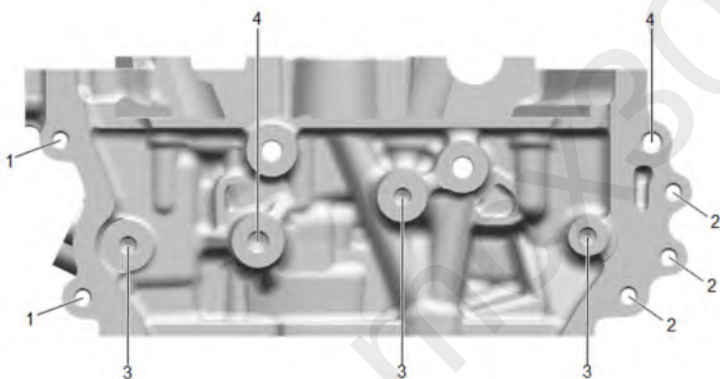
Cylinder Head Left Side View - Exhaust Manifold Deck Face



Cylinder Head Left Side View - Exhaust Manifold Deck Face

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385 - 850							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M8x1.25	210	206	207	208	209	29.0	1.14	29.0	1.14

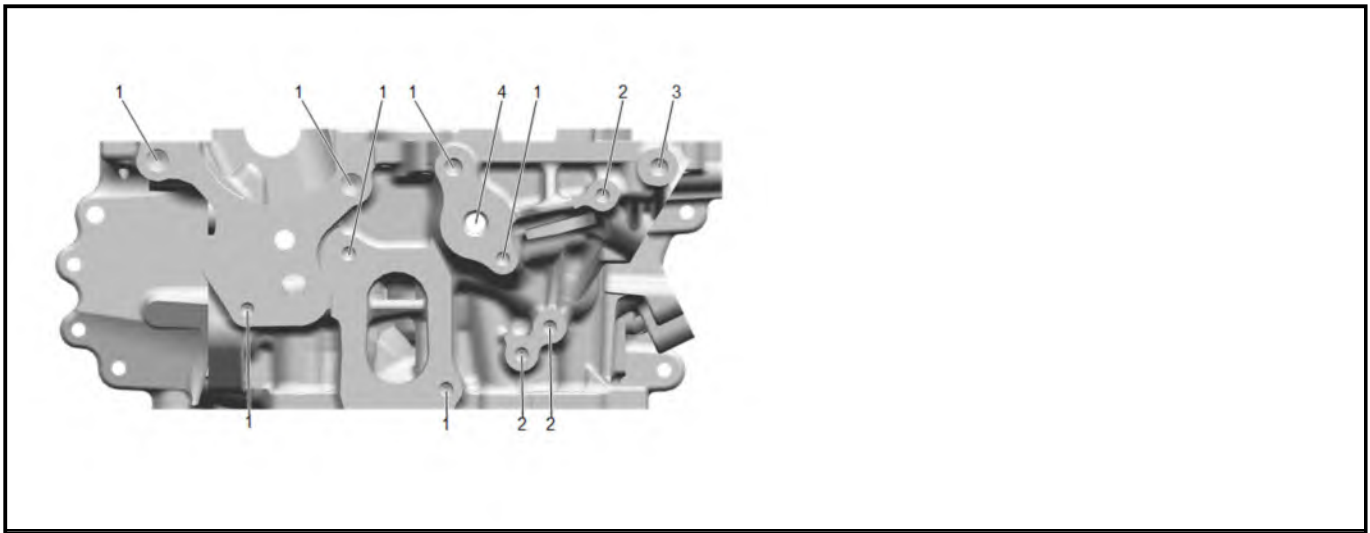
Cylinder Head - Front View



Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M8x1.25	18129	206	207	208	209	29.0	1.14	29.0	1.14
2	M8x1.25	18127	206	207	208	209	29.0	1.14	29.0	1.14
3	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
4	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

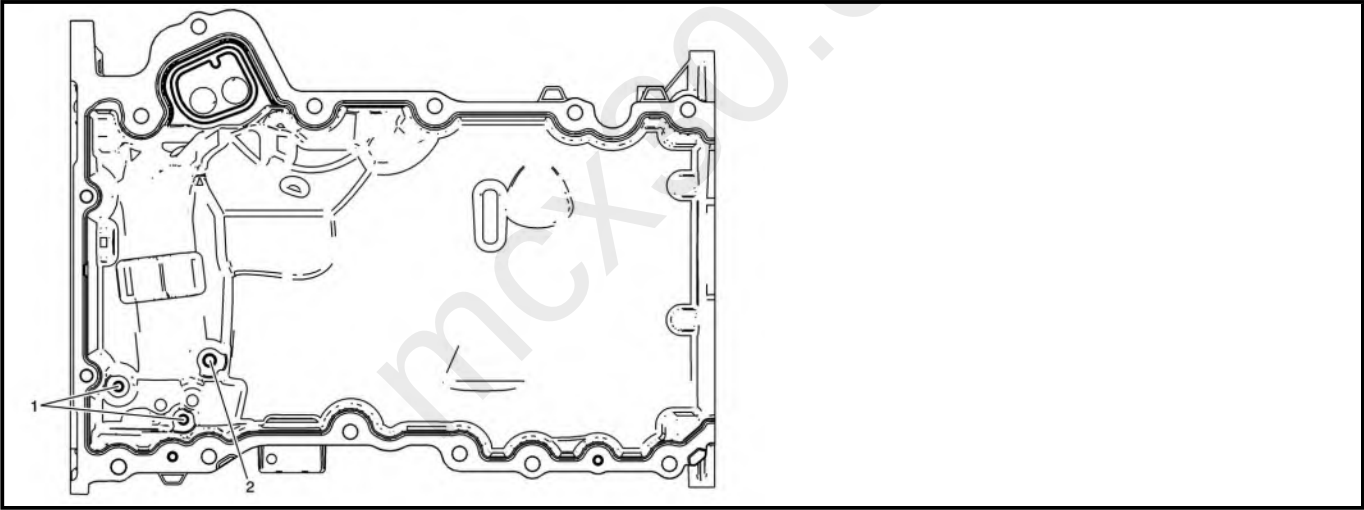
Cylinder Head - Back View



Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
EN 42385							MM	IN	MM	IN
1	M6X1	205	201	202	203	204	20	0.787	16	0.63
2	M6X1	205	701	one	203	204	20	0.787	16	0.63
3	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
4	M12x1.75	865	856	857	858	859	18	0.709	14	0.551

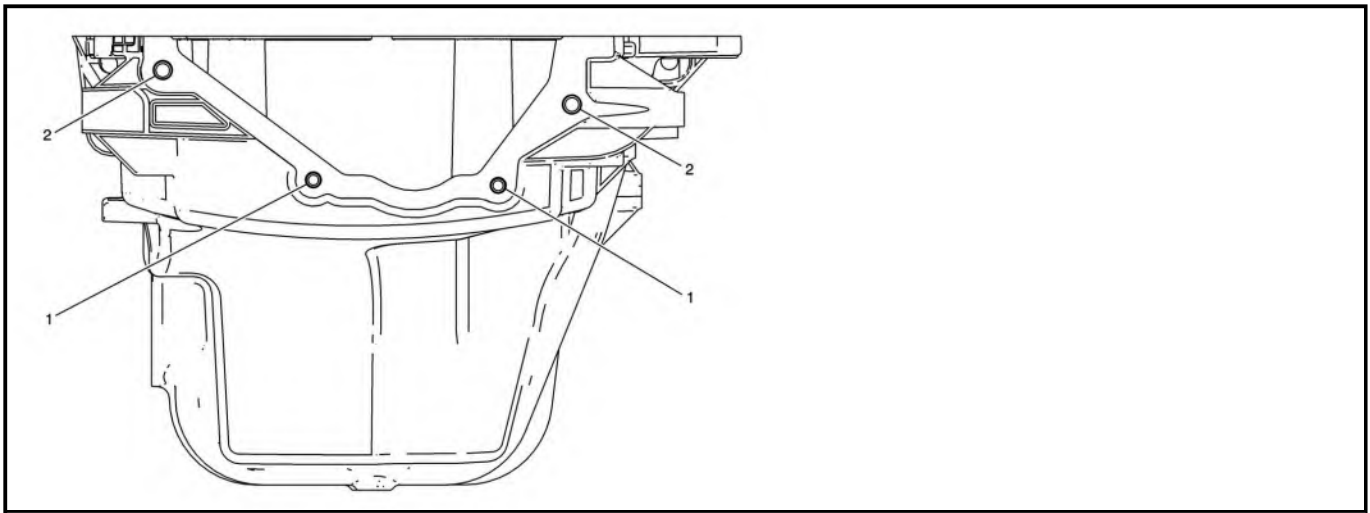
Oil Pan - Top View



Oil Pan - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

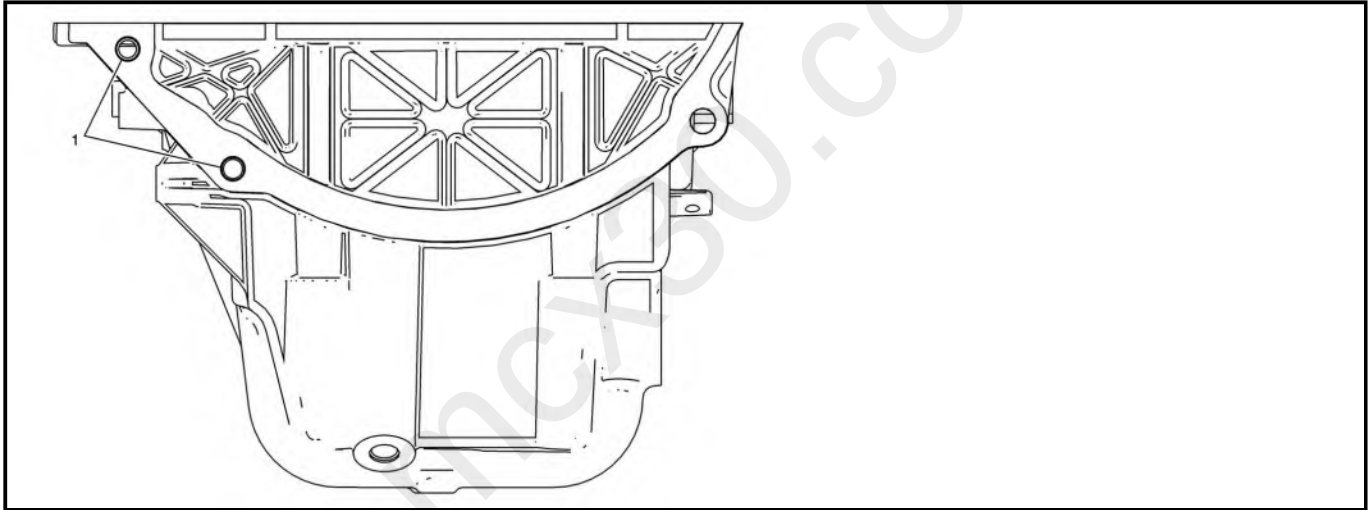
Oil Pan - Front View



Oil Pan - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M10x1.5	216	211	212	213	214	34.0	1.35	34.0	1.35
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

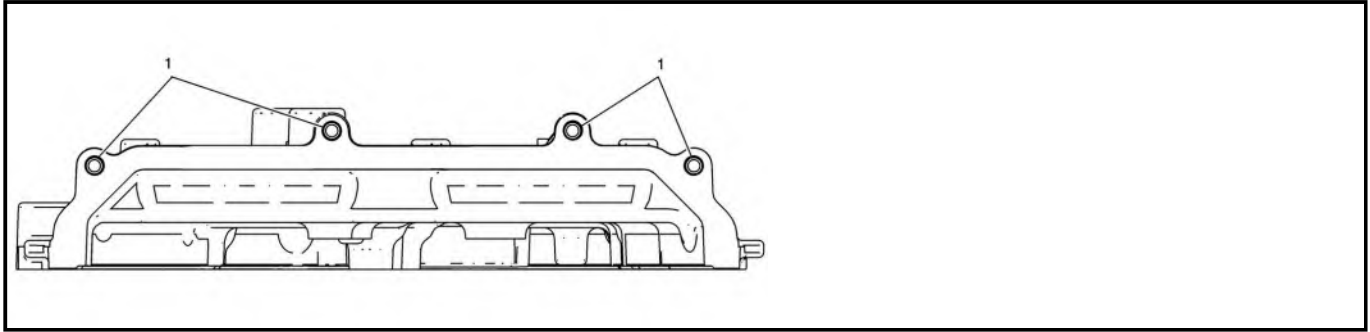
Oil Pan - Back View



Oil Pan - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907

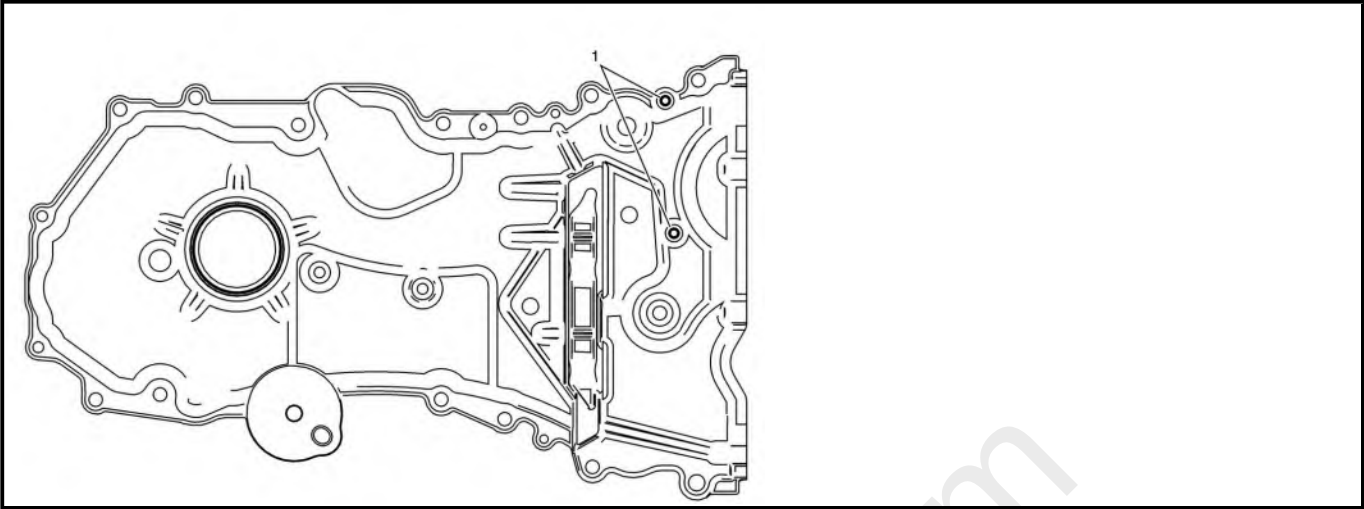
Engine Front Cover - Top View



Engine Front Cover - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M5x0.8	3005	3001	3002	3003	3004	23.0	0.907	23.0	0.907

Engine Front Cover - Front View



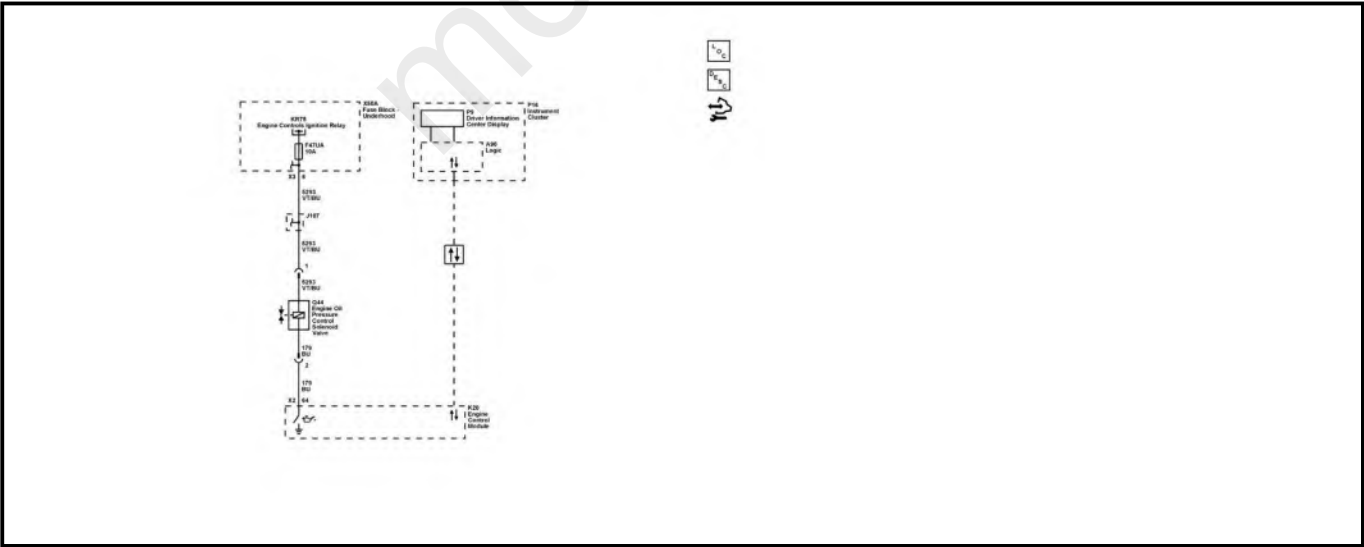
Engine Front Cover - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385 - 850							MM	(IN)	MM	(IN)
1	M6x1.0	420	201	202	203	204	23.0	0.907	23.0	0.907

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS

Engine Oil Pressure Control - 2.5 (LCV)



DISASSEMBLED VIEWS

CAMSHAFT COVER AND COMPONENTS

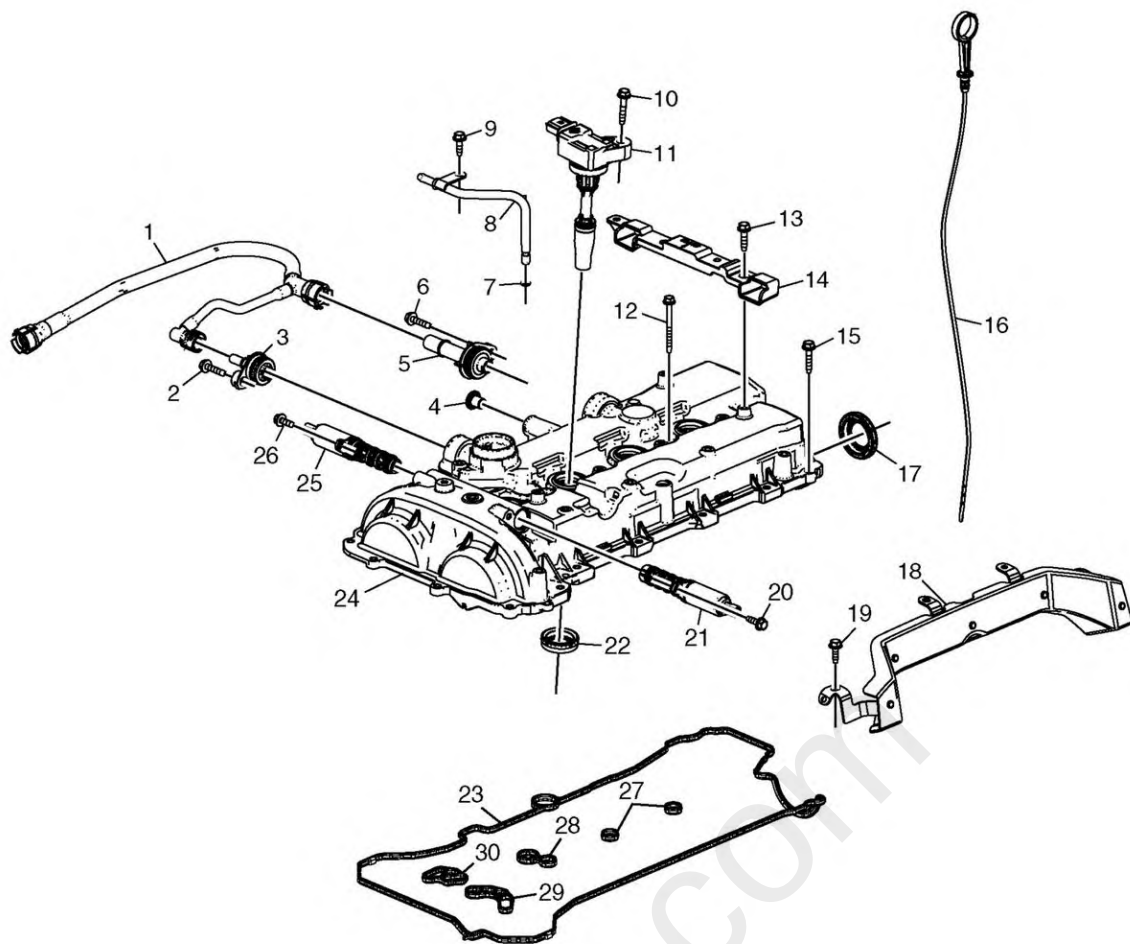


Fig. 1: Exploded View Of Camshaft Cover Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	PCV Tube Assembly
2	PCV Valve Bolt
3	PCV Valve
4	Camshaft Cover Plug
5	PCV Valve
6	PCV Valve Bolt
7	Engine Coolant Air Bleed Pipe O-ring
8	Engine Coolant Air Bleed Pipe
9	Engine Coolant Air Bleed Bolt
10	Ignition Coil Bolt
11	Ignition Coil
12	Camshaft Cover Bolt (Qty: 4)
13	Upper Intake Manifold Bracket Bolt (Qty: 2)
14	Upper Intake Manifold Bracket
15	Camshaft Cover Bolt (Qty: 19)
16	Oil Level Indicator
17	Vacuum Pump Seal
18	Camshaft Housing Cover Heat Shield
19	Camshaft Housing Cover Heat Shield Bolt (Qty: 4)
20	Camshaft Position Actuator Control Solenoid Valve Bolt
21	Camshaft Position Actuator Control Solenoid Valve

Callout	Component Name
22	Spark Plug Shield Seal
23	Camshaft Cover Gasket
24	Camshaft Cover
25	Camshaft Position Actuator Control Solenoid Valve
26	Camshaft Position Actuator Control Solenoid Valve Bolt
27	Camshaft Cover Inner Gasket (Qty: 2)
28	Camshaft Cover Inner Gasket
29	Exhaust Camshaft Cover Gasket
30	Intake Camshaft Cover Gasket

CYLINDER HEAD AND COMPONENTS

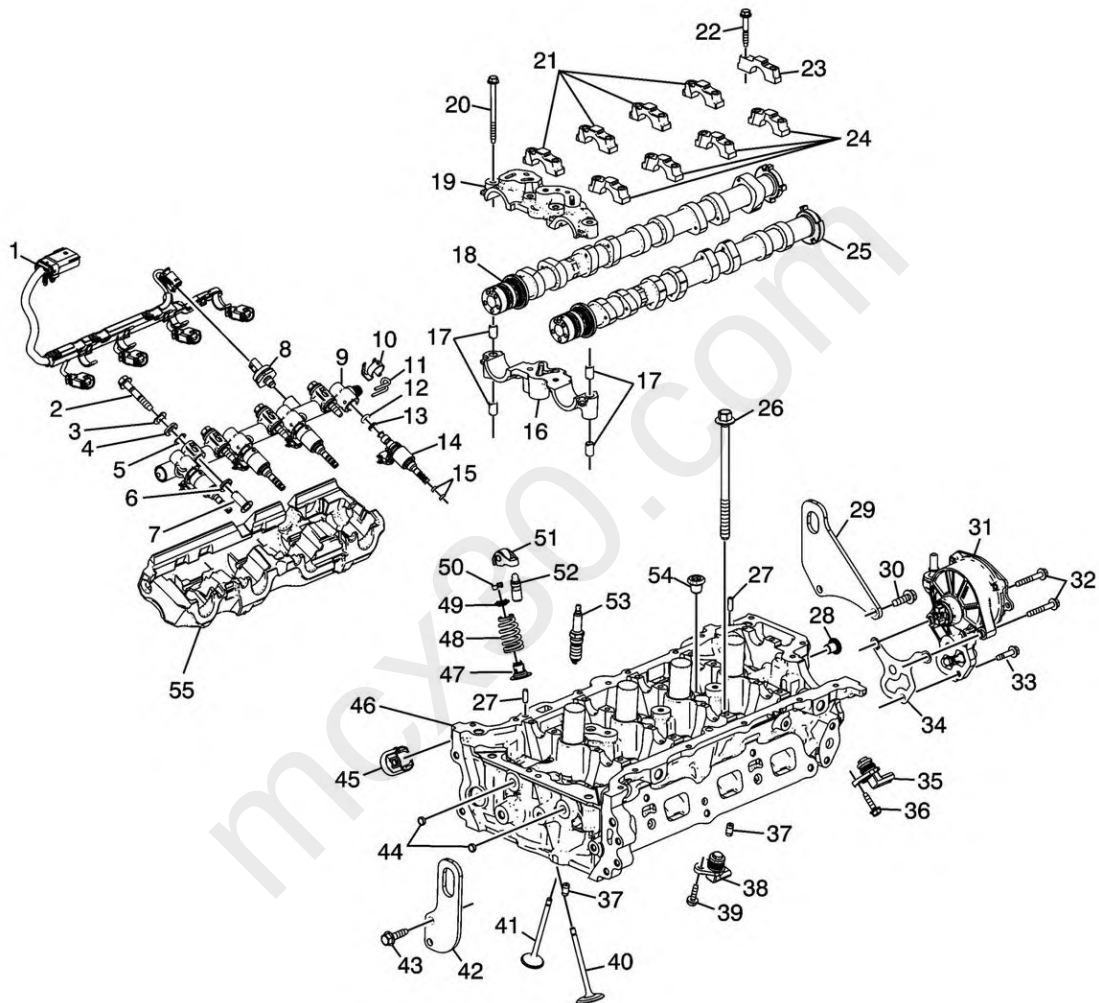


Fig. 2: Exploded View Of Cylinder Head Components
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Fuel Injector Wiring Harness
2	Fuel Injection Fuel Rail Bolt (Qty: 4)
3	Fuel Rail Insulator Bushing
4	Fuel Rail Insulator Washer
5	Fuel Rail Insulator Wave Washer
6	Fuel Rail Insulator Washer
7	Fuel Rail Insulator Sleeve
8	Fuel Pressure Sensor

Callout	Component Name
9	Fuel Injection Fuel Rail
10	Fuel Injector Holding Clamp
11	Fuel Injector Retainer
12	Fuel Injection Fuel Rail O-Ring Seal
13	Fuel Injector Seal Spacer
14	Direct Fuel Injector Assembly
15	Fuel Injector Combustion Seal
16	Camshaft Bearing Front Lower Cap
17	Camshaft Bearing Front Cap Sleeve
18	Intake Camshaft
19	Camshaft Bearing Front Cap
20	Camshaft Bearing Cap Bolt (Qty: 3)
21	Camshaft Bearing Cap - Intake
22	Camshaft Bearing Cap Bolt (Qty: 18)
23	Camshaft Bearing Cap - Rear
24	Camshaft Bearing Cap - Exhaust
25	Exhaust Camshaft
26	Cylinder Head Bolt (Qty: 10)
27	Camshaft Cover Locating Pin (Qty: 2)
28	Cylinder Head Oil Gallery Plug
29	Engine Rear Lift Bracket
30	Engine Rear Lift Bracket Bolt (Qty: 2)
31	Vacuum Pump Assembly
32	Vacuum Pump Bolt (Qty: 2)
33	Vacuum Pump Bolt (Qty: 1)
34	Vacuum Pump Gasket
35	Camshaft Position Sensor
36	Camshaft Position Sensor Bolt
37	Cylinder Head Oil Gallery Restrictor (Qty: 2)
38	Camshaft Position Sensor
39	Camshaft Position Sensor Bolt
40	Intake Valve
41	Exhaust Valve
42	Engine Front Lift Bracket
43	Engine Front Lift Bracket Bolt (Qty: 2)
44	Cylinder Head Oil Gallery Plug (Qty: 2)
45	Valve Lifter Follower
46	Cylinder Head
47	Valve Stem Oil Seal (Qty: 16)
48	Valve Spring (Qty: 16)
49	Valve Spring Retainer (Qty: 16)
50	Valve Stem Key (Qty: 32)
51	Valve Rocker Arm (Qty: 16)
52	Hydraulic Valve Lash Adjuster (Qty: 16)
53	Spark Plug (Qty: 4)
54	Cylinder Head Core Hole Plug (Qty: 3)
55	Fuel Injection Fuel Rail Noise Shield

INTAKE MANIFOLD AND COMPONENTS

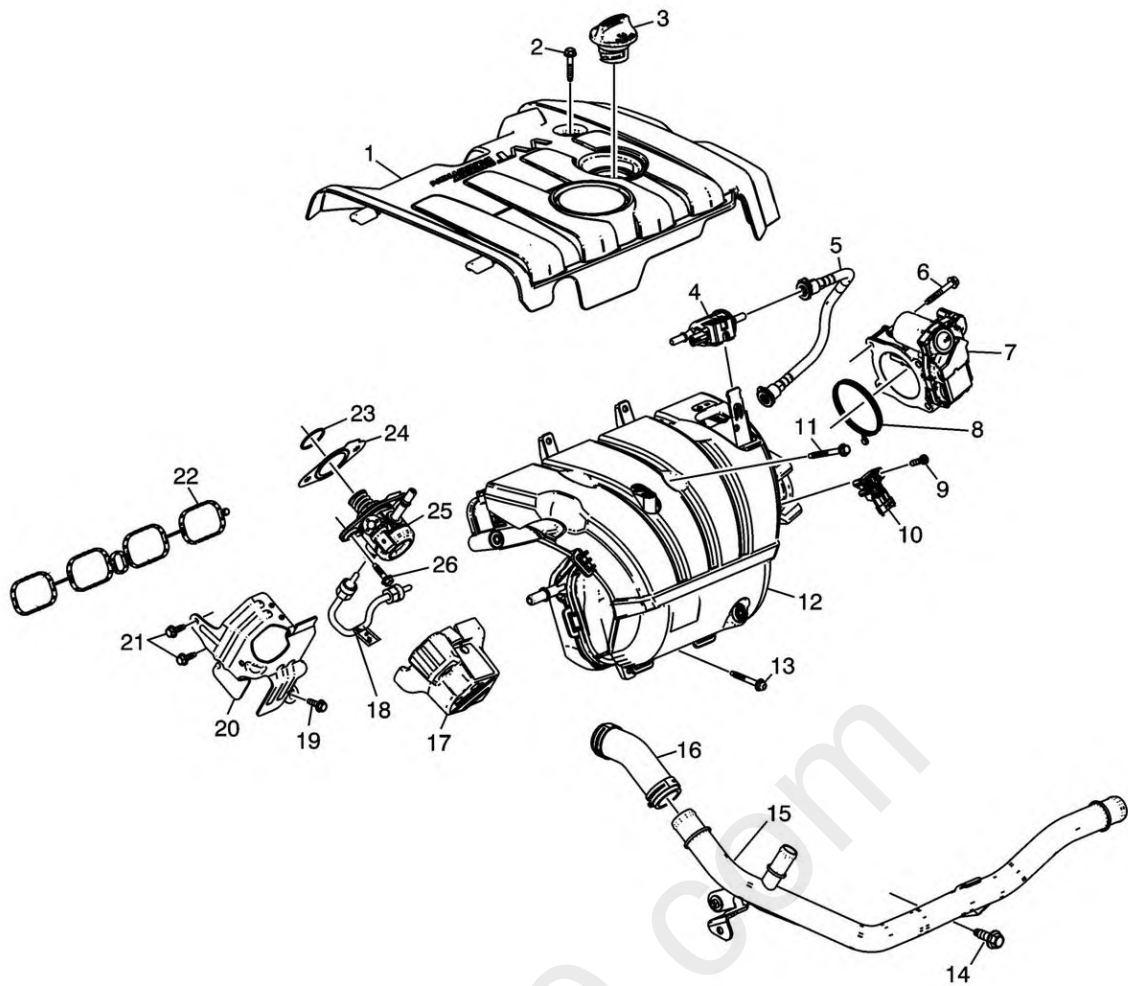


Fig. 3: Exploded View Of Intake Manifold Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Intake Manifold Sight Shield
2	Intake Manifold Sight Shield Bolt (Qty: 1)
3	Oil Fill Cap
4	Evaporative Emission Canister Purge Valve Assembly
5	Evaporative Emission Canister Purge Valve Pipe Assembly
6	Throttle Body Assembly Bolt (Qty: 4)
7	Throttle Body Assembly
8	Throttle Body Assembly Gasket
9	Manifold Absolute Pressure (MAP) Sensor Bolt
10	Manifold Absolute Pressure (MAP) Sensor
11	Intake Manifold Bolt (Qty: 5)
12	Intake Manifold
13	Intake Manifold Bolt (Qty: 1)
14	Radiator Inlet Pipe Bolt (Qty: 1)
15	Radiator Inlet Pipe
16	Radiator Inlet Hose
17	Fuel Pump Insulator
18	Fuel Feed Intermediate Pipe Assembly
19	Fuel Pump Cover Bolt (Qty: 1)
20	Fuel Pump Cover

Callout	Component Name
21	Fuel Pump Cover Bolt (Qty: 2)
22	Intake Manifold Gasket
23	Fuel Pump Housing O-Ring Seal
24	Fuel Pump Housing Gasket
25	Fuel Pump Assembly
26	Fuel Pump Bolt (Qty: 2)

EXHAUST MANIFOLD AND COMPONENTS

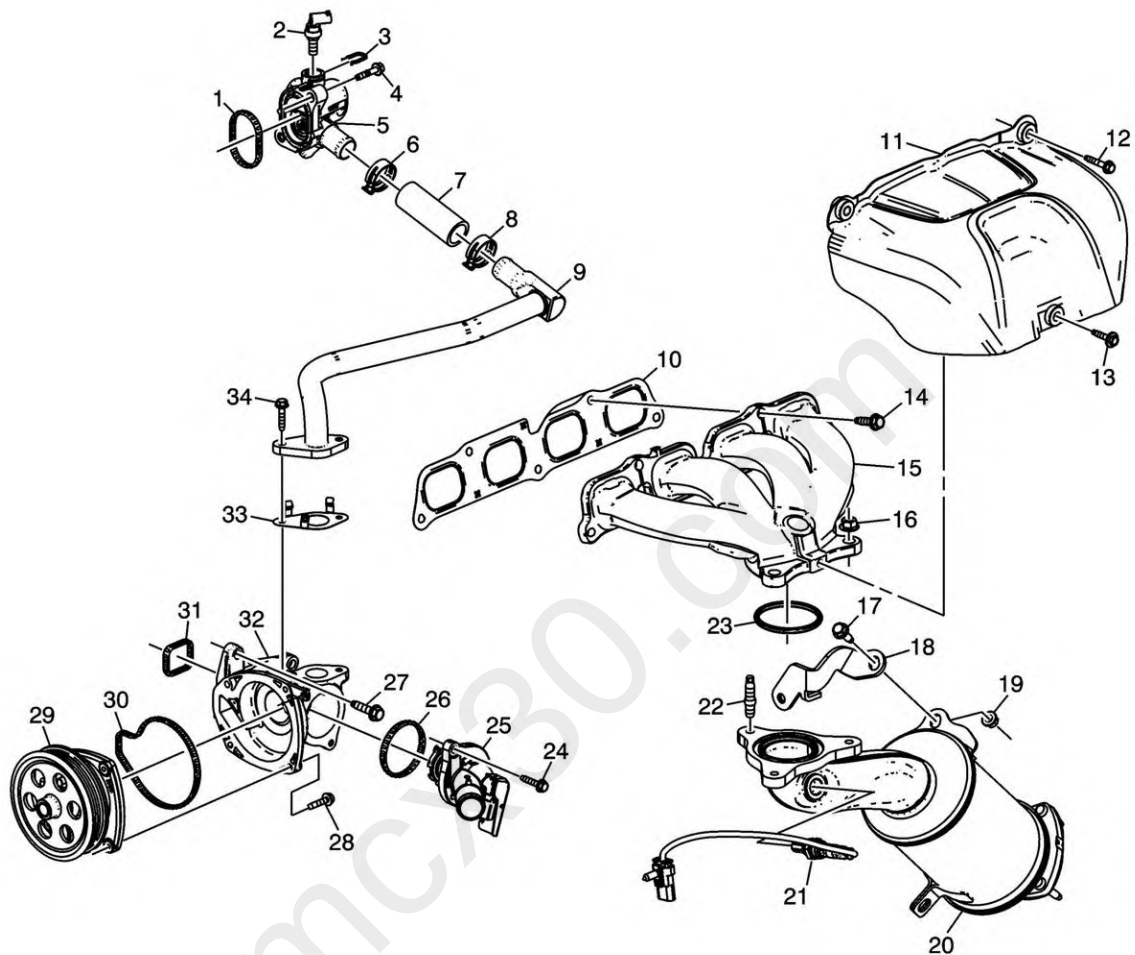


Fig. 4: Exploded View Of Exhaust Manifold Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Water Outlet Gasket
2	Engine Coolant Temperature Sensor
3	Engine Coolant Temperature Sensor Retainer
4	Water Outlet Bolt (Qty: 2)
5	Water Outlet
6	Thermal Bypass Hose Clamp
7	Thermal Bypass Hose
8	Thermal Bypass Hose Clamp
9	Thermal Bypass Pipe
10	Exhaust Manifold Gasket
11	Exhaust Manifold Heat Shield

Callout	Component Name
12	Exhaust Manifold Heat Shield Bolt (Qty: 2)
13	Exhaust Manifold Heat Shield Bolt (Qty: 1)
14	Exhaust Manifold Bolt (Qty: 5)
15	Exhaust Manifold
16	Catalytic Converter Nut (Qty: 3)
17	Catalytic Converter Brace Bolt (Qty: 1)
18	Catalytic Converter Brace
19	Catalytic Converter Brace Nut (Qty: 1)
20	Catalytic Converter
21	Heated Oxygen Sensor Assembly
22	Catalytic Converter Stud (Qty: 3)
23	Exhaust Pipe Gasket
24	Engine Coolant Thermostat Housing Bolt (Qty: 2)
25	Engine Coolant Thermostat Housing
26	Engine Coolant Thermostat Housing Gasket
27	Water Pump Bolt (Qty: 3)
28	Water Pump Housing Bolt (Qty: 4)
29	Water Pump Front Housing
30	Water Pump Inlet Gasket
31	Water Pump Gasket
32	Water Pump Rear Housing
33	Thermal Bypass Pipe Gasket
34	Thermal Bypass Pipe Bolt (Qty: 2)

ENGINE BLOCK AND COMPONENTS

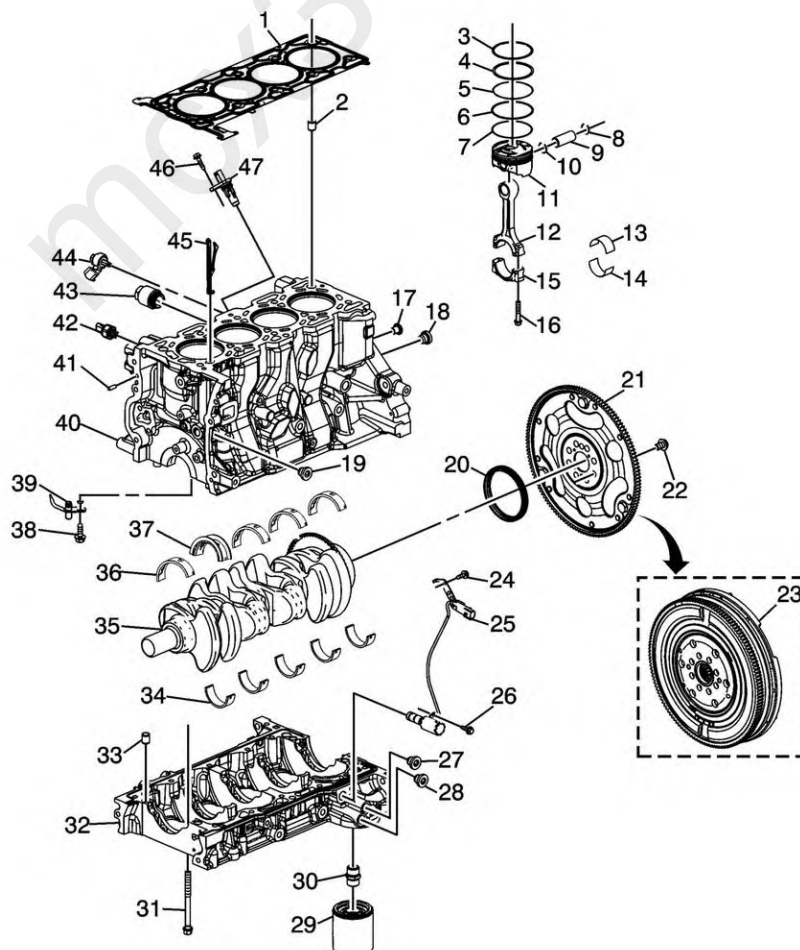


Fig. 5: Exploded View Of Engine Block Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Cylinder Head Gasket
2	Cylinder Head Locating Pin
3	Piston Upper Compression Ring
4	Piston Lower Compression Ring
5	Piston Oil Ring Rail
6	Piston Oil Ring Rail Spacer
7	Piston Oil Ring Rail
8	Piston Pin Retainer
9	Piston Pin
10	Piston Pin Retainer
11	Piston
12	Connecting Rod
13	Connecting Rod Bearing
14	Connecting Rod Bearing
15	Connecting Rod Cap
16	Connecting Rod Bolt
17	Engine Block Oil Gallery Plug
18	Engine Block Oil Gallery Plug
19	Engine Block Oil Gallery Plug
20	Crankshaft Rear Oil Seal
21	Automatic Transmission Flex Plate
22	Automatic Transmission Flex Plate Bolt
23	Flywheel
24	Oil Pump Flow Control Valve Assembly Bolt
25	Oil Pump Flow Control Valve Assembly
26	Oil Pump Flow Control Valve Assembly Bolt
27	Engine Block Oil Gallery Plug
28	Engine Block Oil Gallery Plug
29	Oil Filter
30	Oil Filter Fitting
31	Lower Crankcase Bolt
32	Lower Crankcase
33	Lower Crankcase Locating Pin
34	Crankshaft Lower Bearing
35	Crankshaft
36	Crankshaft Upper Bearing
37	Crankshaft Upper Thrust Bearing
38	Piston Oil Nozzle Bolt
39	Piston Oil Nozzle
40	Engine Block
41	Engine Front Cover Locating Pin
42	Engine Oil Pressure Sensor
43	Engine Coolant Heater
44	Knock Sensor
45	Engine Block Coolant Baffle
46	Crankshaft Position Sensor Bolt

Callout	Component Name
47	Crankshaft Position Sensor

UPPER AND LOWER OIL PAN AND COMPONENTS

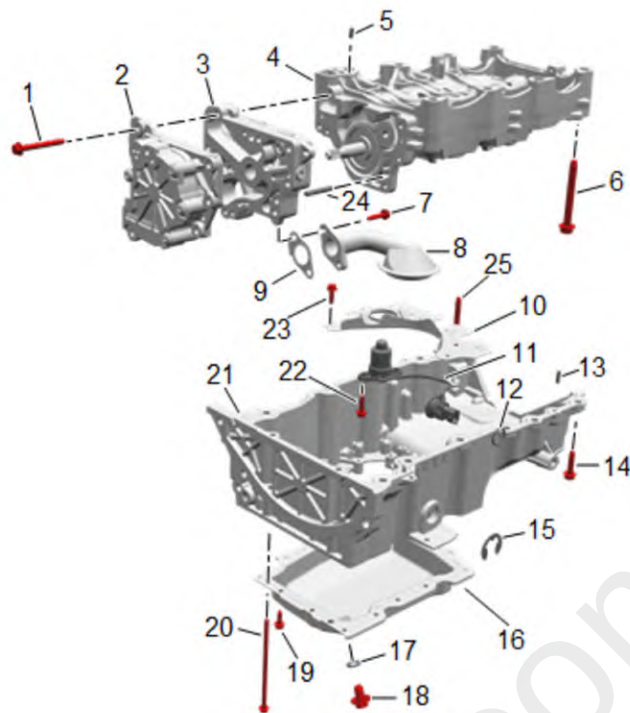


Fig. 6: Exploded View Of Upper And Lower Oil Pan Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Pump Bolt [7x]
2	Oil Pump
3	Oil Pump Cover
4	Balancer Shaft with Oil Pump
5	Balancer Shaft Housing Locating Pin [2x]
6	Balance Shaft Bearing Bolt [8x]
7	Oil Pump Suction Pipe Bolt [2x]
8	Oil Pump Screen
9	Oil Pump Screen Gasket
10	Oil Pan Baffle
11	Engine Oil Level Indicator Switch
12	Engine Oil Level Indicator Switch O-Ring Seal
13	Oil Pan Locating Pin [2x]
14	Oil Pan Bolt [10x]
15	Engine Oil Level Sensor Lead Clip
16	Lower Oil Pan
17	Oil Pan Drain Plug Seal
18	Oil Pan Drain Plug
19	Lower Oil Pan Bolt [15x]
20	Oil Pan Bolt [2x]
21	Oil Pan

Callout	Component Name
22	Engine Oil Level Indicator Switch Bolt [2x]
23	Oil Pan Baffle Bolt [5x]
24	Oil Pump Locating Pin [2x]
25	Oil Pan Bolt

OIL PAN AND COMPONENTS

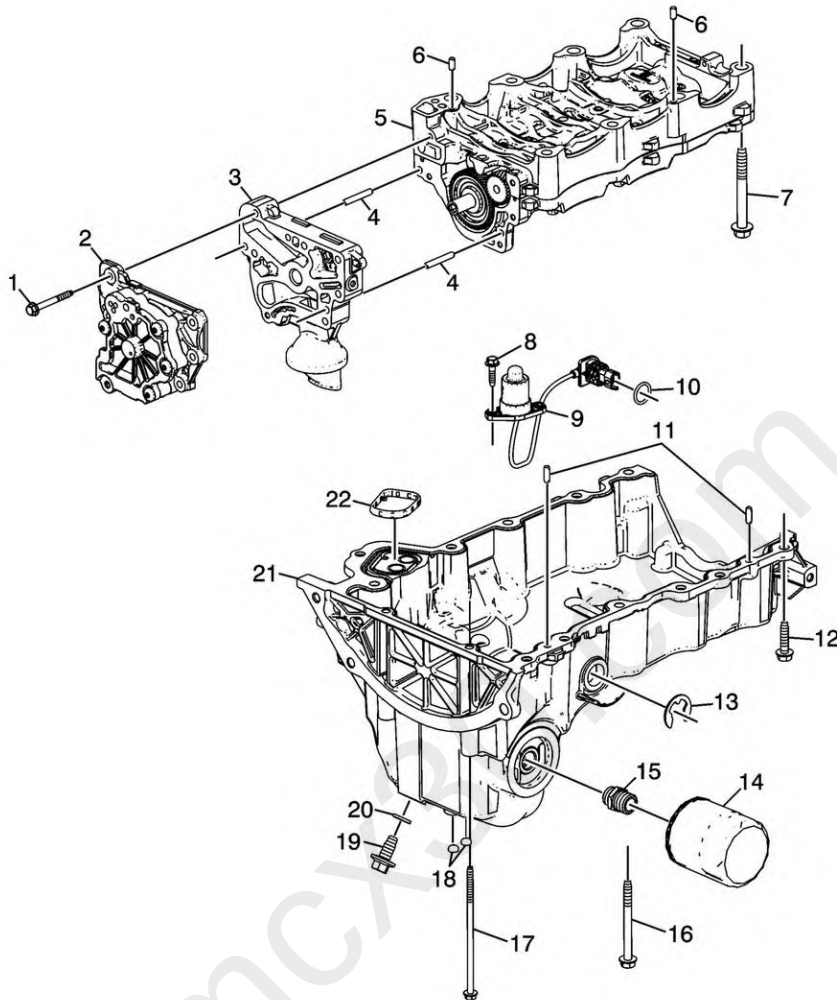


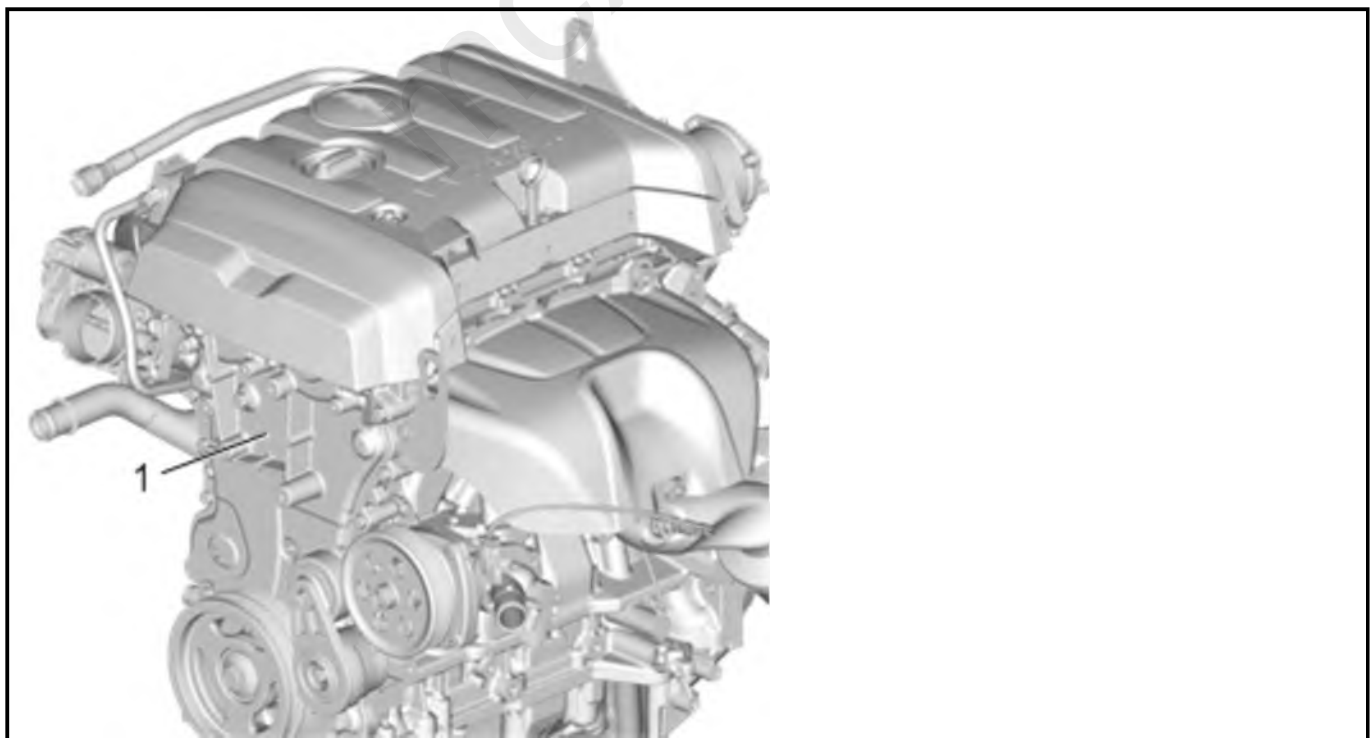
Fig. 7: Exploded View Of Oil Pan Components
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Pump Assembly Bolt (Qty: 7)
2	Oil Pump Assembly
3	Oil Pump Cover
4	Oil Pump Locating Pin (Qty: 2)
5	Balancer Shaft Module
6	Balancer Shaft Housing Locating Pin (Qty: 2)
7	Balancer Shaft Housing Bolt (Qty: 8)
8	Engine Oil Level Indicator Switch Bolt (Qty: 2)
9	Engine Oil Level Indicator Switch
10	Engine Oil Level Indicator O-ring Seal
11	Oil Pan Locating Pin (Qty: 2)
12	Oil Pan Bolt (Qty: 11)
13	Engine Oil Level Sensor Lead Clip

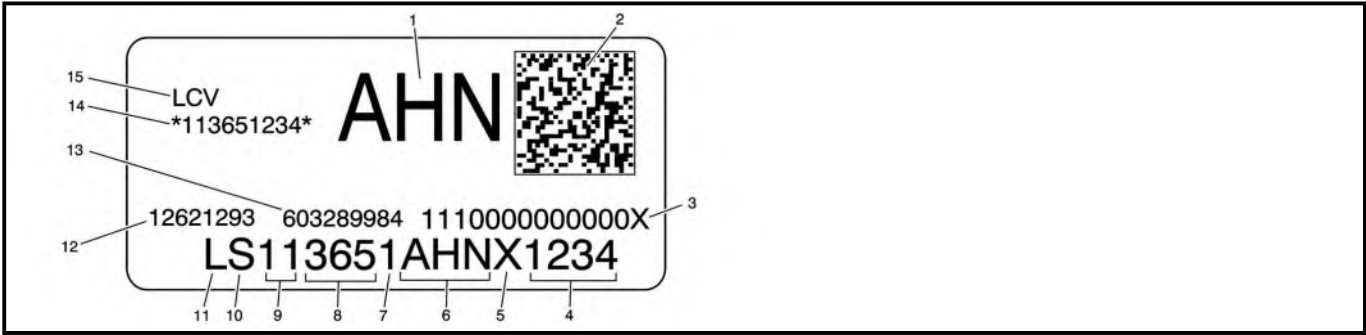
Callout	Component Name
9	Camshaft Bearing Cap Bolt
10	Timing Chain Guide Bolt
11	Camshaft Position Actuator Bolt
12	Intake Camshaft Position Actuator
13	Exhaust Camshaft Position Actuator
14	Camshaft Position Actuator Bolt
15	Timing Chain Oil Nozzle
16	Timing Chain Guide
17	Timing Chain Guide Bolt (Qty: 2)
18	Crankshaft Sprocket
19	Balancer Chain
20	Balancer Chain Tensioner Bolt (Qty: 2)
21	Balancer Chain Tensioner
22	Balancer Shaft Driven Sprocket
23	Balancer Shaft Sprocket Bolt
24	Balancer Chain Guide
25	Balancer Chain Guide Bolt (Qty: 2)
26	Drive Belt Tensioner
27	Drive Belt Tensioner Bolt
28	Engine Front Cover Bolt (Qty: 2)
29	Crankshaft Balancer Bolt
30	Crankshaft Balancer
31	Crankshaft Front Oil Seal
32	Engine Front Cover Bolt (Qty: 2)
33	Engine Front Cover Bolt (Qty: 1)
34	Engine Front Cover Bolt (Qty: 2)
35	Engine Front Cover Bolt (Qty: 13)

ENGINE IDENTIFICATION



Identification can be made through the use of the Engine Traceability label (1) on the engine.

IDENTIFICATION LABEL



Callout	Component Name
1	Broadcast Code
2	Machine Readable 2D Matrix
3	VPPS Code
4	Part Sequence Number
5	Reserved Use
6	Broadcast Code
7	Model Year
8	Julian Date
9	Build Year
10	Shift ID
11	Plant ID
12	GM Part Number
13	Plant DUNS Number
14	Sequence Number
15	RPO/Engine Family Code

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: [Diagnostic System Check - Vehicle](#)
- Review the description of Strategy Based Diagnosis: [Strategy Based Diagnosis](#)
- An overview of each diagnostic category can be found here: [Diagnostic Procedure Instructions](#)

DTC Descriptor

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P06DA, P06DB*	P06DA, P06DB	-	-
Control	P06DB	P06DA	P06DC	P06DD, P06DE
*Additional DTCs may set.				

Circuit/System Description

Circuit	Description
Ignition	Supplied from a fuse.
Control	The output circuit is switched to ground to activate the component.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
Q44 Engine Oil Pressure Control Solenoid Valve	A solenoid valve is an electro-mechanically operated valve. The valve is controlled by an electric current through the solenoid.

The engine oil pressure control solenoid valve is used to control engine oil pressure inside the mechanical engine oil pump. The control module controls the commanded state of the solenoid valve based on the following inputs:

- Engine Speed
- Calculated Engine Oil Temperature
- Engine Oil Pressure
- Engine Run Time

When the solenoid valve is commanded Off, oil pressure is higher. When the solenoid valve is commanded On, oil pressure is lower.

Conditions for Running the DTC

P06DA, P06DB, P06DC

- Engine = Running
- Ignition Voltage = Greater than 11 V

Frequency the DTC runs = Continuously - After the running conditions are met

P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229, P2230 = Not set
- Engine Speed = 1, 500 to 2, 500 RPM
- Engine = Running - For greater than 10 s
- Engine Oil Pressure Control Solenoid Valve = On - For greater than 1.5 s
- Engine Speed = 1, 350 to 2500 RPM

Frequency the DTC runs = Continuously - After the running conditions are met

P06DE

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229, P2230 = Not set
- Engine = Running - For greater than 10 s
- Engine Speed = 1, 300 to 2, 500 RPM
- Engine Oil Pressure Control Solenoid Valve = On - For greater than 1.5 s

Frequency the DTC runs = Continuously - After the running conditions are met

Conditions for Setting the DTC

P06DA, P06DB, P06DC

Control Circuit = Commanded state does not match the actual state - For greater than 1 s

P06DD

Engine Oil Pressure = Greater than a predefined threshold

P06DE

Engine Oil Pressure = Less than a predefined threshold

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category = Type B DTC - Exceptions listed below

DTC P06DB, P06DE = Type A DTC

- Engine Oil Pressure Control Solenoid Valve = Off
- Reduced Engine Power = Active

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category = Type B DTC - Exceptions listed below

DTC P06DB, P06DE = Type A DTC

Reference Information

Schematic Reference

Engine Mechanical Wiring Schematics

Connector End View Reference

Master Electrical Component List , or **Inline Harness Connector End Views - Index** or **Component Connector End Views - Index**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

NOTE: The engine oil level and condition is critical to the correct operation of the system.

1. Ignition - On / Vehicle - In Service Mode
2. Verify there are no DTCs set related to the following component/system:

- B35B Engine Oil Level Sensor
- B37 Engine Oil Pressure Switch
- B37B Engine Oil Pressure Sensor
- **If other DTCs are set**

Refer to [Diagnostic Trouble Code \(DTC\) List - Vehicle](#)

- **Go to next step: If no other DTCs are set**

3. Verify the condition does not exist: Engine Oil - Contaminated/Dirty/Fill Level = Low

- **If a condition exists**

Repair as necessary

- **Go to next step: If no condition exists**

4. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure - High Pressure

Verify the scan tool parameter:

- Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status = OK or Not Run
- Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run
- **If not the specified state**

Refer to: Circuit/System Testing

- **Go to next step: If the specified state**

5. Engine - Running @ 1, 800 to 2, 000 RPM

NOTE: Using the scan tool line graph function may make it easier to identify if the value changes.

6. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure = Change is greater than 30 kPa (4 PSI)

- **If the change is less than 30 kPa (4 PSI)**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If the change is greater than 30 kPa (4 PSI)**

7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Verify the DTC does not set.

- **If the DTC sets**

Refer to: Circuit/System Testing

- **Go to next step: If the DTC is not set**

8. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems - Off
 2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
 3. Ignition - On / Vehicle - In Service Mode
 4. Verify a test lamp turns On between the test points: Ignition circuit terminal 1/A & Ground
 - **If the test lamp does not turn On and the circuit fuse is OK**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Test for less than 2 ohms between the test points: Ignition circuit terminal 1/A & Output terminal @ Fuse
 - If 2 ohms or greater - Repair the open/high resistance in the circuit.
 - If less than 2 ohms - Verify the fuse is OK and there is voltage at the fuse.
 - **If the test lamp does not turn On and the circuit fuse is open**
 1. Ignition/Vehicle - Off & Remove - Test lamp
- NOTE:** The ignition circuit supplies voltage to other components. Test all circuits for a short to ground or test all components for being shorted.
2. Test for infinite resistance between the test points: Ignition circuit terminal 1/A & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance - Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
 - **Go to next step: If the test lamp turns On**
 5. Verify a test lamp does not turn On between the test points: Control circuit terminal 2/B & B+
 - **If the test lamp turns On**
 1. Ignition/Vehicle - Off & Remove - Test lamp
 2. Disconnect the electrical connector: K20 Engine Control Module
 3. Test for infinite resistance between the test points: Control circuit terminal 2/B @ Component harness & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance - Replace the component: K20 Engine Control Module
 - **Go to next step: If the test lamp does not turn On**
 6. Remove - Test Lamp
 7. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = OK or Not Run

- **If not the specified state**
 1. Ignition/Vehicle - Off
 2. Disconnect the electrical connector: K20 Engine Control Module
 3. Ignition - On / Vehicle - In Service Mode
 4. Test for less than 1 V between the test points: Control circuit terminal 2/B @ Component harness & Ground
 - If 1 V or greater - Repair the short to voltage on the circuit.
 - If less than 1 V - Replace the component: K20 Engine Control Module

- **Go to next step: If the specified state**

8. Connect a 3 A fused jumper wire between the test points: Control circuit terminal 2/B & Ignition circuit terminal 1/A
9. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status = Male function

- **If not the specified state**

1. Ignition/Vehicle - Off & Remove - Jumper wire(s)
2. Disconnect the electrical connector: K20 Engine Control Module
3. Test for less than 2 ohms between the test points: Control circuit terminal 2/B @ Component harness & The other end of the circuit @ Control module harness
 - If 2 ohms or greater - Repair the open/high resistance in the circuit.
 - If less than 2 ohms - Replace the component: K20 Engine Control Module

- **Go to next step: If the specified state**

10. Test or replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

Component Testing

Static Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Test for 10 to 30 ohms between the test points: Control terminal 2/B & Ignition terminal 1/A
 - **If not between 10 and 30 ohms**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
 - **Go to next step: If between 10 and 30 ohms**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
 - **If less than infinite resistance**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
 - **Go to next step: If infinite resistance**
5. All OK.

Dynamic Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Connect a 3 A fused jumper wire between the test points: Ignition terminal 1/A & 12 V

CAUTION: Complete the testing as quickly as possible in order to prevent overheating and damaging the component.

4. Momentarily connect a jumper wire between the test points: Control terminal 2/B & Ground

Verify the component turns On and Off when connecting and disconnecting the jumper wire: Q44 Engine Oil Pressure Control Solenoid Valve

- **If the component does not turn On and Off**

Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If the component turns On and Off**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: [Diagnostic Repair Verification](#)

- [Oil Pump Flow Control Valve Replacement](#) - Q44 Engine Oil Pressure Control Solenoid Valve
- For control module replacement, programming, and setup refer to [Control Module References](#)

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the [Diagnostic System Check - Vehicle](#) before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to [Disassembled Views](#), or [Engine Component Description](#), or [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 condition. 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 Noise on Start-Up, but Only Lasting a Few Seconds](#)
- [Upper Engine Noise, Regardless of Engine Speed](#)
- [Lower Engine Noise, Regardless of Engine Speed](#)
- [Engine Noise Under Load](#)
- [Engine Will Not Crank - Crankshaft Will Not Rotate](#)
- [Engine Compression Test](#)
- [Oil Consumption Diagnosis](#)
- [Oil Pressure Diagnosis and Testing](#)
- [Oil Leak Diagnosis](#)

- [Drive Belt Chirping, Squeal, and Whine Diagnosis](#)
- [Drive Belt Rumbling and Vibration Diagnosis](#)
- [Drive Belt Falls Off and Excessive Wear Diagnosis](#)
- [Drive Belt Tensioner 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 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.
A 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 heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, 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	Replace the intake manifold.
Worn or loose 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.
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 and valve lash adjusters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace the oil pump as required. • Replace the oil control valve solenoid as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads 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 heads, engine block, and/or head gaskets. • Repair or replace as required.

Cause	Correction
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	Replace the crankshaft and bearings as required.

Cause	Correction
and/or thrust bearing may permit fore and aft movement of the crankshaft, and create a DTC without an actual misfire condition.	

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose 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 to not 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 roller finger followers.
Sticking valve lash adjusters	Replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to Oil Pressure Diagnosis and Testing. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to Camshaft Position Actuator and Intake Camshaft Replacement, or Camshaft Position Actuator and Exhaust Camshaft Replacement.

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.

Cause	Correction
	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.
High valve lash adjuster leak down rate	Replace the lash adjusters as required.
Worn crankshaft thrust bearing	1. Inspect the thrust bearing and crankshaft. 2. Repair or replace as required.
Damaged or faulty oil filter by-pass valve	1. Inspect the oil filter by-pass valve for proper operation. 2. Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to Oil Pressure Diagnosis and Testing. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to Camshaft Position Actuator and Intake Camshaft Replacement, or Camshaft Position Actuator and Exhaust Camshaft Replacement.

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 valve rocker arm	Replace the valve rocker arm.
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: - The valve rocker arm - The valve lifter - The oil filter bypass valve - 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, damaged, or faulty timing chain tensioners	Replace tensioners

Cause	Correction
Worn engine camshaft lobes	- Inspect the engine camshaft lobes. - Replace the camshaft and valve lash adjusters 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.
Damaged oil pan, contacting the oil pump screen - an oil pan that has been damaged, may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	- Inspect the oil pan. - Inspect the oil pump screen. - Repair or replace as required.
Oil pump screen loose, damaged or restricted	- Inspect the oil pump screen. - 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.

Cause	Correction
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin, and connecting rod installation - pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. Refer to Symptoms - Engine Controls .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair as required.
Cracked flywheel, automatic transmission	1. Inspect the flywheel bolts and flywheel. 2. 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
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to Oil Pressure Diagnosis and Testing.

Cause	Correction
	2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to Camshaft Position Actuator Intake Solenoid Valve Replacement , or Camshaft Position Actuator Exhaust Solenoid Valve Replacement .

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder - Coolant/antifreeze in cylinder - Oil in cylinder - Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Inspect for cracked cylinder wall.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	1. Inspect timing chain and gears. 2. Repair as required.
Seized balance shaft	1. Inspect balance shaft. 2. Repair as required.
Material in cylinder - Broken valve - Piston material - Foreign material - Cracked cylinder wall	1. Inspect cylinder for damaged components and/or foreign materials. 2. Inspect for fallen cylinder wall. 3. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Inspect for fallen cylinder wall. 3. Repair as required.
Bent or broken connecting rod	1. Inspect connecting rods.

Cause	Correction
	2. Repair as required.
Broken crankshaft	1. Inspect crankshaft. 2. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. NOTE: While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in cooling system. It is important to follow the kit instructions. This is not a substitute for service information. Combustion leak tests are available from a wide variety of aftermarket suppliers. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection , or Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.

Cause	Correction
Cylinder head or block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

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

ENGINE COMPRESSION TEST

Special Tools

EN-51749 Compression Gauge Tester Kit

Equivalent regional tools: [Special Tools](#)

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

NOTE: The battery must be at or near full charge.

1. Connect a battery charger to the battery for the duration of the test to maintain an adequate battery level.
2. Engine OFF.
3. Remove the ignition coils and spark plugs from all cylinders. Refer to [Gas Engine Ignition Spark Plug Replacement](#).
4. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.
5. Measure the engine compression, using the following procedure:
 1. Install the EN-51749 adapter into the spark plug hole.
 2. Install the EN-51749 gauge into the EN-51749 adapter.

NOTE: When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.

3. Enable cranking via the GDS2 or remote start switch. When using a remote start switch, crank the engine for four compression strokes. Record the reading after the cranking cycle completes.

4. Repeat the compression test for each cylinder.
6. Compare the compression readings from all of the cylinders.
 - The lowest reading should not be less than 70 percent of the highest reading.
 - No cylinder should read less than 690 kPa (100 psi).
 - For example, if the highest pressure in any 1 cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1035 \times 70\% = 725$) ($150 \times 70\% = 105$).
7. The following are indicators of potential problems:
 - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
 - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
 - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
8. Disconnect GDS2 diagnostic tool or remote start switch.
9. Install the spark plugs for all cylinders. Refer to [Gas Engine Ignition Spark Plug Replacement](#).
10. Install the ignition coils for all cylinders. Refer to [Ignition Coil Replacement](#).

CYLINDER LEAKAGE TEST

Special Tools

EN 35667-A Cylinder Head Leakdown Tester

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

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

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

WARNING: Unless directed otherwise, the ignition must be OFF with the key removed, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStarB® (UE1) with Back Up Battery:

The Back Up Battery is a redundant power supply to allow limited OnStarB® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStarB® module). Do not disconnect the main vehicle battery or remove the OnStarB® fuse with the ignition key in any position other than OFF. Retained accessory power should be allowed to time out or be disabled

(simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStarB® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStarB® Back-Up Battery system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The back-up battery is not rechargeable and once activated the back-up battery must be replaced.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to [Gas Engine Ignition Spark Plug Replacement](#) in Engine Controls.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install the EN 35667-A tester or equivalent.

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

5. Apply shop air pressure to the EN 35667-A tester and adjust according to the manufacturers instructions.
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 body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
 - Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
 - Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
 - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 0.9 L (1 qt) or greater of engine oil within 3 200 kilometers (2, 000 miles). The causes of excessive oil consumption include the following conditions:

- External oil leaks

Tighten bolts and/or replace gaskets and oil seals as necessary.

- Incorrect oil level or improper reading of oil level indicator

With the vehicle on a level surface, allow adequate drain down time and inspect for the correct oil level.

- Improper oil viscosity

Use recommended SAE viscosity for the prevailing temperatures.

- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, or the seal omitted

Ream guides and install oversize service valves and/or new valve stem oil seals.

- Piston rings broken, improperly installed, worn, or not seated properly

Allow adequate time for rings to seat. Replace broken or worn rings, as necessary.

- Piston improperly installed or mis-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-21867-850** Oil Pressure Gauge Adapter
- **GE-21867-A** Oil Pressure Gauge Kit

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

1. With the vehicle on a level surface, allow adequate drain down time of 2 - 3 minutes and measure for a low oil level.

Add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.

2. Run the engine, and verify low, or no oil pressure on the vehicle gauge or light.

Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:

- Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
- Oil diluted by moisture or unburned fuel mixtures
- Improper oil viscosity for the expected temperature
- Incorrect or malfunctioning oil pressure sender
- Incorrect or malfunctioning oil pressure gauge
- Plugged oil filter
- Malfunctioning oil bypass valve

4. Remove the oil pressure sender or another engine block oil gallery plug.

5. Install **EN-21867-850** adapter and **GE-21867** gauge and measure the engine oil pressure.

6. Compare the readings to specifications. Refer to [Engine Mechanical Specifications](#).

7. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:

- Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
- Oil pump worn or dirty

Refer to [Balancer Shaft with Oil Pump Cleaning and Inspection](#).

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Malfunctioning oil control valve solenoid
- Excessive bearing clearance

Refer to [Crankshaft and Bearing Cleaning and Inspection](#).

- Cracked, porous or restricted oil galleries
- Oil gallery plugs missing or incorrectly installed

Refer to [Engine Block Assemble](#).

- Broken lash adjusters

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
DEFINITION: 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.			

Step	Action	Yes	No
Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to Engine Mechanical Specifications. 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 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, for example, baby powder or foot powder, to the suspected area. 3. Operate the vehicle for several 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.	Go to Step 10	Go to Step 7

Step	Action	Yes	No
	Can you identify the type of fluid and the approximate location of the leak?		
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 EN 28428-E Dye and Light Kit, in order to identify the type of fluid, and the approximate location of the leak. 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 interest 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. Did you complete the repair?	Go to Step 1	-

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Special Tools

EN 23951 Valve Manometer

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

1. Verify clean air cleaner.
2. Verify oil fill cap is in place.
3. Verify oil level indicator is installed.
4. Remove the oil level indicator. Install a **EN 23951** valve manometer or equivalent into the oil level indicator hole.
5. Start the engine.
6. Check for slight vacuum. The vacuum level should be less than 1 in H₂O.
7. If vacuum is higher, inspect and verify that the clean air hose from cam cover to air intake is not blocked or kinked.
8. If vacuum is in the normal range, remove PCV line from fresh air valve near the oil fill cap. Block the fresh air valve and also plug the fresh air hose. Vacuum should increase on the manometer. If held too long, vacuum will be drawn through the crankshaft seals creating a sucking sound.
9. If vacuum does not increase, the orifice between the camshaft cover assembly and the cylinder head assembly could be plugged.
10. If there is zero vacuum or pressure, verify compression of the engine.
11. If compression is normal, check for a blocked orifice between the camshaft cover assembly and the cylinder head assembly. Clean the orifice.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

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

2

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

3

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

4

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

6

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a

previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

10

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

12

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

14

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

15

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

16

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

17

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

19

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

Step	Action	Yes	No
CAUTION: Refer to Belt Dressing Caution .			
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.			

Step	Action	Yes	No
	- The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: - A high pitched continuous noise. - The noise may be caused by an accessory drive component failed bearing.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
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	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component.	Go to Step 20	Go to Step 14

Step	Action	Yes	No
	If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?		
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Replacement . 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 AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

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.

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

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.

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
CAUTION: Refer to Belt Dressing Caution . DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: • Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove • The separation of the drive belt • A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s).	Go to Symptoms - Engine Mechanical or Vibration Analysis - Engine	Go to Step 4

Step	Action	Yes	No
	Does the rumbling or vibration still exist?		
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	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener 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 (LCV) , or Water Pump Replacement (LWN) , or Water Pump Replacement (LGZ) . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2

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

4

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 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 too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

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
CAUTION: Refer to Belt Dressing Caution . 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.			

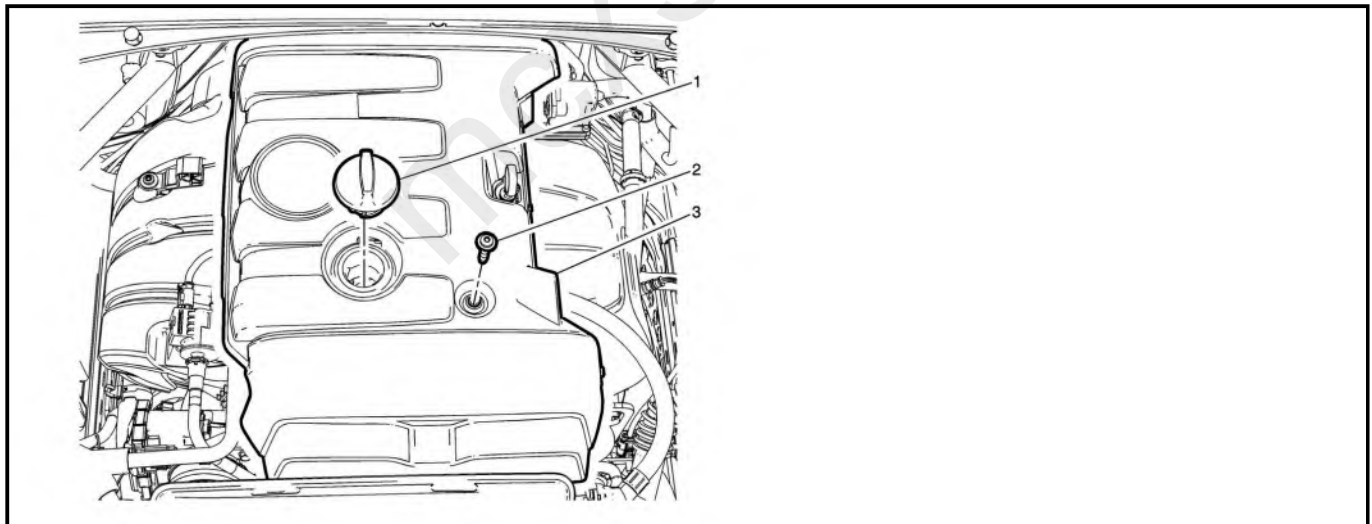
Step	Action	Yes	No
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical .
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the 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	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener 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 Replacement . 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

Step	Action	Yes	No
1	1. Remove the drive belt. Refer to Drive Belt Replacement . 2. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 6	Go to Step 2
2	Rotate the drive belt tensioner pulleys. Do the pulleys rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 6
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	Go to Step 4	Go to Step 6
4	Inspect tensioner for indication of oil leaks. Does it show signs of oil leaking?	Go to Step 6	Go to Step 5
5	Remove top tensioner bolt, above hydraulic tensioner and verify tensioner assembly moves about center pivot by applying light force. Does the tensioner ASM move without binding?	System OK	Go to Step 6
6	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS

INTAKE MANIFOLD COVER REPLACEMENT

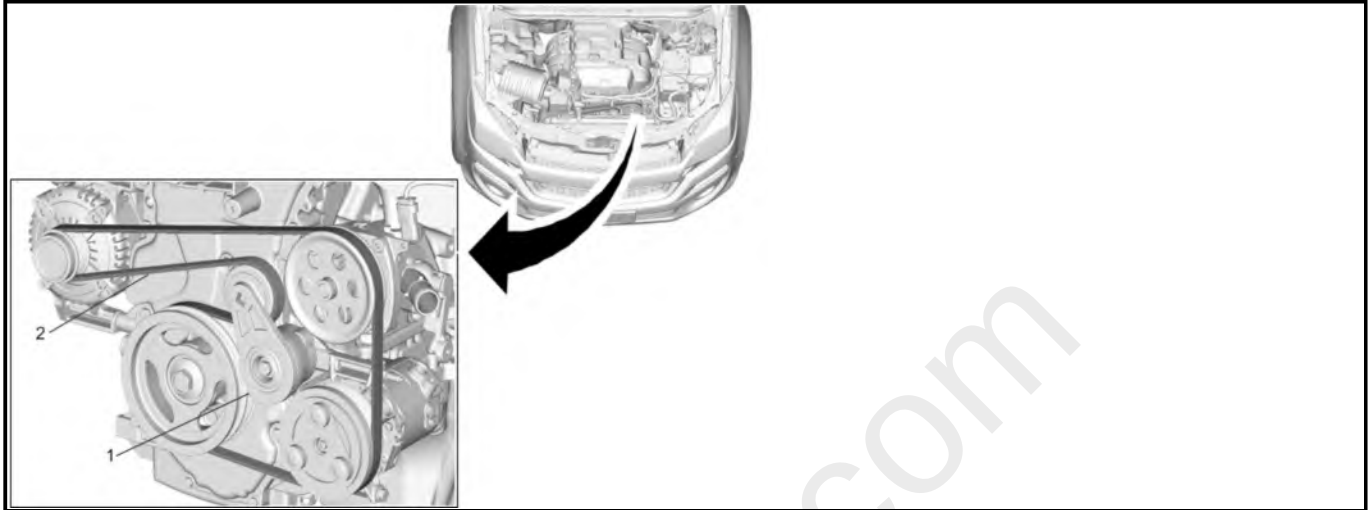


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Air Cleaner Outlet Duct Replacement	
1	Oil Cap
2	Intake Manifold Cover Fastener
CAUTION:	

Callout	Component Name
	Refer to <u>Fastener</u> <u>Caution</u> . Tighten 9 N.m (80 lb in)
3	Intake Manifold Cover

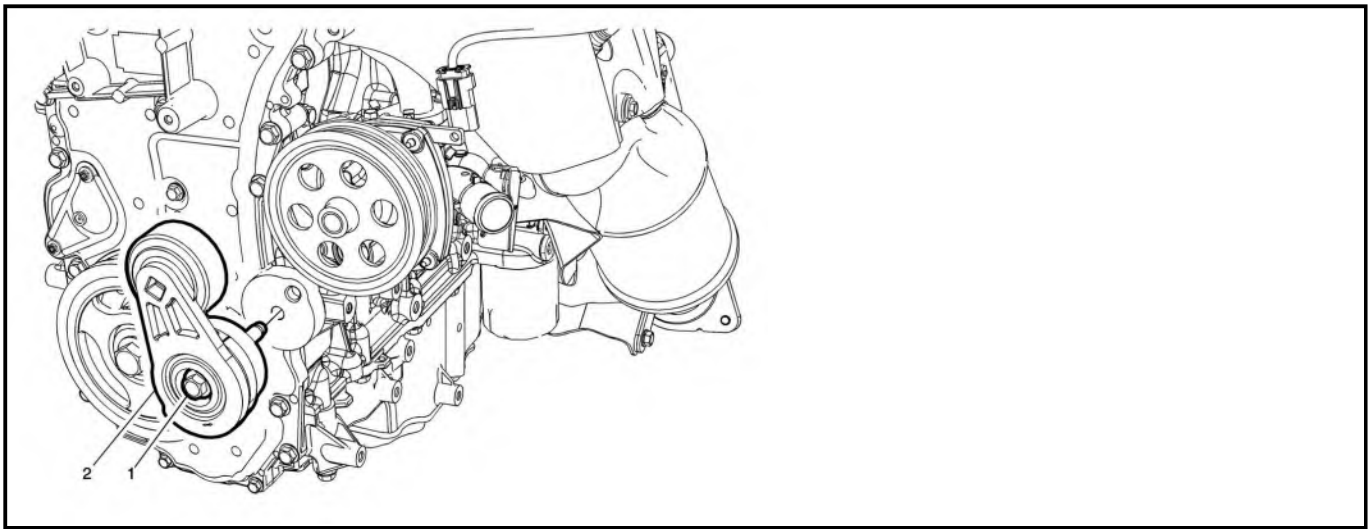
DRIVE BELT REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Air Cleaner Outlet Duct Replacement</u>	
1	Drive Belt Tensioner Procedure Use the proper tool to rotate the drive belt tensioner.
2	Drive Belt Procedure 1. Remove the drive belt from the pulleys and tensioner. 2. Clean and inspect the drive belt surfaces of all the pulleys. 3. Inspect the drive belt for correct alignment.

DRIVE BELT TENSIONER REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Remove the drive belt. Refer to Drive Belt Replacement .	
1	Drive Belt Tensioner Fastener CAUTION: Refer to Fastener Caution . Tighten 58 N.m (43 lb ft)
2	Drive Belt Tensioner

ENGINE MOUNT INSPECTION

CAUTION: 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.

CAUTION: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

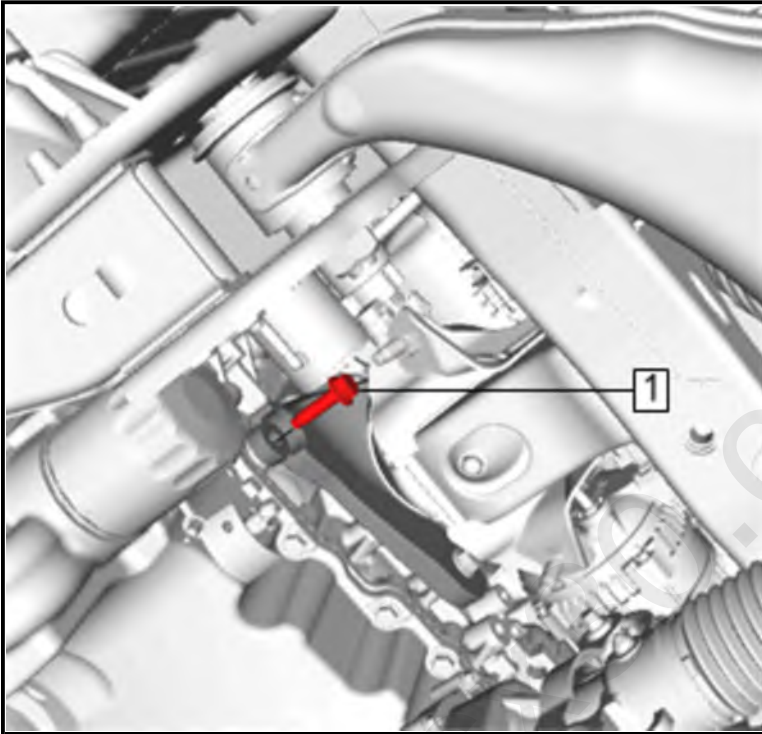
1. Measure the engine movement at the engine mount in order to inspect for damage to the rubber portions of the mount.
 1. Apply the park brake.
 2. Start the engine.
 3. Firmly apply and hold the primary brakes.
 4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
 5. Slightly load the engine shifting from drive to reverse a few times.
 6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, inspect for loose engine mount bolts.
2. If the engine mount bolt torque is within specifications, inspect the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:

- Heat check cracks cover the rubber cushion surface.
- The rubber cushion is separated from the metal plate of the mount.
- There is a split through the rubber cushion.

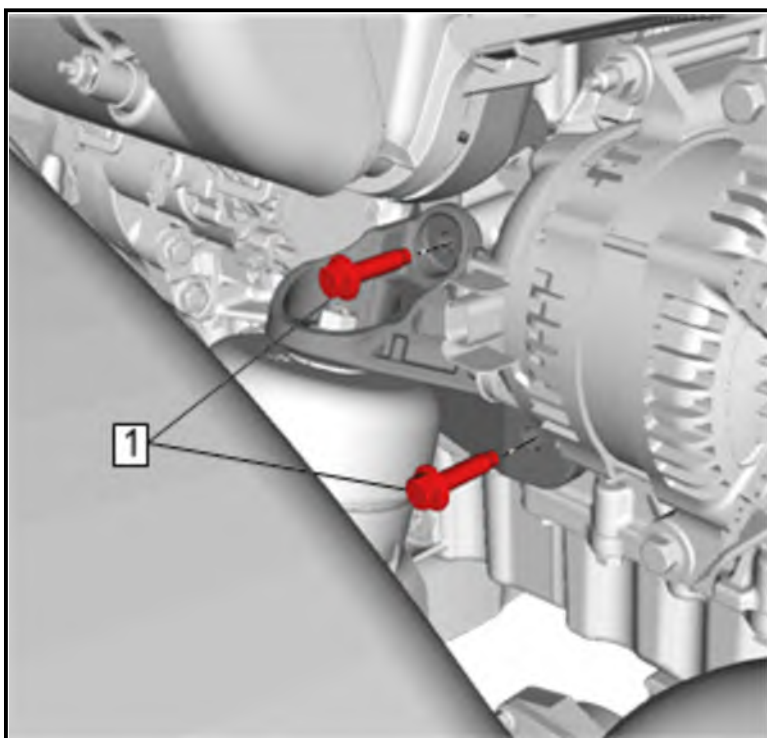
ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

Removal Procedure

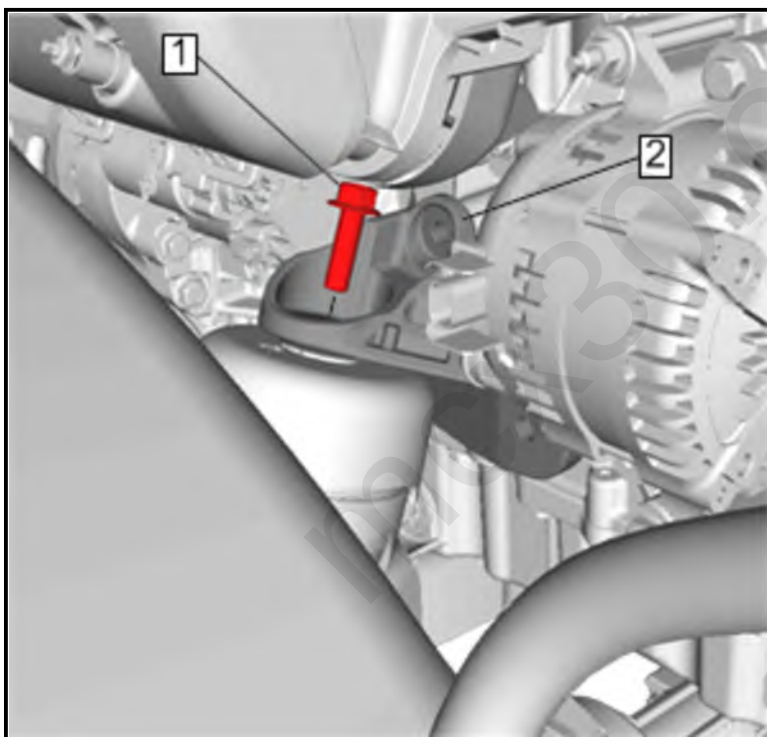
1. Remove the air cleaner assembly. Refer to [Air Cleaner Assembly Replacement](#) .
2. Install the engine support fixture. Refer to [Engine Support Fixture](#).
3. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .
4. Remove and DISCARD the lower engine mount bracket fastener (1).



5. Lower the vehicle.
6. Remove and DISCARD the upper engine mount bracket fasteners (1).

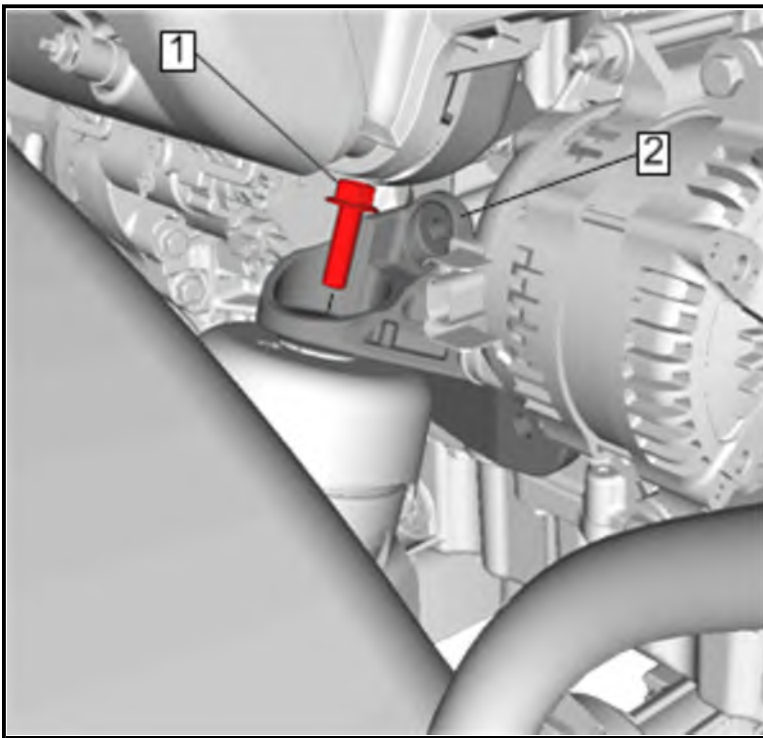


7. Remove the engine mount to bracket fastener (1) then remove the engine mount bracket (2).



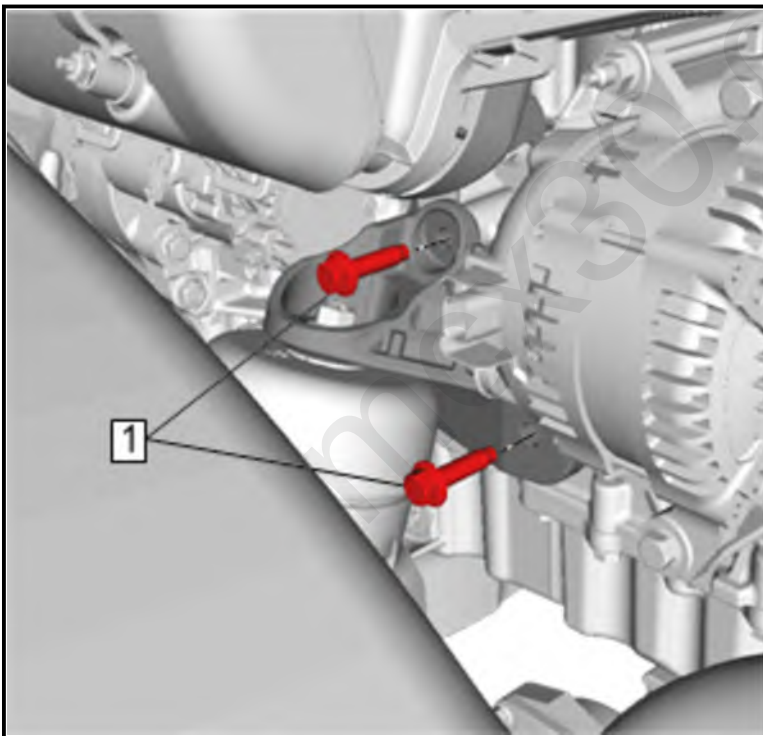
Installation Procedure

1. Position the engine mount bracket (2) then hand start the engine mount to bracket bolt (1). Tighten bolt (1) to 100 N.m (74 lb ft).

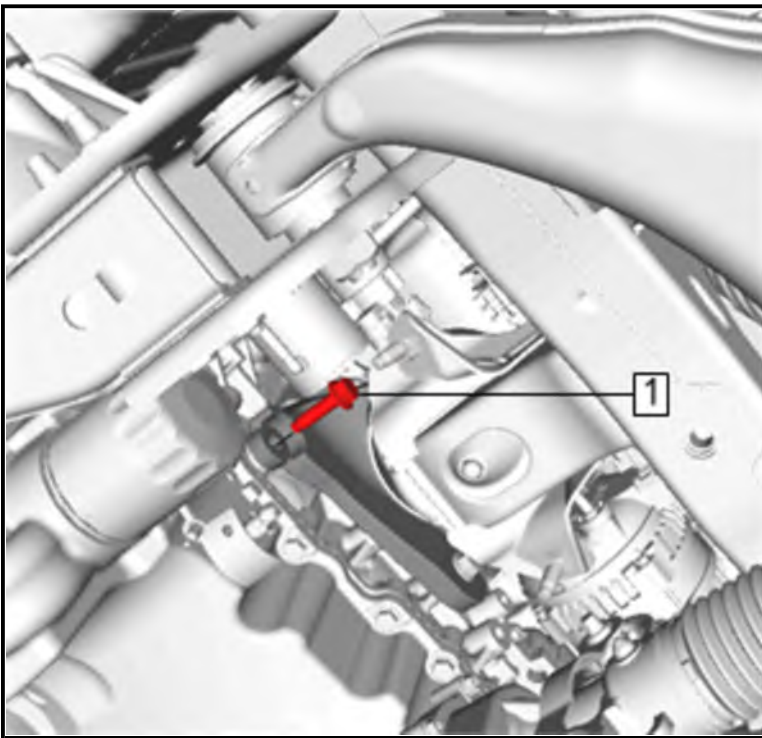


CAUTION: Refer to [Fastener Caution](#) .

2. Install NEW upper engine mount bracket fasteners (1). Tighten to 60 N.m (44 lb ft) plus 75 degrees.



3. Raise the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .
4. Install a NEW lower engine mount bracket fastener (1). Tighten to 60 N.m (44 lb ft) plus 75 degrees.

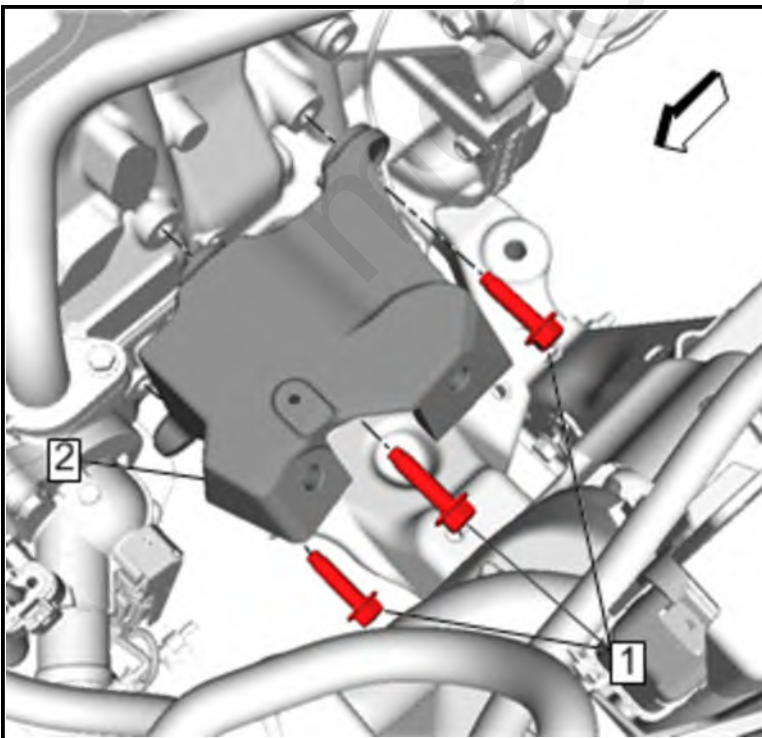


5. Lower the vehicle.
6. Remove the engine support fixture. Refer to [Engine Support Fixture](#).
7. Install the air cleaner assembly. Refer to [Air Cleaner Assembly Replacement](#).

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE

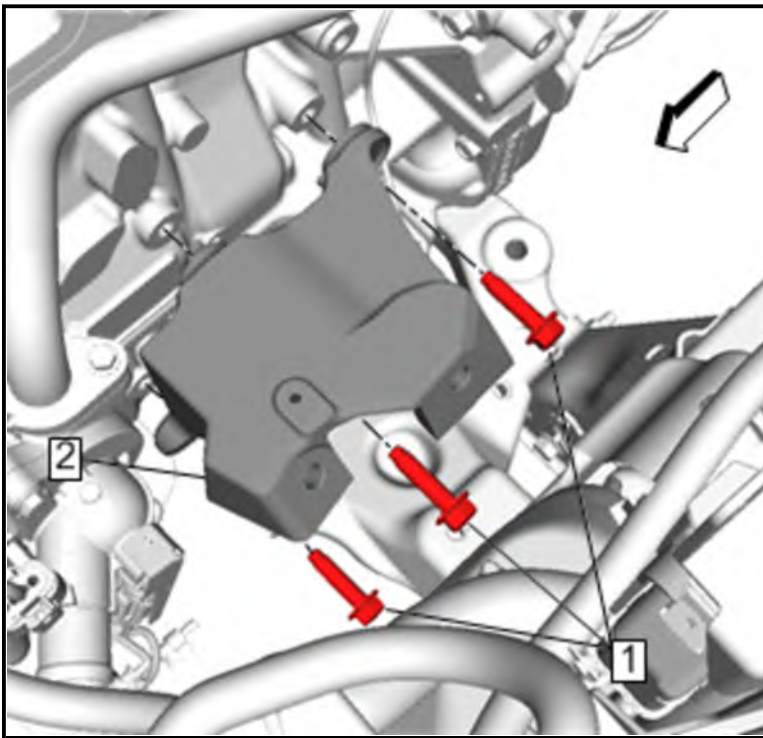
Removal Procedure

1. Remove the engine mount. Refer to [Engine Mount Replacement - Left Side](#).
2. Remove the engine mount bracket fasteners (1), then remove the engine mount bracket (2).



Installation Procedure

1. Position the engine mount bracket (2) then install NEW engine mount bracket fasteners (1). Tighten to 60 N.m (44 lb ft) plus 75 degrees.



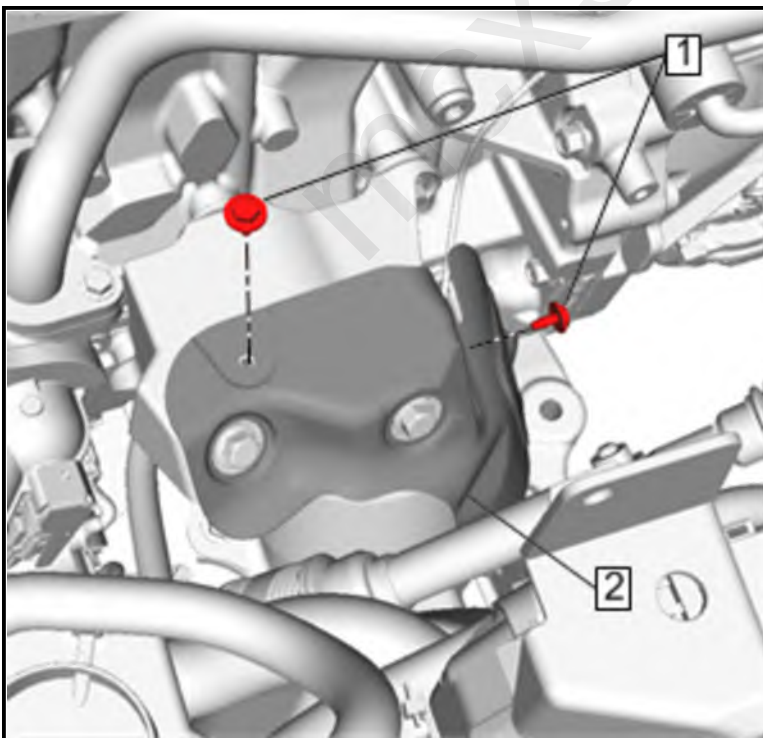
CAUTION: Refer to [Fastener Caution](#) .

2. Install the engine mount. Refer to [Engine Mount Replacement - Left Side](#).

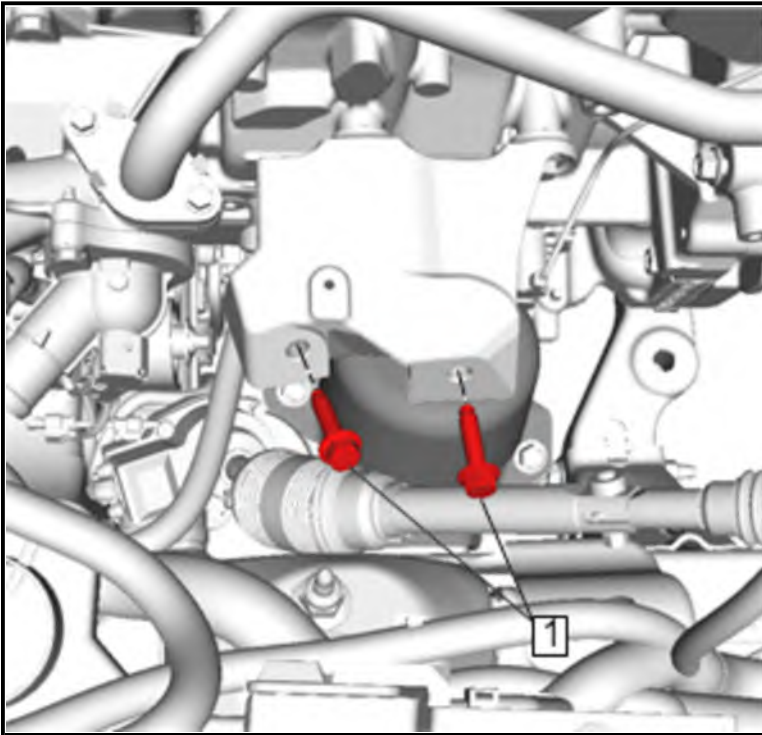
ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

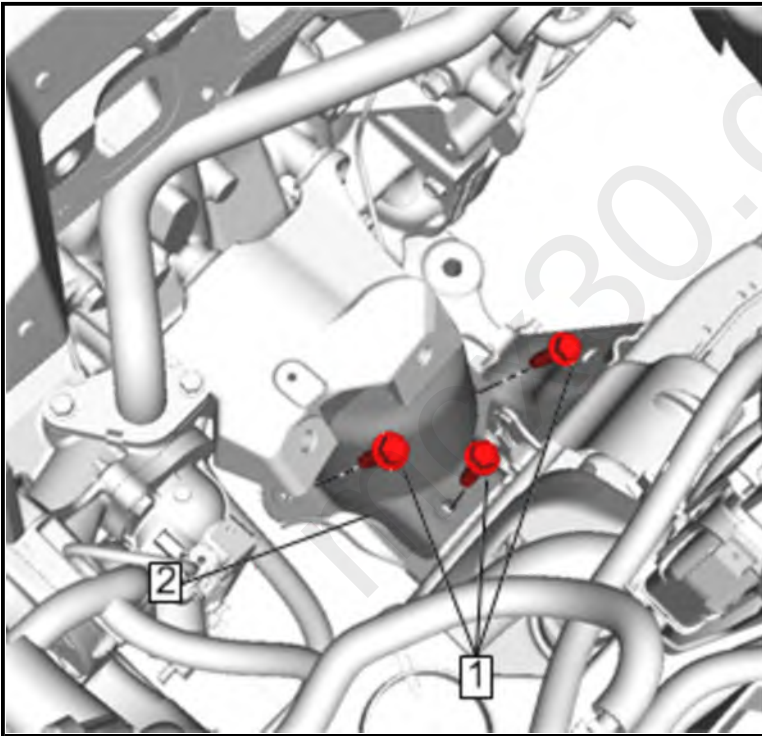
1. Remove the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LCV\)](#) , or [Exhaust Manifold Replacement \(LWN\)](#) .
2. Remove the engine mount heat shield fasteners (1), then remove the heat shield (2).



3. Install the engine support fixture. Refer to [Engine Support Fixture](#).
4. Remove and DISCARD the engine mount to engine mount bracket fasteners (1).

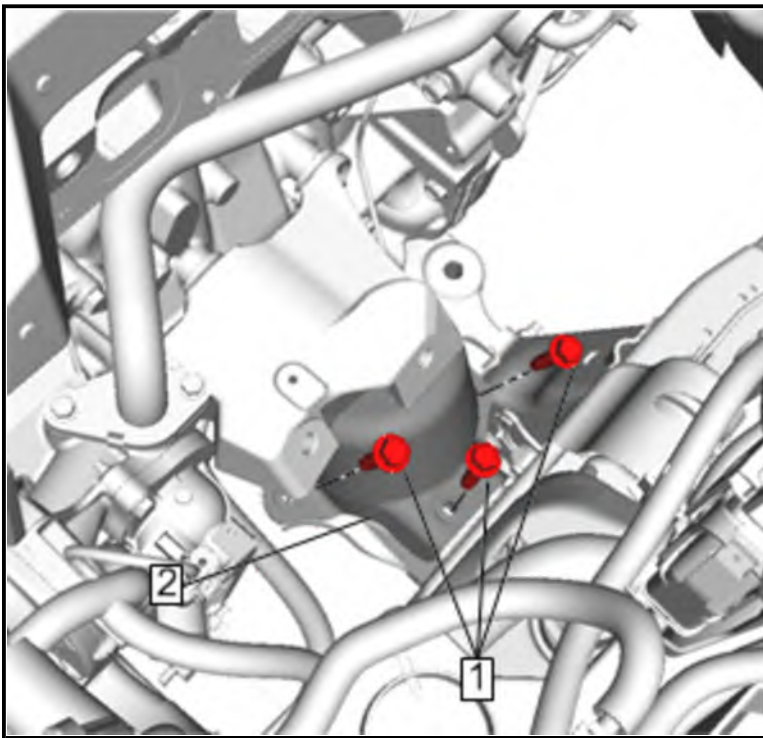


5. Remove the engine mount to frame fasteners (1), then remove the engine mount (2).



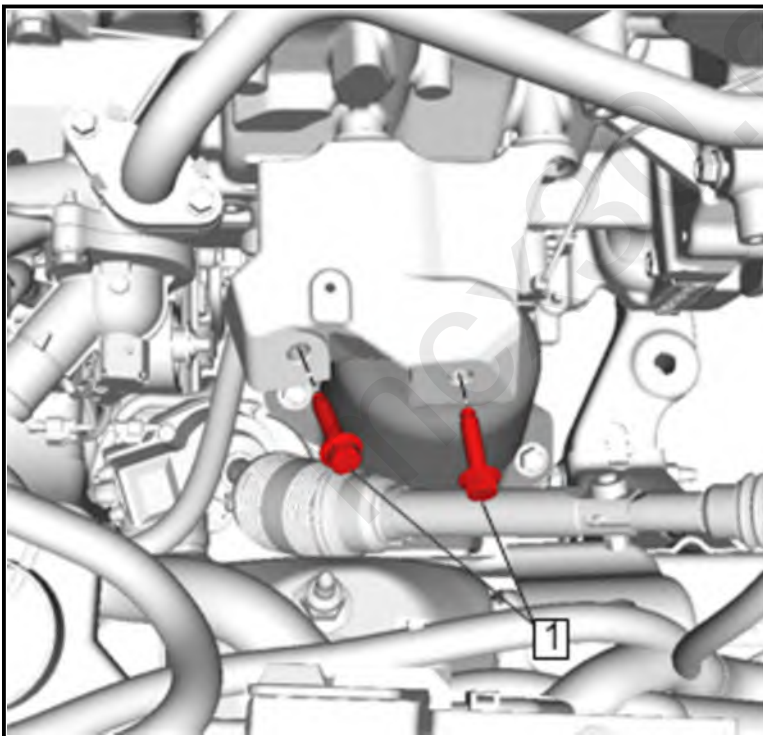
Installation Procedure

1. Position the engine mount (2), then install the engine mount to frame fasteners (1). Tighten to 58 N.m (43 lb ft).

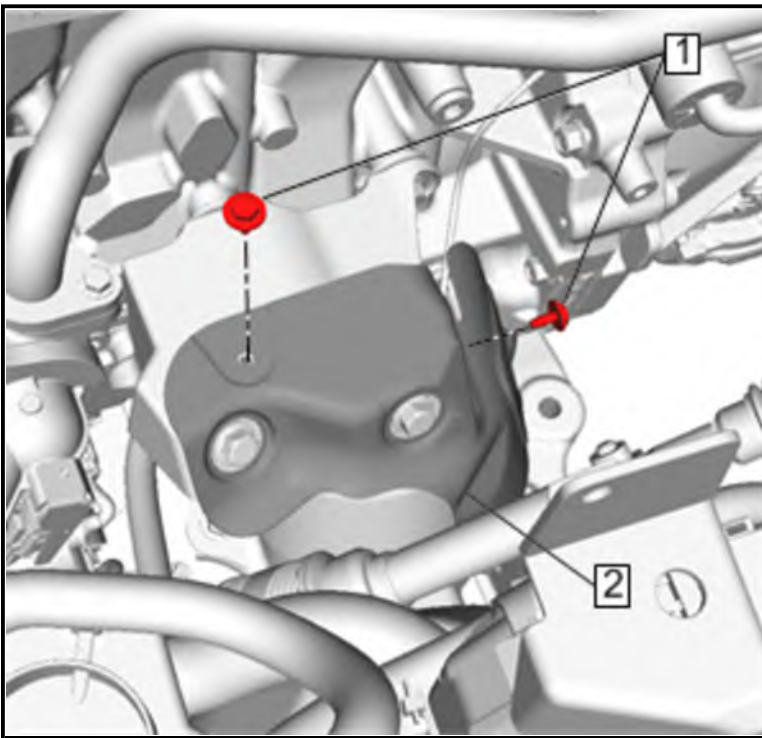


CAUTION: Refer to [Fastener Caution](#) .

2. Install NEW engine mount to engine mount bracket fasteners (1). Tighten to 60 N.m (44 lb ft) plus 75 degrees.



3. Position the engine mount heat shield (2), then install the fasteners (1). Tighten to 9 N.m (80 lb in).

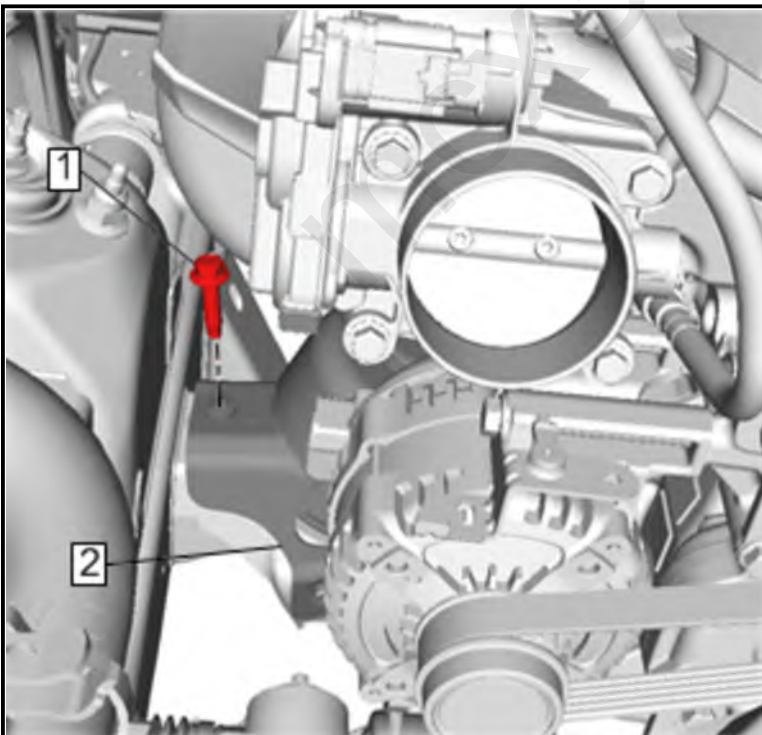


4. Remove the engine support fixture. Refer to [Engine Support Fixture](#).
5. Install the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LCV\)](#) , or [Exhaust Manifold Replacement \(LWN\)](#) .

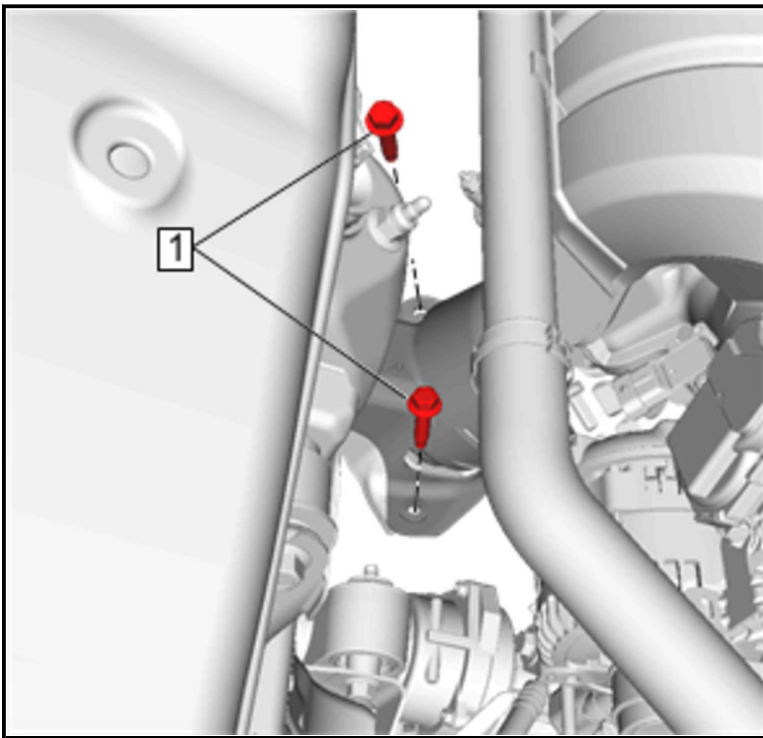
ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Remove the engine mount bracket. Refer to [Engine Mount Bracket Replacement - Right Side](#).
2. Remove the engine mount to body fastener (1).

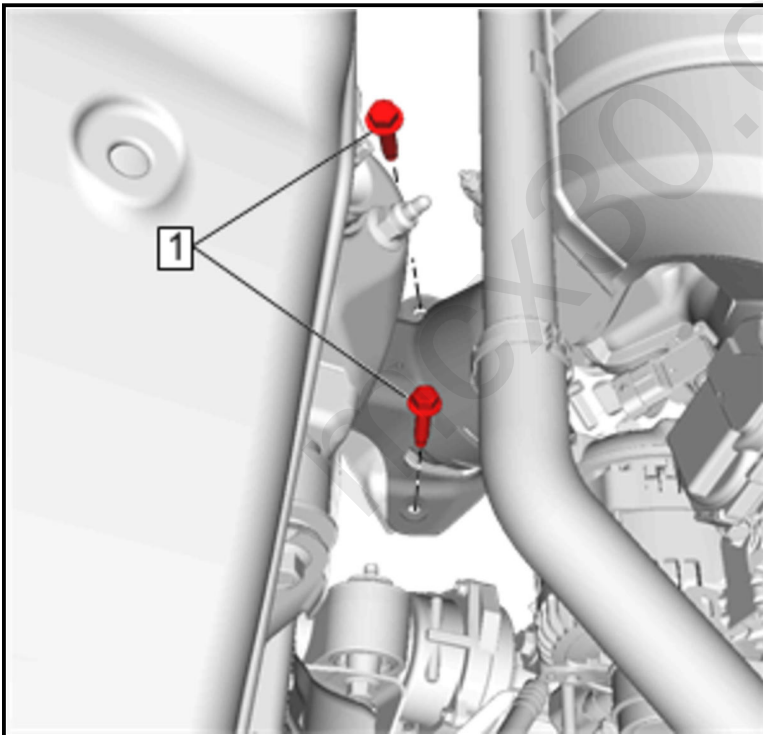


3. Remove the remaining two engine mount to body fasteners (1) then remove the engine mount.



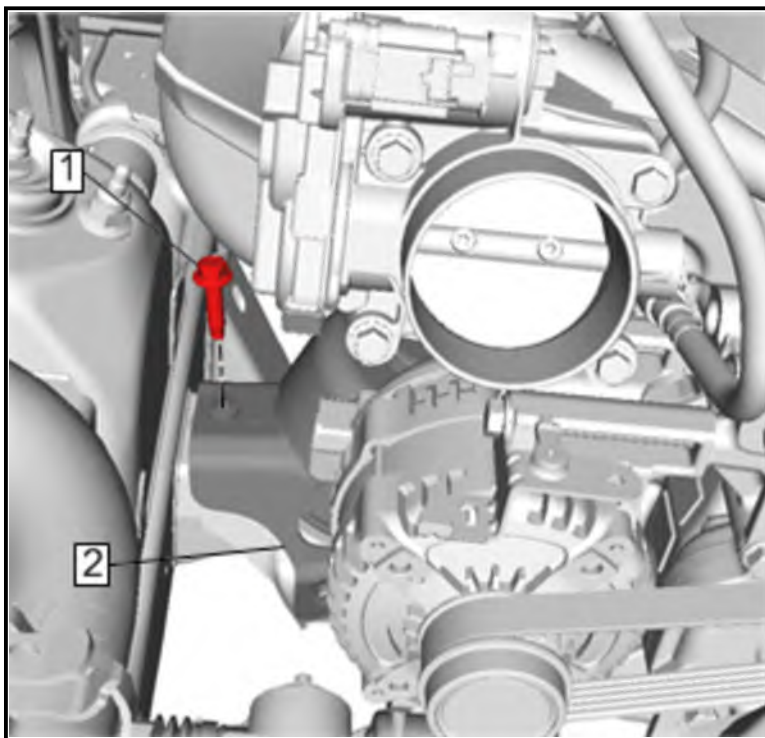
Installation Procedure

1. Install the engine mount.



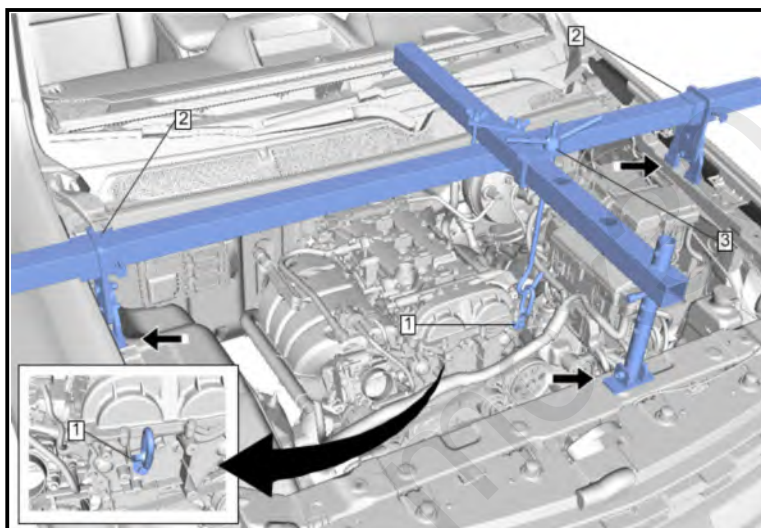
CAUTION: Refer to [Fastener Caution](#) .

2. Hand start the two engine mount to body fasteners (1). Tighten to 60 N.m (44 lb ft).
3. Install the remaining engine mount to body fastener (1). Tighten to 60 N.m (44 lb ft).



4. Install the engine mount bracket. Refer to [Engine Mount Bracket Replacement - Right Side](#).

ENGINE SUPPORT FIXTURE

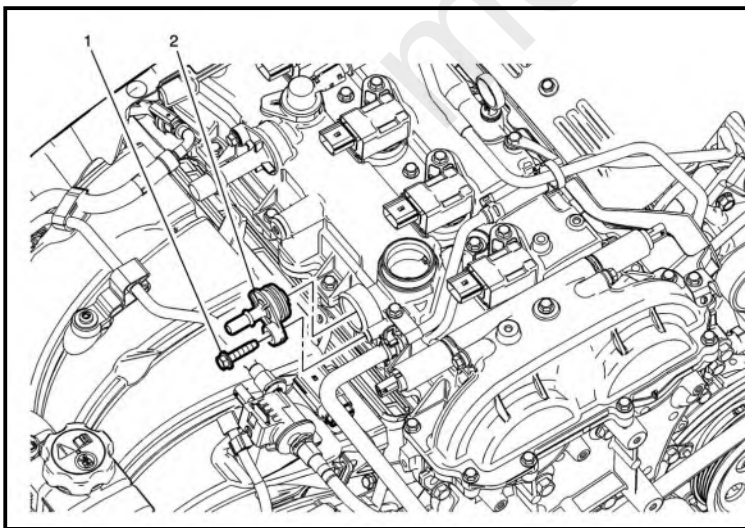


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures	
1. Intake manifold cover. Refer to Intake Manifold Cover Replacement .	
2. Remove the left and right side front compartment sight shields. Refer to Front Compartment Side Sight Shield Replacement .	
Special Tools	
• EN-51007 Engine Support Fixture • J-36857 Engine Lift Bracket	
For equivalent regional tools, refer to Special Tools .	
1	Engine Lift Brackets Procedure

Callout	Component Name
	NOTE: The engine support fixture and lift brackets can be repositioned to lift either side of the engine. Install and reposition the lift brackets and support fixture as needed.
2	Support Brackets Procedure NOTE: Ensure that the engine support fixture only contacts the frame in the area indicated by arrows. Install the brackets to frame as shown. Do not install on top of fender lip.
3	Support Handle Procedure Tighten the handle to raise the engine as needed.

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT (FRONT)

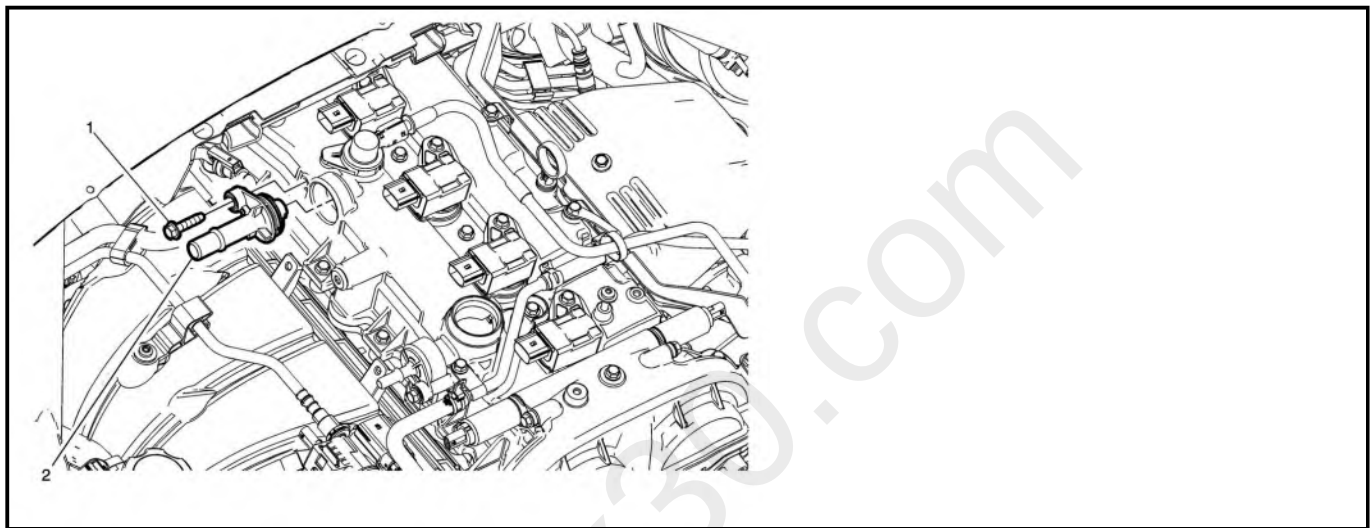


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Disconnect the positive crankcase ventilation hose/pipe. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.	

Callout	Component Name
1	Positive Crankcase Ventilation Valve Fastener CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Positive Crankcase Ventilation Valve Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.

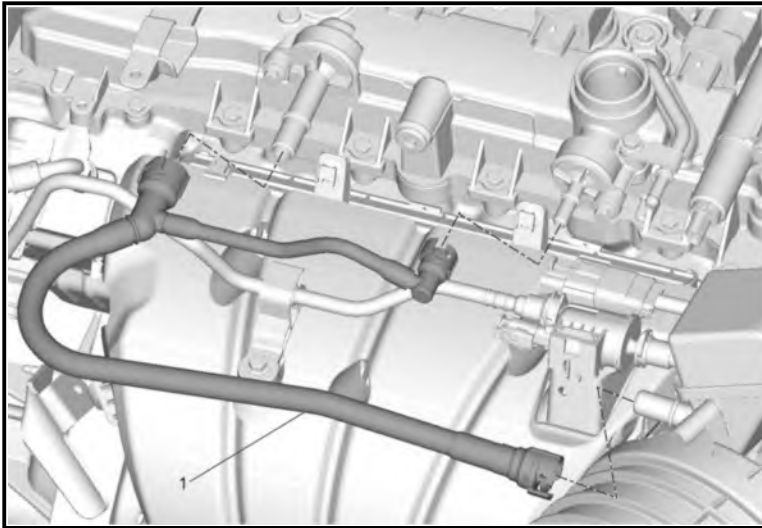
POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT (REAR)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Disconnect the positive crankcase ventilation hose/pipe. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement .	
1	Positive Crankcase Ventilation Valve Fastener CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Positive Crankcase Ventilation Valve Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT



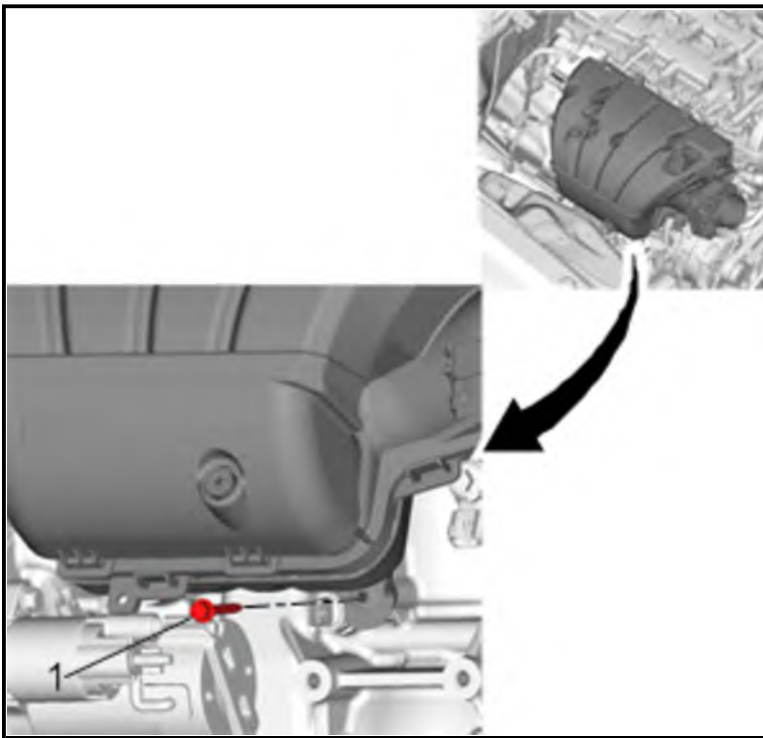
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .	
1	Positive Crankcase Ventilation Hose Procedure Disconnect the Positive Crankcase Ventilation Hose. Refer to Plastic Collar Quick Connect Fitting Service .

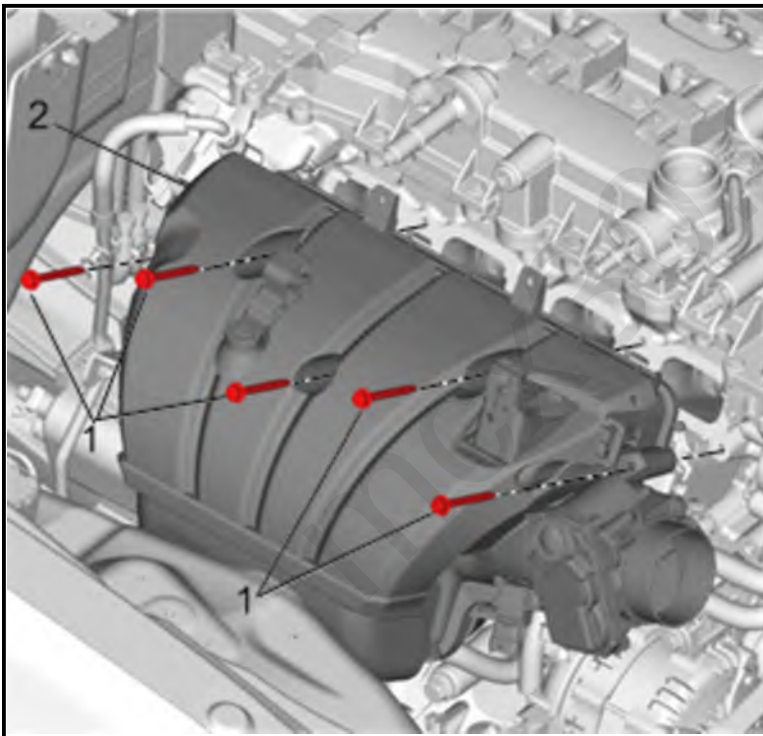
INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove the positive crankcase ventilation hose. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).
2. Disconnect the evaporative emissions canister purge valve and reposition the hose. Refer to [Evaporative Emission Canister Purge Solenoid Valve Replacement](#) .
3. Disconnect the wire harness retainers from the intake manifold and reposition the harness aside.
4. Remove the air cleaner outlet duct and air cleaner assembly. Refer to [Air Cleaner Outlet Duct Replacement](#) , or [Air Cleaner Assembly Replacement](#) .
5. Remove the radiator inlet pipe. Refer to [Radiator Inlet Pipe Replacement \(LCV\)](#) .
6. Remove the lower intake manifold fastener (1).

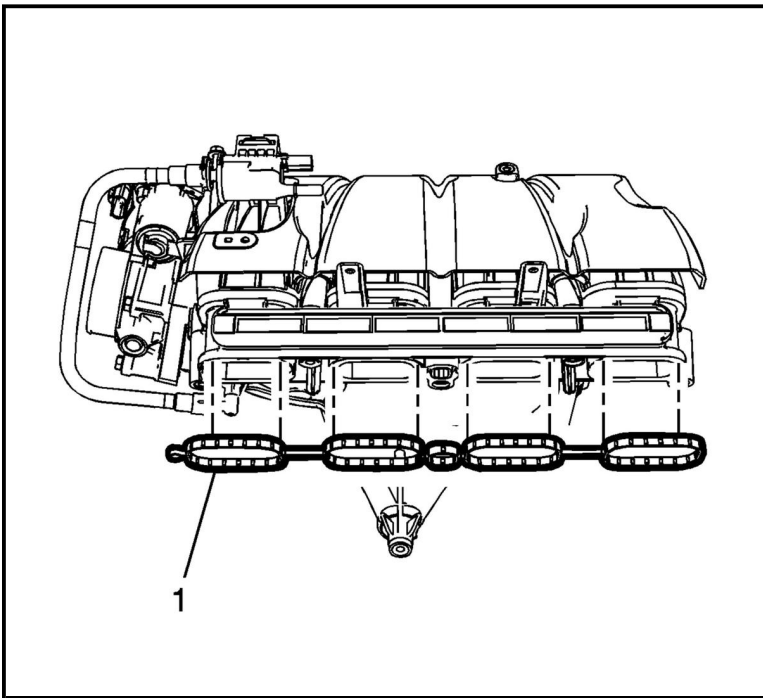


7. Remove the intake manifold fasteners (1) then remove the intake manifold (2).



8. Disconnect the evaporative emission pipe from the intake manifold retainer.

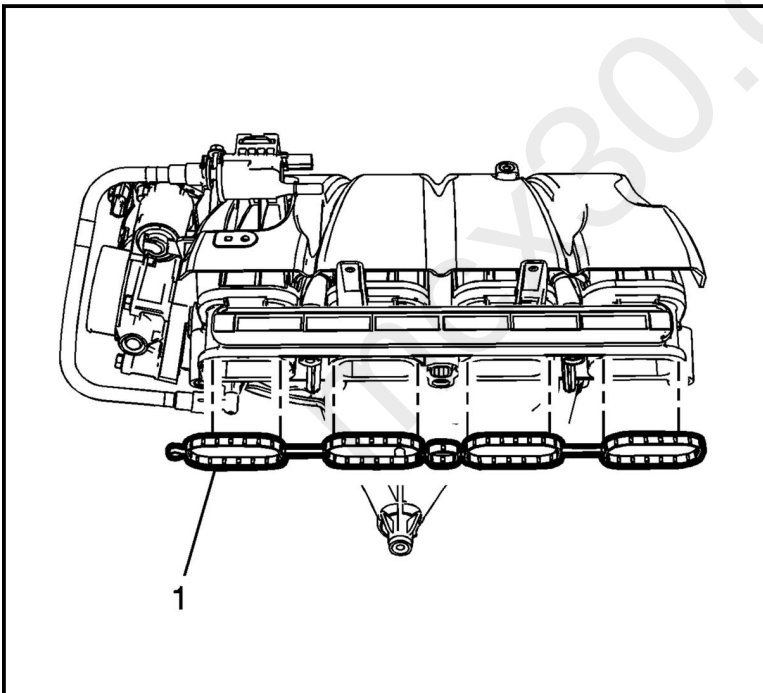
9. Remove the intake manifold gasket (1) and DISCARD.



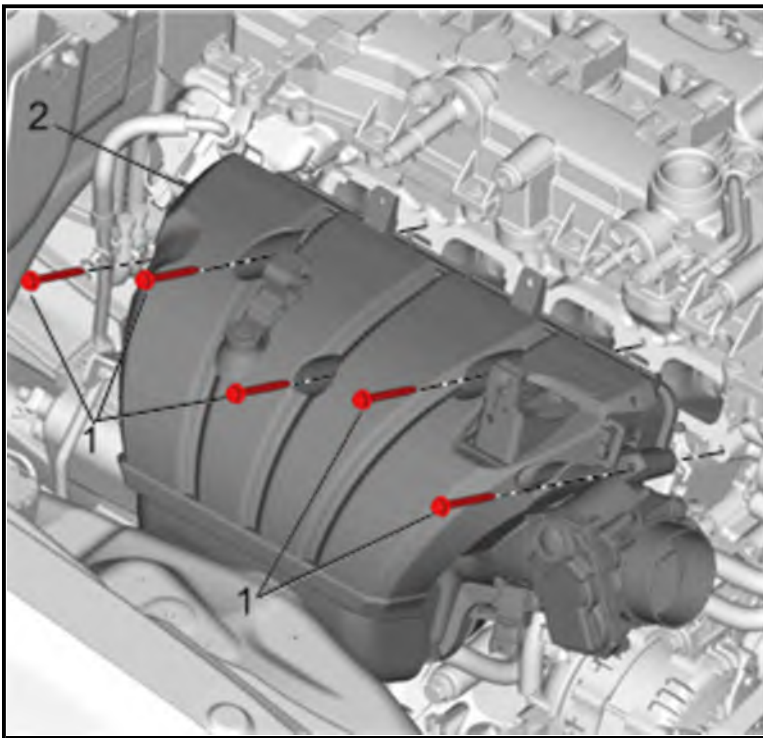
10. For intake manifold cleaning and inspection. Refer to [Intake Manifold Cleaning and Inspection](#).
11. If replacing the intake manifold, transfer all necessary parts.

Installation Procedure

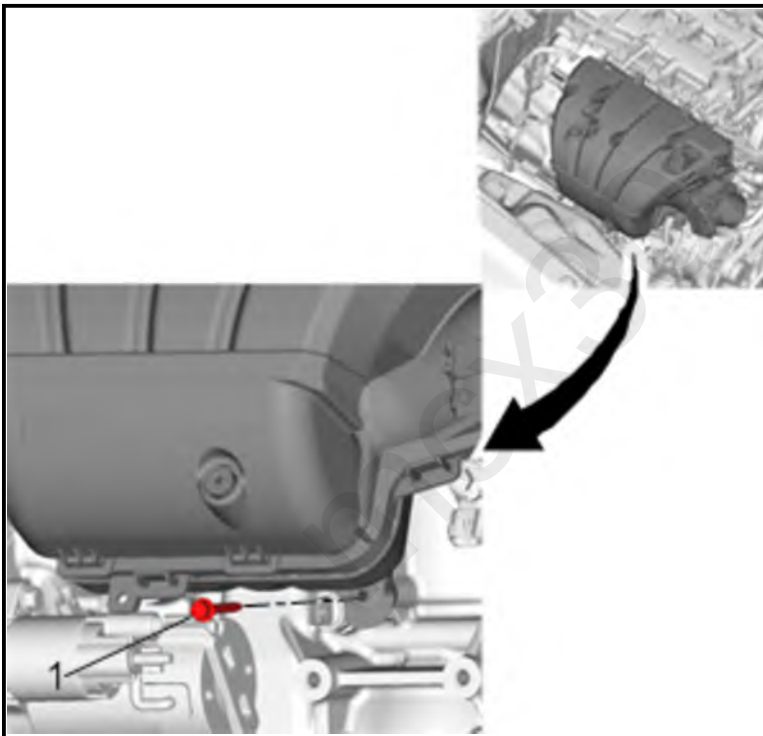
1. Install the intake manifold gasket (1).



2. Position the intake manifold (2) then hand start the five intake manifold fasteners (1).



3. Hand start the lower intake manifold fastener (1).



4. Tighten the intake manifold fasteners in sequence twice to 12 N.m (106 lb in).

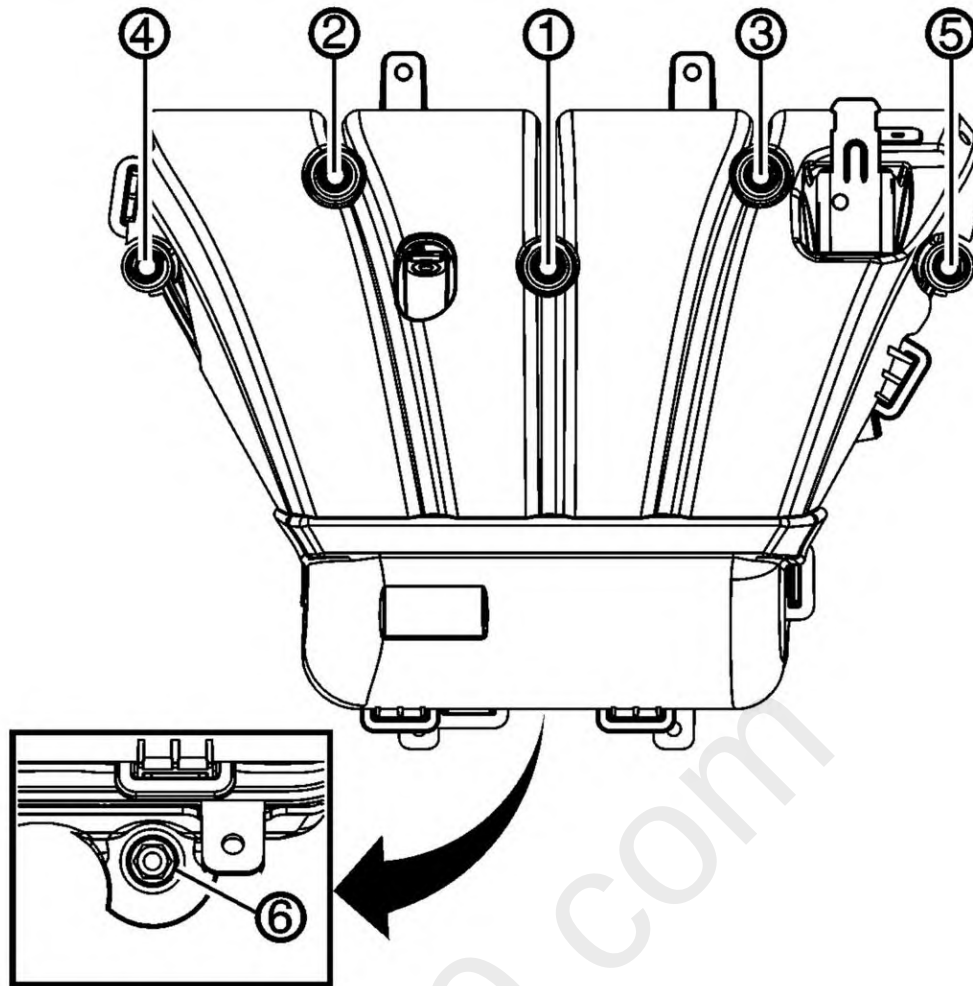


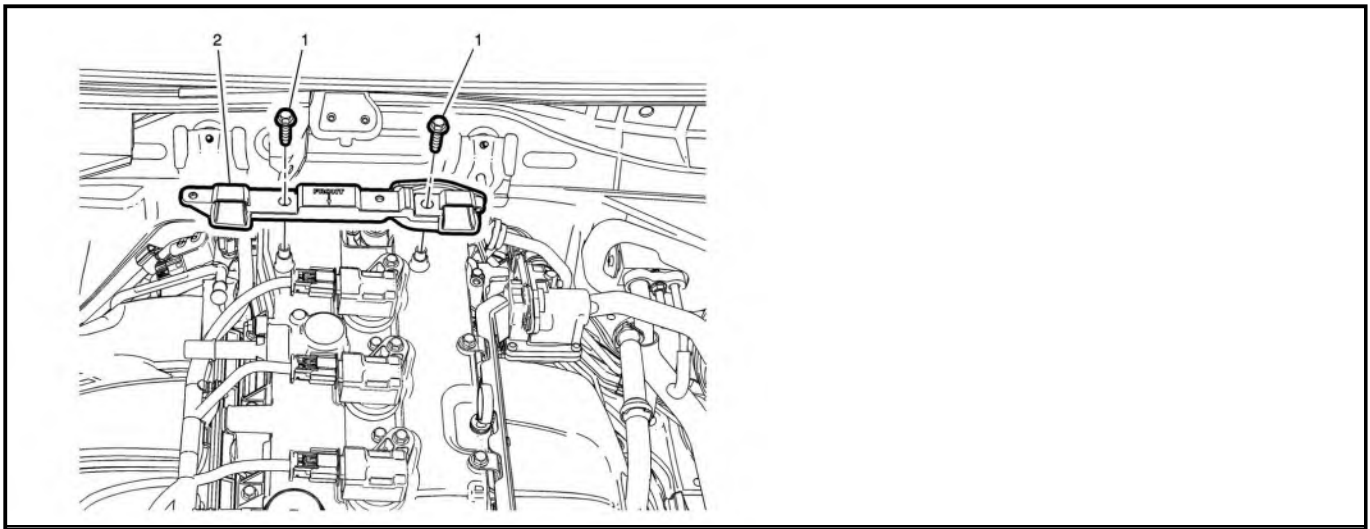
Fig. 9: Intake Manifold Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

5. Install the radiator inlet pipe. Refer to [Radiator Inlet Pipe Replacement \(LCV\)](#) .
6. Reposition the wiring harness and connect the retainers to the intake manifold as necessary.
7. Connect the evaporative emission pipe to the intake manifold retainer.
8. Install and connect the evaporative emissions canister purge valve. Refer to [Evaporative Emission Canister Purge Solenoid Valve Replacement](#) .
9. Install the positive crankcase ventilation hose. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).
10. Install the air cleaner outlet duct and air cleaner assembly. Refer to [Air Cleaner Outlet Duct Replacement](#) , or [Air Cleaner Assembly Replacement](#) .

UPPER INTAKE MANIFOLD BRACKET REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .	
1	Upper Intake Manifold Bracket Fastener (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Upper Intake Manifold Bracket

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- EN-45059 Angle Meter

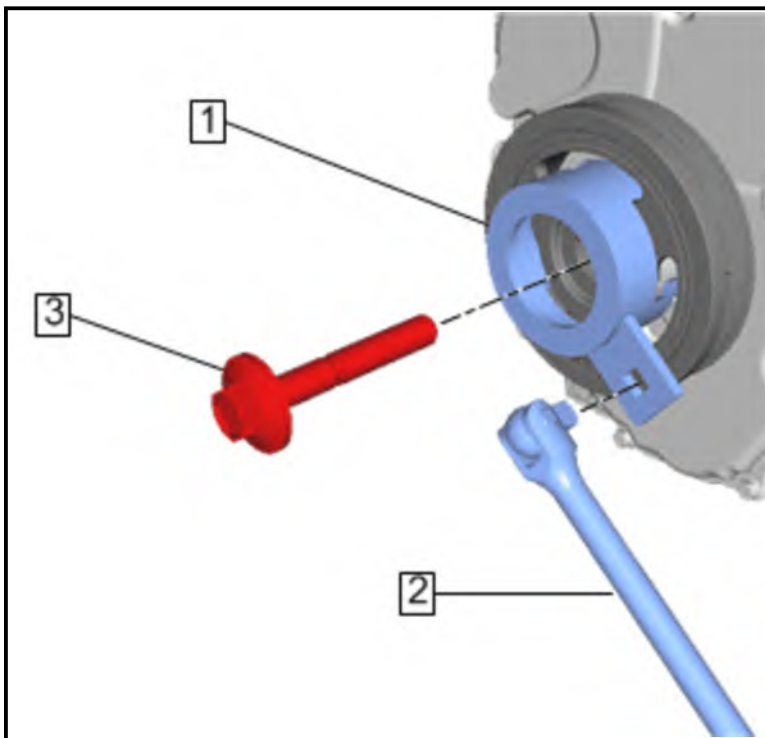
NOTE: EN-52287 with KM-956-1 optional.

- EN-51577 Crankshaft Balancer Holder/Remover
- J-41816-2 or EN-38416-2 Crankshaft End Protector

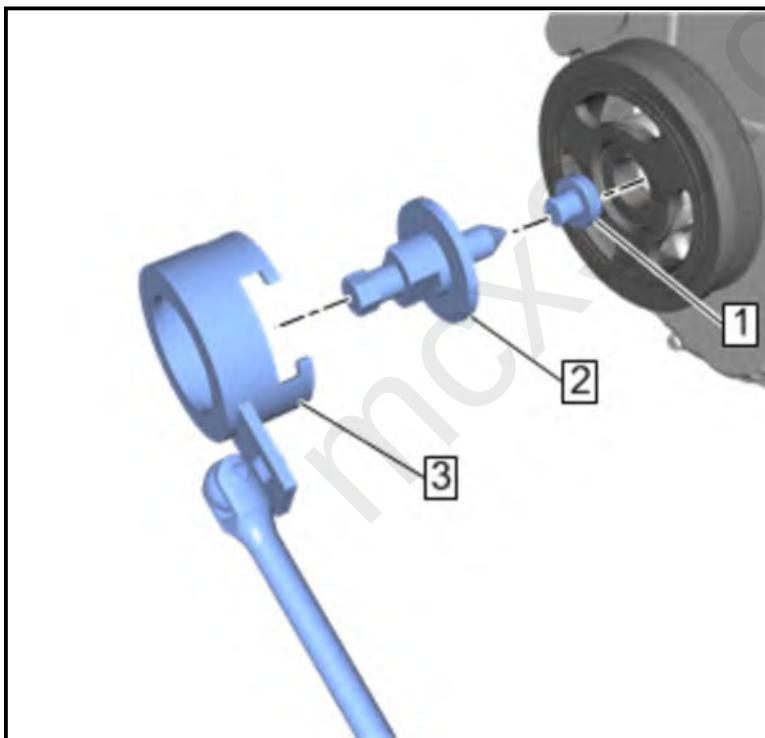
Equivalent regional tools: [Special Tools](#)

Removal Procedure

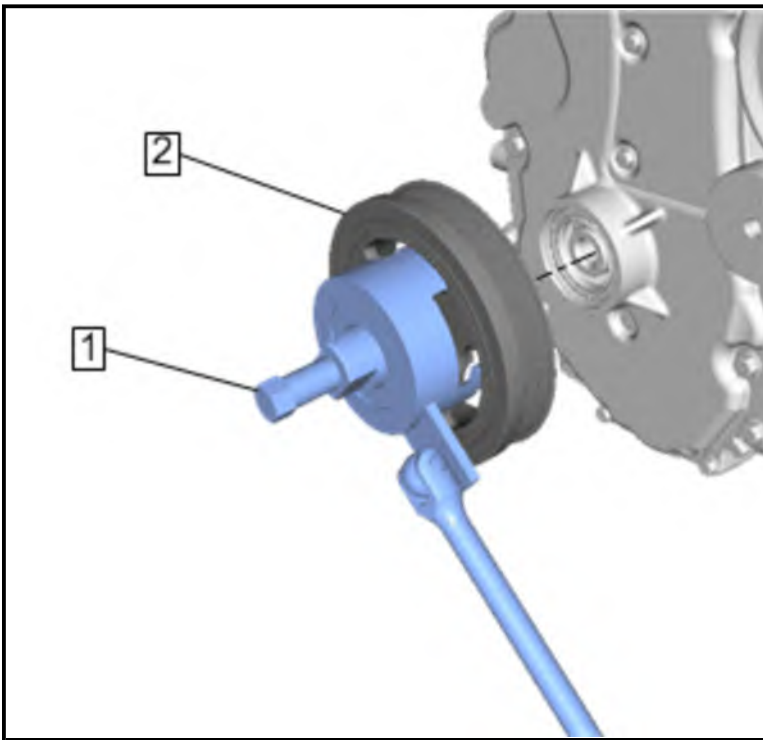
1. Remove the drive belt. [Drive Belt Replacement](#)
2. Use **EN-51577-1** Crankshaft Balancer Remover (1) and breaker bar (2) prevent the crankshaft from rotating while loosening the crankshaft balancer fastener (3).



3. Remove and DISCARD the crankshaft balancer fastener (3).
4. Remove the crankshaft balancer holder then install the **J-41816-2** or **EN-38416-2** Crankshaft End Protector (1) and all components of **EN-51577** Crankshaft Balancer Remover (2, 3) as shown.

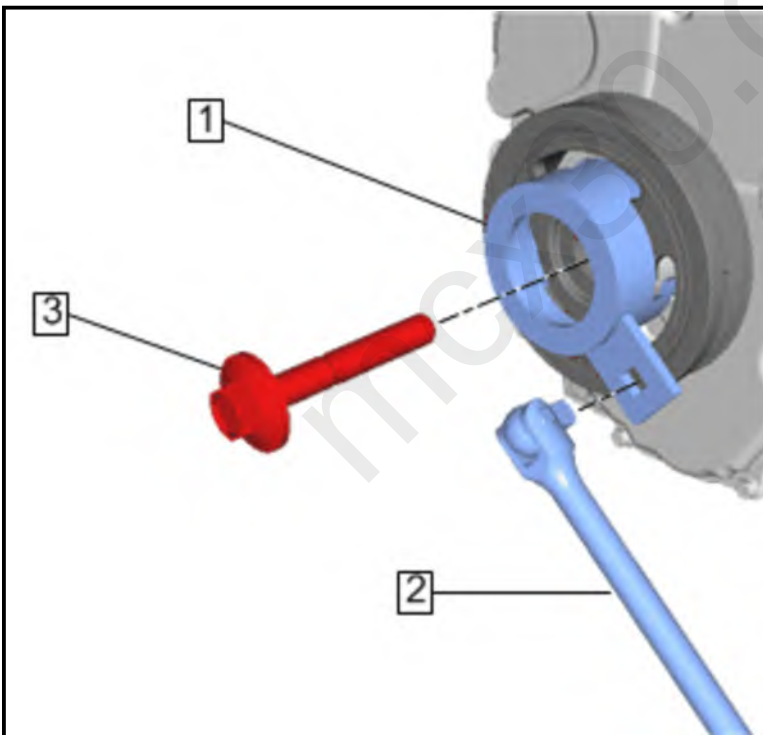


5. Tighten the crankshaft balancer remover (1) in order to remove the crankshaft balancer (2).



Installation Procedure

1. Tighten the crankshaft balancer bolt to 150 N.m (111 lb ft) plus an additional 140 degrees using the **EN-45059** meter.



Install the crankshaft balancer with NEW fastener. Use **EN-51577-1** Crankshaft Balancer Remover (1) and breaker bar (2) prevent the crankshaft from rotating while tightening the NEW crankshaft balancer fastener (3).

CAUTION: Refer to [Fastener Caution](#) .

2. Install the drive belt. [Drive Belt Replacement](#)
3. Perform the crankshaft position variation learn procedure. [Crankshaft Position Variation Learn](#)

TIMING CHAIN CRANKSHAFT SPROCKET REPLACEMENT

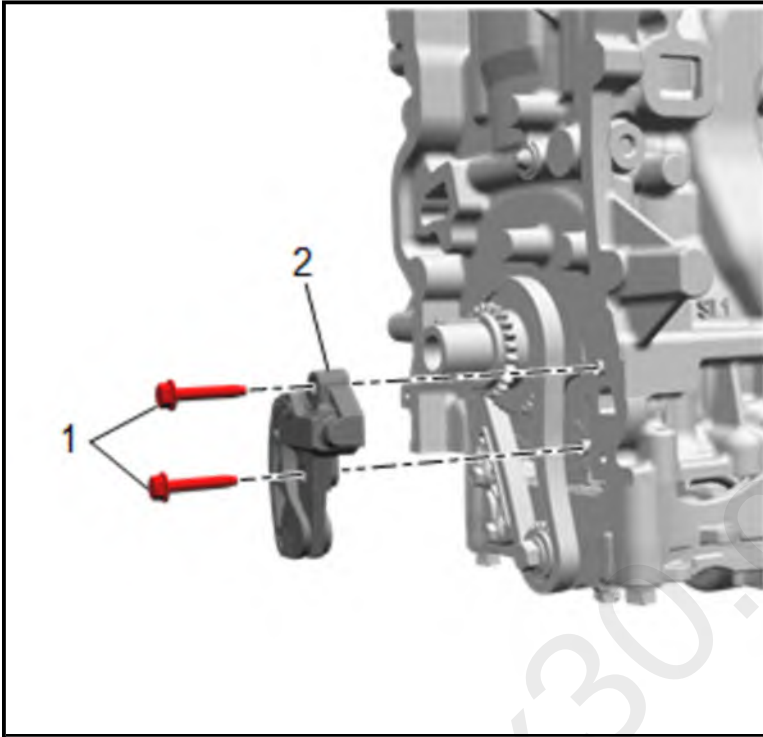
Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

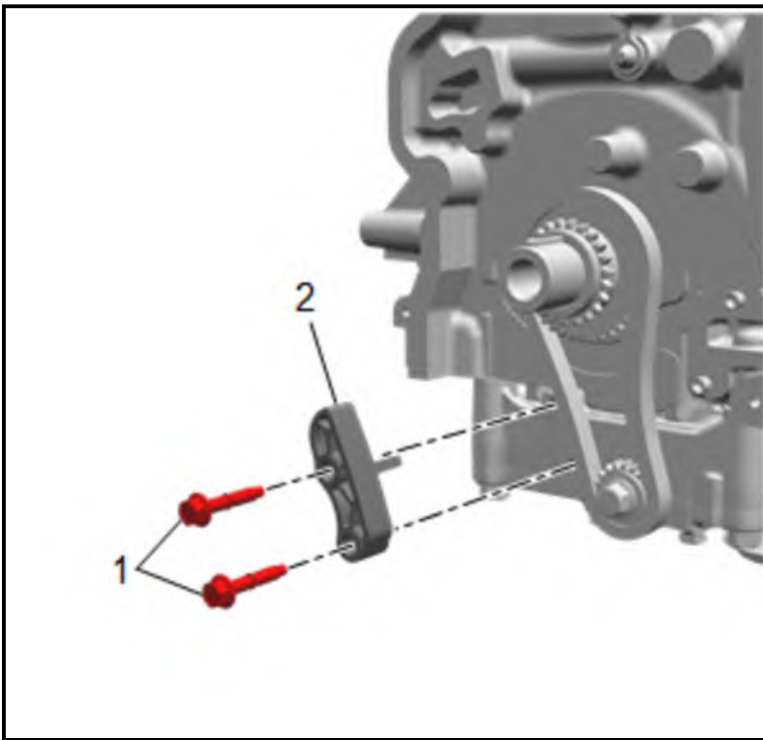
For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
2. Remove the timing chain. Refer to [Camshaft Timing Chain and Tensioner Replacement](#).
3. Remove the balancer chain tensioner bolt (1).

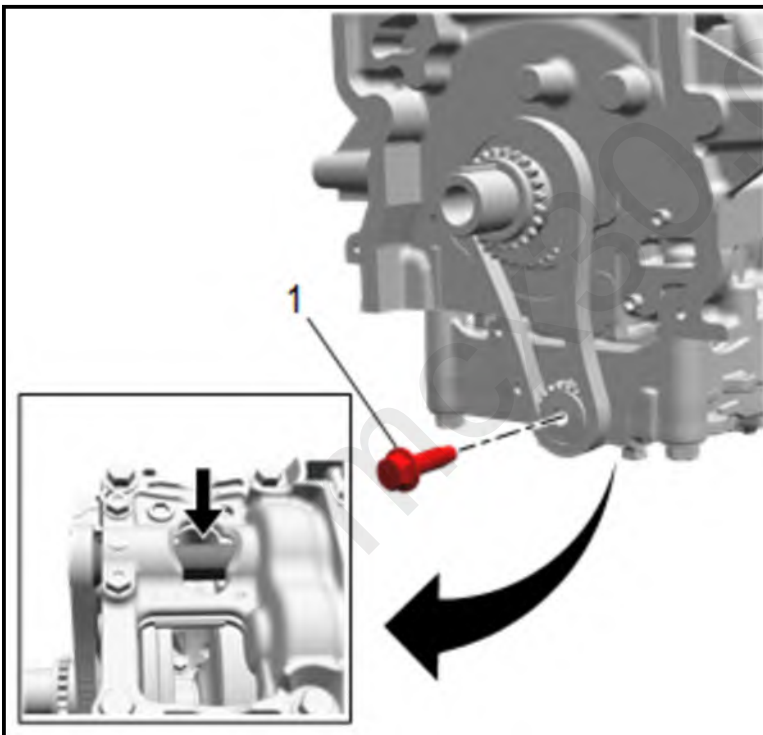


4. Remove the balancer chain tensioner (2).
5. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.
6. Remove the balancer chain guide bolt (1).

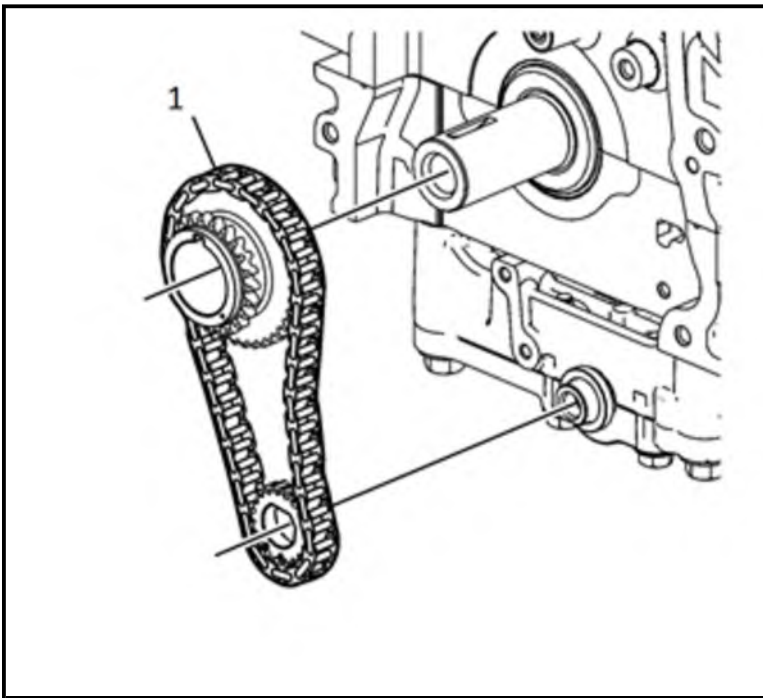


7. Remove the balancer chain guide (2).

8. Remove and discard the balancer shaft driven sprocket bolt (1).

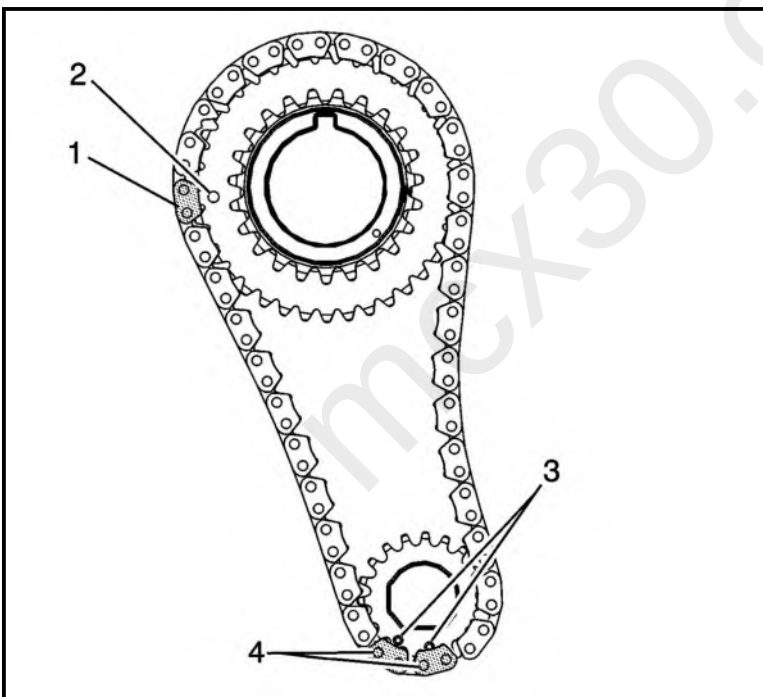


9. Remove the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain (1) simultaneously.



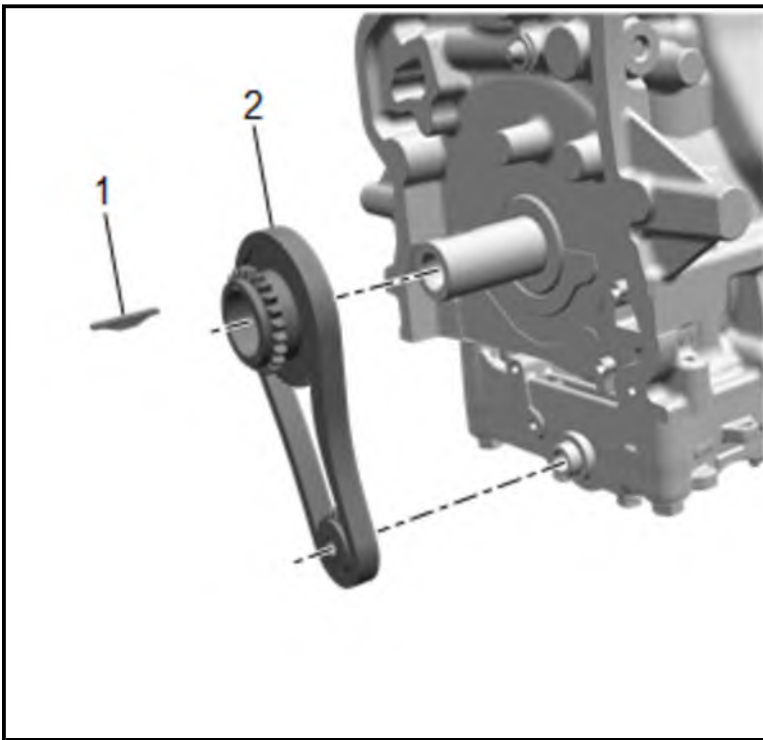
Installation Procedure

1. Assemble the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain. Ensure the timing link (1) lines up with the timing mark (2) on the crankshaft sprocket. Ensure that both timing teeth (3) on the balancer shaft driven sprocket line up with the timing links (4).



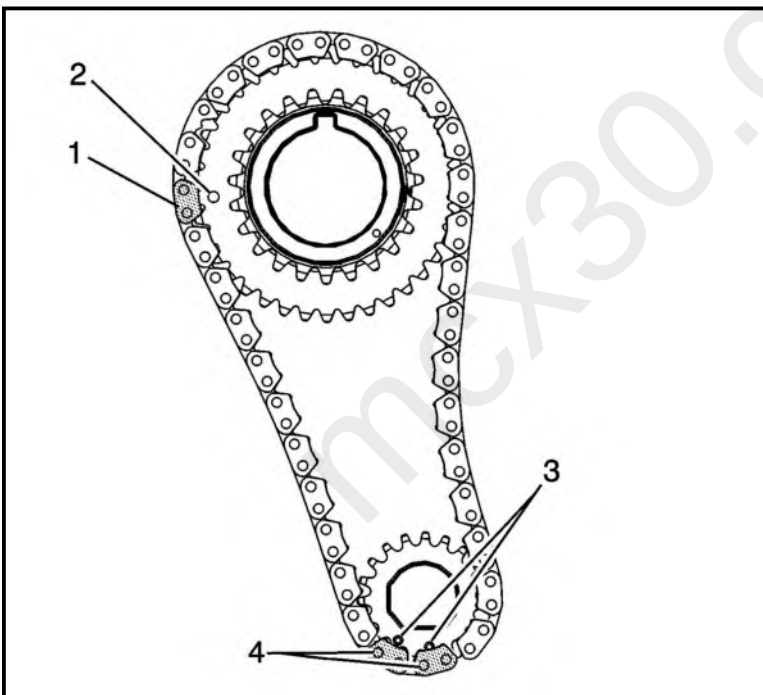
NOTE: Proper setup is critical to ensure correct timing when installing the sprockets and chain simultaneously onto the shafts. The timing links are heat treated blued steel.

2. Install the sprockets and chain (2) as an assembly to the crankshaft and balancer shaft assembly.

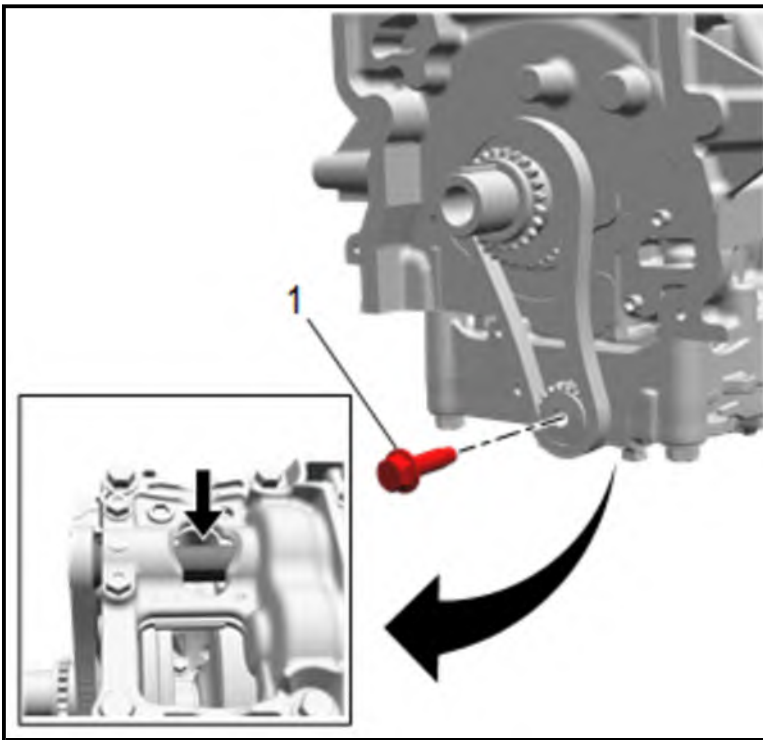


NOTE: The crankshaft keyway (1) should be in the 12 O'clock position.

3. Ensure the timing link (1) is aligned with the crankshaft sprocket timing mark (2).



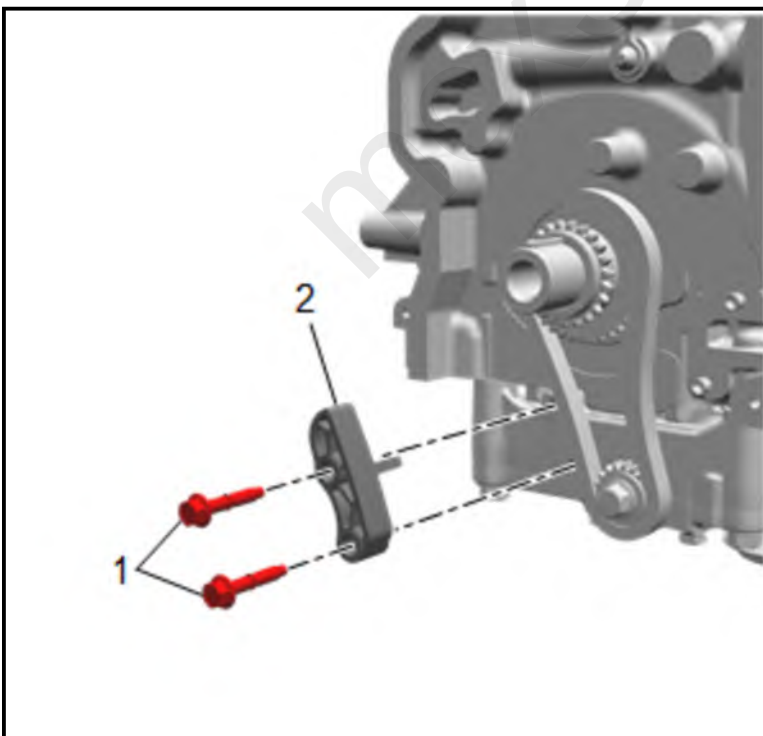
4. Ensure the adjacent timing links (4) are aligned with both of the timing marks (3) on the balancer shaft driven sprocket.
5. Install the NEW balancer shaft driven sprocket bolt (1).



CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

CAUTION: Refer to [Fastener Caution](#) .

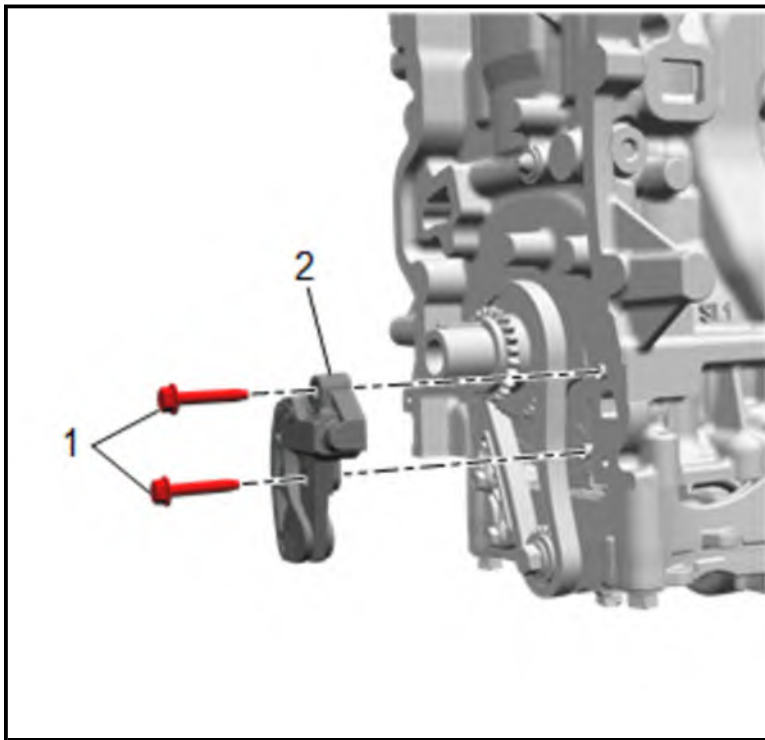
6. Tighten the balancer shaft driven sprocket bolt to 40 N.m (30 lb ft) plus 50 degrees.
7. Install the balancer chain guide (2).



NOTE: Ensure the guide is installed in the correct orientation. The long end must point toward the crankshaft and the flat edge must be adjacent to the balance chain.

8. Install the balancer chain guide bolts (1). Tighten the bolts to 10 N.m (89 lb in).

9. Install the balancer chain tensioner (2).



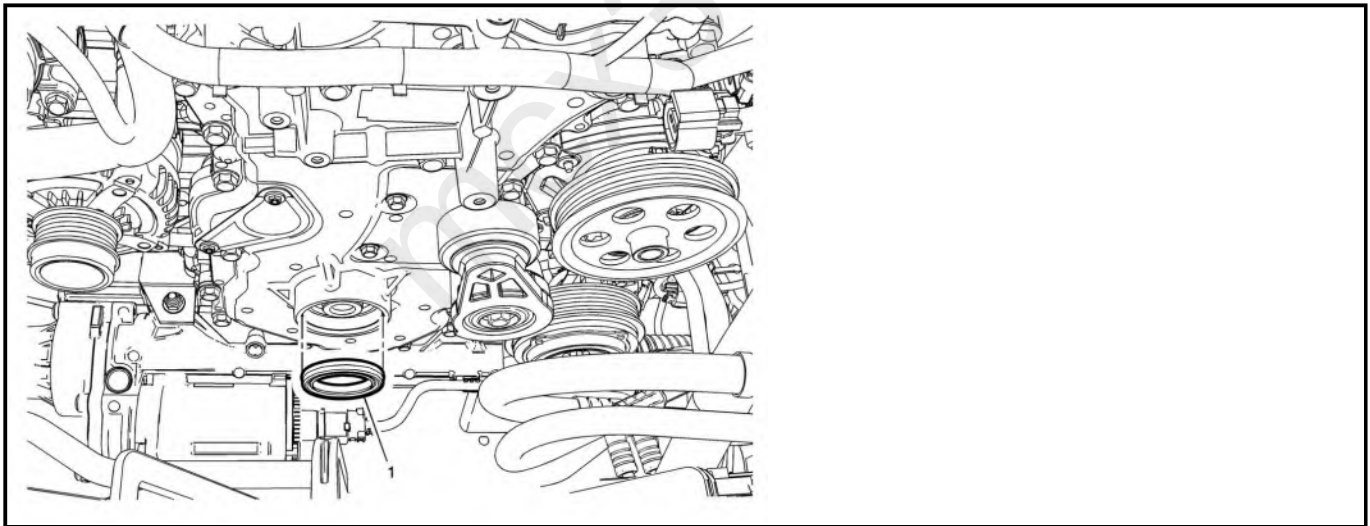
10. Install the balancer chain tensioner bolts (1). Tighten the bolts to 10 N.m (89 lb in).

11. Remove **EN-50837** retention tool to restore the tension to the balancer chain.

12. Install the timing chain. Refer to [Camshaft Timing Chain and Tensioner Replacement](#).

13. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).

CRANKSHAFT FRONT OIL SEAL REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Remove the crankshaft balancer. Refer to Crankshaft Balancer Replacement .	
1	Front Crankshaft Seal
Procedure 1. Use a suitable tool to remove the front cover oil seal. 2. Use the EN 50820 Front Crankshaft Seal Installer to install the seal.	

Callout	Component Name
	Special Tools EN 50820 Front Crankshaft Seal Installer For equivalent regional tools, refer to Special Tools .

ENGINE FRONT COVER REPLACEMENT

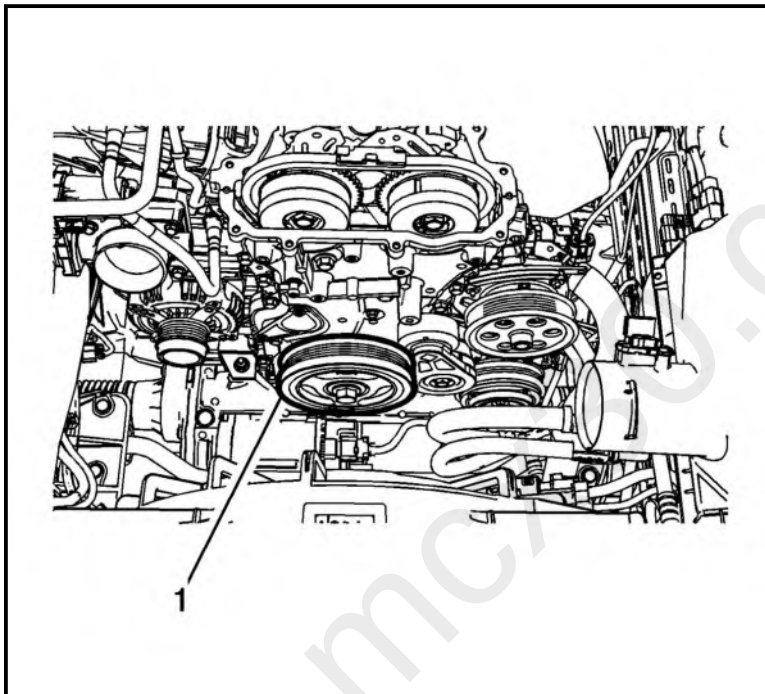
Special Tools

- **EN-45059** Angular Meter
- **EN-50820** Front Crankshaft Seal Installer

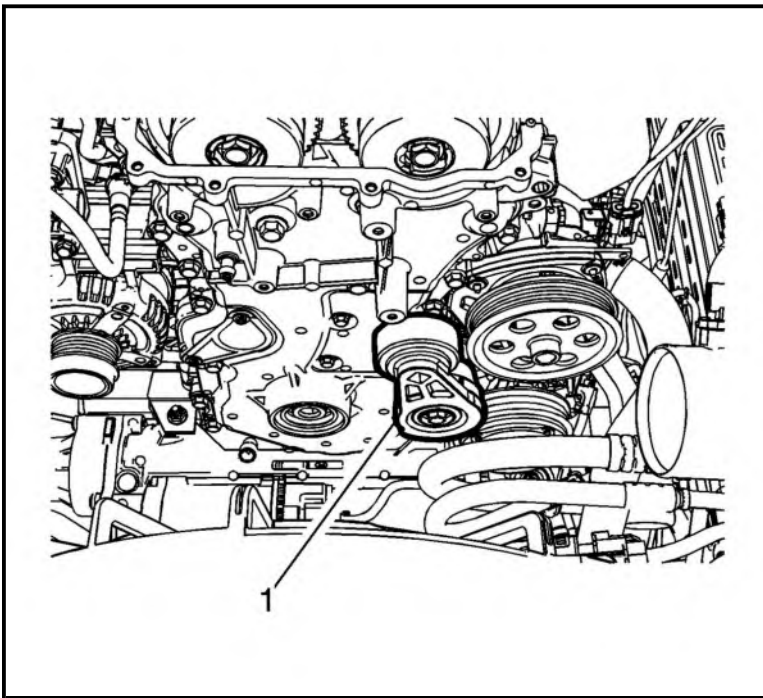
For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

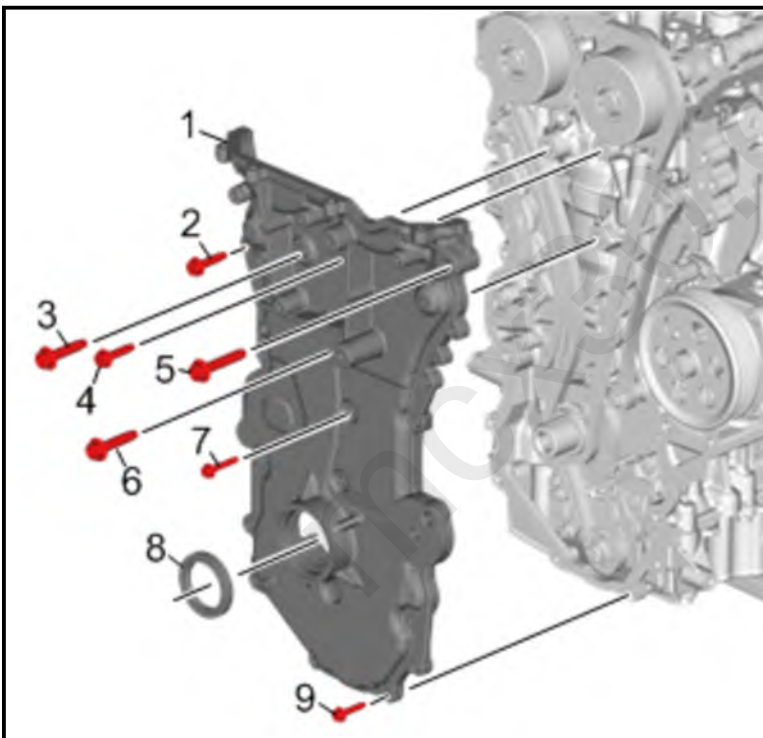
1. Remove the camshaft cover. [Camshaft Cover Replacement](#)
2. Remove the crankshaft balancer (1). [Crankshaft Balancer Replacement](#)



3. Remove the drive belt tensioner (1). [Drive Belt Tensioner Replacement](#)



4. Disconnect the wire harness retainers from the front cover.
5. Engine Front Cover Bolt (3, 5 and 6) - Remove and DISCARD

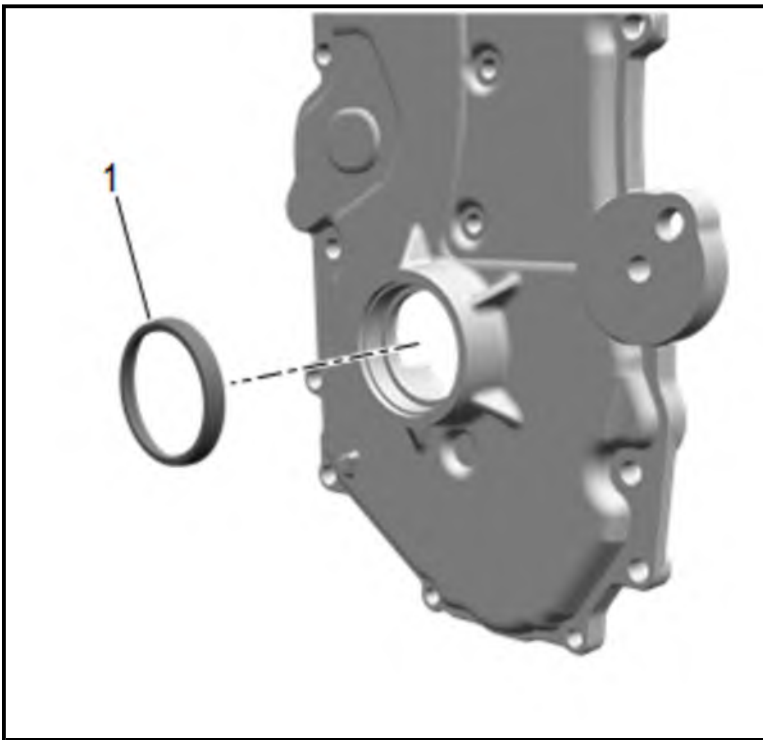


NOTE: Only bolts 3, 5 and 6 will be replaced with NEW bolts.

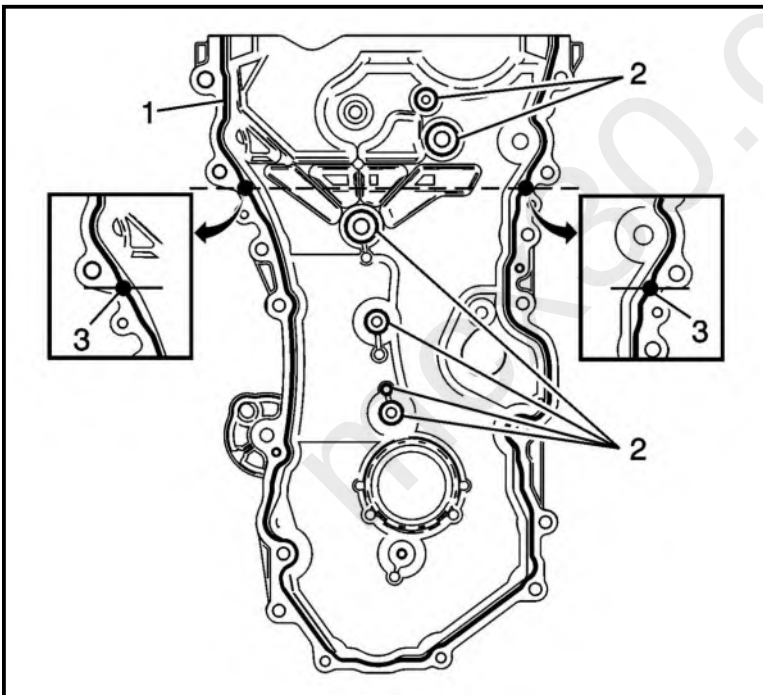
6. Engine Front Cover Bolt (2-7, 9) - Remove
7. Engine Front Cover (1) - Remove
8. If reusing the engine front cover, remove and DISCARD the crankshaft front oil seal (8) using an appropriate tool.
9. Clean the engine block and cylinder head to front cover sealing surfaces.
10. Clean the front cover sealing surface.

Installation Procedure

1. If replacing or removing the crankshaft seal, use **EN-50820** installer to install a NEW front crankshaft seal (1) into the engine front cover.



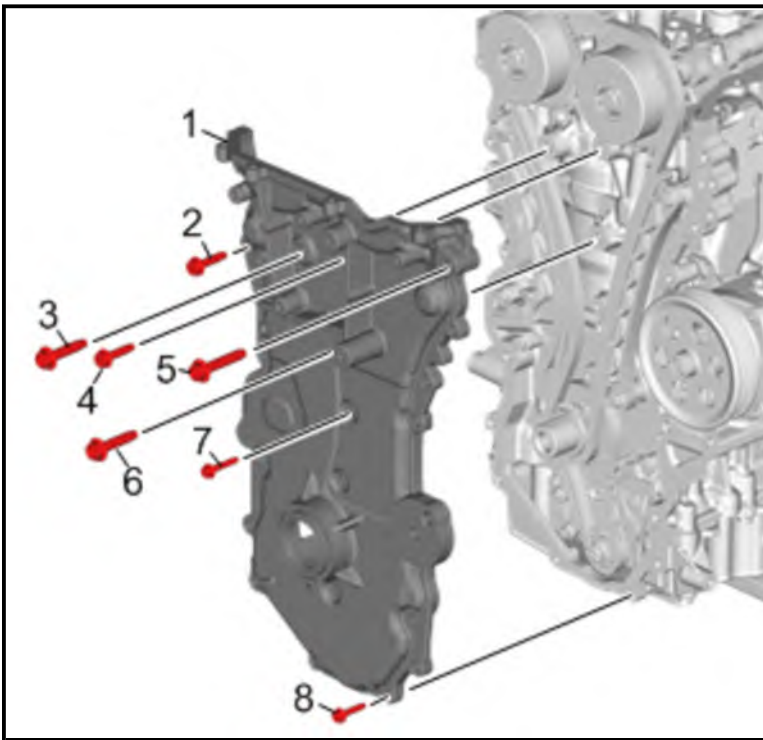
2. Apply a 5 mm bead of sealer directly in the flange (1) of the engine front cover perimeter mating surface. Also apply a 5 mm bead of sealer directly to the locations indicated (2). Finally, apply a 14 mm dab of sealant at the locations indicated (3). [Adhesives, Fluids, Lubricants, and Sealers](#)



NOTE:

- The engine front cover surface must be free of contamination prior to applying the sealer.
- Install and align the cover within 20 minutes of applying the sealer.
- The cover must be fastened to final torque specification within 60 minutes of applying the sealer.
- Additional sealant is necessary to reduce the possibility of leakage where the cylinder head to engine block interface along the bead path flange on the front cover.

3. Install the engine front cover (1).



NOTE: Only bolts 3, 5 and 6 will be replaced with NEW bolts.

4. Install by hand 3 NEW M10 bolts (3, 5, 6) in the engine front cover, as shown.
5. Hand start the remaining engine front cover bolts (2, 4, 7, 8).
6. Tighten the engine front cover bolts in sequence to final torque twice:

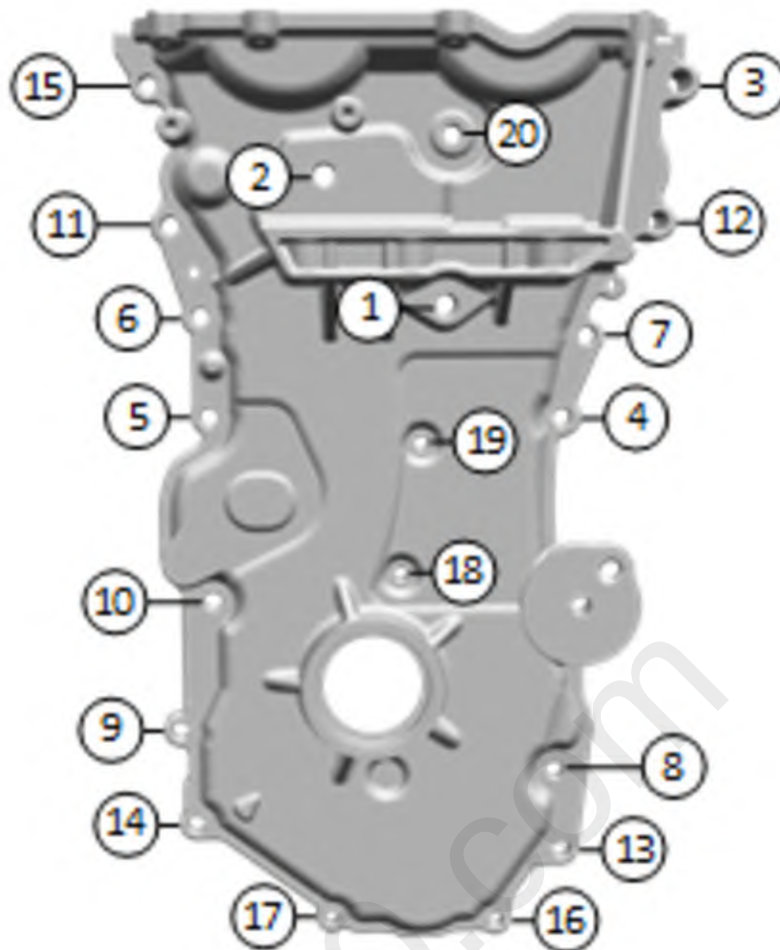
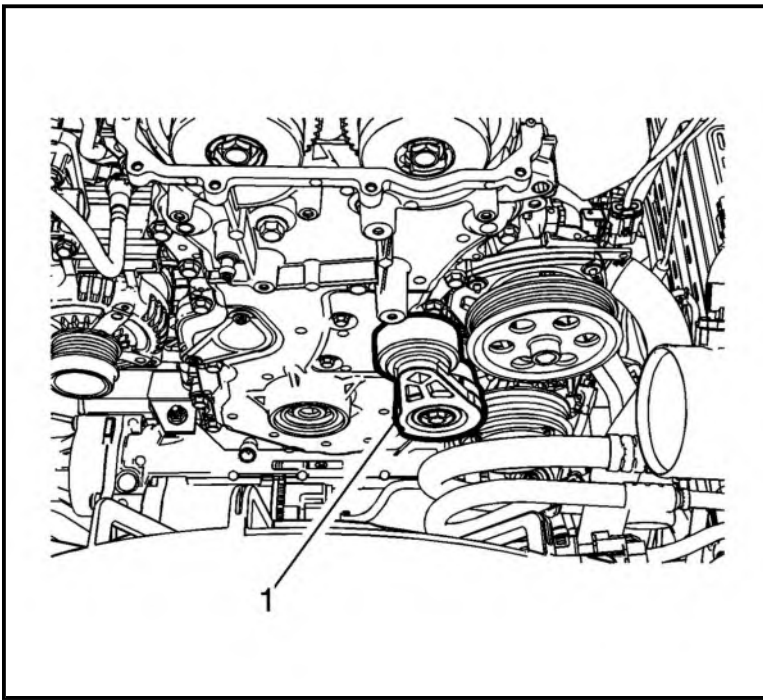


Fig. 10: Engine Front Cover Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

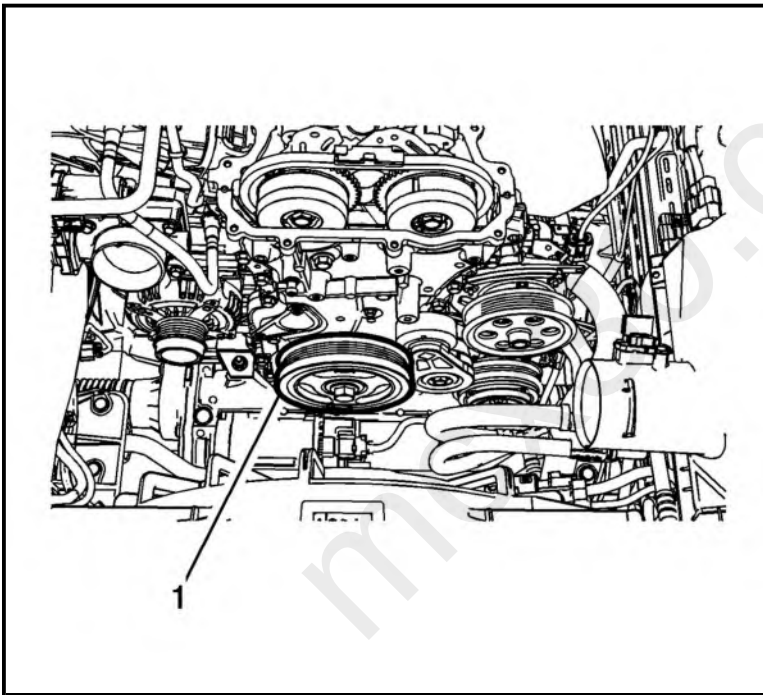
CAUTION: Refer to [Fastener Caution](#) .

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

1. Tighten NEW sequence 1-3 bolts a first pass to 15 N.m (11 lb ft).
2. Tighten NEW sequence bolts 1-3 a final pass to 130 degrees using **EN-45059** Angular Meter.
3. Tighten sequence 4 - 15 bolts to 25 N.m (18 lb ft).
4. Tighten sequence 16 - 19 bolts to 10 N.m (89 lb in).
5. Tighten sequence 20 bolt to 25 N.m (18 lb ft).
7. Connect the wire harness retainers to the front cover.
8. Install the drive belt tensioner (1). [Drive Belt Tensioner Replacement](#)



9. Install the crankshaft balancer (1). [Crankshaft Balancer Replacement](#)

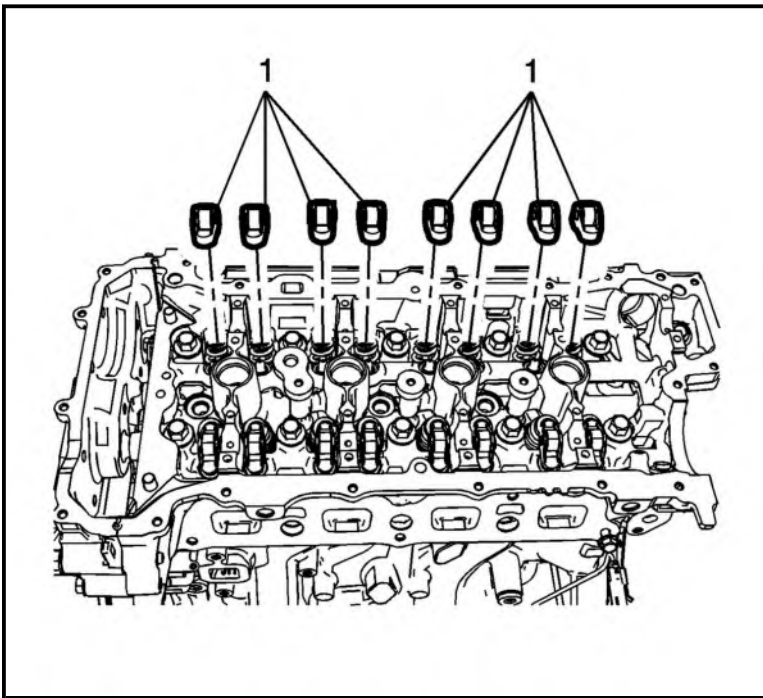


10. Install the camshaft cover. [Camshaft Cover Replacement](#)

INTAKE VALVE ROCKER ARM REPLACEMENT

Removal Procedure

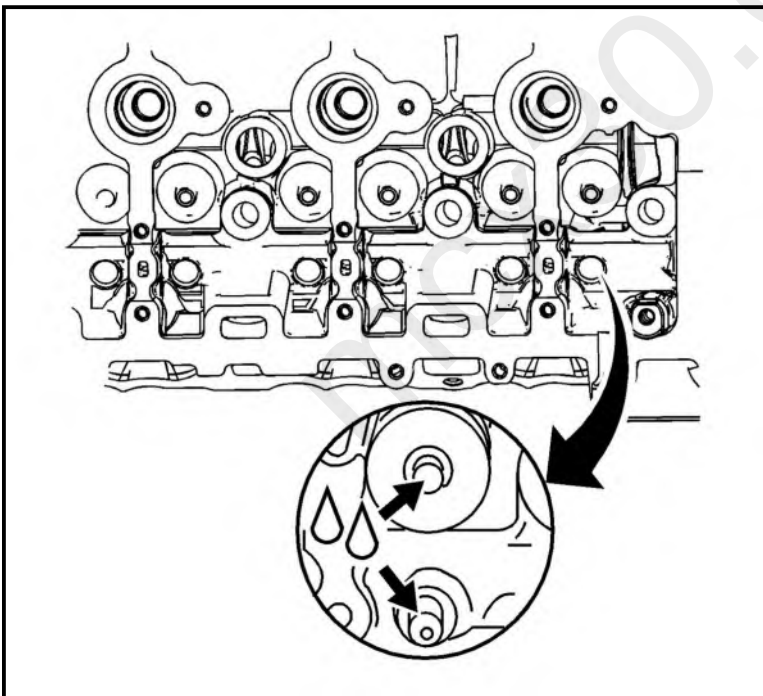
1. Remove the camshaft position actuator and camshaft - intake. Refer to [Camshaft Position Actuator and Intake Camshaft Replacement](#).
2. Remove the intake rocker arm (1).



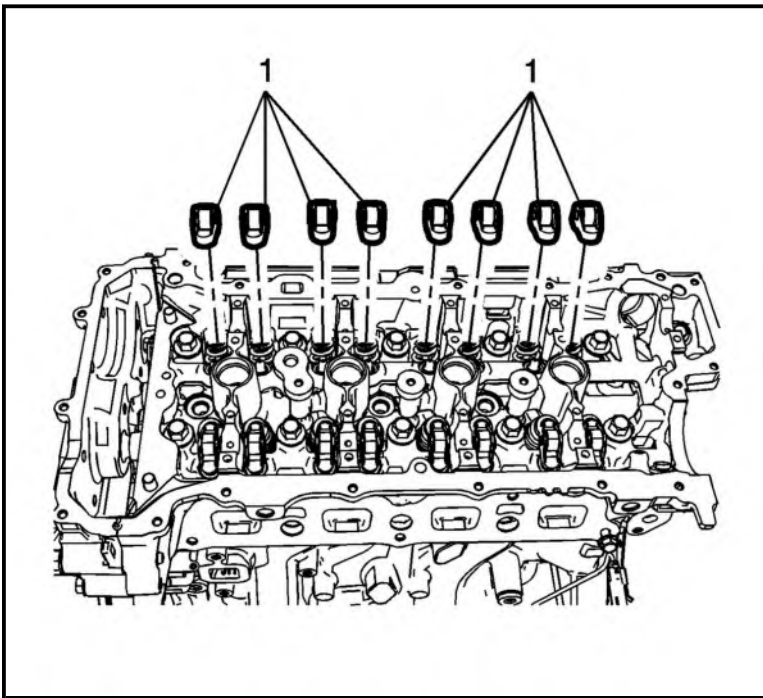
NOTE: Keep all of the valve rocker arms and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

Installation Procedure

1. Lubricate the valve tips. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



2. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE:

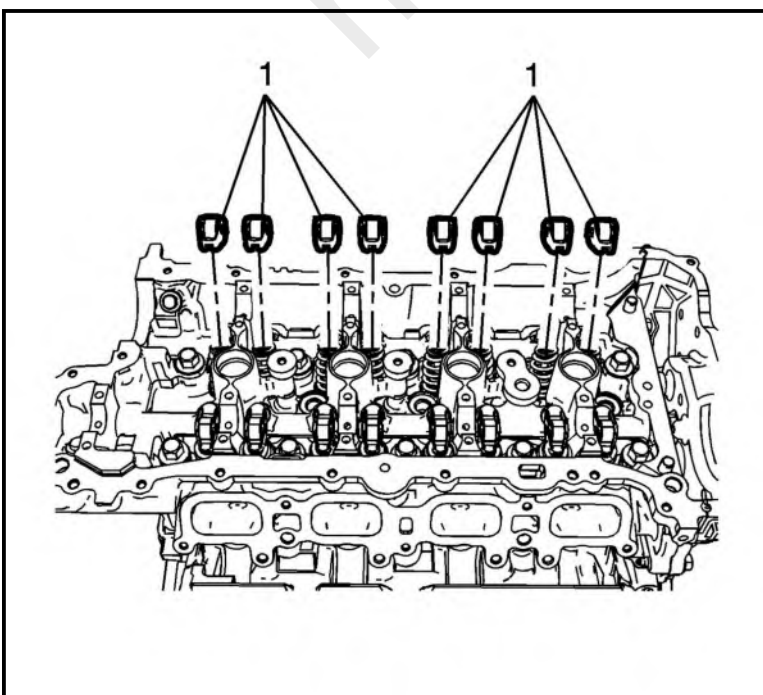
- Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.
- Pre-oil roller bearings before installation.

3. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
4. Install the camshaft position actuator and camshaft - intake. Refer to [Camshaft Position Actuator and Intake Camshaft Replacement](#).

EXHAUST VALVE ROCKER ARM REPLACEMENT

Removal Procedure

1. Remove the camshaft position actuator and camshaft - exhaust. Refer to [Camshaft Position Actuator and Exhaust Camshaft Replacement](#).
2. Remove the exhaust rocker arm (1).

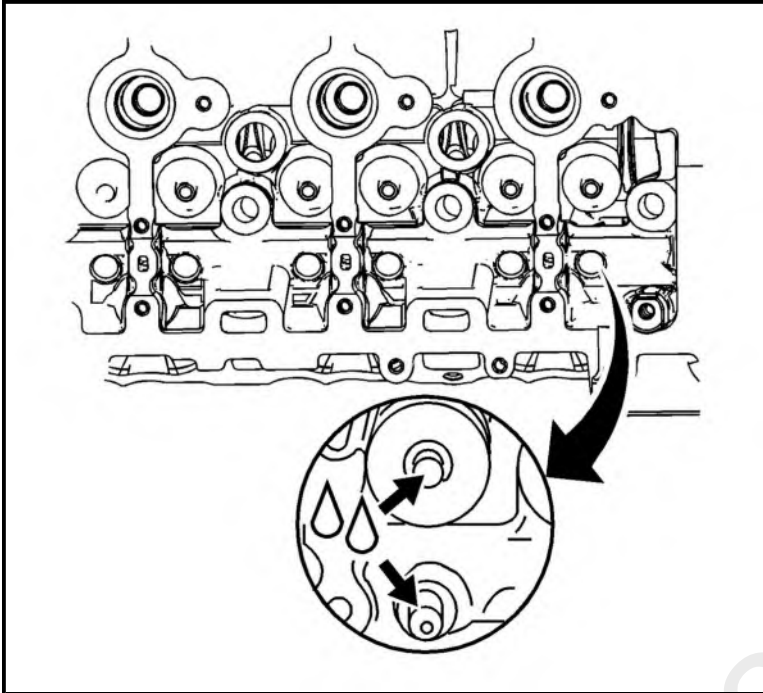


NOTE:

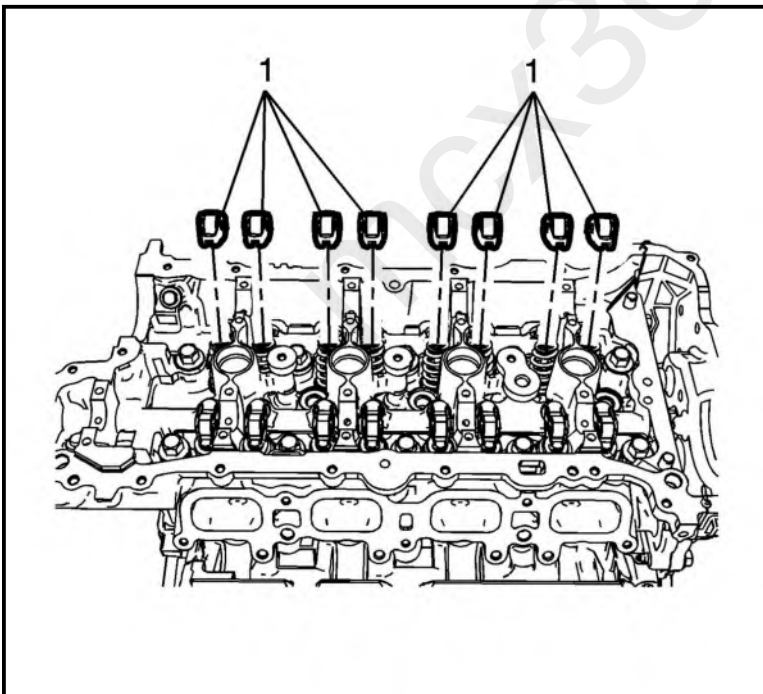
Keep all of the Valve Rocker Arms and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

Installation Procedure

1. Lubricate the valve tips. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



2. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

**NOTE:**

- Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.
- Pre-oil roller bearings before installation.

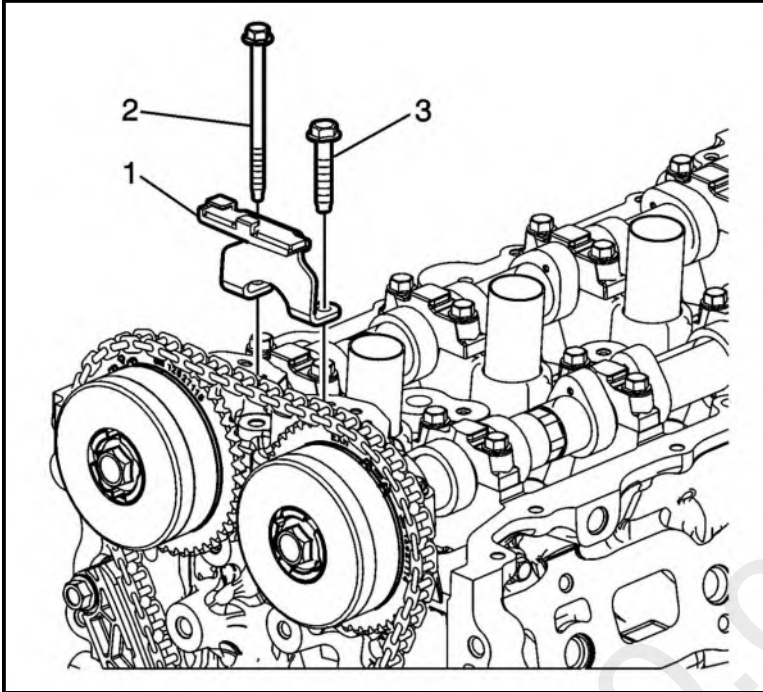
3. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

4. Install the camshaft position actuator and camshaft - exhaust. Refer to [Camshaft Position Actuator and Exhaust Camshaft Replacement](#).

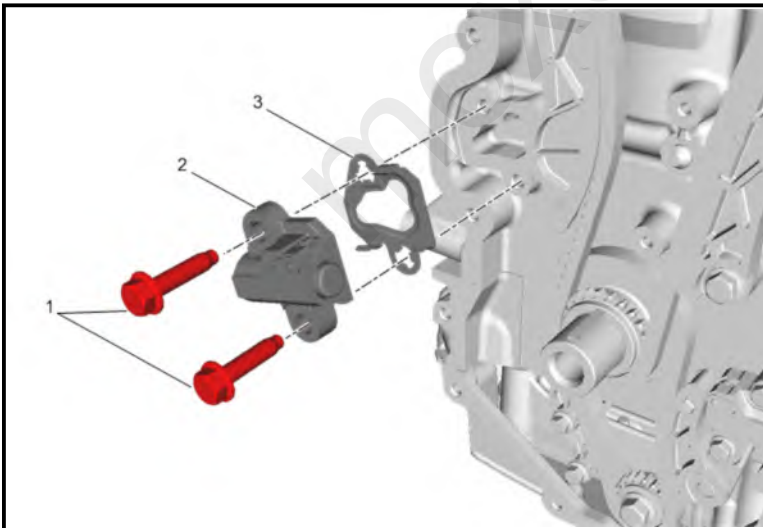
CAMSHAFT TIMING CHAIN AND TENSIONER REPLACEMENT

Removal Procedure

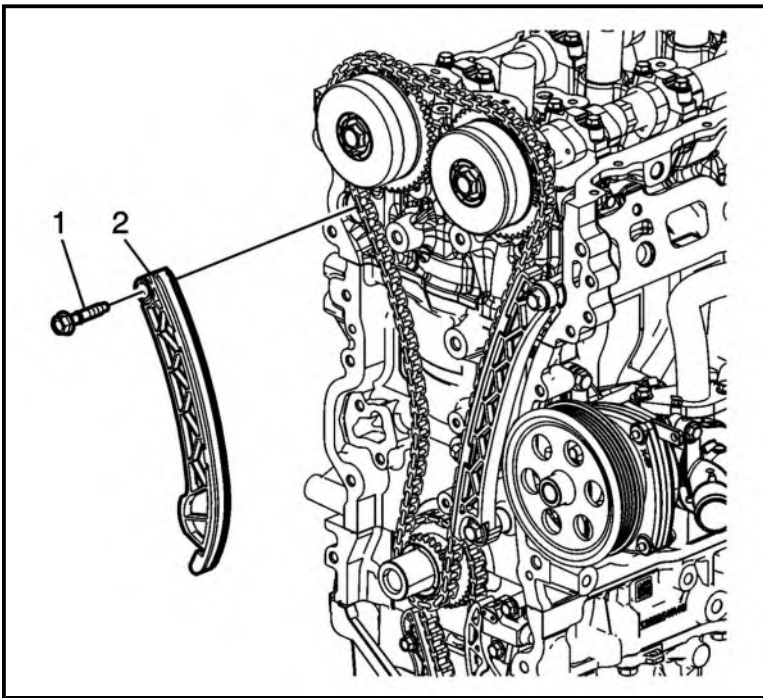
1. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
2. Remove the upper timing chain guide bolts (2, 3).



3. Remove the upper timing chain guide (1).
4. Remove the timing chain tensioner bolts (1) and timing chain tensioner (2).

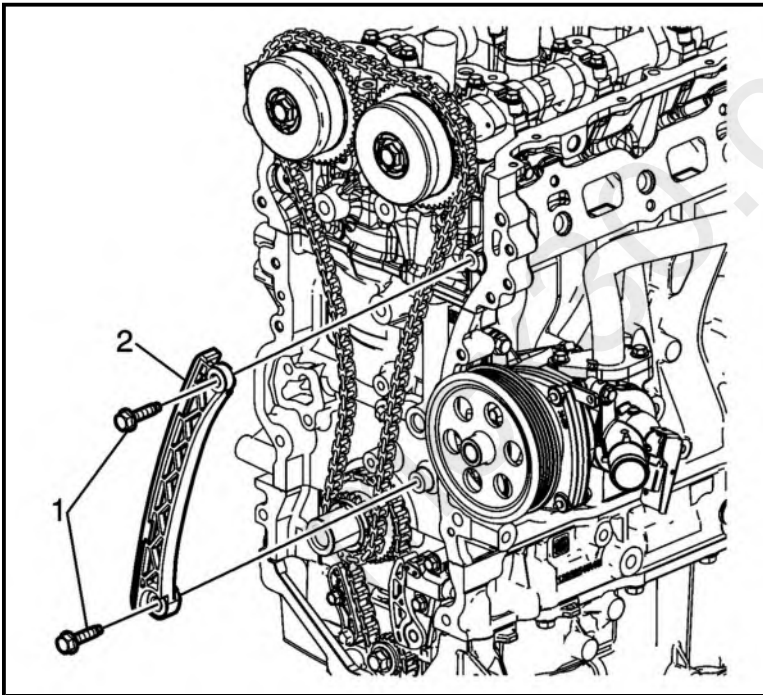


5. Remove the timing chain tensioner pivot arm bolt (1).



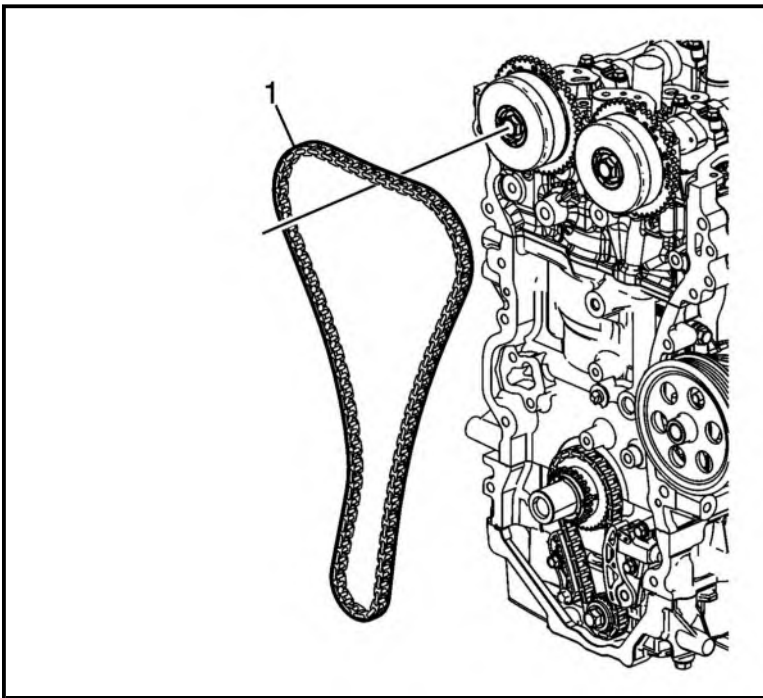
6. Remove the timing chain tensioner pivot arm (2).

7. Remove the timing chain guide bolts (1).

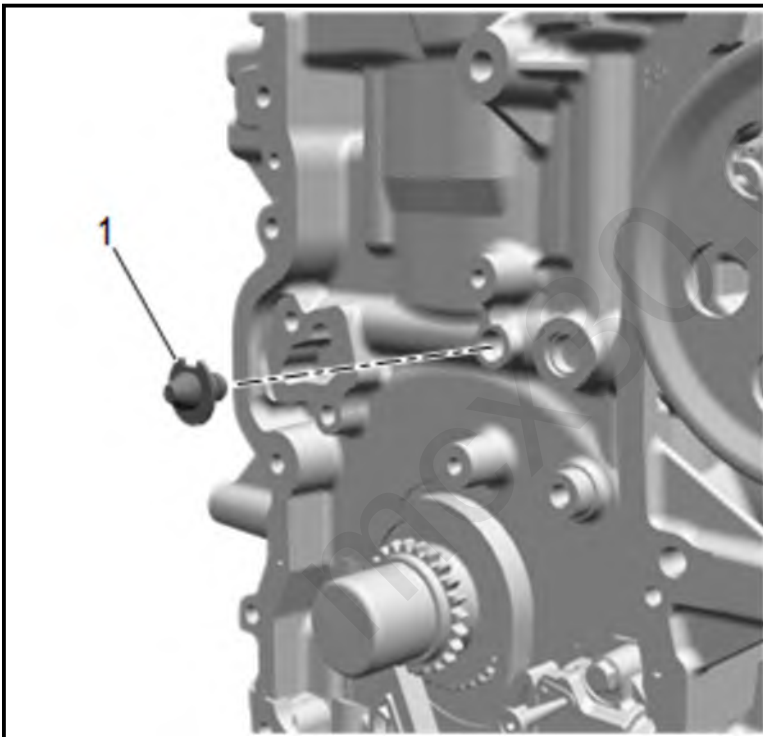


8. Remove the timing chain guide (2).

9. Remove the timing chain (1).



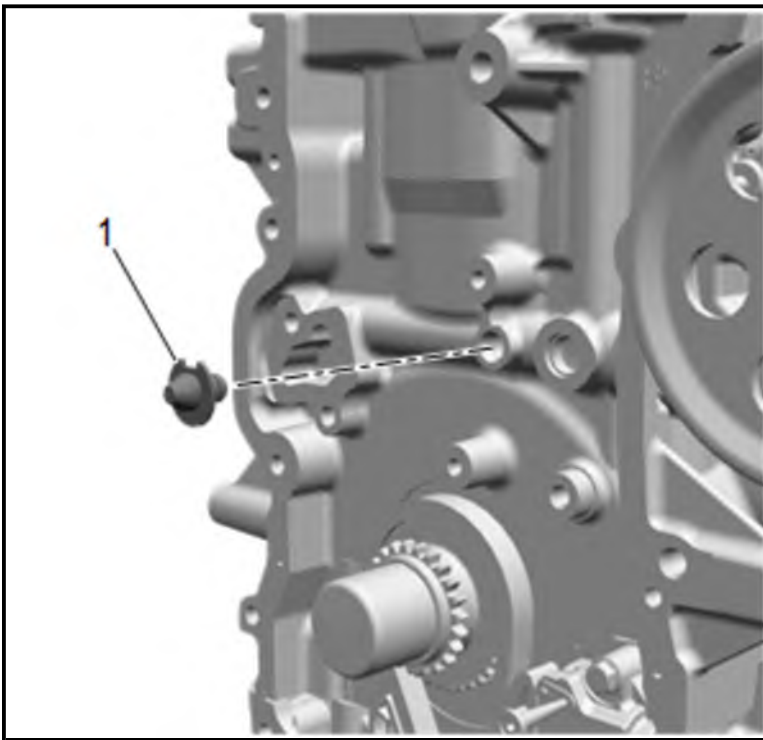
10. Remove the timing chain oil nozzle (1).



11. For camshaft timing chain, sprocket, and tensioner cleaning and inspection. Refer to [Camshaft Timing Chain, Sprocket, and Tensioner Cleaning and Inspection](#).

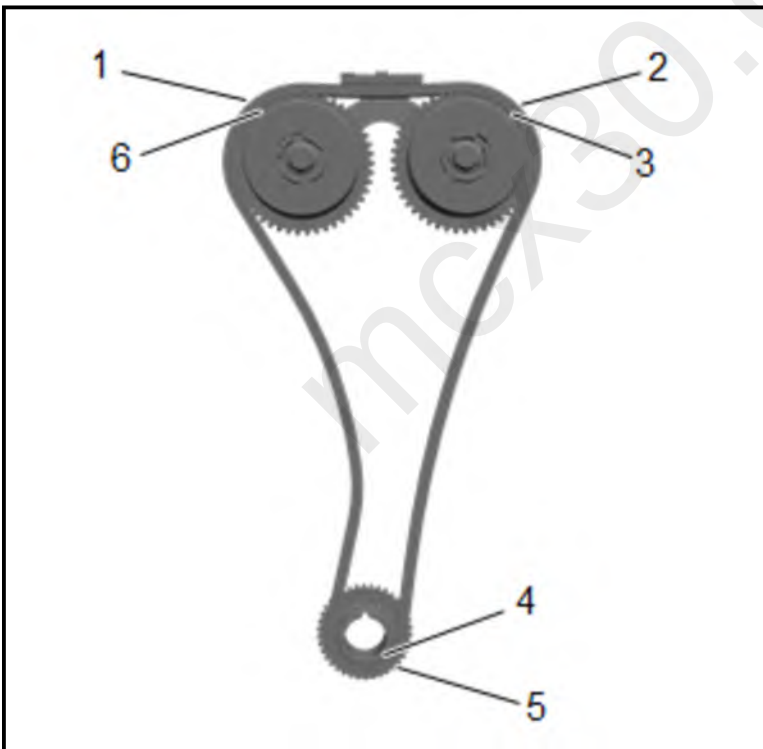
Installation Procedure

1. Install the timing chain oil nozzle (1).



NOTE: Ensure the timing chain oil nozzle is rotated with the notch facing upward, and aligned with the tab on the engine block.

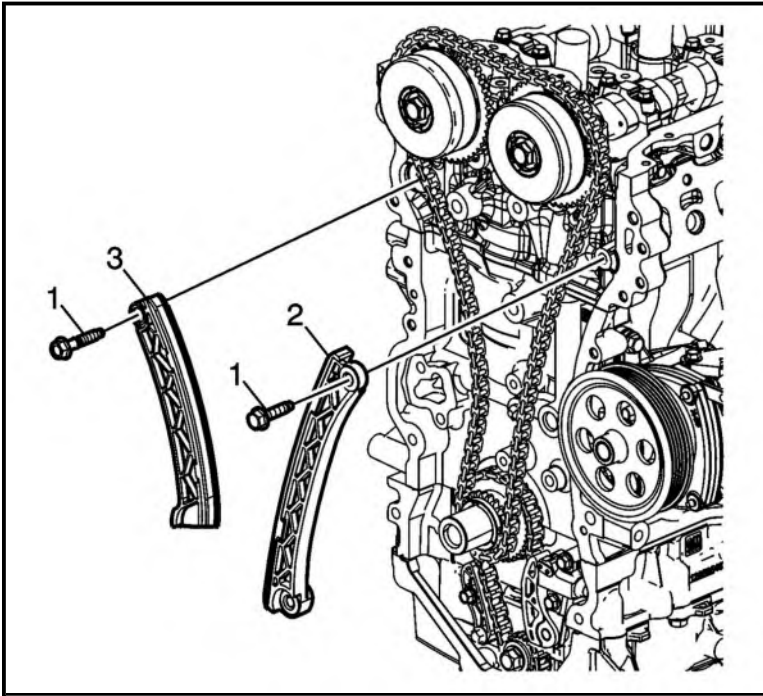
2. Loop the timing chain over the intake and exhaust camshaft actuators, aligning the unique colored link (2) with the timing mark on the exhaust camshaft actuator (3).



NOTE: There are three colored links on the timing chain. The two links that align to the timing marks on the actuators are the same color. The timing link that aligns with the timing mark on the crankshaft sprocket is a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

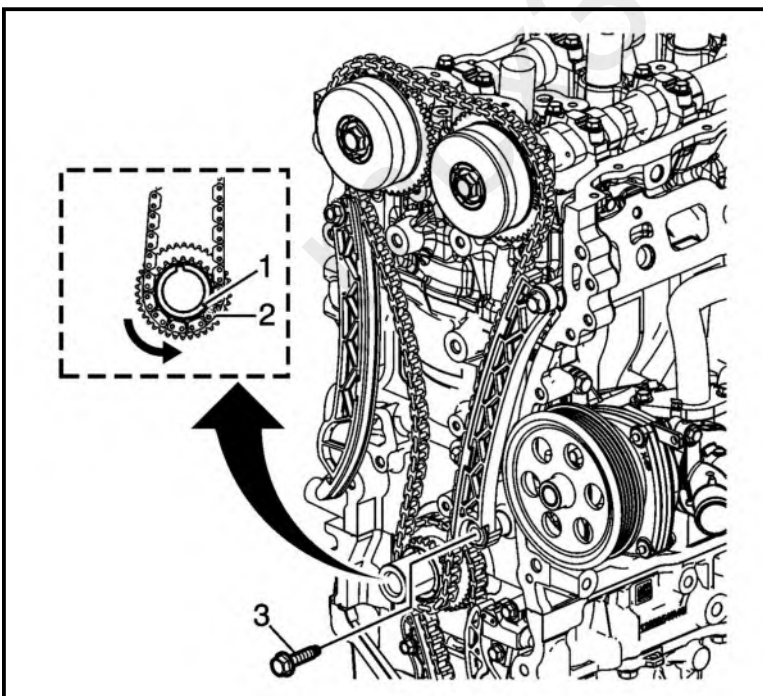
NOTE: The same colored link corresponding to the intake actuator will not initially align with the intake actuator timing mark, nor the unique colored timing chain link align with the crankshaft sprocket timing mark.

3. Ensure the crankshaft key in the 12 O'clock position. Loop the timing chain onto the crankshaft sprocket.
4. Install the timing chain guide (2) and upper bolt (1) only, finger tight.



NOTE: Timing will be established before the final install and torque of the guide bolts.

5. Install the timing chain tensioner pivot arm (3).
6. Install the pivot arm bolt (1) finger tight.
7. With a suitable tool, rotate the crankshaft counterclockwise to align the timing mark on the crankshaft sprocket (1) with the timing link (2).



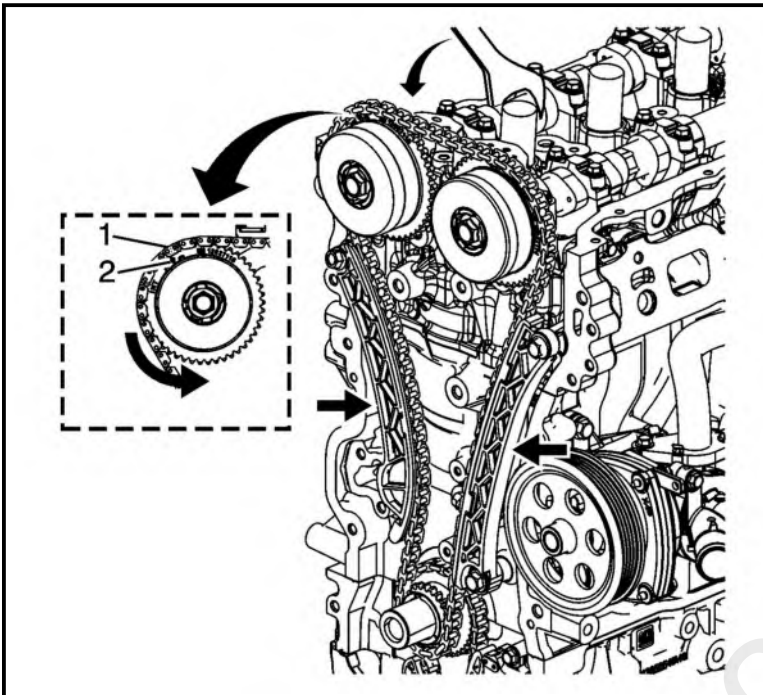
NOTE:

- Continue to rotate the crankshaft counterclockwise as necessary to maintain timing alignment.
- Ensure that the alignment mark on the exhaust camshaft actuator remains aligned with the timing link.

8. Rotate the lower end of the fixed timing chain guide into installation position and install the lower bolt (3).

CAUTION: Refer to [Fastener Caution](#) .

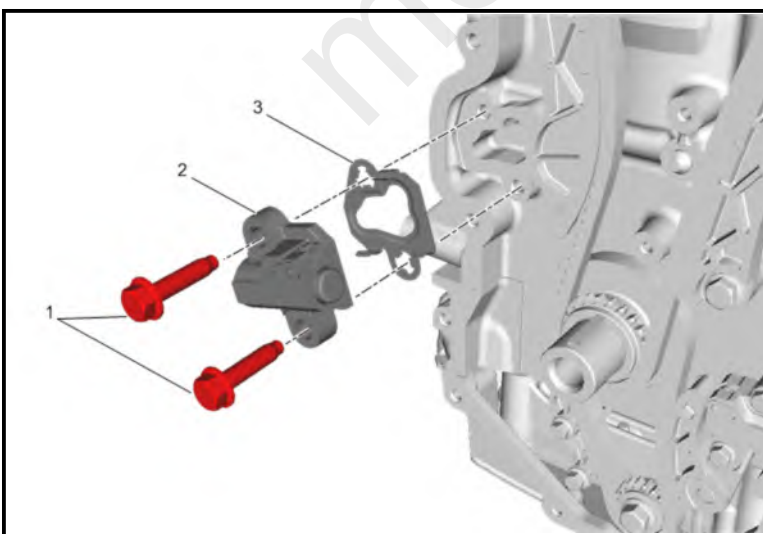
9. Tighten the timing chain guide upper and lower bolts to 25 N.m (18 lb ft).
10. Using a suitable tool, rotate the intake camshaft counterclockwise until the timing mark on the intake actuator (2) is aligned with the timing link (1). Maintain tension on intake camshaft until the timing chain tensioner can be installed and activated.



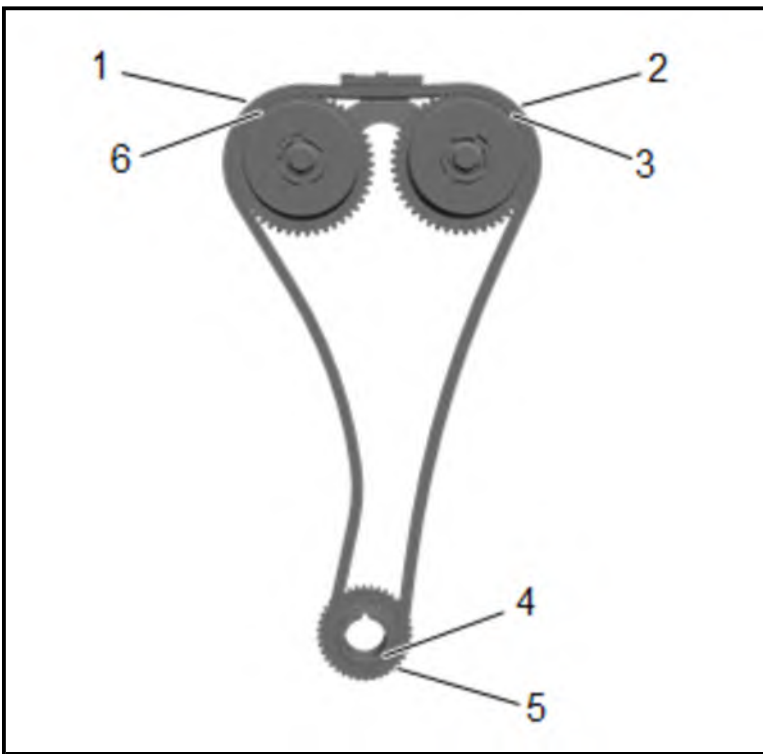
NOTE:

- The timing for the exhaust camshaft actuator and the crankshaft sprocket has been established.
- Applying or loosening pressure by hand between the timing chain guides will allow the chain to slip or bind during counterclockwise rotation of the camshaft.

11. Install the timing chain tensioner (2) and tighten timing chain tensioner bolts (1) to 25 N.m (18 lb ft)

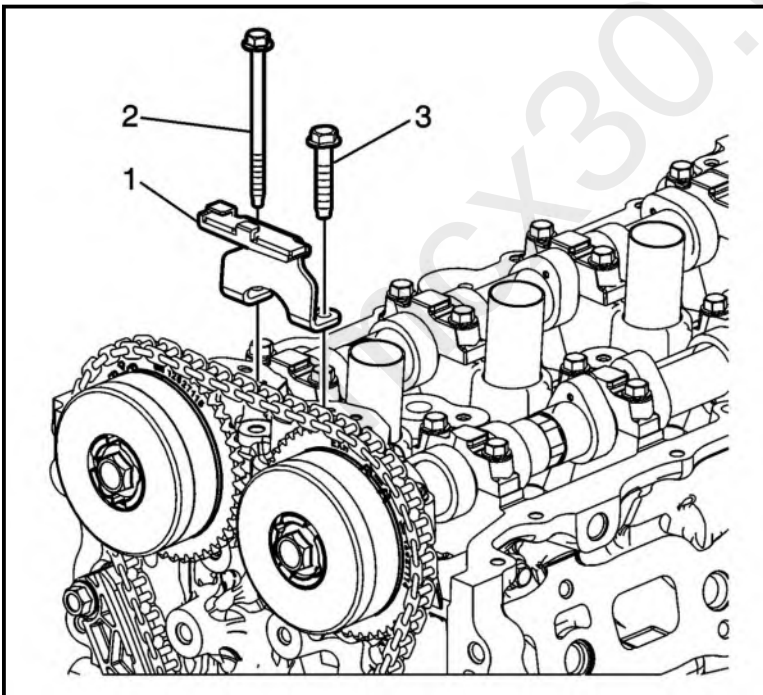


12. Verify the timing links on the timing chain are properly aligned to the timing marks:

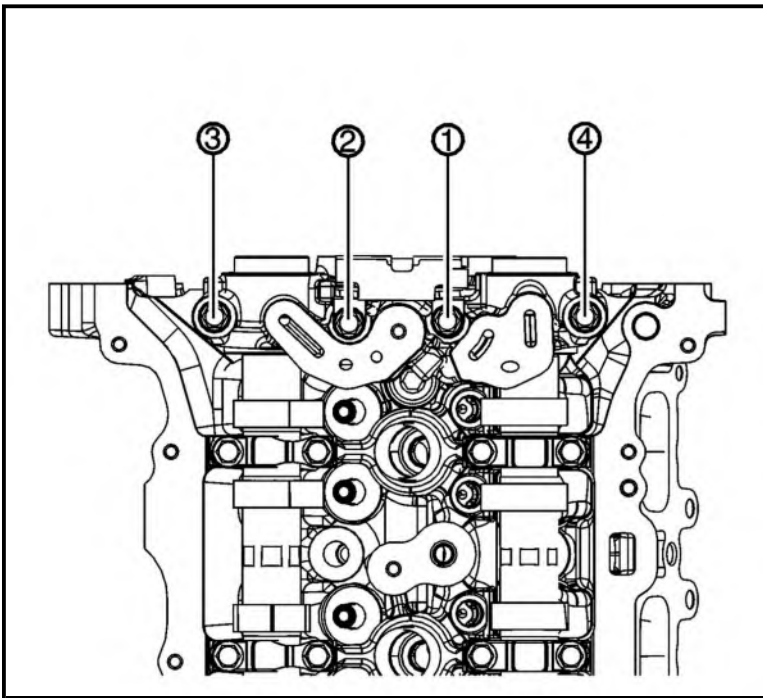


1. The timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).

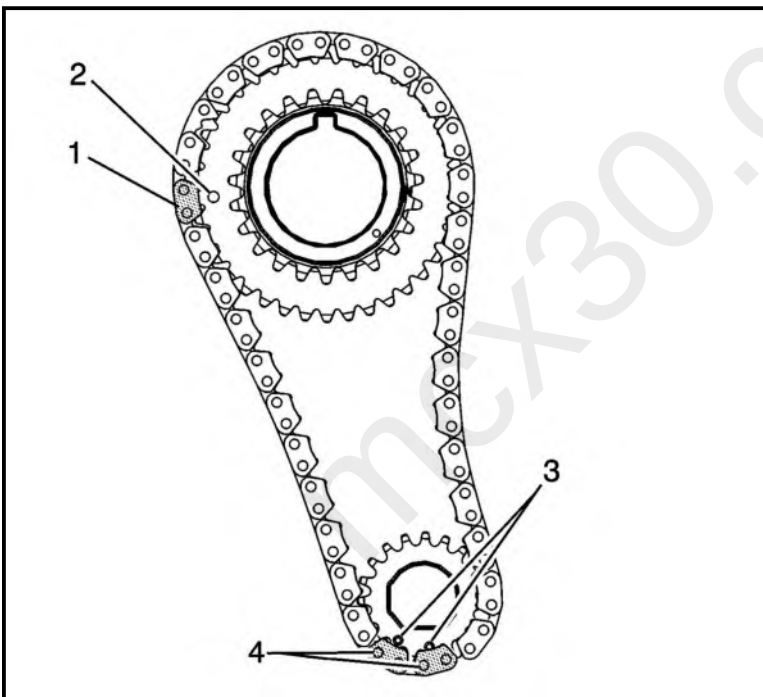
13. If they are not, repeat the portion of the procedure necessary to align the timing marks.
14. Install the timing chain guide (1) and bolts (2, 3) finger tight.



15. Tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.



16. Rotate the crankshaft clockwise to see if either of the actuators or the crankshaft sprocket jump timing chain teeth. If this occurs, repeat procedure to align the timing marks.
17. Verify the timing links on the balance chain are properly aligned to the timing marks:



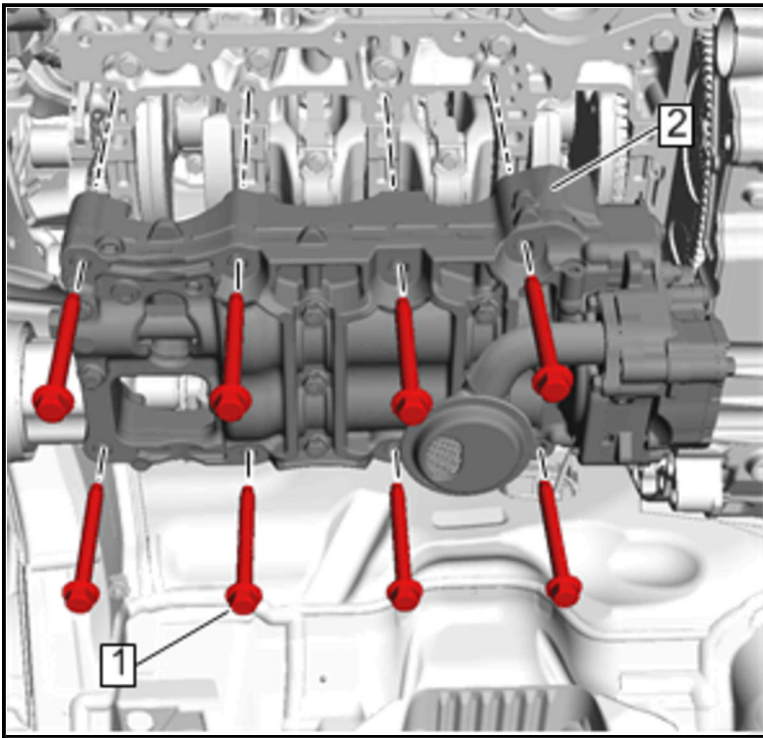
NOTE: Due to the difference of crankshaft sprocket and balance shaft sprocket, timing marks on the chain will not match during every crankshaft revolution. Ensure that the marks on the sprockets are aligned appropriately before installing the timing chain.

1. The timing link (1) is aligned to the timing mark on the crankshaft sprocket (2).
 2. The adjacent timing links (4) are aligned with both timing marks (3) on the balancer shaft driven sprocket.
18. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).

BALANCER SHAFT WITH OIL PUMP REPLACEMENT

Removal Procedure

1. [Oil Pan Replacement \(4WD\)](#), or [Oil Pan Replacement \(2WD\)](#) - Remove
2. [Timing Chain Crankshaft Sprocket Replacement](#) - Remove
3. Balancer Shaft with Oil Pump Bolt (1) - Remove [8x]



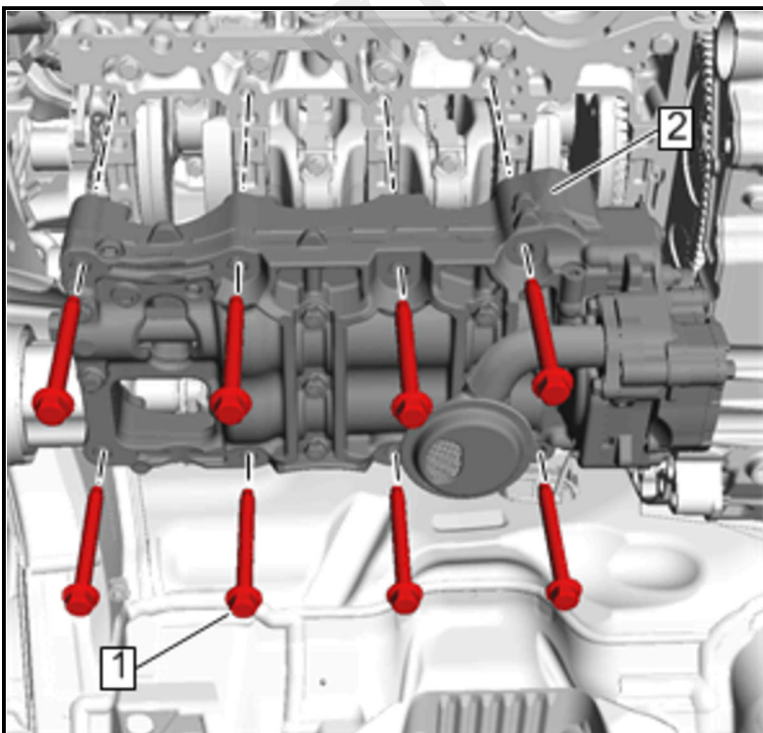
4. Balancer Shaft with Oil Pump (2) - Remove

NOTE: If replacing the oil pump, remove it from the balancer shaft.

5. Remove the oil pump. [Balancer Shaft with Oil Pump Disassemble](#)

Installation Procedure

1. Install the oil pump. [Balancer Shaft with Oil Pump Assemble](#)
2. Balancer Shaft with Oil Pump (2) - Install



3. Balancer Shaft with Oil Pump Bolt (1) - Loosely install [8x]
4. Balancer Shaft with Oil Pump Bolt - Tighten in sequence [8x]

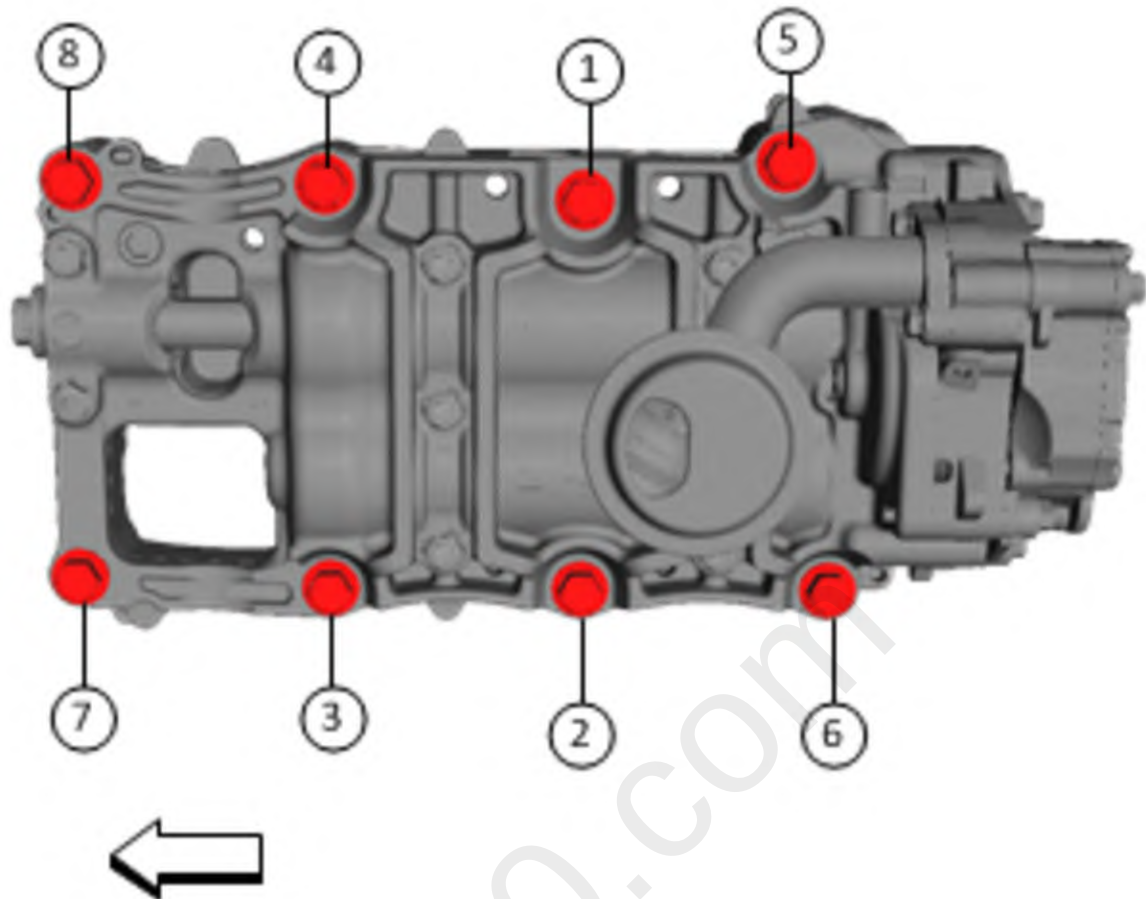


Fig. 11: Engine Balancer Shaft And Oil Pump Bolts With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

Tighten

1. **First pass** 58 N.m (43 lb ft)
2. **Final pass** 58 N.m (43 lb ft)
5. [Timing Chain Crankshaft Sprocket Replacement](#) - Install
6. [Oil Pan Replacement \(4WD\)](#), or [Oil Pan Replacement \(2WD\)](#) - Install

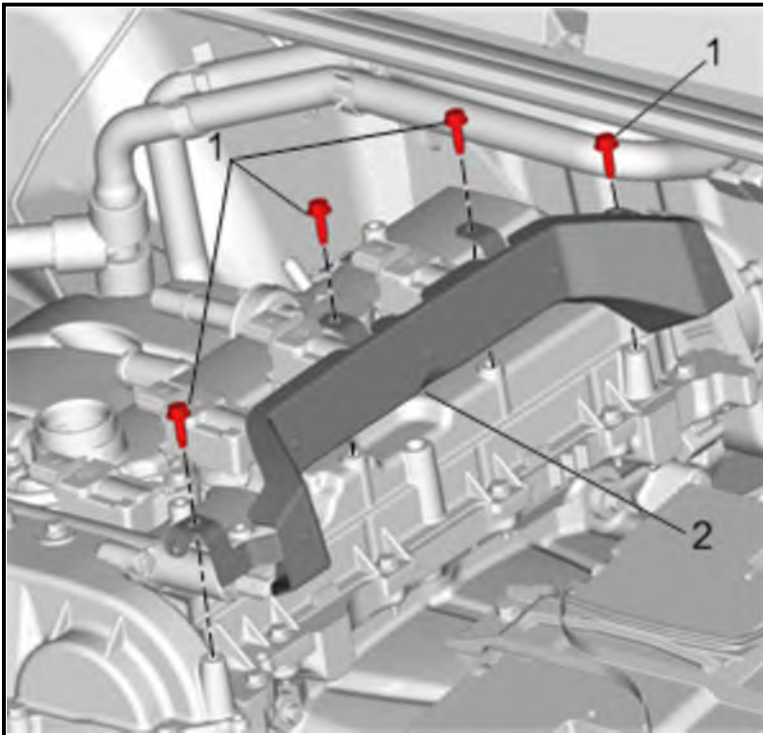
CAMSHAFT COVER REPLACEMENT

Removal Procedure

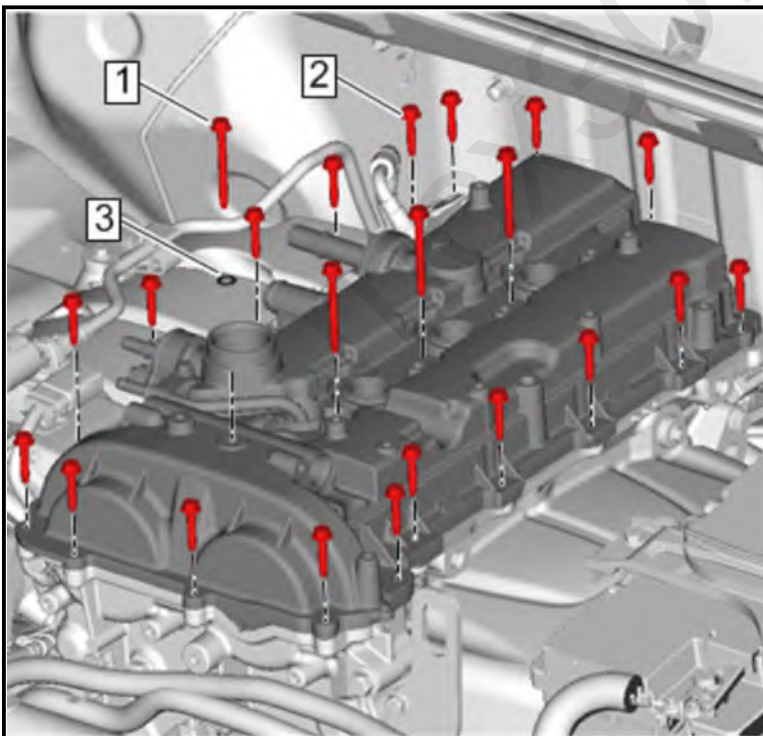
1. Remove the positive crankcase ventilation hose/pipe/tube. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).
2. Remove the oil level indicator.
3. Remove the ignition coils. Refer to [Ignition Coil Replacement](#) .
4. Remove the engine coolant air bleed pipe. Refer to [Engine Coolant Air Bleed Pipe Replacement \(LGZ\)](#) .
5. Remove the intake and exhaust camshaft position actuator solenoid valves. Refer to [Camshaft Position Actuator Exhaust Solenoid Valve Replacement](#) , or [Camshaft Position Actuator Intake Solenoid Valve Replacement](#) .

Replacement .

6. Disconnect the wire harness retainers at the camshaft cover heat shield.
7. Remove the camshaft cover heat shield bolts (1) then remove the camshaft cover heat shield (2).

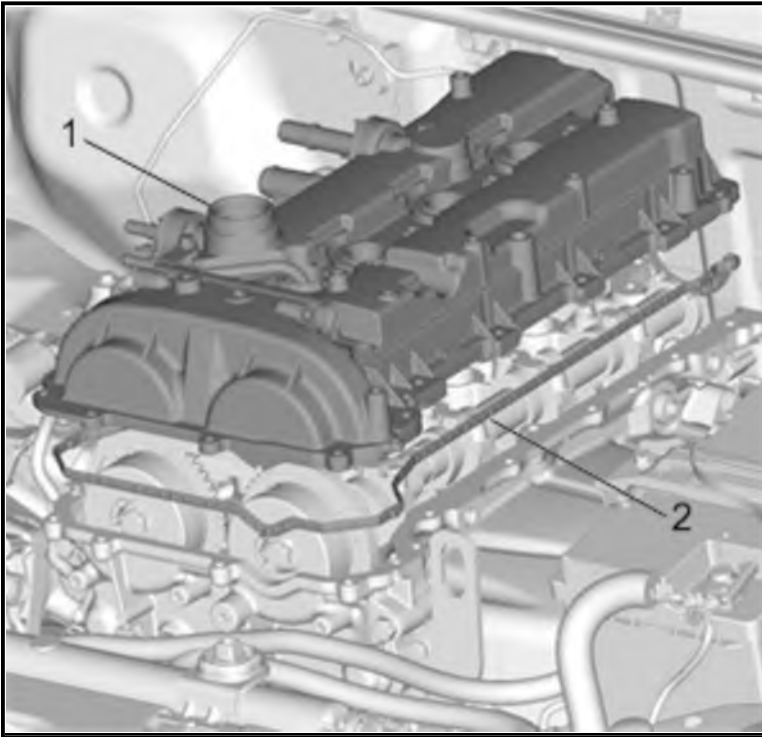


8. Remove the vacuum pump. Refer to [Vacuum Pump Replacement](#) .
9. Remove the camshaft cover bolts (1) and (2).



NOTE: Note the location of the longer bolts (1) for proper installation.

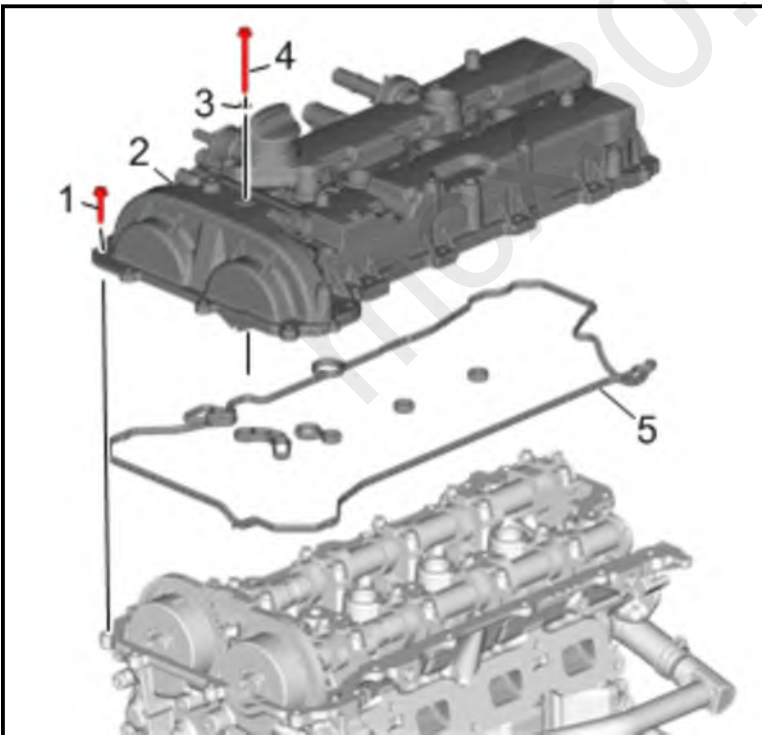
10. Camshaft Cover Washer (3) - Remove
11. Remove the camshaft cover (1) and camshaft cover gasket (2).



12. When replacing or reinstalling the camshaft cover. Refer to [Camshaft Cover Cleaning and Inspection](#) for transferring components and properly resealing the camshaft cover.

Installation Procedure

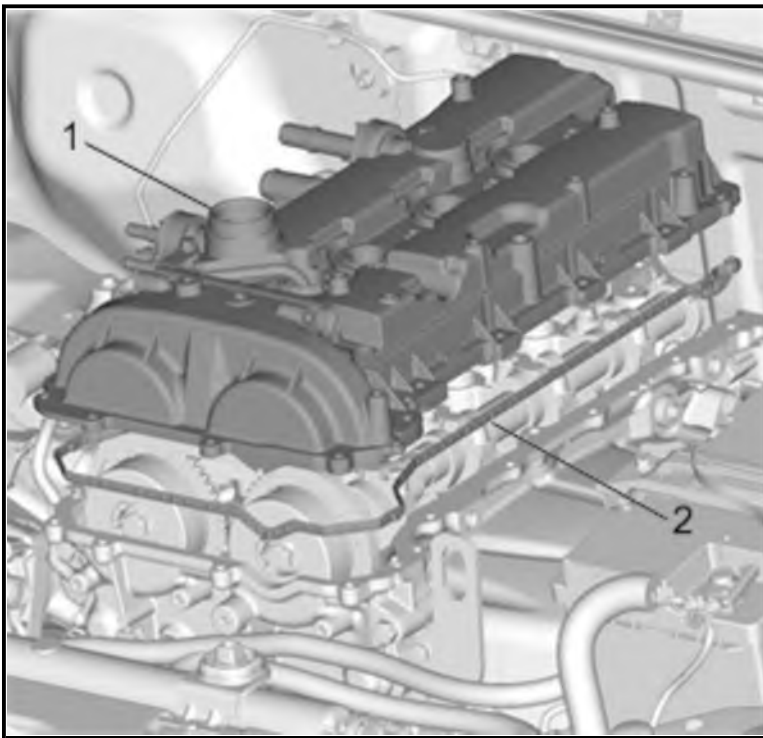
1. Assemble the camshaft cover (2) and a NEW gasket (4). Ensure that the gasket is located in the retaining groove in the camshaft cover.



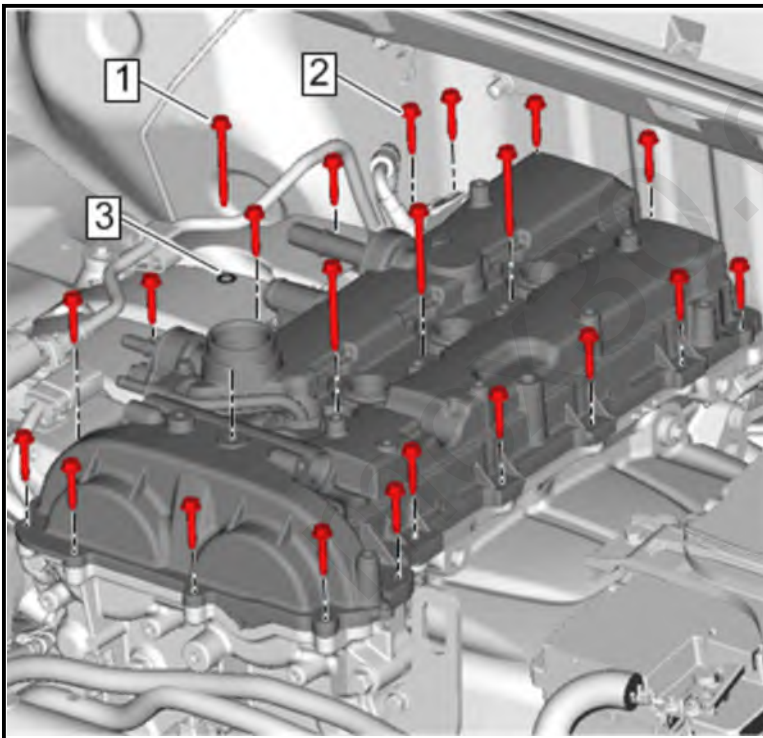
NOTE:

Add 14mm bead of sealant at right and left T-Joint where front cover meets head and at rear of camshaft cover right and left T-Joint where vacuum pump bolts on. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

2. Install the camshaft cover (1) and gasket (2) on the cylinder head.



3. Camshaft Cover Washer (3) - Install



NOTE: Be sure to install the longer camshaft cover bolts (1) in the previously noted location.

4. Hand start the camshaft cover bolts (1) and (2).
5. Tighten the camshaft cover bolts in sequence to 10 N.m (89 lb in).

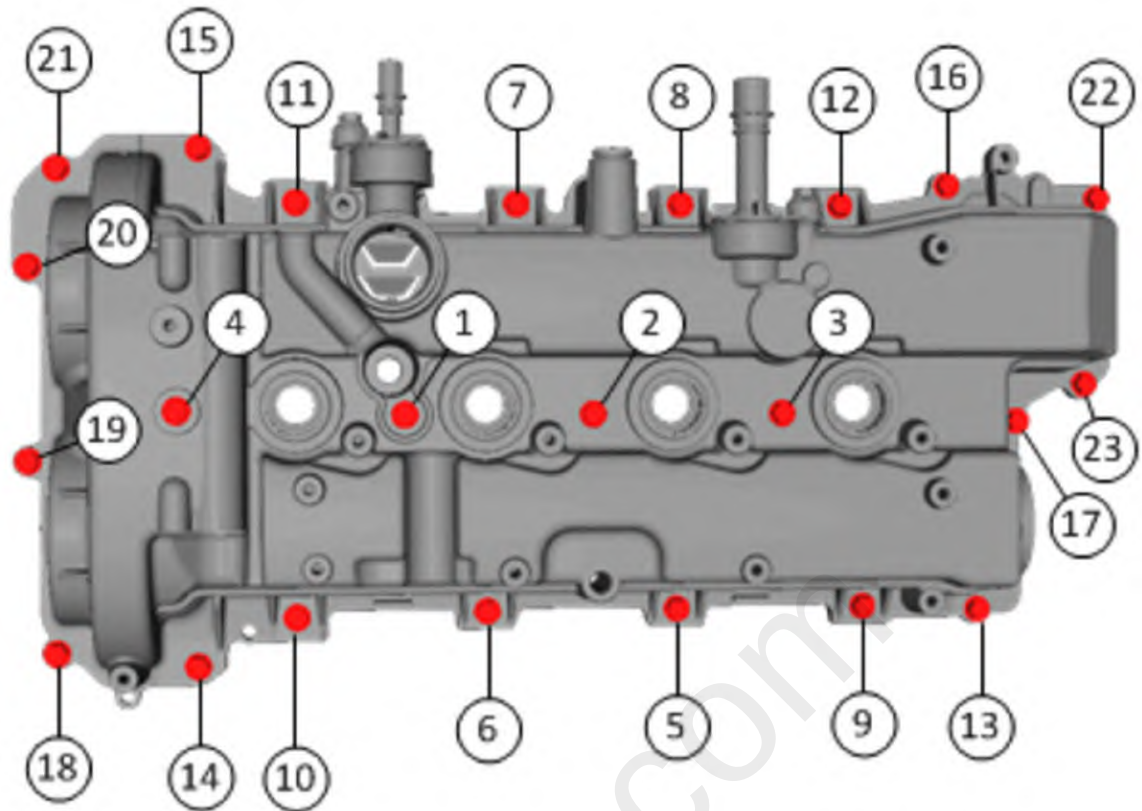
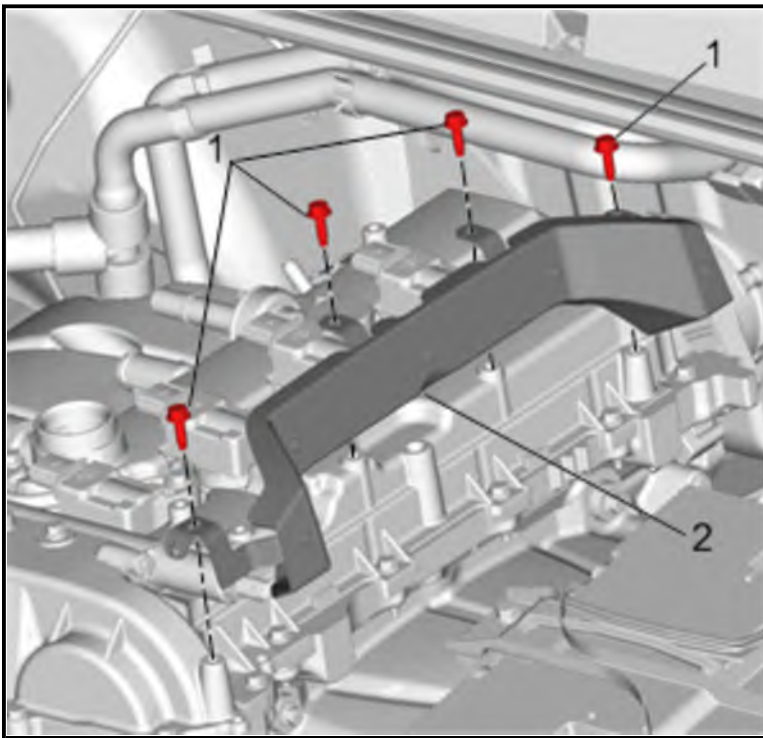


Fig. 12: Camshaft Cover Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

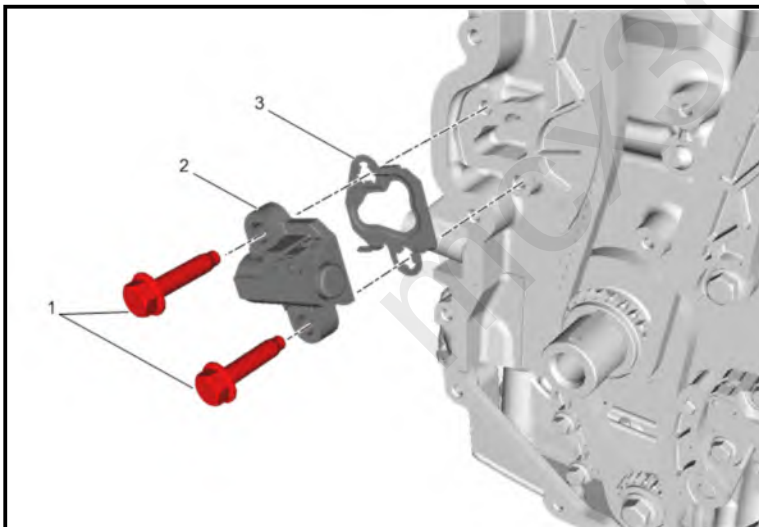
CAUTION: Refer to [Fastener Caution](#) .

6. Install the intake and exhaust camshaft position actuator solenoid valves. Refer to [Camshaft Position Actuator Exhaust Solenoid Valve Replacement](#) , or [Camshaft Position Actuator Intake Solenoid Valve Replacement](#) .
7. Install the vacuum pump. Refer to [Vacuum Pump Replacement](#) .
8. Install the ignition coils. Refer to [Ignition Coil Replacement](#) .
9. Position the camshaft cover heat shield (2) then install the bolts (1). Tighten the bolts to 10 N.m (89 lb in)



10. Install the engine coolant air bleed pipe. Refer to [Engine Coolant Air Bleed Pipe Replacement \(LGZ\)](#) .
11. Connect the wire harness retainers at the camshaft cover heat shield.
12. Install the positive crankcase ventilation hose/pipe/tube. Refer to [Positive Crankcase Ventilation Hose/Pipe/Tube Replacement](#).
13. Install the oil level indicator.

TIMING CHAIN TENSIONER REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

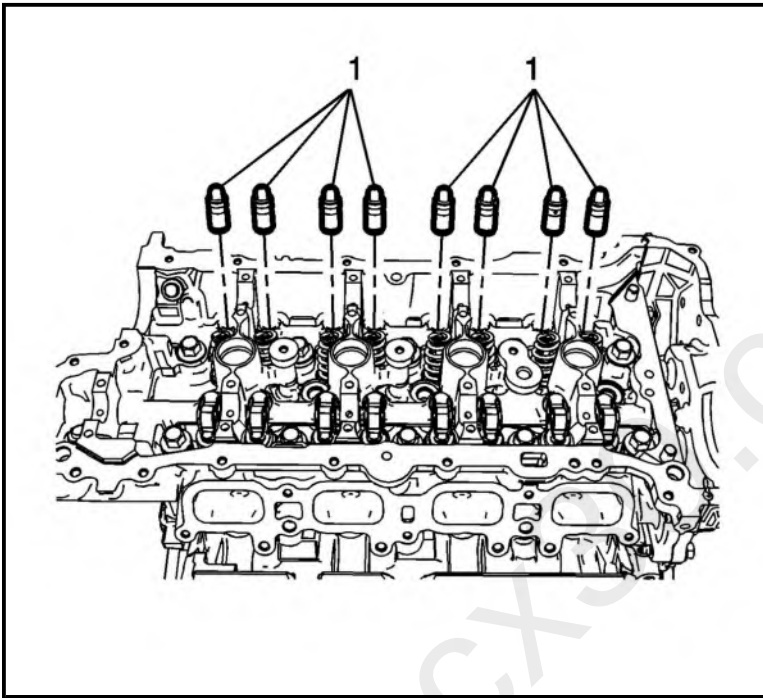
Callout	Component Name
Preliminary Procedure Engine Front Cover Replacement	
1	Timing Chain Tensioner Bolt [2x] CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Tighten 25 N.m (18 lb ft)
2	Timing Chain Tensioner
3	Timing Chain Tensioner Gasket Preliminary Procedure Install a NEW gasket.

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT - EXHAUST

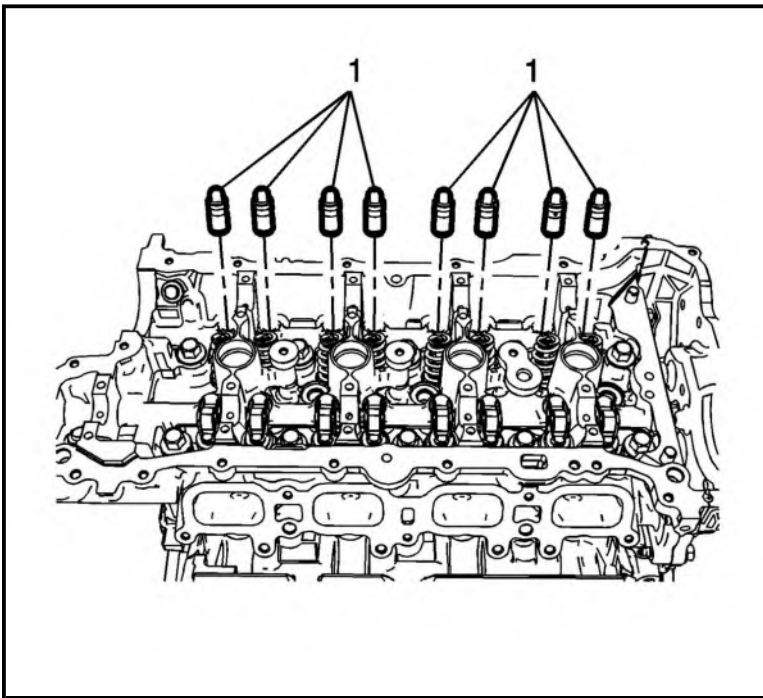
Removal Procedure

1. Remove the exhaust valve rocker arm. Refer to [Exhaust Valve Rocker Arm Replacement](#).
2. Remove the hydraulic lash adjusters (1).



Installation Procedure

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



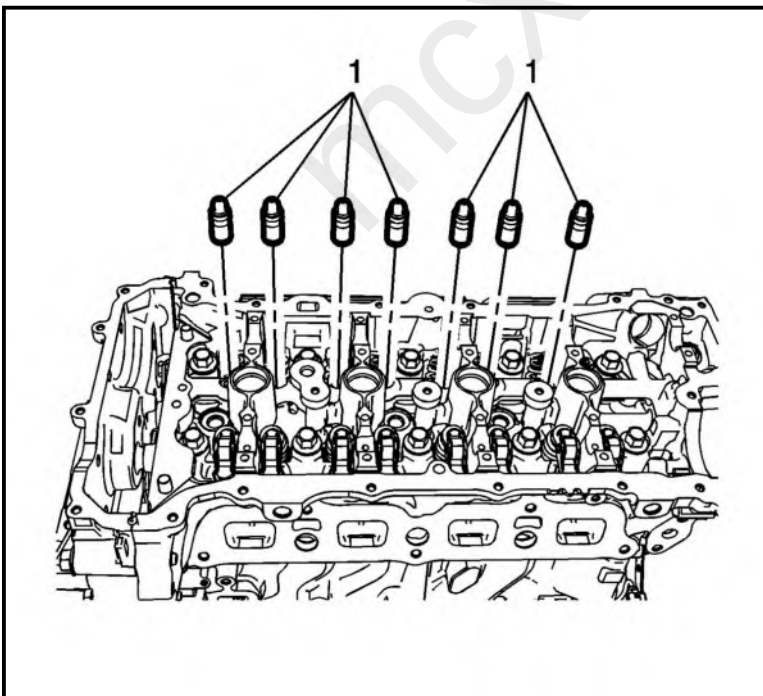
NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

2. Install the exhaust valve rocker arm. Refer to [Exhaust Valve Rocker Arm Replacement](#).

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT - INTAKE

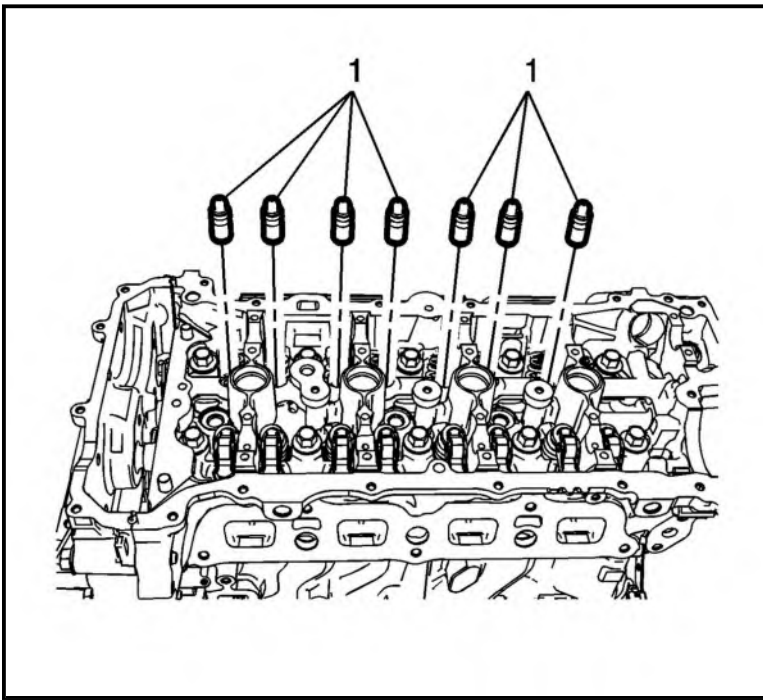
Removal Procedure

1. Remove the Intake valve rocker arm. Refer to [Intake Valve Rocker Arm Replacement](#).
2. Remove the hydraulic lash adjusters (1).



Installation Procedure

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

2. Install the Intake valve rocker arm. Refer to [Intake Valve Rocker Arm Replacement](#).

CAMSHAFT POSITION ACTUATOR AND INTAKE CAMSHAFT REPLACEMENT

Special Tools

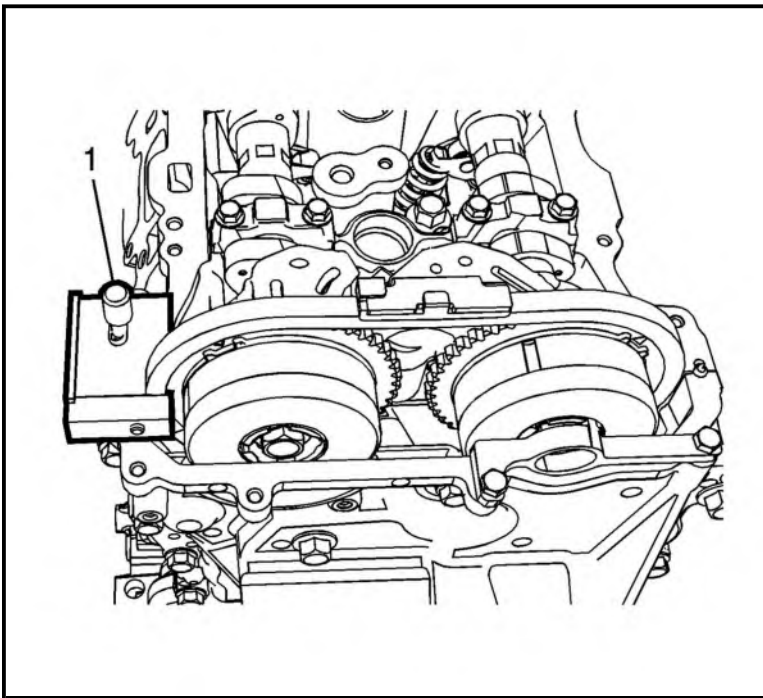
- EN-50656 Holding Tool
- EN 50793 Locking Tool

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

Removal Procedure

NOTE: Ensure the engine is properly timed to Top Dead Center (TDC), prior to performing repairs.

1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
2. Remove the high pressure fuel pump. Refer to [Fuel Pump Replacement](#).
3. Install EN-50656 timing chain holding tool (1) and tighten to 8 N.m (71 lb in).

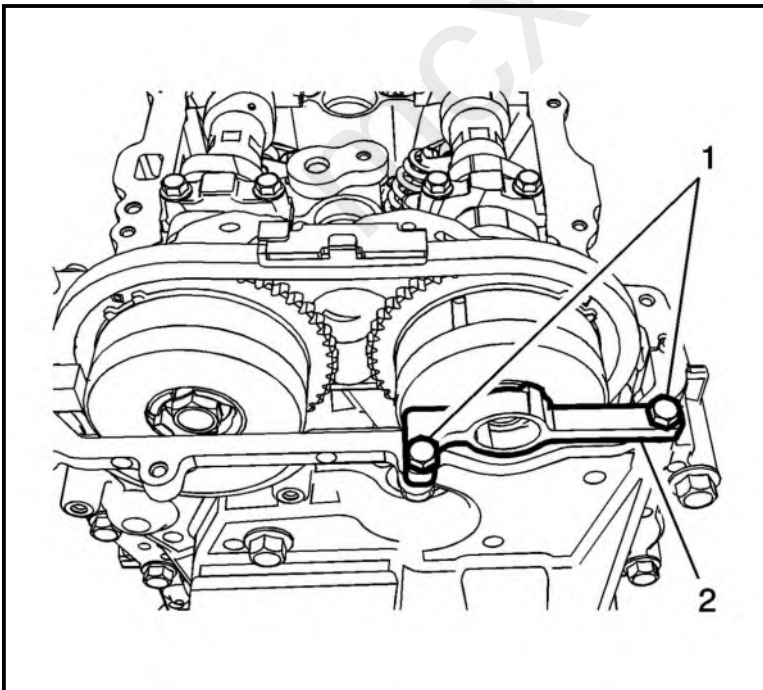


CAUTION: Refer to [Fastener Caution](#) .

NOTE: Ensure the EN-50656 holding tool is installed and securely tightened to prevent the camshaft chain from dropping into the front engine cover during camshaft actuator replacement.

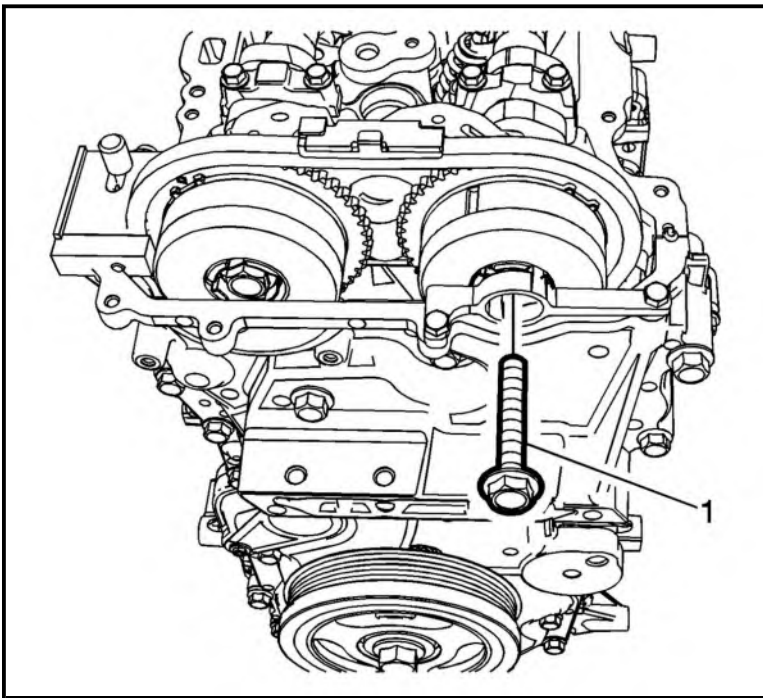
NOTE: To remove the Intake camshaft position actuator, it is necessary to place the intake camshaft into the exhaust camshaft position due to the engine block design.

4. Align and install camshaft actuator locking tool (2) EN 50793 into the slots of the exhaust camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

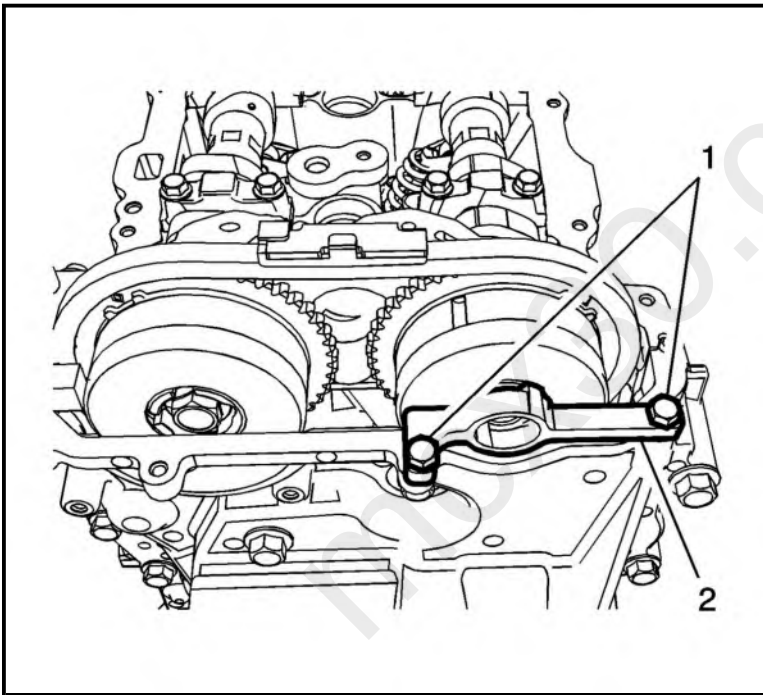


NOTE: Ensure to mark actuator sprocket and chain before removal.

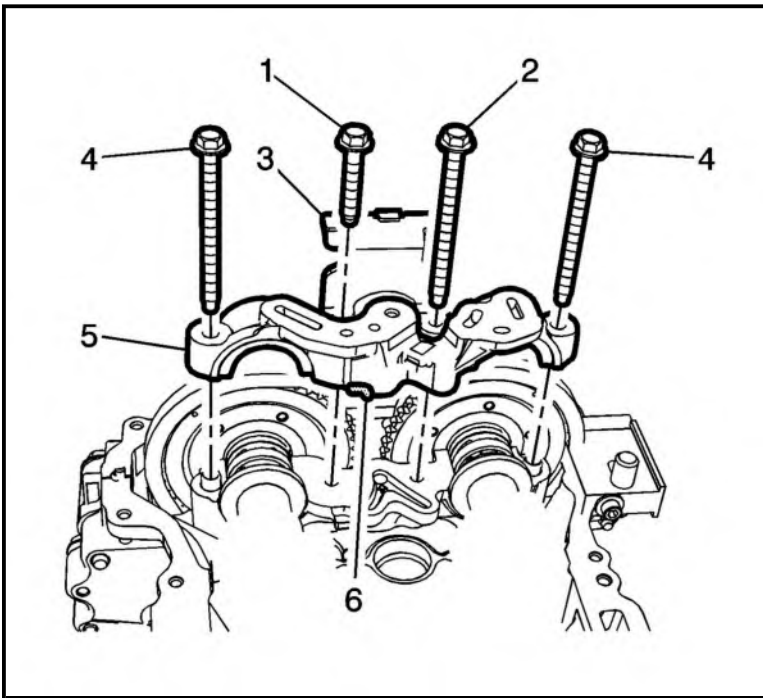
5. Remove and DISCARD the camshaft actuator bolt (1).



6. Remove the **EN-50793** holding tool (2).



7. Remove the upper timing chain guide bolts (1, 2).



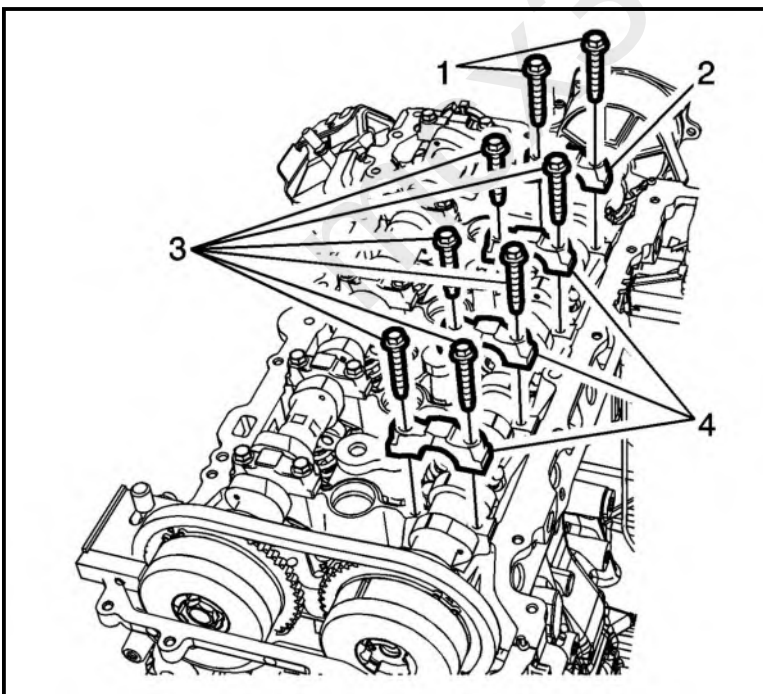
8. Remove the upper timing chain guide (3).

9. Remove the camshaft front bearing cap bolts (4).

NOTE: Locate the pry points (6) in the camshaft front bearing cap. When using the 3 pry points to remove the front bearing cap evenly, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.

10. Remove the camshaft front bearing cap (5).

11. Mark the exhaust camshaft rear cap to ensure it is installed in the same position. Remove the exhaust camshaft bearing rear cap bolts (1) and cap (2).



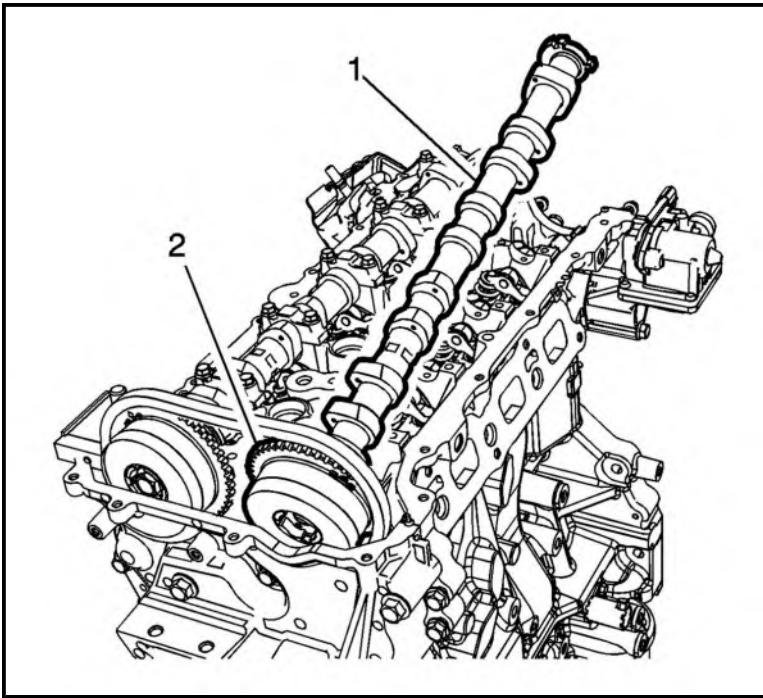
NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

12. Mark the camshaft caps (4) to ensure they are installed in the same position.

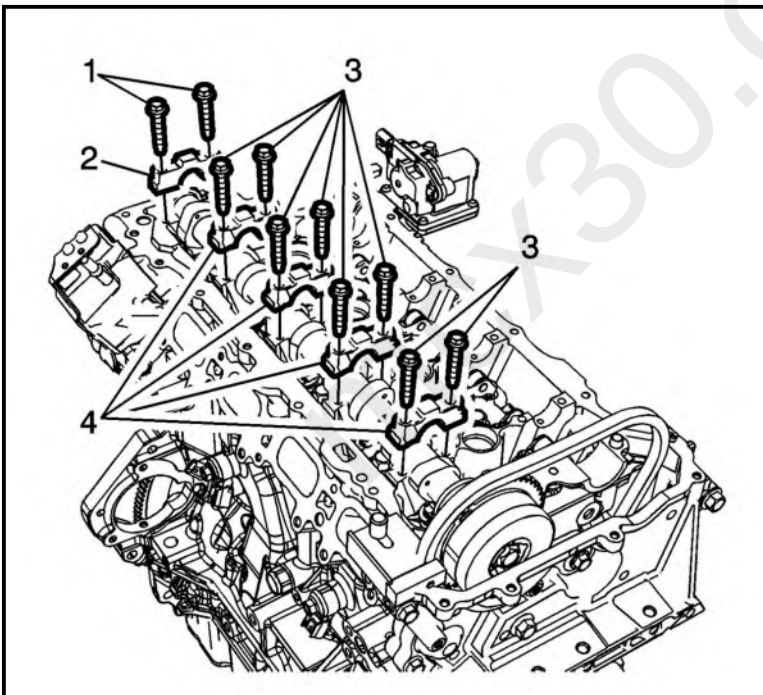
13. Remove the exhaust camshaft cap bolts (3).

14. Remove the camshaft caps (4).

15. Pull exhaust camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of exhaust camshaft assembly to a tilt and pull free from exhaust camshaft actuator assembly (2).

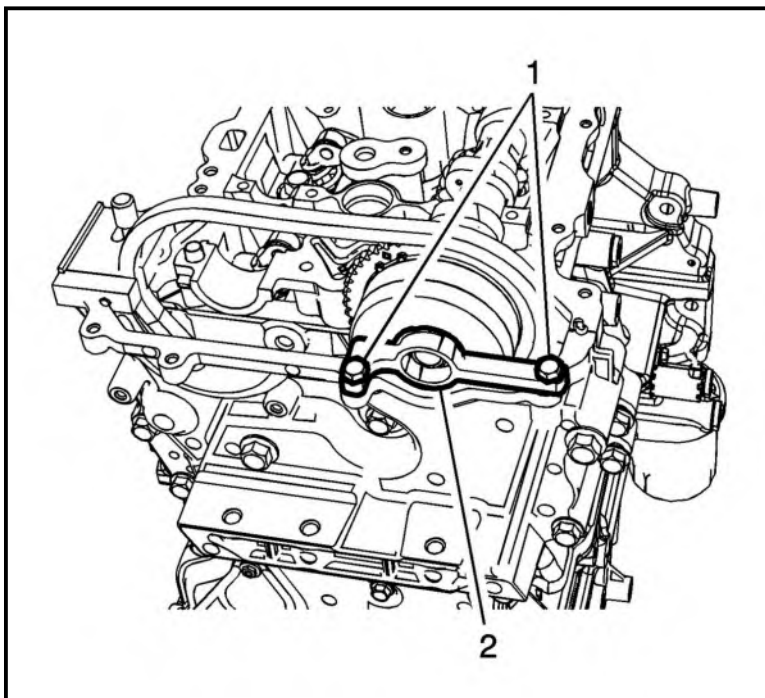


16. Mark the intake camshaft rear cap to ensure it is installed in the same position. Remove the intake camshaft bearing rear cap bolts (1) and cap (2).

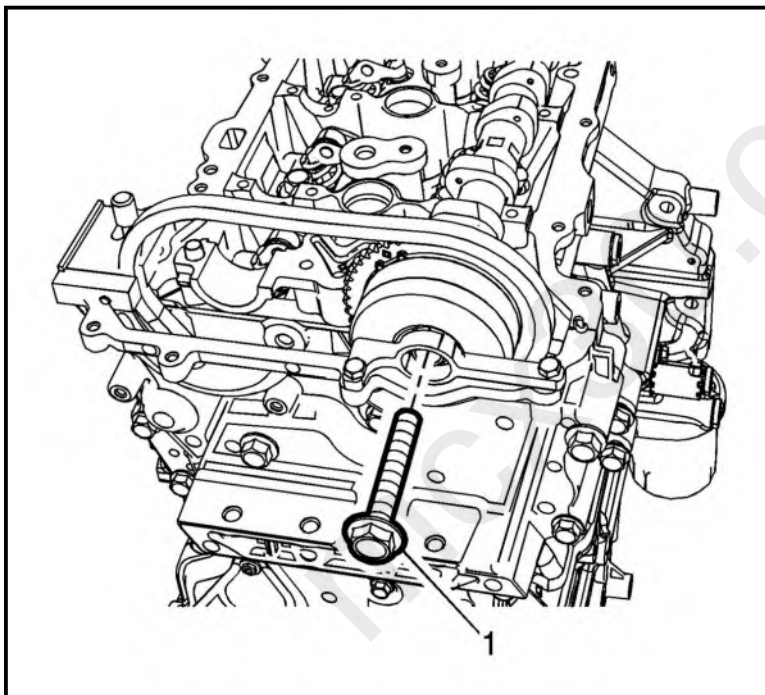


NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

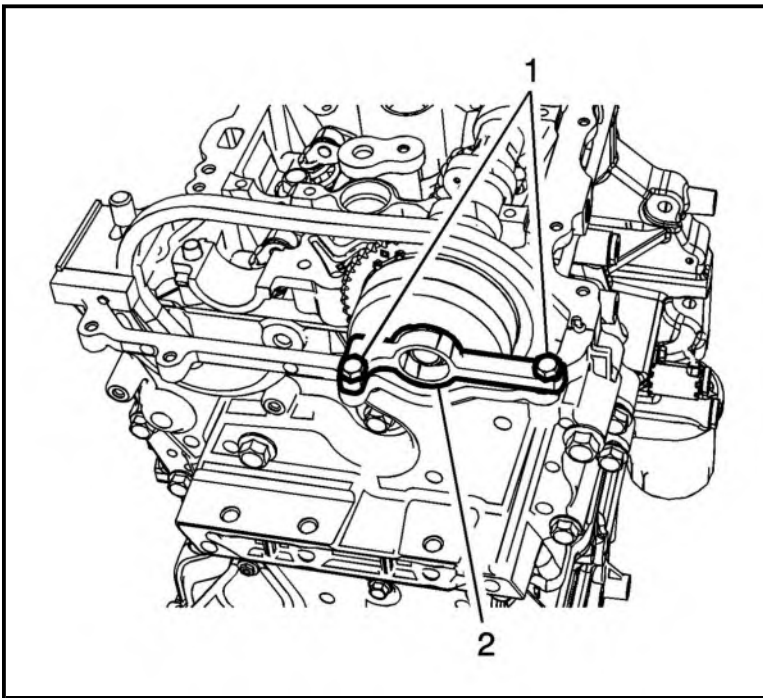
17. Mark the camshaft caps (4) to ensure they are installed in the same position.
18. Remove the intake camshaft cap bolts (3).
19. Remove the camshaft caps (4).
20. Lift and roll intake camshaft assembly from original position over into exhaust camshaft position within engine head assembly.
21. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).



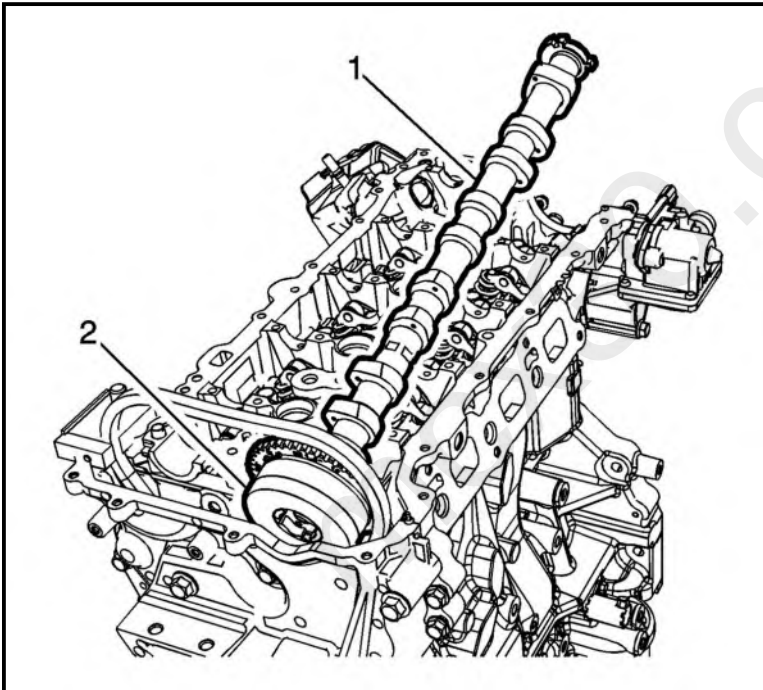
22. Remove the camshaft actuator bolt (1).



23. Remove the **EN-50793** holding tool (2).



24. Pull intake camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of intake camshaft assembly to a tilt and pull free from intake camshaft actuator assembly (2).

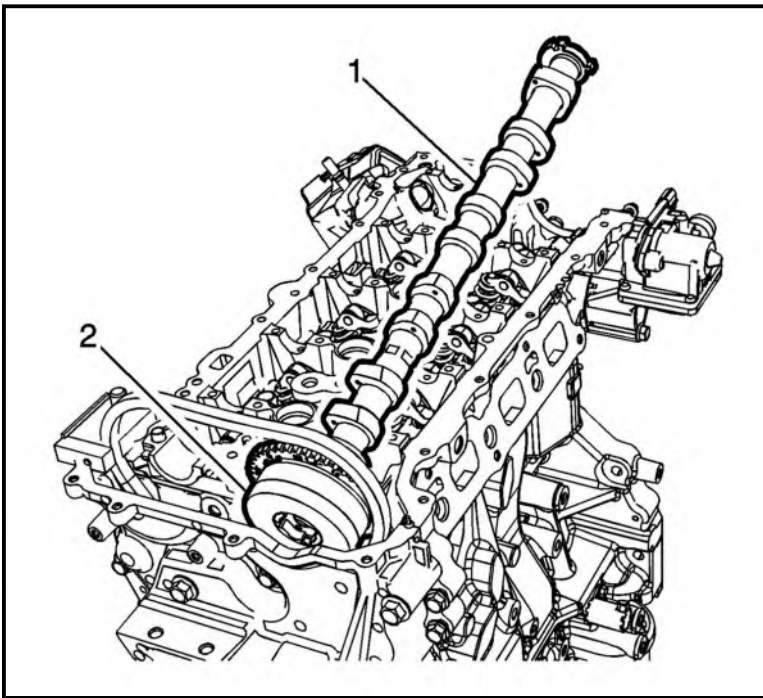


NOTE: If replacing the camshaft, ensure to transfer any marking from the old camshaft to the new one.

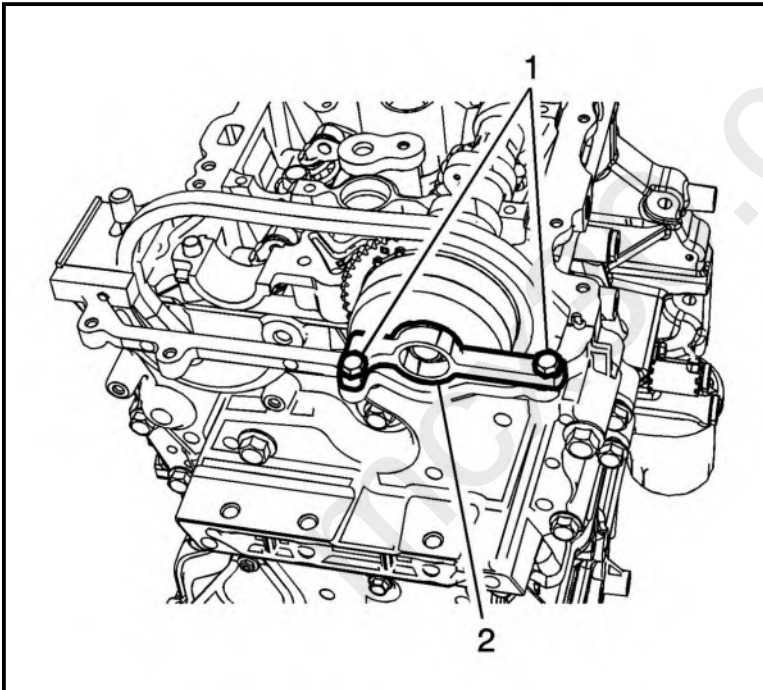
25. Replace the camshaft if necessary.

Installation Procedure

1. Install the intake camshaft (1) and camshaft actuator (2).

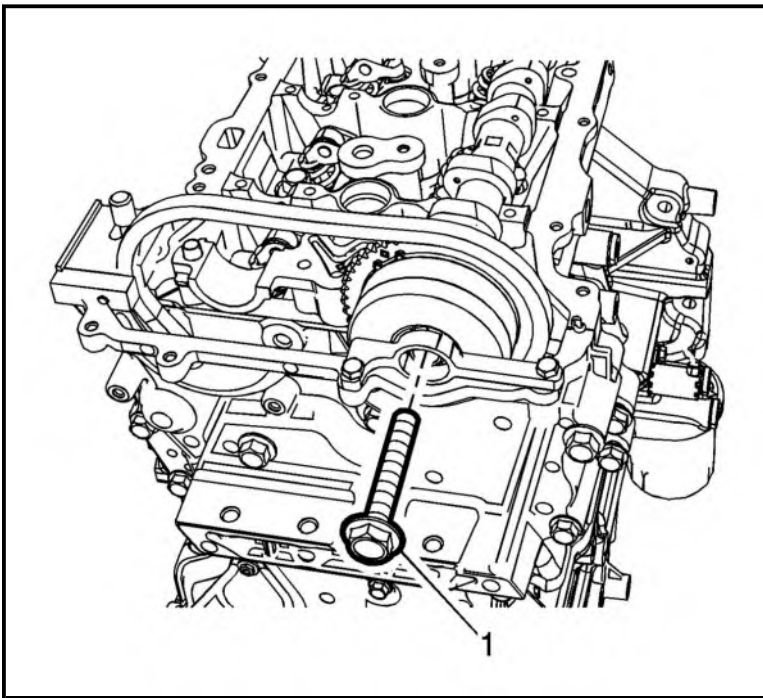


2. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

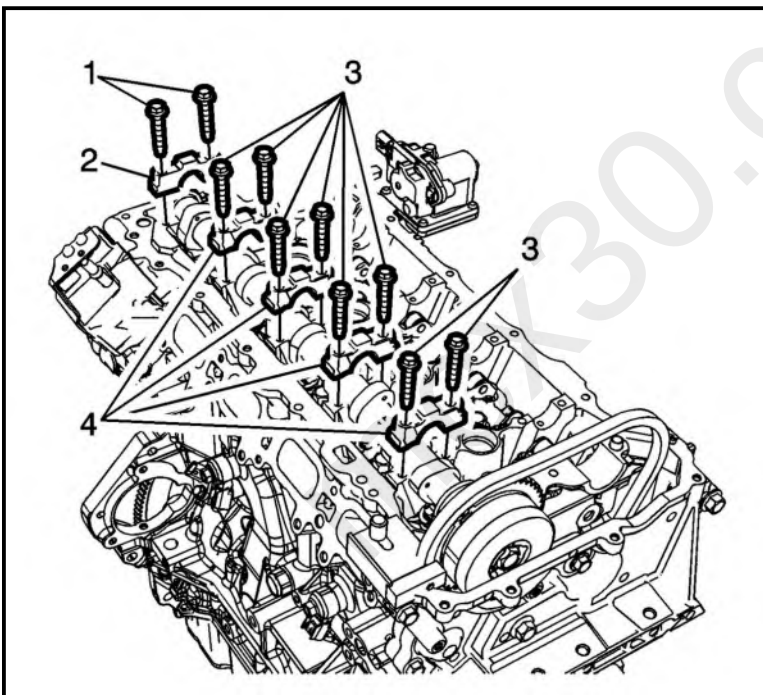


CAUTION: Refer to [Fastener Caution](#) .

3. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.



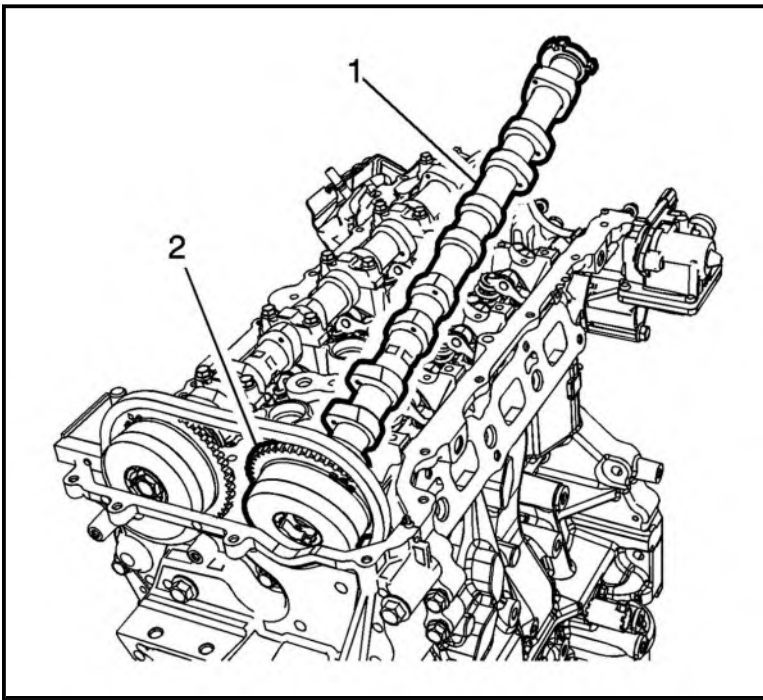
4. Lift and roll intake camshaft assembly from exhaust camshaft position over into original position.
5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals with the intake actuator timing mark at approximately the 11 O'clock position.



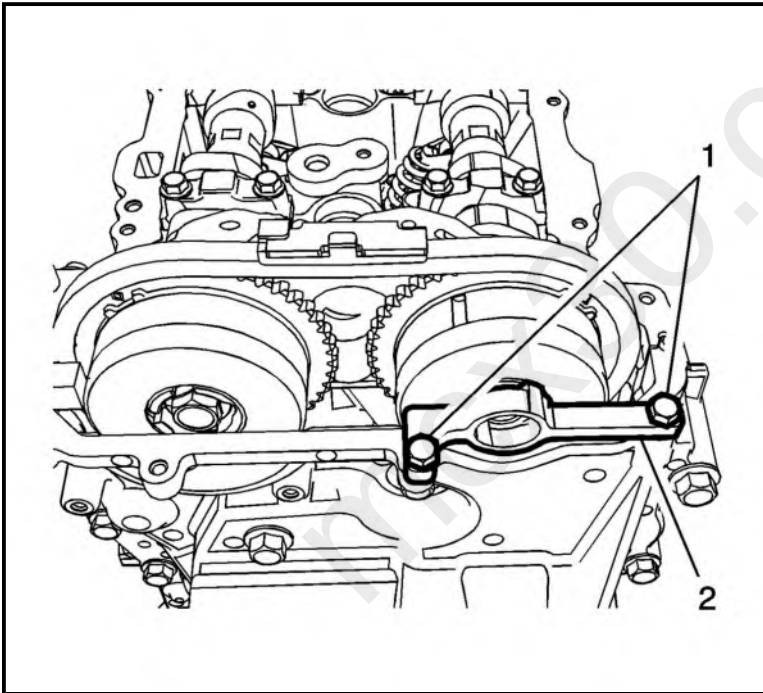
NOTE: Apply approved lubricant to all lobes and journals prior to installing the camshafts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for approved lubricant.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

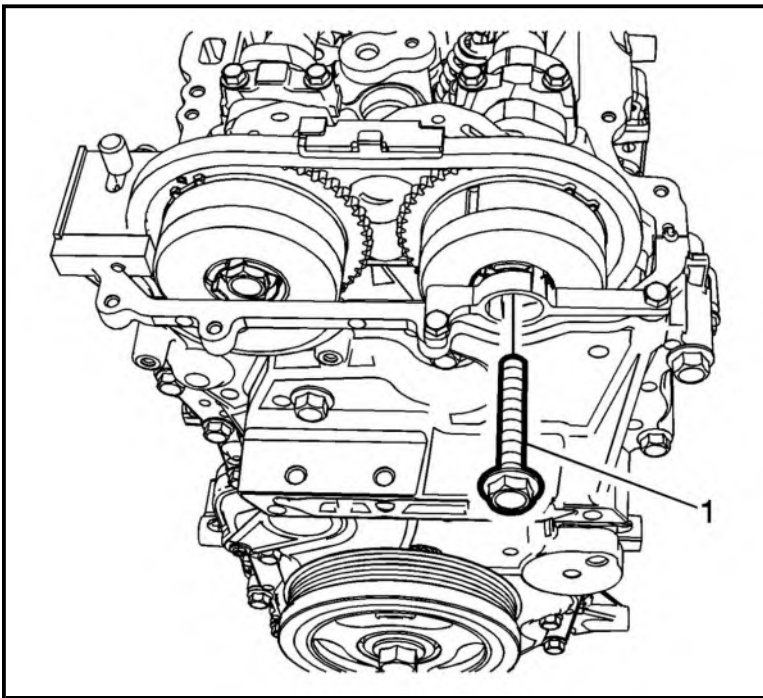
6. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
7. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).
8. Install the exhaust camshaft (1) and camshaft actuator (2).



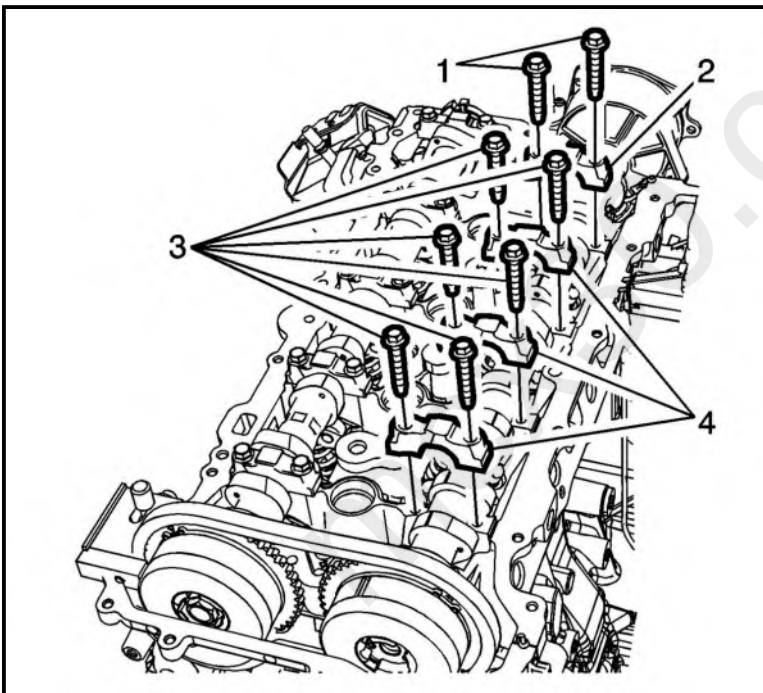
9. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).



10. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.



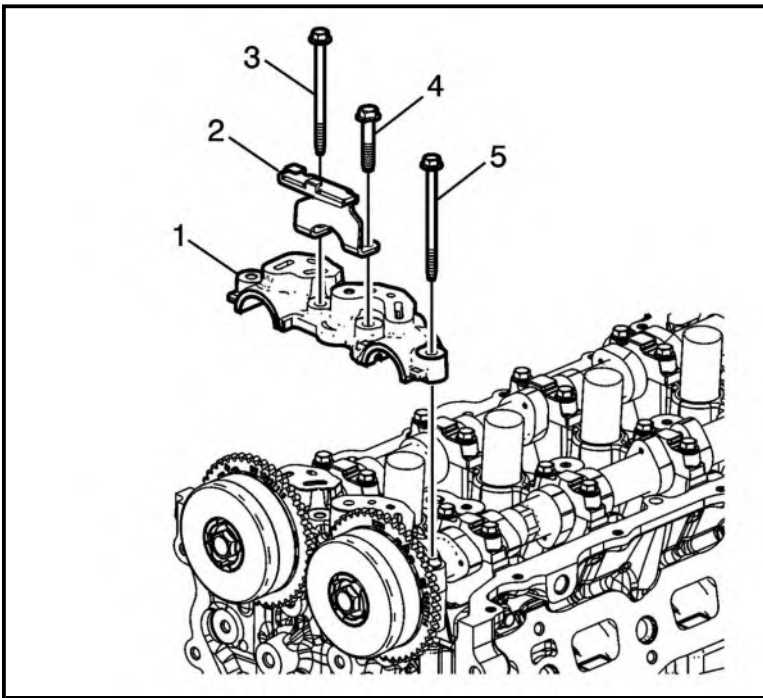
11. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals with the exhaust actuator timing mark at approximately the one O'clock position.



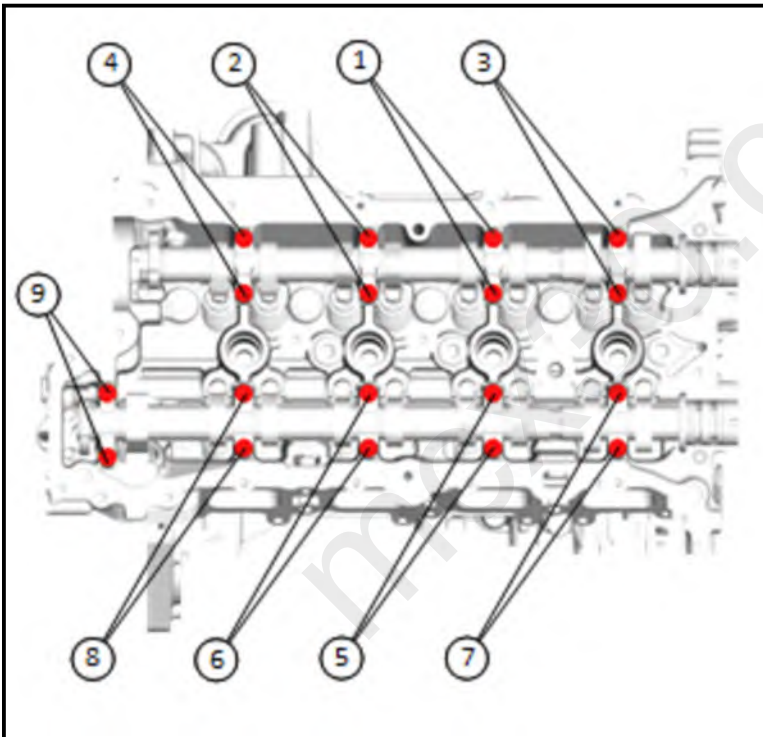
NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for approved lubricant.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

12. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
13. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).
14. Install the front camshaft bearing cap (1). Install the timing chain guide (2) onto the front camshaft bearing cap, then hand start the camshaft cap bolts (3 - 5).

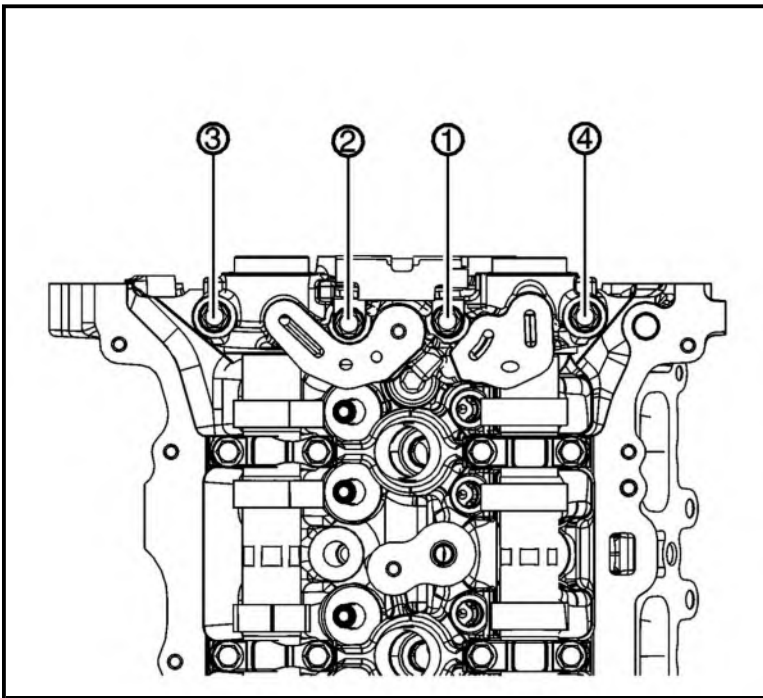


15. Tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in).

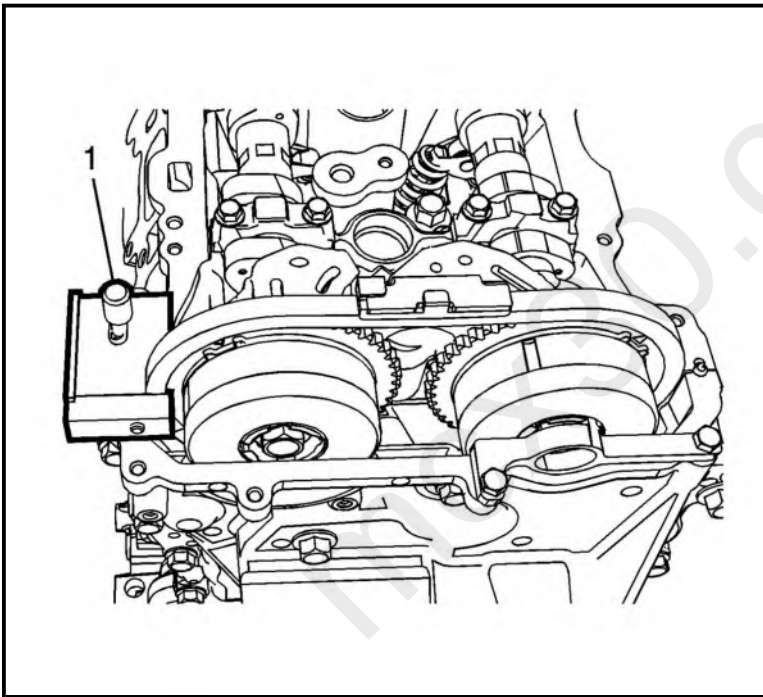


NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

16. Tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.



17. Remove **EN-50656** timing chain holding tool (1).



18. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).

19. Install the high pressure fuel pump. Refer to [Fuel Pump Replacement](#).

CAMSHAFT POSITION ACTUATOR AND EXHAUST CAMSHAFT REPLACEMENT

Special Tools

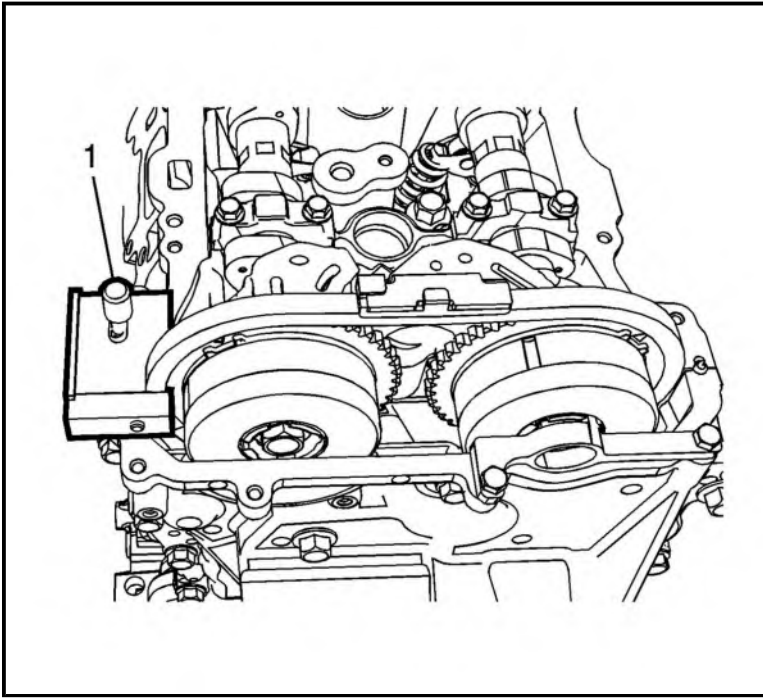
- **EN-50656** Holding Tool
- **EN 50793** Locking Tool

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

Removal Procedure

NOTE: Ensure the engine is properly timed to Top Dead Center (TDC), prior to performing repairs.

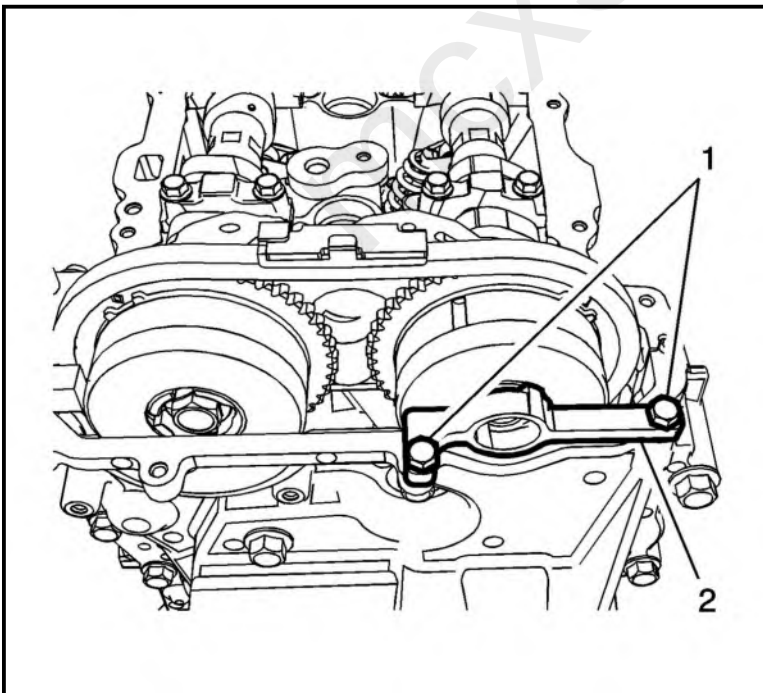
1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
2. Install **EN-50656** timing chain holding tool (1) and tighten to 8 N.m (71 lb in).



CAUTION: Refer to [Fastener Caution](#) .

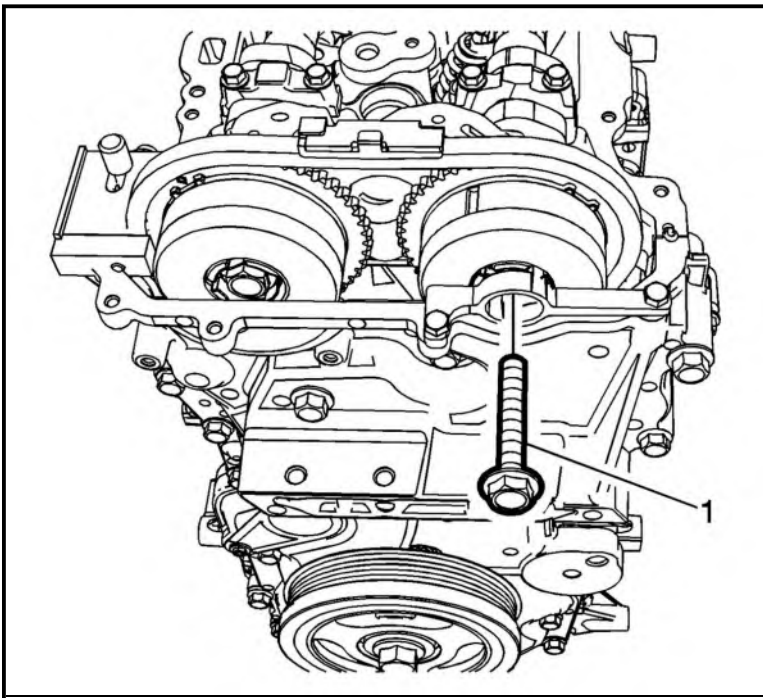
NOTE: Ensure the EN-50656 Holding tool is installed and securely tightened to prevent the camshaft chain from dropping into the front engine cover during camshaft actuator replacement.

3. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the exhaust camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

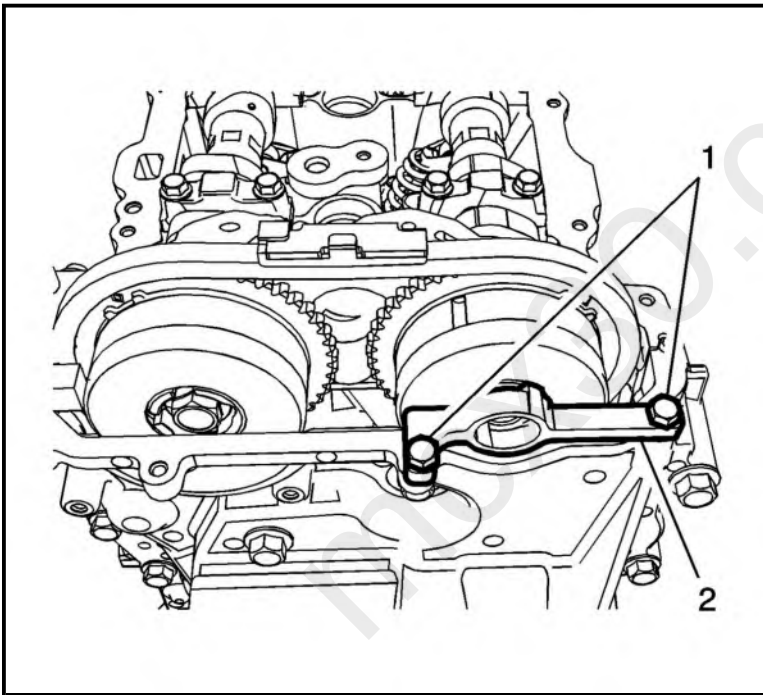


NOTE: Ensure to mark actuator sprocket and chain before removal.

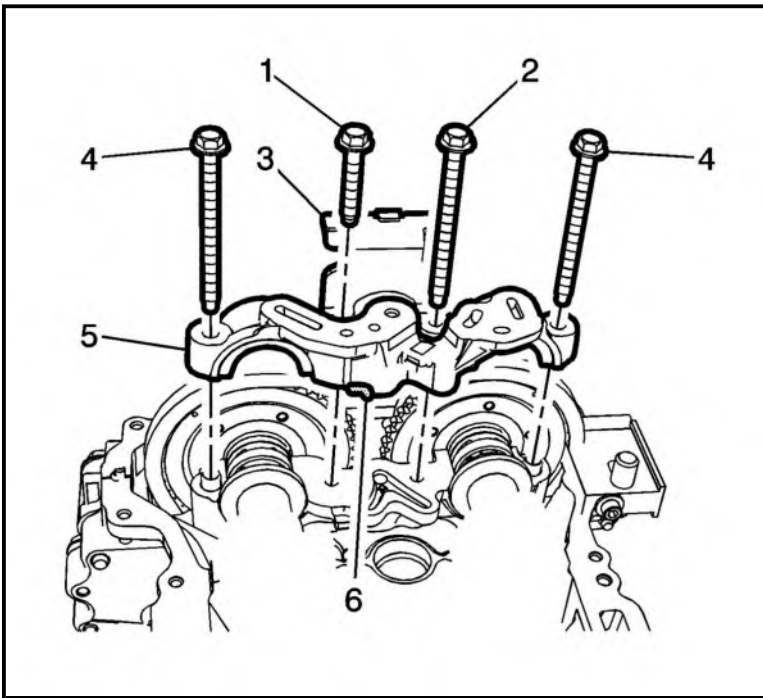
4. Remove and DISCARD the camshaft actuator bolt (1).



5. Remove the **EN-50793** holding tool (2).



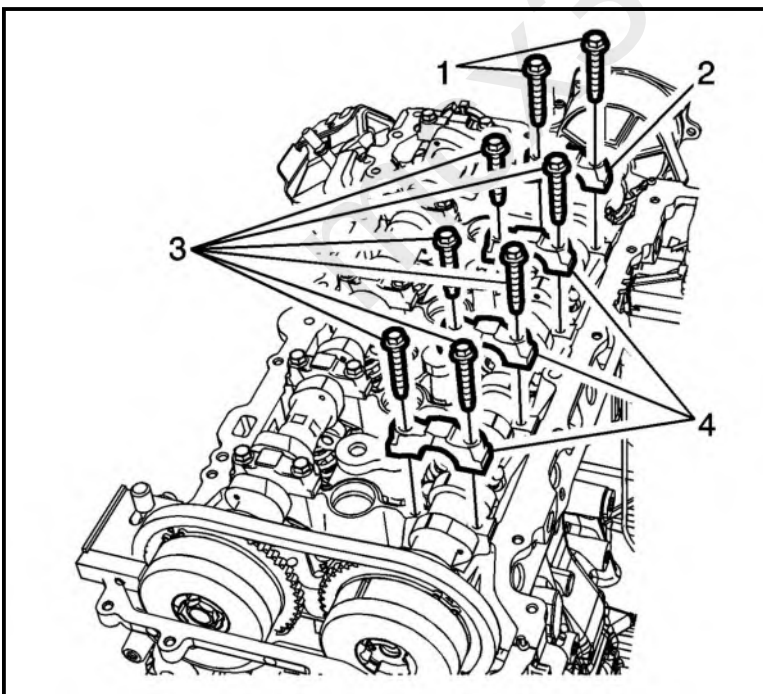
6. Remove the upper timing chain guide bolts (1, 2).



7. Remove the upper timing chain guide (3).
8. Remove the camshaft front bearing cap bolts (4).

NOTE: Locate the pry points (6) in the camshaft front bearing cap. When using the 3 pry points to remove the front bearing cap evenly, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.

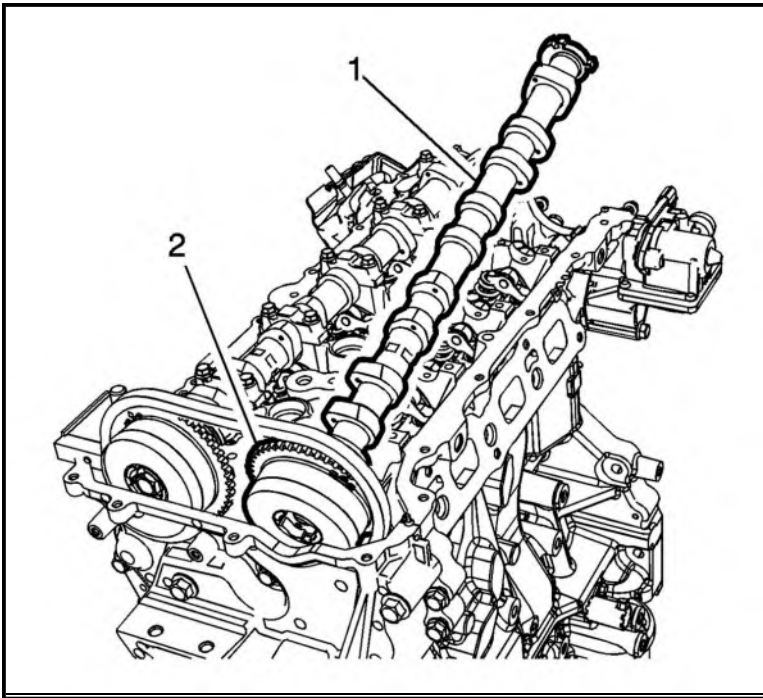
9. Remove the camshaft front bearing cap (5).
10. Mark the exhaust camshaft rear cap to ensure it is installed in the same position. Remove the exhaust camshaft bearing rear cap bolts (1) and cap (2).



NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

11. Mark the camshaft caps (4) to ensure they are installed in the same position.
12. Remove the exhaust camshaft cap bolts (3).
13. Remove the camshaft caps (4).

14. Pull exhaust camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of exhaust camshaft assembly to a tilt and pull free from exhaust camshaft actuator assembly (2).

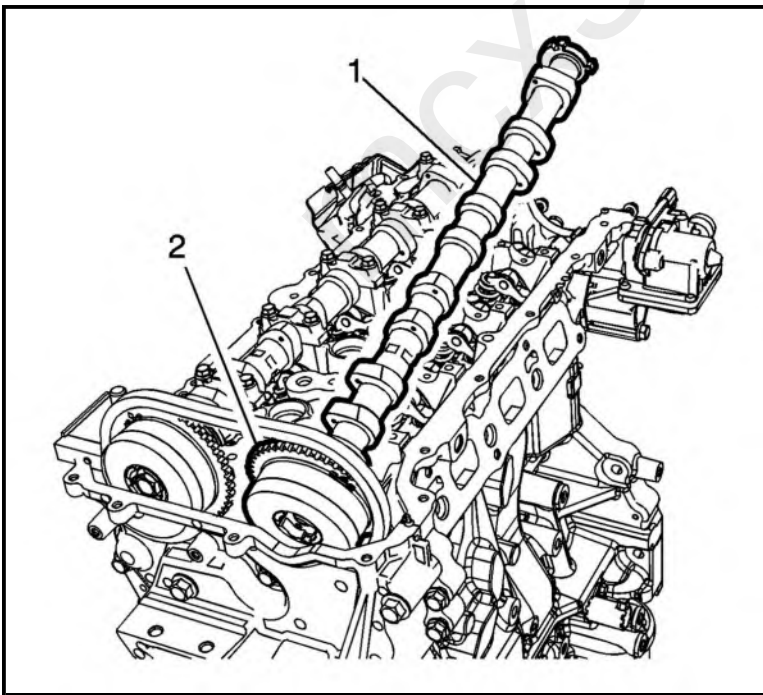


NOTE: If replacing the camshaft, ensure to transfer any marking from the old camshaft to the new one.

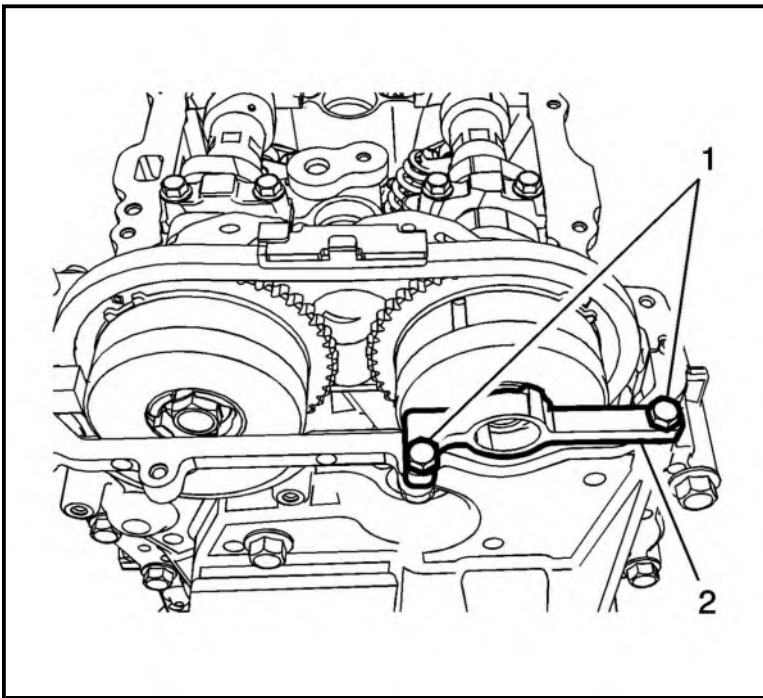
15. Replace the camshaft if necessary.

Installation Procedure

1. Install the exhaust camshaft (1) and camshaft actuator (2).

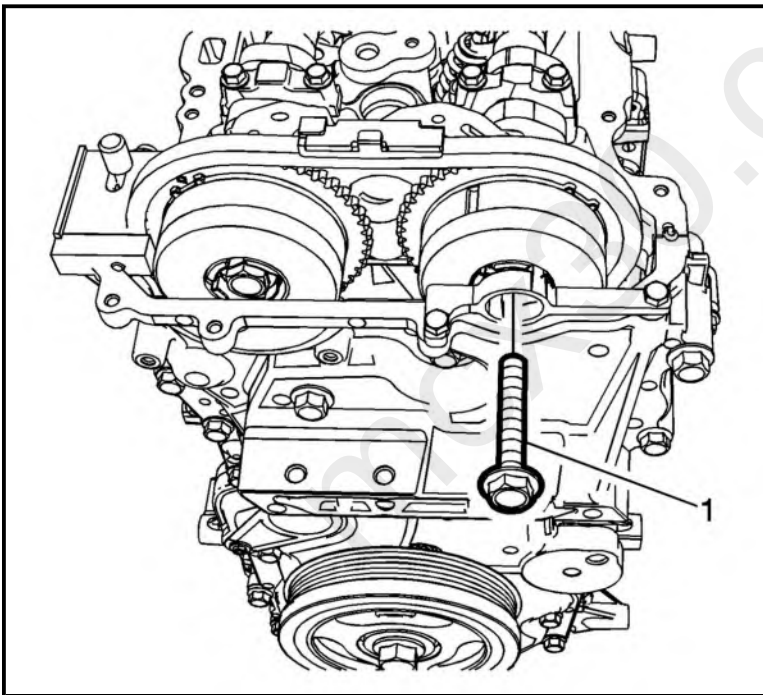


2. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

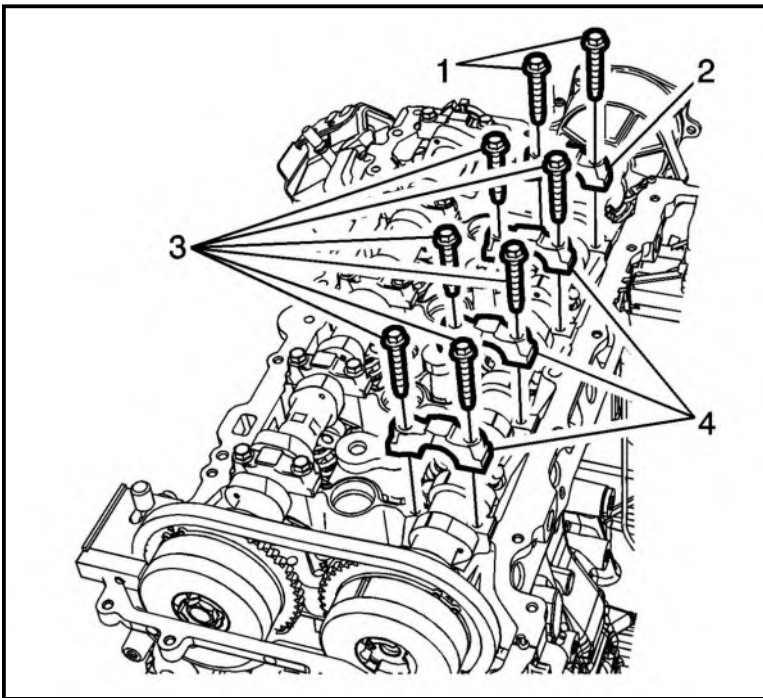


CAUTION: Refer to [Fastener Caution](#) .

3. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.



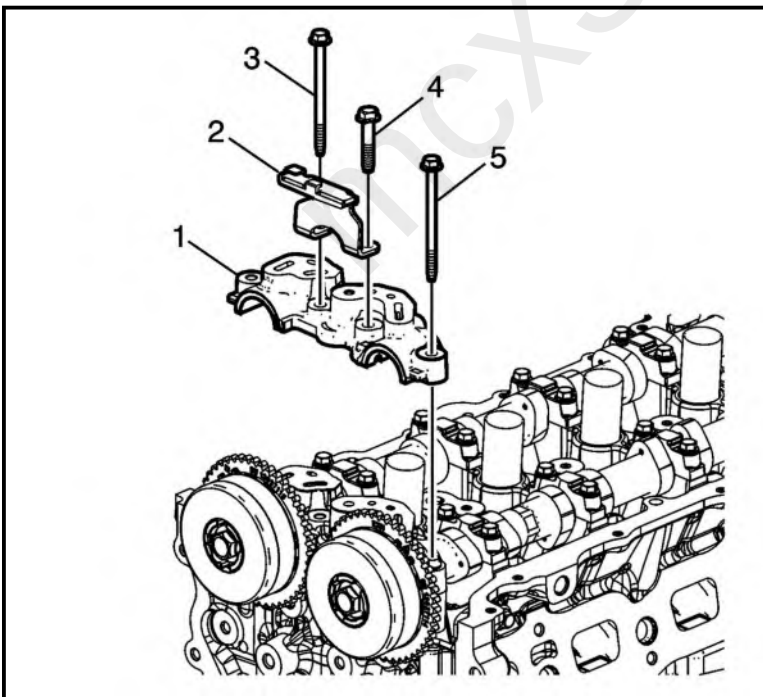
4. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals with the exhaust actuator timing mark at approximately the one O'clock position.



NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for approved lubricant.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

5. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
6. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).
7. Install the front camshaft bearing cap (1). Install the timing chain guide (2) onto the front camshaft bearing cap, then hand start the camshaft cap bolts (3 - 5).



8. Install the camshaft cap bolts in sequence using the following procedure:

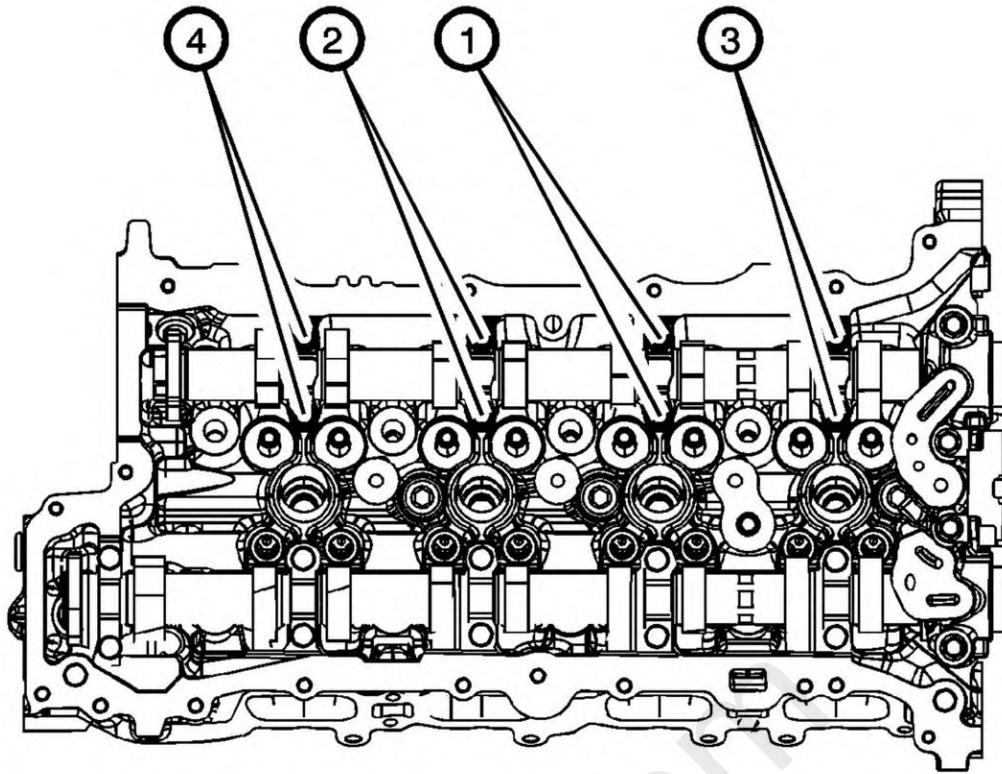
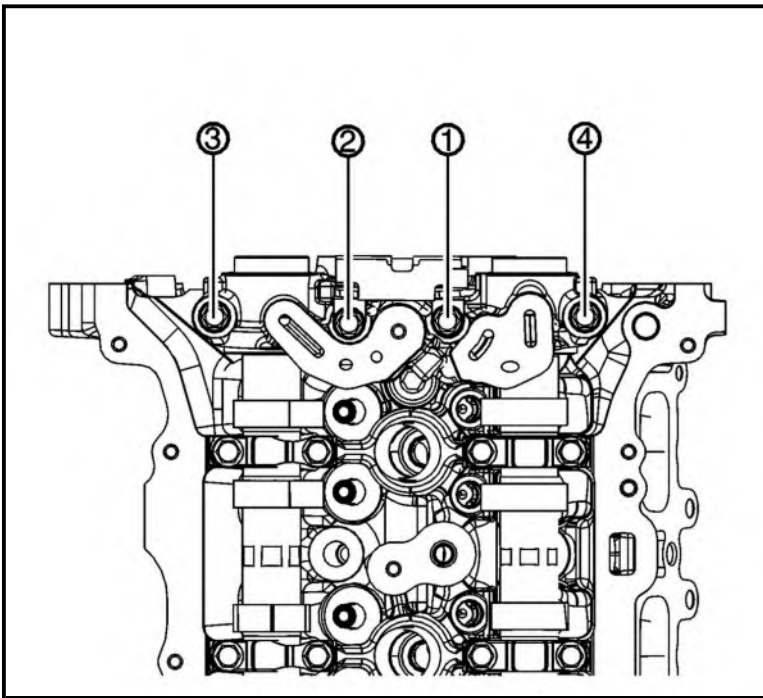


Fig. 13: Camshaft Cap Bolt Tightening Sequence

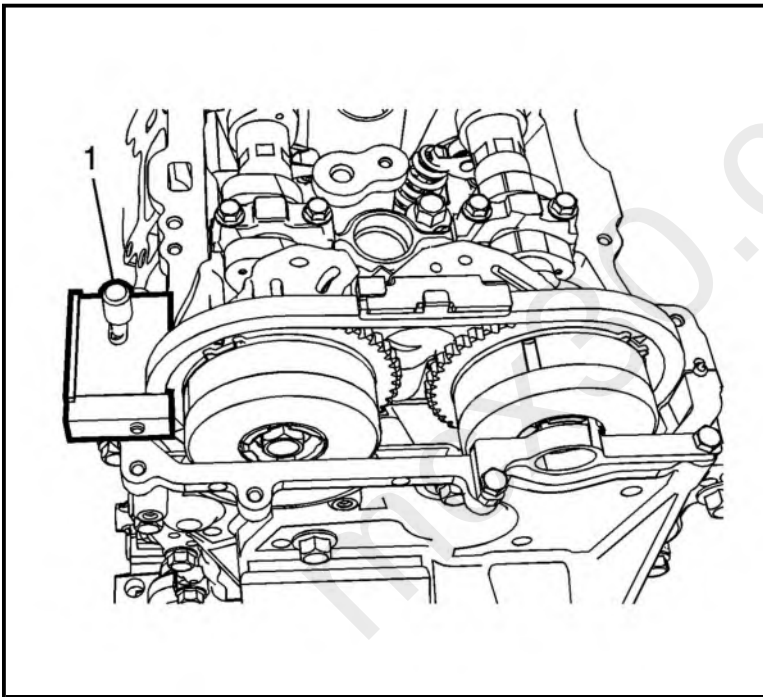
Courtesy of GENERAL MOTORS COMPANY

NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

1. Tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) **First Pass** .
2. Tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) **Final Pass** .
9. Tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

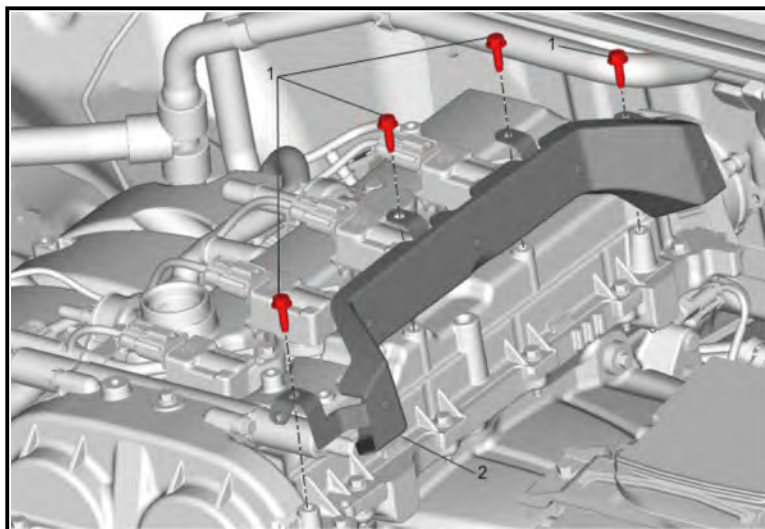


10. Remove **EN-50656** timing chain holding tool (1).



11. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).

CAMSHAFT COVER HEAT SHIELD REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .	
1	Camshaft Heat Shield Cover Fastener (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Camshaft Heat Shield Cover

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- EN-35667-A Cylinder Head Leakdown Adapter
- EN-37281-A Valve Guide Seal Remover
- EN-50717 Valve Spring Compressor
- EN-50792 Flywheel Holding Tool

Equivalent regional tools: [Special Tools](#)

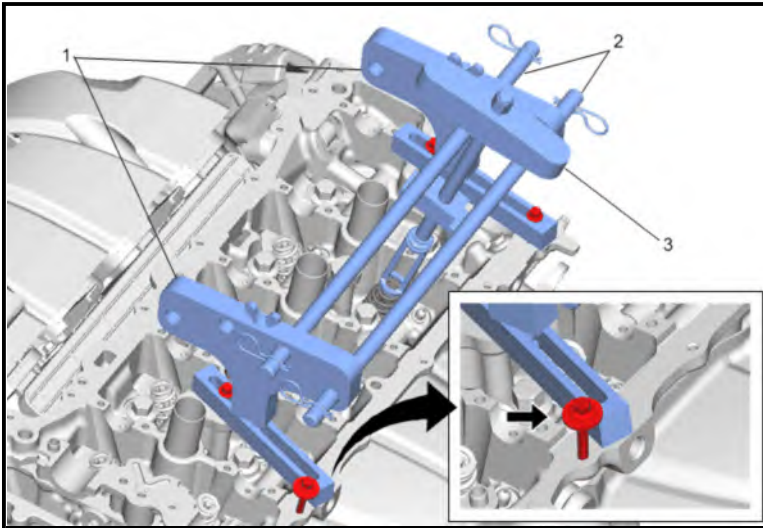
Removal Procedure

NOTE: Prevent the crankshaft from rotating clockwise or counterclockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-50792 Flywheel Holding Tool.

1. If equipped with a manual transmission, leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped with an automatic transmission, remove the starter. [Starter Replacement \(LCV\)](#) , or [Starter Replacement \(LGZ\)](#) , or [Starter Replacement \(LWN\)](#).
3. Install EN-50792 holding tool.
4. Remove the camshaft. [Camshaft Position Actuator and Intake Camshaft Replacement](#), or [Camshaft Position Actuator and Exhaust Camshaft Replacement](#)

5. Valve Rocker Arm - Remove - [Intake Valve Rocker Arm Replacement](#), or [Exhaust Valve Rocker Arm Replacement](#)

6. Install the **EN-50717** compressor (1) to the front and rear of the cylinder head as shown.



NOTE: When mounting the valve spring compressor to the cylinder head, a suitable large washer should be used as indicated by the arrow.

7. Install the cross bars and locks (2) of the **EN-50717** compressor to the valve spring compressor adaptors.

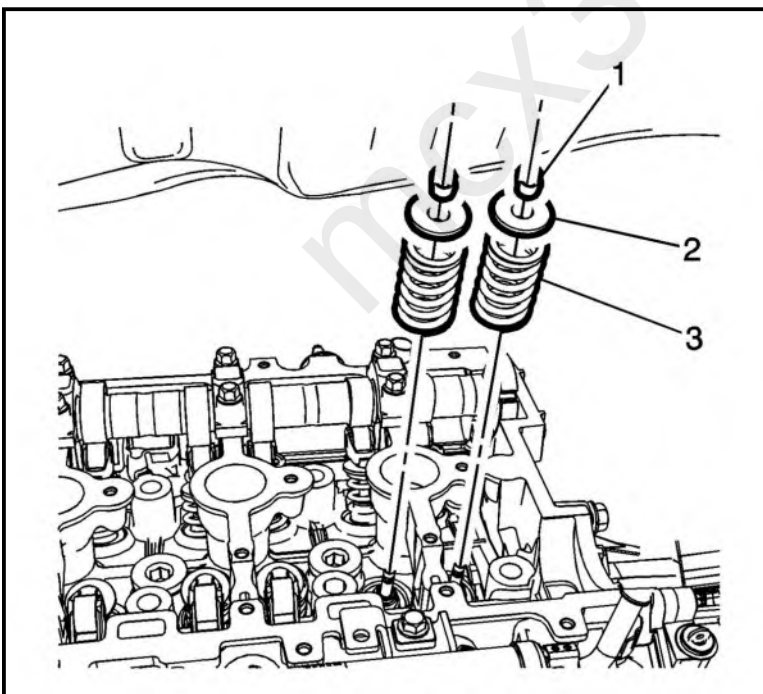
8. Remove the spark plugs. [Gas Engine Ignition Spark Plug Replacement](#)

9. Install **EN-35667-A** leakdown adapter into the spark plug hole.

10. Attach an air hose to the **EN-35667-A** leakdown adapter and pressurize the cylinder to 690 kPa (100 psi).

11. Compress the valve spring using the valve spring compressor (3).

12. Remove the valve spring keepers (1).



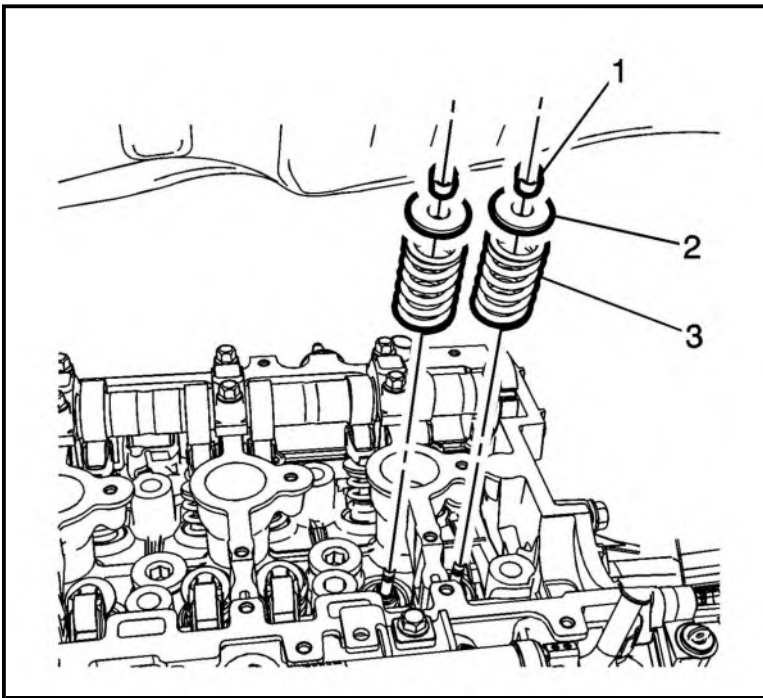
13. Remove the valve spring (3) and retainer (2).

14. Use the **EN-37281-A** seal remover to remove and DISCARD the valve seal.

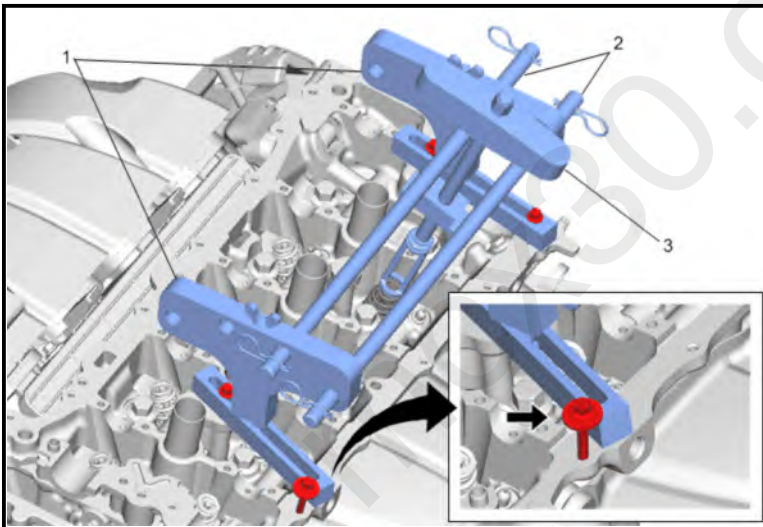
Installation Procedure

1. Using the **EN-37281-A** seal remover, install the NEW valve seal. Fully seat the seal onto the valve guide.

2. Install the valve spring (3) and retainer (2).



3. Compress the valve spring using the valve spring compressor.
4. Install the valve spring keepers (1).
5. Disconnect the air hose and remove the **EN-35667-A** leakdown adapter.
6. Remove the **EN-50717** compressor and **EN-50717** compressor adapter set from the cylinder head.



7. Install the spark plugs. [Gas Engine Ignition Spark Plug Replacement](#)
8. Valve Rocker Arm - Install - [Intake Valve Rocker Arm Replacement](#), or [Exhaust Valve Rocker Arm Replacement](#)
9. Install the camshaft. [Camshaft Position Actuator and Intake Camshaft Replacement](#), or [Camshaft Position Actuator and Exhaust Camshaft Replacement](#)
10. Remove the **EN-50792** holding tool.
11. If equipped with an automatic transmission, install the starter. [Starter Replacement \(LCV\)](#), or [Starter Replacement \(LGZ\)](#), or [Starter Replacement \(LWN\)](#)

CYLINDER HEAD REPLACEMENT

Special Tools

- **EN 38188** Cylinder Head Broken Bolt Extractor Kit - or equivalent aftermarket tool
- **EN 45059** Angle Meter
- For equivalent regional tools, refer to [Special Tools](#).

Removal Procedure

1. Drain the coolant system. Refer to [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(VAC n Fill\)](#) .
2. Drain the engine oil. Refer to [Engine Oil and Oil Filter Replacement \(2WD\)](#), or [Engine Oil and Oil Filter Replacement \(4WD\)](#).
3. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
4. Remove the intake manifold. Refer to [Intake Manifold Replacement](#).
5. Remove the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LCV\)](#) , or [Exhaust Manifold Replacement \(LWN\)](#) .
6. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
7. Remove the camshaft timing chain and tensioner. Refer to [Camshaft Timing Chain and Tensioner Removal](#).
8. Remove the fuel pump. Refer to [Fuel Pump Replacement](#) .
9. Remove the intake and exhaust camshafts. Refer to [Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Removal](#).
10. Remove the ground wire bolt and wire at the right rear of the cylinder head.
11. Disconnect the right camshaft position sensor electrical.
12. Disconnect the left camshaft position sensor electrical.
13. Disconnect the thermostat bypass hose from the water outlet housing.
14. Remove the water outlet housing. Refer to [Water Outlet Replacement \(LCV\)](#) , or [Water Outlet Replacement \(LGZ\)](#) .
15. Remove the injector fuel rail. Refer to [Fuel Injection Fuel Rail Assembly Replacement](#) .
16. Remove the cylinder head to the block bolts in sequence. Discard the bolts.

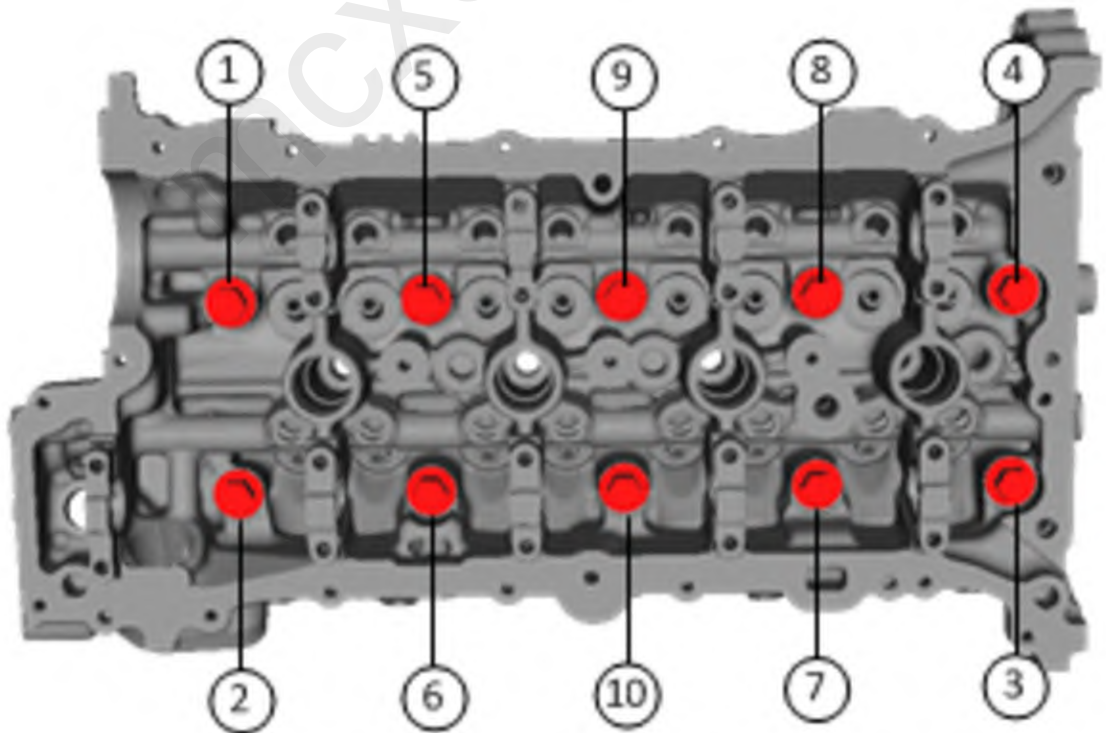
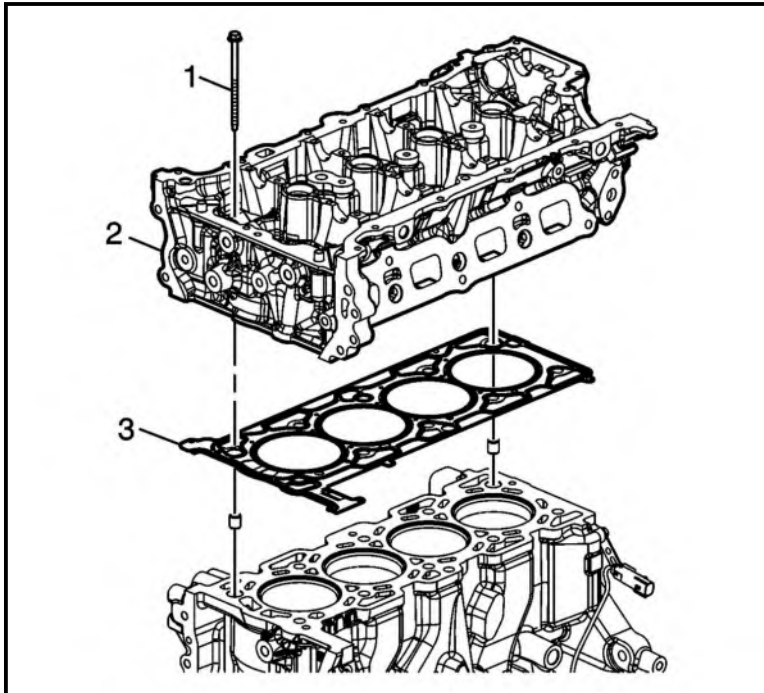


Fig. 14: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS COMPANY

17. Remove the cylinder head (2) and bolts (1).



CAUTION: In order to prevent damage to the valves and injectors during cylinder head removal, set the cylinder head on blocks.

18. Remove the cylinder head gasket (3).

NOTE: A nylon bristle brush should be used to clean the bolt holes. Do not use a tap to clean the cylinder head bolt holes.

19. Clean the old sealer/lube and dirt from the bolt holes.

20. Remove any broken cylinder head bolts using the EN 38188 kit.

21. For cylinder head disassemble. Refer to [Cylinder Head Disassemble](#).

22. If not replacing the cylinder head, clean and inspect the cylinder head. Refer to [Cylinder Head Cleaning and Inspection](#)

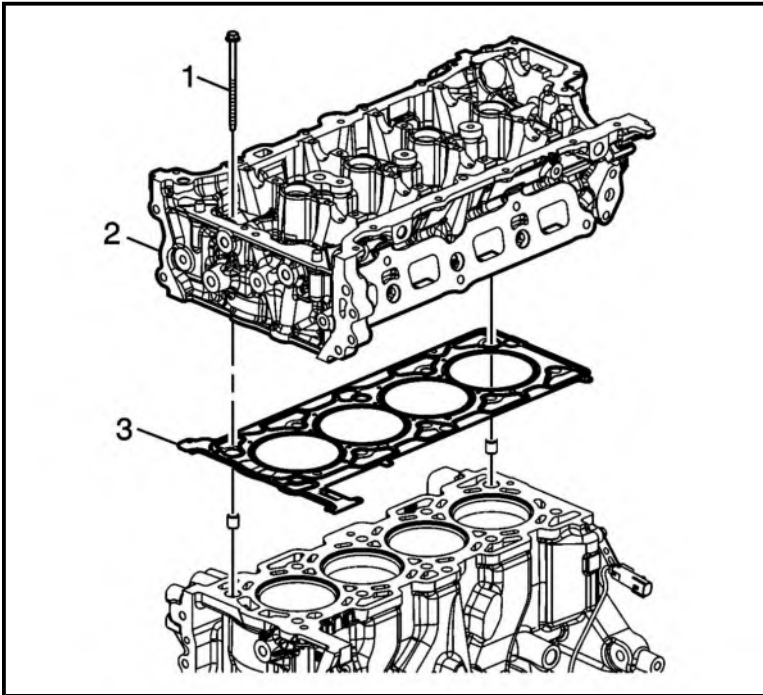
WARNING: Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.

NOTE:

- When cleaning the engine block cylinder head bolt holes use a suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun to reach the bottom of the holes.
- Use a gasket scraper to clean the cylinder head and block surfaces.
- Be careful not to gouge or scratch the gasket surfaces. Do not gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the new gasket.
- Do not use a tap to clean the cylinder head bolt holes

23. Clean the mating surfaces at the engine block.

1. For cylinder head assemble. Refer to [Cylinder Head Assemble](#).
2. Ensure the number one cylinder is at top dead center. The crankshaft key should be on top at the 12 o'clock position.
3. Install the cylinder head gasket (3) to the block.



NOTE: Do not use any sealing material.

4. Install the cylinder head (2).
5. Install the NEW cylinder head bolts.

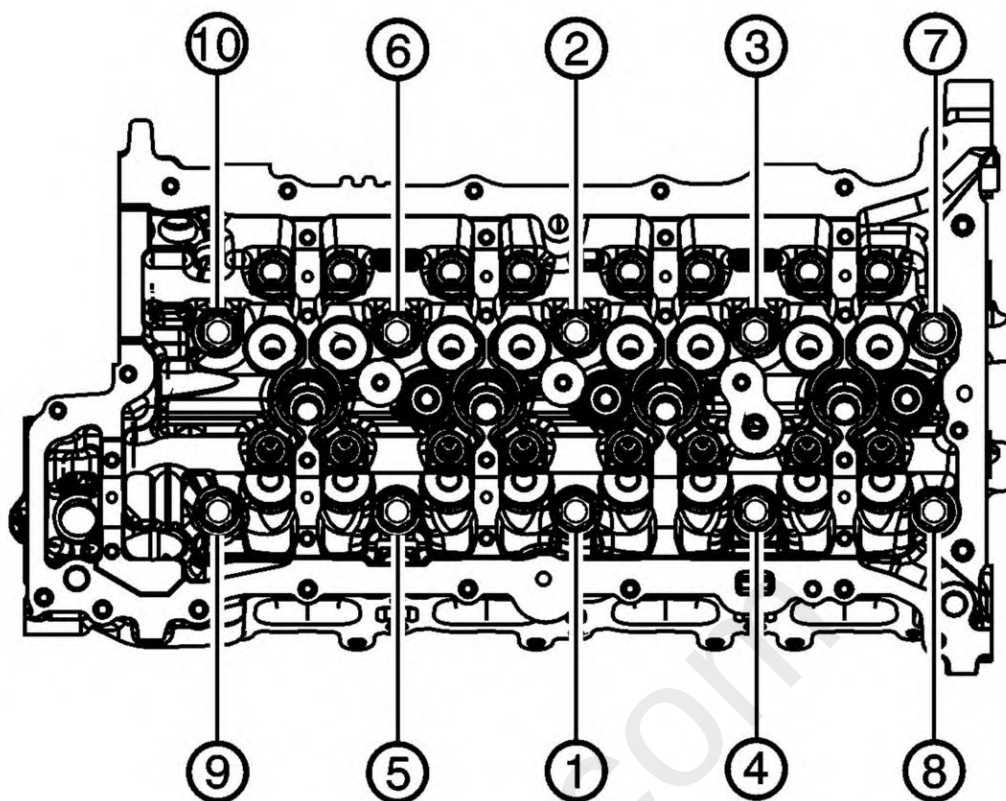


Fig. 15: Cylinder Head Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

NOTE: Always use **NEW** cylinder head bolts.

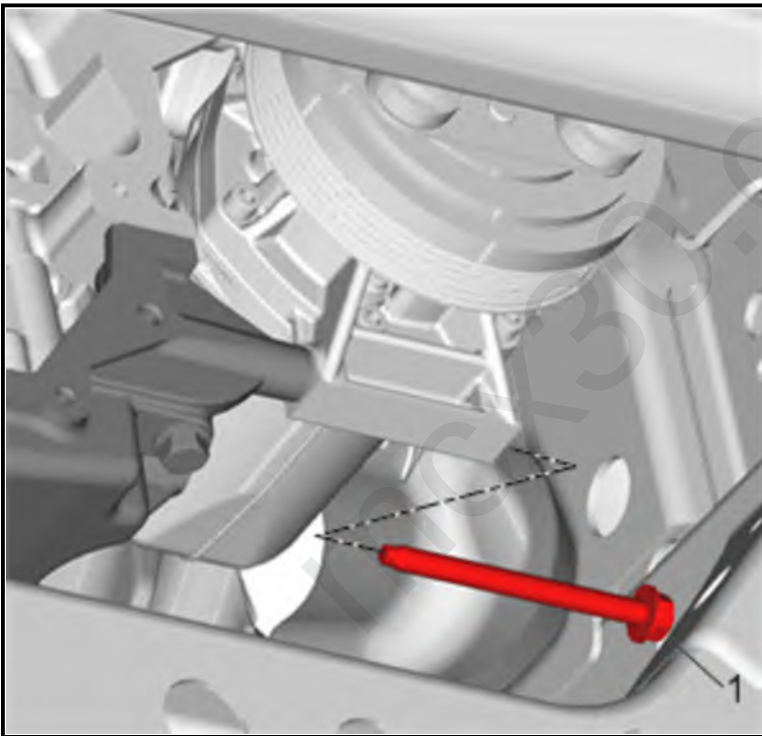
1. Tighten the bolts in sequence to 30 N.m (22 lb ft).
2. Tighten the bolts an additional 190 degrees in sequence using the **EN-45059** meter.
3. Install the water outlet housing. Refer to [Water Outlet Replacement \(LCV\)](#) , or [Water Outlet Replacement \(LGZ\)](#) .
6. Connect the left side camshaft electrical connector.
7. Connect the right side camshaft electrical connector.
8. Install the ground wire at the right rear of the cylinder head. Tighten to 10 N.m (7 lb ft)
9. Install the injector fuel rail. Refer to [Fuel Injection Fuel Rail Assembly Replacement](#) .
10. Install the intake and exhaust camshafts. Refer to [Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Installation](#) .
11. Install the fuel pump. Refer to [Fuel Pump Replacement](#) .
12. Install the camshaft timing chain and tensioner. Refer to [Camshaft Timing Chain and Tensioner Installation](#) .
13. Install the engine front cover. Refer to [Engine Front Cover Replacement](#) .
14. Install the exhaust manifold. Refer to [Exhaust Manifold Replacement \(LCV\)](#) , or [Exhaust Manifold Replacement \(LWN\)](#) .

15. Install the intake manifold. Refer to [Intake Manifold Replacement](#).
16. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).
17. Refill the engine with NEW oil. Refer to [Engine Oil and Oil Filter Replacement \(2WD\)](#), or [Engine Oil and Oil Filter Replacement \(4WD\)](#).
18. Refill the coolant system. Refer to [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(VAC n Fill\)](#) .

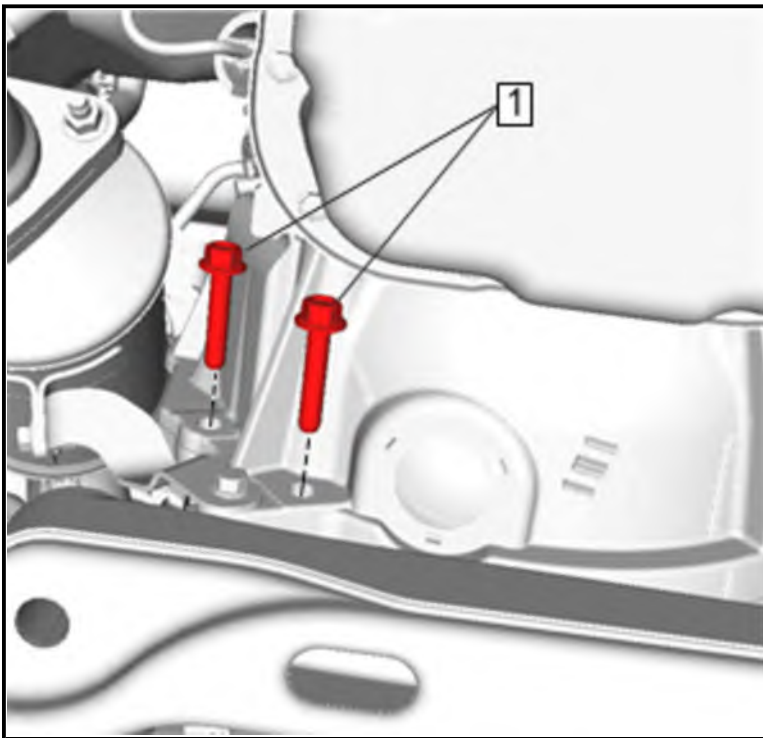
OIL PAN REPLACEMENT (4WD)

Removal Procedure

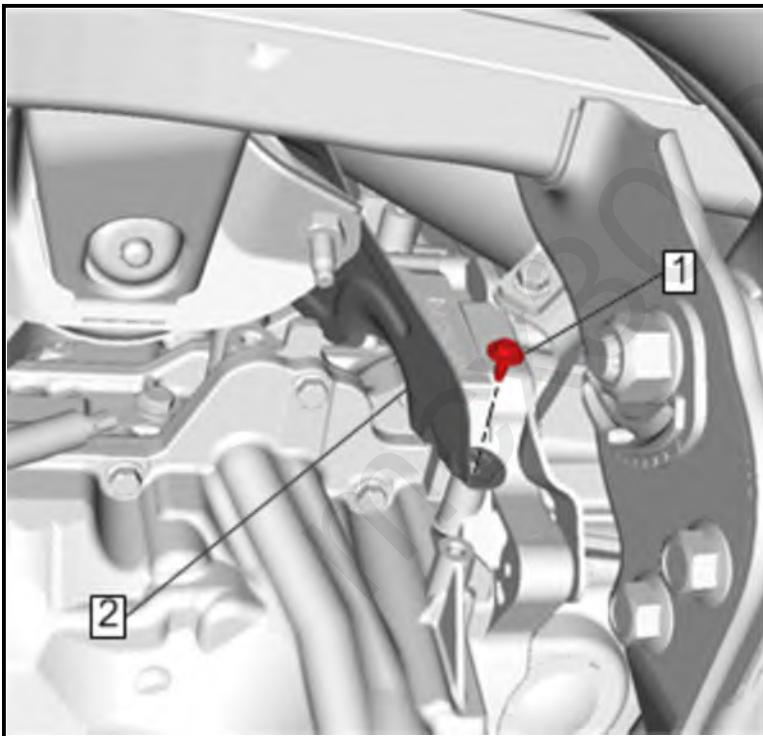
1. Drain the engine oil. Refer to [Engine Oil and Oil Filter Replacement \(4WD\)](#).
2. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
3. Remove the steering gear. Refer to [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(4WD\)](#) .
4. If equipped with AWD, remove the front axle. Refer to [Front Axle Replacement \(without ZR2\)](#) , or [Front Axle Replacement \(with ZR2\)](#) .
5. Remove the underbody splash shield. Refer to [Underbody Splash Shield Replacement \(without ZR2\)](#) , or [Underbody Splash Shield Replacement \(with ZR2\)](#) , or [Underbody Splash Shield Replacement \(Bison\)](#) .
6. Remove the lower air conditioning compressor bolt (1).



7. Remove the transmission to oil pan bolts (1).

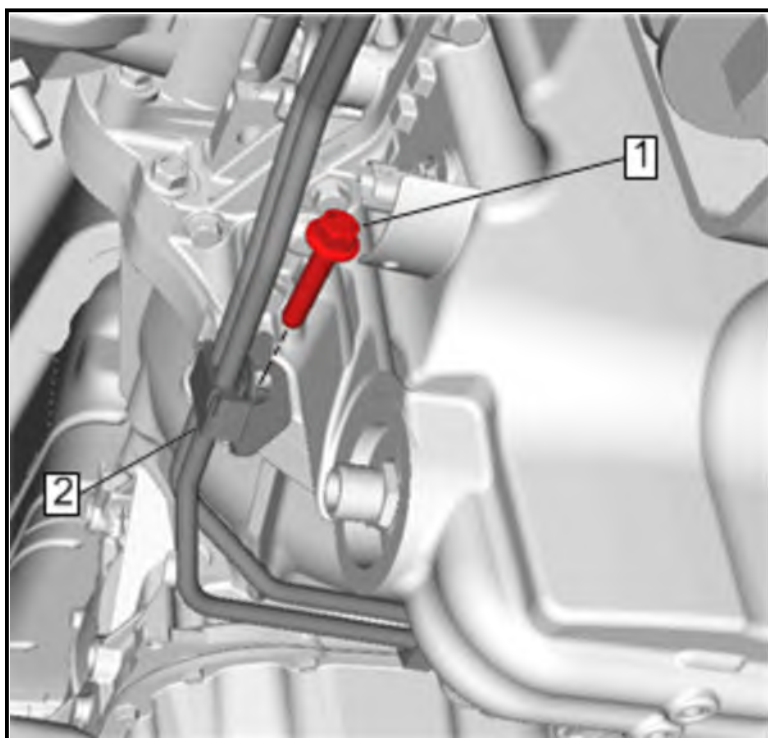


8. Remove the engine mount heat shield lower fastener.

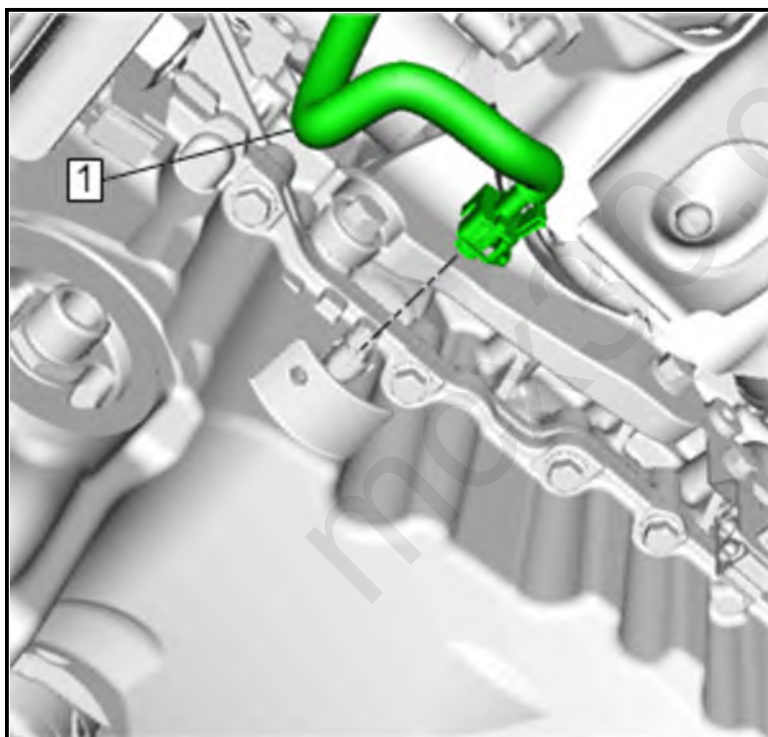


NOTE: It is not necessary to remove the engine mount heat shield. Only the lower fastener requires removal to allow removal of the oil pan.

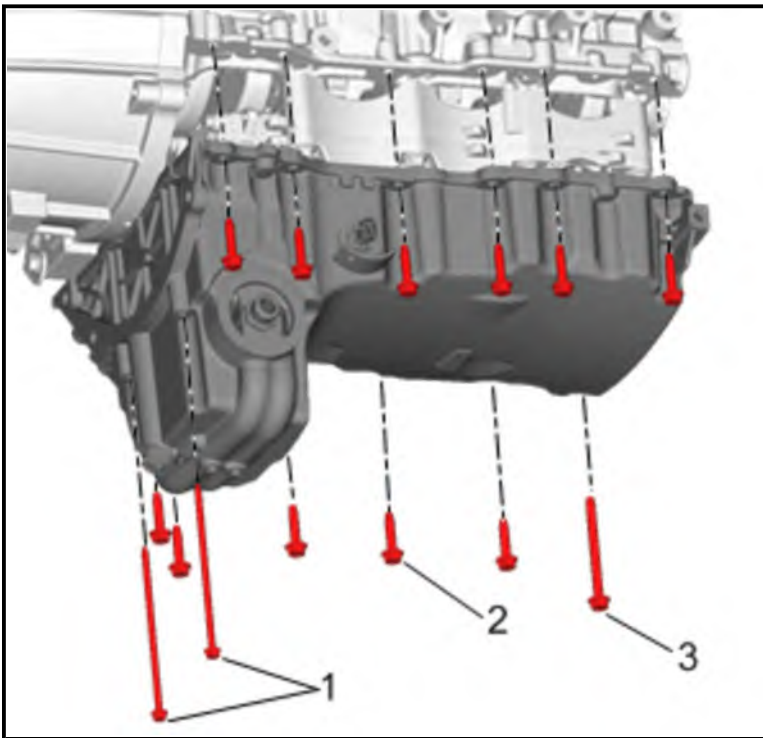
9. Remove the transmission to oil pan bolt (1), then reposition the cooler lines (2) as needed.



10. Disconnect and reposition the oil level switch connector (1).



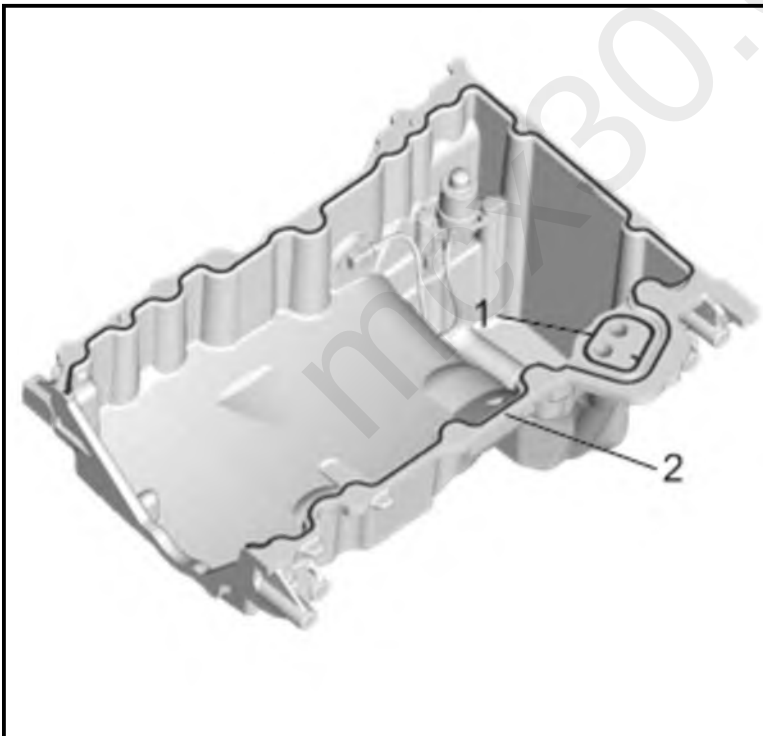
11. Remove the long oil pan bolts (1), short bolts (2) and medium bolts (3), then remove the oil pan.



12. For part transfer, cleaning and inspection, refer to [Oil Pan Cleaning and Inspection \(4WD\)](#).

Installation Procedure

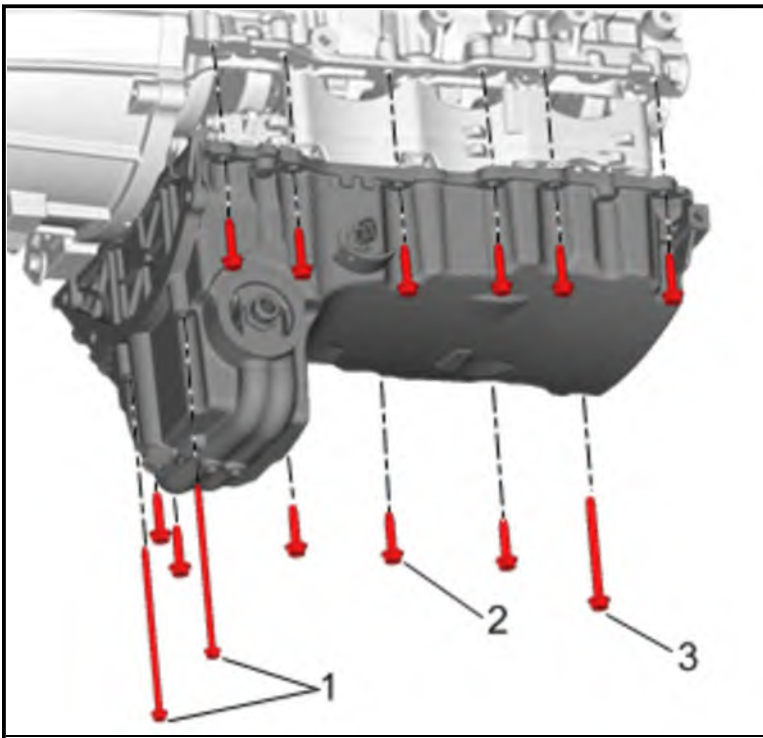
1. Install a NEW oil pan gasket (1) then apply a 4.25 mm bead of sealer (2) on the level part of the flange around the perimeter of the oil pan as shown. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 10 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

2. Install the oil pan and hand start the oil pan bolts (1),(2) and (3).



NOTE: When installing the oil pan, carefully align the oil pan to the locating pins and install the pan onto the lower crankcase.

3. Tighten the oil pan bolts in sequence to final torque twice using the following procedure:

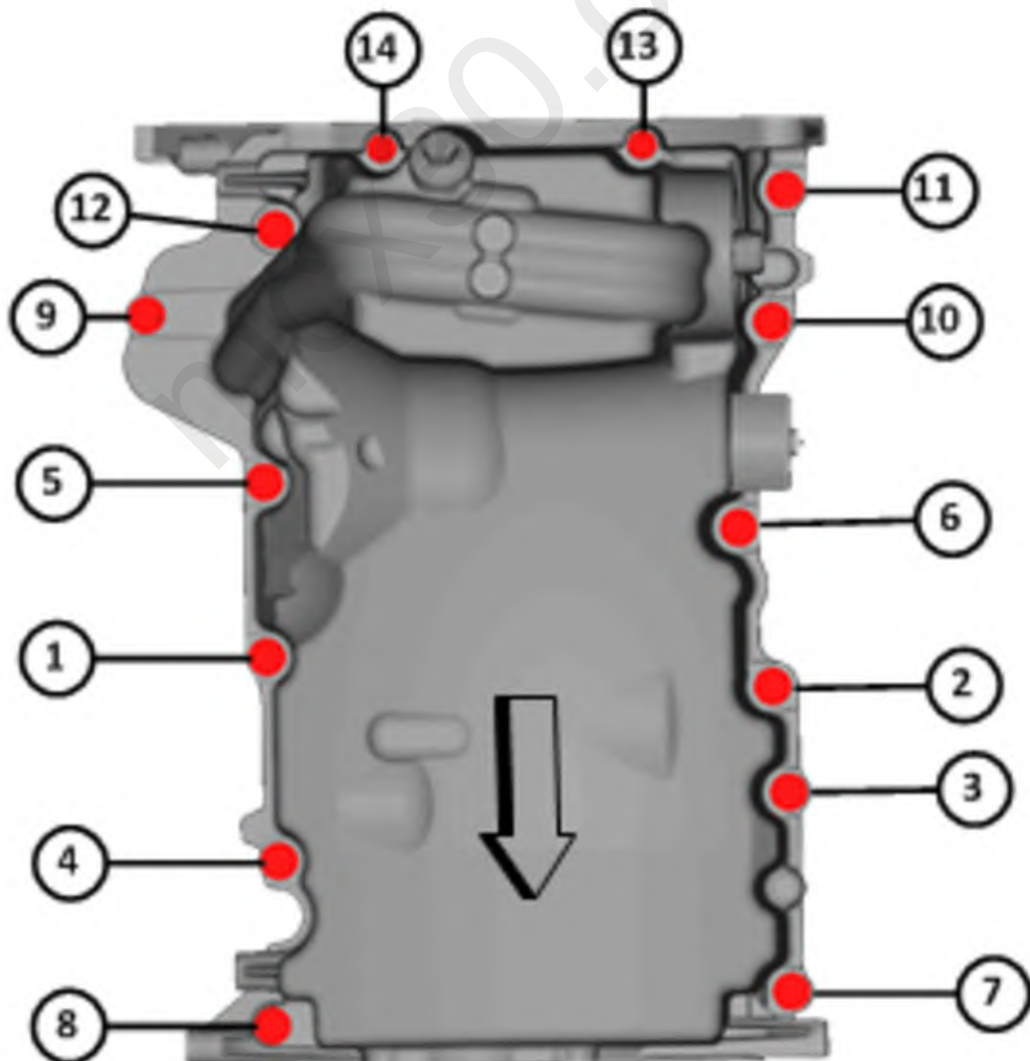
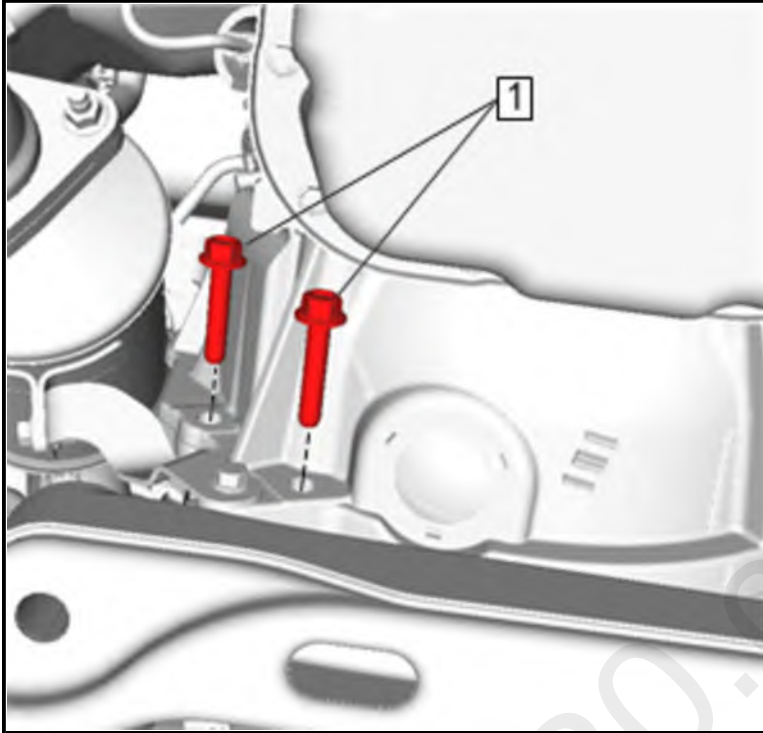


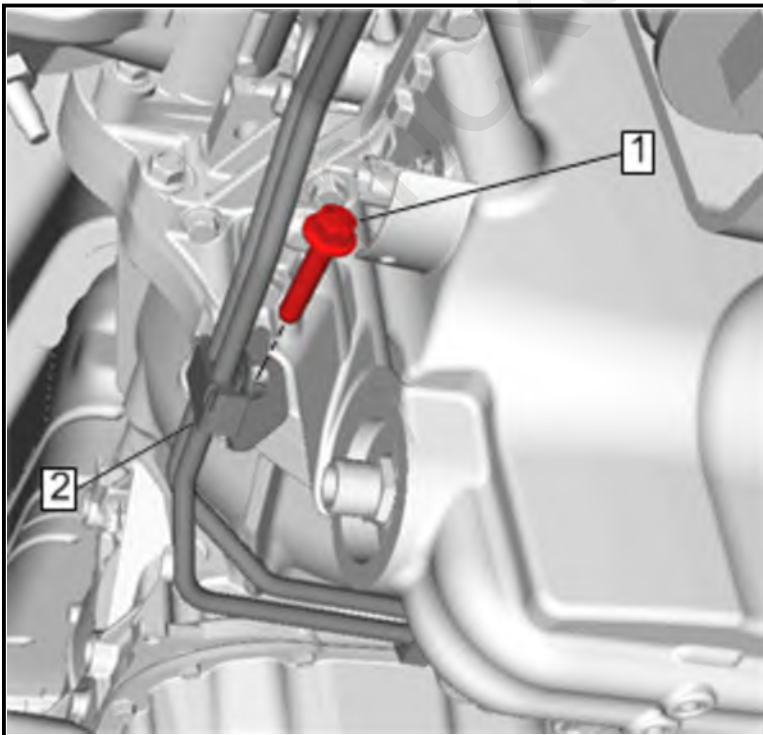
Fig. 16: Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

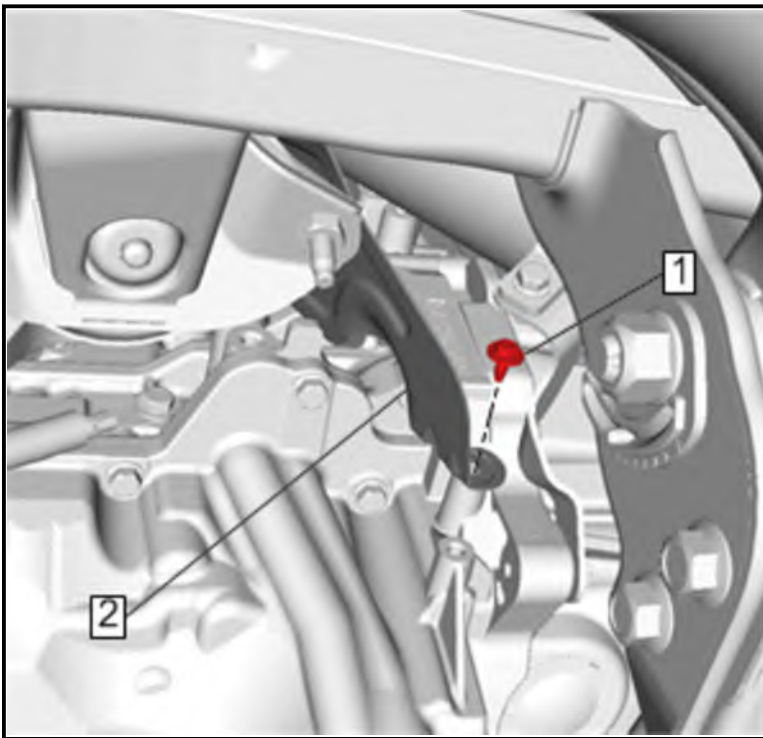
1. Tighten bolts in sequence 1 - 12 to 25 N.m (18 lb ft).
2. Tighten bolts in sequence 13 - 14 to 10 N.m (89 lb in).
4. Install the transmission to oil pan bolts (1). Tighten to 58 N.m (43 lb ft).



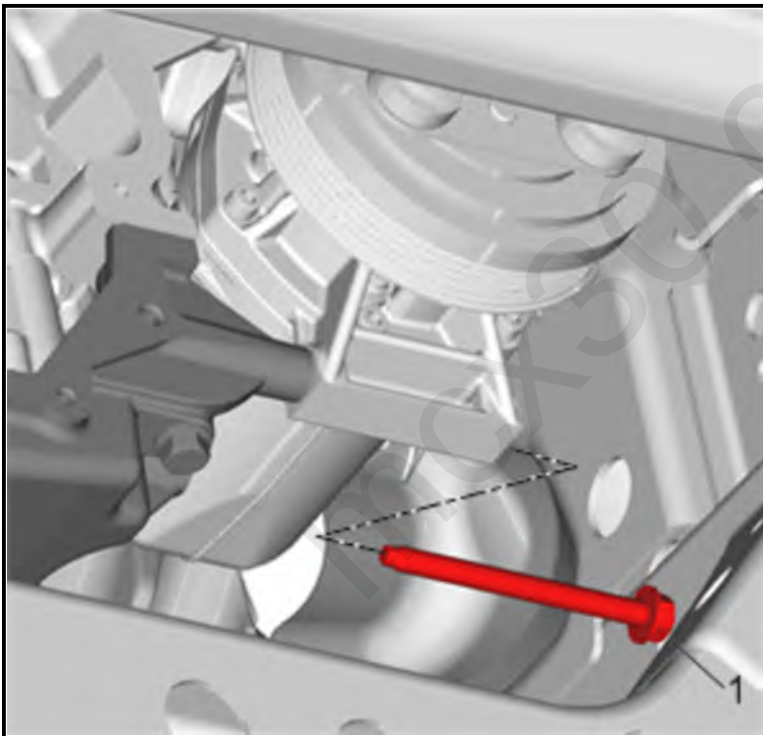
5. Install the transmission to oil pan bolt (1), and secure the cooler lines (2). Tighten to 58 N.m (43 lb ft).



6. Install the engine mount heat shield lower fastener. Tighten to 10 N.m (89 lb in)



7. Install the lower air conditioning compressor bolt (1). Tighten to 25 N.m (18 lb ft)

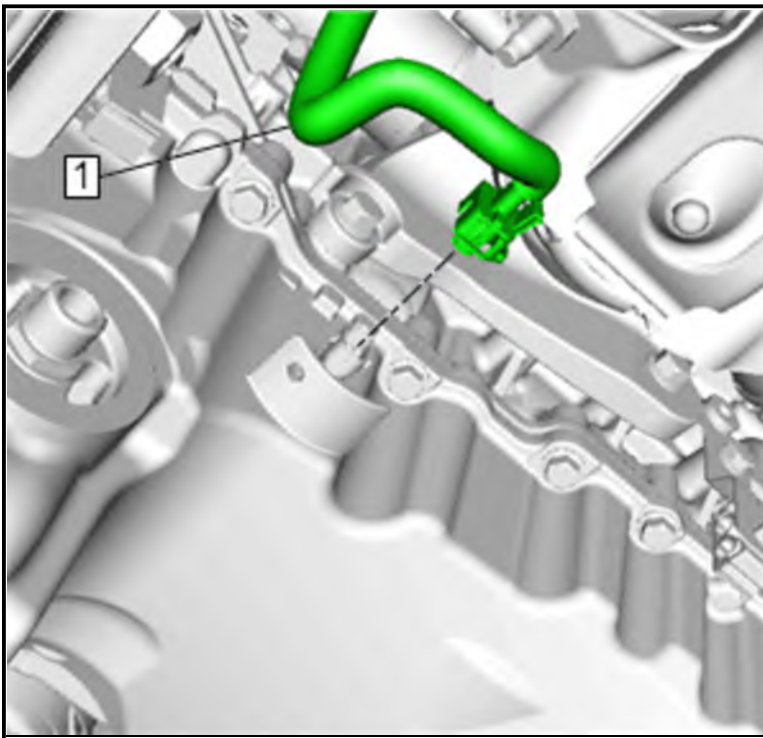


8. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).

9. If equipped with AWD, install the front axle. Refer to [Front Axle Replacement \(without ZR2\)](#), or [Front Axle Replacement \(with ZR2\)](#).

10. Install the steering gear. Refer to [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(4WD\)](#).

11. Connect the oil level switch connector (1).

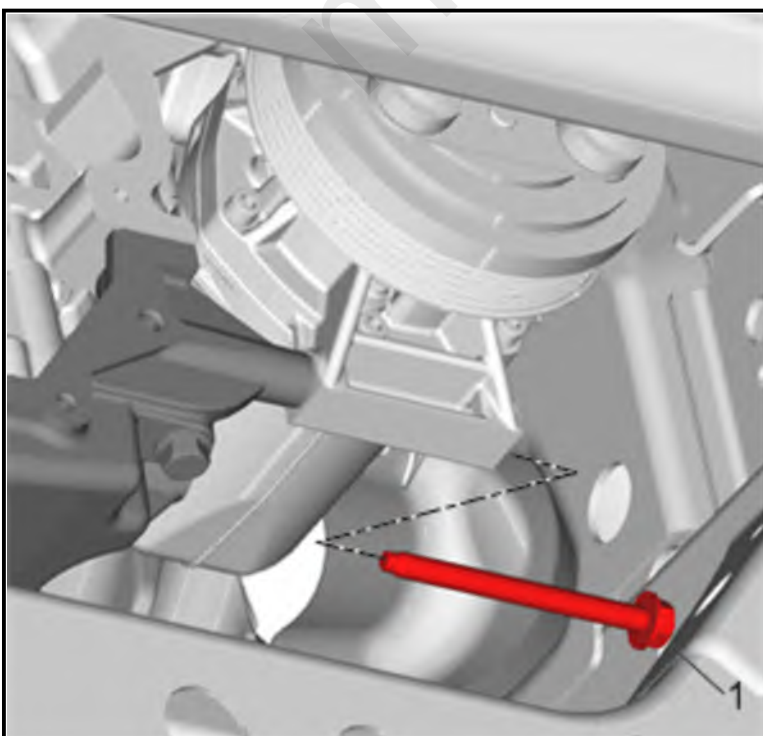


12. Install a NEW oil filter and fill the engine oil. Refer to [Engine Oil and Oil Filter Replacement \(4WD\)](#).
13. Install the underbody splash shield. Refer to [Underbody Splash Shield Replacement \(without ZR2\)](#) , or [Underbody Splash Shield Replacement \(with ZR2\)](#) , or [Underbody Splash Shield Replacement \(Bison\)](#) .

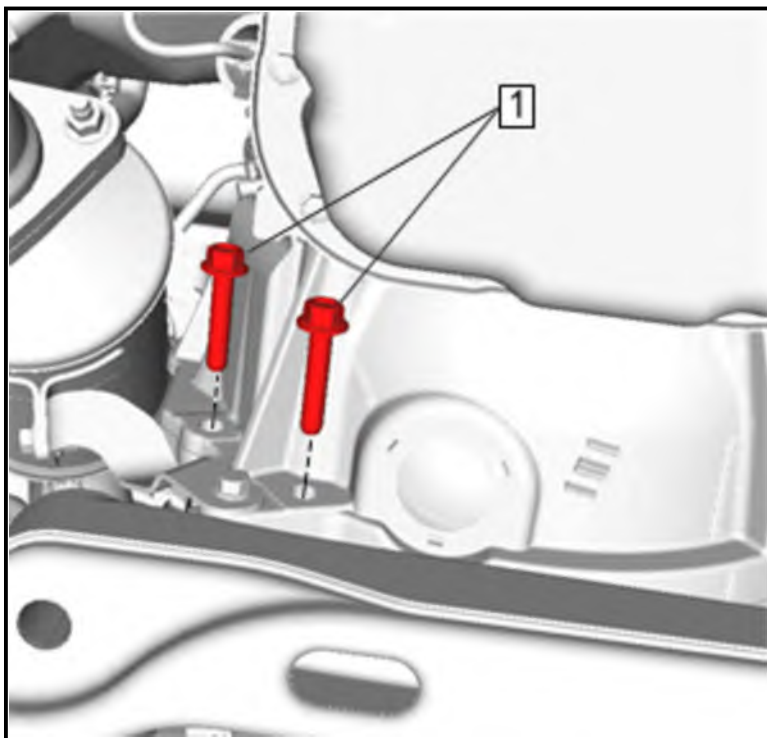
OIL PAN REPLACEMENT (2WD)

Removal Procedure

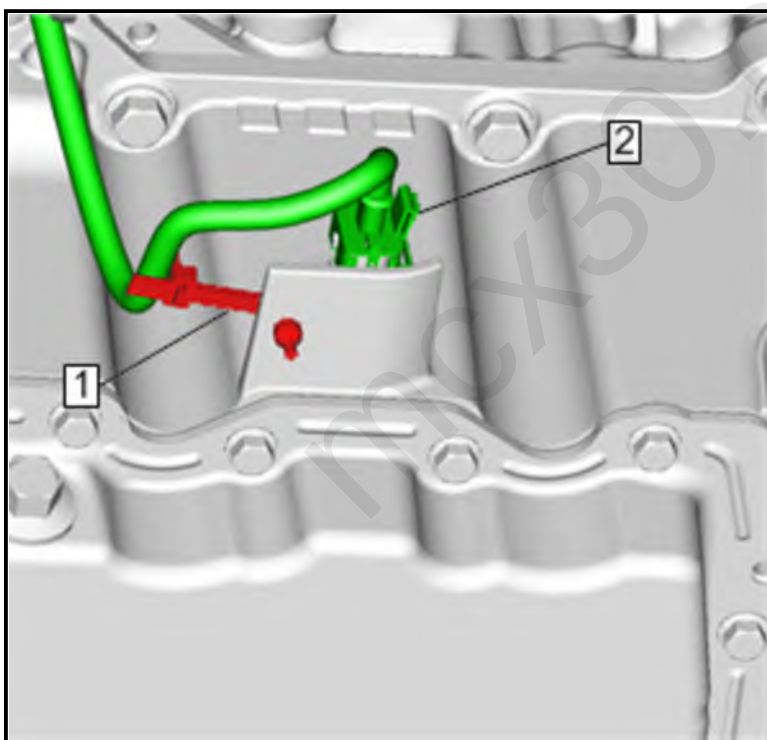
1. Remove the underbody splash shield. Refer to [Underbody Splash Shield Replacement \(without ZR2\)](#) , or [Underbody Splash Shield Replacement \(with ZR2\)](#) , or [Underbody Splash Shield Replacement \(Bison\)](#) .
2. Drain the engine oil. Refer to [Engine Oil and Oil Filter Replacement \(2WD\)](#) .
3. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
4. Remove the steering gear. Refer to [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(2WD\)](#) .
5. Remove the lower air conditioning compressor bolt (1).



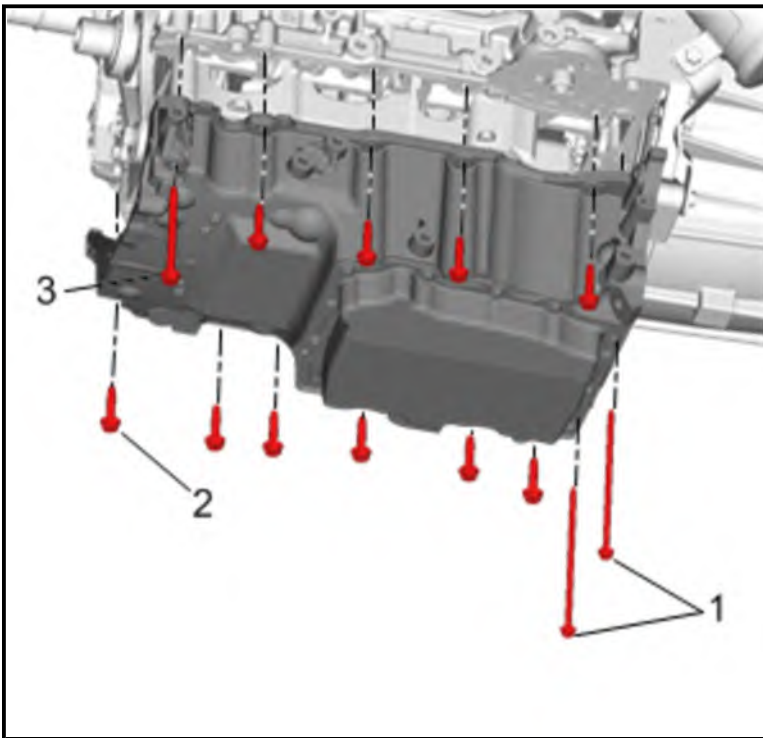
6. Remove the transmission to oil pan bolts (1).



7. Disconnect the retainer (1) and electrical connector (2).



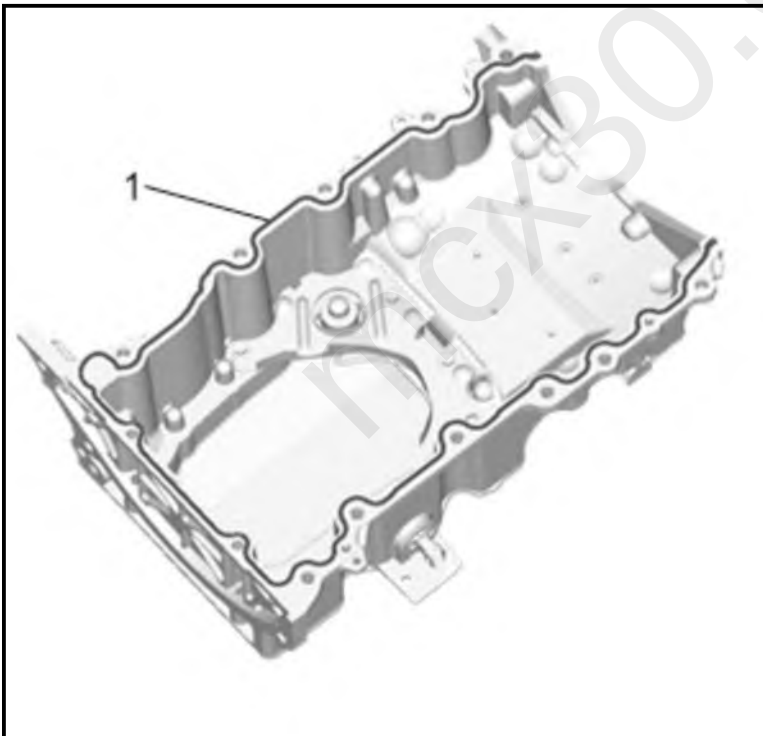
8. Remove the long oil pan bolts (1), short bolts (2) and medium bolts (3), then remove the oil pan.



9. For part transfer, cleaning and inspection, refer to [Oil Pan Cleaning and Inspection \(2WD\)](#) .

Installation Procedure

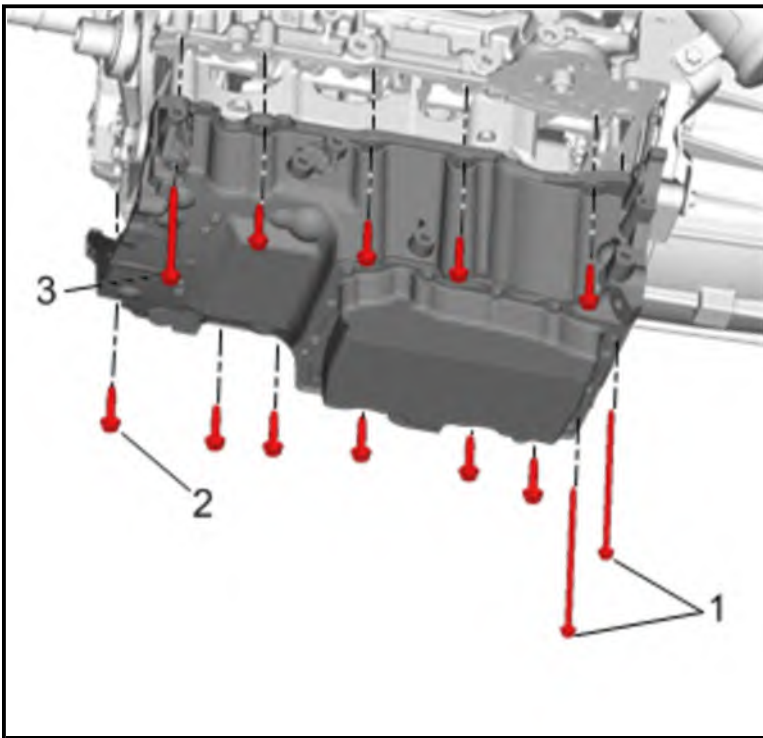
1. Install a NEW oil pan gasket (1) then apply a 4.25 mm bead of sealer (2) on the level part of the flange around the perimeter of the oil pan as shown. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 10 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

2. Install the oil pan and hand start the oil pan bolts (1), (2) and (3).



NOTE: When installing the oil pan, carefully align the oil pan to the locating pins and install the pan onto the lower crankcase.

3. Tighten the oil pan bolts in sequence to final torque twice using the following procedure:

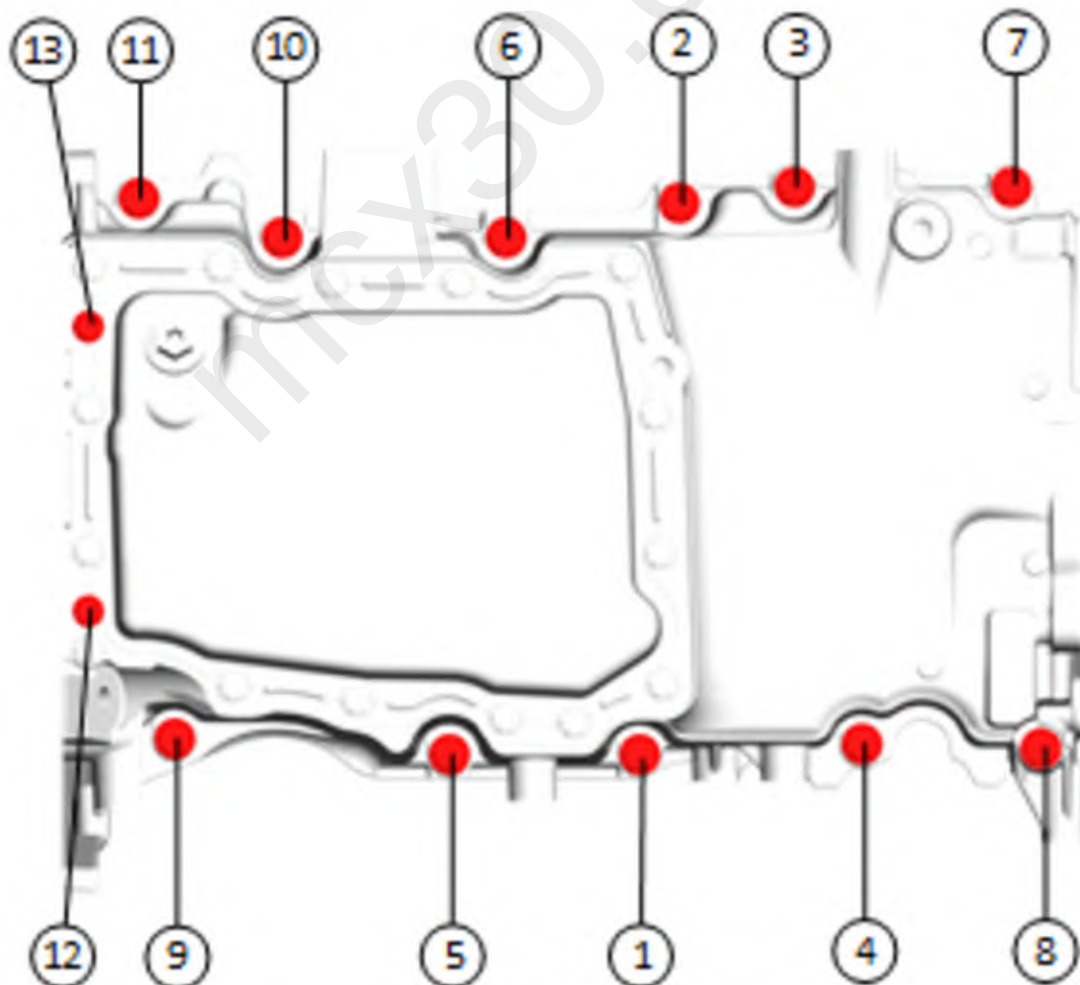
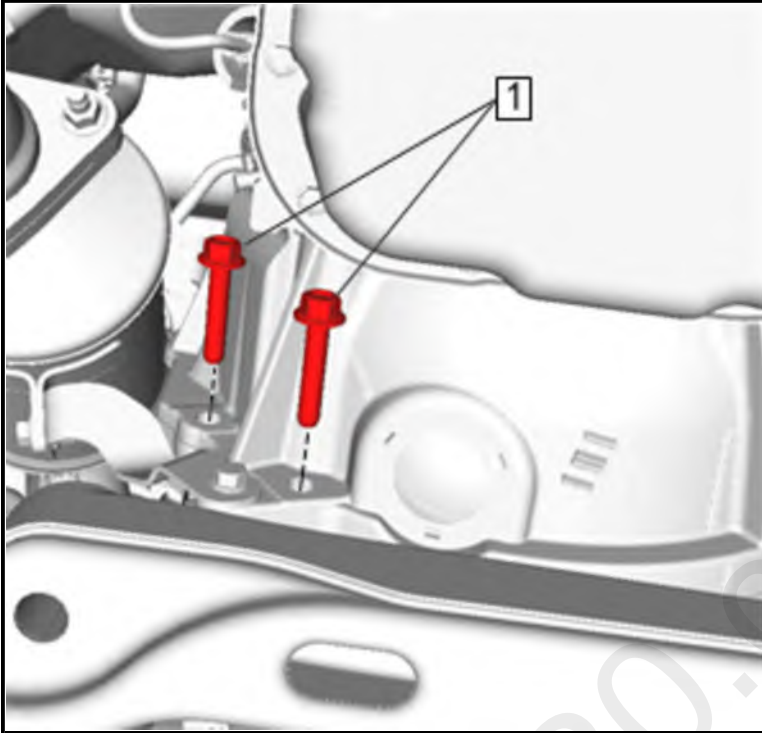


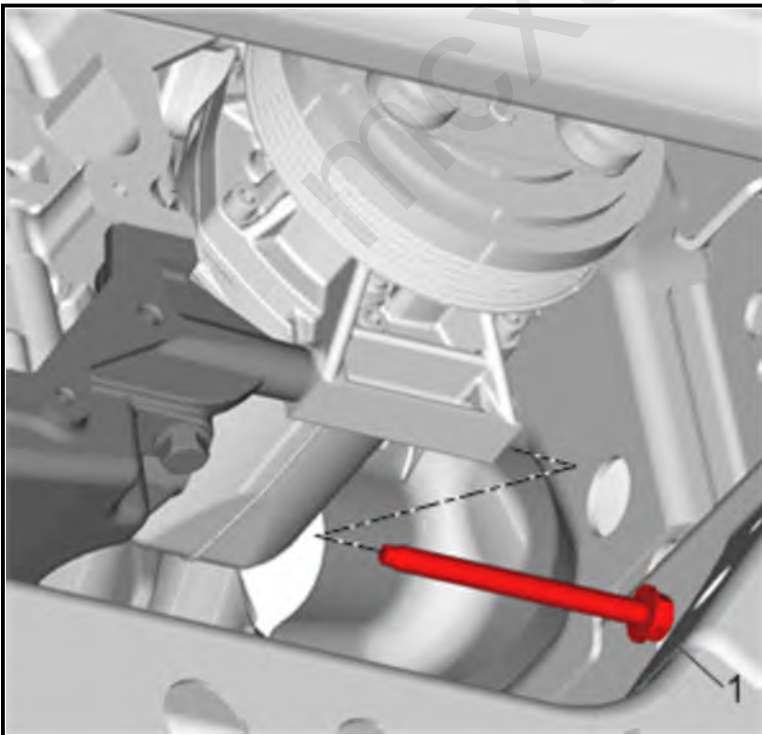
Fig. 17: Engine Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

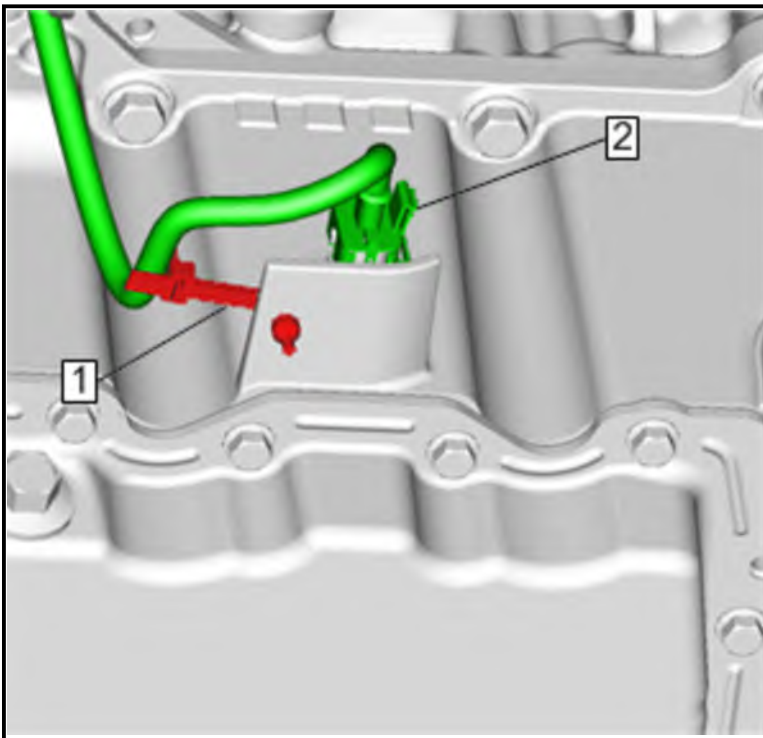
1. Tighten bolts in sequence 1 - 12 to 25 N.m (18 lb ft).
2. Tighten bolts in sequence 13 - 14 to 10 N.m (89 lb in).
4. Install the transmission to oil pan bolts (1). Tighten to 58 N.m (43 lb ft).



5. Install the lower air conditioning compressor bolt (1). Tighten to 25 N.m (18 lb ft)

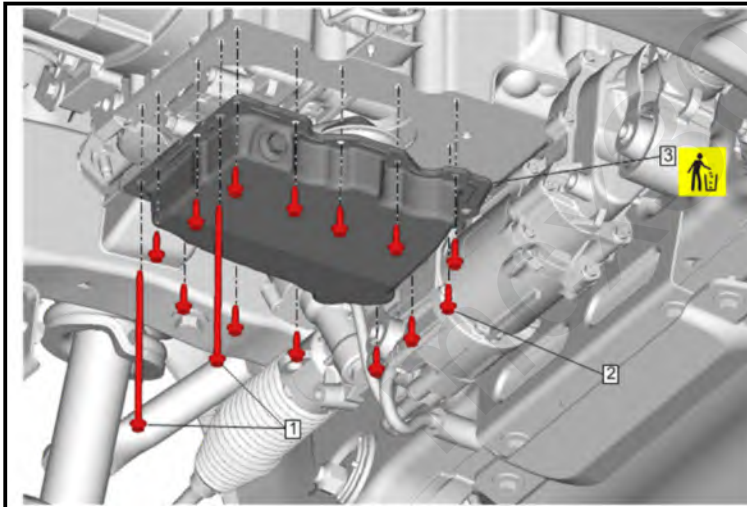


6. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).
7. Install the steering gear. Refer to [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(2WD\)](#) .
8. Connect the retainer (1) and electrical connector (2).



9. Install a NEW oil filter and fill the engine oil. Refer to [Engine Oil and Oil Filter Replacement \(2WD\)](#) .
10. Install the underbody splash shield. Refer to [Underbody Splash Shield Replacement \(without ZR2\)](#) , or [Underbody Splash Shield Replacement \(with ZR2\)](#) , or [Underbody Splash Shield Replacement \(Bison\)](#) .

LOWER OIL PAN REPLACEMENT

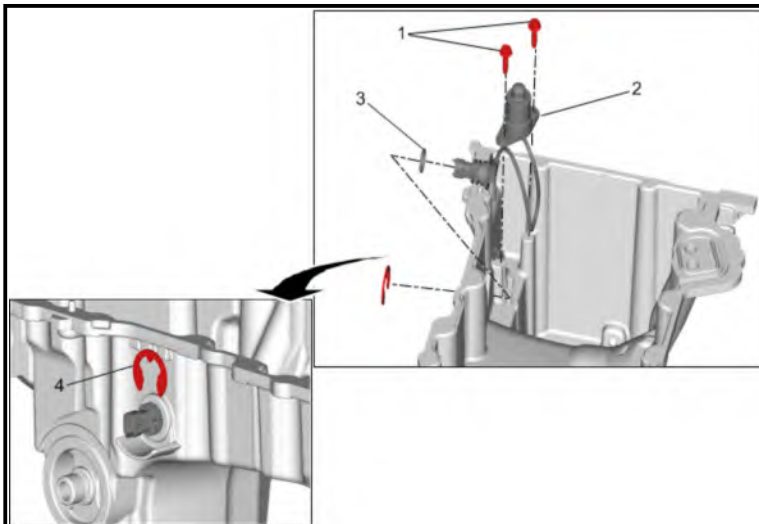


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures	
1. Remove steering gear skid shield. Refer to Steering Gear Skid Shield Replacement (without ZR2) , or Steering Gear Skid Shield Replacement (with ZR2) , or Steering Gear Skid Shield Replacement (Bison) . 2. Drain engine oil. Refer to Engine Oil and Oil Filter Replacement (2WD), or Engine Oil and Oil Filter Replacement (4WD).	
1	Oil Pan Bolts (Qty 2) CAUTION: Refer to Fastener

Callout	Component Name
	Caution . Tighten 10 N.m (89 lb in)
2	Oil Pan Bolts (Qty; 12) Tighten 10 N.m (89 lb in)
3	Oil Pan Procedure Apply a 2.25 mm bead of sealer on the level part of the flange around the perimeter of the oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. NOTE: • The lower crankcase surface must be free of contamination prior to applying the sealer. • Install and align the oil pan to block within 20 minutes of applying the sealer. • The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT (AWD)



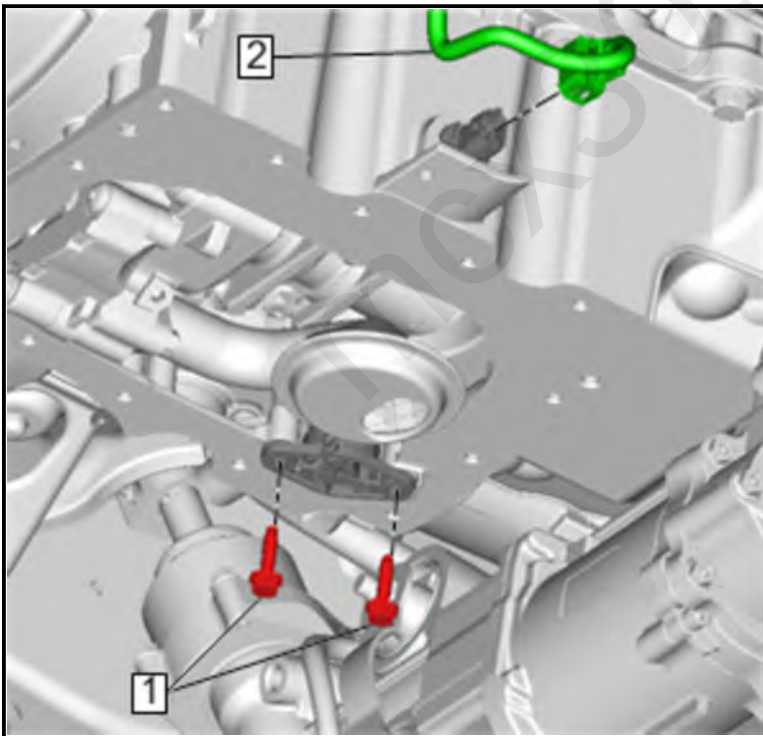
NOTE:

Callouts in the following chart represent components shown in graphic above.

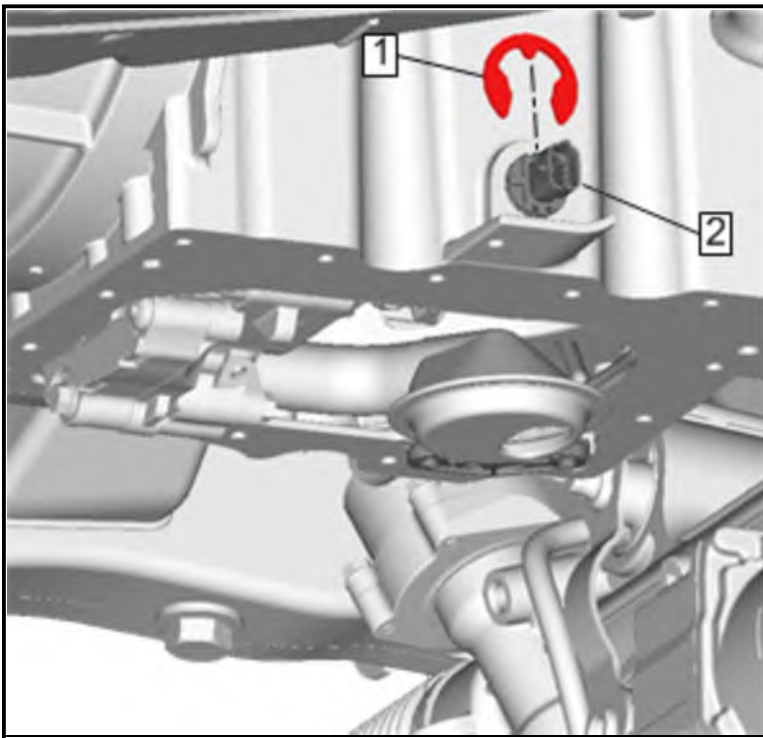
Callout	Component Name
Preliminary Procedure Remove the engine oil pan. Refer to Oil Pan Replacement (4WD) , or Oil Pan Replacement (2WD) .	
1	Engine Oil Level Indicator Fastener (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Engine Oil Level Indicator
3	Engine Oil Level Indicator Seal Procedure Install a NEW seal when replacing the oil level indicator.
4	Engine Oil Level Indicator C-clip (Qty: 1)

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT (2WD)**Removal Procedure**

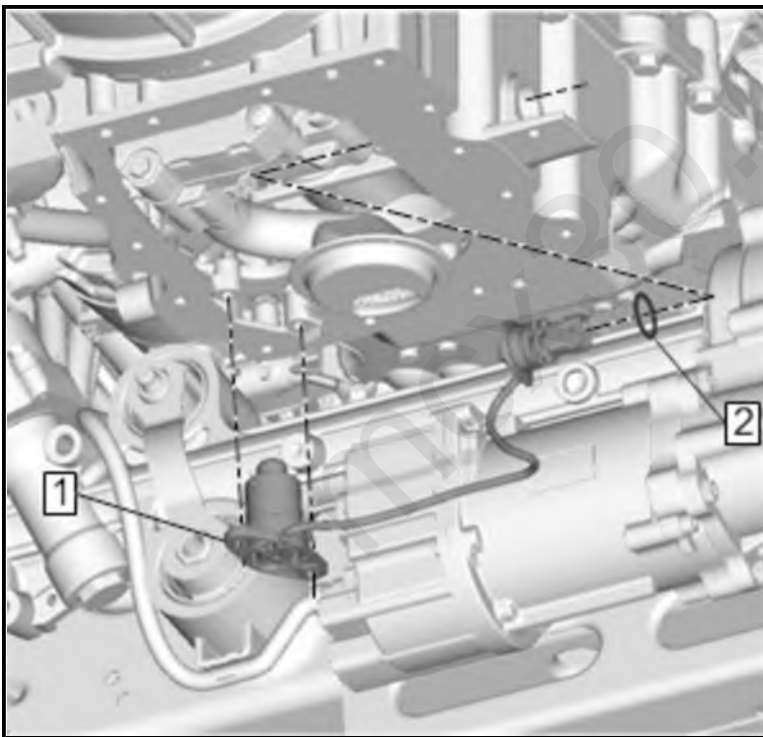
1. Remove the lower oil pan. Refer to [Lower Oil Pan Replacement](#).
2. Remove the engine oil level sensor fasteners (1).



3. Disconnect the oil level sensor electrical connector (2).
4. Remove the engine oil level sensor C-clip (1).

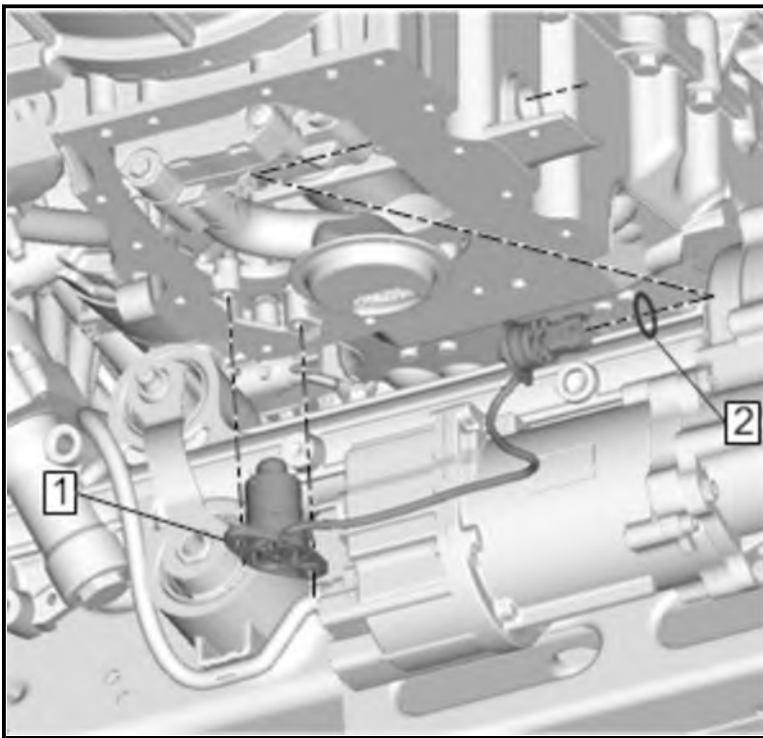


5. Push the sensor connector (2) through the oil pan to remove.
6. Remove the engine oil level sensor (1) from the oil pan.



Installation Procedure

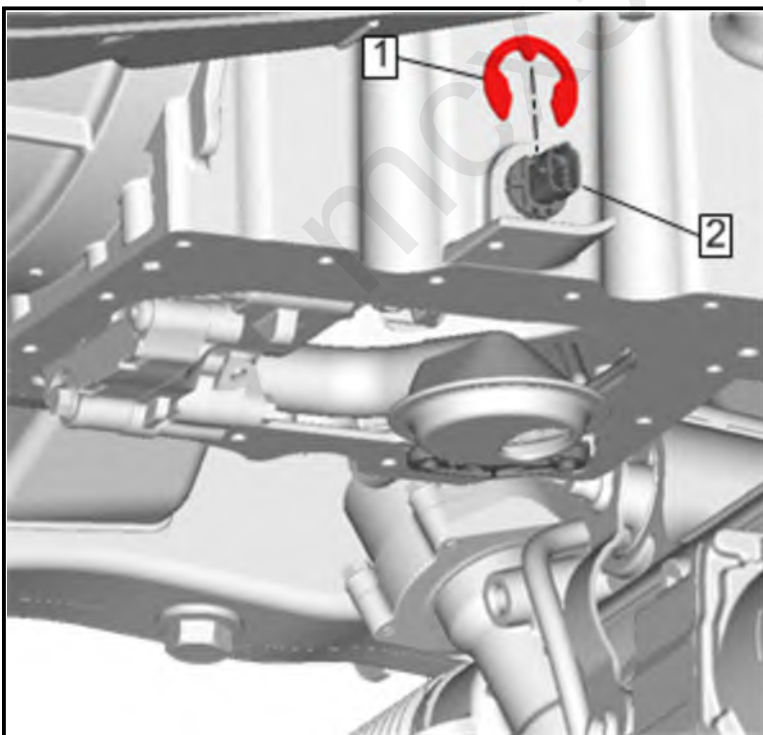
1. Install the engine oil level sensor (1).



NOTE:

- Lubricate the O-ring seal with clean engine oil prior to installing the sensor. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
- Use wire or suitable device to route the sensor connector through the oil pan opening.
- If reinstalling the sensor, replace the O-ring seal (2) around the level sensor connector.

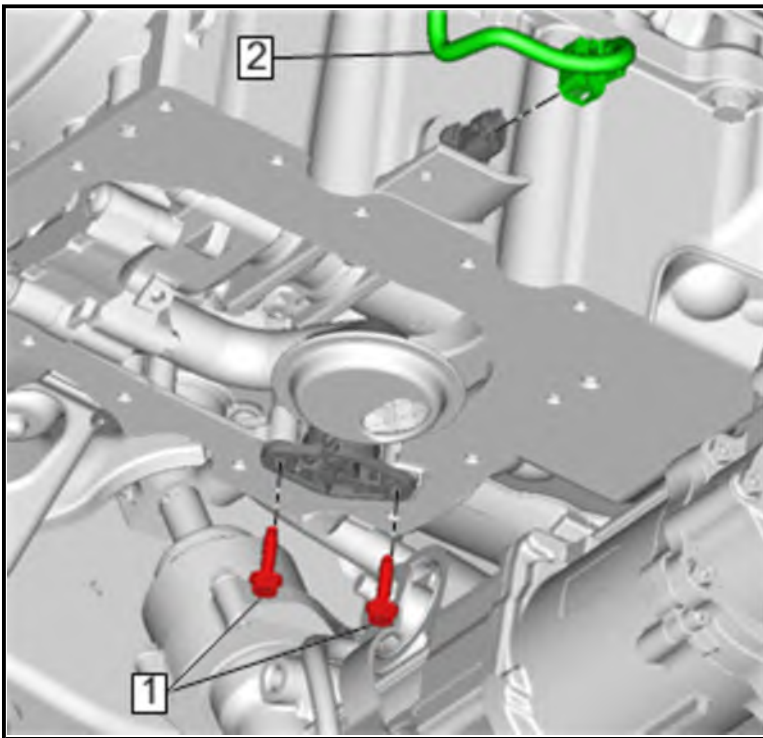
Install the engine oil level sensor C-clip (1).



NOTE:

Pull the sensor connector (2) through the connector opening and ensure that it is properly seated.

2. Install the engine oil level sensor fasteners (1) and tighten to 10 N.m (89 lb in).



CAUTION: Refer to [Fastener Caution](#) .

3. Connect the oil level sensor electrical connector (2).
4. Install the lower oil pan. Refer to [Lower Oil Pan Replacement](#).

FLYWHEEL REPLACEMENT

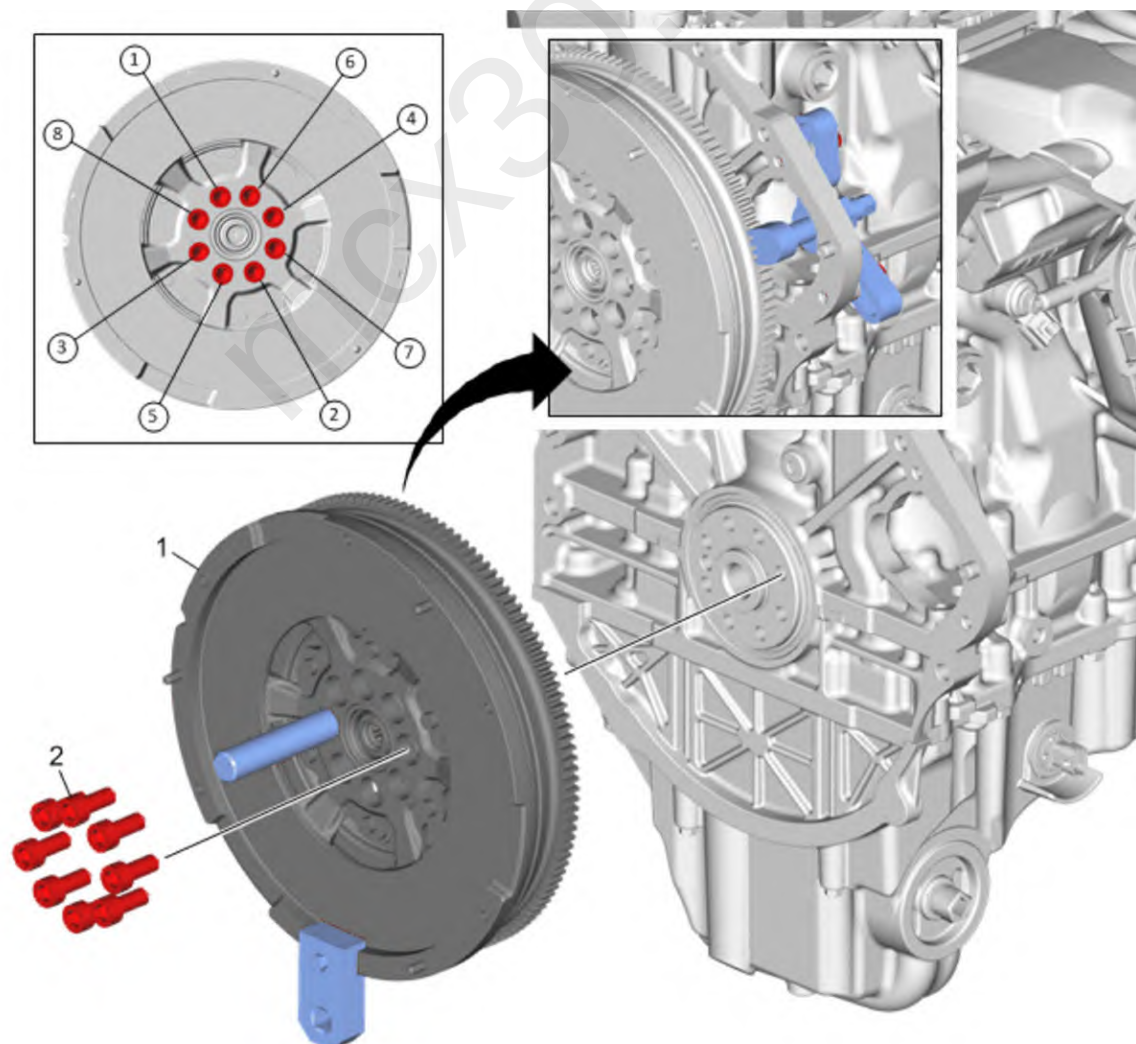


Fig. 18: Engine Flywheel With Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure	
1. Starter Replacement (LCV)	
1	Engine Flywheel Procedure Clean and inspect flywheel. Flywheel Cleaning and Inspection NOTE: EN-51701-2 holder and EN-51701-1 aligner may be installed on the flywheel to maintain alignment of the secondary mass to the primary mass. Special Tools EN-51701 Flywheel Aligner and Holder Equivalent regional tools: Special Tools
2	Engine Flywheel Bolt [8x] CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause

Callout	Component Name
	damage to the vehicle or component. CAUTION: Refer to Fastener Caution . Procedure 1. Install the NEW bolts loosely by hand. If necessary, remove EN-51701-2 holder and rotate the secondary mass using EN-51701-1 aligner and a breaker bar to align the holes in the secondary mass with the primary mass. 2. To prevent crankshaft rotation, install EN-50792 holding tool and starter motor bolts at the starter motor location, engaging the flywheel. 3. Tighten the bolts evenly using the following procedure: Tighten 1. Tighten the bolts a first pass in sequence to 30 N.m (22 lb ft). 2. Tighten the bolts a final pass in sequence 80 degrees using the EN-45059 meter. 4. Remove EN-50792 holding tool from the starter mount. Remove any remaining special tools, if present. NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes. Special Tools • EN-45059 Angle Meter • EN-50792 Flywheel Holding Tool • EN-51701 Flywheel Aligner and Holder Equivalent regional tools: Special Tools

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

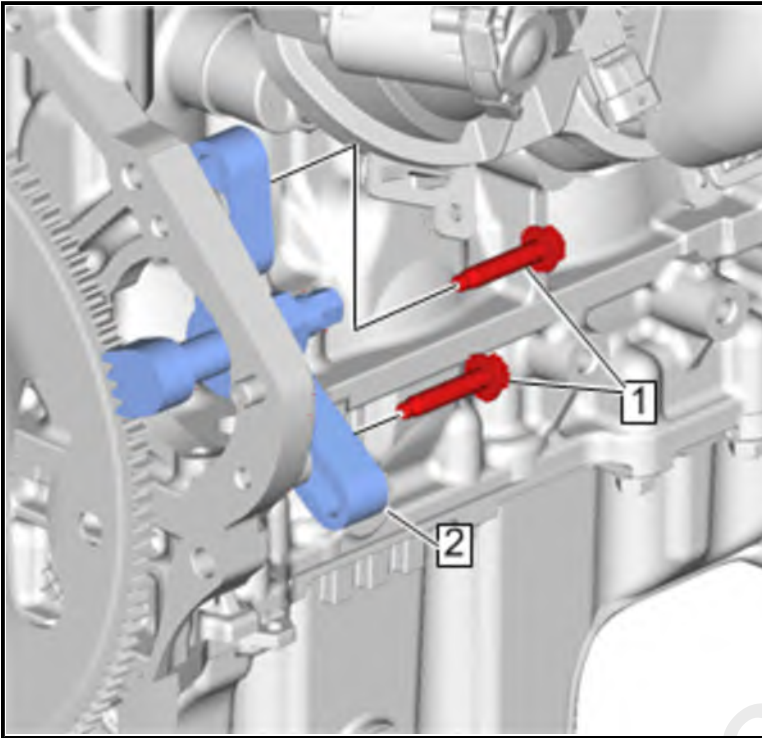
Removal Procedure

Special Tools

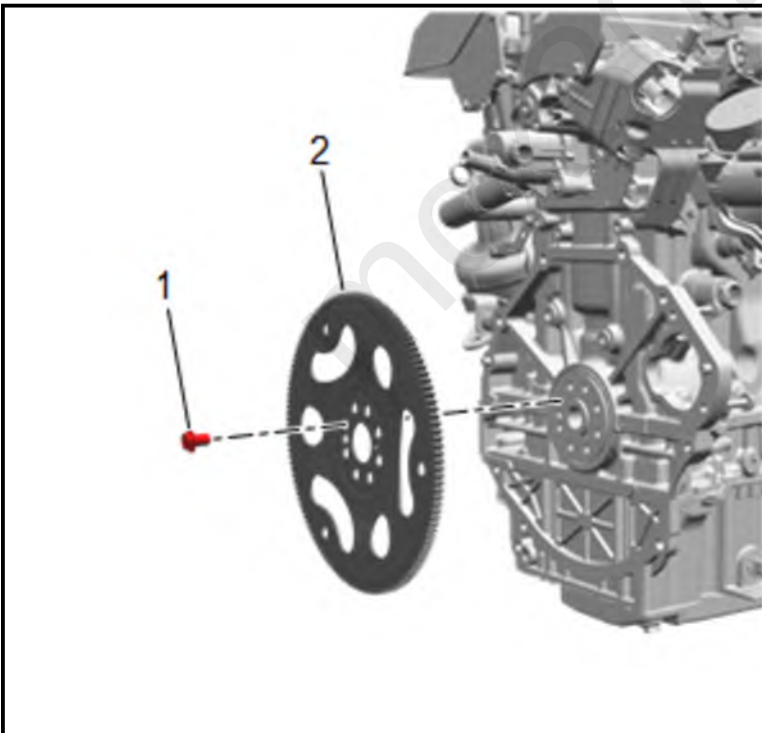
- **EN-45059** Angle Meter
- **EN-50792** Holding Tool

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

1. Remove the transmission. Refer to [Transmission Replacement \(LCV Engine with 4WD\)](#) , or [Transmission Replacement \(LCV Engine with 2WD\)](#) .
2. To prevent crankshaft rotation, install the **EN-50792** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the automatic flex plate.



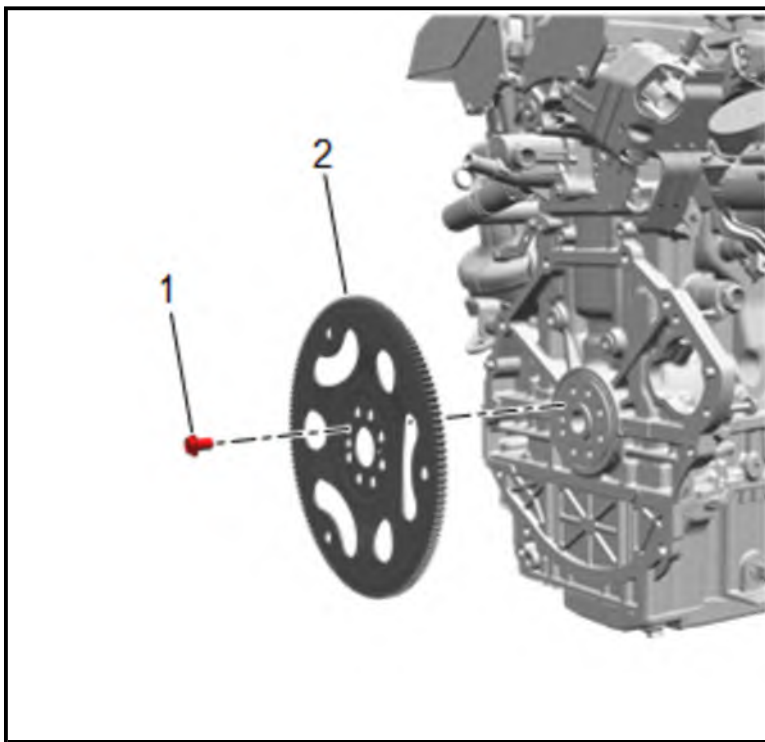
3. Remove and DISCARD the automatic transmission flex plate attaching bolts (1).



4. Remove the automatic transmission flex plate (2).
5. Remove the **EN-50792** holding tool.
6. For automatic transmission flex plate cleaning and inspection. Refer to [Automatic Transmission Flex Plate Cleaning and Inspection](#).

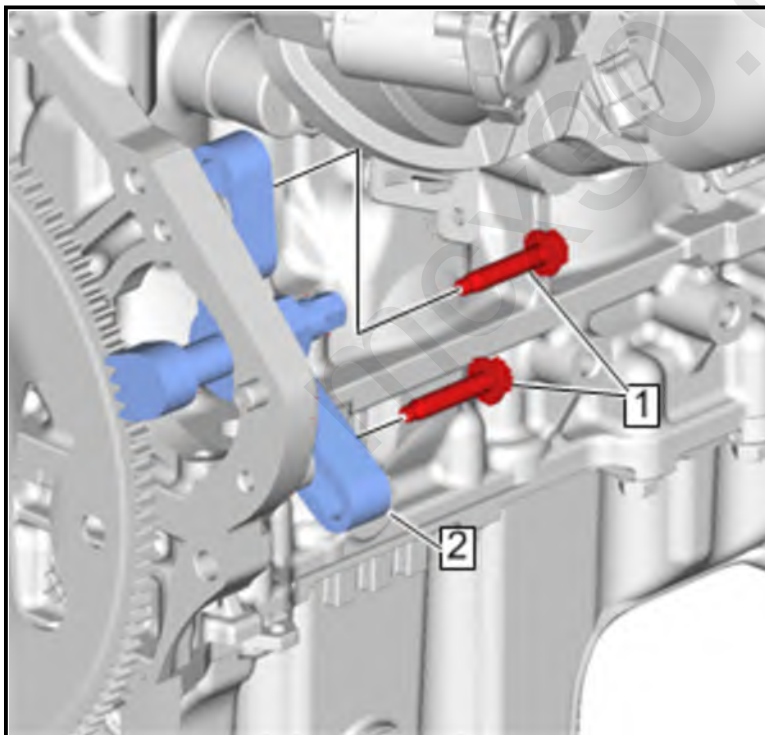
Installation Procedure

1. Install the automatic transmission flex plate (2) and hand start NEW bolts (1).

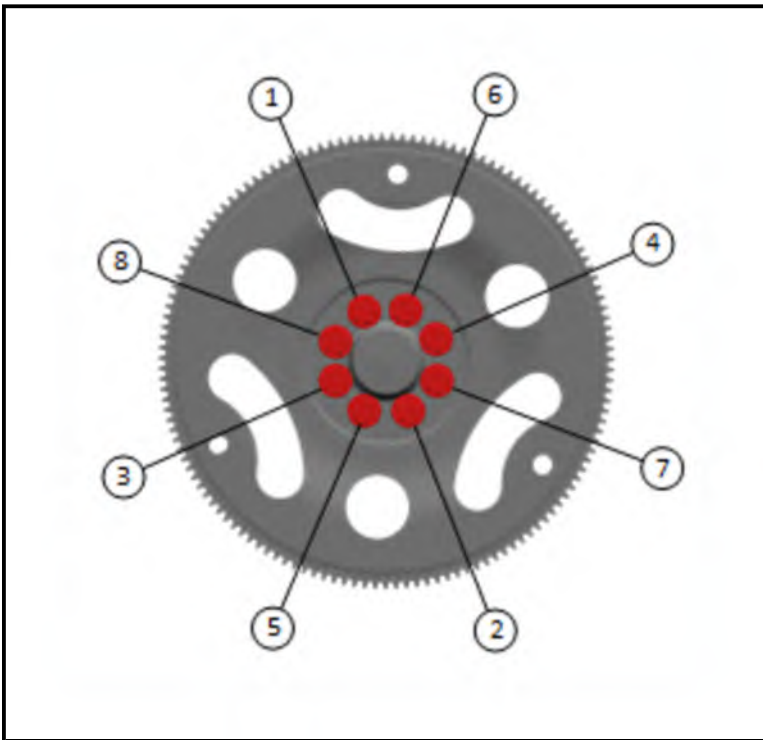


NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

2. To prevent crankshaft rotation, install **EN-50792** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flex plate.



3. Tighten the NEW bolts evenly using the following procedure:



CAUTION: Refer to [Fastener Caution](#) .

1. Tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the bolts a second pass in sequence to 30 N.m (22 lb ft).
3. Tighten the bolts a final pass in sequence 40 degrees using the **EN 45059** meter.
4. Remove the **EN-50792** holding tool.
5. Install the transmission. Refer to [Transmission Replacement \(LCV Engine with 4WD\)](#) , or [Transmission Replacement \(LCV Engine with 2WD\)](#) .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

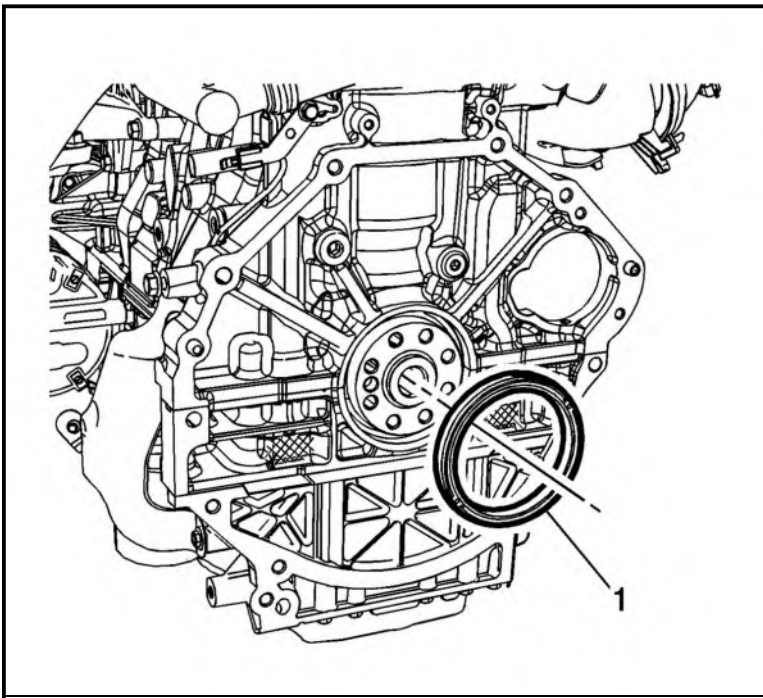
Special Tools

EN-51380 Rear Main Seal Installer

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

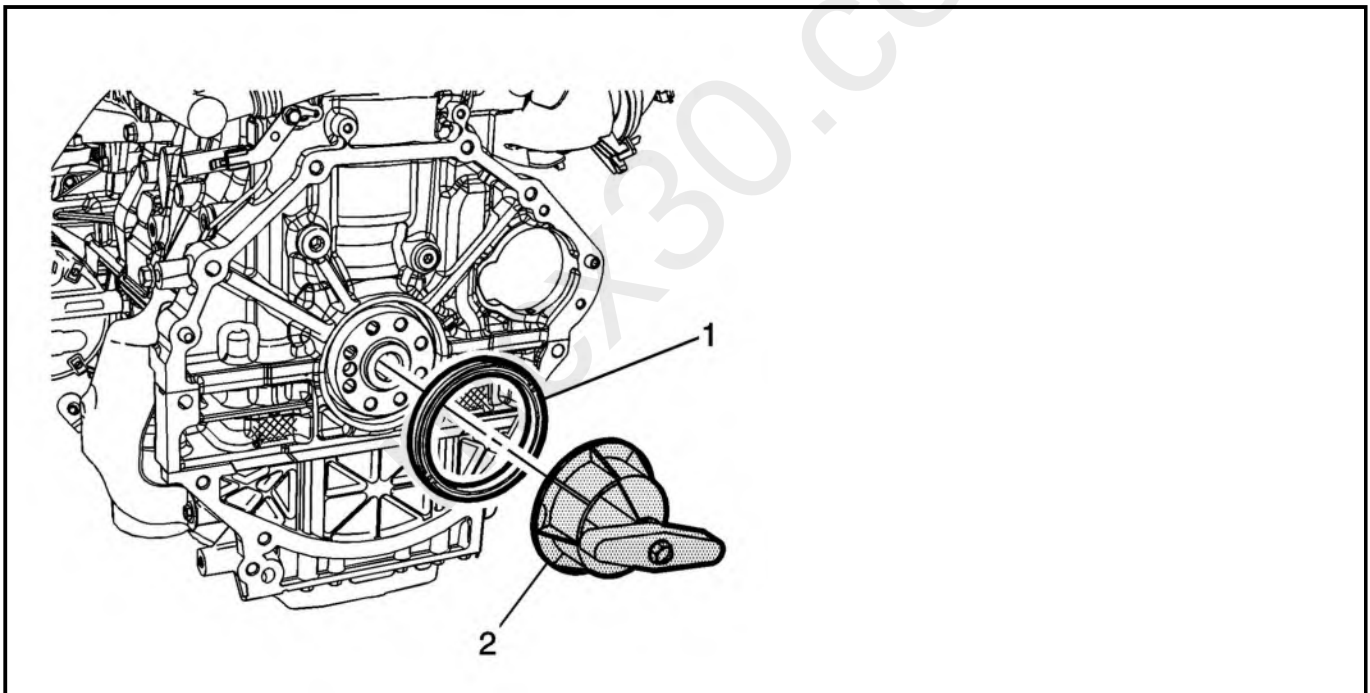
Removal Procedure

1. If equipped with manual transmission, remove the engine flywheel. Refer to [Flywheel Replacement](#).
2. If equipped with an automatic transmission, remove the flex plate. Refer to [Automatic Transmission Flex Plate Replacement](#).
3. Use a suitable tool to remove the crankshaft rear oil seal (1).



NOTE: Do not damage the outside diameter of the crankshaft or chamfer with any tool.

Installation Procedure



1. Using the **EN-51380** rear main seal installer (2), install a NEW crankshaft rear oil seal (1).
2. If equipped with manual transmission, install the engine flywheel. Refer to [Flywheel Replacement](#).
3. If equipped with an automatic transmission, install the flex plate. Refer to [Automatic Transmission Flex Plate Replacement](#).

ENGINE REPLACEMENT

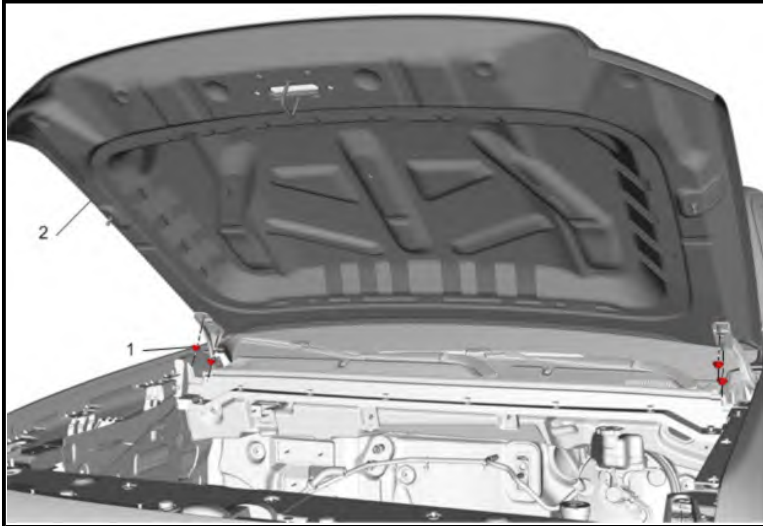
Special Tools

- **EN-36857** Engine Lift Bracket
- **EN-51768** Engine Support Fixture Adapter Bolts M8

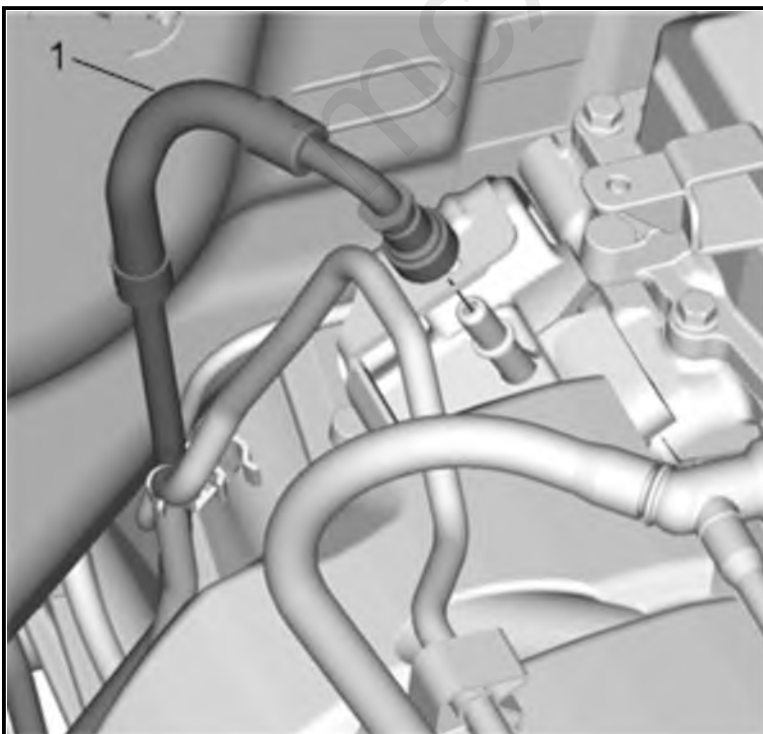
Equivalent regional tools: [Special Tools](#)

Removal Procedure

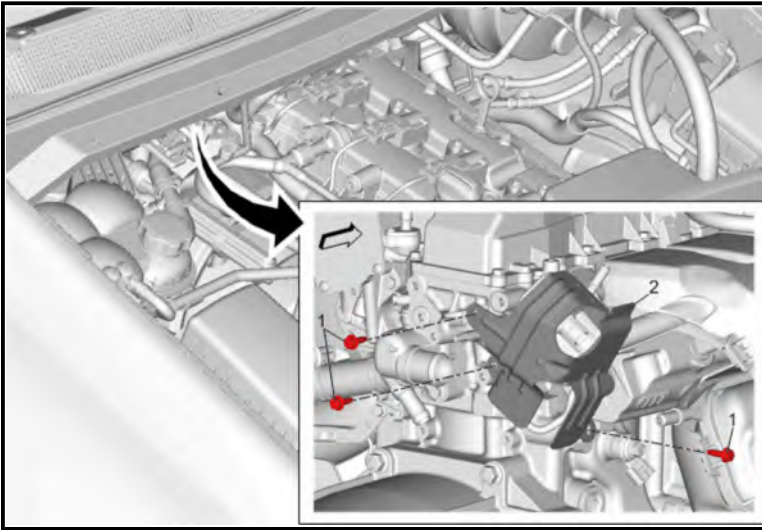
1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)
2. Recover the refrigerant. [Refrigerant Recovery and Recharging \(R-1234yf\)](#).
3. Drain the cooling system. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(VAC n Fill\)](#).
4. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
5. Hood (2) - Remove - [Hood Replacement](#)



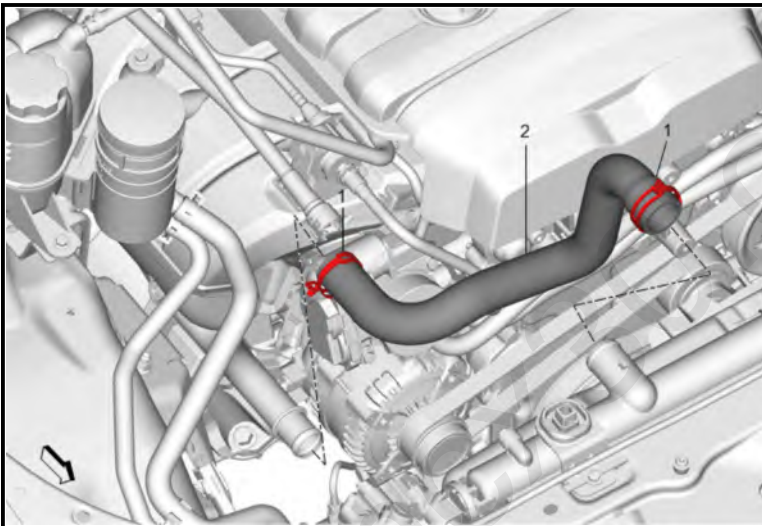
6. Intake Manifold Cover - Remove - [Intake Manifold Cover Replacement](#)
7. Evaporative Emission Line @ Engine - Disconnect and reposition - [Evaporative Emission Line Replacement - Engine to Chassis](#)
8. Air Cleaner Assembly - Remove - [Air Cleaner Assembly Replacement](#)
9. Air Cleaner Outlet Duct - Remove - [Air Cleaner Outlet Duct Replacement](#)
10. Plenum Front Panel - Remove - [Plenum Front Panel Replacement](#)
11. Fuel Feed Pipe (1) - Disconnect - [Metal Collar Quick Connect Fitting Service](#)



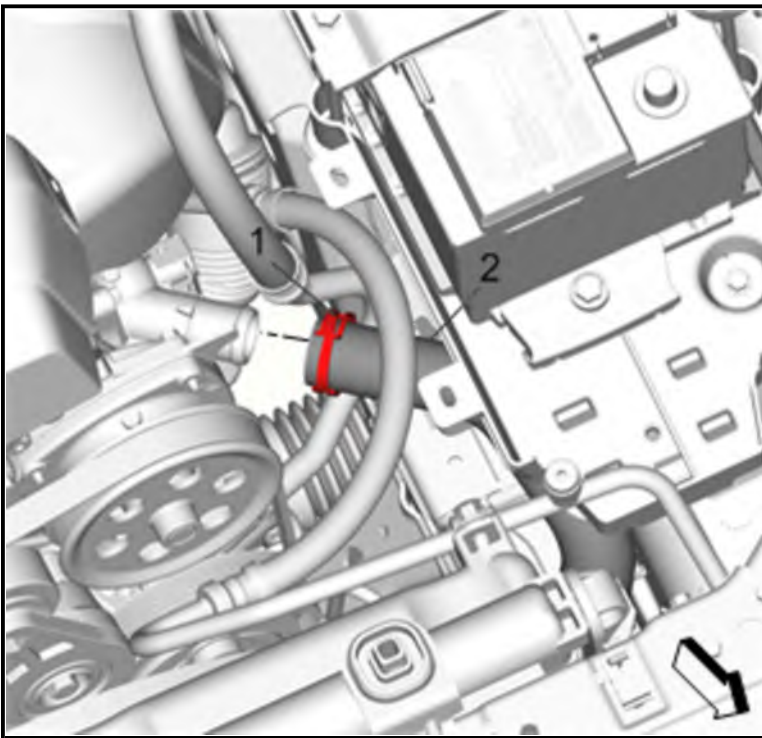
12. Fuel Pump Cover (2) - Remove - [Fuel Pump Cover Replacement](#)



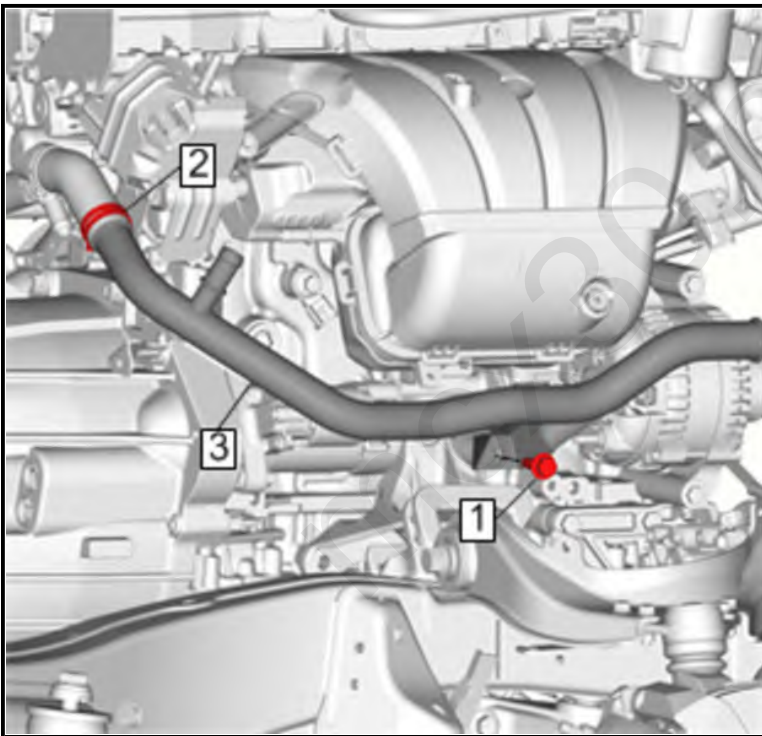
13. Front End Upper Tie Bar - Remove - [Front End Upper Tie Bar Replacement](#)
14. Remove the radiator, the engine coolant fan shroud and engine coolant fan as an assembly. [Radiator Replacement \(LCV\)](#)
15. Radiator Inlet Hose (2) - Remove - [Radiator Inlet Hose Replacement \(LCV Radiator to Inlet Pipe\)](#) , or [Radiator Inlet Hose Replacement \(LCV Inlet Pipe to Water Outlet\)](#)



16. Radiator Outlet Hose (2) - Remove - [Radiator Outlet Hose Replacement \(LCV\)](#)



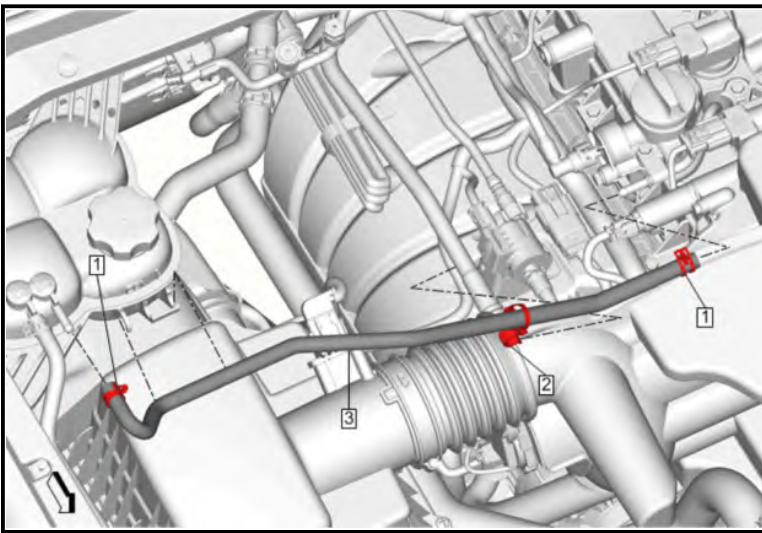
17. Radiator Inlet Pipe (3) - Remove - [Radiator Inlet Pipe Replacement \(LCV\)](#).



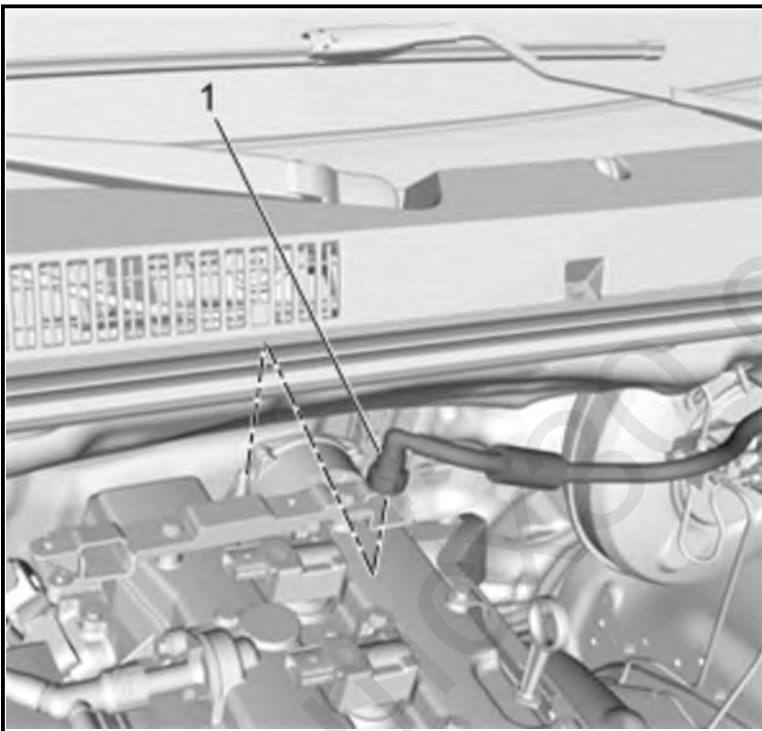
18. Disconnect heater inlet and outlet hoses from the engine side and reposition away from the engine.

- [Heater Inlet Hose Replacement \(Heater Core Inlet Pipe to Radiator Surge Tank Outlet Pipe LWN\)](#) , or [Heater Inlet Hose Replacement \(LCV\)](#)
- [Heater Outlet Hose Replacement \(Heater Outlet Hose Tee to Heater Core Tube LCV\)](#) , or [Heater Outlet Hose Replacement \(Heater Outlet Hose Tee to Water Outlet LCV\)](#)

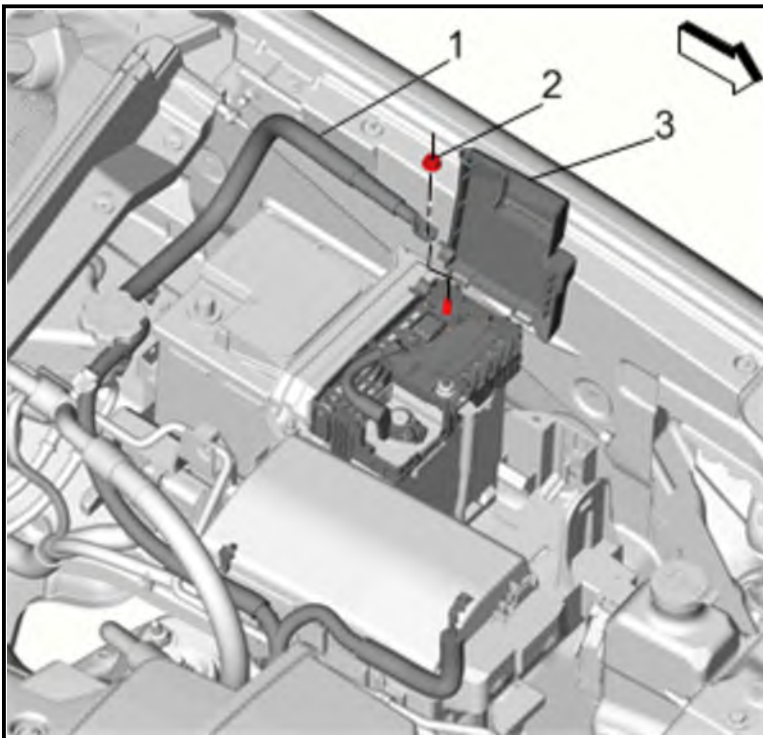
19. Coolant Recovery Reservoir Hose (3) @ Engine - Disconnect - [Coolant Recovery Reservoir Hose Replacement \(LCV\)](#).



20. Power Brake Booster Vacuum Hose (1) - Disconnect and reposition - [Plastic Collar Quick Connect Fitting Service](#)

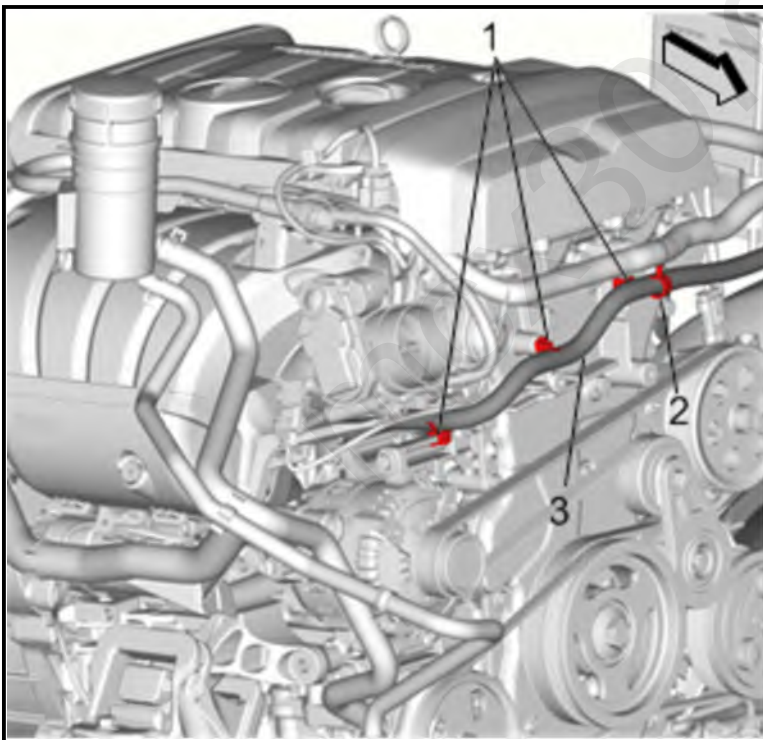


21. Battery Positive Cable (1) @ Battery - Disconnect and reposition - [Battery Positive Cable Replacement \(LCV\)](#)



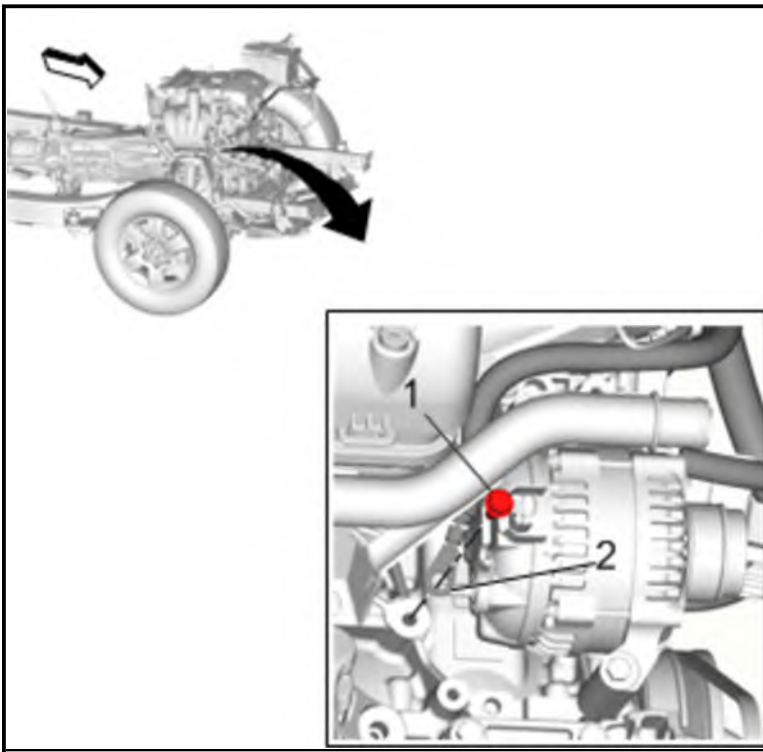
NOTE: Once disconnected, reposition the battery positive cable (1) on top of the engine.

22. Retainer (1) - Unclip [3x]



23. Engine Wiring Harness (3) @ Retainer (2) - Unclip

24. Engine Wiring Harness Bolt (1) - Remove



25. Battery Negative Cable (2) - Reposition
26. Disconnect and reposition remaining harnesses as necessary.
27. Air Conditioning Evaporator Hose - Remove - [Air Conditioning Evaporator Hose Replacement \(LCV\)](#).
28. Disconnect both A/C compressor hoses from the compressor, then reposition away from the engine. [Air Conditioning Compressor Hose Replacement \(LCV\)](#).
29. Transmission - Remove - [Transmission Replacement \(LCV Engine with 4WD\)](#) , or [Transmission Replacement \(LCV Engine with 2WD\)](#).
30. Exhaust Manifold - Remove - [Exhaust Manifold Replacement \(LCV\)](#).
31. If the vehicle engine lift brackets are not present, install the **EN-36857** Engine Lift Bracket with **EN-51768** Engine Support Fixture Adapter Bolts M8.

NOTE: It is not necessary to install the engine support fixture when only removing the body to engine mount bolts from the mounts.

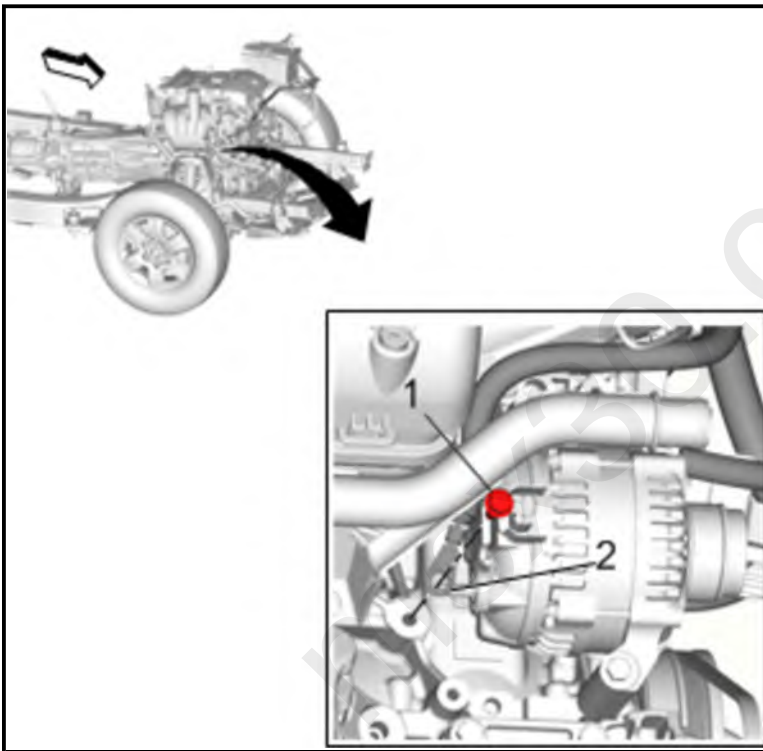
32. Remove only the body to engine mount bolts from the left and right side engine mounts.
 - [Engine Mount Replacement - Left Side](#)
 - [Engine Mount Replacement - Right Side](#)
33. Ensure the following items are clear from the frame:
 - Vacuum lines
 - Steering knuckles
 - Electrical wiring harnesses
 - Oil cooler lines
34. Using a suitable engine lifting device, remove the engine from the vehicle.
35. Transfer components as necessary.

Installation Procedure

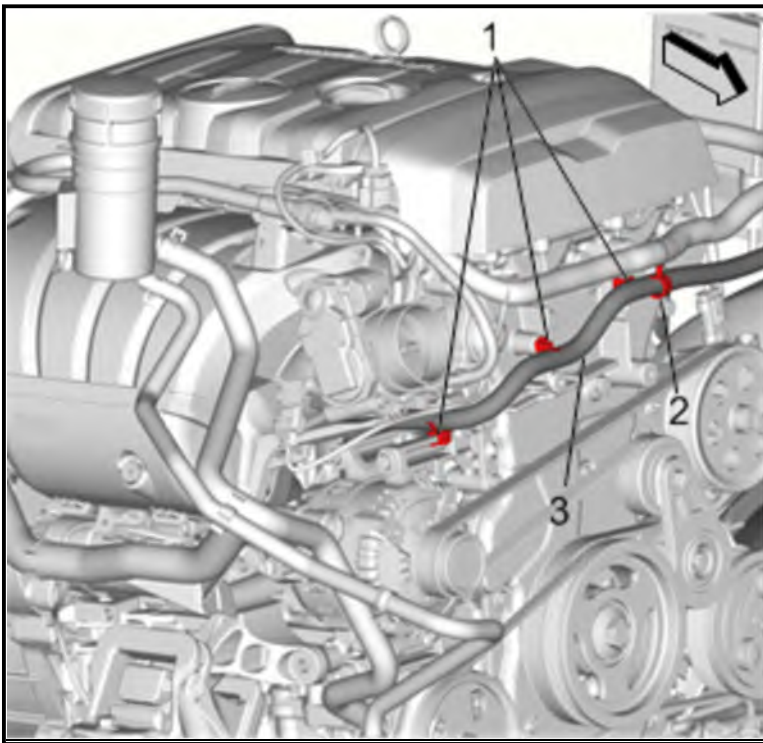
1. With the aid of an assistant, carefully lower the engine into the vehicle.
2. Ensure when lowering the engine the following items are clear from the frame:
 - Vacuum lines
 - Steering knuckles
 - Electrical wiring harnesses
 - Oil cooler lines

CAUTION: Refer to [Fastener Caution](#) .

3. Install the left and right side engine mount to body bolts and tighten.
 - [Engine Mount Replacement - Left Side](#)
 - [Engine Mount Replacement - Right Side](#)
4. Remove the engine lifting device.
5. Remove the **EN-51768** Engine Support Fixture Adapter Bolts M8 and **EN-36857** Engine Lift Bracket.
6. Exhaust Manifold - Install - [Exhaust Manifold Replacement \(LCV\)](#) , or [Exhaust Manifold Replacement \(LWN\)](#).
7. Transmission - Install - [Transmission Replacement \(LCV Engine with 4WD\)](#) , or [Transmission Replacement \(LCV Engine with 2WD\)](#).
8. Connect both A/C compressor hoses to the compressor. [Air Conditioning Compressor Hose Replacement \(LCV\)](#).
9. Air Conditioning Evaporator Hose - Install - [Air Conditioning Evaporator Hose Replacement \(LCV\)](#).
10. Reposition and connect the electrical wiring harnesses as necessary.
11. Battery Negative Cable (2) - Reposition

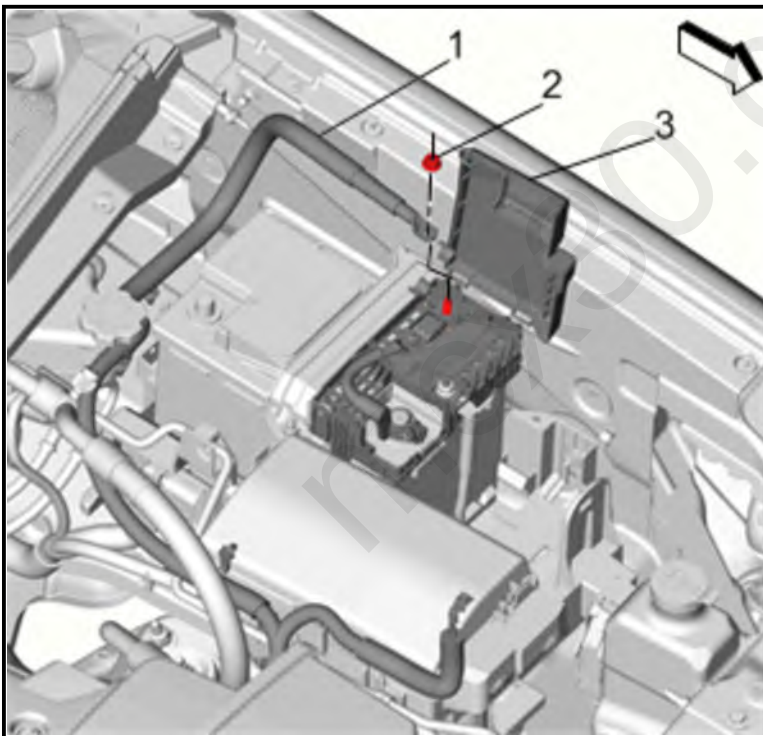


12. Engine Wiring Harness Bolt (1) - Install and tighten 58 N.m (43 lb ft)
13. Engine Wiring Harness (3) @ Retainer (2) - Install

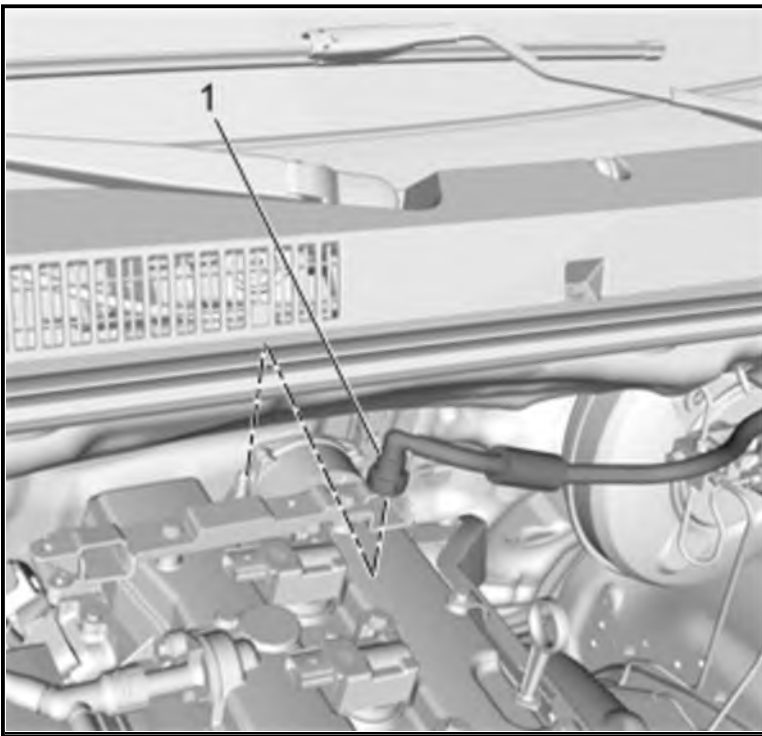


14. Retainer (1) - Install [3x]

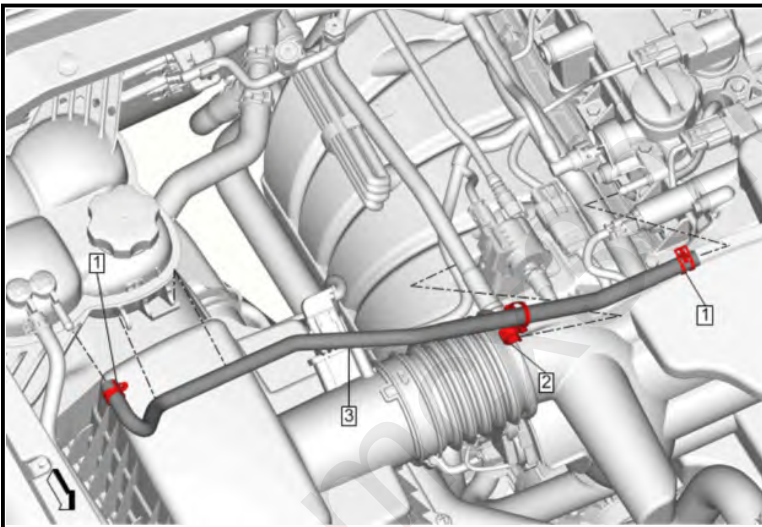
15. Battery Positive Cable (1) @ Battery - Connect - [Battery Positive Cable Replacement \(LCV\)](#)



16. Power Brake Booster Vacuum Hose (1) - Connect - [Plastic Collar Quick Connect Fitting Service](#)



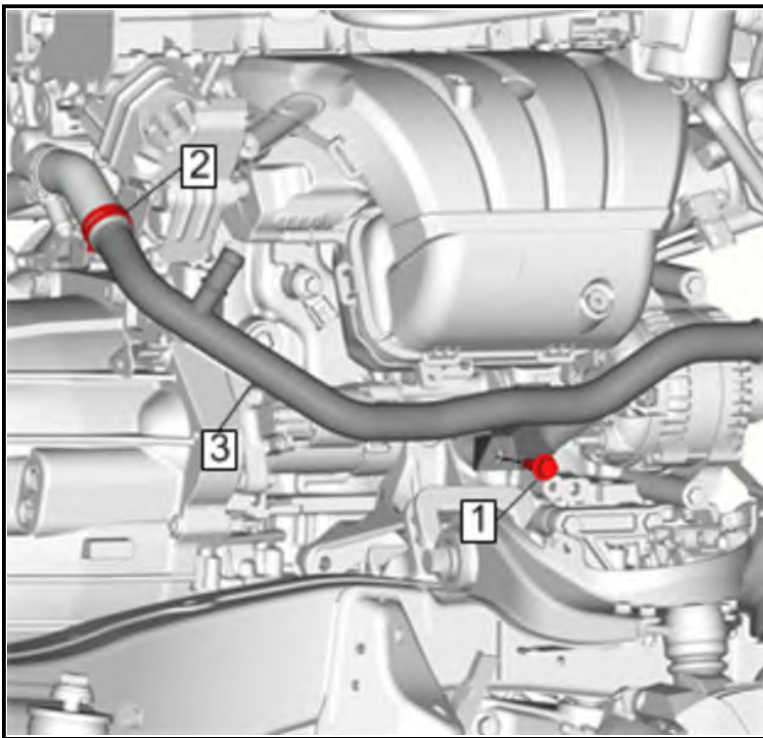
17. Coolant Recovery Reservoir Hose (3) @ Engine - Connect - [Coolant Recovery Reservoir Hose Replacement \(LCV\)](#).



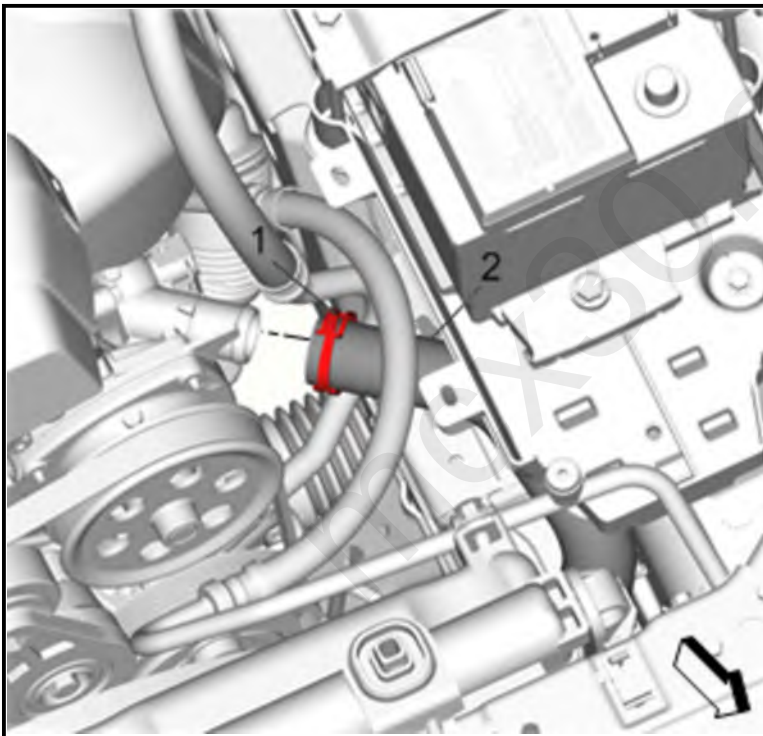
18. Connect heater inlet and outlet hoses.

- [Heater Inlet Hose Replacement \(LCV\)](#)
- [Heater Outlet Hose Replacement \(Heater Outlet Hose Tee to Heater Core Tube LCV\)](#) , or [Heater Outlet Hose Replacement \(Heater Outlet Hose Tee to Water Outlet LCV\)](#).

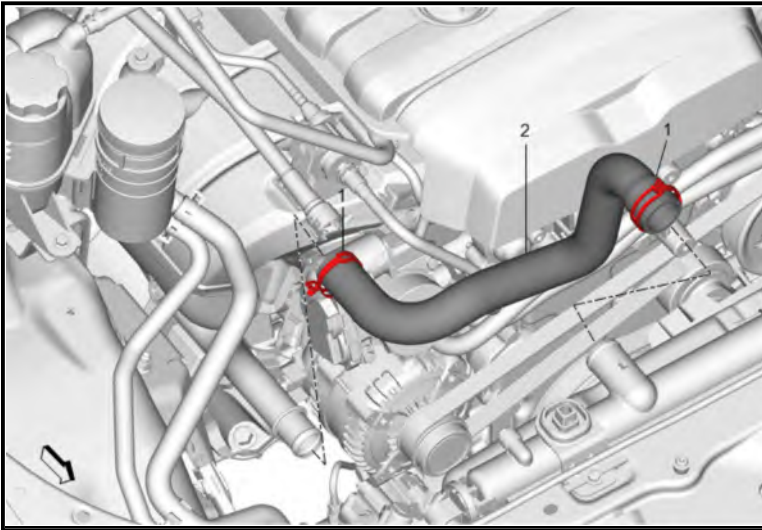
19. Radiator Inlet Pipe (3) - Install - [Radiator Inlet Pipe Replacement \(LCV\)](#).



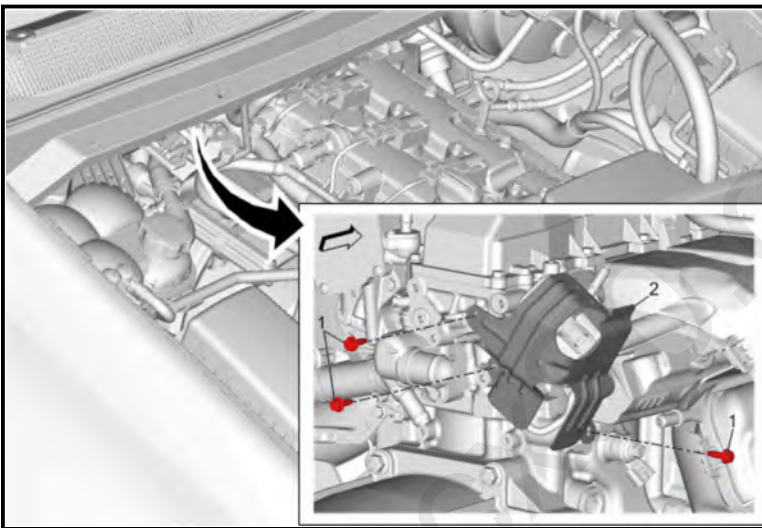
20. Radiator Outlet Hose (2) - Install - [Radiator Outlet Hose Replacement \(LCV\)](#).



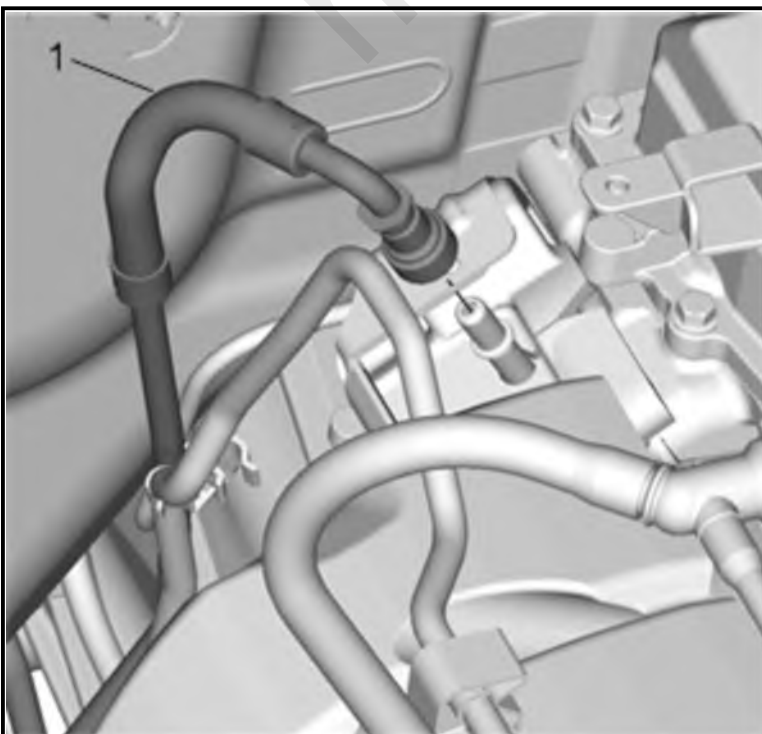
21. Radiator Inlet Hose (2) - Install - [Radiator Inlet Hose Replacement \(LCV Radiator to Inlet Pipe\)](#) , or [Radiator Inlet Hose Replacement \(LCV Inlet Pipe to Water Outlet\)](#).



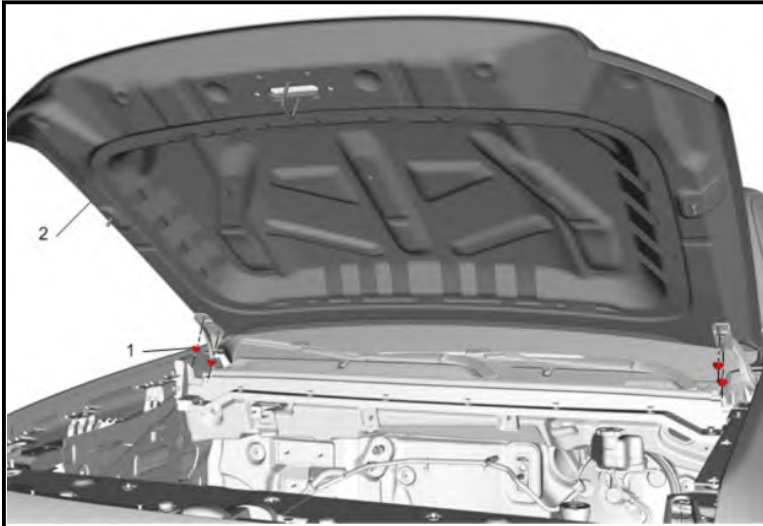
- 22. Install the radiator, engine coolant fan shroud, and engine coolant fan assembly. [Radiator Replacement \(LCV\)](#)
- 23. Front End Upper Tie Bar - Install - [Front End Upper Tie Bar Replacement](#)
- 24. Fuel Pump Cover (2) - Install - [Fuel Pump Cover Replacement](#)



- 25. Fuel Feed Pipe (1) - Connect - [Metal Collar Quick Connect Fitting Service](#)



- 26. Plenum Front Panel - Install - [Plenum Front Panel Replacement](#)
- 27. Air Cleaner Outlet Duct - Install - [Air Cleaner Outlet Duct Replacement](#)
- 28. Air Cleaner Assembly - Install - [Air Cleaner Assembly Replacement](#)
- 29. Evaporative Emission Line @ Engine - Connect - [Evaporative Emission Line Replacement - Engine to Chassis](#)
- 30. Intake Manifold Cover - Install - [Intake Manifold Cover Replacement](#)
- 31. Hood (2) - Install - [Hood Replacement](#)



- 32. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection](#)
- 33. Fill the cooling system to the proper level. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(VAC n Fill\)](#)
- 34. Recharge the refrigerant. [Refrigerant Recovery and Recharging \(R-1234yf\)](#)

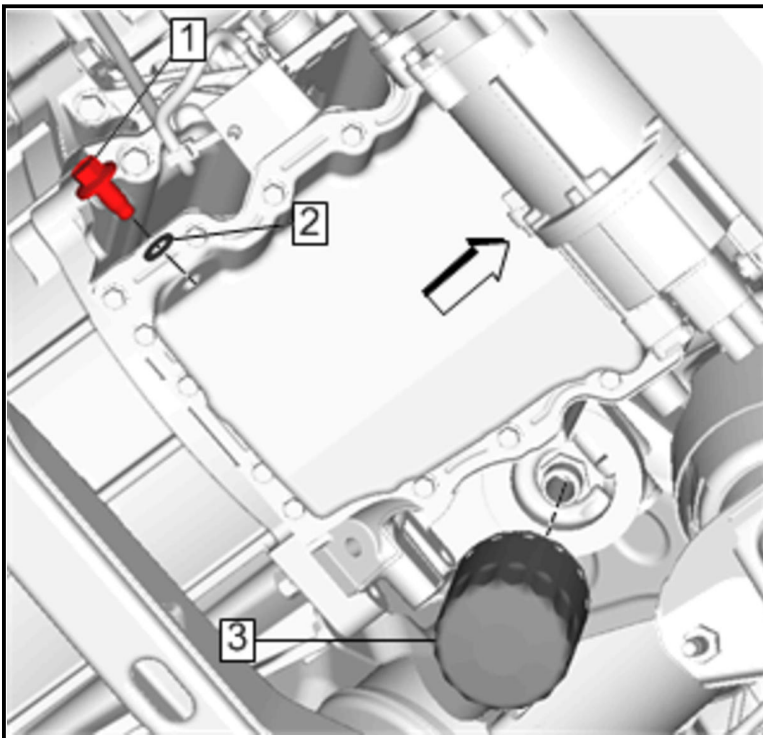
NOTE: **Prelube is necessary if the engine is replaced or overhauled.**

- 35. If the engine is replaced with a new engine or has been overhauled, perform the engine pre-lube procedure. [Engine Prelubing](#)
- 36. Perform the throttle learn procedure. [Throttle Body Idle Air Flow Compensation Reset](#)

ENGINE OIL AND OIL FILTER REPLACEMENT (2WD)

Removal Procedure

- 1. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .
- 2. Place a suitable drain pan below the oil pan drain plug.



3. Remove the oil pan drain plug (1) and seal (2).

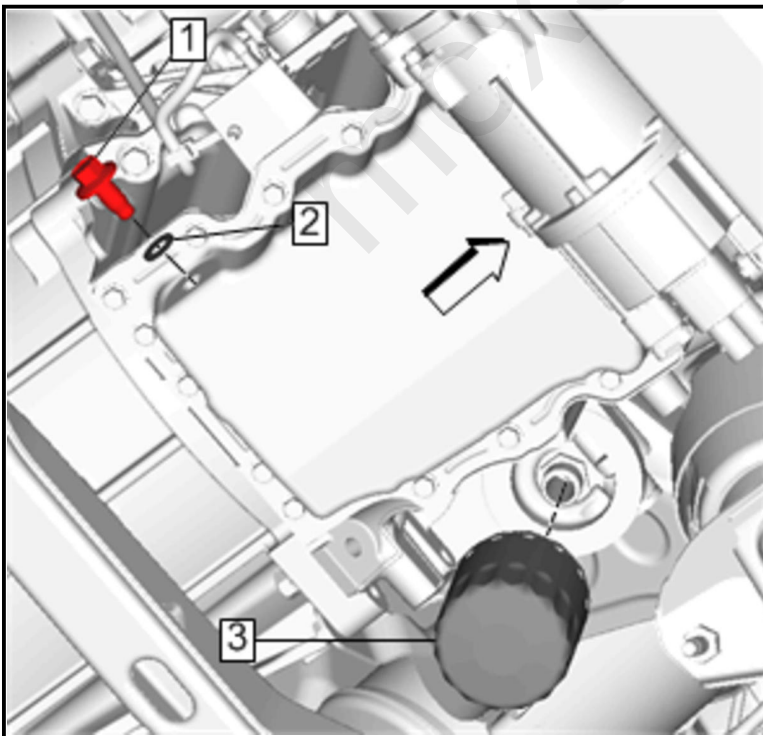
4. Allow the oil to drain completely.

NOTE: Ensure that the old oil filter gasket is still on the oil filter. If it is not, remove the old gasket from the engine and dispose of it.

5. Remove and properly dispose of the oil filter (3).

Installation Procedure

1. Install seal (2) and oil pan drain plug (1) and tighten to 25 N.m (18 lb ft).



CAUTION: Refer to [Component Fastener Tightening Caution](#) .

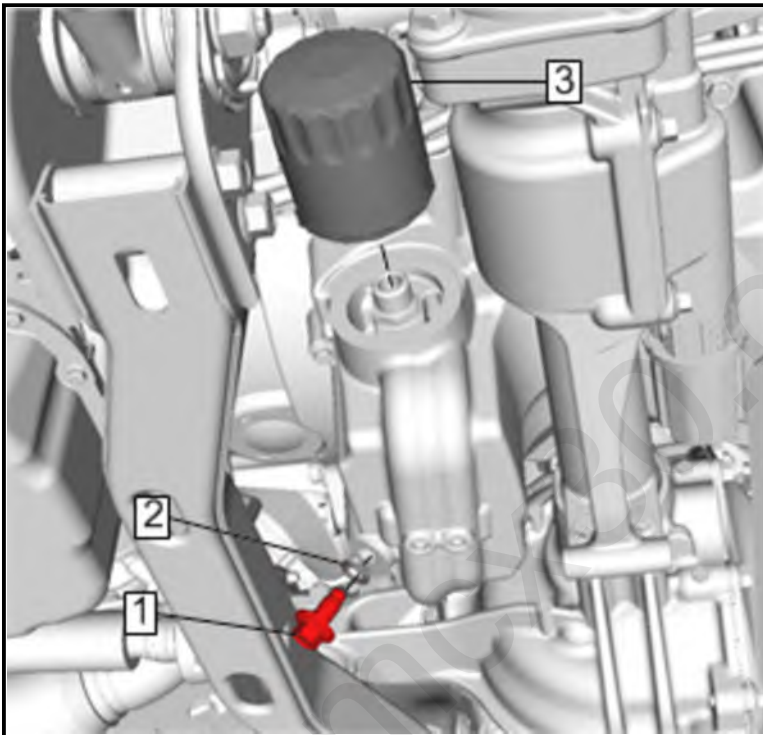
NOTE: Clean and inspect the oil drain plug and seal, replace if necessary.

2. Lubricate the NEW oil filter gasket with clean engine oil.
3. Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.
4. Remove the drain pan.
5. Lower the vehicle.
6. Fill the engine with the appropriate oil type and quantity. [Approximate Fluid Capacities](#), or [Adhesives, Fluids, Lubricants, and Sealers](#)
7. Reset the oil life. Refer to [GM Oil Life System Resetting](#) , or [GM Oil Life System Resetting \(With Scan Tool\)](#) .

ENGINE OIL AND OIL FILTER REPLACEMENT (4WD)

Removal Procedure

1. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#) .
2. Place a suitable drain pan below the oil pan drain plug.



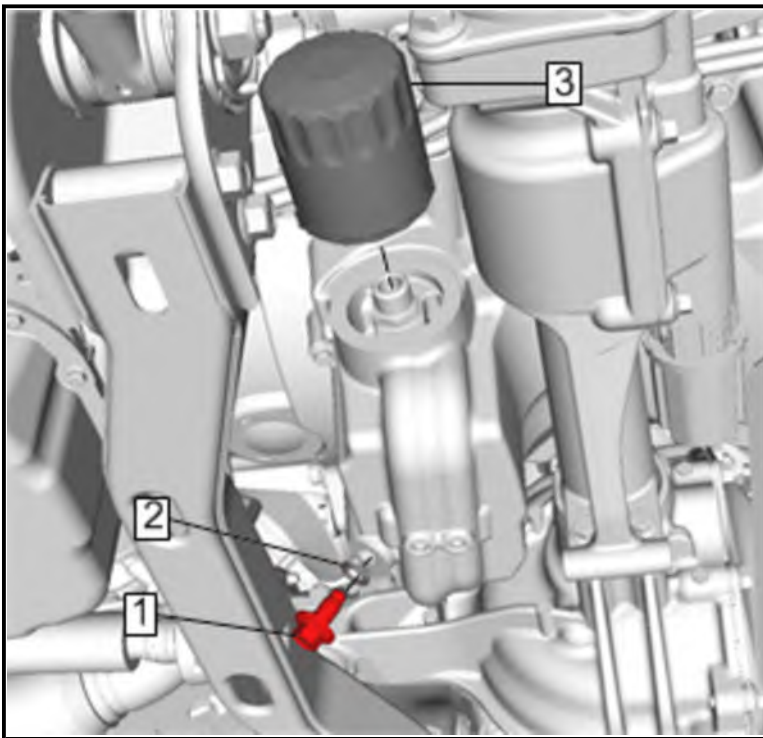
3. Remove the oil pan drain plug (1) and seal (2).
4. Allow the oil to drain completely.

NOTE: Ensure that the old oil filter gasket is still on the oil filter. If it is not, remove the old gasket from the engine and dispose of it.

5. Remove and properly dispose of the oil filter (3).

Installation Procedure

1. Install seal (2) and oil pan drain plug (1) and tighten to 25 N.m (18 lb ft).



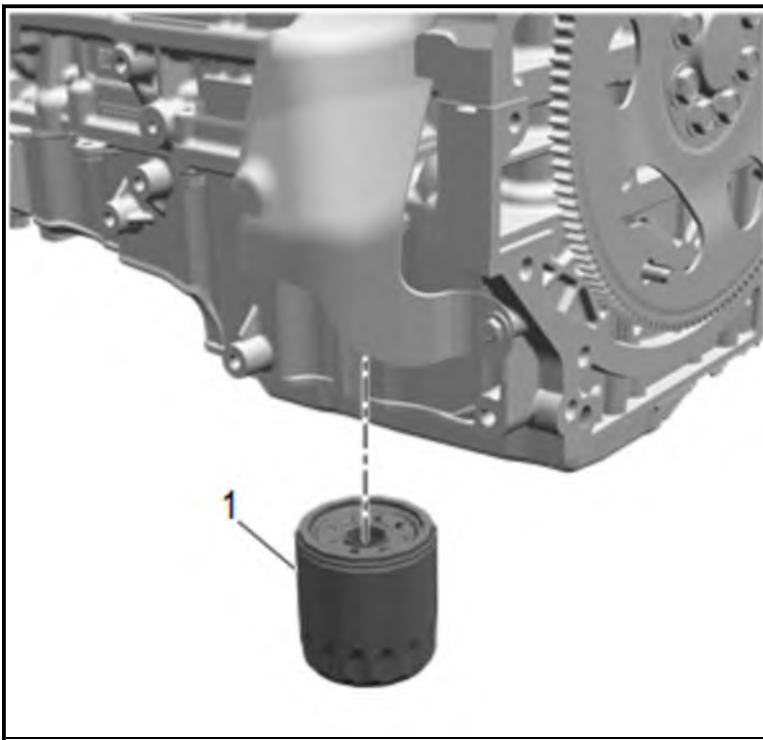
CAUTION: Refer to [Component Fastener Tightening Caution](#) .

NOTE: Clean and inspect the oil drain plug and seal, replace if necessary.

2. Lubricate the NEW oil filter gasket with clean engine oil.
3. Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.
4. Remove the drain pan.
5. Lower the vehicle.
6. Fill the engine with the appropriate oil type and quantity. [Fluid and Lubricant Recommendations](#) , or [Approximate Fluid Capacities](#)
7. Reset the oil life. [GM Oil Life System Resetting](#) , or [GM Oil Life System Resetting \(With Scan Tool\)](#)

DRAINING FLUIDS AND OIL FILTER REMOVAL (2WD)

1. Remove the oil filter (1). Remove the oil pan drain plug and allow the oil to drain out.



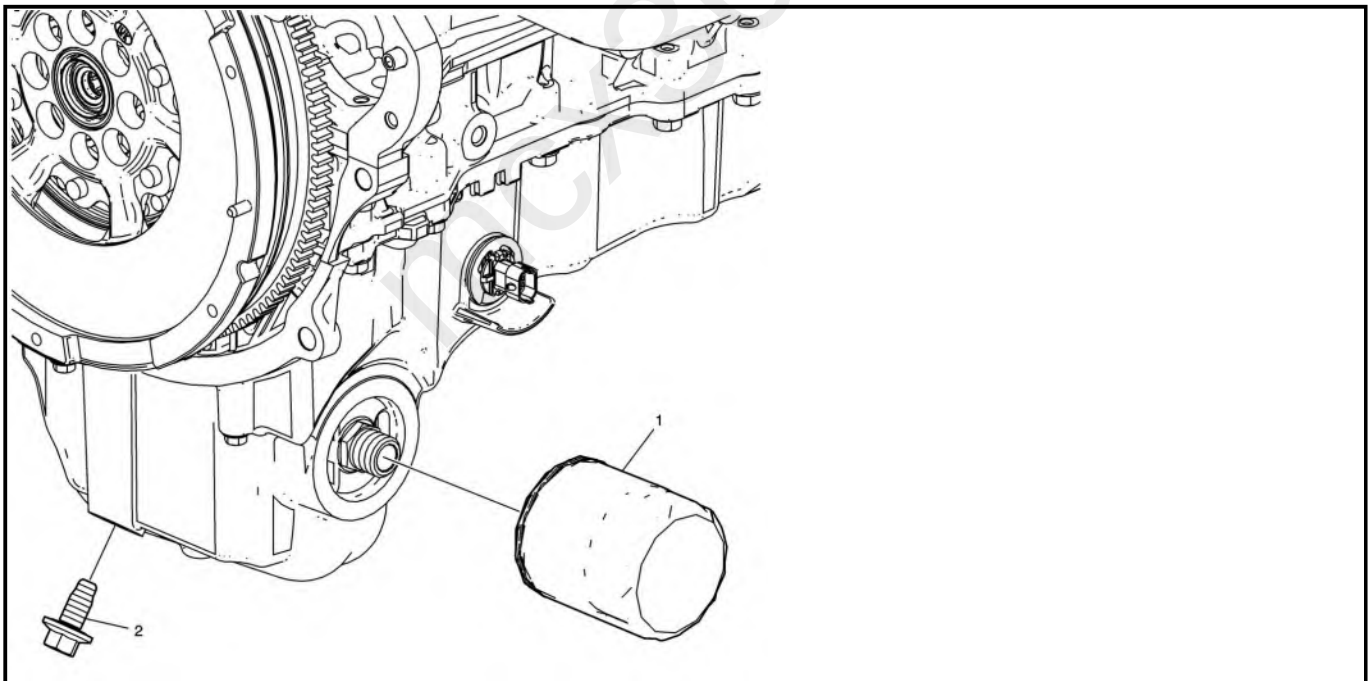
2. Clean the oil filter housing in the engine block.

CAUTION: Refer to **Fastener Caution** .

3. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).

4. If cleaning or repairing the engine block, it is not necessary to reinstall the plug.

DRAINING FLUIDS AND OIL FILTER REMOVAL (4WD)

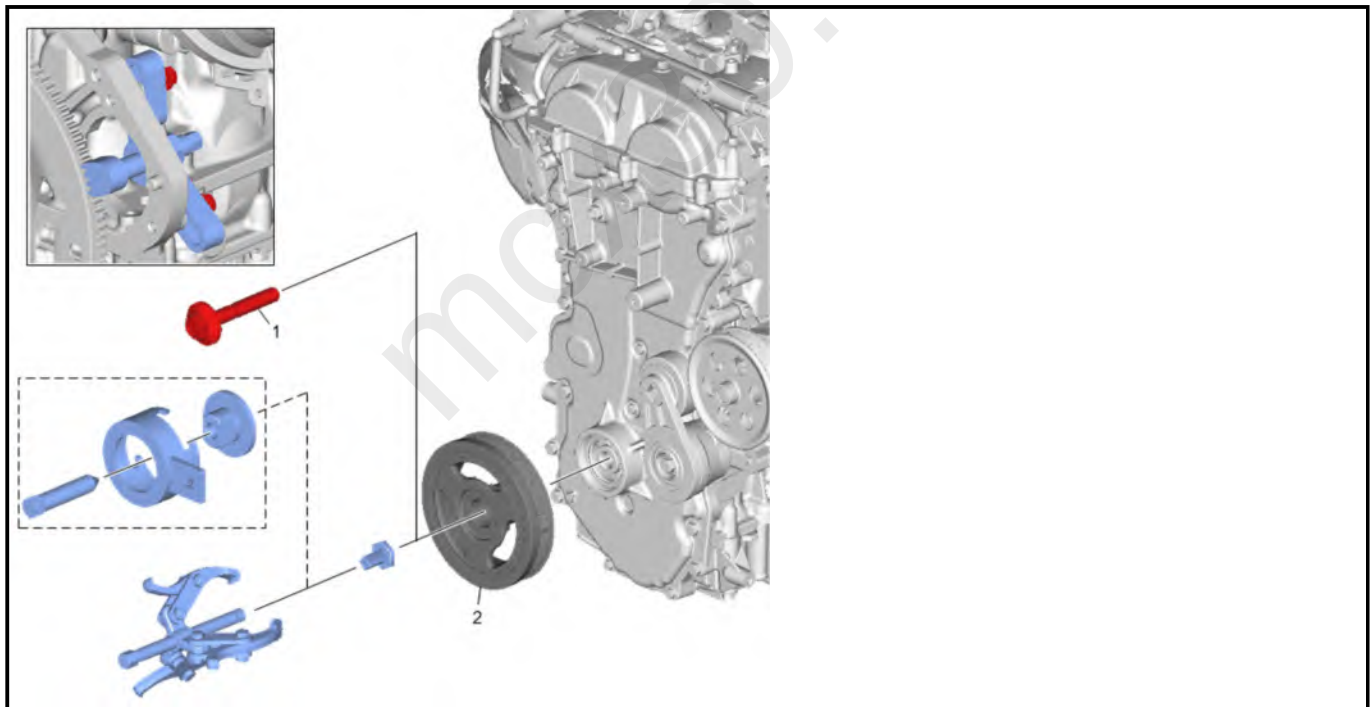


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Filter
2	Oil Pan Drain Plug
CAUTION:	

Callout	Component Name
	Refer to Component Fastener Tightening Caution . Procedure: 1. Remove the oil pan drain plug and allow the oil to drain out. 2. Clean the oil filter housing in the engine block. NOTE: If cleaning or repairing the engine block, it is not necessary to reinstall the plug. Tighten 25 N.m (18 lb ft)

CRANKSHAFT BALANCER REMOVAL

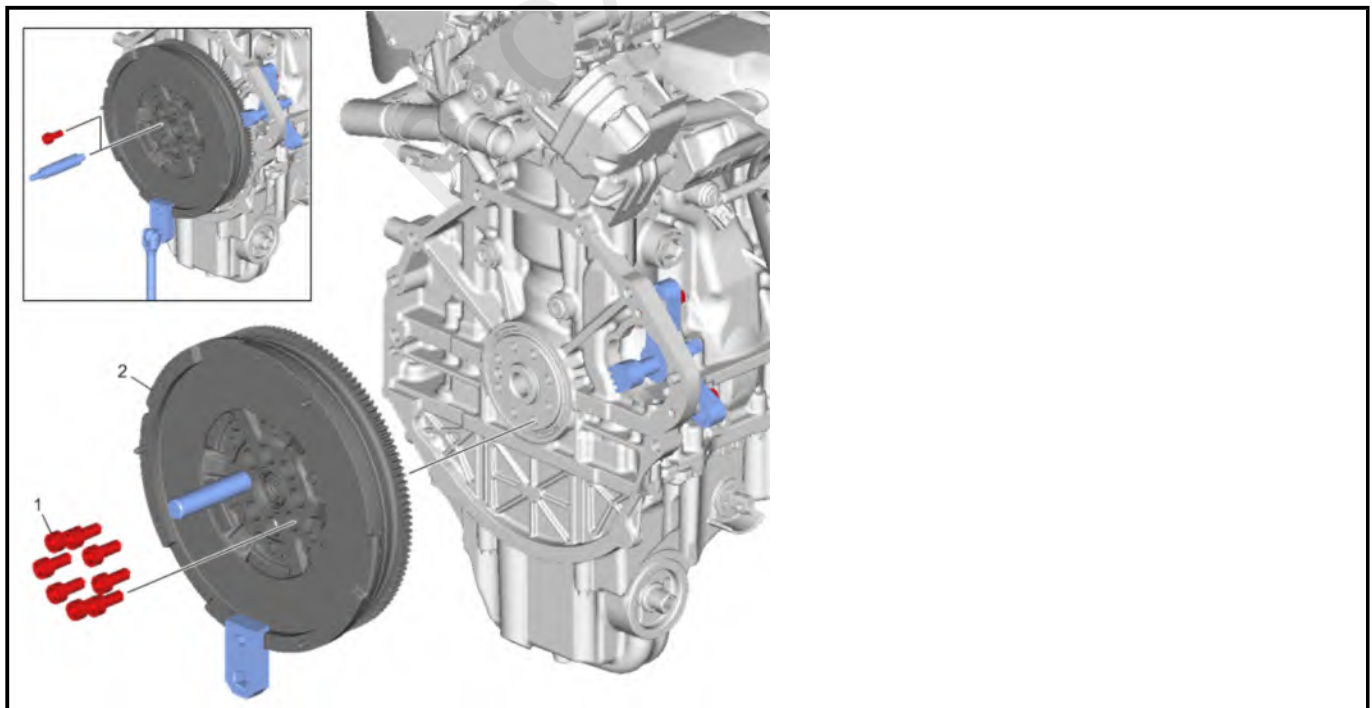


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure To prevent crankshaft rotation, install EN-51760 holding tool at the starter motor location, engaging the flywheel.	
Special Tools EN-51760 Flywheel Holding Tool For equivalent regional tools, refer to Special Tools .	

Callout	Component Name
1	Crankshaft Balancer Bolt NOTE: Discard the crankshaft balancer bolt and washer.
2	Crankshaft Balancer Procedure 1. Install EN-41816-2 protector to protect the crankshaft end during balancer removal. NOTE: EN-51577-1 remover can be used alternatively for EN-41816 remover. 2. Using EN-41816 remover, remove the balancer. Special Tools • EN-41816 Crankshaft Balancer Remover • EN-41816-2 Crankshaft End Protector For equivalent regional tools, refer to Special Tools .

FLYWHEEL REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure 1. To prevent crankshaft rotation, install EN-51760 holding tool and starter motor bolts at the starter motor location, engaging the flywheel. 2. Install EN-51701-1 aligner to the front secondary mass component of the flywheel. 3. Evaluate the flywheel condition prior to removal from the engine. Refer to Dual Mass Flywheel Mounted Inspection in Flywheel Cleaning and Inspection. Special Tools • EN-51701 Flywheel Aligner and Holder • EN-51760 Flywheel Holding Tool	
Equivalent regional tools: Special Tools	
1	Engine Flywheel Bolt [8x] Procedure 1. As necessary, rotate the front secondary mass component of the flywheel using EN-51701-1 aligner and a breaker bar to align the holes in the secondary mass with the flywheel bolts in the primary mass. 2. Remove and discard the engine flywheel bolts. 3. Install EN-51701-2 holder through the secondary mass into the primary mass to lock the flywheel in alignment. Special Tools EN-51701 Flywheel Aligner and Holder Equivalent regional tools: Special Tools
2	Engine Flywheel Procedure 1. Remove the flywheel. 2. If flywheel is suitable for re-installation, leave EN-51701 aligner and holder installed to flywheel for ease of install. 3. If flywheel is not suitable for re-installation, remove EN-51701 aligner and holder and discard the flywheel. 4. Remove EN-51760 holding tool from the starter mount. Special Tools • EN-51701 Flywheel Aligner and Holder • EN-51760 Flywheel Holding Tool Equivalent regional tools: Special Tools

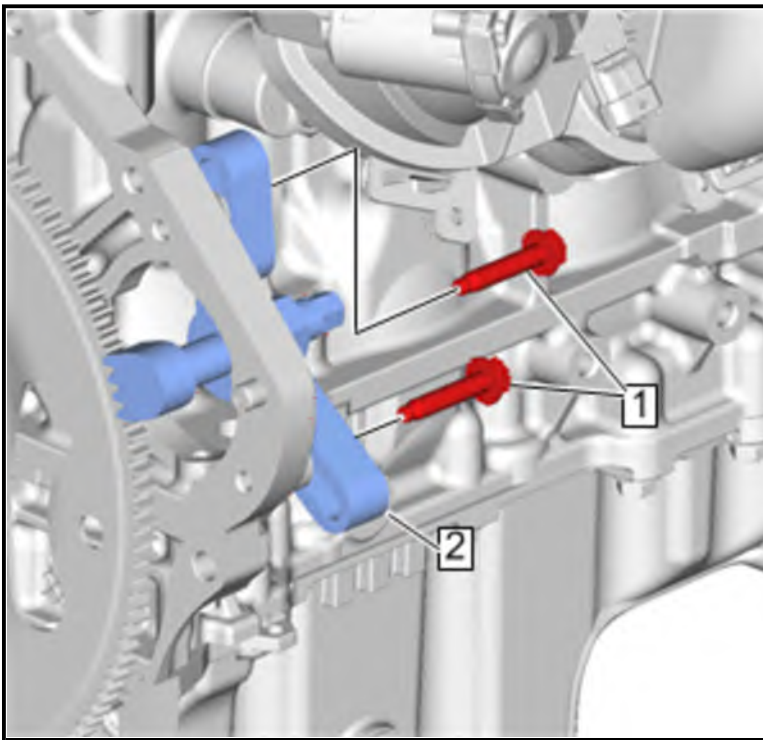
AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

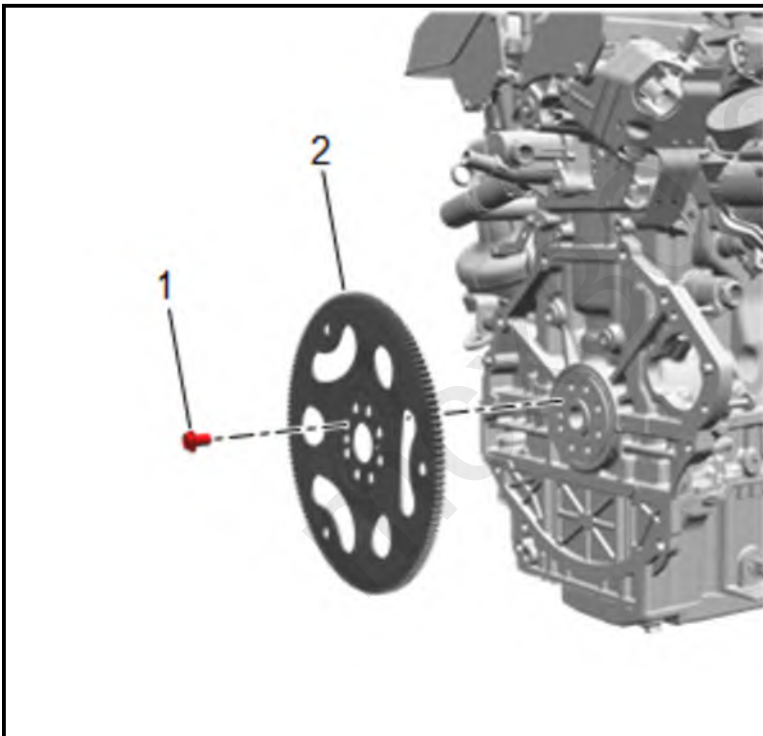
EN-51760 Flywheel Holding Tool

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

1. To prevent crankshaft rotation, install **EN-51760** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.



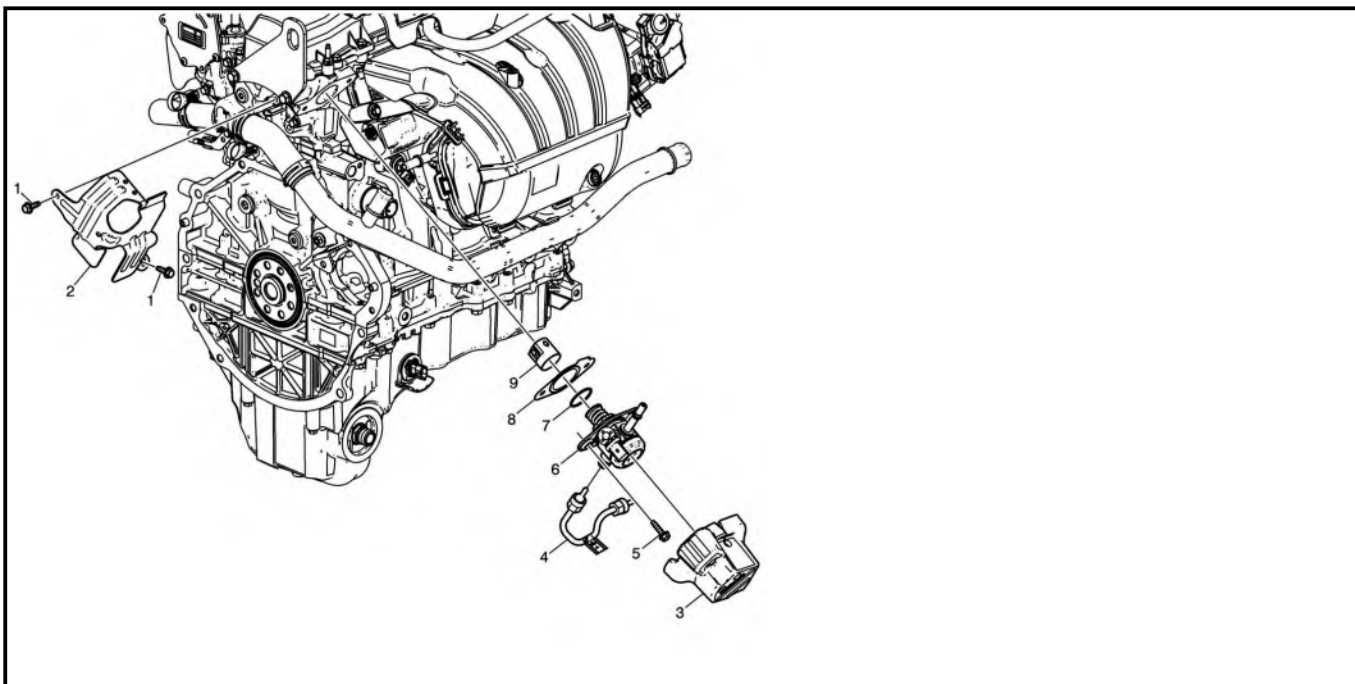
2. Remove and discard the flywheel attaching bolts (1).



3. Remove the flywheel (2).

4. Remove **EN 51760** holding tool.

FUEL INJECTION PUMP REMOVAL

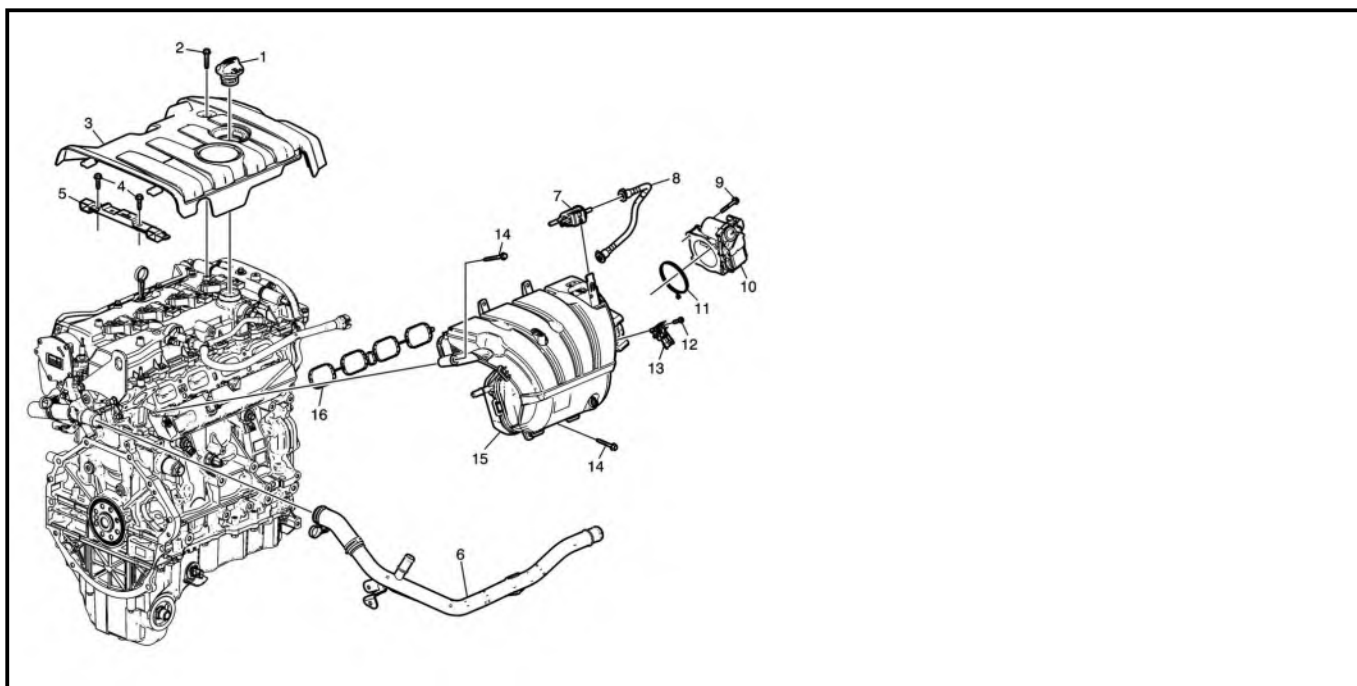


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Fuel Pump Cover Bolt (Qty: 3)
2	Fuel Pump Cover
3	Fuel Pump Insulator WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

Callout	Component Name
4	Fuel Feed Intermediate Pipe NOTE: Discard the pipe.
5	Fuel Pump Bolt (Qty: 2) CAUTION: Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage NOTE: Discard the bolts.
6	Fuel Pump
7	Fuel Pump O-Ring NOTE: Discard the O-ring.
8	Fuel Pump Gasket NOTE: Discard the gasket.
9	Valve Lifter Follower

INTAKE MANIFOLD REMOVAL

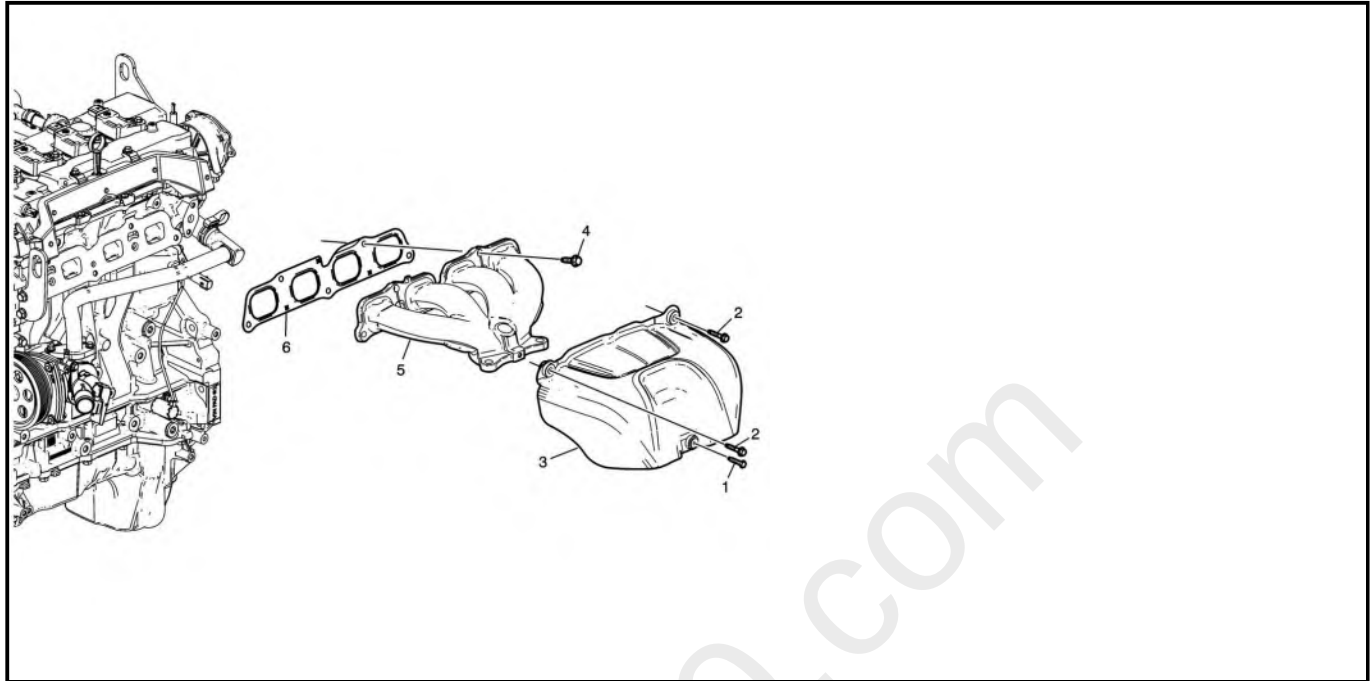


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Fill Cap
2	Intake Manifold Cover Bolt
3	Intake Manifold Cover
4	Upper Intake Manifold Bracket Bolt (Qty: 2)
5	Upper Intake Manifold Bracket
6	Radiator Inlet Pipe And Hose Assembly Procedure: Disconnect the radiator inlet hose from the water outlet assembly.
7	Evaporative Emission Canister Purge Valve
8	Evaporative Emission Canister Purge Valve Pipe Assembly
9	Throttle Body Bolt (Qty: 4)
10	Throttle Body
11	Throttle Body Gasket NOTE: Discard the gasket.
12	Manifold Absolute Pressure (MAP) Sensor Bolt
13	MAP Sensor
14	Intake Manifold Bolt (Qty: 6)
15	Intake Manifold NOTE: If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

Callout	Component Name
16	Intake Manifold Gasket NOTE: Discard the gasket.

EXHAUST MANIFOLD REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Exhaust Manifold Heat Shield Bolt (Qty: 1)
2	Exhaust Manifold Heat Shield Bolt (Qty: 2)
3	Exhaust Manifold Heat Shield
4	Exhaust Manifold Bolt (Qty: 5) NOTE: Discard the bolts.
5	Exhaust Manifold NOTE: Clean all of the sealing surfaces. If the exhaust manifold is being replaced, transfer the exhaust manifold heat shield.
6	Exhaust Manifold Gasket

Callout	Component Name
	NOTE: Discard the gasket.

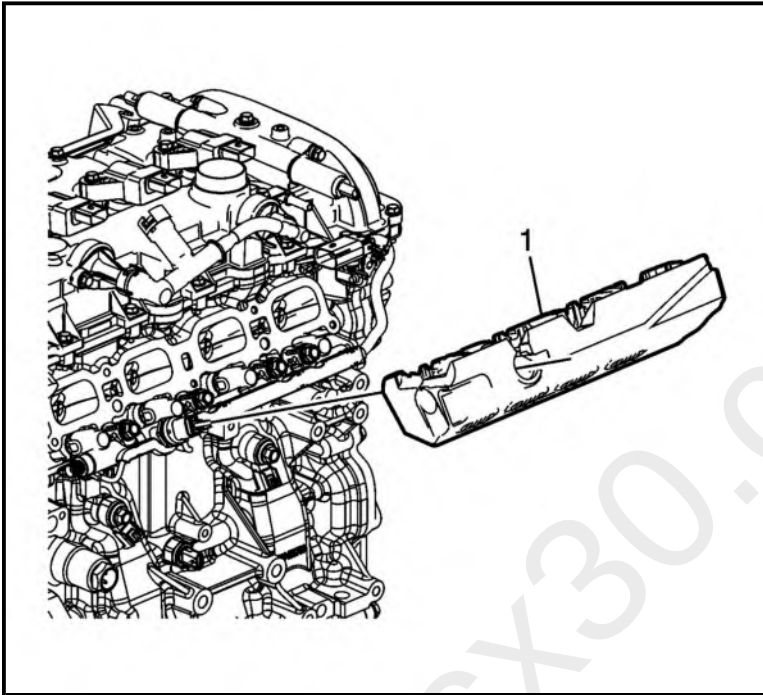
FUEL RAIL AND INJECTORS REMOVAL

Special Tools

EN-49248 Fuel Rail Assembly Remover

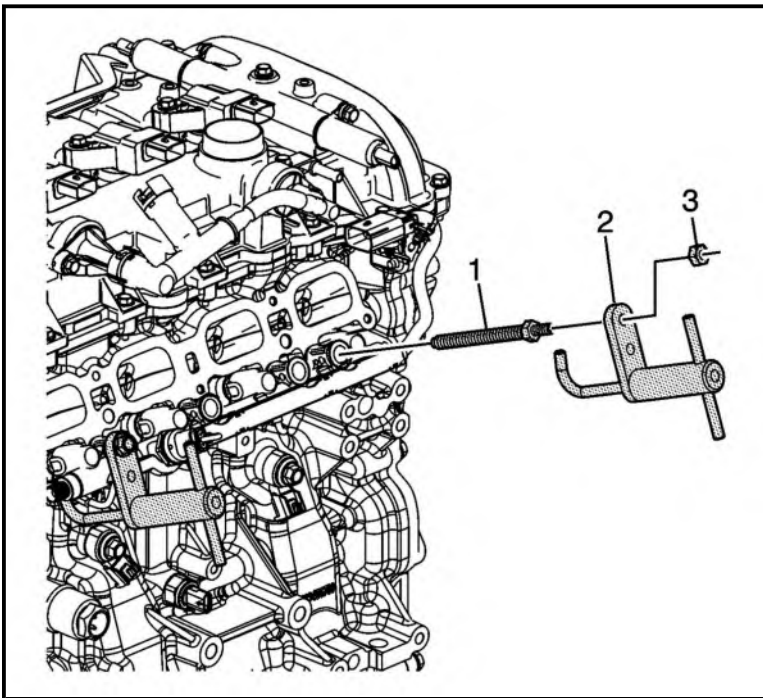
For equivalent regional tools, refer to [Special Tools](#)

1. Remove the fuel injection fuel rail noise shield (1).



WARNING: The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

2. Disconnect the electrical harness from the fuel rail harness connection.



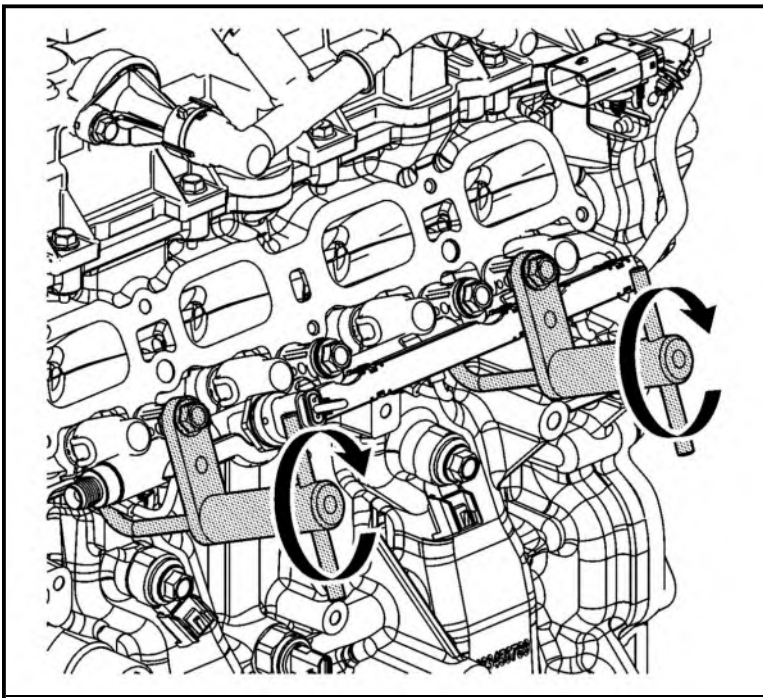
NOTE: Fuel rail bolts are captured in the fuel rail assembly

- Ensure the bolt is completely loosened, and the threads are no longer engaged.
- Use a suitable tool to apply enough force to pull the bolt straight out of the fuel rail.

3. Remove the fuel rail assembly retaining bolts.

NOTE: Use care to avoid contact with the fuel rail harness during special tool installation and fuel rail removal.

4. Install **EN-49248** studs (1) into the 2 outermost fuel rail assembly retaining bolt locations. Tighten the studs to 22 N.m (16 lb ft).
5. Install **EN-49248** remover (2) onto each stud, and engage the hooks to the fuel rail. Install the nuts (3) retaining the remover onto the studs and tighten until snug.
6.
 - Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
 - Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.



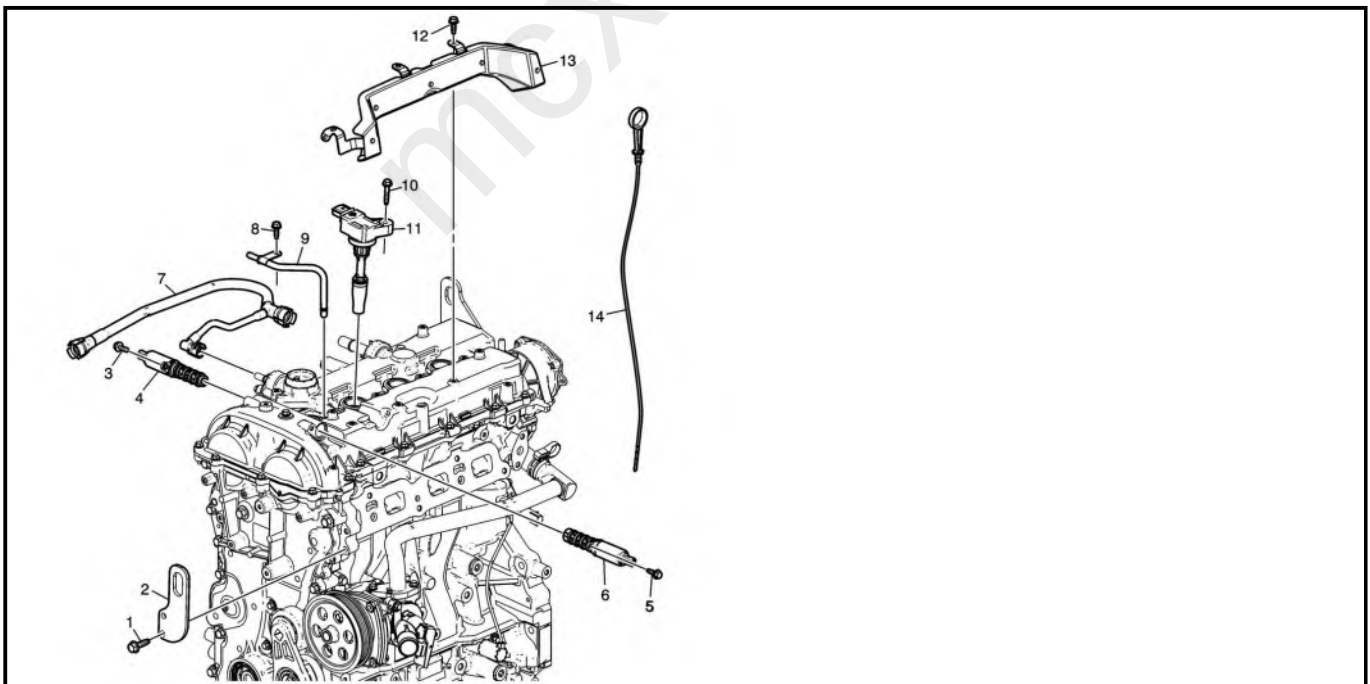
NOTE: EN-49248 will assist in the proper removal of the fuel rail assembly. Ensure that the following conditions are met:

- Turn the handles simultaneously in order to pull the fuel rail straight out along the fuel injector axis.
- DO NOT twist when pulling out on the fuel rail and injector assembly.

Using EN-49248 remover, remove the fuel rail assembly.

CAMSHAFT COVER REMOVAL

Camshaft Cover Components Removal



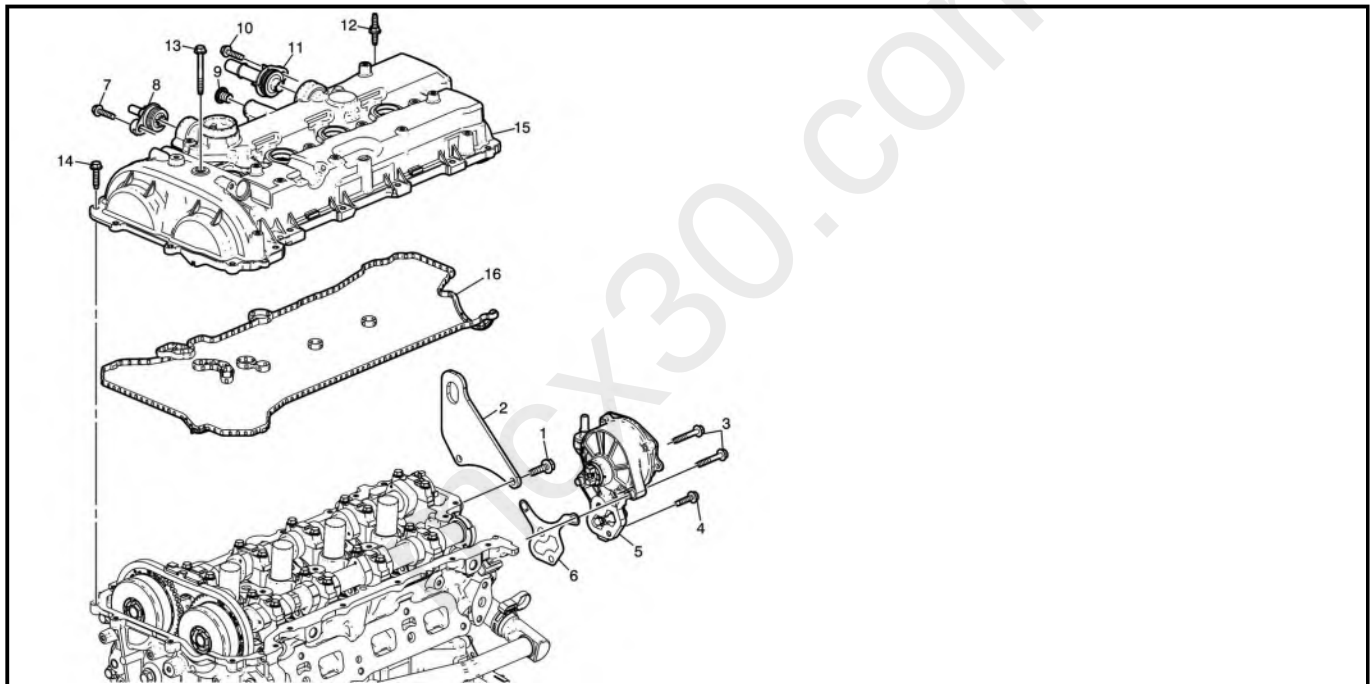
NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover Components Removal

Callout	Component Name
1	Front Lift Bracket Bolt (Qty: 2)

Callout	Component Name
2	Front Lift Bracket
3	Camshaft Position Actuator Control Solenoid Valve Bolt
4	Intake Camshaft Position Actuator Control Solenoid Valve
5	Camshaft Position Actuator Control Solenoid Valve Bolt
6	Exhaust Camshaft Position Actuator Control Solenoid Valve
7	PCV Hose Assembly Procedure: Disconnect the PCV hose at the quick-connect fittings.
8	Engine Coolant Air Bleed Pipe Bolt
9	Engine Coolant Air Bleed Pipe Procedure: Inspect and replace the O-ring if necessary.
10	Ignition Coil Bolt (Qty: 4)
11	Ignition Coil (Qty: 4)
12	Camshaft Cover Heat Shield Bolt (Qty: 4)
13	Camshaft Cover Heat Shield
14	Oil Level Indicator

Camshaft Cover and Components Removal



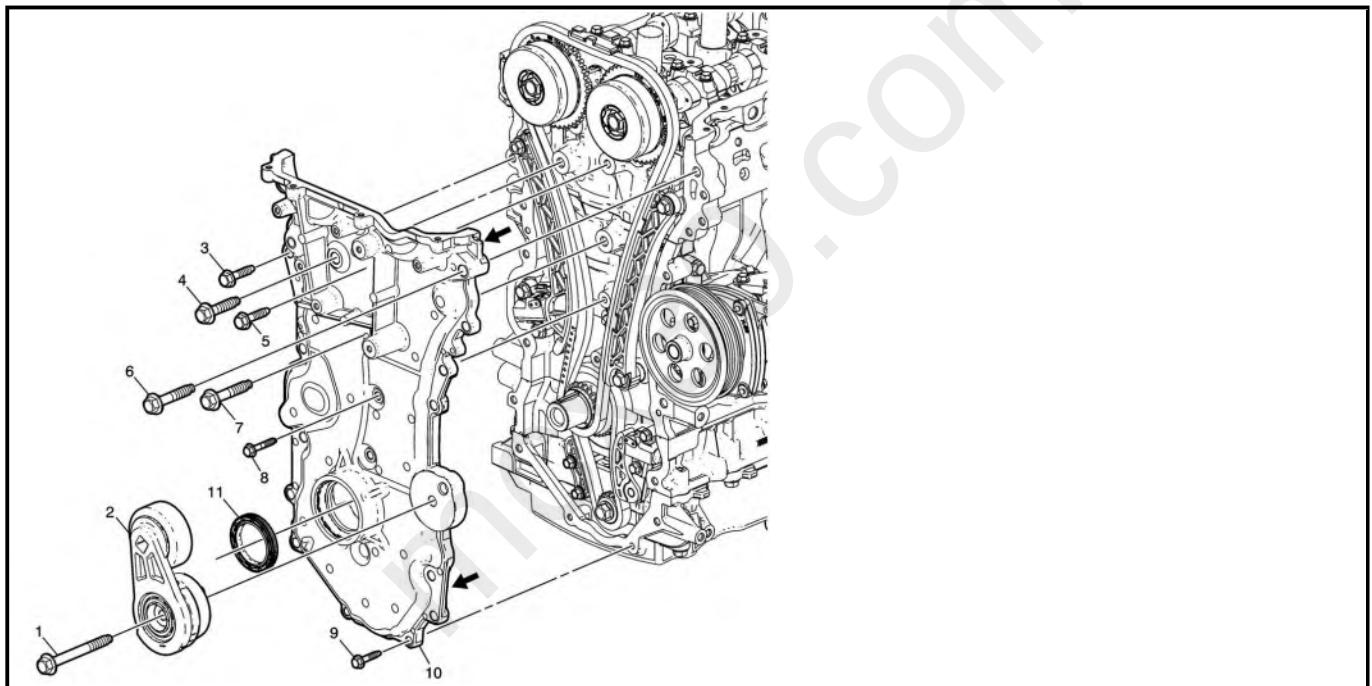
NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover and Components Removal

Callout	Component Name
1	Rear Lift Bracket Bolt (Qty: 2)
2	Rear Lift Bracket
3	Vacuum Pump Assembly Bolt (Qty: 2)
4	Vacuum Pump Assembly Bolt (Qty: 1)
5	Vacuum Pump Assembly
6	Vacuum Pump Assembly Gasket
7	PCV Valve Bolt
8	PCV Valve
9	Camshaft Cover Plug
10	PCV Valve Bolt

Callout	Component Name
11	PCV Valve
12	Camshaft Cover Stud (Qty: 1)
13	Camshaft Cover Bolt (Qty: 4)
14	Camshaft Cover Bolt (Qty: 19)
15	Camshaft Cover
16	Camshaft Cover Gasket NOTE: Ensure all camshaft cover gaskets, including the inner gaskets, are removed and discarded.

ENGINE FRONT COVER REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Drive Belt Tensioner Bolt
2	Drive Belt Tensioner
3	Engine Front Cover Bolt (Qty: 12)
4	Engine Front Cover Bolt NOTE: Discard the bolt.
5	Engine Front Cover Bolt
6	Engine Front Cover Bolt NOTE:

Callout	Component Name
	Discard the bolt.
7	Engine Front Cover Bolt NOTE: Discard the bolt.
8	Engine Front Cover Bolt (Qty: 2)
9	Engine Front Cover Bolt (Qty: 2)
10	Engine Front Cover Procedure 1. Locate pry points to aid in loosening the cover. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 3. Clean and Inspect the engine front cover mating surface.
11	Crankshaft Front Oil Seal Procedure Remove the seal with an appropriate tool.

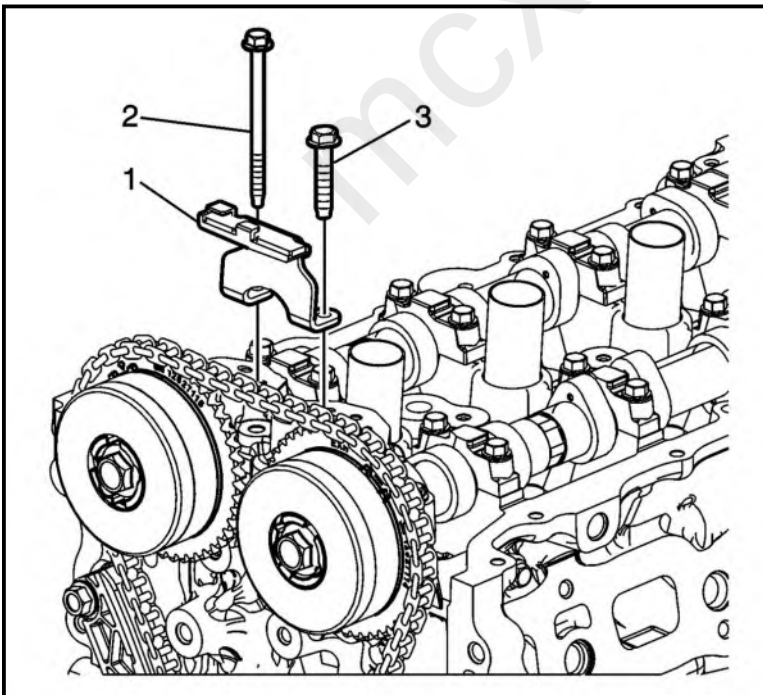
CAMSHAFT TIMING CHAIN AND TENSIONER REMOVAL

Special Tools

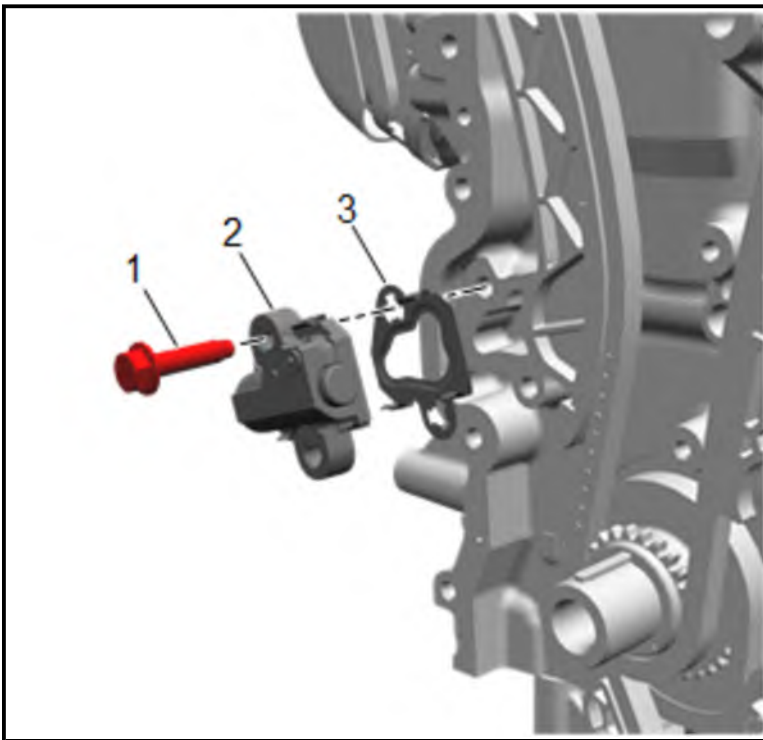
EN 50837 Timing Chain Tensioner Retraction Tool

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

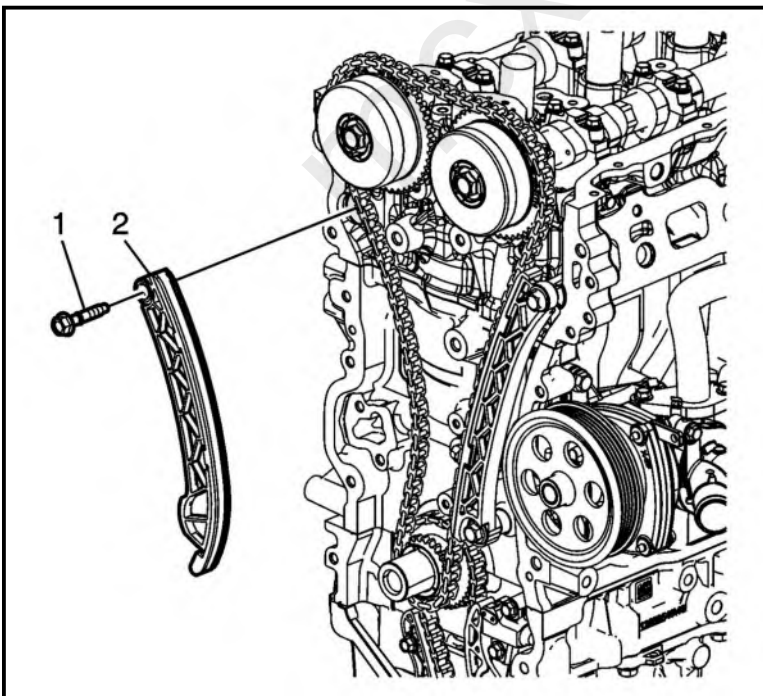
1. Remove the upper timing chain guide bolts (2, 3).



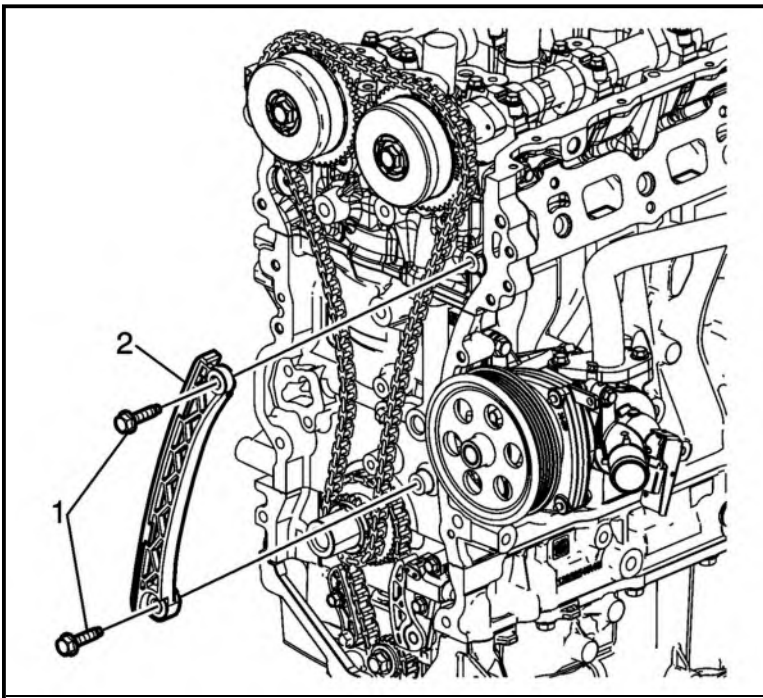
2. Remove the upper timing chain guide (1).
3. Remove the timing chain tensioner bolts (1) and timing chain tensioner (2).



4. Remove the timing chain tensioner gasket (3) and discard.
5. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.
6. Remove the timing chain tensioner pivot arm bolt (1).

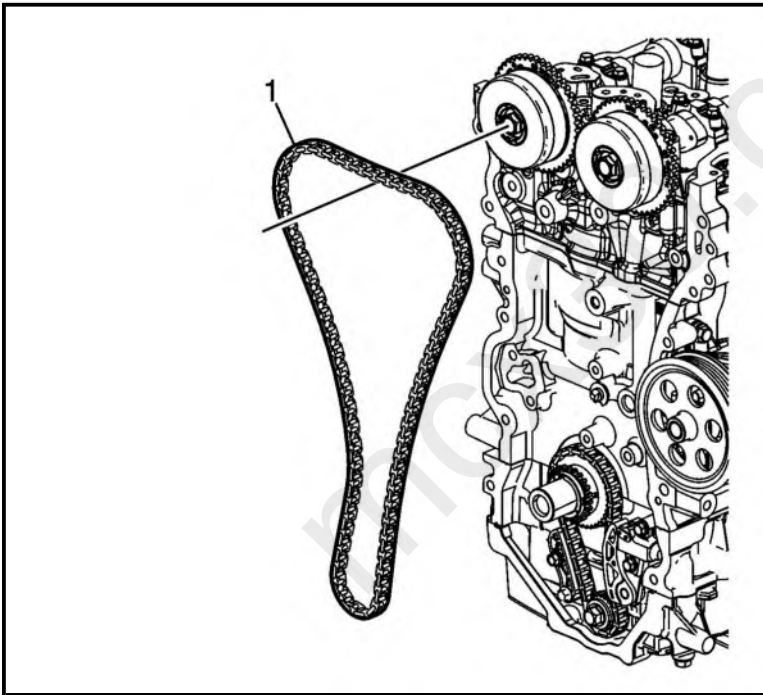


7. Remove the timing chain tensioner pivot arm (2).
8. Remove the timing chain guide bolts (1).

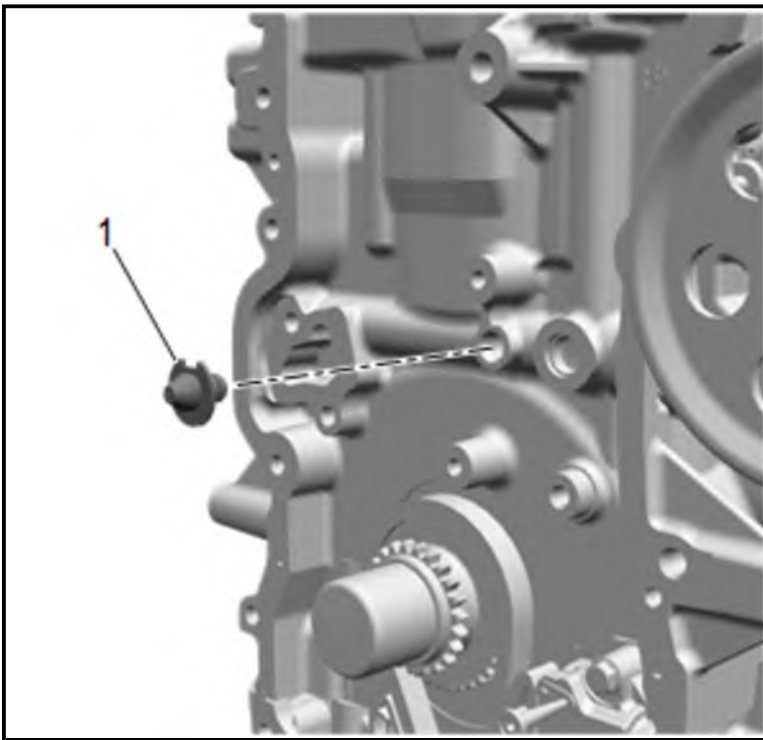


9. Remove the timing chain guide (2).

10. Remove the timing chain (1).

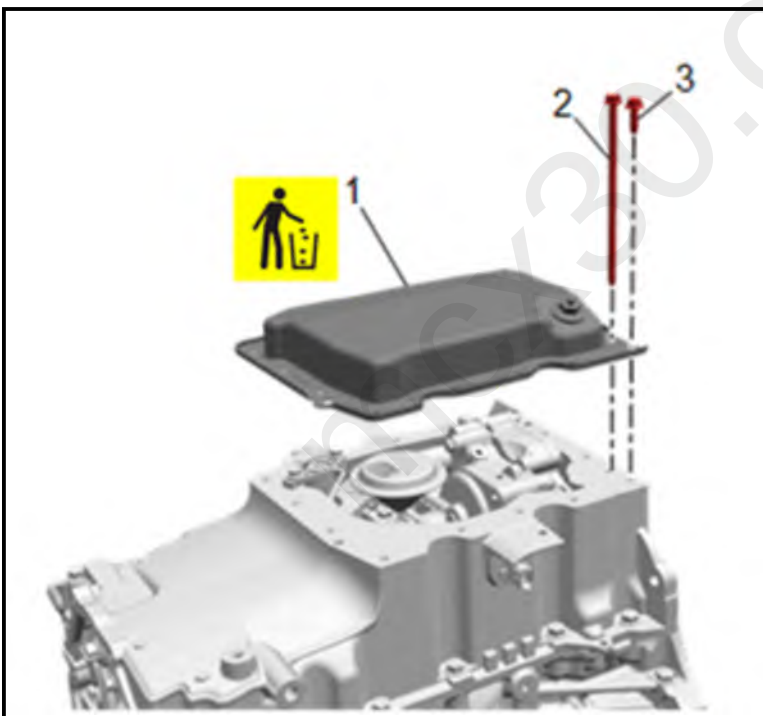


11. Remove the timing chain oil nozzle (1).



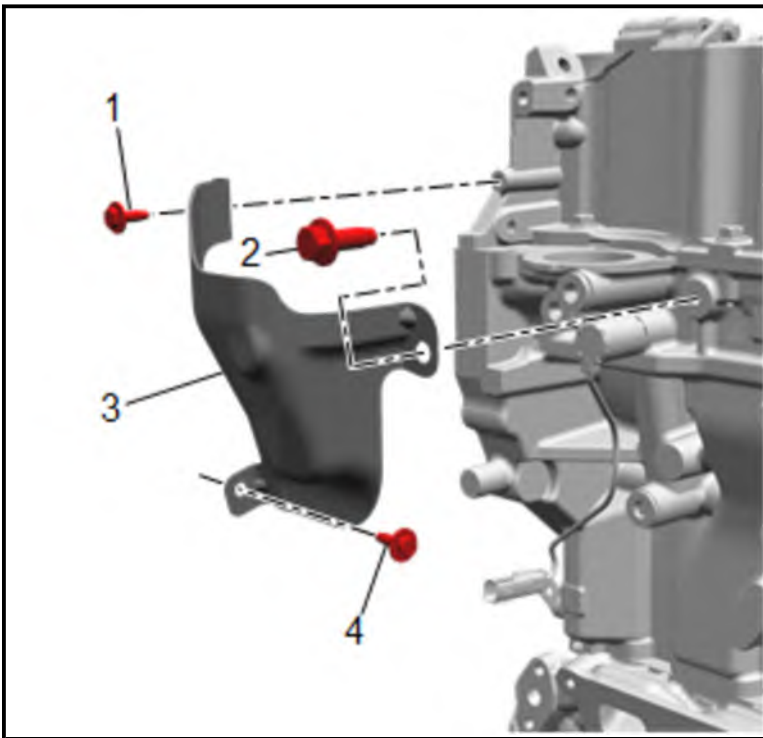
OIL PAN REMOVAL (2WD)

1. Remove the lower oil pan bolts (3) and two oil pan to lower crankcase bolts (2).

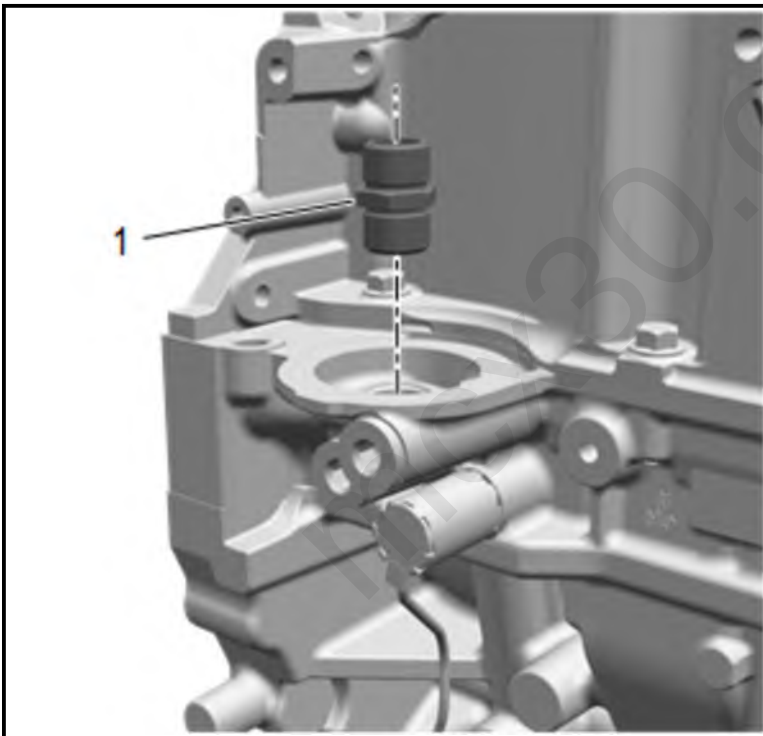


CAUTION: Always replace the used oil pan with a new oil pan. The lower oil pan becomes damaged during removal and oil leaks may occur if it is not replaced with a new oil pan.

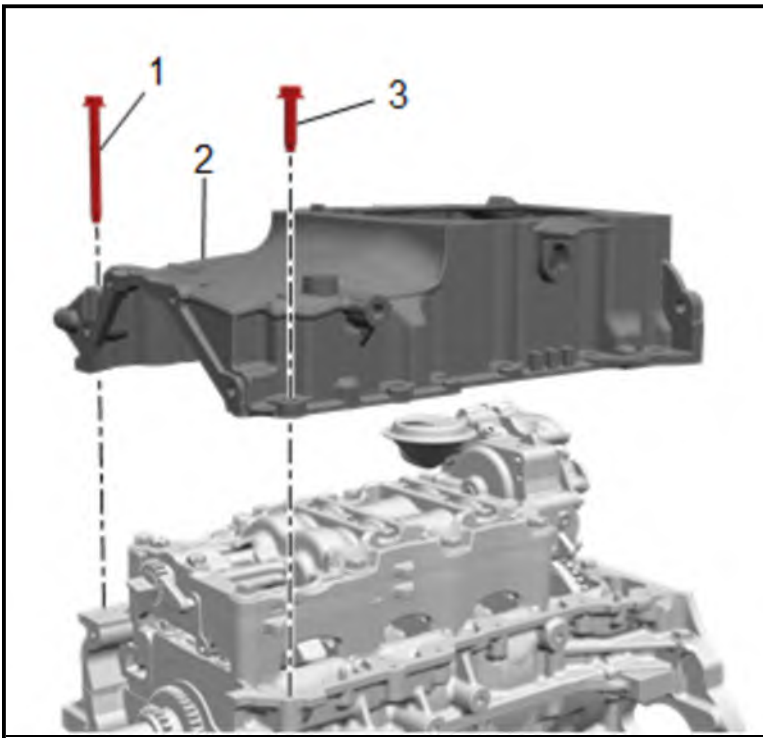
2. Lower Oil Pan (1) - Remove and DISCARD
3. Remove the oil pump flow control valve cover (3) and bolts (1, 2, 4).



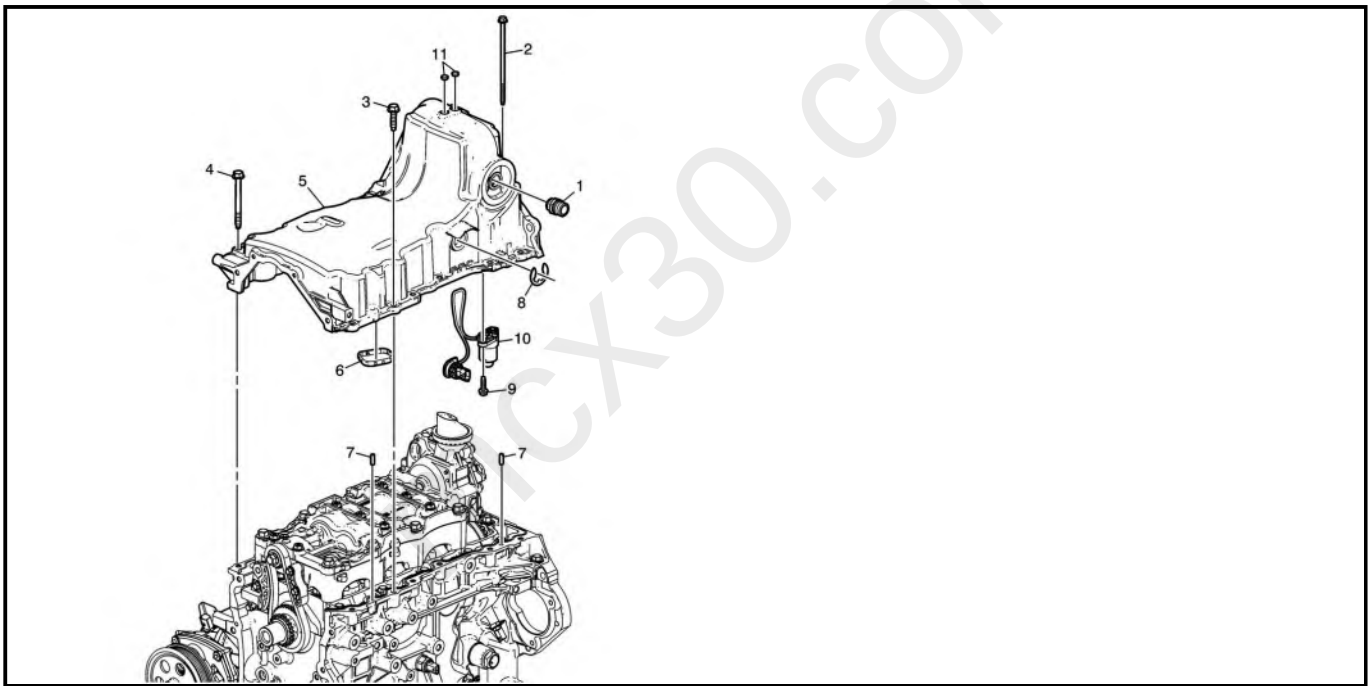
4. Remove the oil filter adapter (1).



5. Remove the upper oil pan (2) and bolts (1, 3).



OIL PAN REMOVAL (4WD)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Filter Fitting
2	Oil Pan Bolt (Qty: 2)
3	Oil Pan Bolt (Qty: 11)
4	Oil Pan Bolt (Qty: 1)
5	Oil Pan
6	Oil Pan Gasket
	NOTE: Discard the gasket.

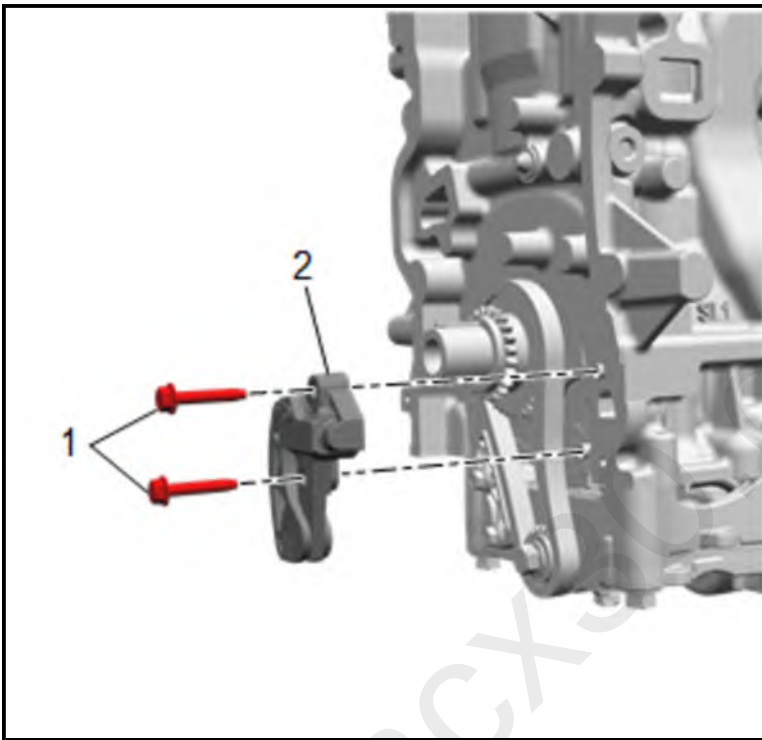
Callout	Component Name
7	Oil Pan Locating Pin (Qty: 2)
8	Engine Oil Level Sensor Lead Clip
9	Engine Oil Level Indicator Switch Bolt (Qty: 2)
10	Engine Oil Level Indicator Switch
11	Oil Gallery Plug (Qty: 2)

BALANCER CHAIN, SPROCKET, AND TENSIONER REMOVAL

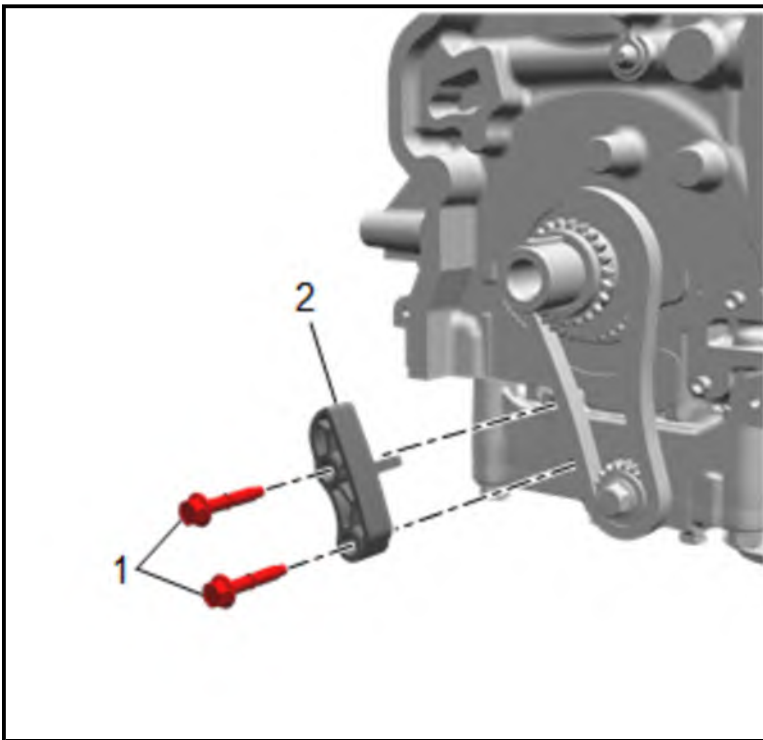
Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

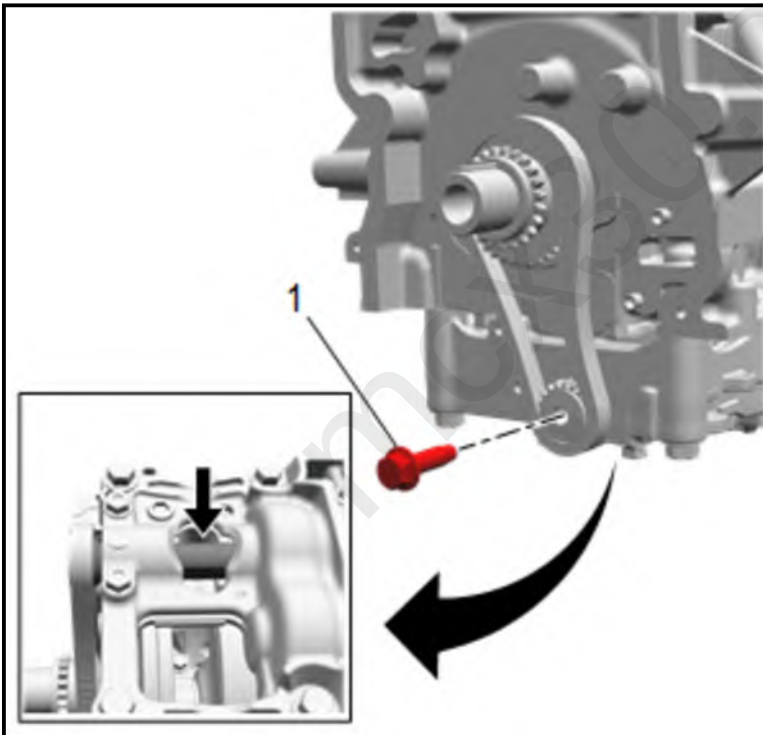
1. Remove the balancer chain tensioner bolt (1).



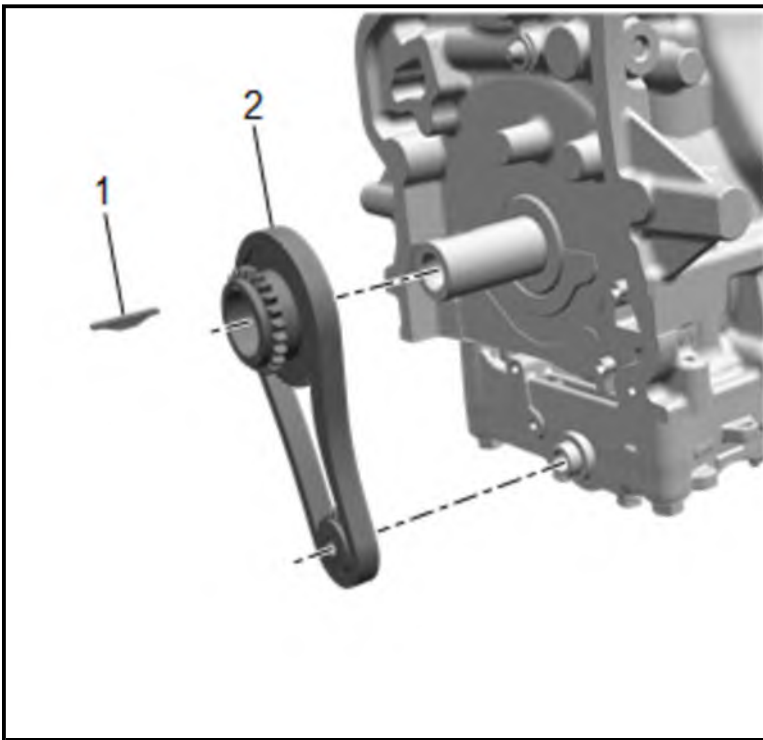
2. Remove the balancer chain tensioner (2).
3. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a clockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever counterclockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.
4. Remove the balancer chain guide bolt (1).



5. Remove the balancer chain guide (2).
6. Use an open end wrench over flat on balance shaft while loosening balancer shaft sprocket bolt. Remove and discard the balancer shaft driven sprocket bolt (1).



7. Remove the crankshaft key (1).

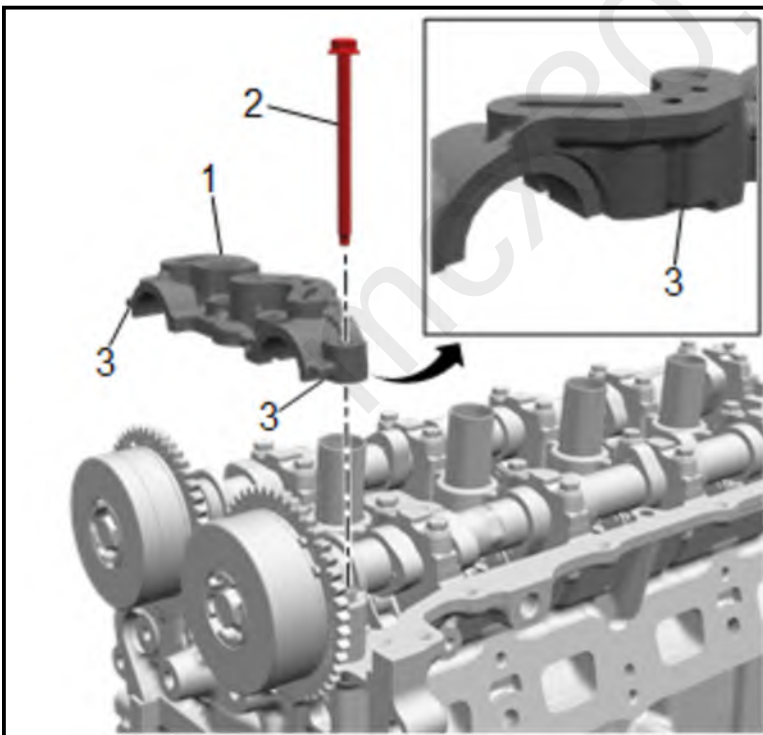


8. Remove the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain (2) simultaneously.

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

Intake Camshaft and Components Removal

1. Remove the camshaft front bearing cap bolts (2).

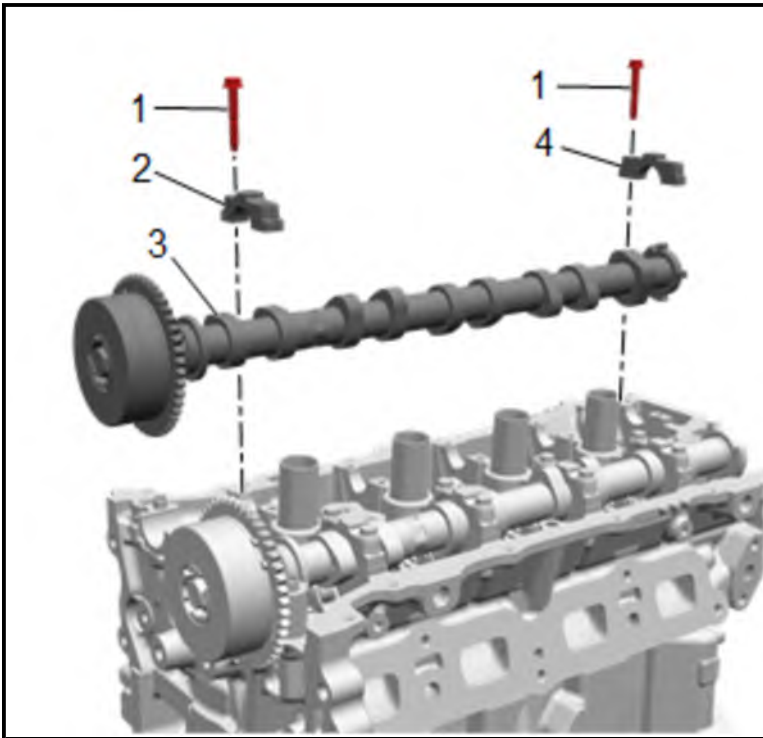


NOTE:

- Locate the pry points (3) on the camshaft front bearing cap.
- When using the pry points to remove the front bearing cap, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.
- Use 2 pry tools simultaneously to pry the upper front bearing cap away from the lower bearing cap evenly.

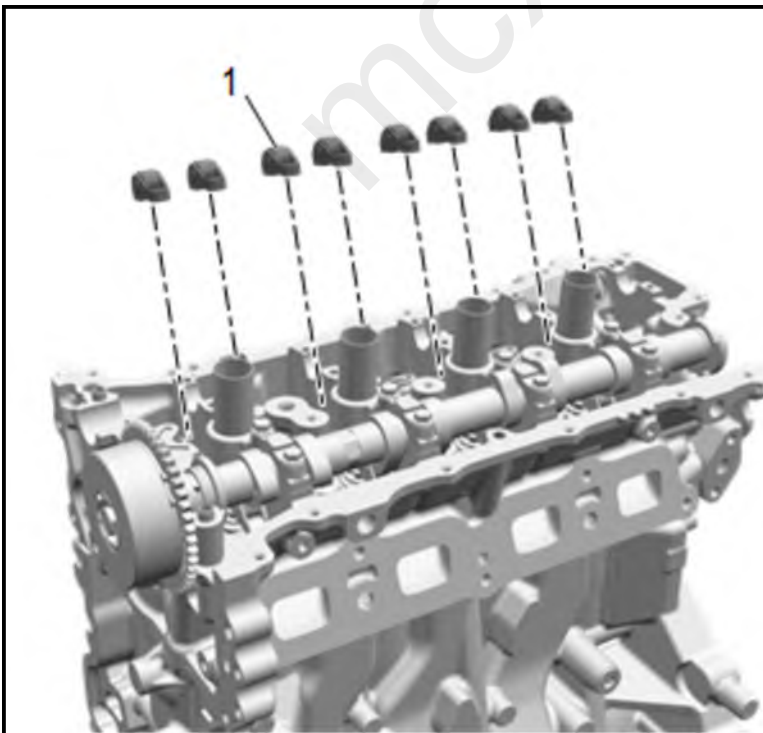
2. Using suitable pry tools, remove the camshaft front bearing cap (1)

3. Mark the intake camshaft rear cap to ensure it is installed in the same position. Remove the intake camshaft bearing rear cap bolts (1) and cap (4).



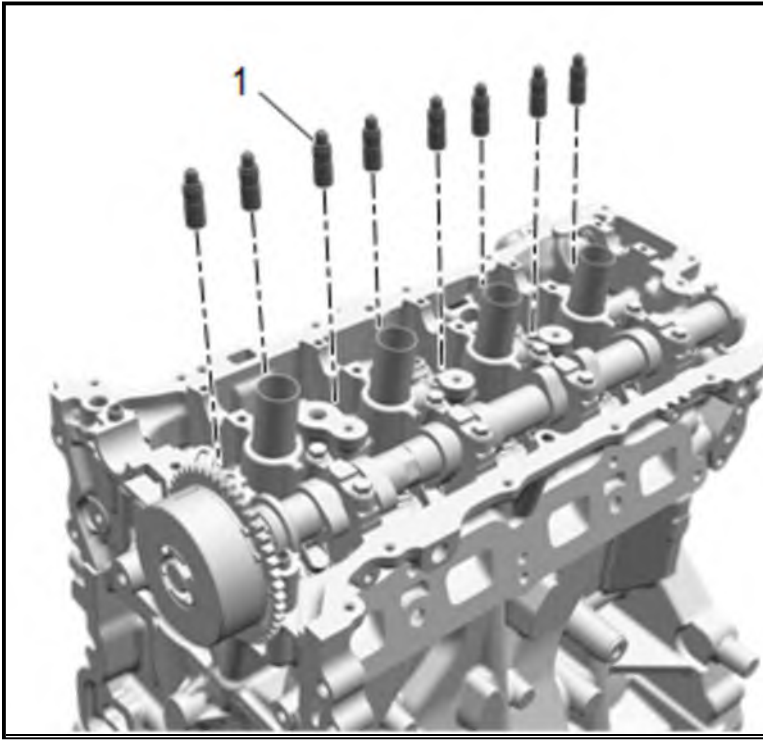
NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

4. Mark the camshaft caps (2) to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts (1).
6. Remove the camshaft caps (2).
7. Remove the intake camshaft (3).
8. Remove the intake camshaft roller finger followers (1).



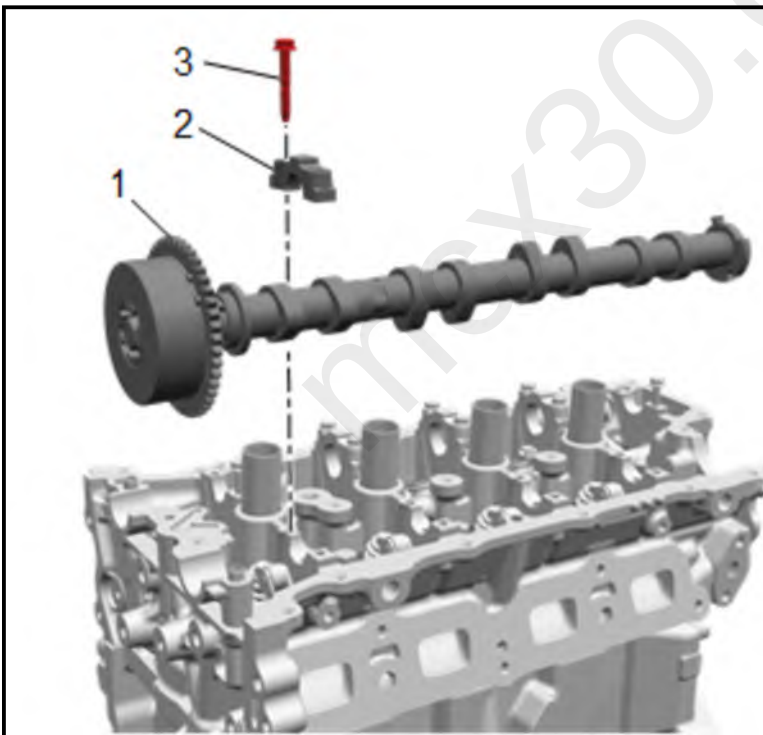
NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

9. Remove the hydraulic lash adjusters (1).



Exhaust Camshaft and Components Removal

1. Mark camshaft caps (2) to ensure they are installed in the same position.



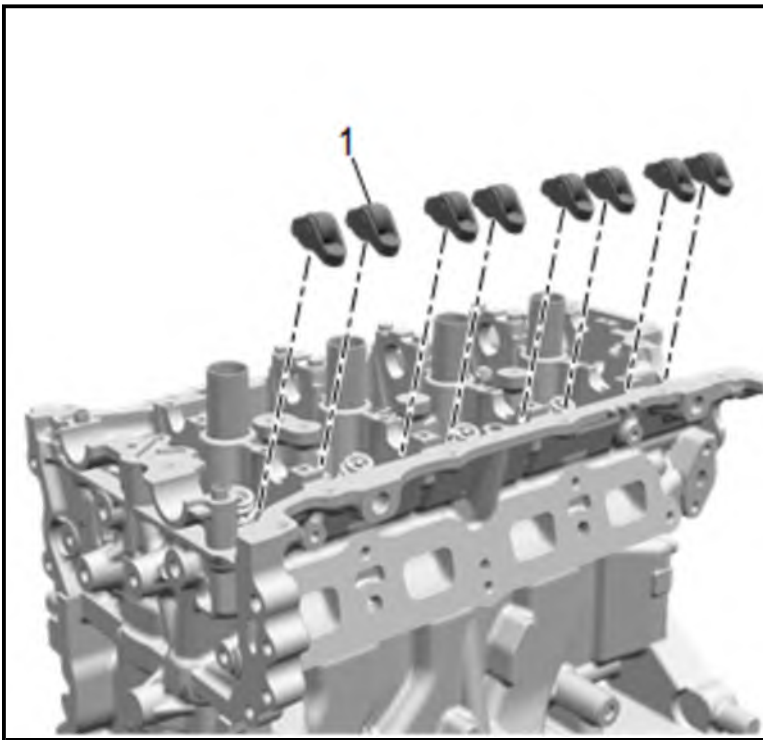
NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Remove the exhaust camshaft cap bolts (3).

3. Remove the camshaft caps (2) ensuring they are marked and refitted in same position on assembly.

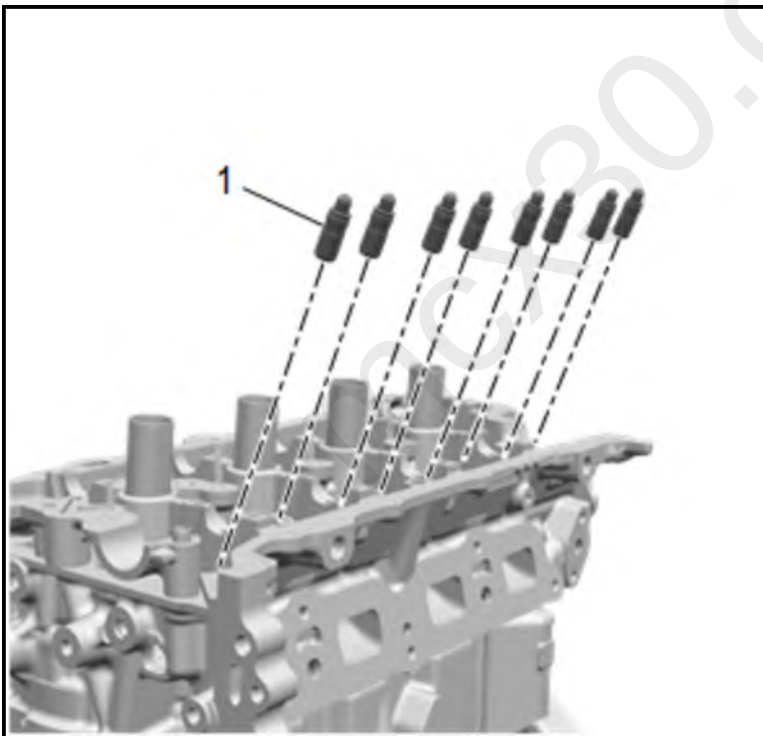
4. Remove the exhaust camshaft (1).

5. Remove the exhaust camshaft roller finger followers (1).

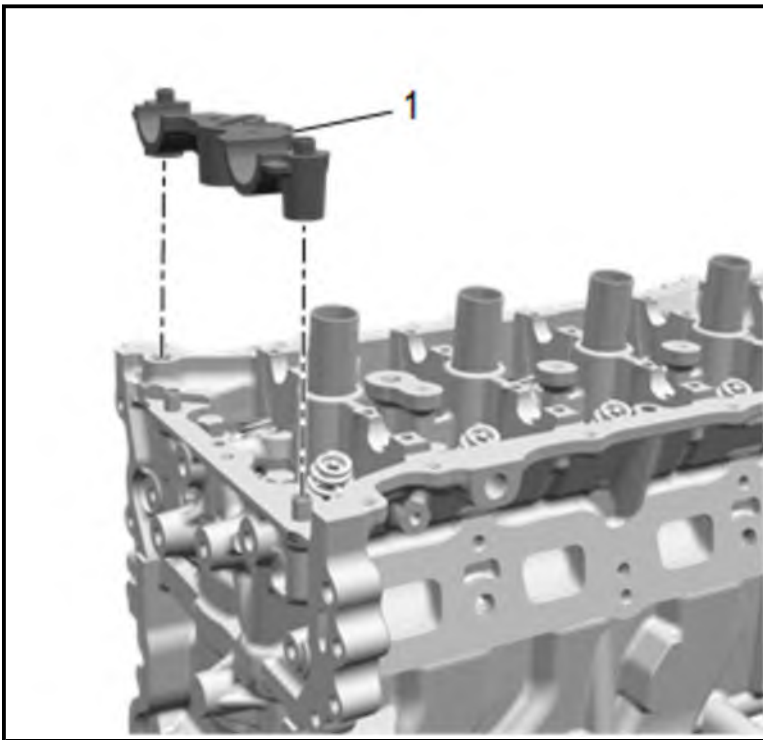


NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the hydraulic lash adjusters (1).

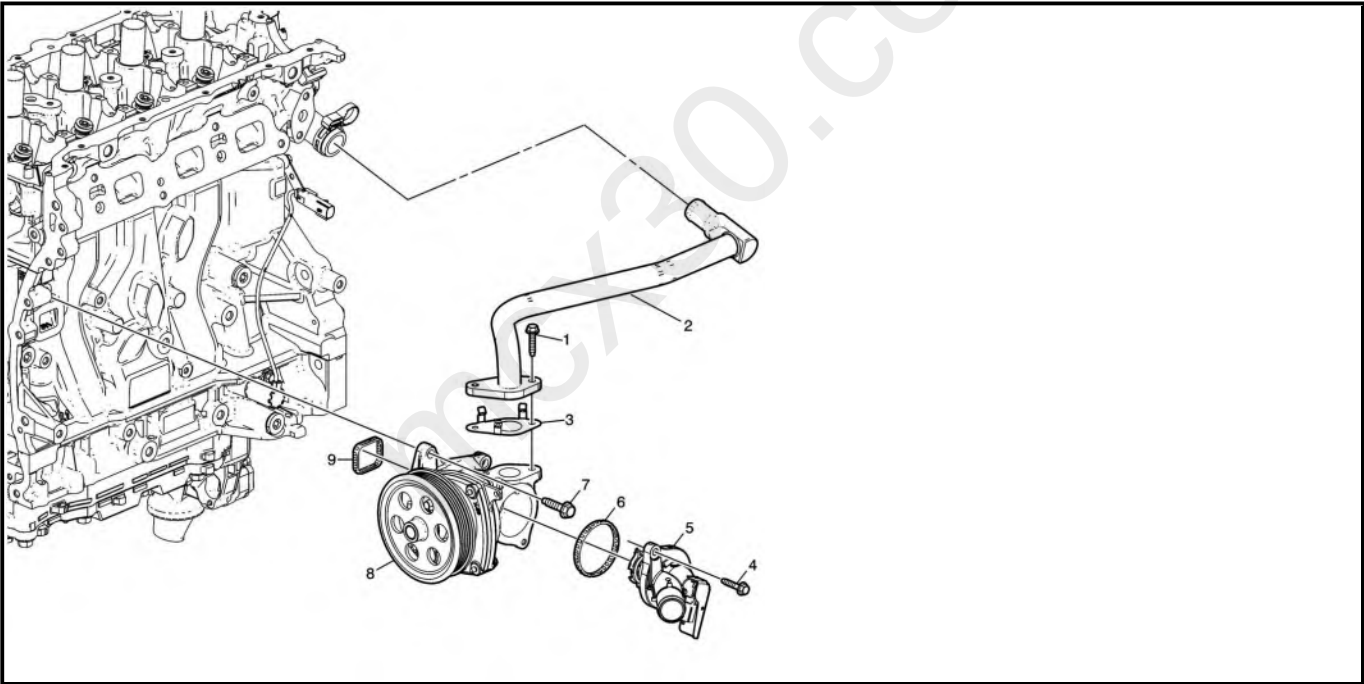


7. Remove the camshaft bearing lower front cap (1).



WATER PUMP REMOVAL

Thermal Bypass Pipe and Water Pump Removal



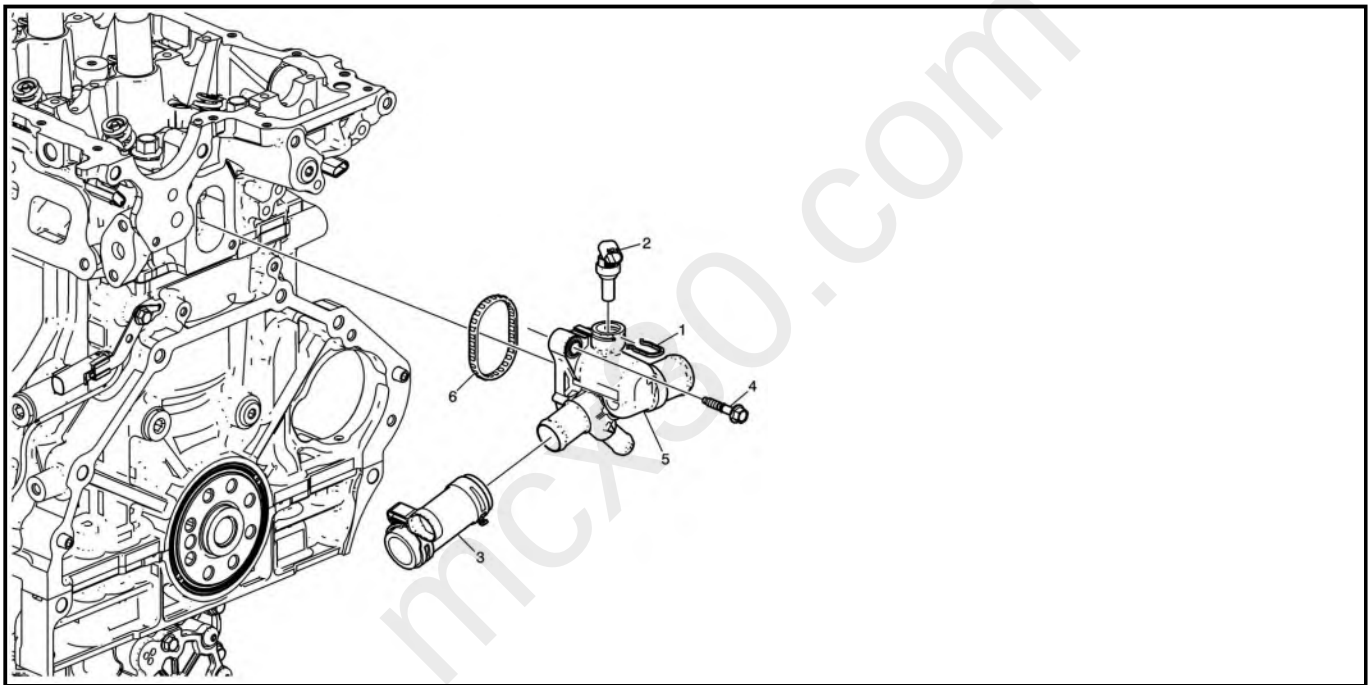
NOTE: Callouts in the following chart represent components shown in graphic above.

Thermal Bypass Pipe and Water Pump Removal

Callout	Component Name
1	Thermal Bypass Pipe Bolt (Qty: 2)
2	Thermal Bypass Pipe
3	Thermal Bypass Pipe Gasket
	Procedure: Disconnect the pipe from the water outlet assembly.
	NOTE: Discard the

Callout	Component Name
	gasket.
4	Thermostat Assembly Bolt (Qty: 2)
5	Thermostat Assembly
6	Thermostat Assembly Gasket NOTE: Discard the gasket.
7	Water Pump Bolts (Qty: 3)
8	Water Pump
9	Water Pump Gasket NOTE: Discard the gasket.

Water Outlet Removal



NOTE: Callouts in the following chart represent components shown in graphic above.

Water Outlet Removal

Callout	Component Name
1	Engine Coolant Temperature Sensor Retainer
2	Engine Coolant Temperature Sensor
3	Thermal Bypass Hose
4	Water Outlet Bolt (Qty: 2)
5	Water Outlet
6	Water Outlet Gasket NOTE: Discard the gasket.

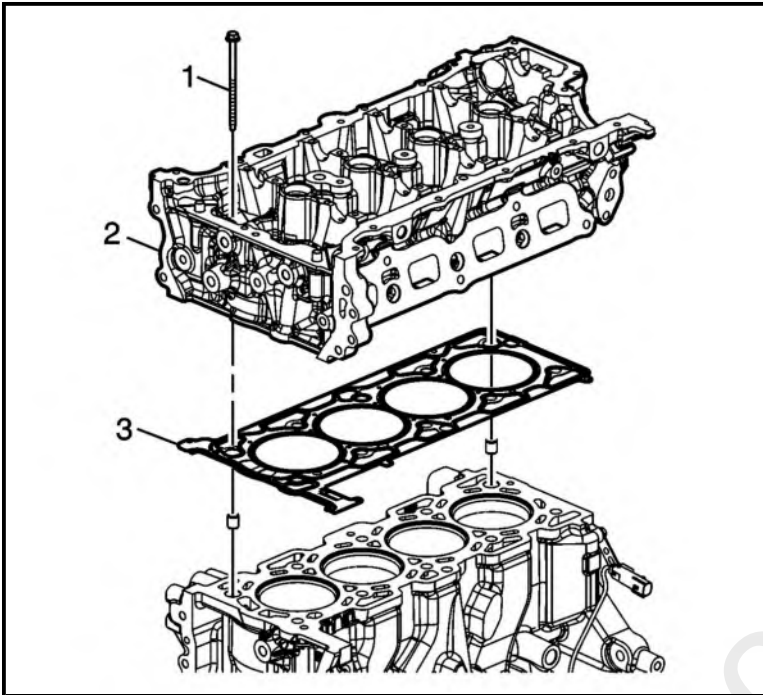
CYLINDER HEAD REMOVAL

Special Tools

EN 38188 Cylinder Head Broken Bolt Extractor Kit - or equivalent aftermarket tool

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

1. Remove and discard the cylinder head bolts (1).



CAUTION: In order to prevent damage to the valves and injectors during cylinder head removal, set the cylinder head on blocks.

2. Remove the cylinder head (2).
3. Remove the cylinder head gasket (3).
4. Inspect the cylinder head locating pins. Remove the locating pins and discard, if necessary.
5. Clean all of the gasket surfaces.
6. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:
 - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

NOTE: Do not use any other method or technique to clean these gasket surfaces.

- Use a new razor blade for each cylinder head and cylinder block.

NOTE: Be careful not to gouge or scratch the gasket surfaces. Do not gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the new gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

NOTE: Do not use a tap to clean the cylinder head bolt holes.

7. Clean the old sealer/lube and dirt from the bolt holes.
8. Clean the bolt holes with a nylon bristle brush.

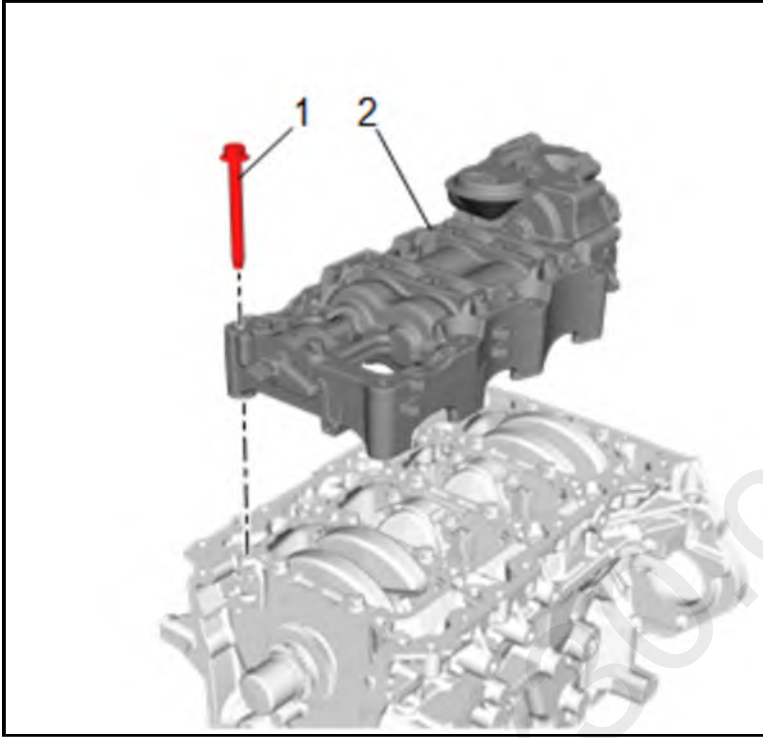
WARNING:

Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.

9. When cleaning the cylinder head bolt holes use a suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun to reach the bottom of the holes.
10. Remove any broken long cylinder head bolts using the **EN 38188** kit.

BALANCER SHAFT WITH OIL PUMP REMOVAL

1. Remove the 8 balancer and oil pump shaft assembly bolts (1) along the perimeter of the assembly.

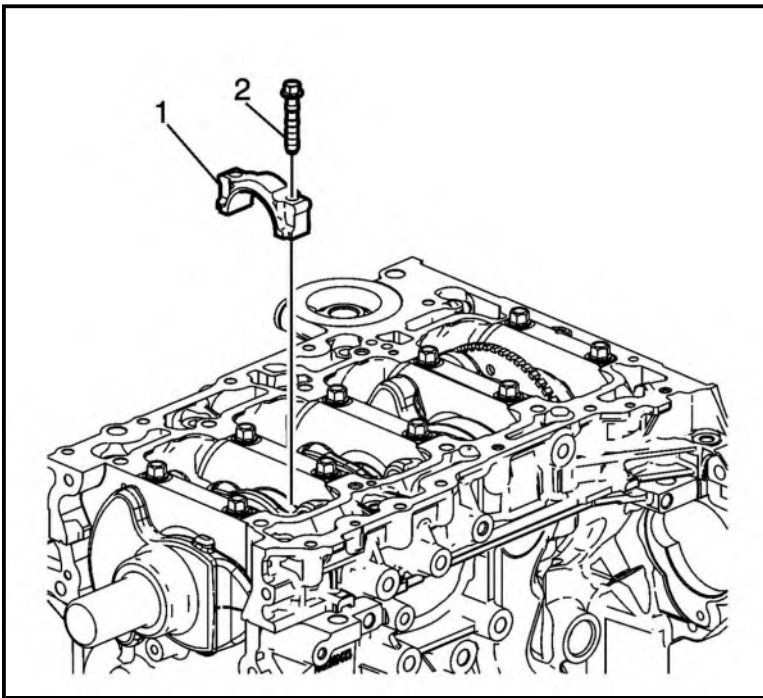
**NOTE:**

DO NOT remove or loosen the balancer assembly bolts that join the two halves of the assembly together. Identify the bolts that retain the balancer assembly to the lower crankcase and ensure only these bolts are removed.

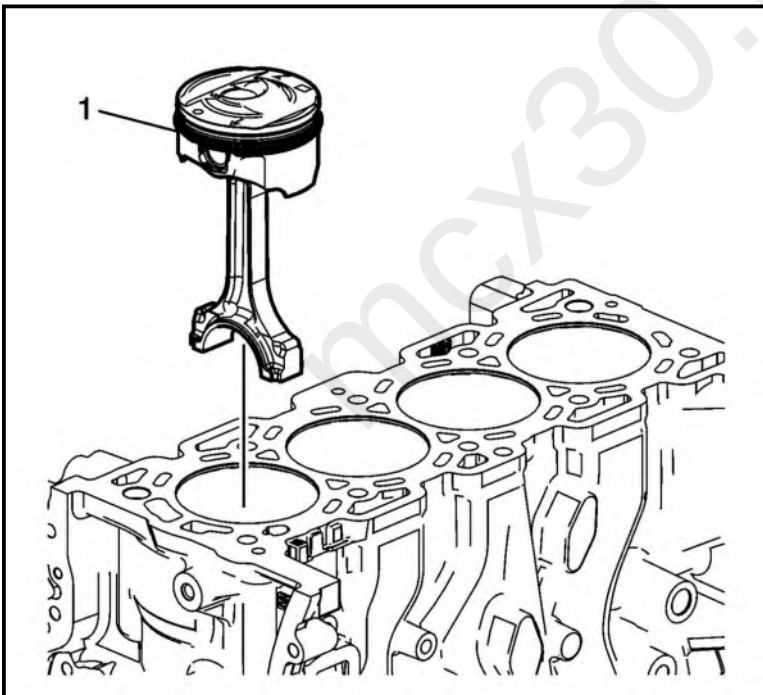
2. Remove the balancer and oil pump shaft assembly (2).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.

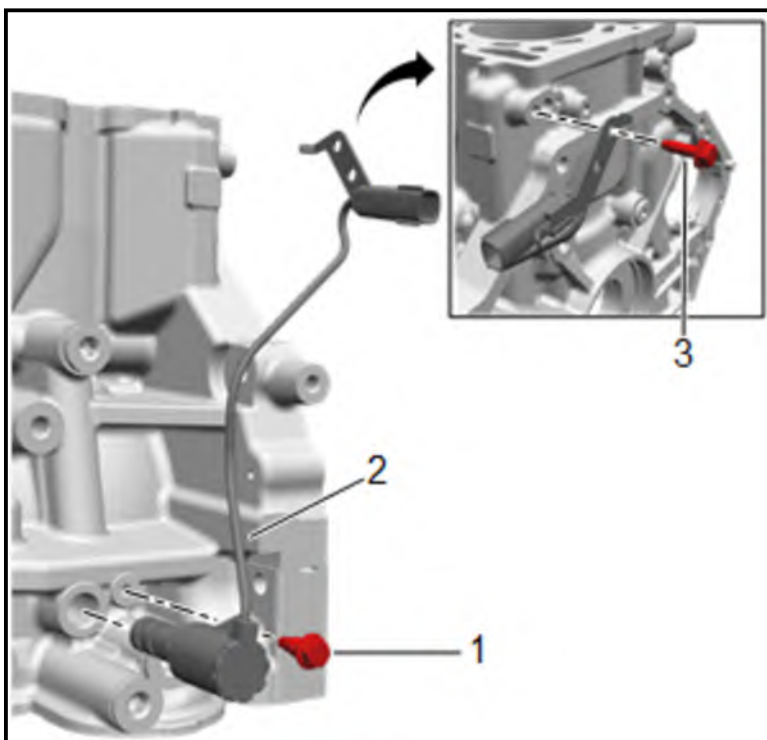


2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove and discard the connecting rod bolts (2).
5. Remove the connecting rod cap (1).
6. Remove the piston and connecting rod assembly (1).

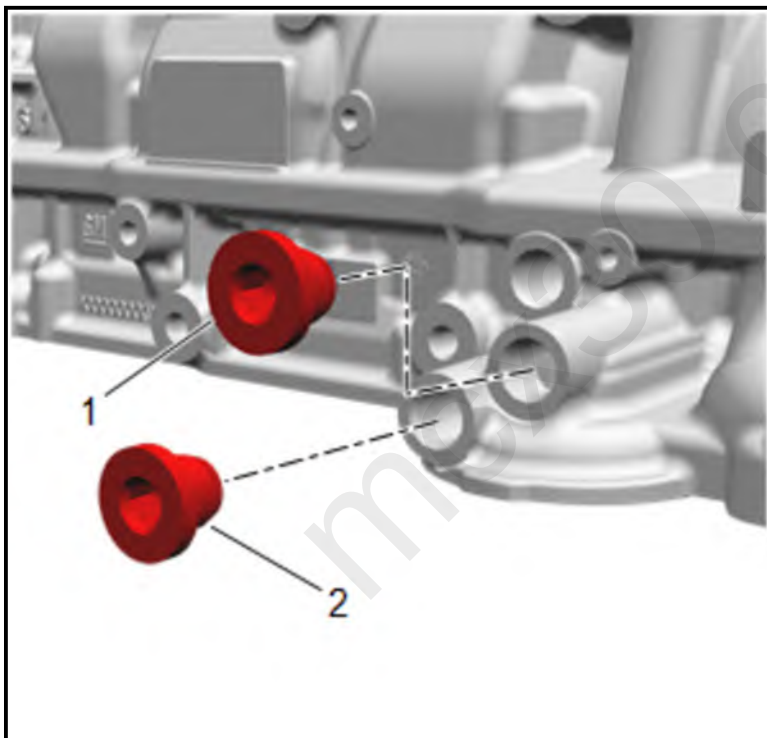


LOWER CRANKCASE REMOVAL

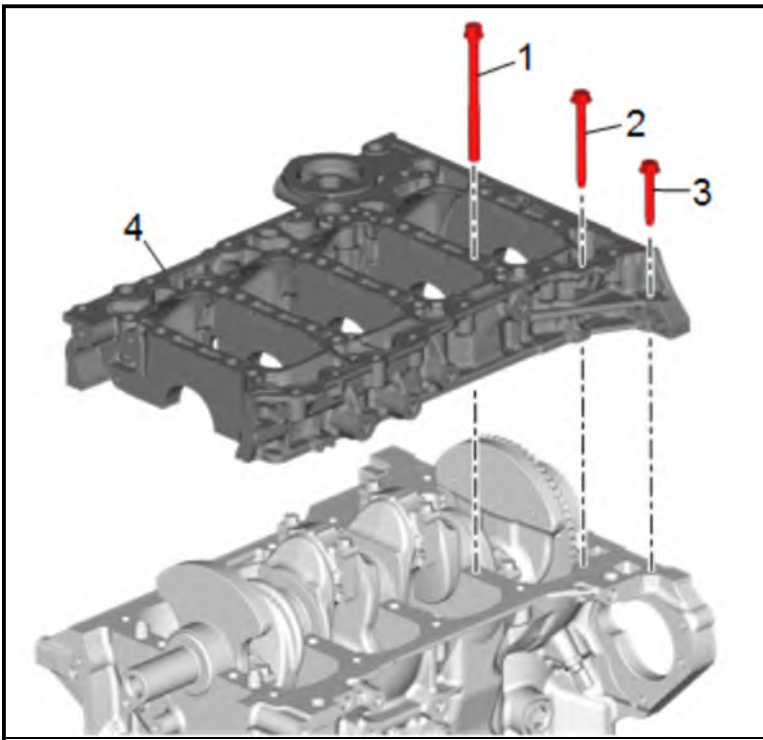
1. Remove the oil pump flow control valve (2) and bolts (1, 3).



2. Remove the oil gallery plugs (1, 2).



3. Remove the lower crankcase bolts (2, 3) from the perimeter of the lower crankcase.



NOTE: Separate, mark, and organize all reusable lower crankcase bolts to ensure installation in the correct locations.

4. Remove and discard the inner lower crankcase bolts (1).
5. Gently separate the lower crankcase (4) from the block.

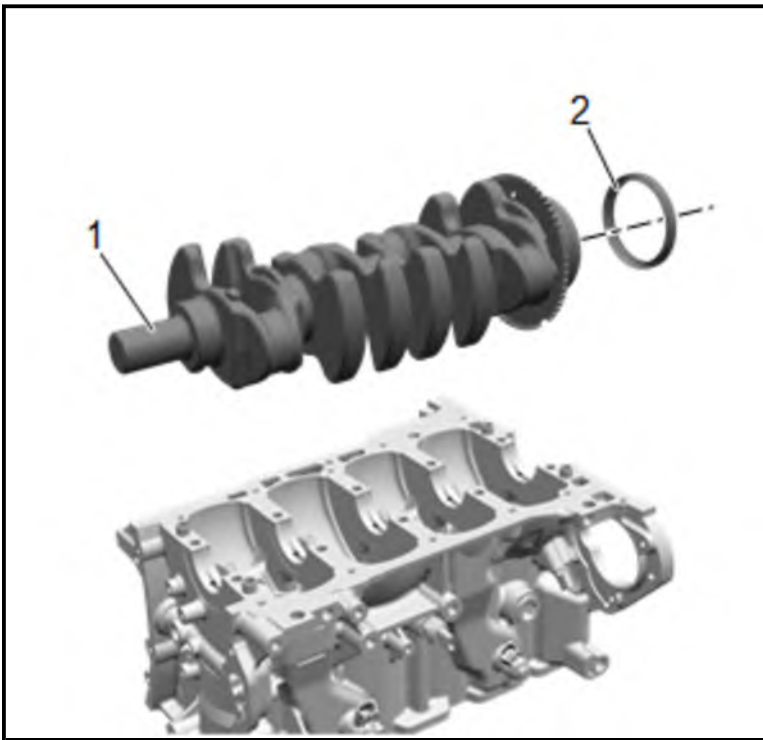
CRANKSHAFT AND BEARING REMOVAL

Crankshaft End Play Measurement

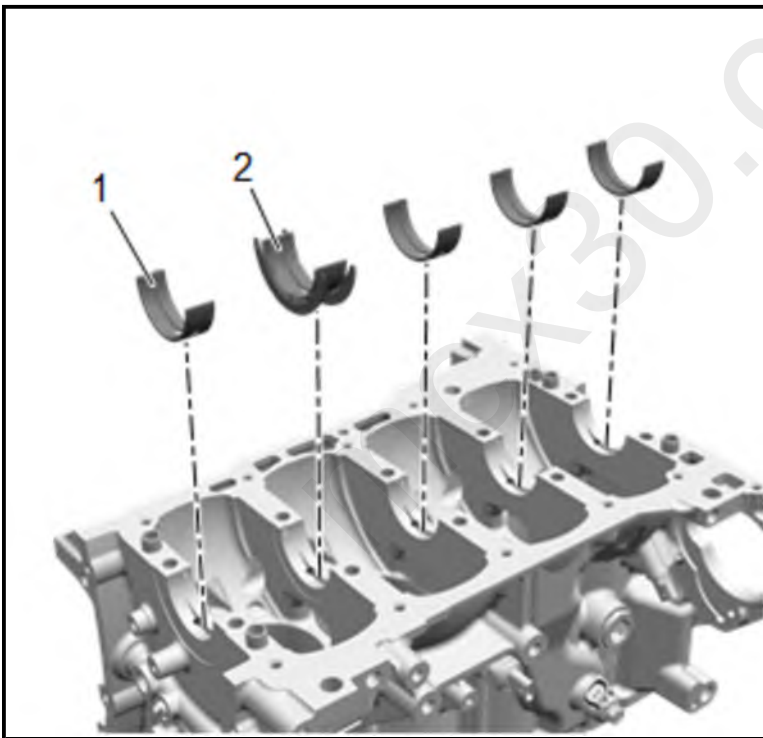
1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to [Engine Mechanical Specifications](#).
4. If the specifications are exceeded inspect the thrust bearing and the crankshaft thrust wall for wear. Refer to [Engine Mechanical Specifications](#).
5. Replace the thrust bearing or crankshaft as necessary.

Crankshaft and Bearing Removal

1. Remove the crankshaft (1) from the block.

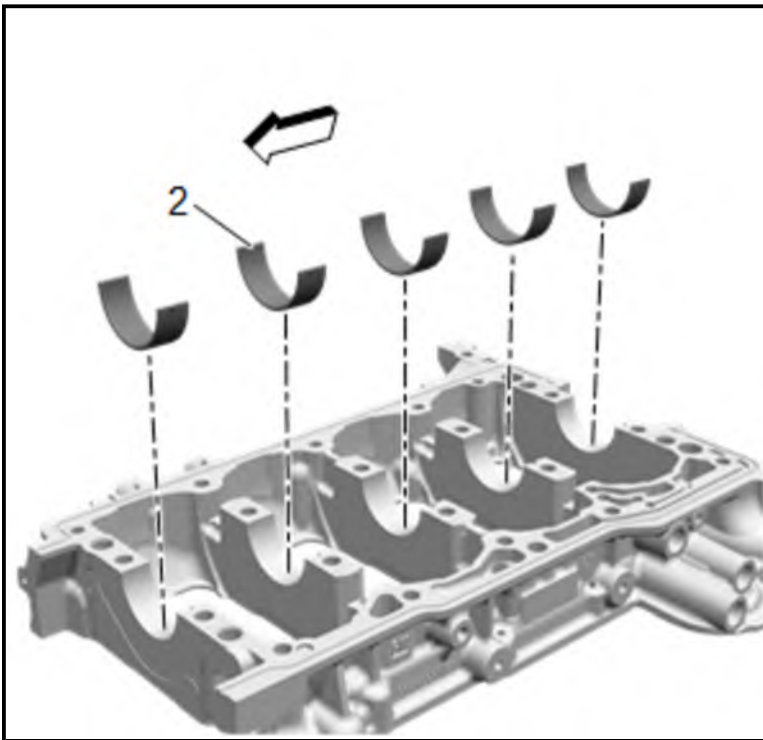


2. Remove the crankshaft rear oil seal (2) from the block and discard.
3. Remove the crankshaft upper bearings (1) and the crankshaft upper thrust bearing (2) from the block.



NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

4. Remove the crankshaft lower bearings (2) from the lower crankcase (1).



5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves
 - Overheating (discoloration)

9. Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

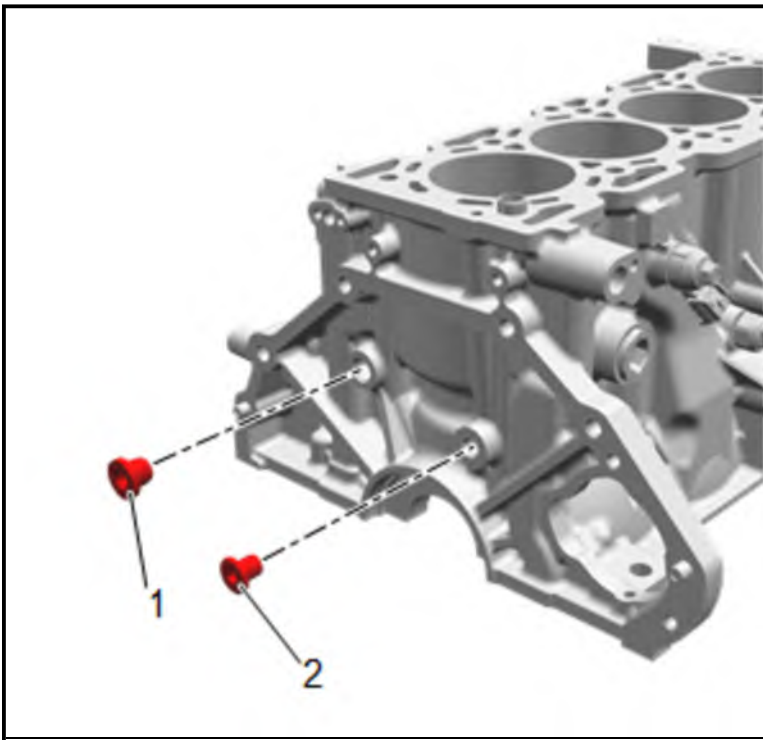
NOTE: Replace the crankshaft if cracks, severe gouges or burned spots are found. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

10. Measure the crankshaft journals. Use a micrometer or dial indicator to measure the taper and runout. Note the result for the later selection of bearing inserts. If not within limits the crankshaft must be replaced.

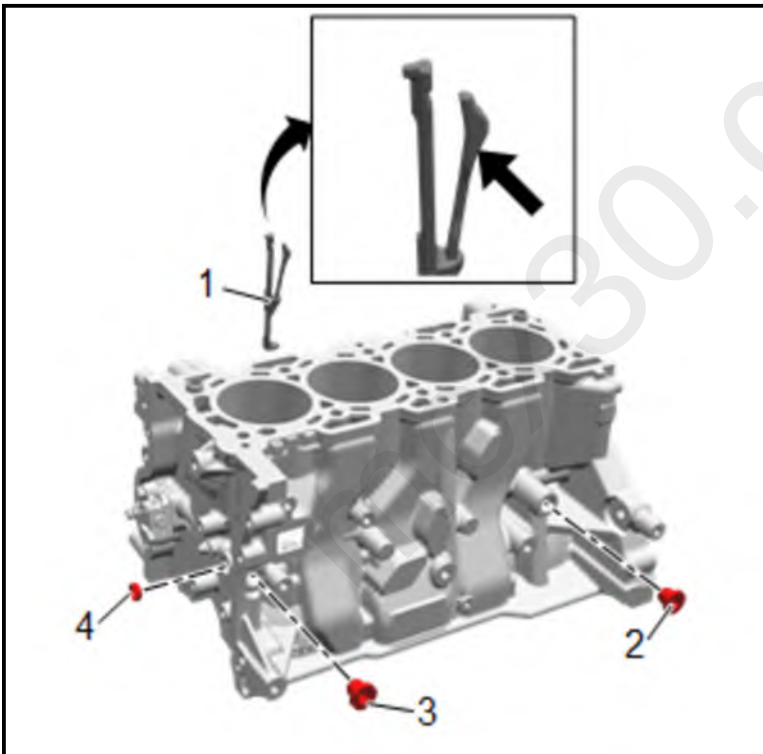
Note the location of the main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

ENGINE BLOCK DISASSEMBLE

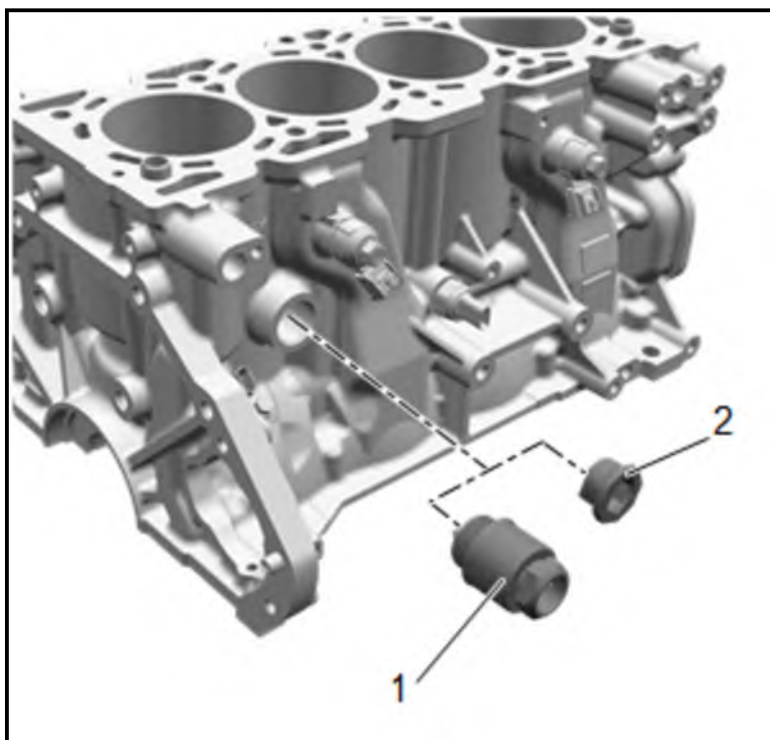
1. Remove the engine oil gallery plugs (1, 2) from the rear of the block.



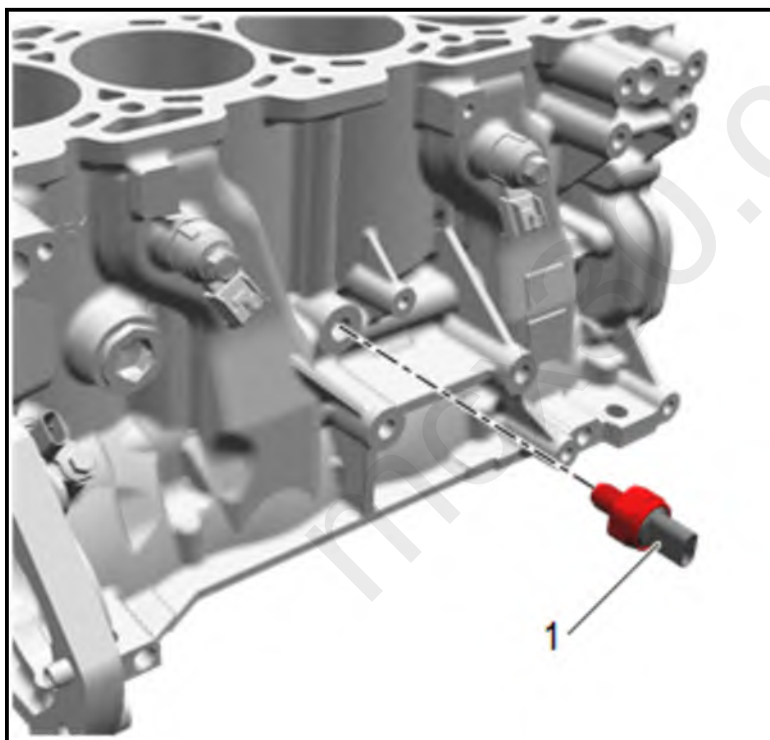
2. Remove the engine oil gallery plugs (2, 3, 4) from the left side and front of the block.



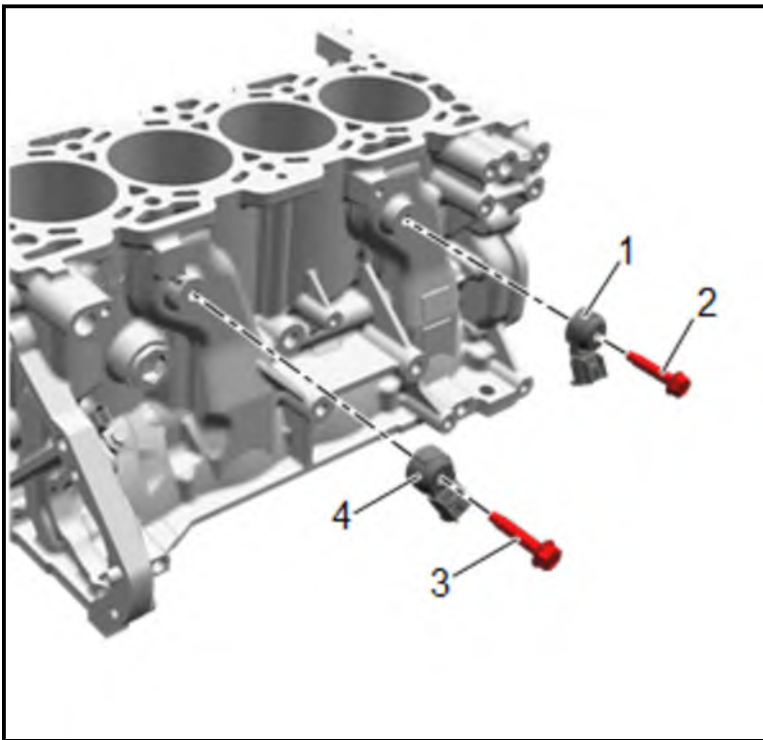
3. Use a suitable hook tool to catch the clip feature and gently remove the engine block coolant baffle (1).
4. Remove the engine coolant heater (1), if equipped. Remove the engine coolant heater hole plug (2) if the heater is not present.



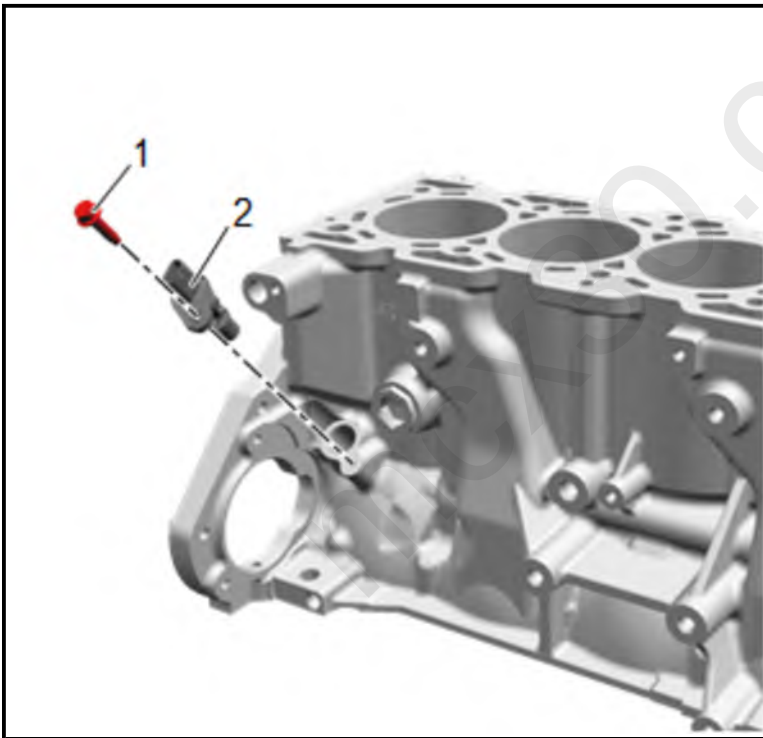
5. Remove the engine oil pressure sensor (1).



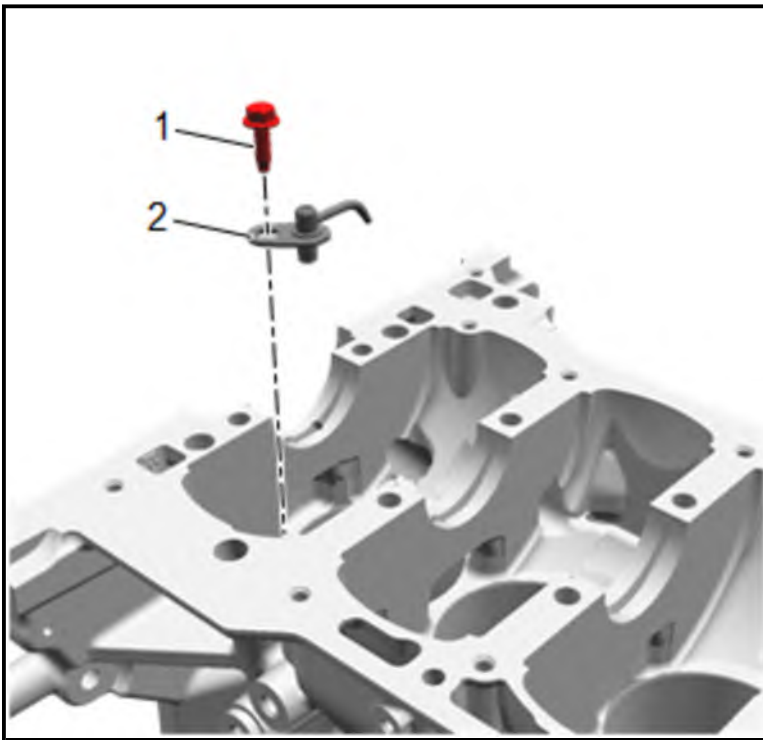
6. Remove the knock sensors (1, 4) and bolts (2, 3).



7. Remove the crankshaft position (CKP) sensor (2) and bolt (1).



8. Loosen the piston oil nozzle assembly bolt (1) and remove the piston oil nozzle assembly (2).



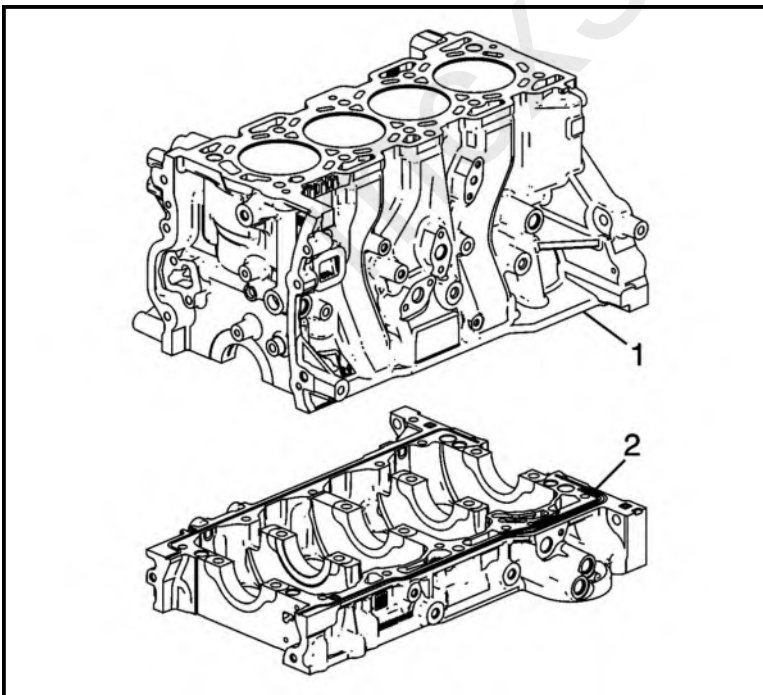
ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator

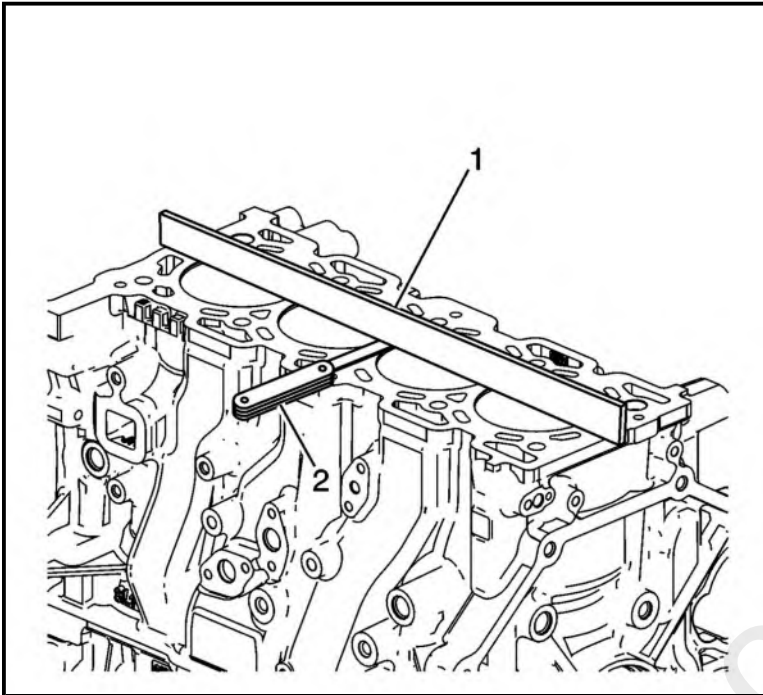
For equivalent regional tools, refer to [Special Tools](#).

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)



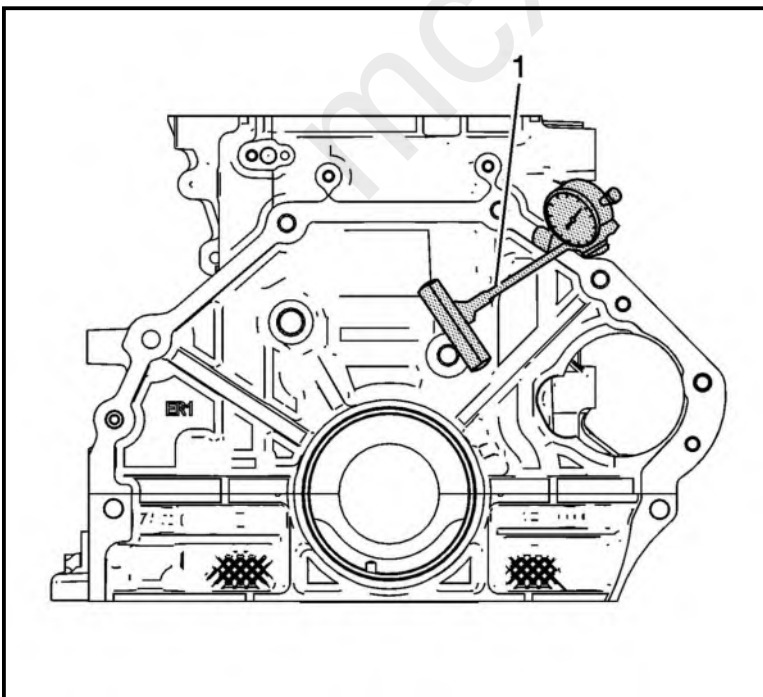
2. Clean the sealing material from the engine block (1) and lower crankcase (2) gasket mating surfaces with a suitable tool.
3. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
4. Flush the engine block with clean water or steam.
5. Clean the oil passages.

6. Clean the blind holes.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair**.
9. Use a straight edge (1) and a feeler gauge (2) to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.



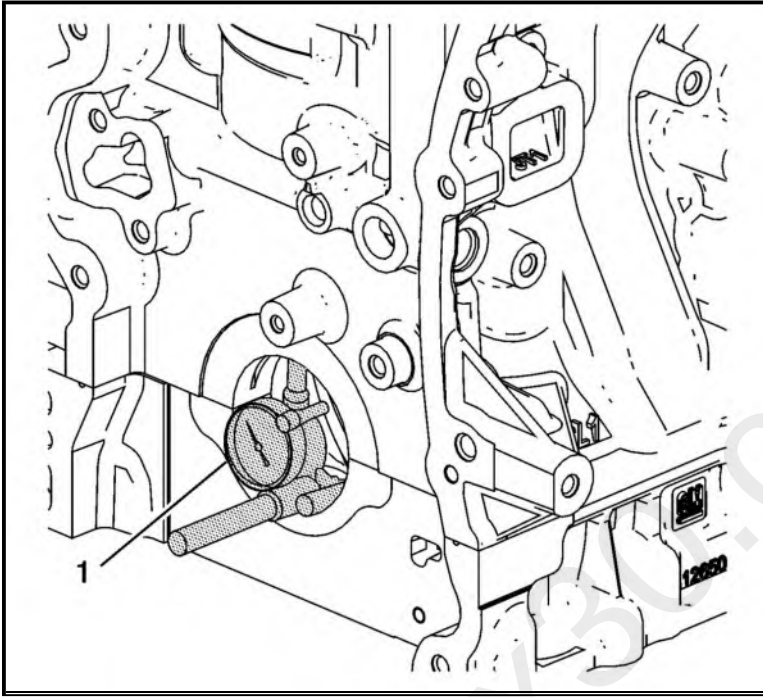
NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.
11. Inspect the mating surfaces of the transmission face.



CAUTION: A broken flywheel may result if the transmission case mating surface is not flat.

12. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
 1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **GE-7872** dial indicator (1)
 2. Hold the gauge plate flat against the crankshaft flange.
 3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
 4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.203 mm (0.008 in).
 5. Recheck the crankshaft flange runout if the readings vary more than 0.203 mm (0.008 in).
 6. Remove the crankshaft and bearings.
13. Install the bed plate and bolts. Tighten the bed plate bolts to specification.

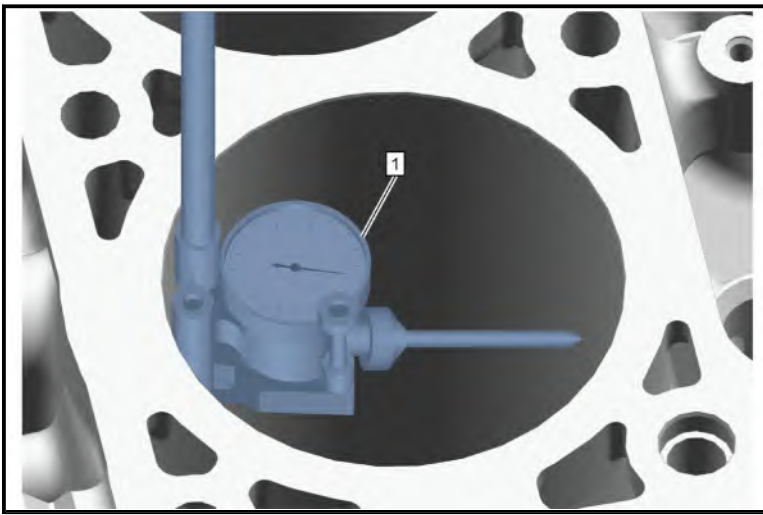


NOTE: A commercially available bore gauge with dial indicator graduations in ten thousandths inch (0.0001") is necessary for measuring engine specification range.

14. Inspect the crankshaft main bearing bores. Use a commercially available bore gauge to measure the bearing bore concentricity and alignment. Refer to [Engine Mechanical Specifications](#).
15. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
16. Remove the bed plate.

Measuring Cylinder Bore Diameter

1. Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.

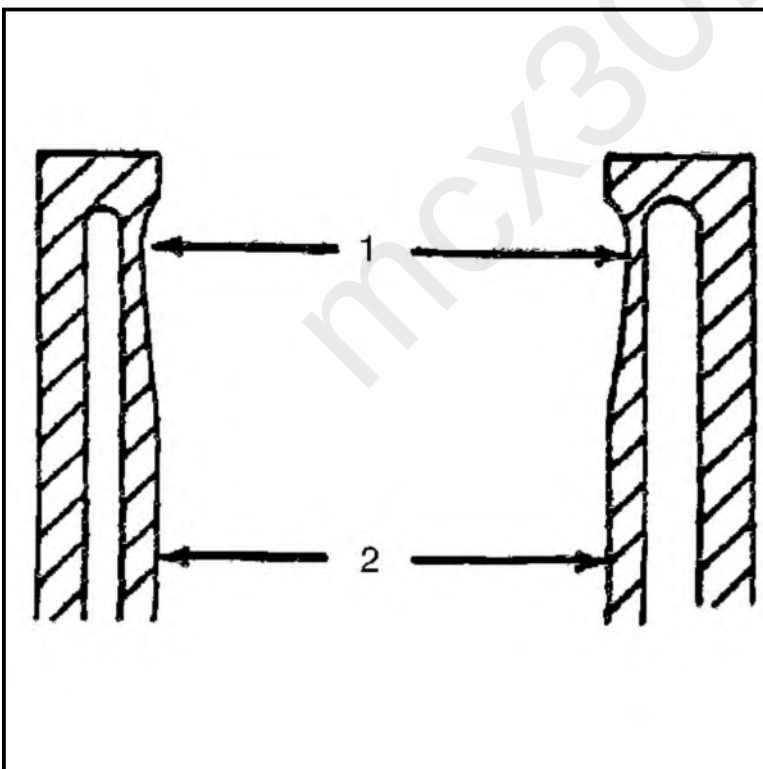


NOTE: A commercially available bore gauge with dial indicator graduations in ten thousandths inch (0.0001") is necessary for measuring engine specification range.

2. Measure the cylinder bore diameter 35 mm (1.378 in) from the deck face using a commercially available bore gauge.
3. Compare your results with the [Engine Mechanical Specifications](#). If the cylinder diameter exceeds the specifications, replace the engine block.

Measuring Cylinder Bore Taper

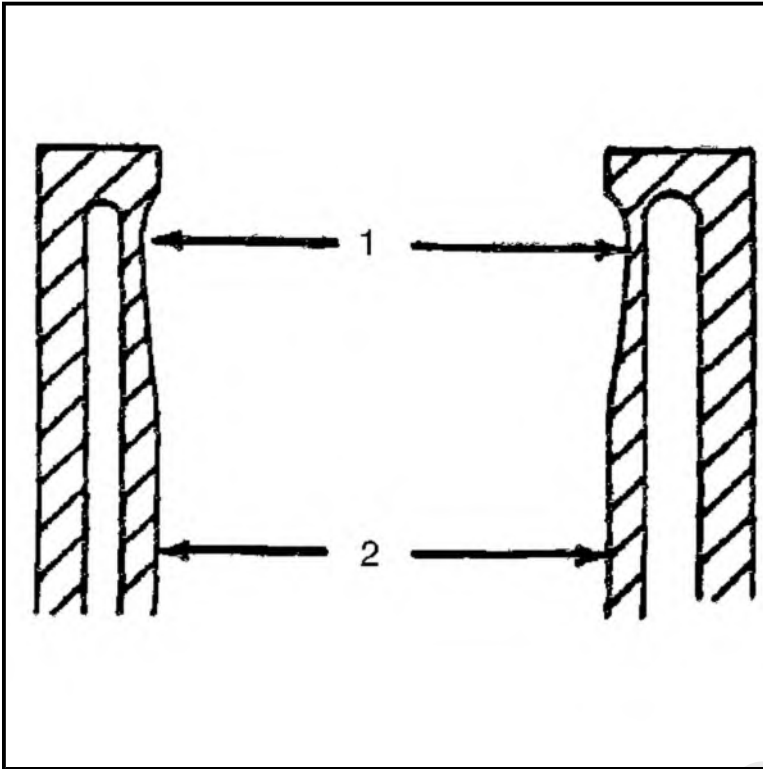
1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.394 in) below the deck surface (1) and record your measurement.



2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 125 mm (4.921 in) below the deck surface (2) and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the [Engine Mechanical Specifications](#). If the cylinders exceed the specifications, replace the engine block.

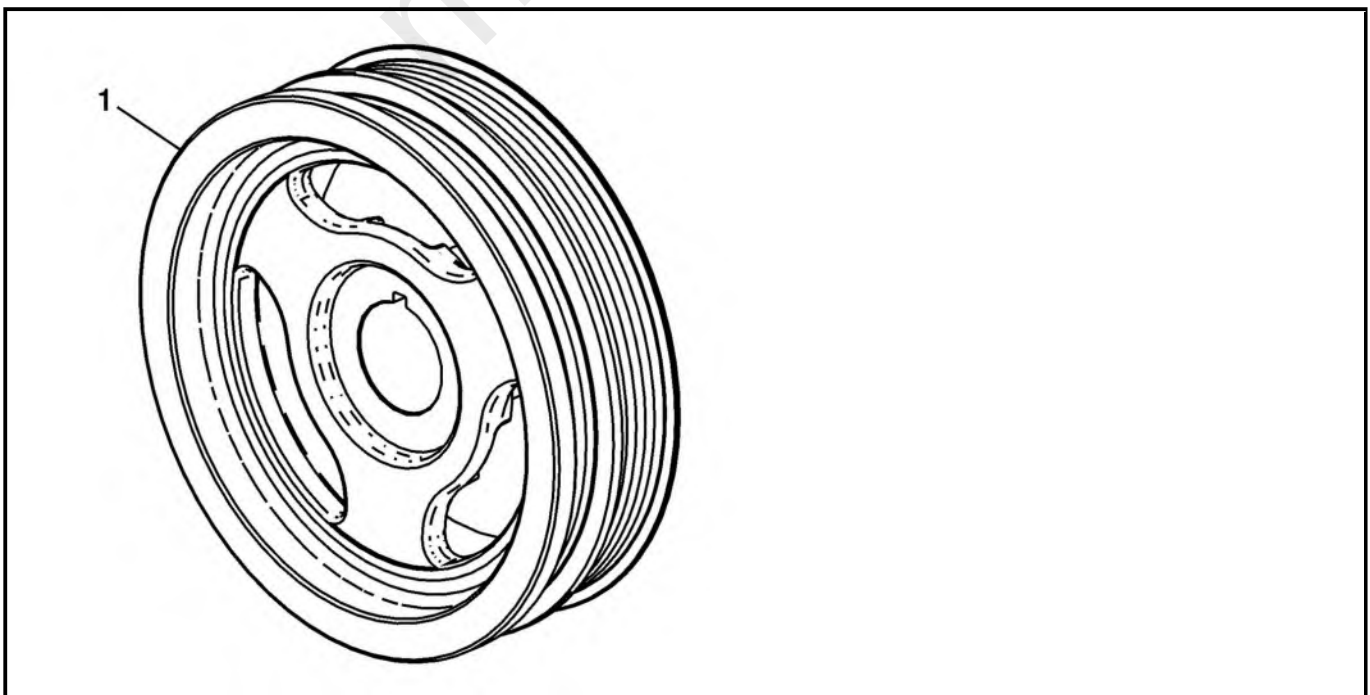
Measuring Cylinder Bore Out-of-Round

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.394 in) below the deck surface (1). Record your measurements.



2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 125 mm (4.921 in) below the deck surface (2). Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the [Engine Mechanical Specifications](#). If the cylinders exceed these specifications, replace the engine block.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

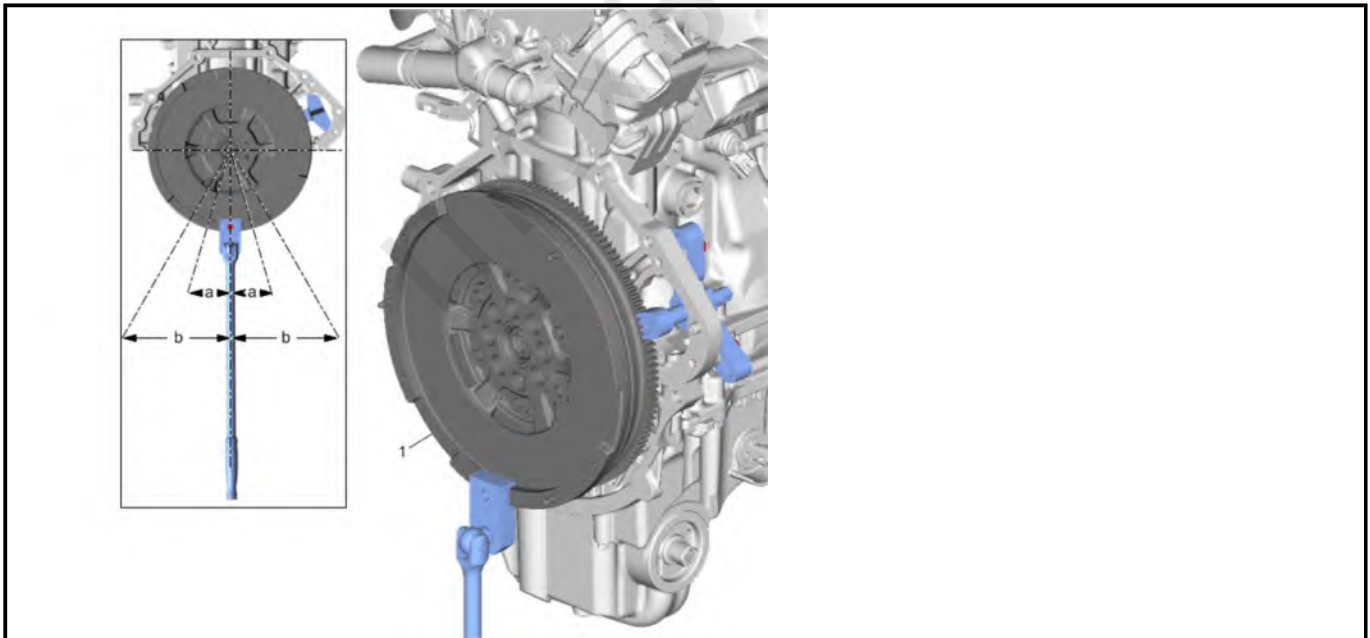


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Crankshaft Balancer Procedure: 1. Clean the crankshaft balancer. 2. Clean the belt grooves of all dirt or debris with a wire brush. WARNING: Refer to Safety Glasses Warning . 3. Dry the crankshaft balancer with compressed air. 4. Inspect the crankshaft balancer for the following: • Worn, grooved, or damaged hub seal surface - a crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced. • Dirty or damaged belt grooves - The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly. • Worn, chunking or deteriorated rubber between the hub and pulley. • Minor imperfections may be removed with a fine file.

FLYWHEEL CLEANING AND INSPECTION

Dual Mass Flywheel Mounted Inspection



NOTE: Callouts in the following chart represent components shown in graphic above.

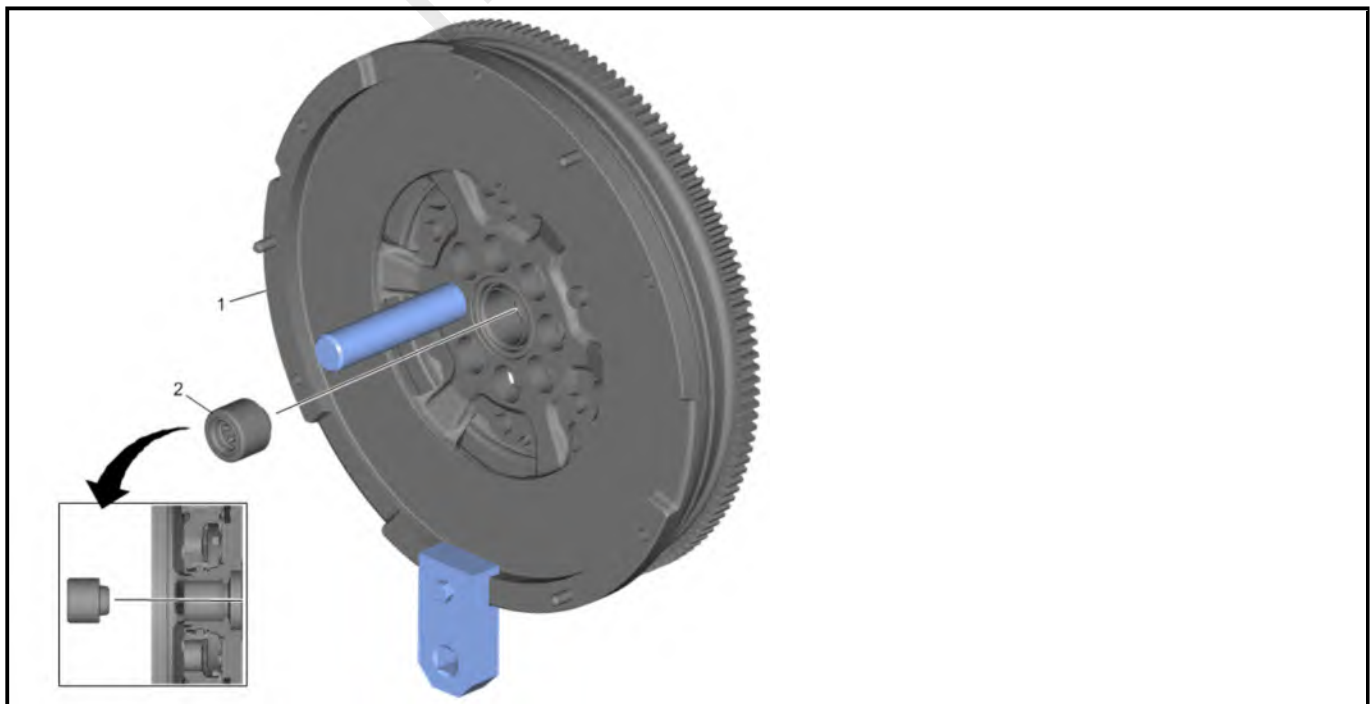
Dual Mass Flywheel Mounted Inspection

Callout	Component Name
Preliminary Procedure WARNING:	

Callout	Component Name
	Refer to Safety Glasses Warning . NOTE: The flywheel must be installed on the engine in order to complete the mounted inspection procedure. The primary mass component of the flywheel should be locked using EN-51760 holding tool to prevent engine rotation. 1. If necessary, install EN-51760 holding tool and starter motor bolts at the starter motor location, engaging the flywheel. 2. If necessary, install EN-51701-1 aligner to the front secondary mass component of the flywheel. Special Tools • EN-51701 Flywheel Aligner and Holder • EN-51760 Flywheel Holding Tool Equivalent regional tools: Special Tools
1	Engine Flywheel Procedure - Dual Mass Flywheel Internal Torque Limiter Inspection NOTE: Inspect and confirm proper operation of the internal arc springs using EN-51701 aligner, a breaker bar, and EN-45049 angle meter to rotate the secondary

Callout	Component Name
	mass of the flywheel in both the clockwise and counter-clockwise direction. 1. In the neutral region (a), without spring load, the secondary mass should experience approximately 8 - 12 degrees of total rotational lash in either direction before the opposing inner springs of the dual mass flywheel engage. 2. Achieve compression of the inner and outer springs by rotating the secondary mass between 25 - 30 degrees (b) in either direction. Rotate the secondary mass in both directions while inspecting for the following conditions: • Scraping or grinding noises • Unacceptable increase in neutral spring zone, resulting in an increased neutral region without spring load greater than 6 degrees in either or both rotational directions, for a total of 12 degrees. • Binding • Rattling noise 3. Replace the flywheel if the conditions are present. Procedure - Secondary to Primary Mass Axial Play Inspection 1. Measure the axial displacement of the secondary flywheel mass. 2. Replace the flywheel if the displacement is greater than 3.1 mm. Special Tools • EN-45049 Angle Meter • EN-51701 Flywheel Aligner and Holder Equivalent regional tools: Special Tools

Dual Mass Flywheel Cleaning and Inspection



NOTE: Callouts in the following chart represent components shown in graphic above.

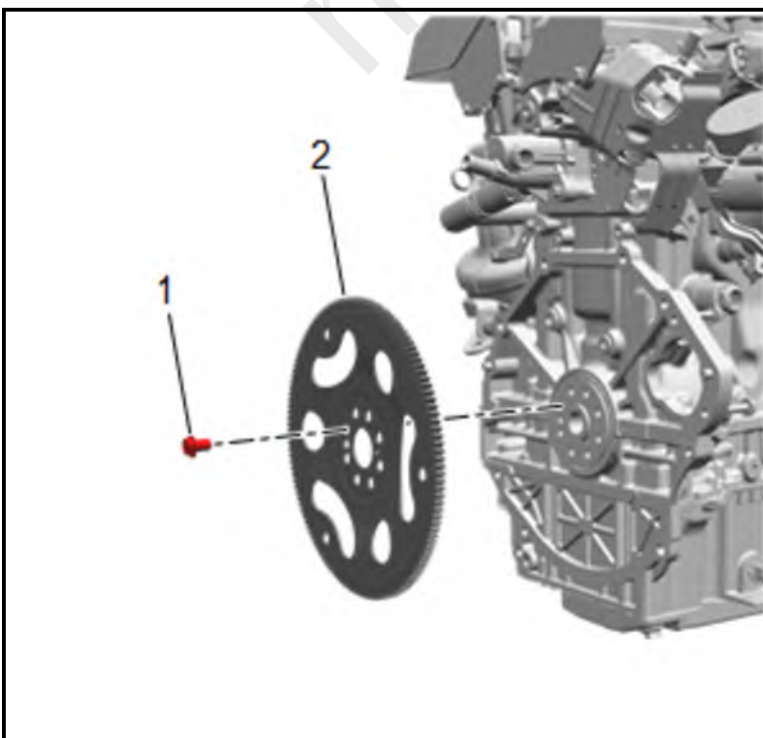
Dual Mass Flywheel Cleaning and Inspection

Callout	Component Name
1	Engine Flywheel NOTE: Complete the cleaning and inspection of flywheel only if the flywheel has passed the torque limiter inspection procedure. The flywheel may have one or both components of EN-51701 flywheel aligner and holder installed. Procedure NOTE: Do not spray solvent directly on the flywheel. 1. Clean the flywheel with cloth dampened with solvent. 2. Dry the flywheel with dry cloth. 3. Inspect the flywheel. The following conditions may be present and require no remedial action: • Localized or many dark spots on friction surface • Light yellow or gold discoloration of friction surface • Friction surface discolored blue due to temporary thermal load with no discoloration in rivet area • Slight trails of grease leaking from the opening or seal caps 4. Inspect the flywheel for the following conditions. Replace the flywheel if any of these conditions are present: • Damaged or heavily worn ring rear teeth • Stress cracks around the flywheel-to-crankshaft bolt hole locations • Scoring of friction surface • Cracking on friction surface • Pilot bearing grease leakage • Tarnish in the rivet area and/or at the outer diameter • Heavy grease leakage from the dual mass flywheel

Callout	Component Name
	• Loose or missing balance weights indicated by clearly visible weld spots • Burnt residue of abraded clutch facing at the flywheel's outer edge or in ventilation holes • Plane bearing clearance is greater than 0.17 mm (0.0067 in) • Flywheel discolored blue or purple at the sides or on the back • Flywheel is cracked or visibly damaged • Secondary mass scores the primary mass
2	Input Shaft Bearing Procedure NOTE: Replace the bearing only if the original flywheel is to be installed and inspection of the bearing indicates replacement is necessary. 1. Press out the input shaft bearing from engine side of the flywheel, using a shop press and a suitable arbor. 2. Press in the input shaft bearing from the transmission side of the flywheel until it bottoms out in the flywheel housing, using a shop press and a suitable arbor.

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

1. Clean the flywheel (2) in solvent.



WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following:
 - Damaged ring gear teeth.
 - Stress cracks around the flywheel-to-crankshaft bolt hole locations.
 - Weight saving holes.

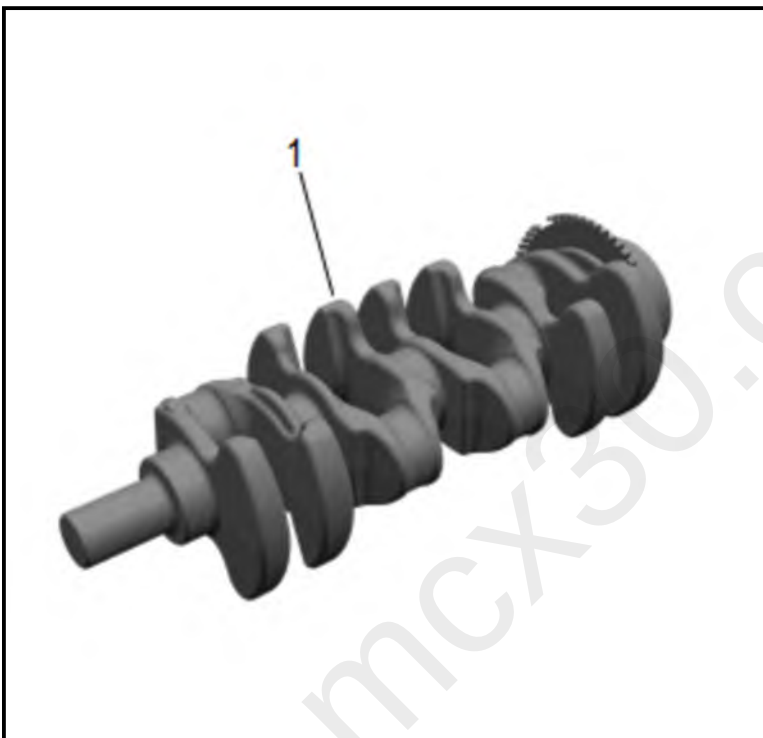
CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator Set

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

1. Clean the crankshaft (1) with solvent.



NOTE: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may affect on-board diagnostic (OBD) II system performance.

2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

WARNING: Refer to [Safety Glasses Warning](#) .

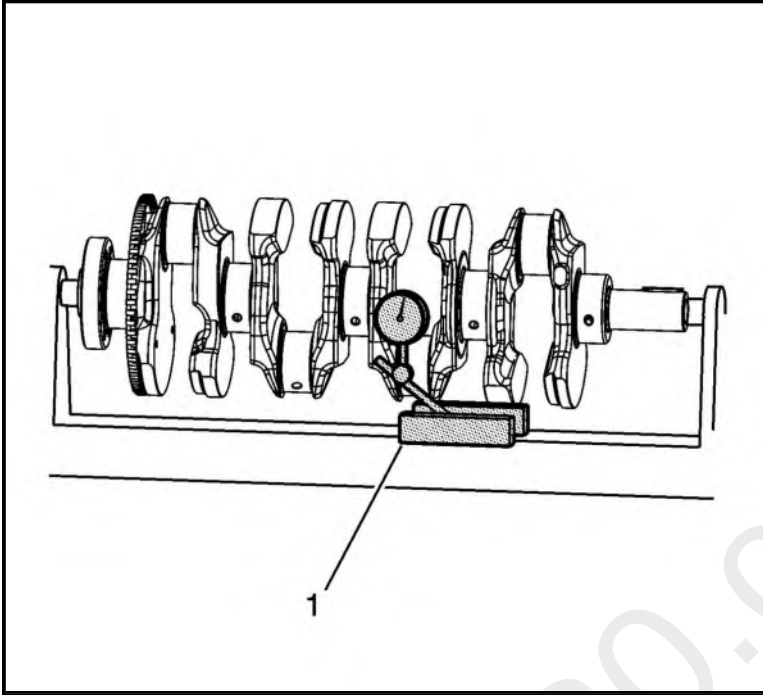
3. Dry the crankshaft with compressed air.

NOTE: Reluctor ring teeth should not have imperfections on the rising or falling edges.

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

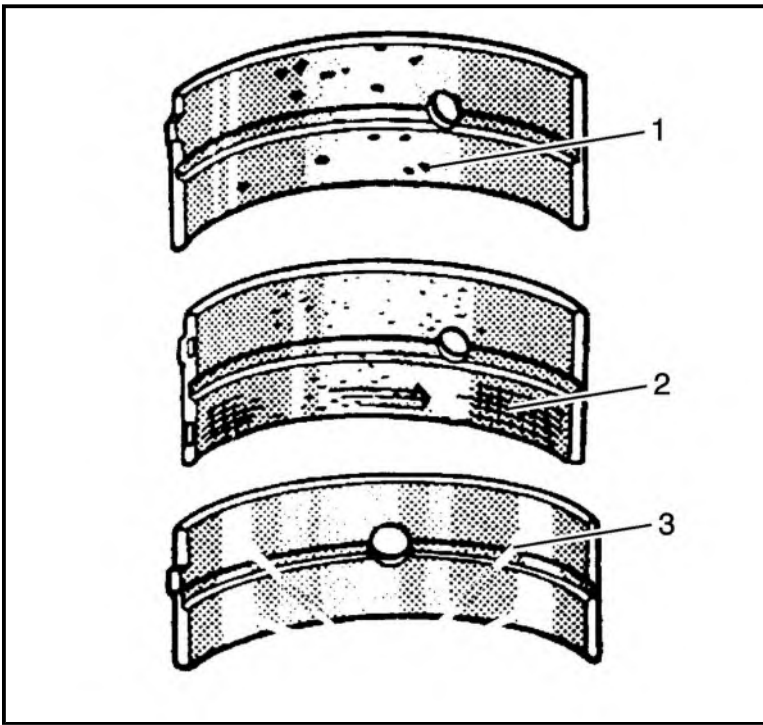
4. Perform a visual inspection of the crankshaft for damage.
5. Inspect the crankshaft reluctor ring. Replace the crankshaft assembly if damage to the reluctor ring is present.

6. Inspect the crankshaft journals for wear. The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring.
8. Inspect the crankshaft journals for scratches or wear.
9. Inspect the crankshaft journals for pitting or imbedded bearing material.
10. Measure the crankshaft journals for out-of-round.
11. Measure the crankshaft journals for taper.
12. Measure the crankshaft runout.



Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **GE-7872** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **GE-7872** indicator in order to measure the runout of the crankshaft rear flange.
15. Replace the crankshaft if the measurements are not within specifications.
16. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.



NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

17. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

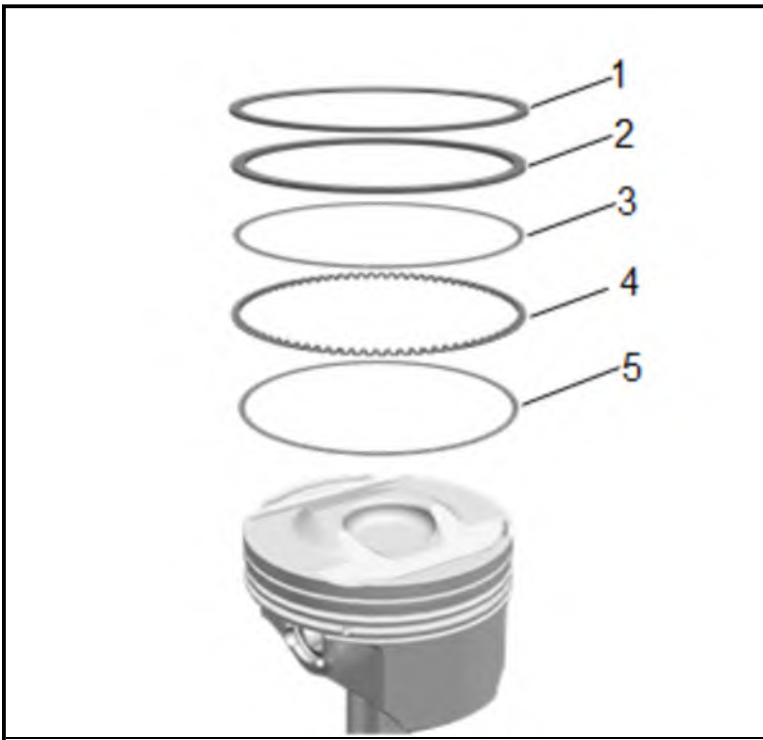
PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

- EN-46745 Piston Pin Clip Remover/Installer
- EN-46745-4 Piston Pin Clip Remover/Installer Adapter

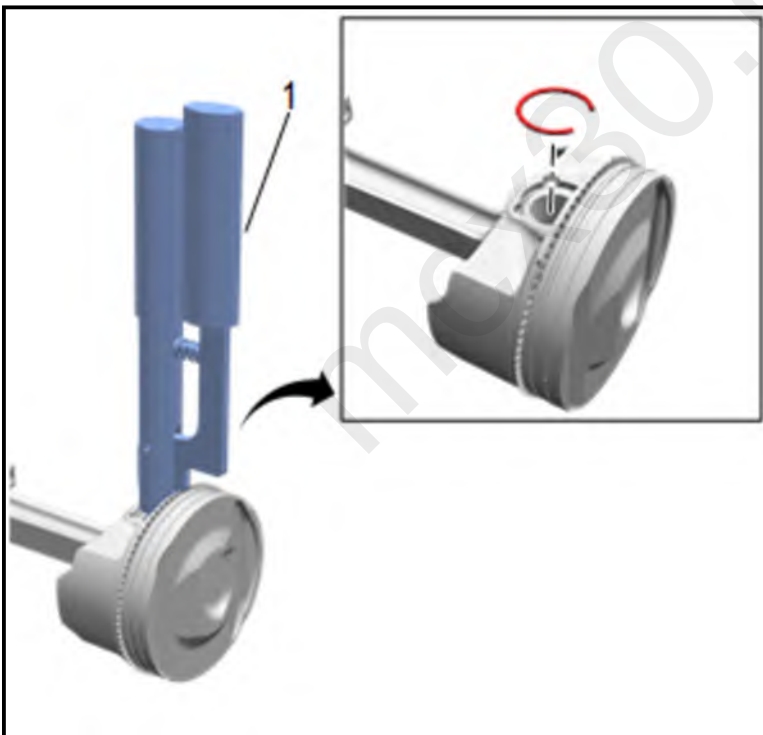
For equivalent regional tools, refer to [**Special Tools**](#).

1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.



WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

2. Remove the piston pin retainers using the **EN-46745** remover (1) and the appropriate adapter. Discard the retainer.

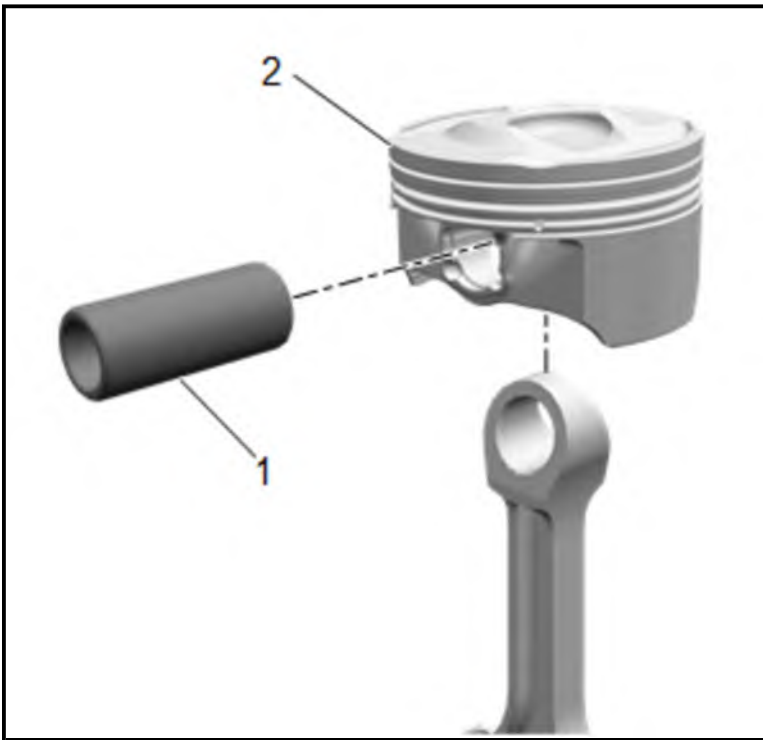


NOTE: Two retainers hold each piston pin in place. Ensure that the piston pin is not damaged. Do not reuse the retainers.

NOTE: Use the appropriate adapter for EN-46745 remover to remove the retainers. The appropriate adapter will fit the piston pin ID and allow the ring to be removed or installed.

- For LCV/LKW/LD4 piston pin, use EN-46745-2 adapter.

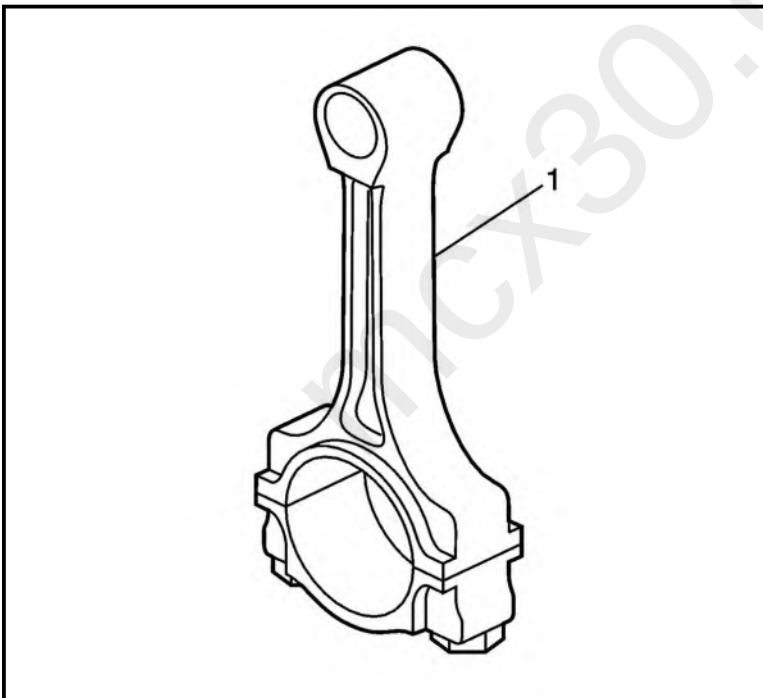
3. Remove the piston pin (1) and the connecting rod (3) from the piston (2).



PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

1. Clean the connecting rods (1) in solvent and dry with compressed air.

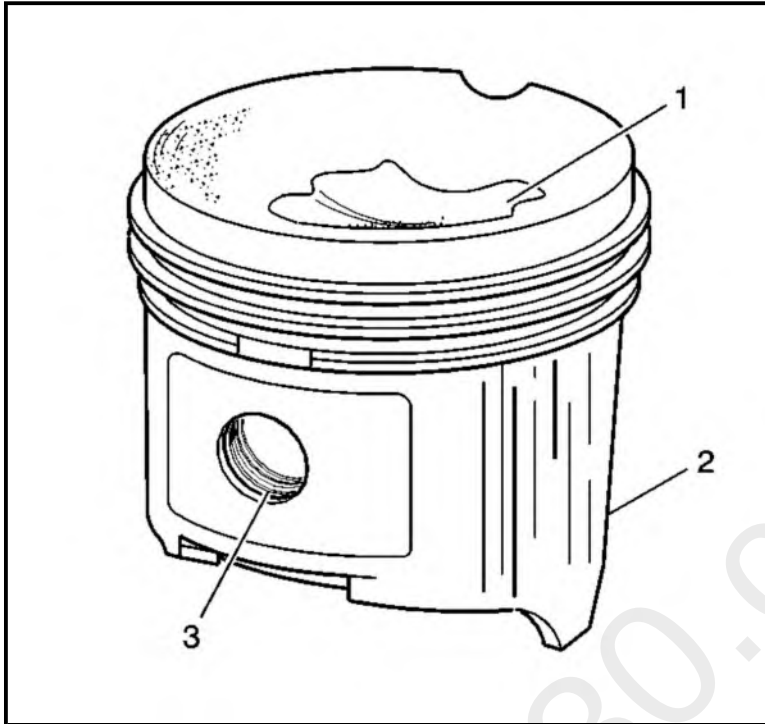


2. Inspect the connecting rods for the following:
 - Signs of being twisted, bent, nicked, or cracked
 - Scratches or abrasion on the rod bearing seating surface
3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT scrape the rod or rod cap.
4. If the beam of the rod is scratched or has other damage replace the connecting rod.
5. Measure the piston pin to connecting rod bore using the following procedure:
 1. Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.

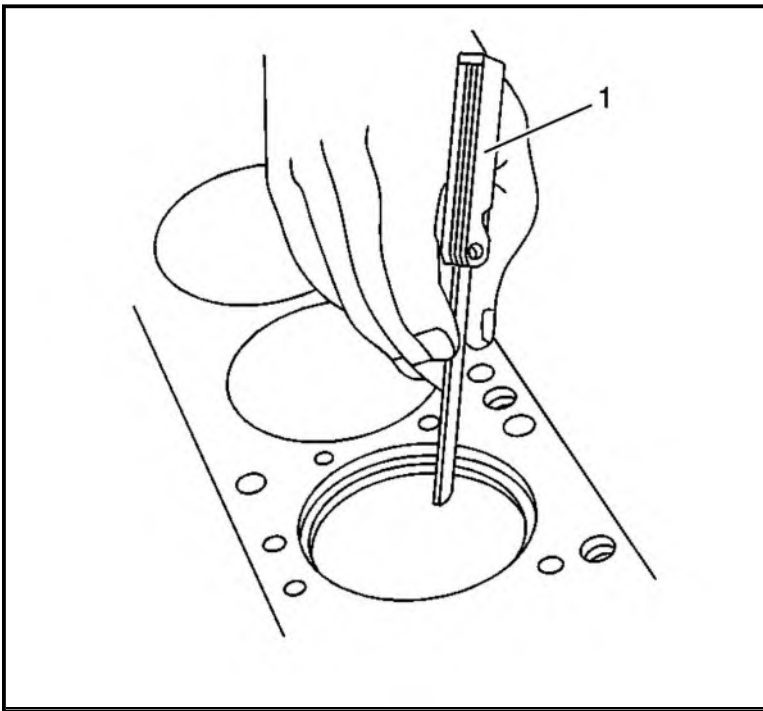
2. Using an inside micrometer, measure the connecting rod piston pin bore.
3. Subtract the piston pin diameter from the piston pin bore diameter.
4. The clearance should not be more than 0.021 mm (0.0008 in).
6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

Piston Measurement

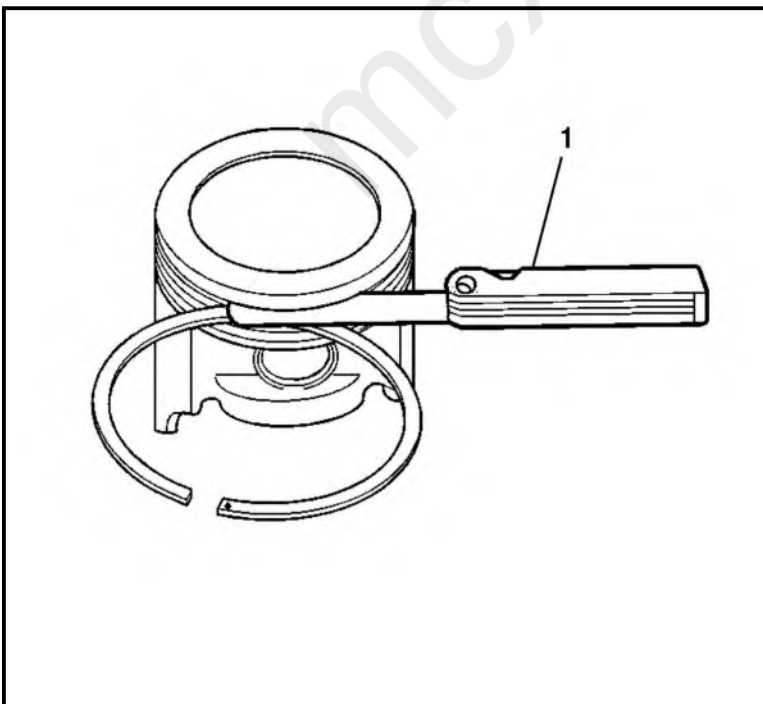
1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.



2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. 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 (1)
 - Scuffed or damaged skirts (2)
 - Worn piston pin bores (3)
4. Replace pistons that show any signs or damage or excessive wear.
5. Measure the piston pin bore to piston pin clearances using the following procedure:
 1. Piston pin bores and pins must be free of varnish or scuffing.
 2. Use an outside micrometer to measure the piston pin in the piston contact areas.
 3. Using an inside micrometer, measure the piston pin bore.
 4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002 - 0.012 mm (0.00007 - 0.00047 in).
 5. If the clearance is excessive, determine which component is out of specification.
6. Measure the piston ring end gap using the following procedure:

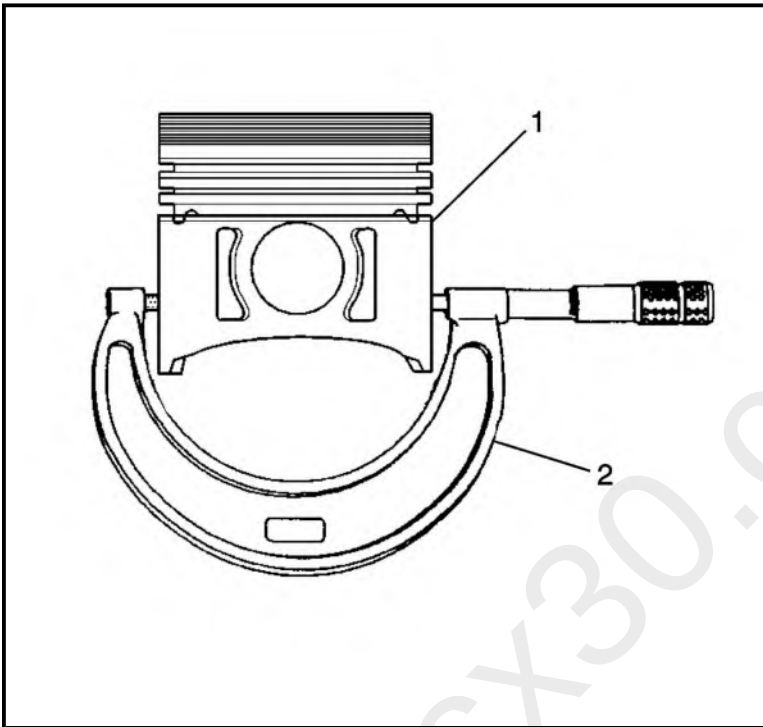


1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gauges (1). Compare the measurements with those provided below:
 - The top compression ring end gap should be 0.20 - 0.40 mm (0.0060 - 0.015 in).
 - The second compression ring end gap should be 0.35 - 0.55 mm (0.0137 - 0.0216 in).
 - The oil ring end gap should be 0.25 - 0.76 mm (0.0098 - 0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.
7. Measure the piston ring side clearance using the following procedure:



1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
2. With the piston ring on the piston, use feeler gauges (1) to check clearance at multiple locations.

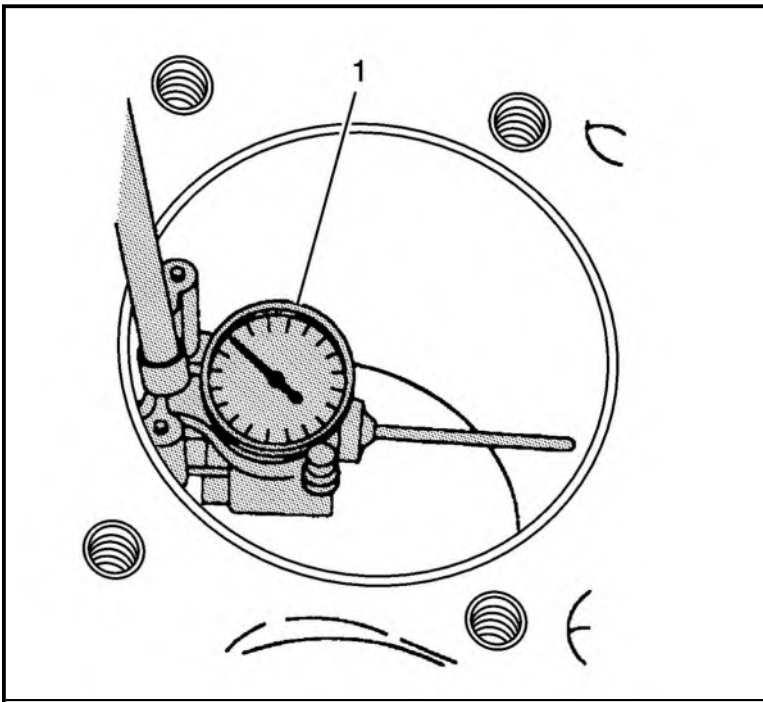
3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
4. If the clearance is greater than specifications, replace the piston ring.
5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.
8. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.
9. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
10. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.
11. Measure piston width using the following procedure:



1. Using an outside micrometer (2), measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
 2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
 3. The proper clearance specification for the piston is 0.010 - 0.041 mm (0.0004 - 0.0016 in).
12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston (1).

Piston Selection

1. Inspect the engine block cylinder bore. Refer to [Engine Block Cleaning and Inspection](#).



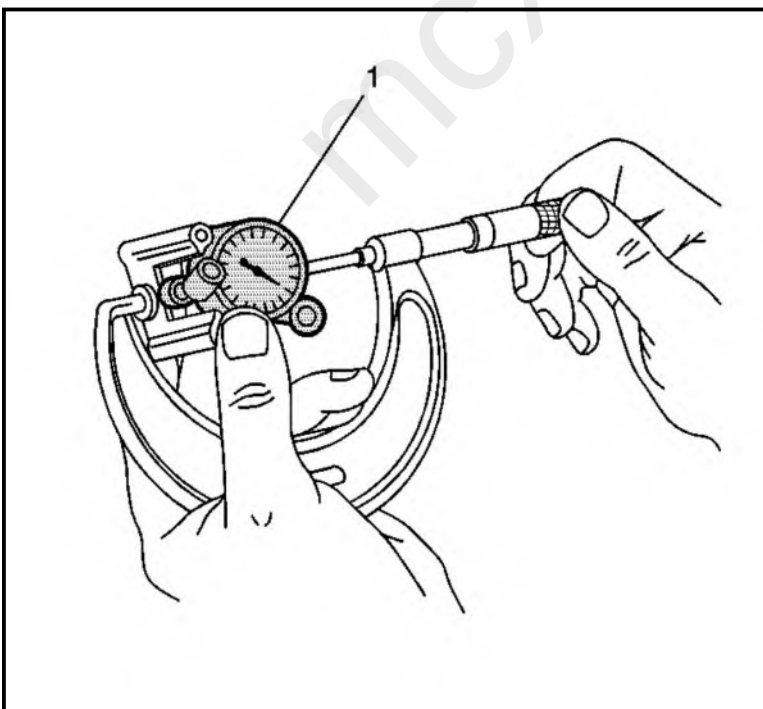
NOTE:

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

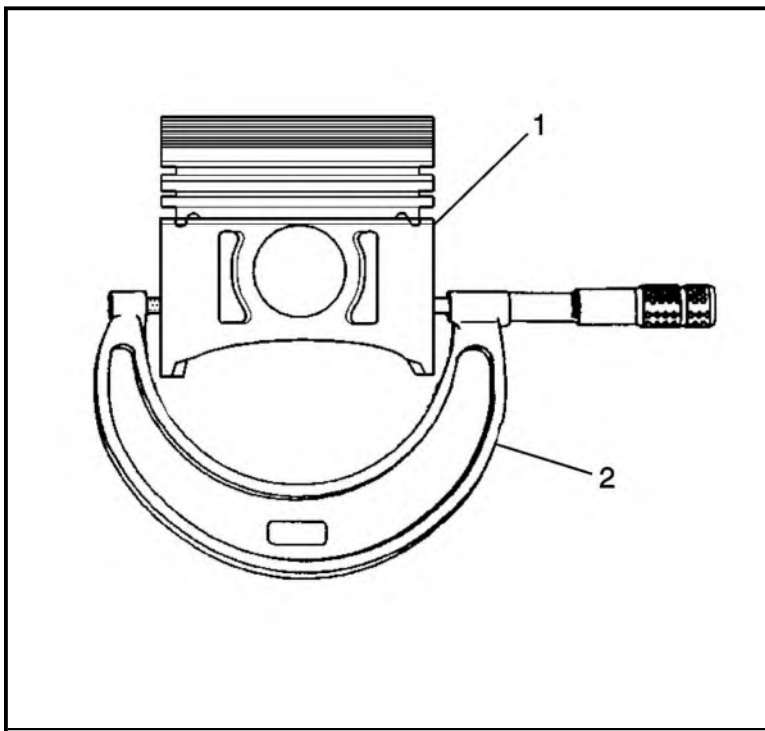
For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

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

2. Inspect the piston and the piston pin.
3. Use a bore gauge (1) and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.
4. Measure the bore gauge with a micrometer (1) and record the reading.



5. With a micrometer (2) or caliper at a right angle to the piston (1), measure the piston 14 mm (0.570 in) from the bottom of the skirt.



6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to [Engine Mechanical Specifications](#).
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to [Separating Parts](#).

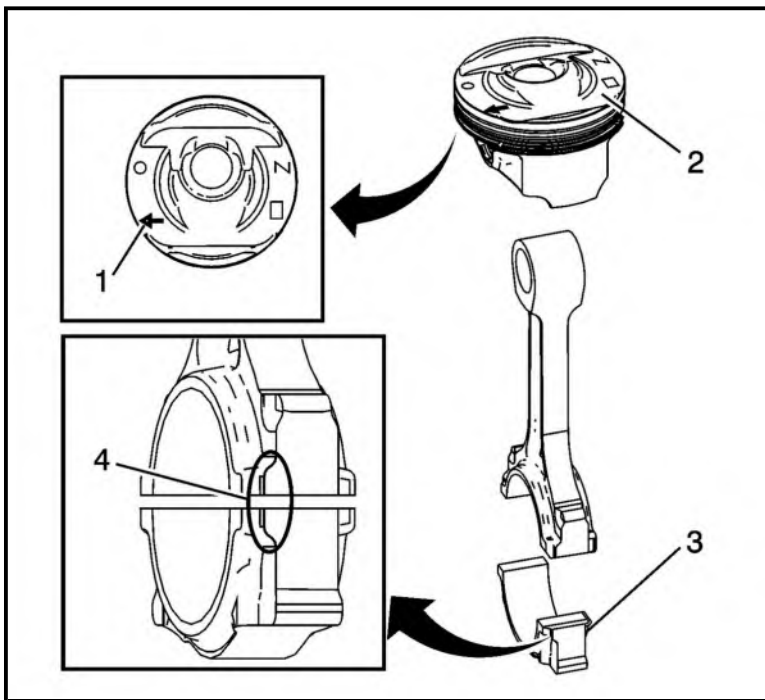
PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

- EN-46745 Piston Pin Clip Remover/Installer
- EN-46745-4 Piston Pin Clip Remover/Installer Adapter

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

1. Install the piston onto the connecting rod with the arrow on top of the piston oriented to the same side as the cast feature at the split line of the connecting rod.

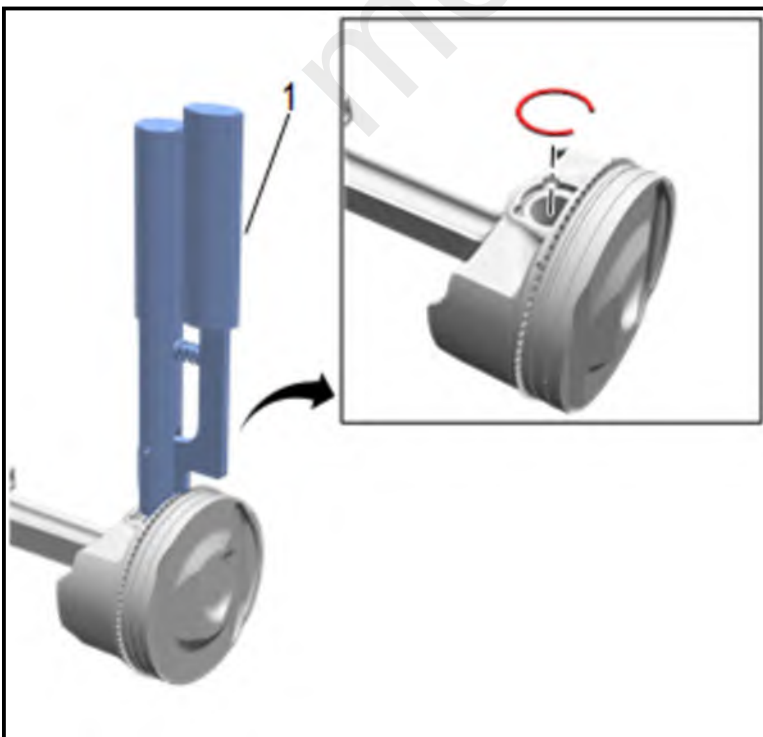


NOTE: The arrow (1), on the top of the piston, must go to the front of the block.

2. The feature at the split line (4), located on one side of the connecting rod, must go to the front of the block.
3. Assemble the connecting rod (3) and the piston (2).
4. Use the following procedure to assemble the piston pin and the retainer:
 1. Coat the piston pin with oil.
 2. Install one NEW piston pin retainer into the retaining groove using **EN-46745** installer and the appropriate adapter. Rotate the retainer until it is fully seated in the groove.
 3. Install the connecting rod and the piston pin.

Push the piston pin until it bottoms in the previously installed retainer.

4. Install the second NEW piston pin retainer, using **EN-46745** installer (1) and the appropriate adapter.
5. Ensure that the piston moves freely.



CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

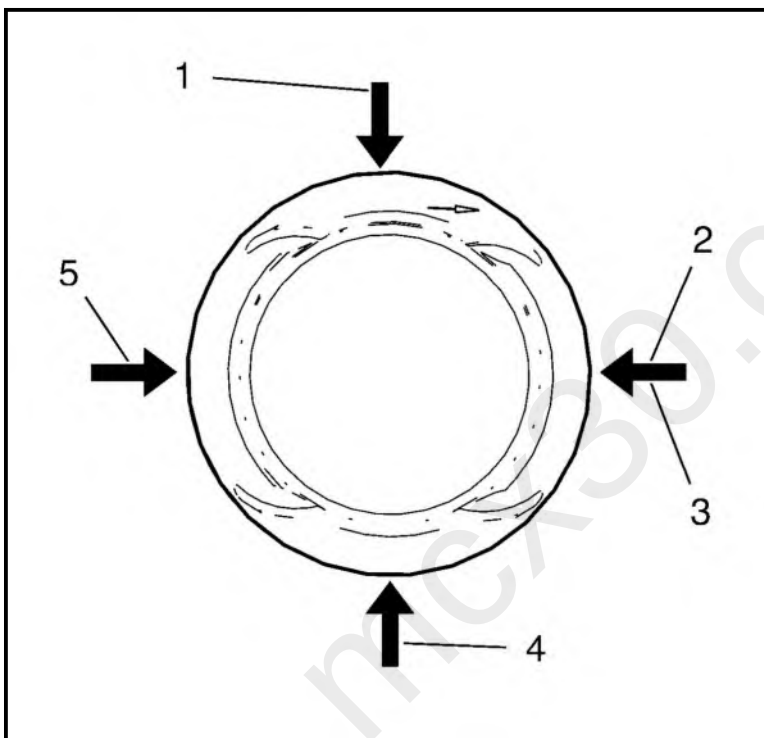
NOTE: Use NEW retainers. Two retainers hold each piston pin in place.

NOTE: Use the appropriate adapter for EN-46745 installer to install the retainers. The appropriate adapter will fit the piston pin ID and allow the ring to be removed or installed.

- For LCV/LKW/LD4 piston pin, use EN-46745-2 adapter.

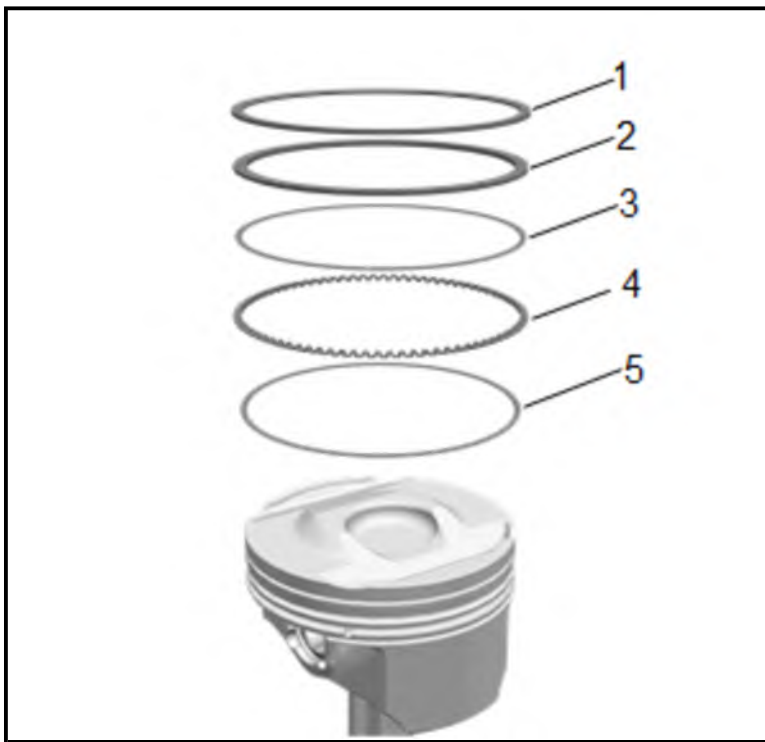
5. The piston ring end gaps must be positioned 90 degrees to each other.

- Upper compression ring joint (1)
- Lower compression ring joint (2)
- Upper oil ring rail joint (5)
- Oil ring rail spacer joint (4)
- Lower oil ring rail joint (3)



6. Install the following components of the oil control ring assembly:

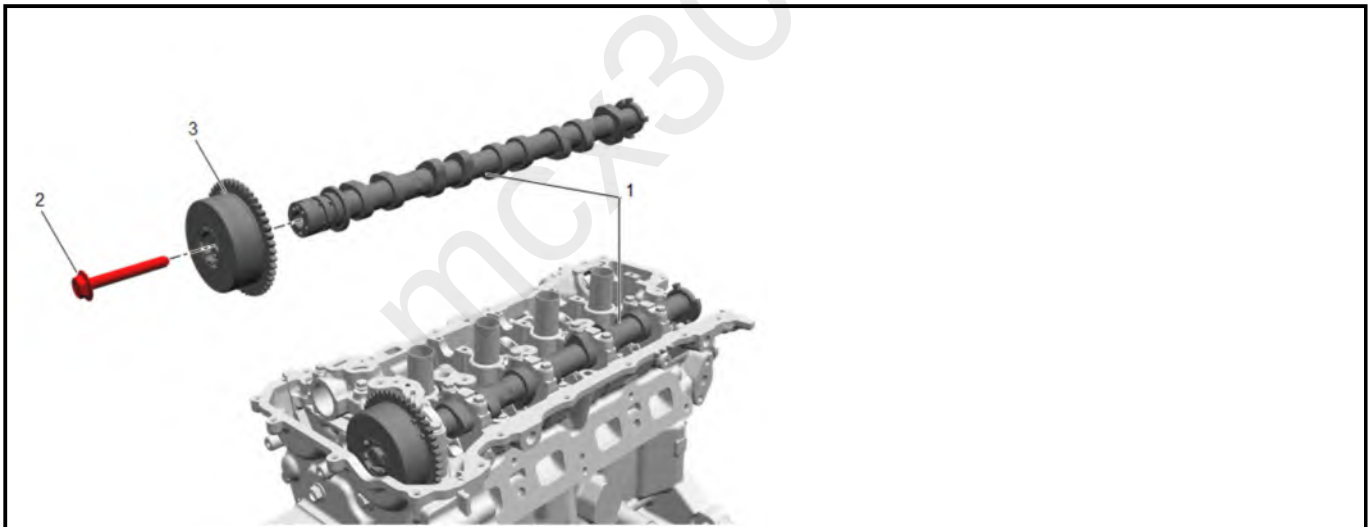
1. The piston oil ring rail (5)
2. The piston oil ring rail spacer (4)
3. The second piston oil ring rail (3)



CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

7. Install the piston lower compression ring (2). Place the manufacturer's mark facing up.
8. Install the piston upper compression ring (1).

CAMSHAFT ASSEMBLY DISASSEMBLE



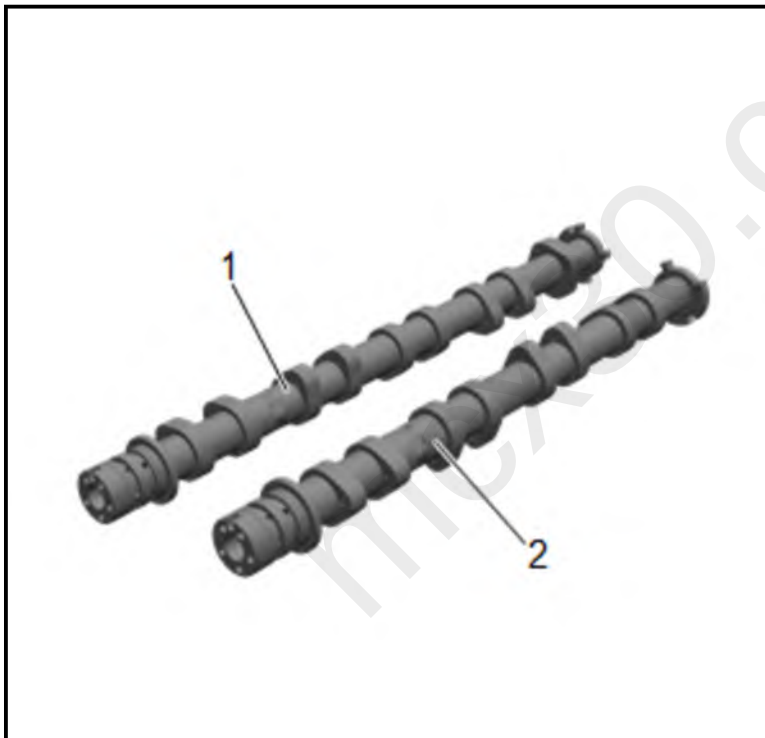
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures	
1.	Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device.
2.	Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position.
3.	Install one of the camshafts in the exhaust camshaft position on the cylinder head.
4.	Install the camshaft bearing front upper cap and bolts.
5.	Install the camshaft bearing caps and bolts.

Callout	Component Name
6. Install EN-50793 locking tool onto the camshaft actuator and engine front cover. 7. The camshaft actuator bolt can now be loosened and the actuator removed from the camshaft. Repeat preliminary procedure for the remaining camshaft assembly.	
1	Camshaft, Intake and Exhaust
2	Camshaft Position Actuator Bolt NOTE: Discard the bolt. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to Special Tools .
3	Camshaft Position Actuator, Intake and Exhaust

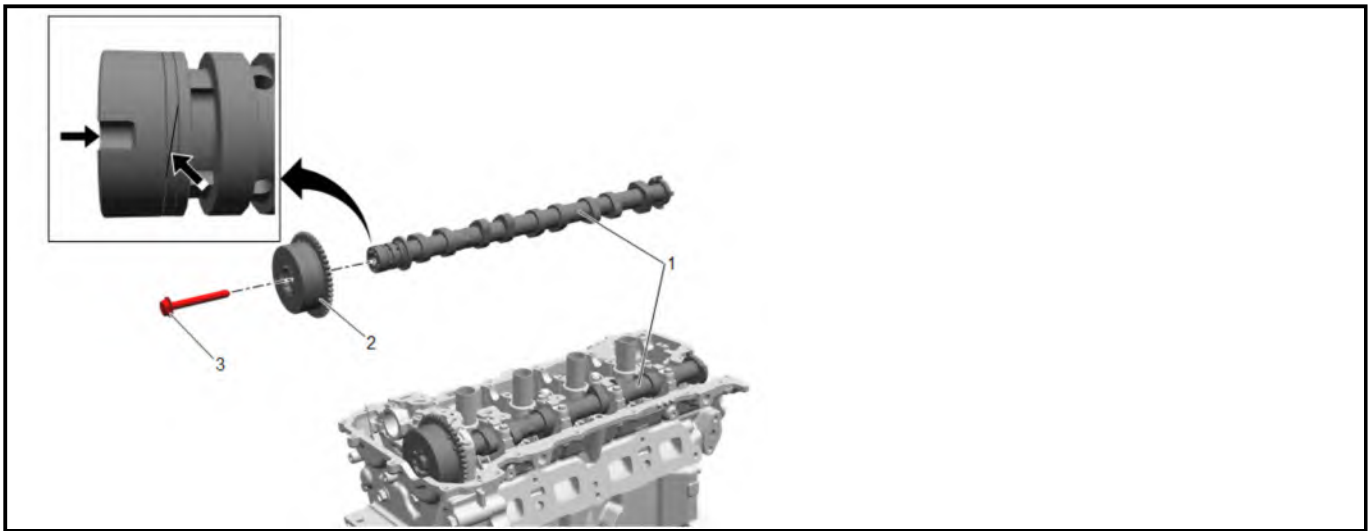
CAMSHAFT CLEANING AND INSPECTION

1. Inspect the camshaft journals and lobes for wear or scoring.



2. Inspect the camshaft sprocket alignment notch for damage.
3. Wash the camshafts (1, 2) in solvent.
4. Oil the camshafts.

CAMSHAFT ASSEMBLY ASSEMBLE



NOTE: Callouts in the following chart represent components shown in graphic above.

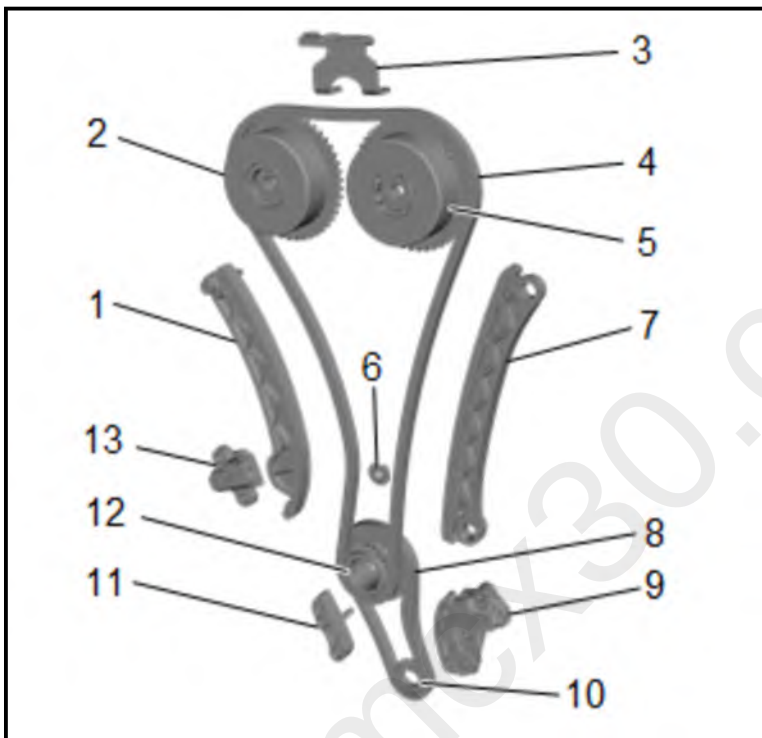
Callout	Component Name
Preliminary Procedures 1. Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device. 2. Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position. 3. Install one of the camshafts in the exhaust camshaft position on the cylinder head. 4. Install the camshaft bearing front upper cap and bolts. 5. Install the camshaft bearing caps and bolts. 6. Install the appropriate actuator for the camshaft currently installed on the cylinder head. 7. Install EN-50793 locking tool onto the camshaft actuator and engine front cover. 8. The camshaft actuator bolt can now be installed and tightened to final specification. Repeat preliminary procedure for the remaining camshaft assembly.	
1	Camshaft, Intake and Exhaust NOTE: Ensure that the oil seal near the front of the camshaft is rotated so that the split line on the oil seal is aligned with the notch, and both the notch and split line are at 12 O'clock when installed on the cylinder head.
2	Camshaft Position Actuator, Intake and Exhaust

Callout	Component Name
	NOTE: Upon camshaft assembly, ensure the camshaft actuator pin aligns with the camshaft notch. The actuator, camshaft, and bolt can be assembled by hand and then placed on the cylinder head for final torque. NOTE: Lubricate the actuator prior to installation.
3	Camshaft Position Actuator Bolt CAUTION: Refer to Fastener Caution . CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause

Callout	Component Name
	damage to the vehicle or component. Tighten 30 N.m (22 lb ft) plus 100 Degrees. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to Special Tools.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER CLEANING AND INSPECTION

1. Inspect the timing chain guides (3, 7) and timing chain tensioner pivot arm (1) for cracking or wear.



2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner (13) shoe for wear.
4. Replace the timing chain tensioner if shoe wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain (4) and actuators (2, 5) for wear.
6. Inspect the camshaft actuator faces for signs of movement.
7. Inspect the camshaft actuator teeth and chain for signs of excessive wear, chipping, or seizure of the timing chain links.
8. Inspect the timing chain oil nozzle (6) for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged.
9. Verify oil nozzle oil flow with compressed air.
10. Inspect the timing chain tensioner (13) for scoring or free movement.
11. Inspect the timing chain tensioner washer. If damaged, replace the timing chain tensioner.
12. Inspect the crankshaft sprocket (12) for excessive wear or chipping.
13. Inspect the balancer chain (8) for wear.
14. Inspect the balancer chain guide (11) for wear.
15. Inspect the balancer chain tensioner (9) for wear.
16. Inspect the balancer shaft driven sprocket (10) for wear or chipping.

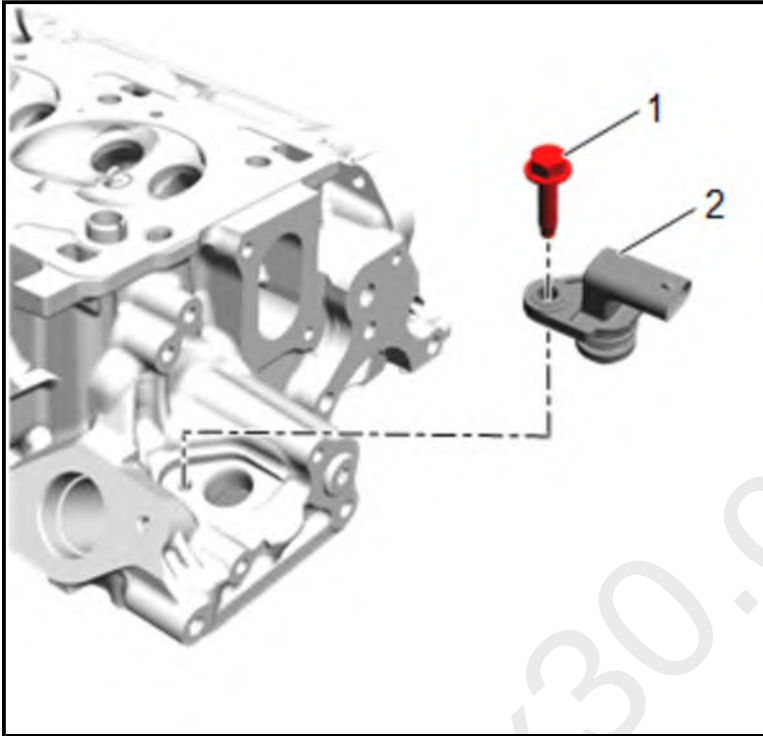
CYLINDER HEAD DISASSEMBLE

Special Tools

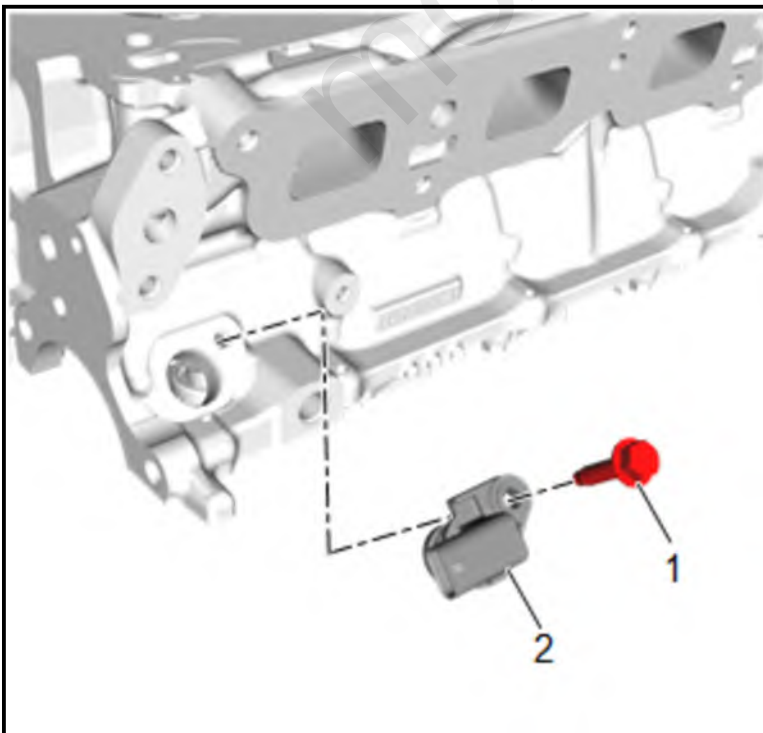
- EN-43963 Valve Spring Compressor (off car)
- EN-46116 Valve Stem Seal Remover/Installer
- EN-50717 Valve Spring Compressor

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

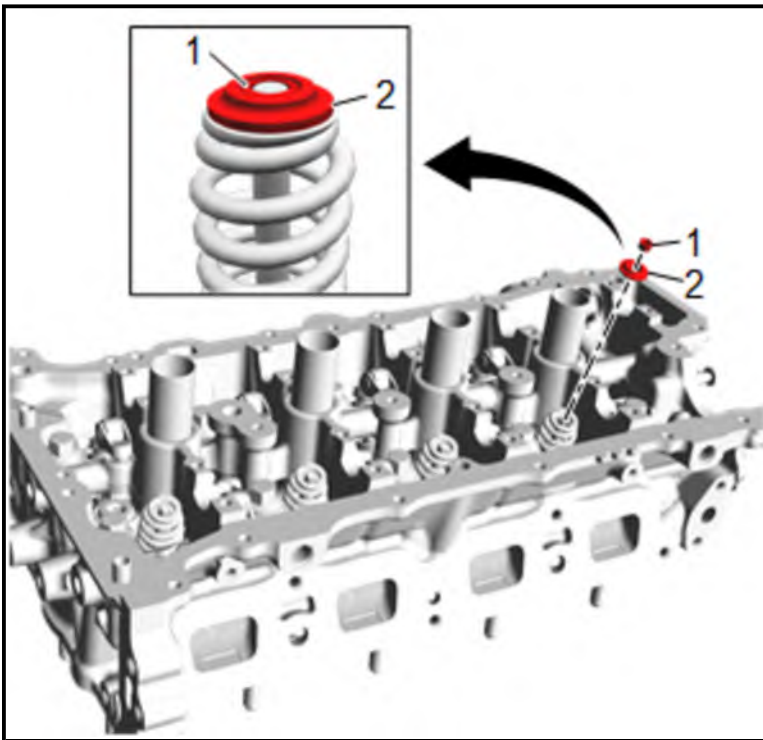
1. Remove the intake camshaft position sensor (2) and bolt (1).



2. Remove the exhaust camshaft position sensor (2) and bolt (1).



3. Perform the following procedure to remove the valve keys, springs, and retainers:



WARNING:

Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

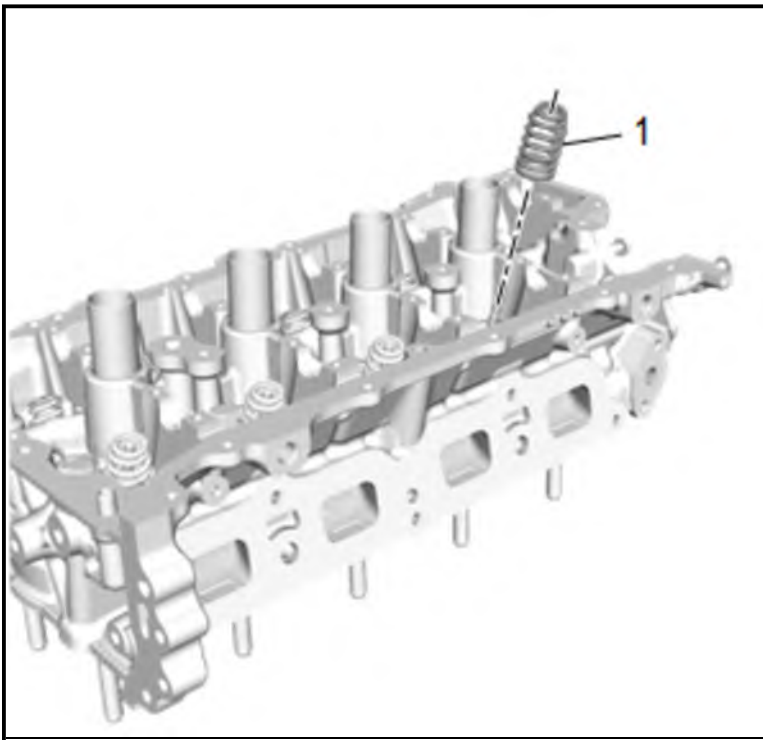
CAUTION:

Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

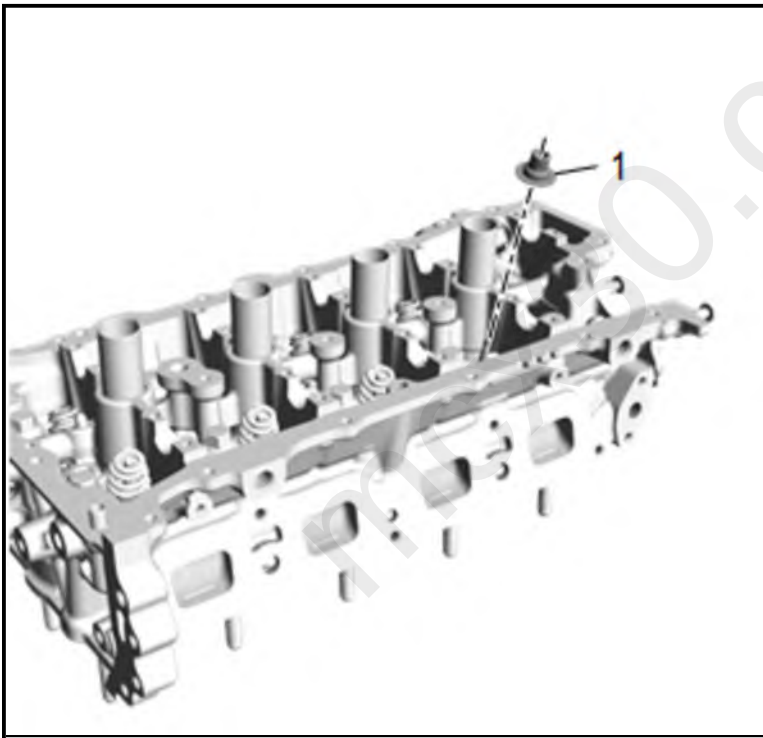
NOTE:

Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

1. Using the **EN-50717** fixture and the **EN-43963** compressor adapter, compress the valve spring.
2. Remove the valve keys (1).
3. Slowly release the compression from the valve spring assembly.
4. Remove the retainer (2).
4. Remove the springs (1).

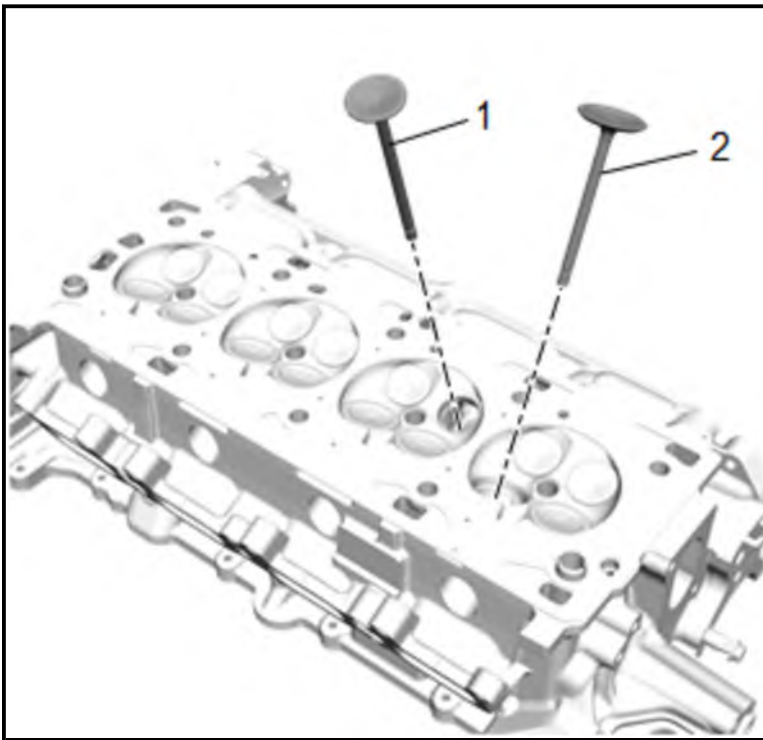


5. Using **EN-46116** remover, remove the valve seals (1). Discard the seals, do not reuse.

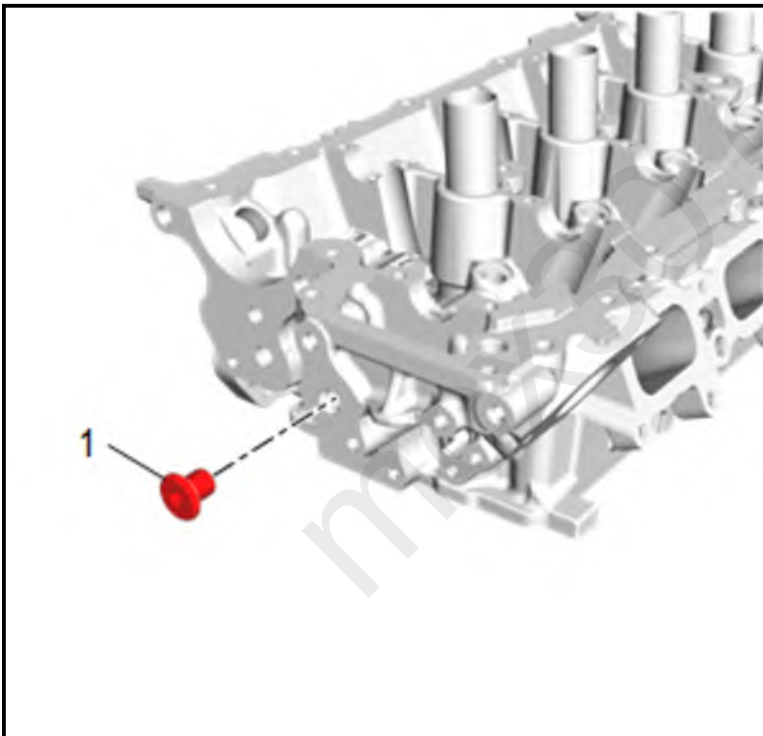


CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

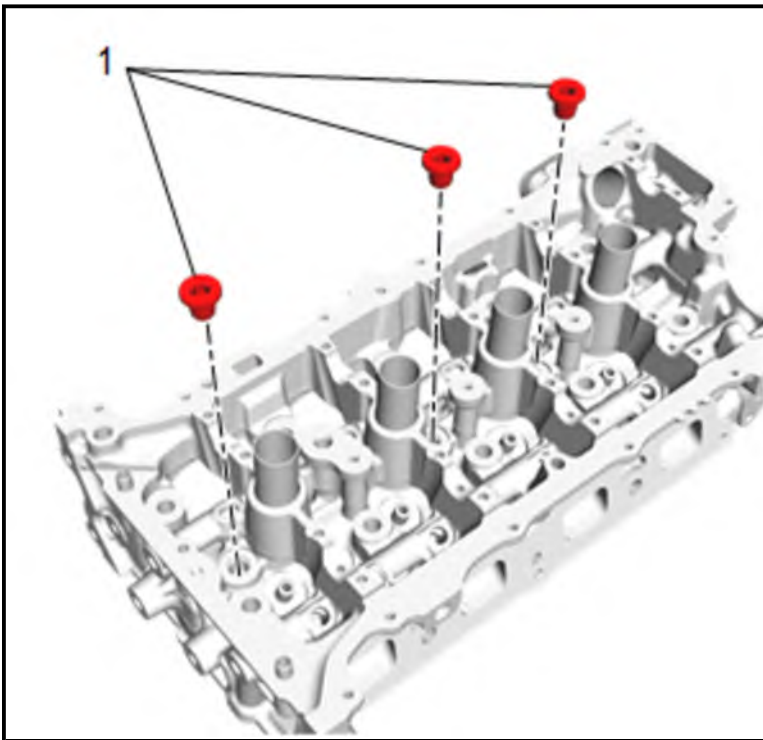
6. Remove the valves (1, 2).



7. Remove the cylinder head plug (1).



8. Remove the cylinder head plugs (1).



CYLINDER HEAD CLEANING AND INSPECTION

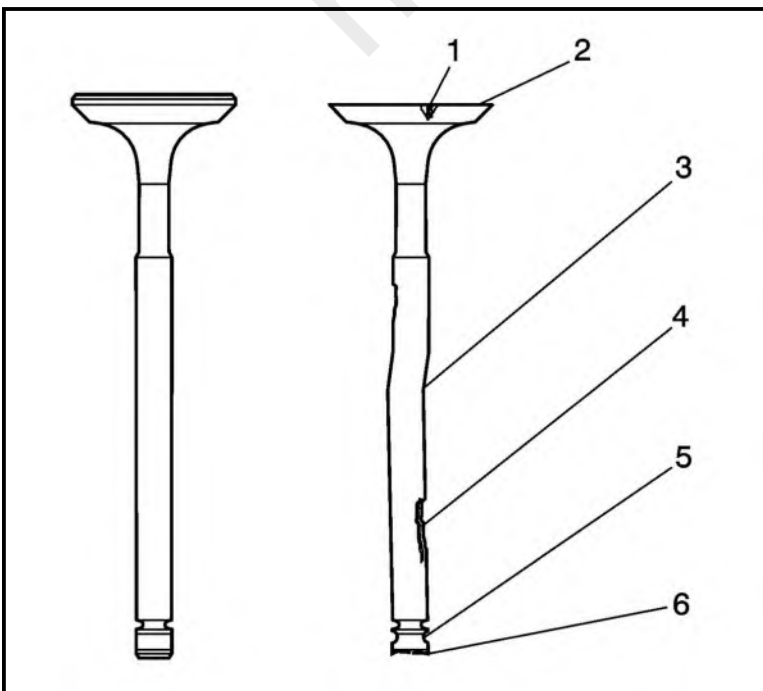
Special Tools

- EN 22738-B Valve Spring Tester
- EN-28410 Gasket Remover
- EN-39358 Spark Plug Socket
- GE 7872 Magnetic Base Dial Indicator

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

Valve Cleaning and Inspection

1. Clean the valves of carbon, oil and varnish. Use a soft bristle wire brush to clean any carbon build-up from the valve head. Varnish can be removed by soaking in Parts Immersion Solvent. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



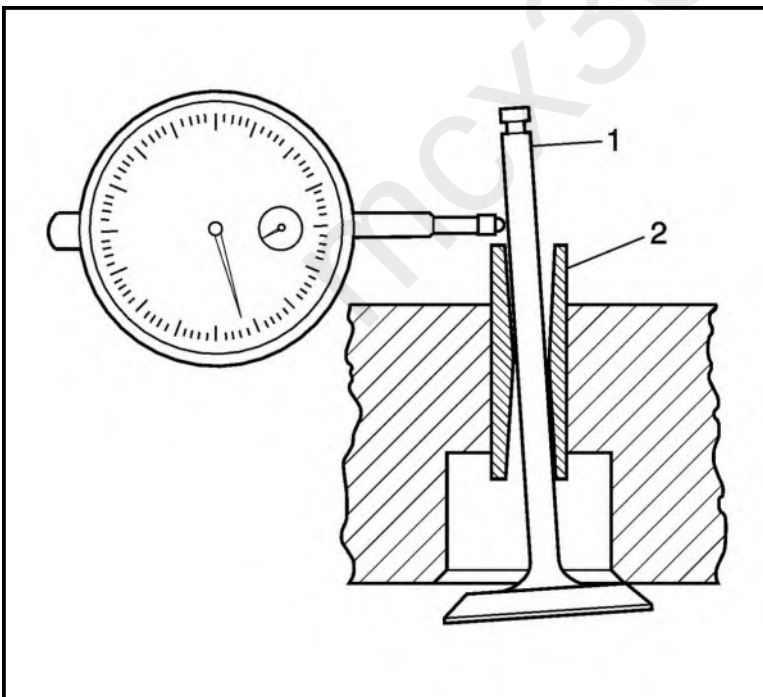
NOTE: Do not use a wire brush on any part of the valve stem.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

2. Clean the valve guides.
3. Inspect the valve stem for pitting or wear (4).
4. Inspect the valve key groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness (3) and the valve head for bending or distortion using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. Replace the valve if the valve head O.D. and chamfer (2) is worn or out of specification. Refer to [Valve and Seat Grinding](#).
11. The valves may be lightly lapped to the valve seats.
12. Replace the valve if the valve tip (6) is worn.
13. If no apparent wear, pitting, grooving, or distortion is present, perform the valve measurement and reconditioning procedure to verify valve specification. Refer to [Valve and Seat Grinding](#).

Valve Guide Measurement

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.



2. Clamp the **GE 7872** dial indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to [Engine Mechanical Specifications](#) for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

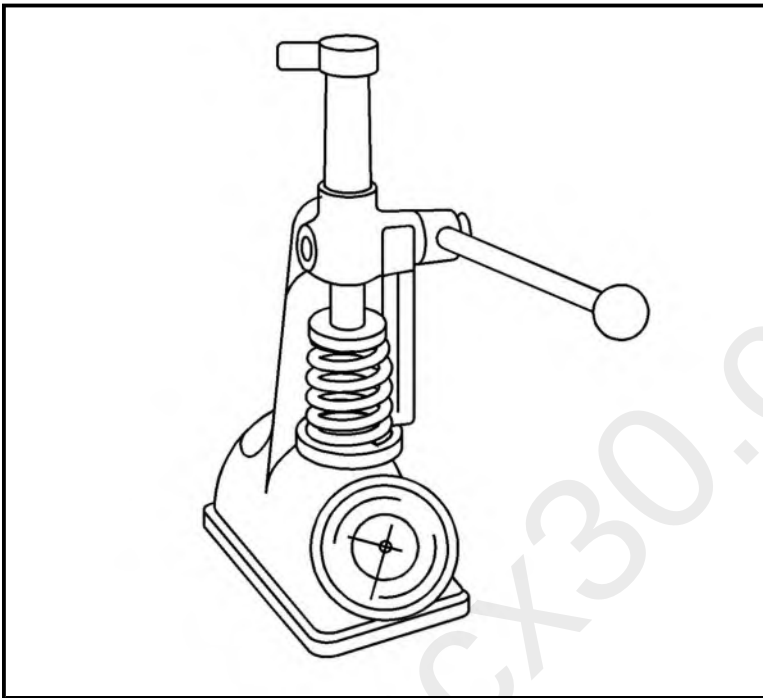
6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

1. Clean the valve springs in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

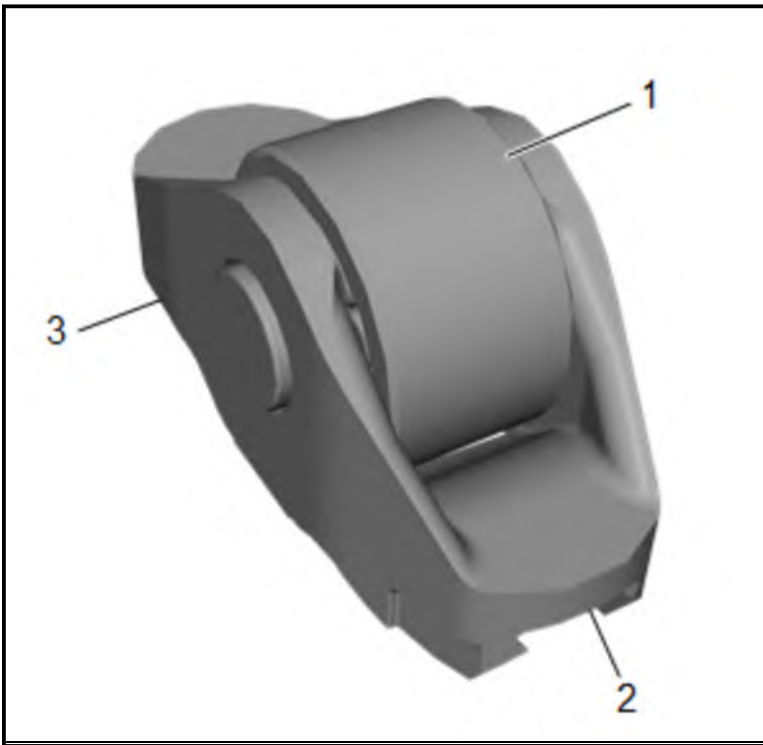
2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.
4. Measure the valve spring tension using the **EN 22738-B** tester. Refer to [Engine Mechanical Specifications](#)



5. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

Valve Rocker Arm Cleaning and Inspection

1. Inspect the camshaft follower roller (1) for the following:



- Flat spots
- Excessive scoring and pitting
- Ensure the roller spins freely

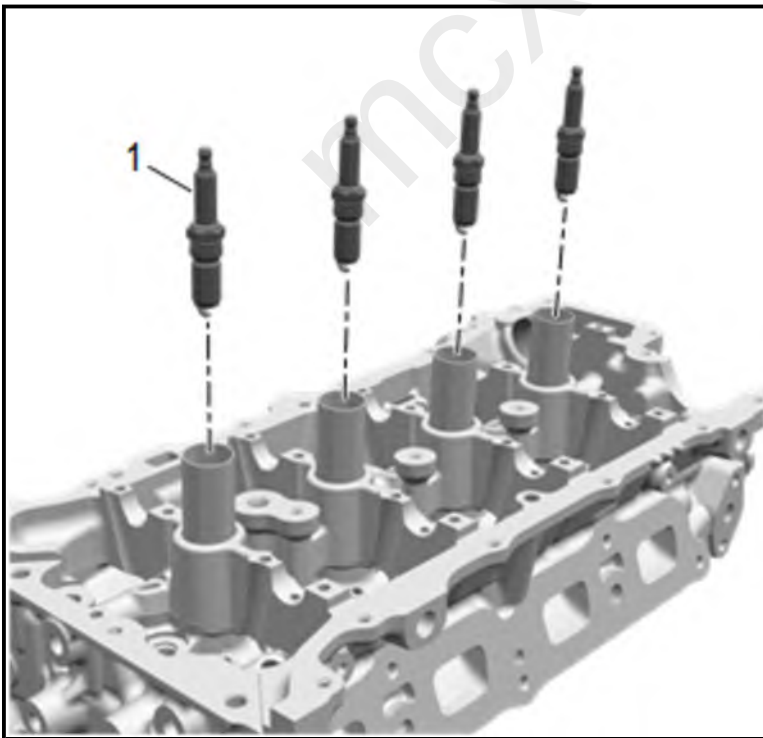
2. Inspect the camshaft follower valve tip area (2).

3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).

4. Replace the camshaft follower or followers as necessary.

Cylinder Head and Gasket Surface Cleaning and Inspection

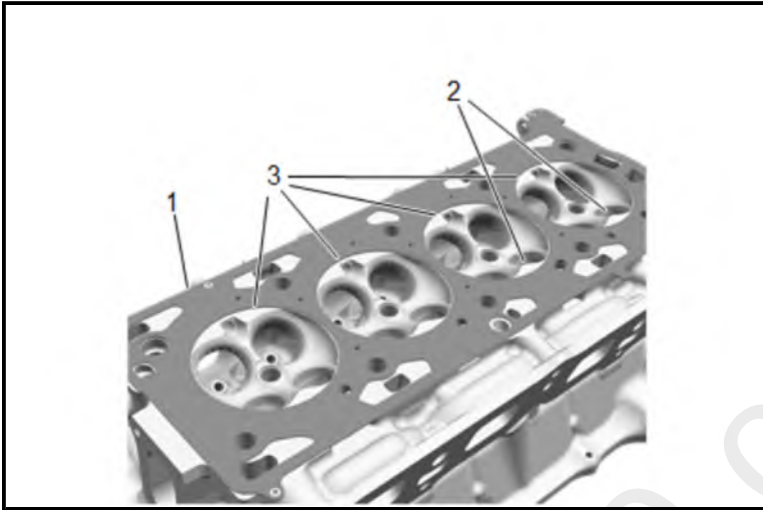
1. Remove the spark plugs (1) using **EN-39358** socket.



2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:

1. Improper installation

2. Loose or warped cylinder head
 3. Missing, off location or not fully seated dowel pins
 4. Corrosion in the seal area around the coolant passages
 5. Chips or debris in the cylinder head bolt holes
 6. Bolt holes in the cylinder block not drilled or tapped deep enough
3. Inspect the cylinder head gasket surface.
- Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
 - Replace the cylinder head if the area between the valve seats is cracked (2).
 - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).



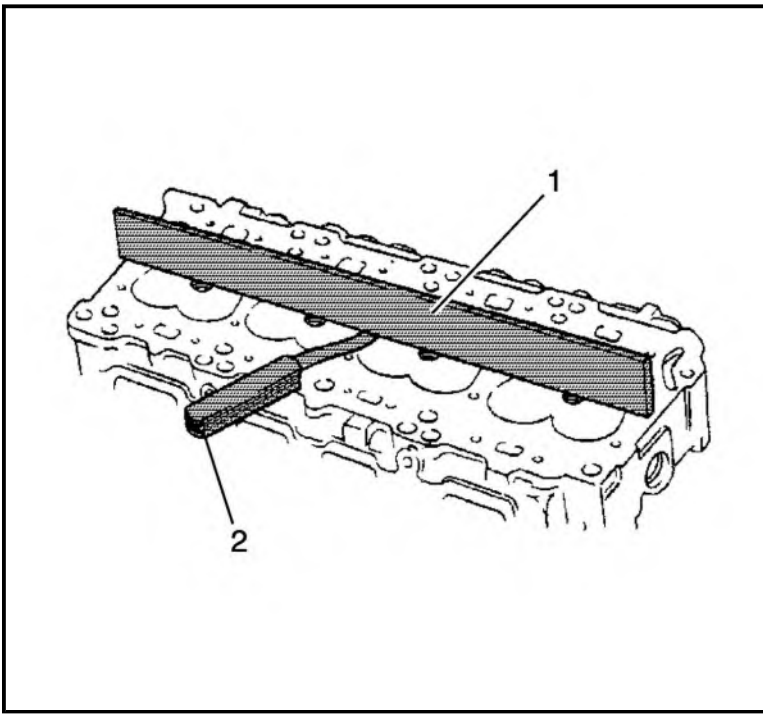
4. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

NOTE: Do not use a wire brush on any gasket sealing surface.

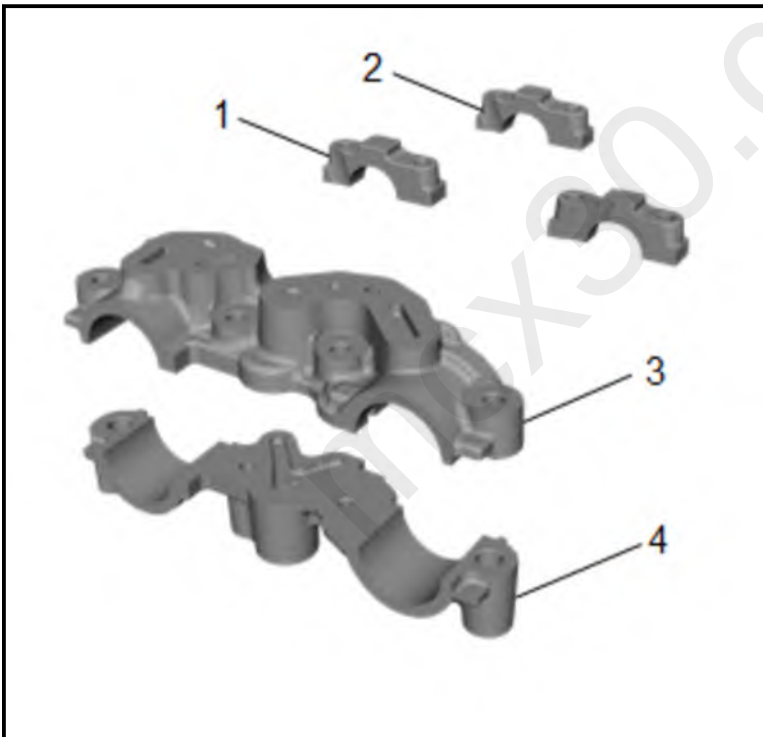
5. Remove the sealant from the rear cap mating surface with **EN-28410** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
6. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
7. Clean the valve guides.
8. Clean the threaded holes. Use a nylon bristle brush.
9. Clean the remains of the sealer from the plug holes.
10. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

NOTE: Do not attempt to weld the cylinder head, replace it.

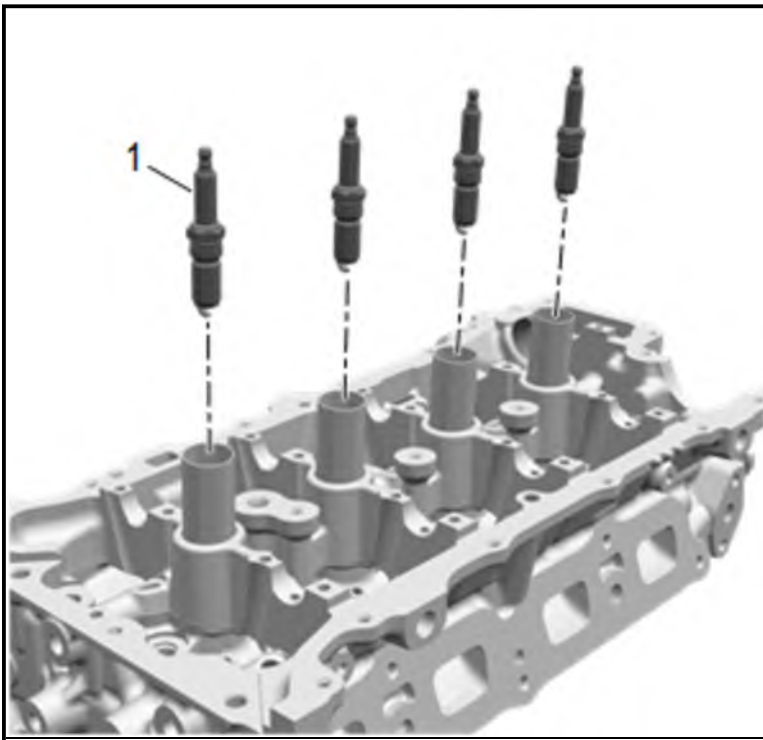
11. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.
12. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to [Engine Mechanical Specifications](#). If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.



13. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
14. Inspect the sealing surfaces.
15. Inspect the intake camshaft bearing rear cap (2) for damage.



16. Inspect the camshaft bearing caps (1) for damage.
17. Inspect the camshaft front upper and lower bearing caps (3, 4) for damage.
18. Install the spark plugs (1) using **EN-39358** socket. Tighten the plugs to 20 N.m (15 lb ft).



CAUTION: Refer to [Component Fastener Tightening Caution](#) .

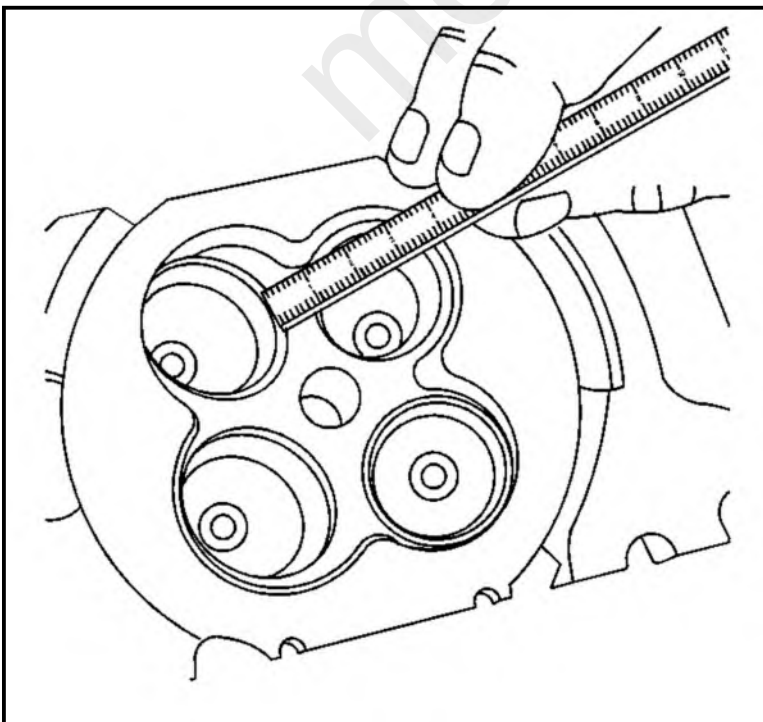
VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

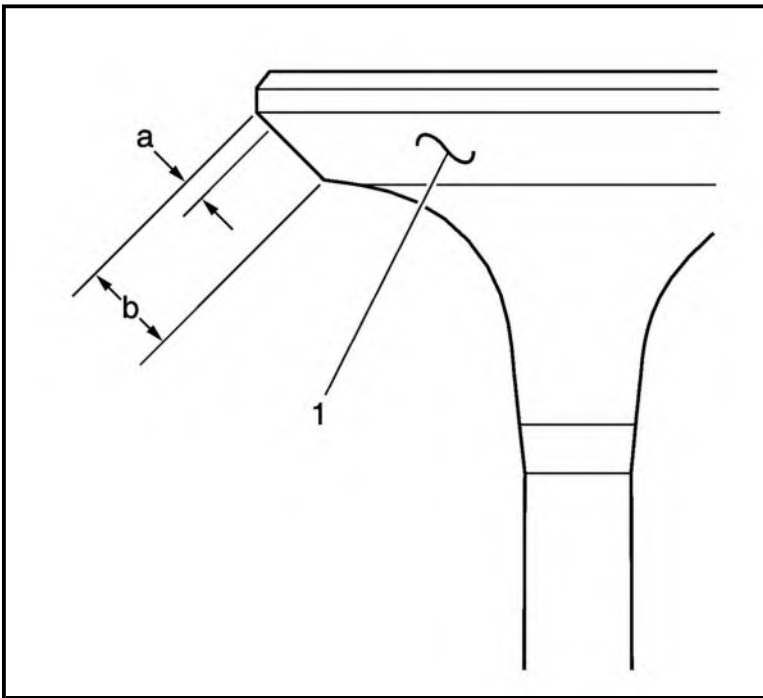
- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure

1. Measure the valve seat width in the cylinder head using a proper scale.



2. Measure the seat width (b) on the valve face (1) using a proper scale.



NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

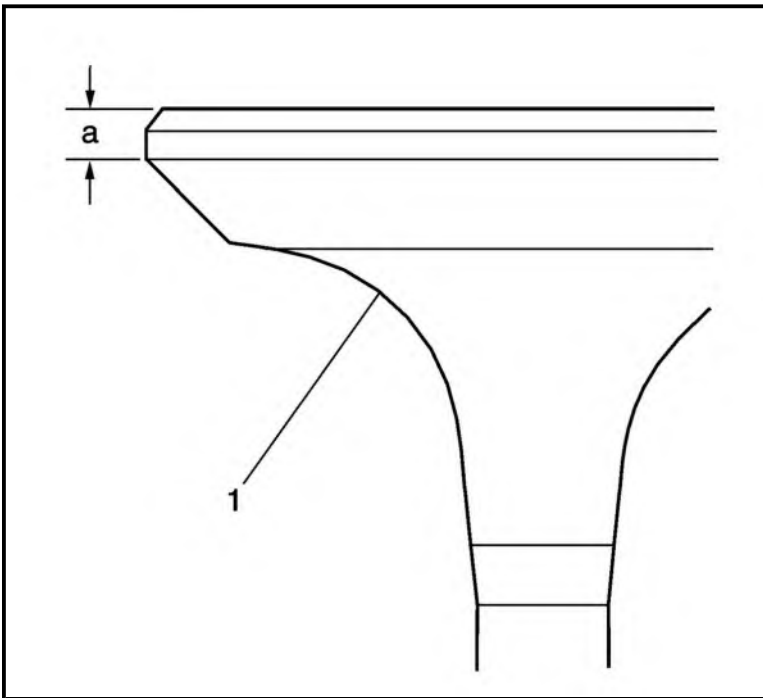
1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Head O.D. and Chamfer Measurement Procedure

1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to [Engine Mechanical Specifications](#).



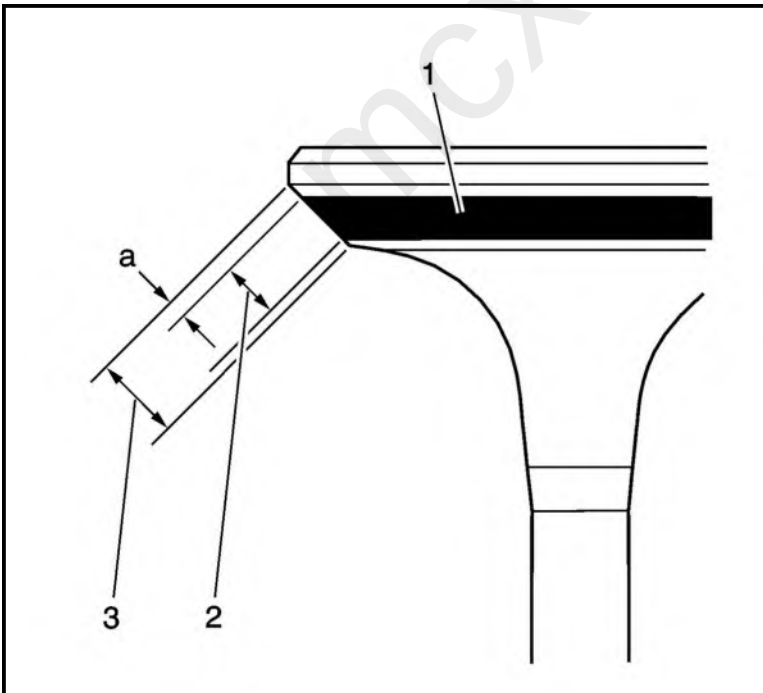
2. If the valve head O.D. and chamfer is within specification, test the valve (1) for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure. Reinspect the valve head O.D. and chamfer after completing the concentricity measurement if valve seat reconditioning is performed.

Valve-to-Seat Concentricity Measurement Procedure

NOTE:

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.

1. Coat the valve face (3) lightly with blue dye (1).



2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.

- If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

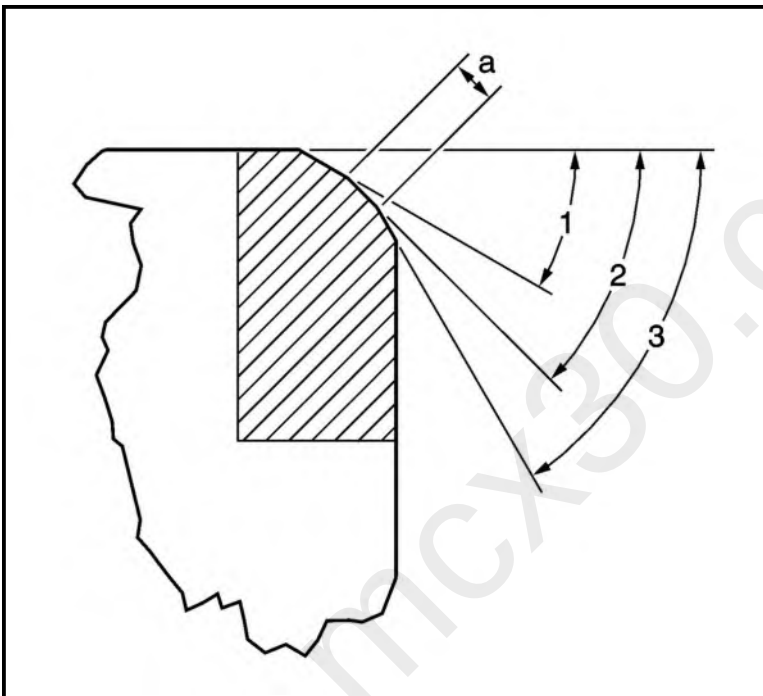
NOTE: The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

1. Grind the valve seating surface (a) to the proper angle specification (2) listed in [Engine Mechanical Specifications](#).



- NOTE:**
- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
 - It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

2. Grind the valve relief surface to the proper angle specification (1) listed in [Engine Mechanical Specifications](#), to correctly position the valve seating surface (a) to the valve.
3. Grind the valve undercut surface to the proper angle specification (3) listed in [Engine Mechanical Specifications](#), to narrow the valve seating surface width (a) to the specifications listed in [Engine Mechanical Specifications](#).

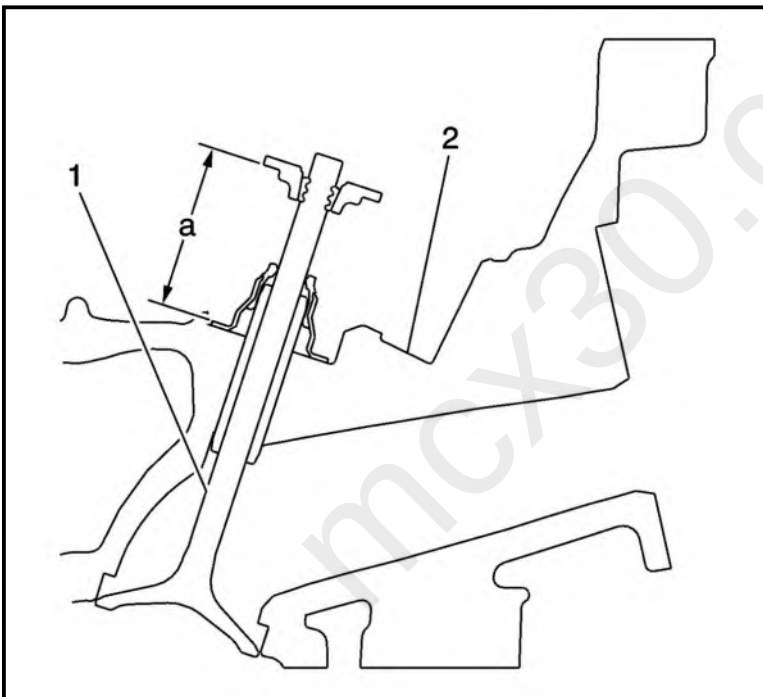
NOTE: Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.

4. Replace the intake valve if it is out of specification. Refer to [Engine Mechanical Specifications](#).

5. If the original exhaust valve is being used, grind the valve to the specifications listed in [Engine Mechanical Specifications](#). Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
 - If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.
 - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

1. Install the valve (1) into the valve guide in the cylinder head (2). Install the valve (1) into the valve guide in the cylinder head (2).



NOTE: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (a) between the valve seal lip to the bottom of the valve spring retainer. Refer to [Engine Mechanical Specifications](#).
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

CAUTION: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

CAUTION: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

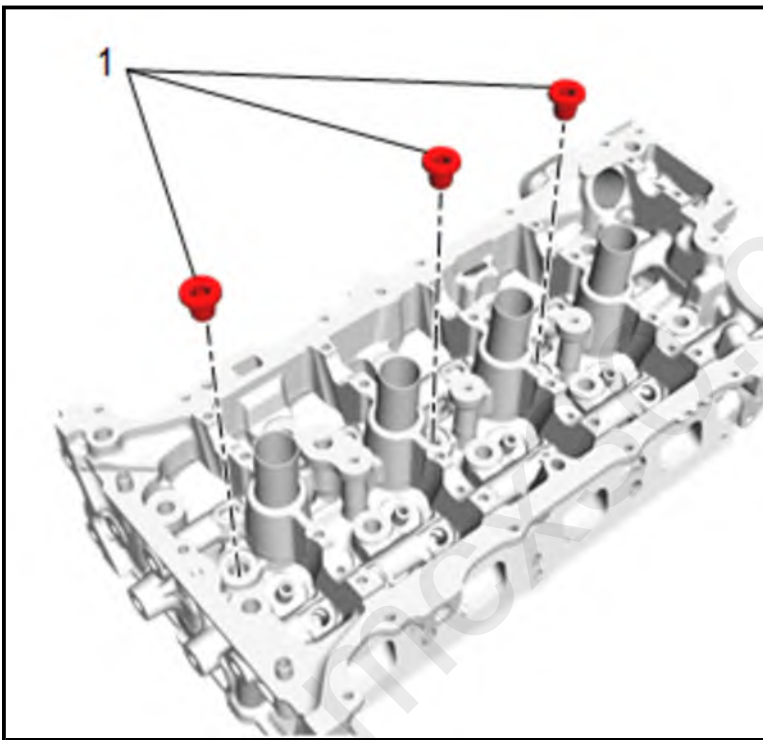
CYLINDER HEAD ASSEMBLE

Special Tools

- EN-50717 Valve Spring Compressor
- EN-9666 Valve Spring Tester
- EN-43963 Valve Spring Compressor (off car)

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

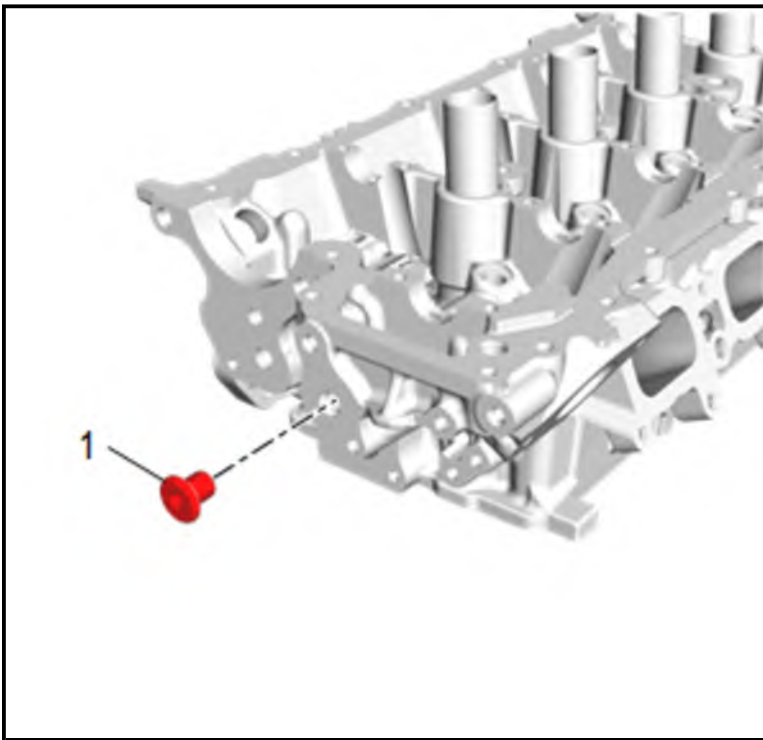
1. Install NEW cylinder head plugs. Coat the plugs with sealer. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



CAUTION: Refer to [Component Fastener Tightening Caution](#) .

CAUTION: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

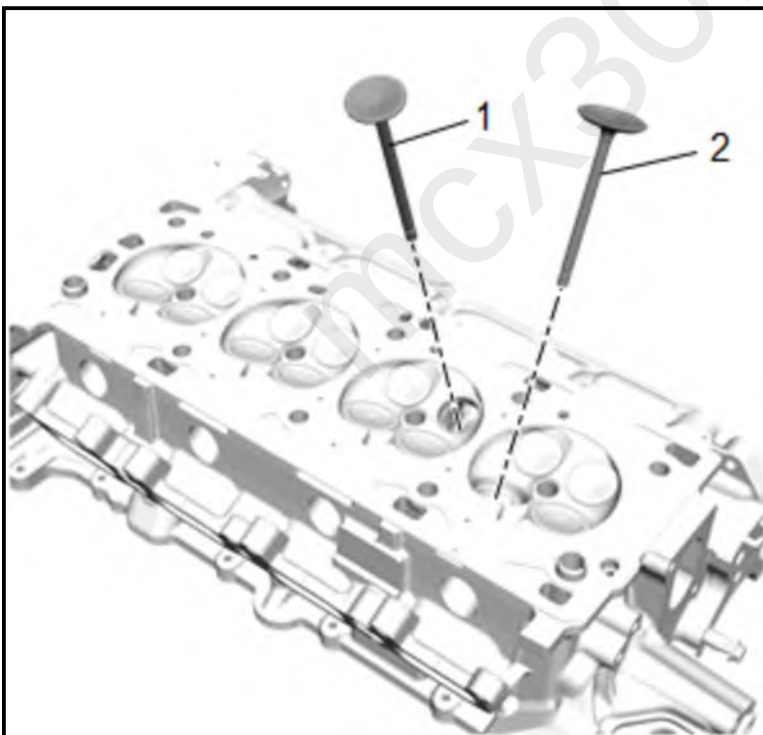
2. Install the water jacket hole plugs (1) in the top of the cylinder head. Tighten the plugs to 50 N.m (37 lb ft).
3. Install the oil gallery plug (1) in the rear of the cylinder head. Tighten the plug to 40 N.m (30 lb ft).



4. Inspect the valve springs for the following conditions:

- Expanded height
- Unparallel spring ends
- Spring tension using **EN-9666** tester
- Any distorted springs should be replaced

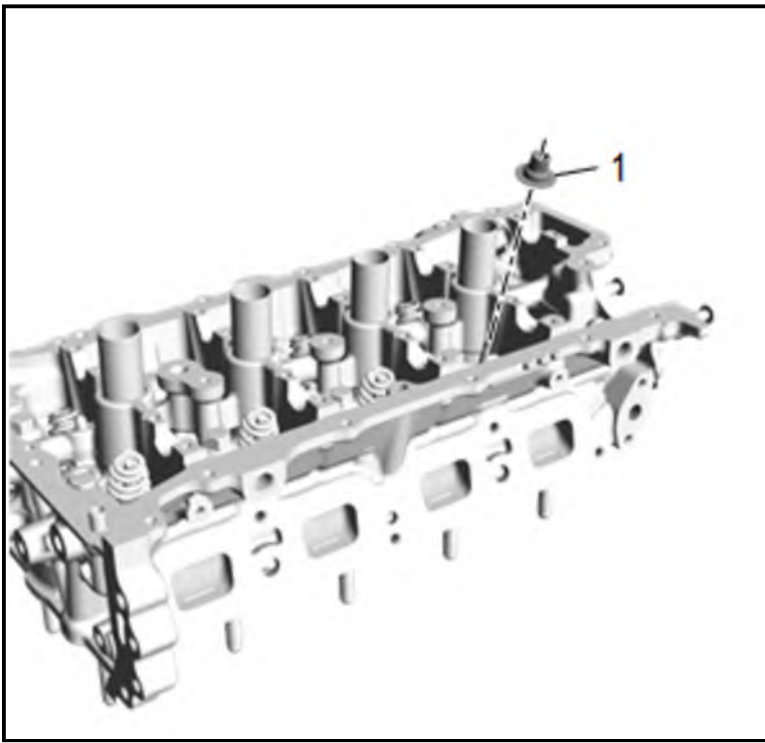
5. Inspect the valves and the valve seats. Refer to [Valve and Seat Grinding](#).



6. Lubricate the valves. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

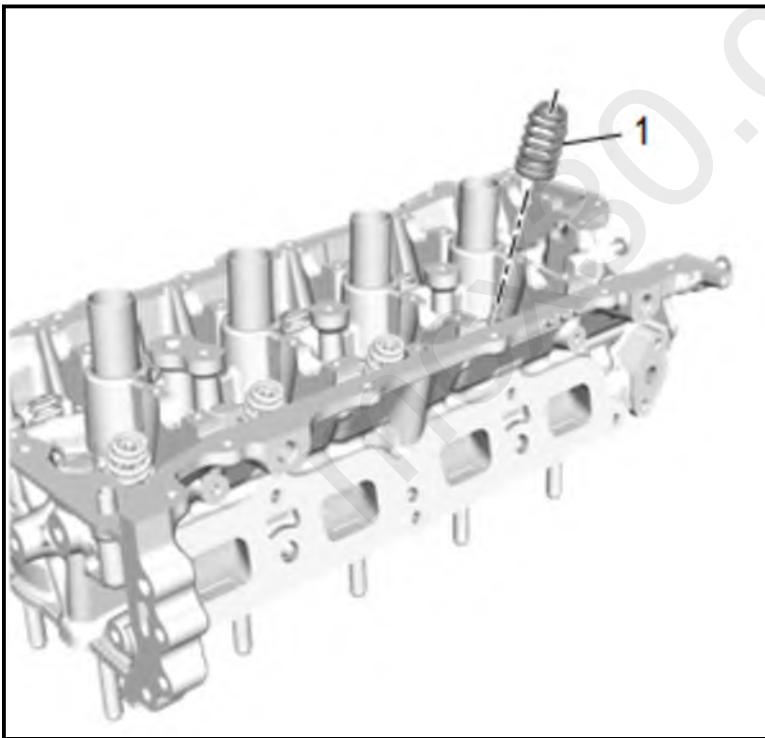
7. Install the valves (1, 2). Replace the valves, if required.

8. Install the NEW valve seals (1). Fully seat the seals on the valve guides.

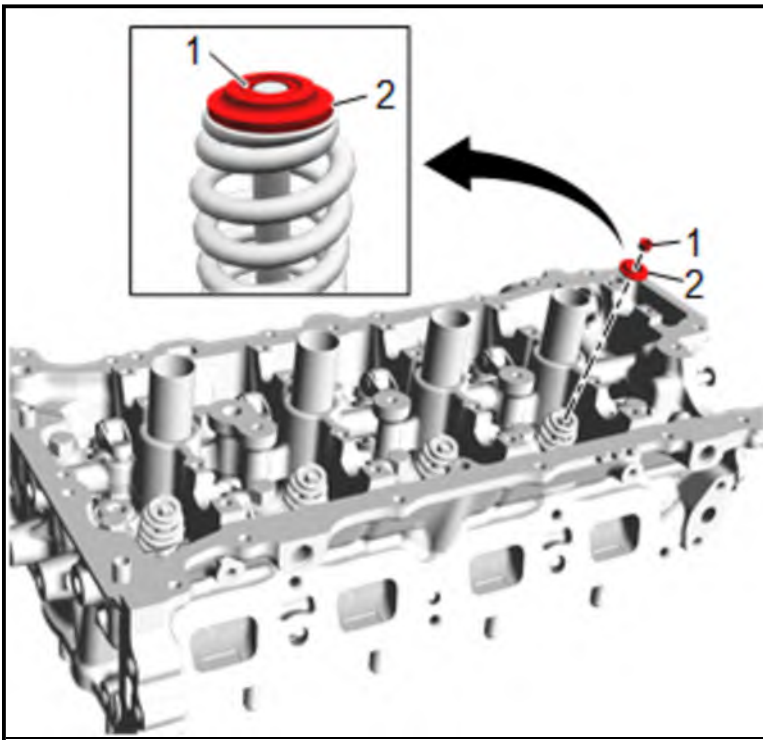


NOTE: Always use NEW valve stem oil seals when assembling the cylinder head.

9. Install the springs (1).



10. Install the retainers and keys using the following procedure:



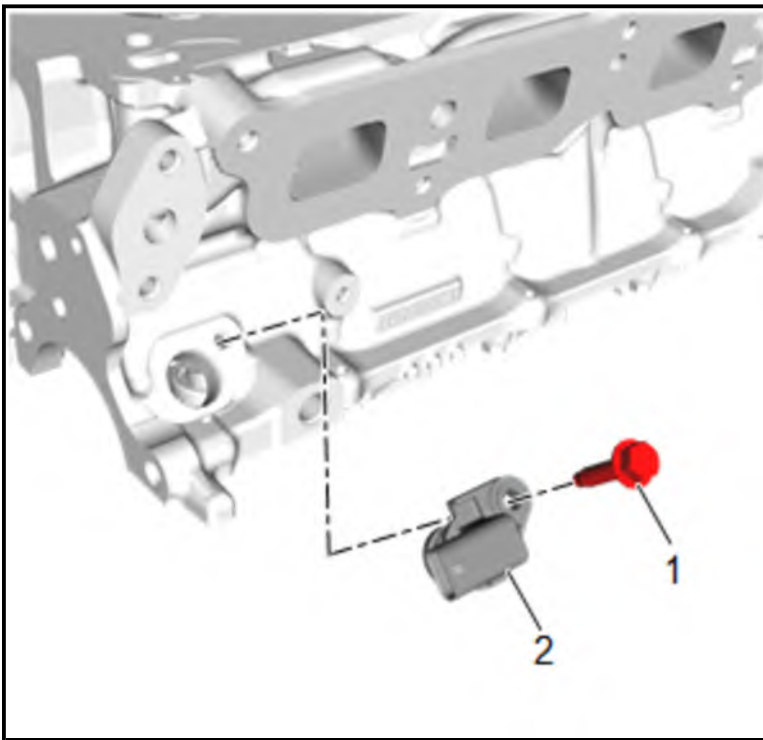
WARNING:

Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION:

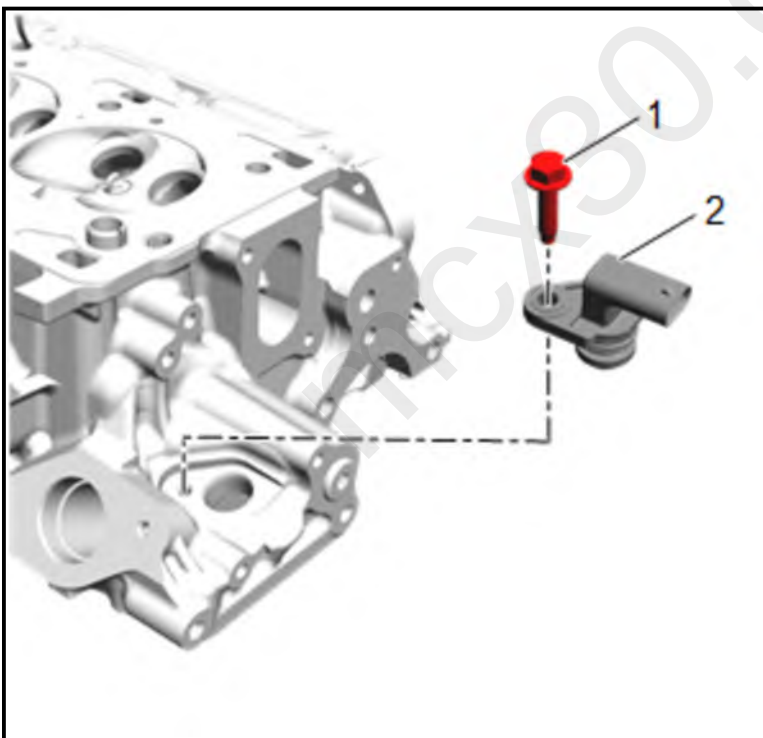
Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

1. Install the retainer (2).
 2. Using the **EN-50717** compressor and the **EN-43963** adapter, compress the valve spring.
 3. Install the valve keys (1).
 4. Slowly release the compression from the valve/spring assembly.
 5. Inspect for proper valve key seating.
11. Lubricate the camshaft position sensor O-ring with clean engine oil.



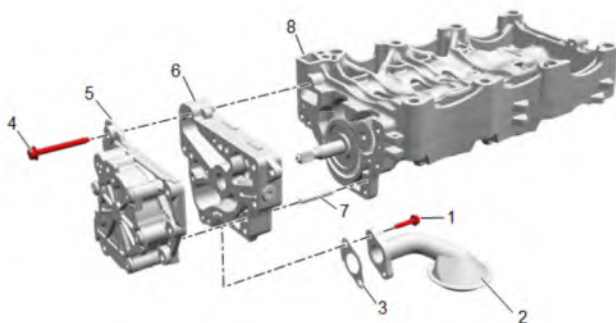
CAUTION: Refer to [Fastener Caution](#) .

12. Install the exhaust camshaft position sensor (2) and bolt (1). Tighten the bolt to 10 N.m (89 lb in).
13. Lubricate the camshaft position sensor O-ring with clean engine oil.



14. Install the intake camshaft position sensor (2) and bolt (1). Tighten the bolt to 10 N.m (89 lb in).

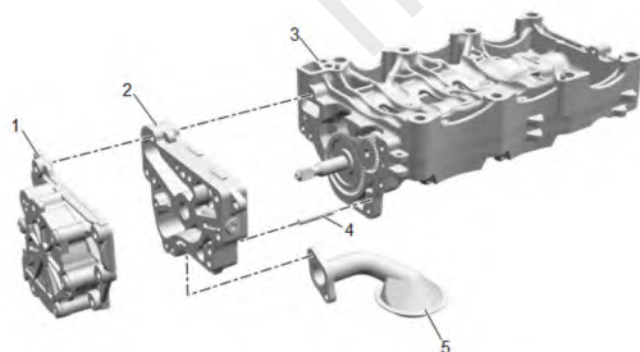
BALANCER SHAFT WITH OIL PUMP DISASSEMBLE



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Pump Suction Pipe Bolt
2	Oil Pump Screen Assembly with Suction Pipe
3	Oil Pump Screen Gasket NOTE: Discard the gasket.
4	Oil Pump Assembly Bolt
5	Oil Pump Assembly
6	Oil Pump Cover
7	Oil Pump Locating Pin
8	Balancer Shaft Module

BALANCER SHAFT WITH OIL PUMP CLEANING AND INSPECTION

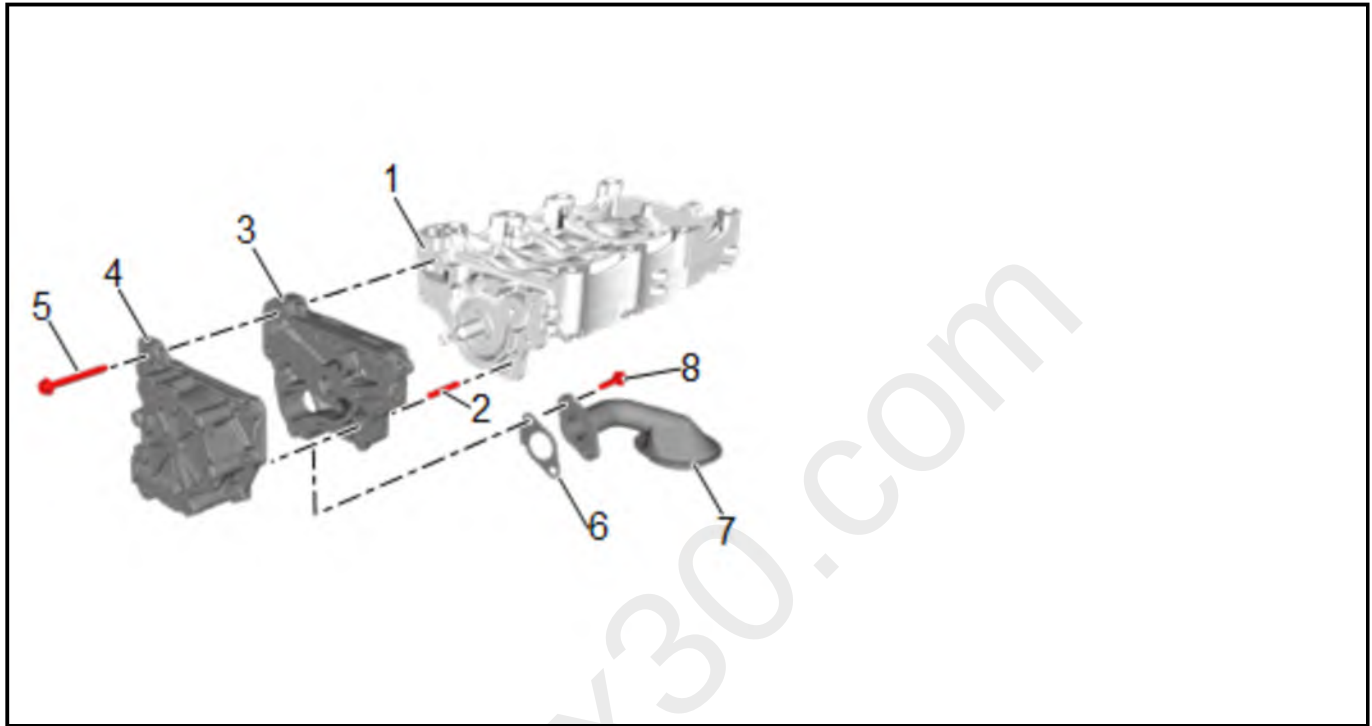


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures	
1. Completely inspect the balancer with oil pump shaft assembly and components. 2. Clean all mating surfaces.	

Callout	Component Name
3. Inspect all threaded holes for damage. 4. Inspect the oil pump screen assembly.	
1	Oil Pump Assembly
2	Oil Pump Cover
3	Balancer Shaft Module
4	Oil Pump Locating Pin
5	Oil Pump Screen Assembly with Suction Pipe

BALANCER SHAFT WITH OIL PUMP ASSEMBLE



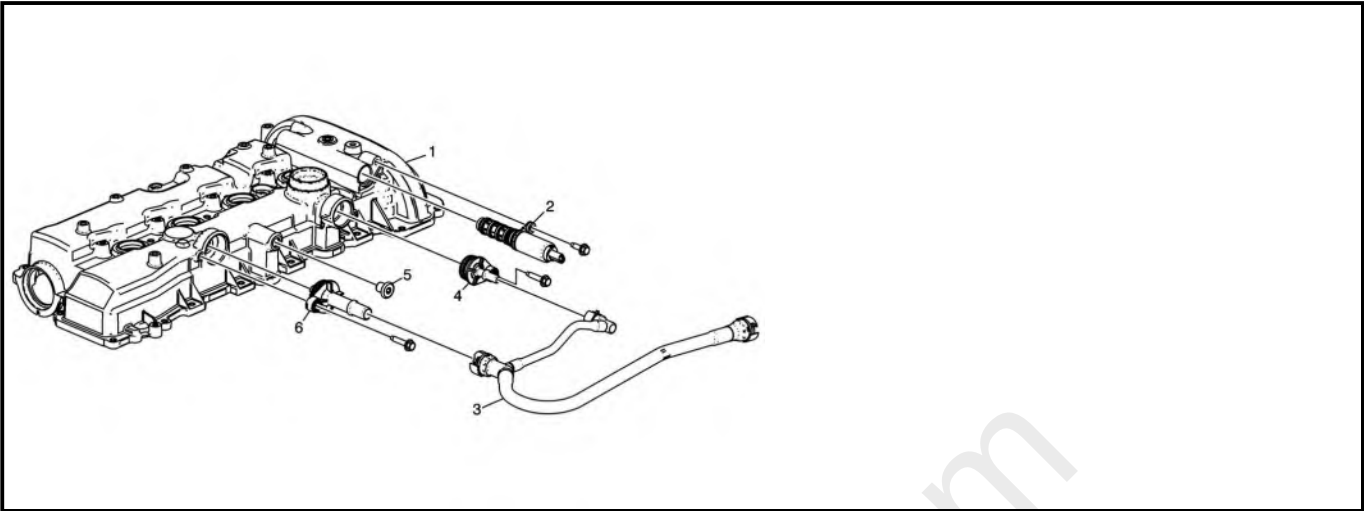
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Balancer Shaft Module
2	Oil Pump Locating Pin
3	Oil Pump Cover
4	Oil Pump Assembly
5	Oil Pump Assembly Bolt CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
6	Oil Pump Screen Gasket NOTE: Use NEW gasket.
7	Oil Pump Screen Assembly with Suction Pipe

Callout	Component Name
8	Oil Pump Suction Pipe Bolt Tighten 10 N.m (89 lb in)

CAMSHAFT COVER CLEANING AND INSPECTION

Camshaft Cover - Right Side

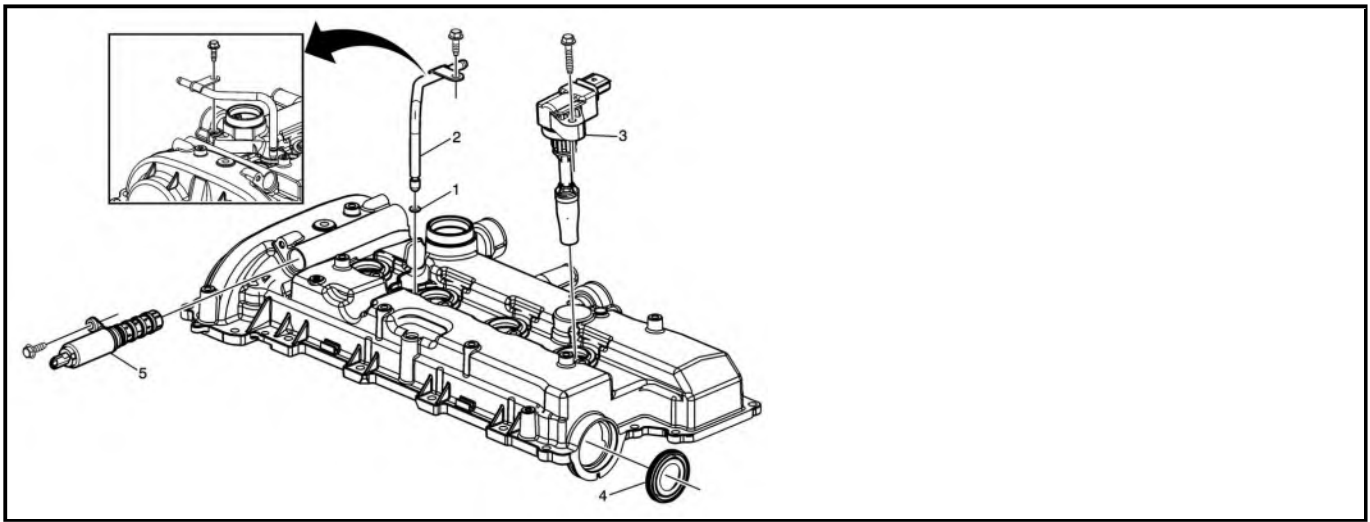


NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover - Right Side

Callout	Component Name
Preliminary Procedure 1. Thoroughly clean the camshaft cover and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u>	
1	Camshaft Cover
2	Camshaft Position Actuator Control Solenoid Valve - Intake
3	PCV Tube Assembly
4	PCV Valve
5	Camshaft Cover Plug
6	PCV Valve

Camshaft Cover - Left Side

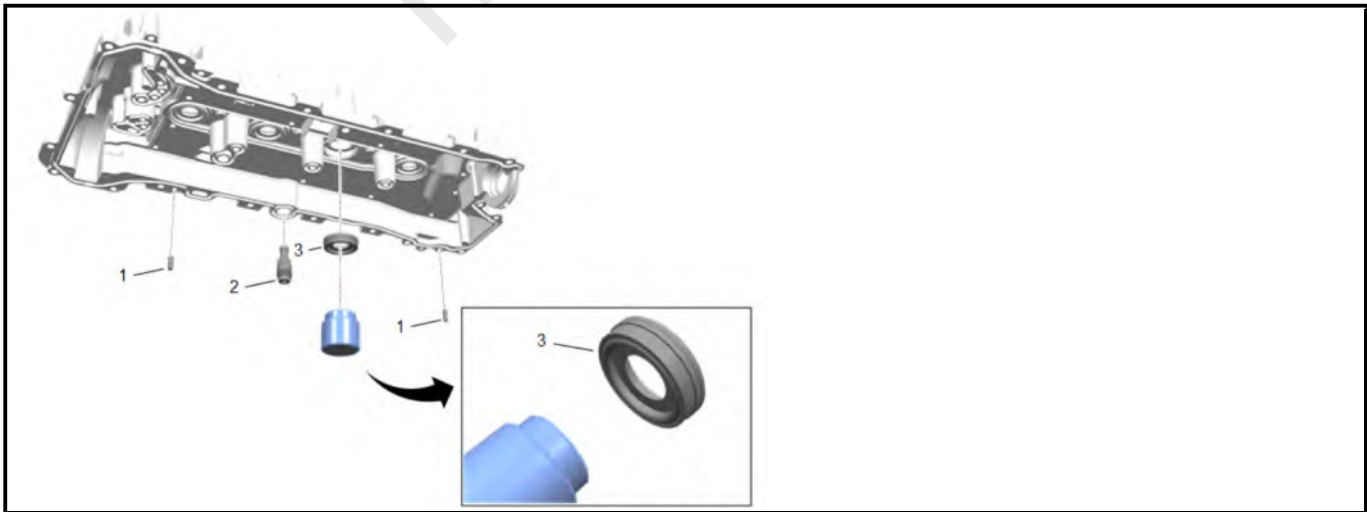


NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover - Left Side

Callout	Component Name
Preliminary Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Engine Coolant Air Bleed Pipe O-Ring
2	Engine Coolant Air Bleed Pipe NOTE: Component may vary by model.
3	Ignition Coil
4	Vacuum Pump Seal Special Tools DT 45866 Input Shaft Seal Installer For equivalent regional tools, refer to Special Tools .
5	Camshaft Position Actuator Control Solenoid Valve

Camshaft Cover - Bottom



NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover - Bottom

Callout	Component Name
Preliminary Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Camshaft Cover Locating Pin
2	Spark Plug Shield Seal Special Tools EN 34115 Sprocket Bearing Installer For equivalent regional tools, refer to Special Tools .

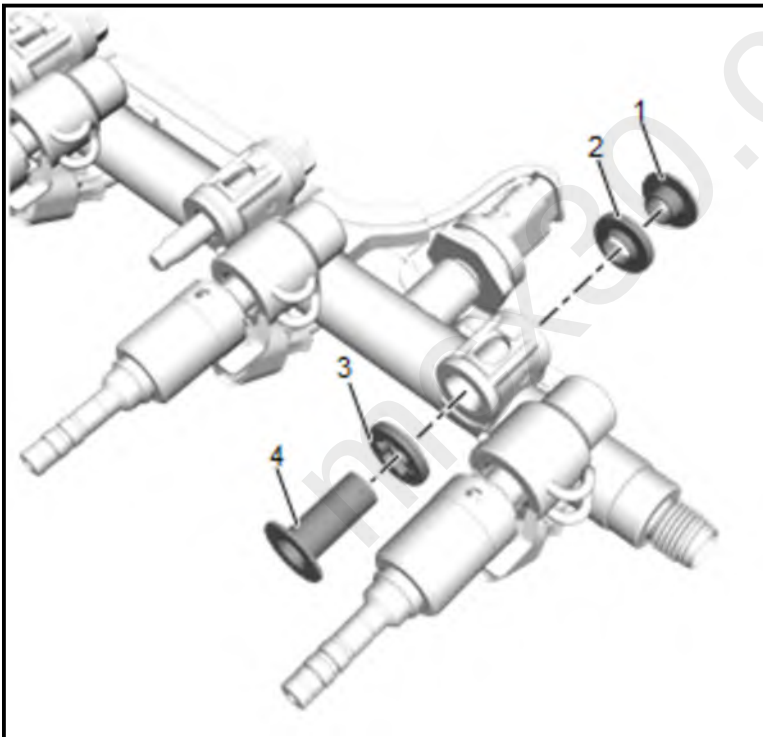
FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

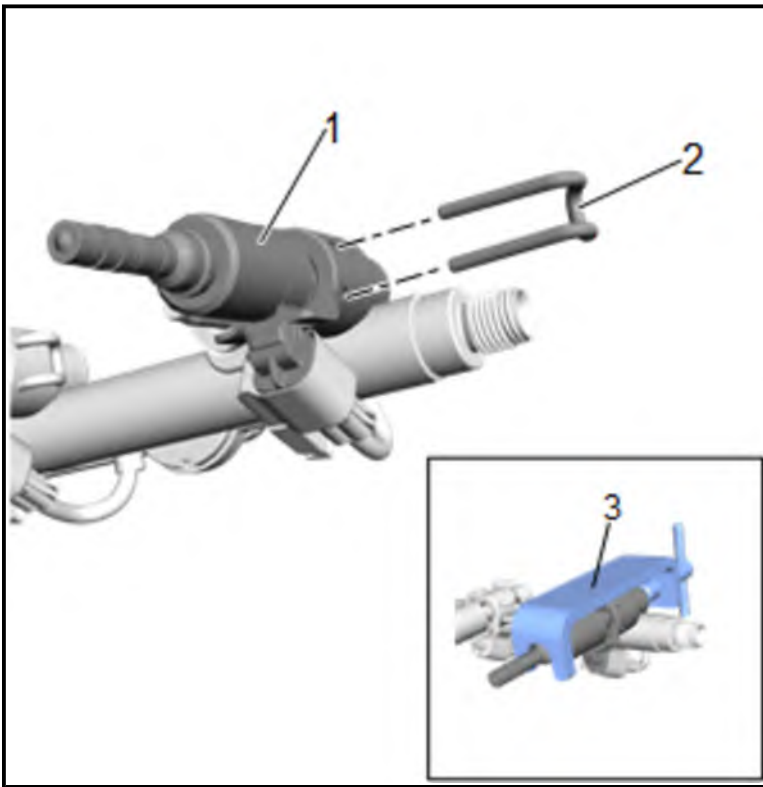
- EN-47909 Injector Bore and Sleeve Cleaning Kit
- EN-49245 Fuel Injector Seal Install/Sizer
- EN-50791 Fuel Injector Nozzle Installer
- EN-51105 Fuel Injector Seal Installer

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

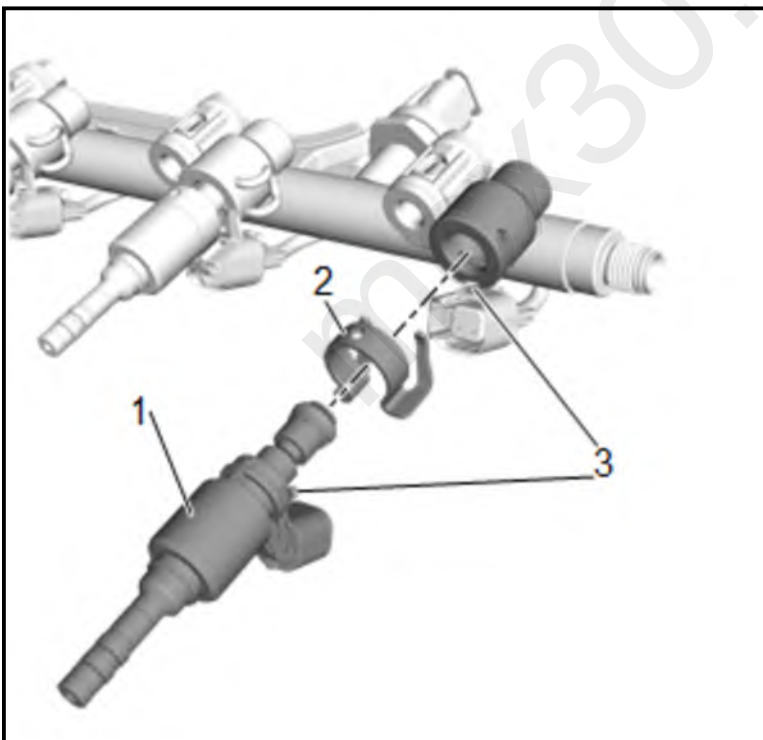
1. Remove and inspect the fuel rail insulator assemblies (1 - 4). Replace the entire assembly if any components show signs of wear or the insulators (4) show the following conditions:



- Dry or cracked appearance
 - Flattened or misshapen appearance
2. Disconnect the electrical connections from the fuel injectors.



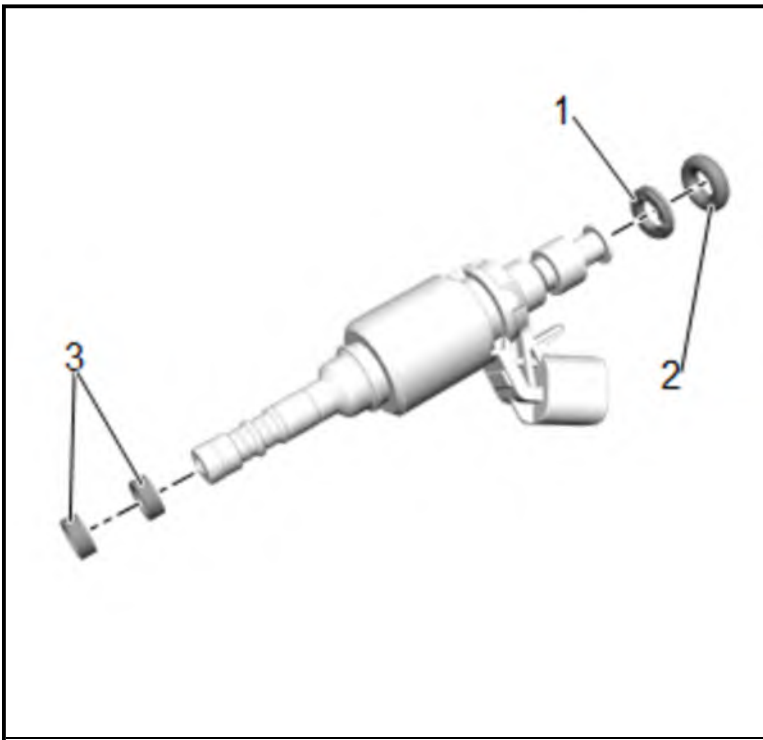
3. Use **EN-50791** installer (3) to compress the fuel injector (1), and relieve pressure on the retaining pin (2). Remove the fuel injector retaining pin (2). Remove **EN-50791** installer once the retaining pin is removed.
4. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable as long as excessive force is not applied to the fuel injector tab while engaged in the fuel rail slot (3).



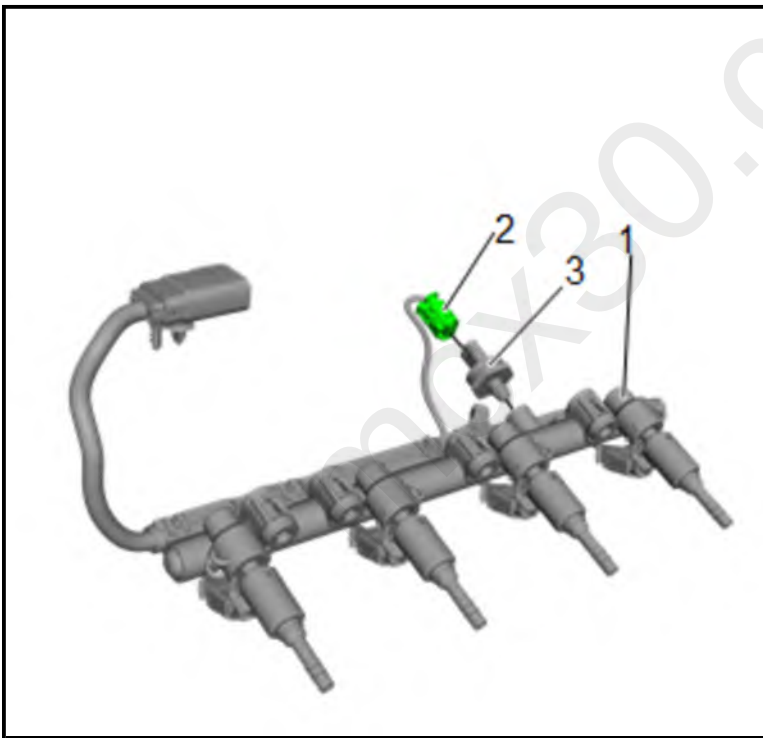
NOTE: Support the fuel injector at the widest point. Support the fuel rail along the bottom.

- **DO NOT** support or hold the fuel injector by the tip or connector
- **DO NOT** tilt or excessively twist the injector during removal

5. Remove the fuel injector holding clamp (2) from the rear of the fuel injector.
6. Remove and discard the fuel injector O-ring (2) and plastic spacer (1).



7. Remove and discard the fuel injector seals (3).
8. Clean the exterior of the fuel rail (1) and injectors in solvent.



NOTE: Do not soak or submerge the fuel rail or injectors in solvent. Do not use solvent on the fuel rail label.

9. Using **EN-47909** cleaning kit, clean the fuel injector bores and sleeves.
10. Inspect the fuel rail and components for the following conditions:
 - Damage, debris, or restrictions to the fuel rail
 - Damage, debris, or restrictions to the fuel ports in the fuel rail
 - Damage to the mounting area for the fuel rail
 - Damage to the fuel rail mounting bolts
 - Damage to the threads on the fuel rail fuel feed fitting
11. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

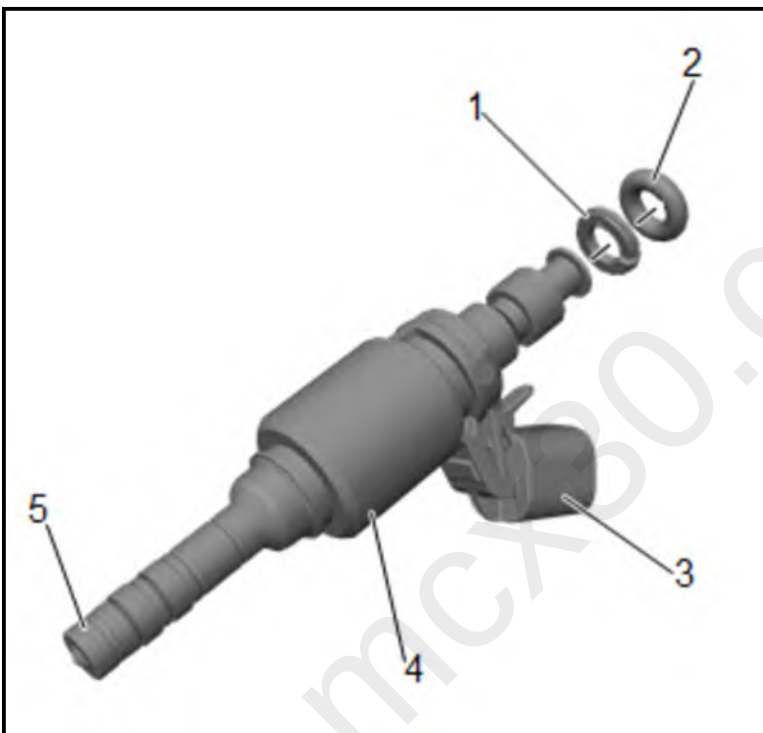
CAUTION: Refer to [Fastener Caution](#) .

NOTE: Remove and inspect the fuel pressure sensor only if the sensor is suspect.

12. Inspect the fuel pressure sensor (3) for damage.

1. Disconnect the harness connector (2) from the fuel pressure sensor.
2. Remove the fuel pressure sensor. Dry the fuel pressure sensor bore in the fuel rail with a lint free cloth. The bore should be free of fuel, debris, and burrs.
3. Lubricate the fuel rail fuel pressure sensor bore with clean engine oil.
4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
5. Install the fuel pressure sensor hand tight.
6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
7. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft).
8. Connect the harness connector to the fuel pressure sensor.

13. Inspect the fuel injectors for the following conditions:



- Damage to the fuel injector connector (3)
- Damage to the fuel injector harness connector
- Damage to the fuel injector tip (5)
- Damage to the fuel injector (4)

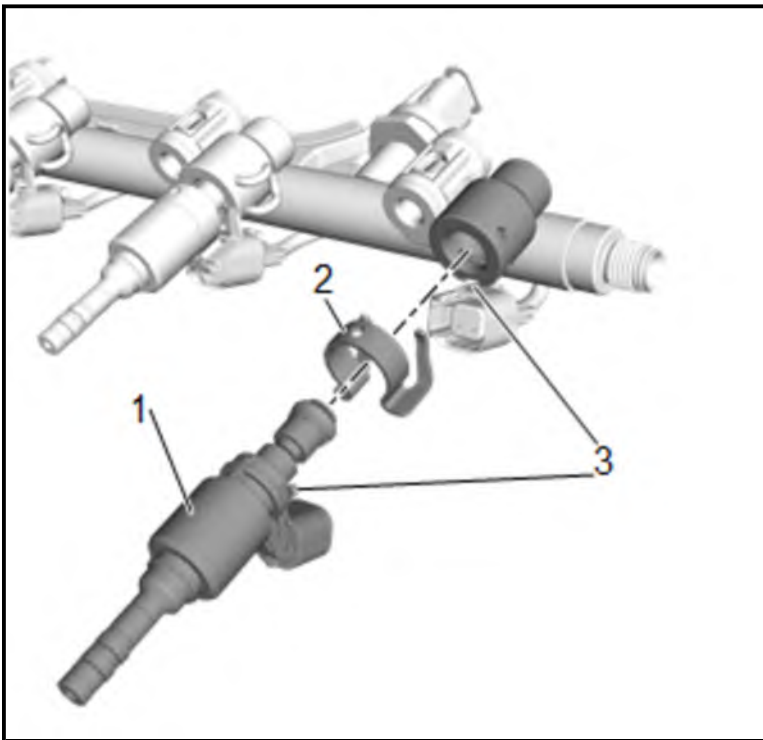
14. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.

15. Install the a new fuel injector spacer (1).

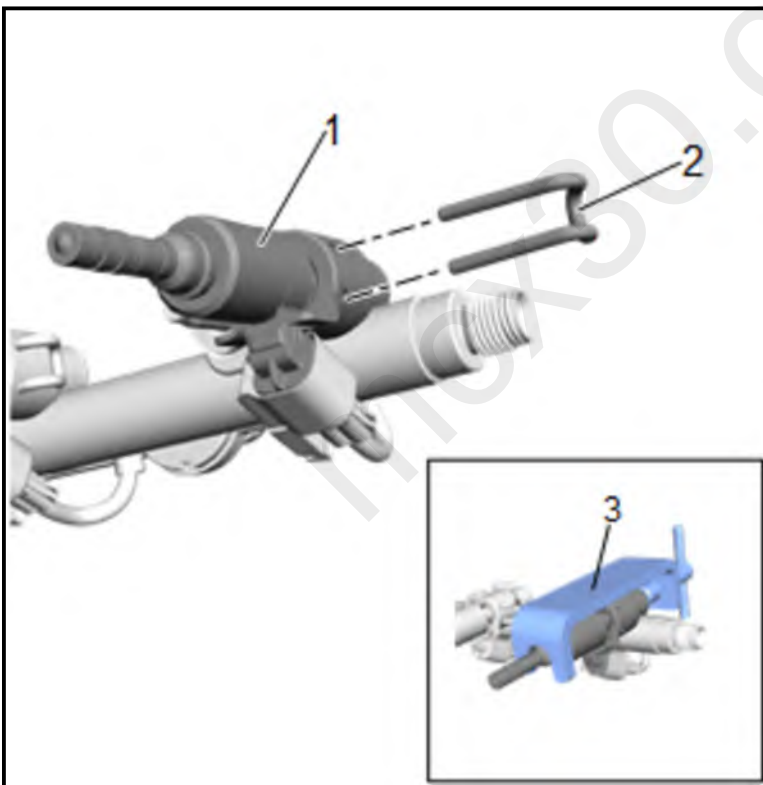
16. Lubricate the NEW O-ring (2) with one drop of clean engine oil.

17. Install the O-ring on the injector.

18. Install the fuel injector holding clamp (2) onto the rear of the fuel injector.

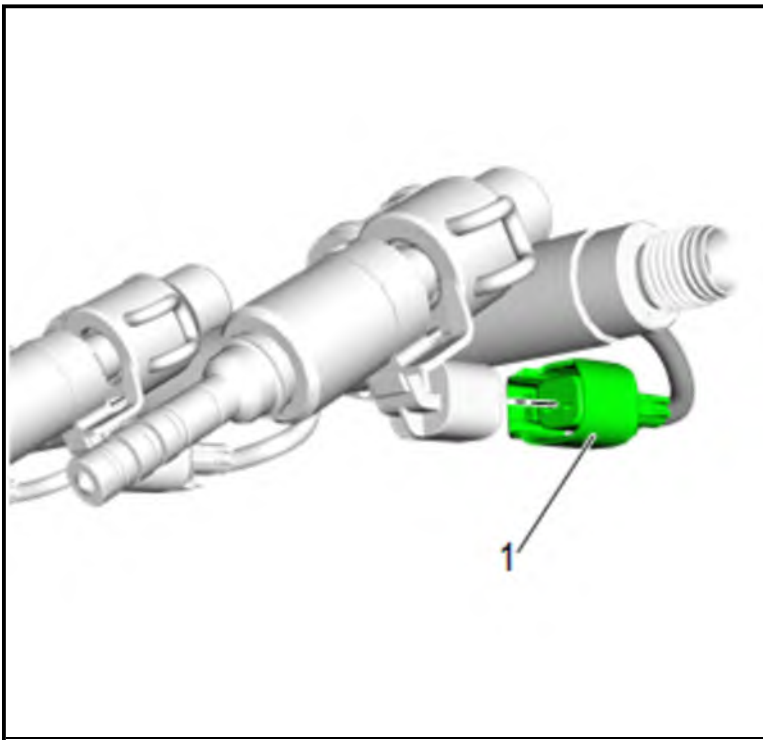


19. Hand install fuel injectors (1) to the fuel rail, carefully aligning the fuel injector tab to the slot in the fuel rail (3).
20. Using **EN-50791** installer (3), compress the fuel injector (1) into the fuel rail.

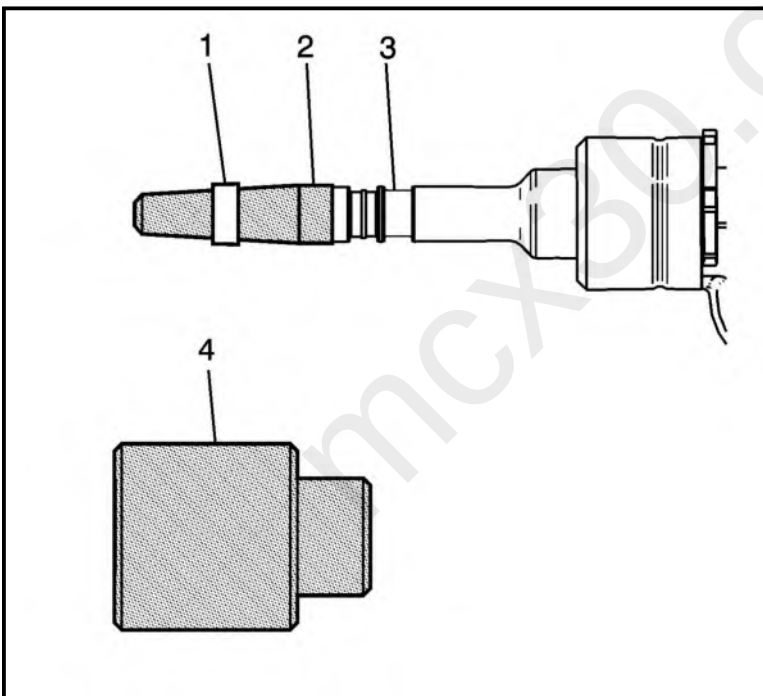


NOTE: The injector must be fully installed and properly aligned with the fuel rail before installing the retaining pin.

21. Ensure the fuel injector is fully seated in the fuel rail, and install the fuel injector retaining pin (4).
22. Ensure the fuel injector retaining pin is fully seated in the fuel rail. Remove **EN-50791** installer. Repeat process until all fuel injectors are properly installed to the fuel rail.
23. Connect the electrical connection to the fuel rail.



24. Connect the fuel rail harness connectors (1) to the fuel injectors.
25. Install **EN-51105-1** long protector (2) onto the fuel injector tip. Place a NEW seal (1) on **EN-51105-1** long protector.



NOTE: Do not use any type of lubricant when installing the NEW seals on the fuel injector tip.

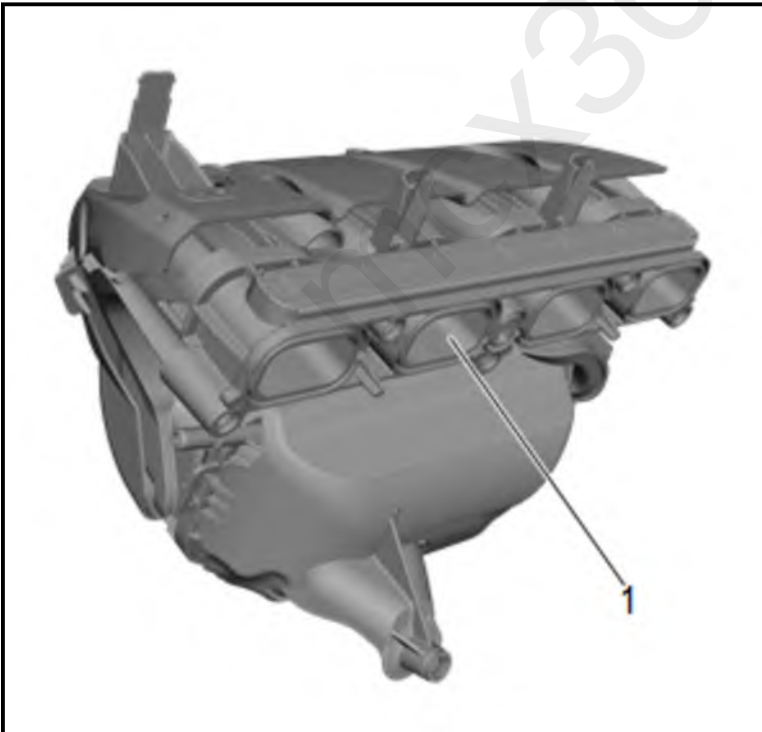
26. Using **EN-49245** pusher, install the seal into the second recessed area (3) of the fuel injector, then remove the **EN-51105-1** long protector.
27. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).
28. Install **EN-51105-2** short protector (2) onto the fuel injector tip. Place a second NEW seal (1) on **EN-51105-2** short protector.
29. Using **EN-49245** pusher, install the seal into the remaining recessed area of the fuel injector, then remove **EN-51105-2** short protector.
30. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).

INTAKE MANIFOLD CLEANING AND INSPECTION

1. Clean the intake manifold (1) mating surfaces.



2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.
4. Inspect the crankcase ventilation passages (1) in the intake manifold face for blockage.

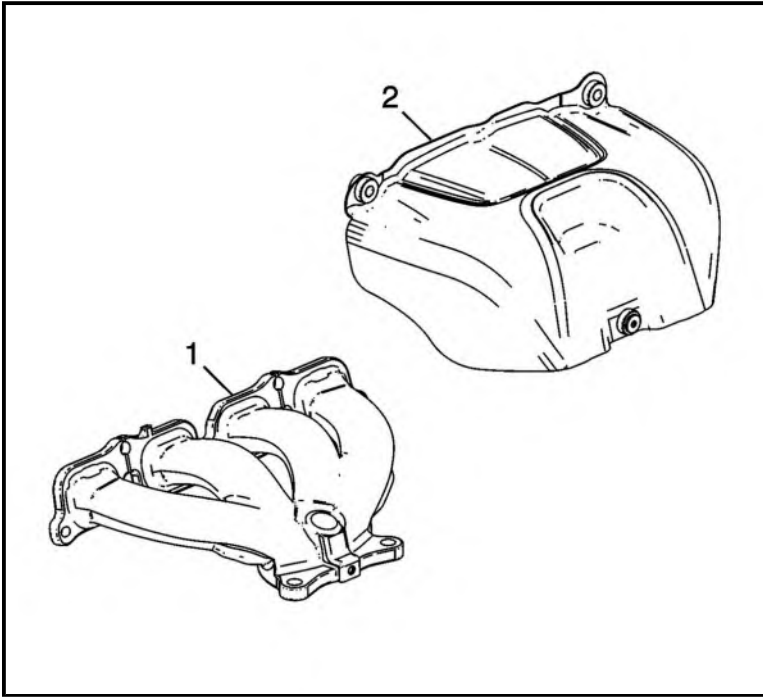


WARNING: Refer to [Safety Glasses Warning](#) .

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

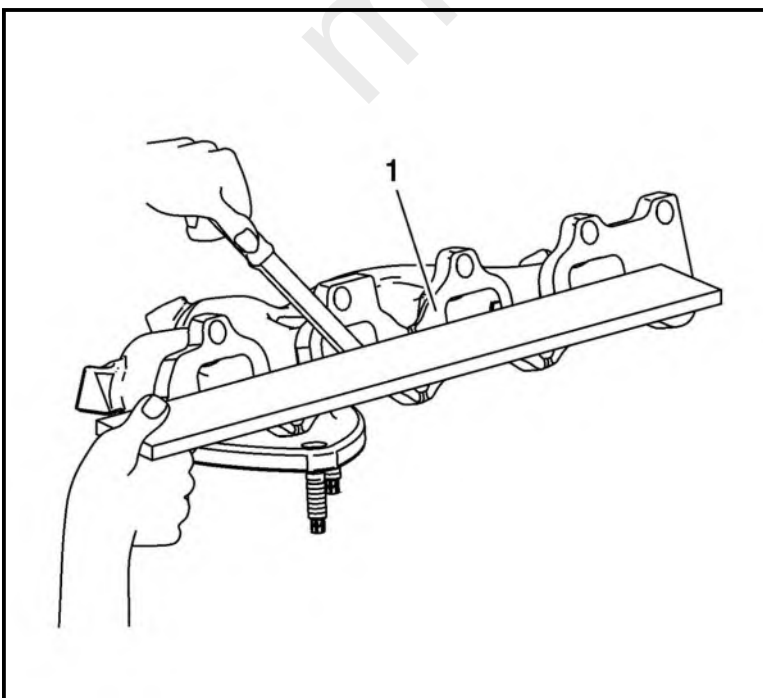
1. Clean the exhaust manifold (1) in solvent.



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

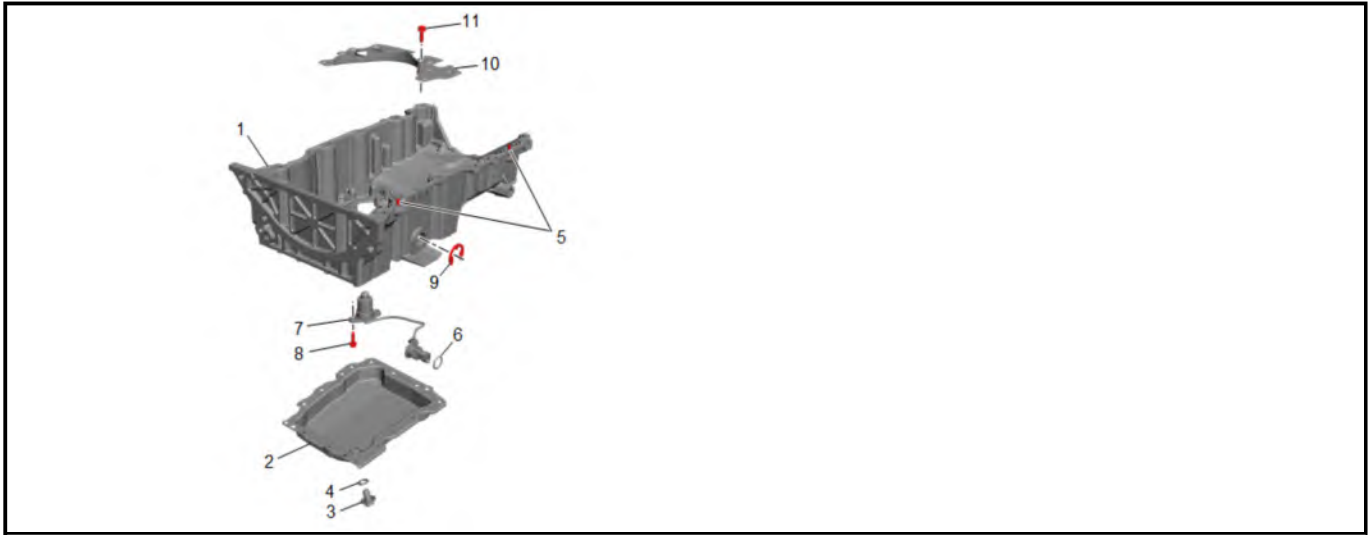
WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold (1) for damage.
4. Inspect the heat shield (2) for damage.
5. An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.



Use a straight edge and a feeler gauge and measure the exhaust manifold mounting face (1) for warpage.

OIL PAN CLEANING AND INSPECTION (2WD)



NOTE:

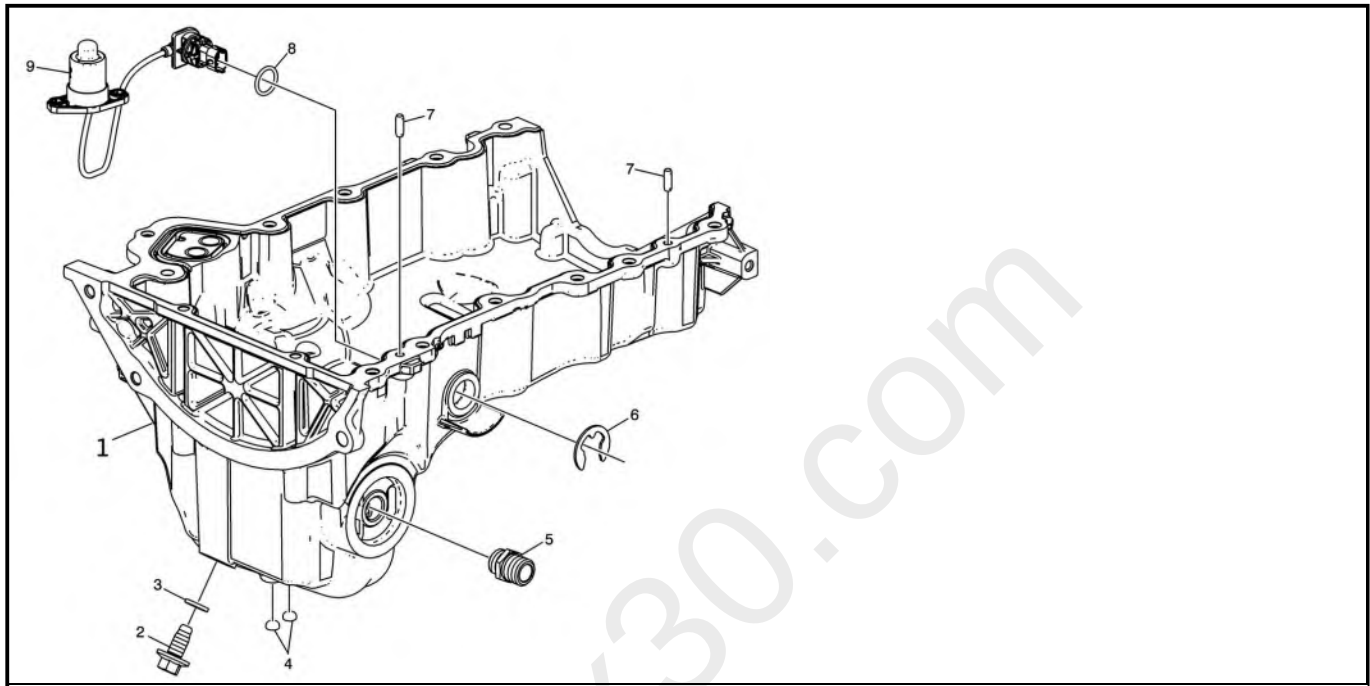
Callouts in the following chart represent components shown in graphic above.

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Callout	Component Name
Preliminary Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 2. Thoroughly clean the oil pans and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 3. Remove all sludge and oil deposits. 4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points. 5. Inspect the oil pan for cracking resulting from impact or flying road debris.	
1	Upper Oil Pan NOTE: Component may vary depending on model.
2	Lower Oil Pan NOTE: Component may vary depending on model.
3	Engine Oil Drain Plug
4	Engine Oil Drain Plug Washer NOTE: It is only necessary to replace the washer if inspection indicates damage is present.
5	Oil Pan Locating Pins NOTE: It is not necessary to remove the locating pins unless the inspection indicates replacement.
6	Engine Oil Level Indicator Switch O-ring Seal
7	Engine Oil Level Indicator Switch
8	Engine Oil Level Indicator Switch Bolt CAUTION: Refer to <u>Fastener Caution</u> .

Callout	Component Name
	Tighten 10 N.m (89 lb in)
9	Engine Oil Level Indicator Switch Connector Retainer
10	Oil Pan Baffle
11	Oil Pan Baffle Bolt Tighten 10 N.m (89 lb in)

OIL PAN CLEANING AND INSPECTION (4WD)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure	
1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Thoroughly clean the oil pan and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 3. Remove all sludge and oil deposits. 4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points. 5. Inspect the oil pan for cracking resulting from impact or flying road debris.	
1	Oil Pan
2	Oil Pan Drain Plug
3	Oil Pan Drain Plug Washer
	NOTE: It is only necessary to replace the washer if inspection indicates

Callout	Component Name
	damage is present.
4	Oil Gallery Plug (Qty: 2)
5	Oil Filter Fitting
6	Engine Oil Level Indicator Switch Connector Retainer
7	Oil Pan Locating Pins NOTE: It is not necessary to remove the locating pins unless the inspection indicates replacement.
8	Engine Oil Level Indicator Switch O-ring Seal
9	Engine Oil Level Indicator Switch

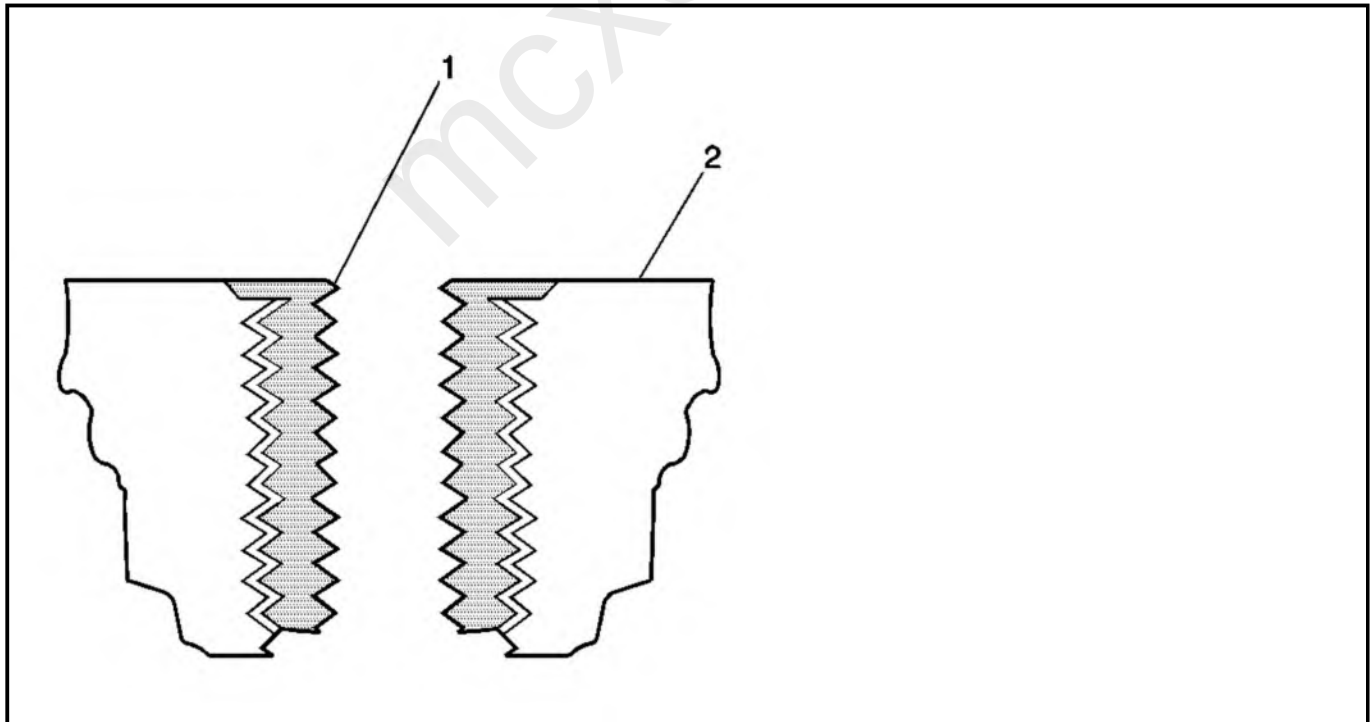
THREAD REPAIR

Special Tools

- EN 42385 - 700 High Feature Thread Repair Kit
- EN 42385 - 850 Thread Repair Kit
- EN 42385 - 880 Head Bolt Thread Repair Adapter Kit

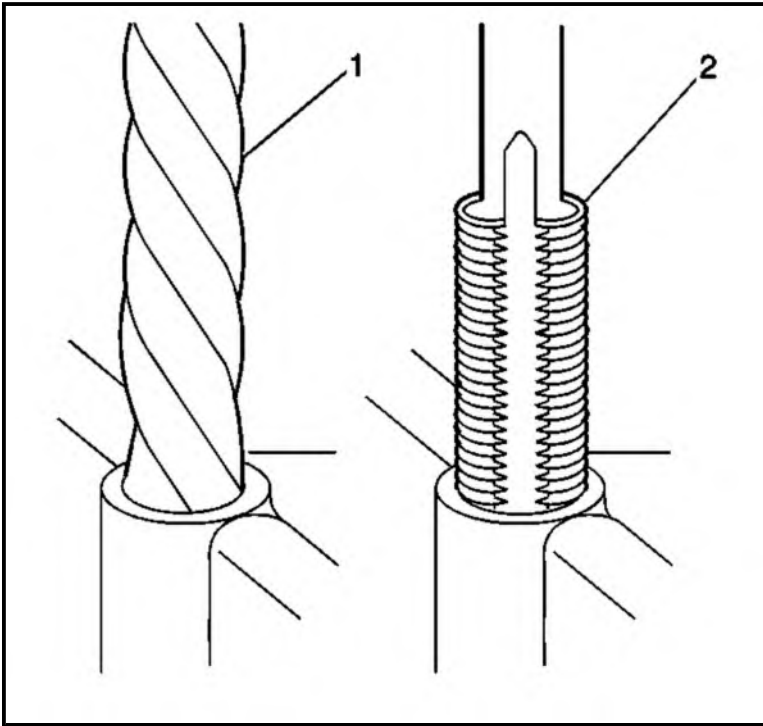
For equivalent regional tools, refer to [Special Tools](#).

General Thread Repair



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

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



NOTE:

The use of a cutting fluid, WD 40B®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

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

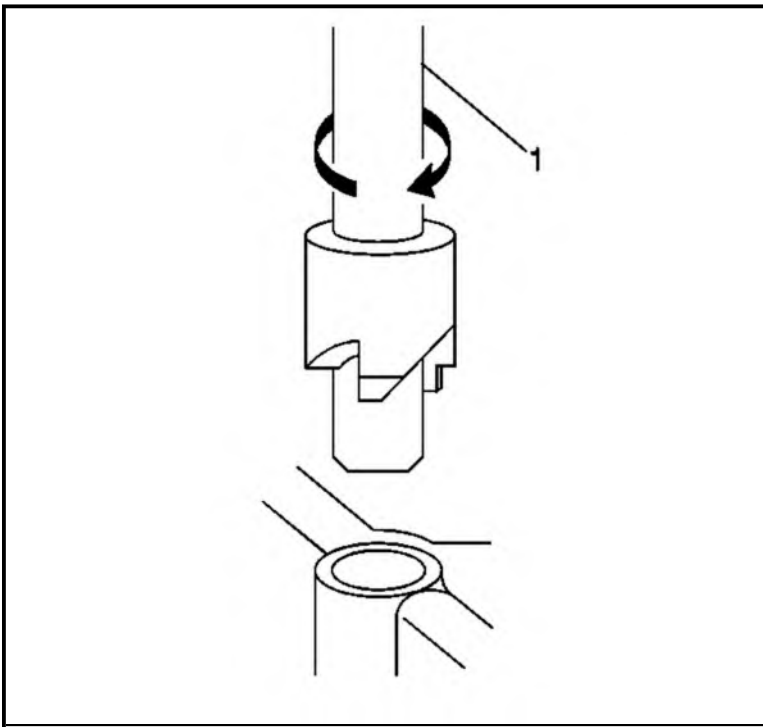
The tool kits are designed for use with either a suitable tap wrench or drill motor.

- 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).

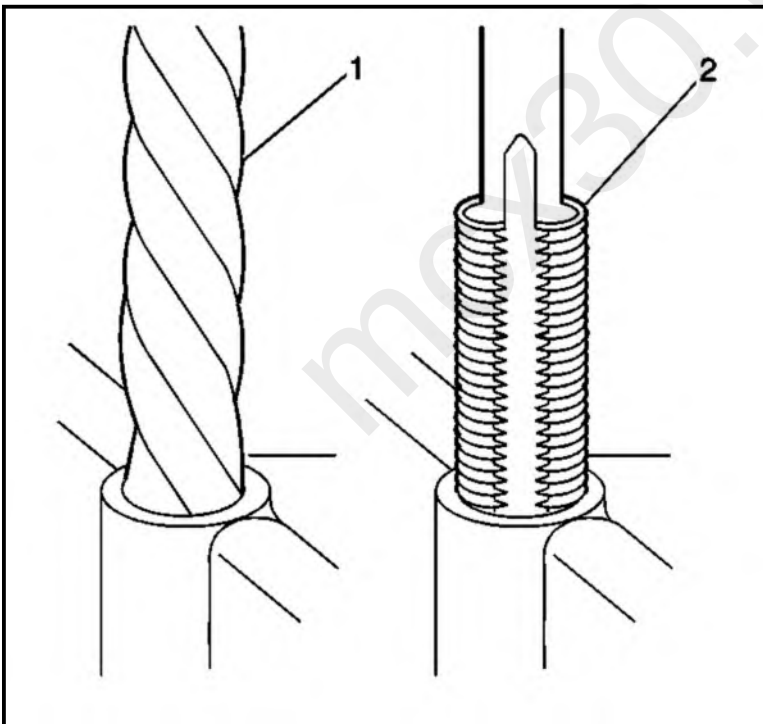
WARNING:

Refer to [Safety Glasses and Compressed Air Warning](#) .

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



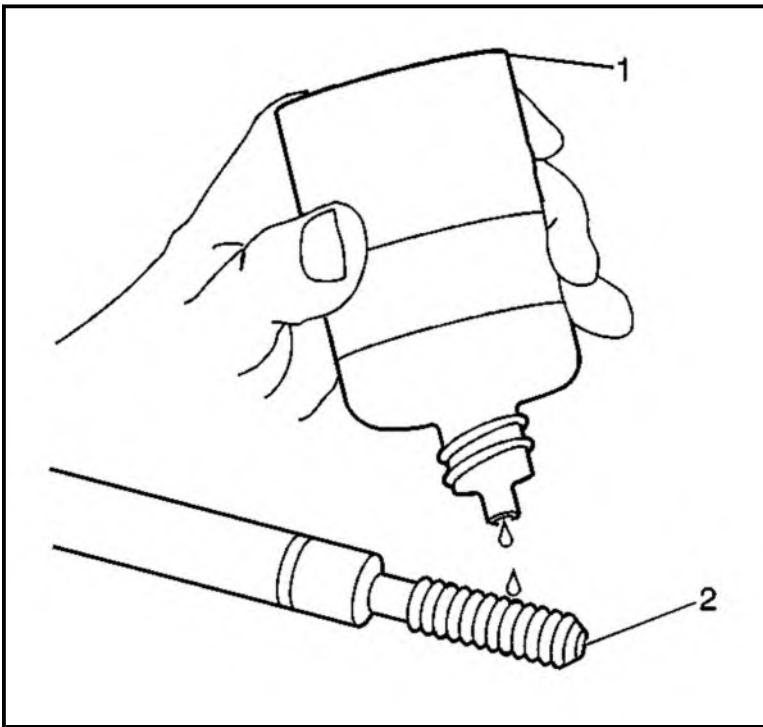
4. Using compressed air, clean out any chips.
5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).



WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

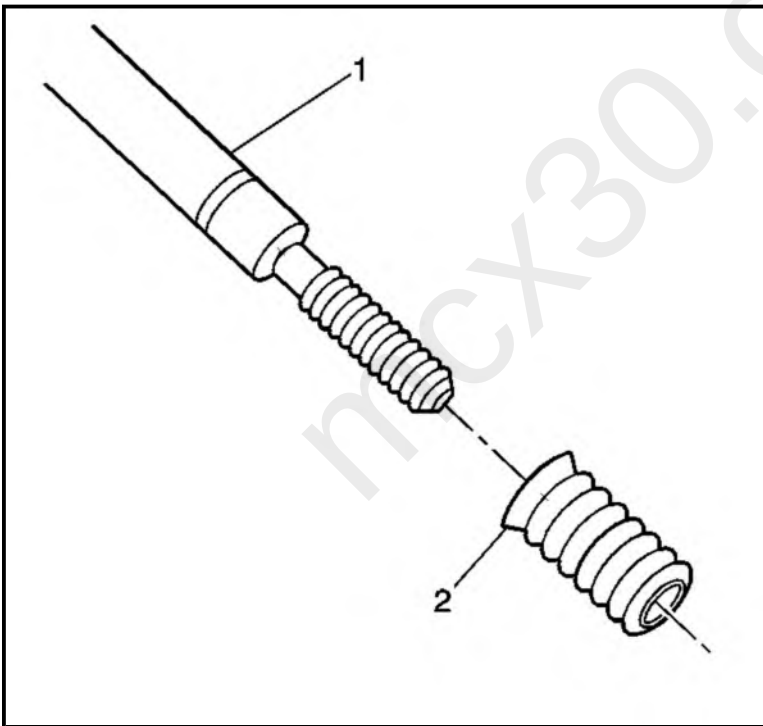
WARNING: Refer to [Cleaning Solvent Warning](#) .

6. Using compressed air, clean out any chips.
7. Spray cleaner into the hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
8. Using compressed air, clean any cutting oil and chips out of the hole.
9. Lubricate the threads of the installer tool (2) with the driver oil (1).

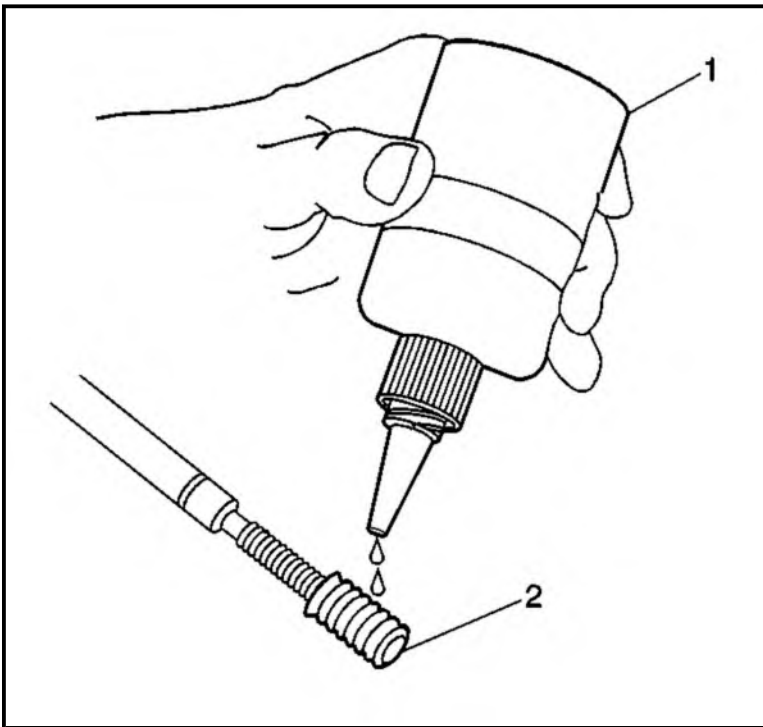


NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

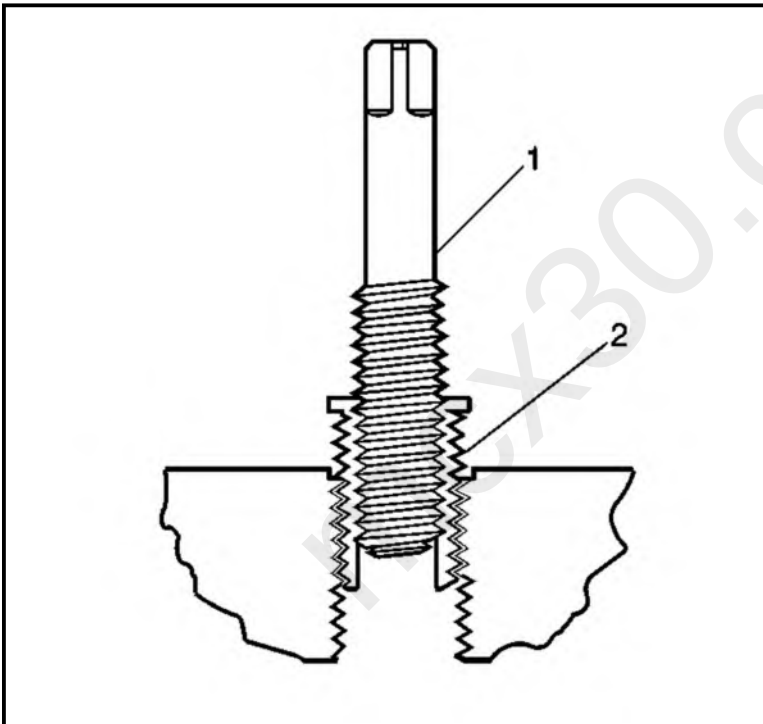
10. Install the insert (2) onto the driver tool (1).



11. Apply threadlock LOCTITE™ 277, EN 42385 - 109 (1) Loctite, or equivalent to the insert OD threads (2).



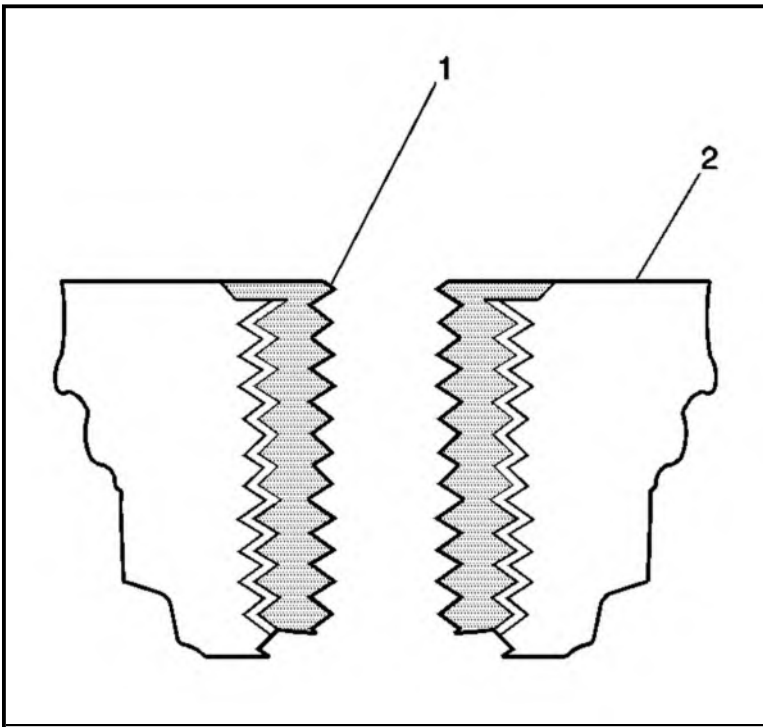
12. Install the insert (2) into the hole.



Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

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

13. Inspect the insert for proper installation into the hole.

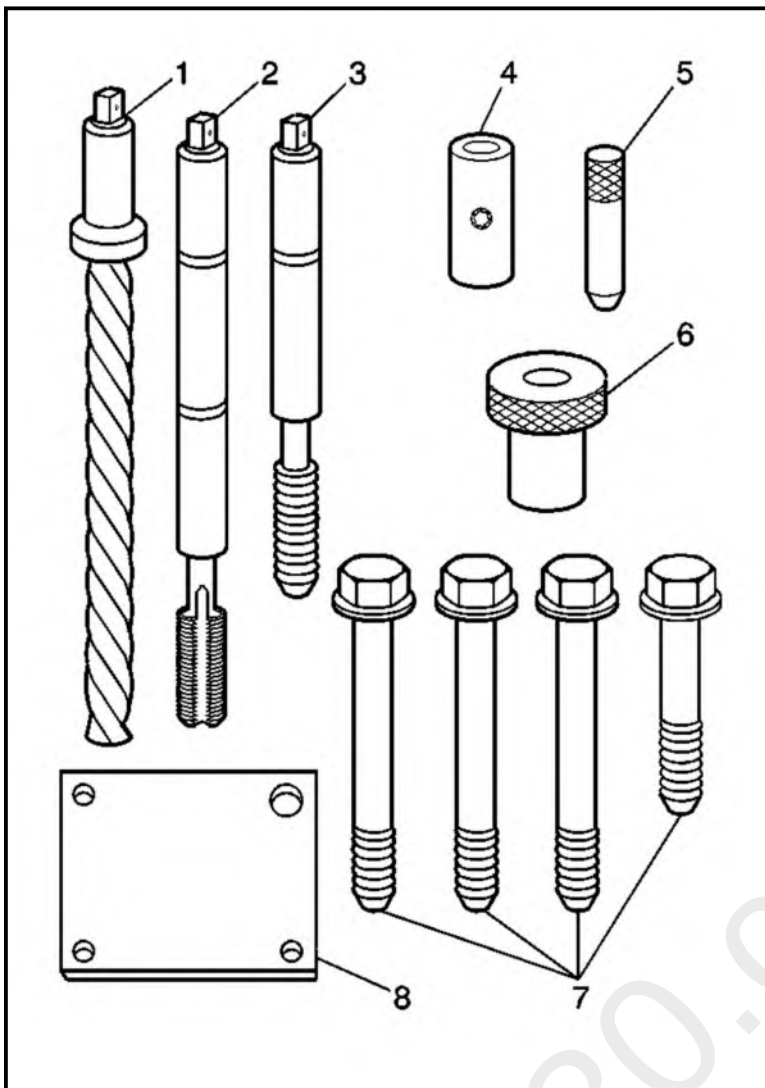


A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

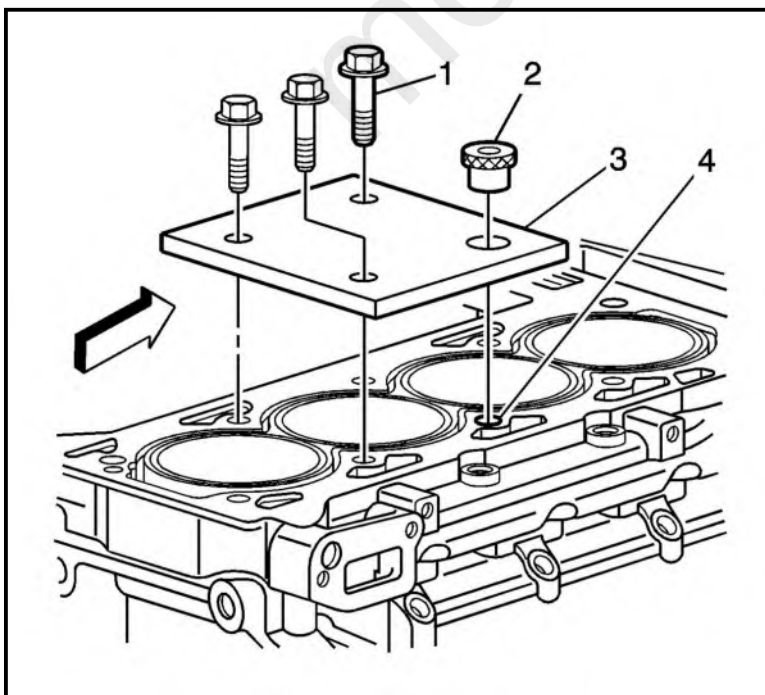
1. The cylinder head bolt hole thread repair kit consists of the following items:

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



NOTE: The tools listed may not necessarily represent the exact tools used for the procedure.

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



WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

NOTE:

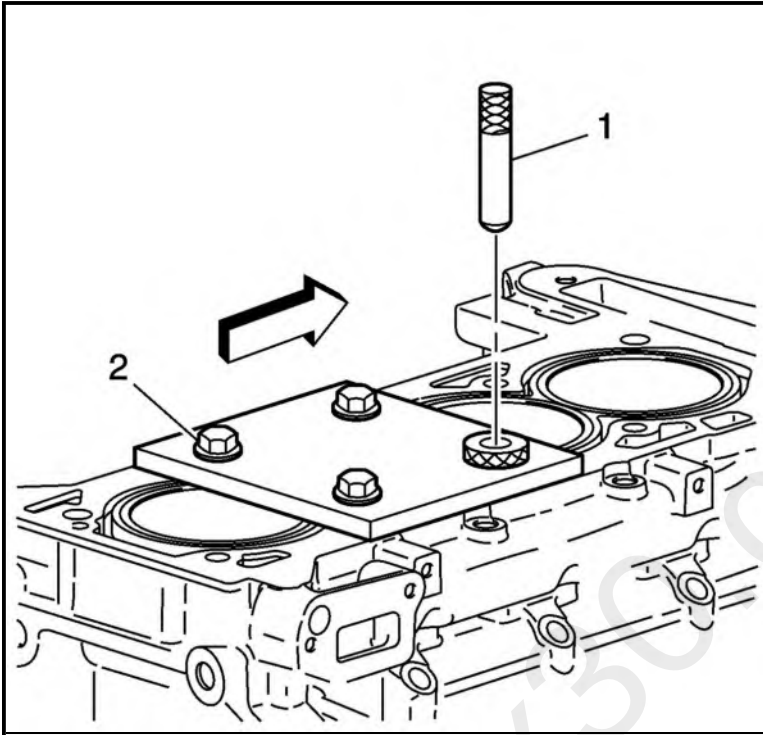
The use of a cutting fluid, WD 40B®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

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

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

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

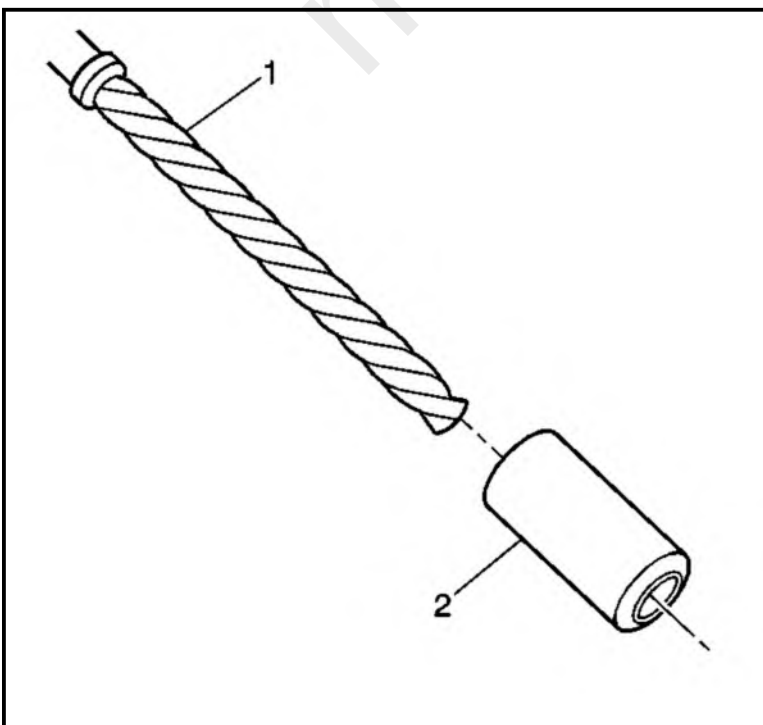
3. Position the alignment pin (1) through the bushing and into the hole.



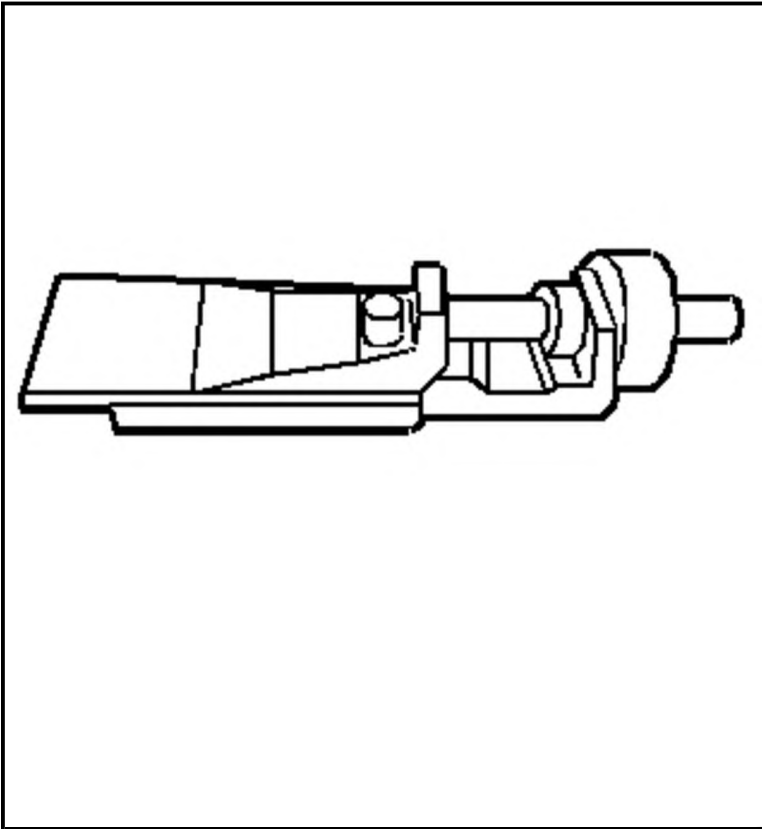
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).

5. Remove the alignment pin from the hole.

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



7. Drill out the threads of the damaged hole.



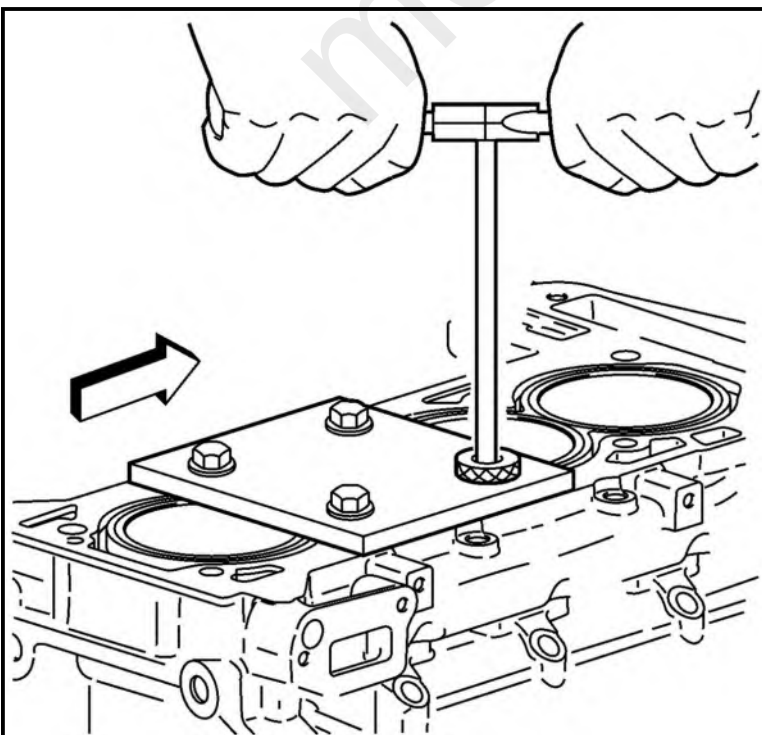
NOTE: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

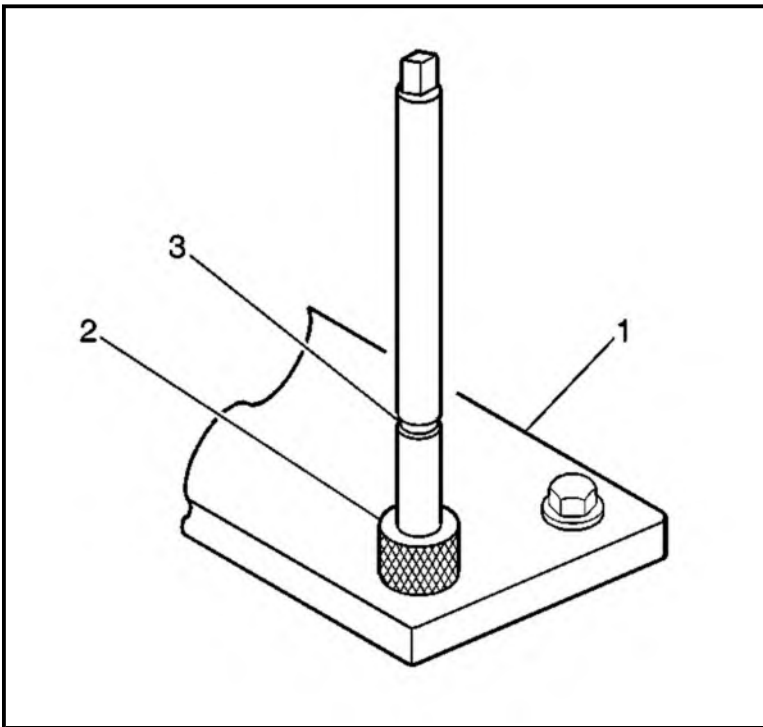
WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

8. Using compressed air, clean out any chips.

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



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



In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

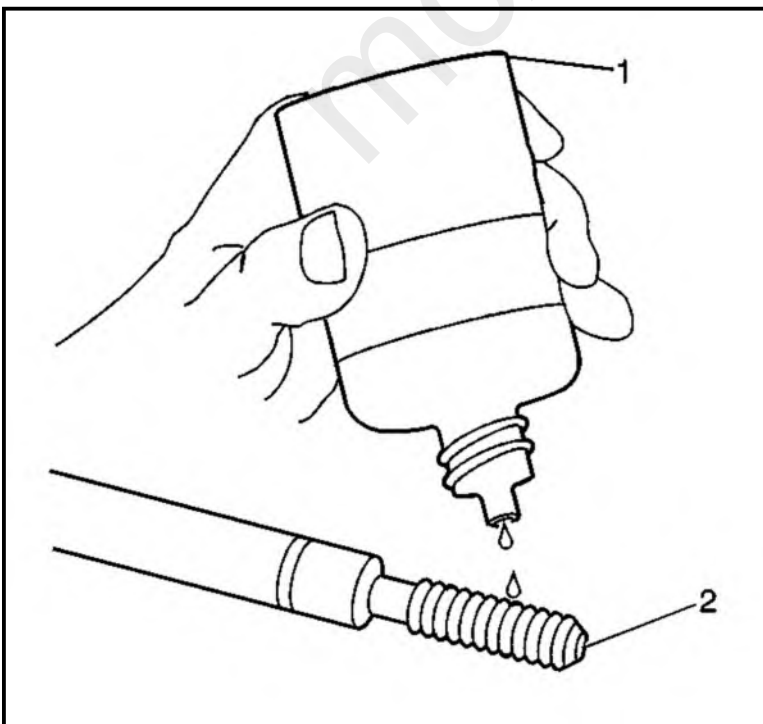
WARNING: Refer to [Cleaning Solvent Warning](#) .

12. Using compressed air, clean out any chips.

13. Spray cleaner into the hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

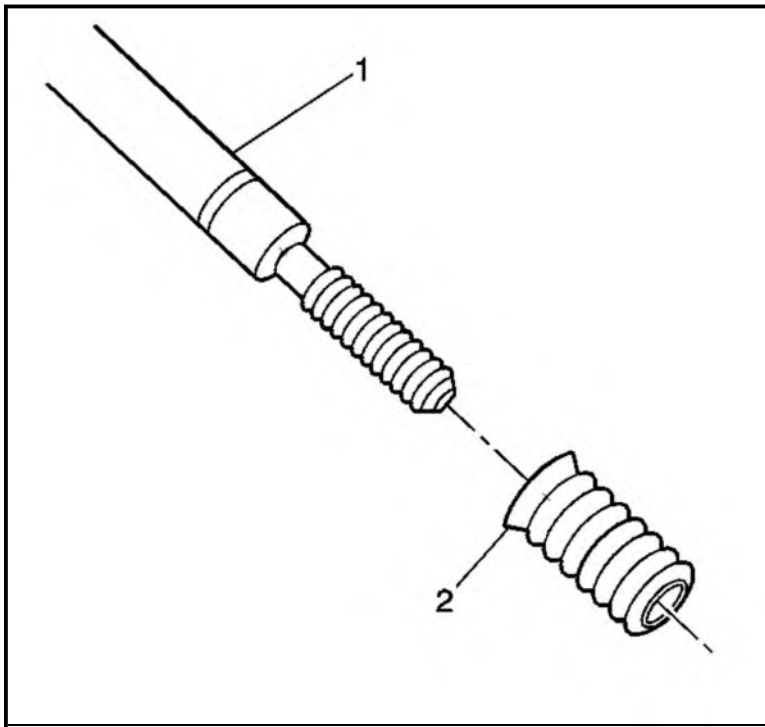
14. Using compressed air, clean any cutting oil and chips out of the hole.

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

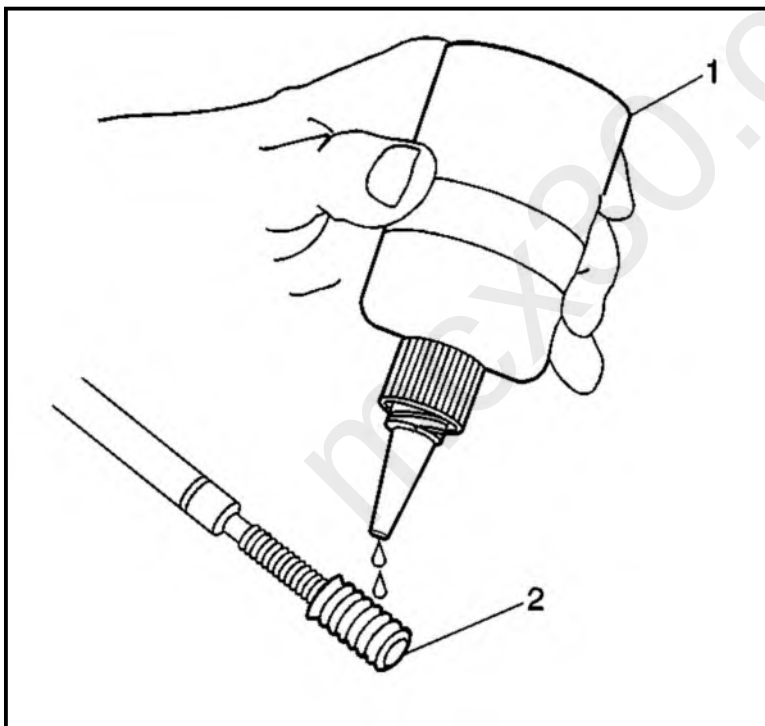


NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

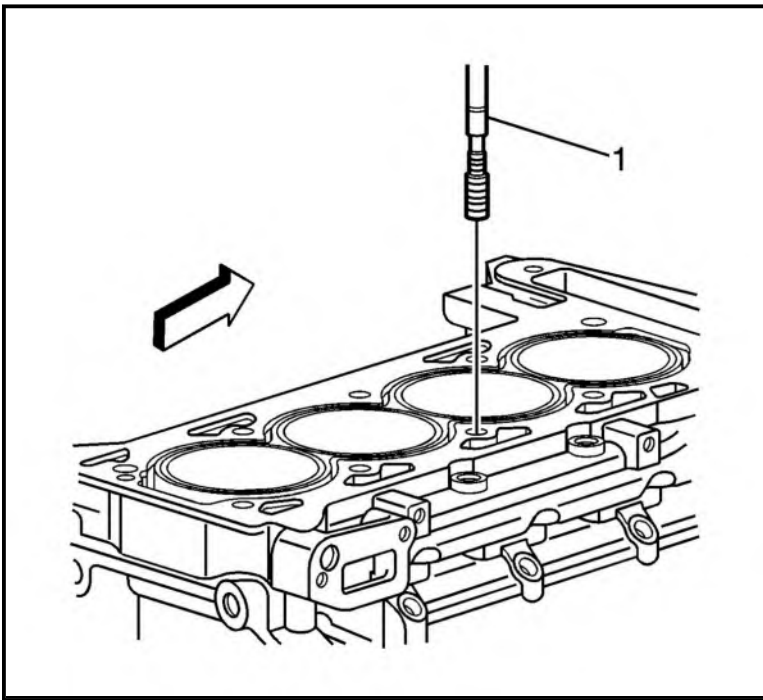
16. Install the insert (2) onto the driver tool (1).



17. Apply threadlock LOCTITE™ 277, EN 42385 - 109 Loctite (1), or equivalent to the insert OD threads (2).



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



Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

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

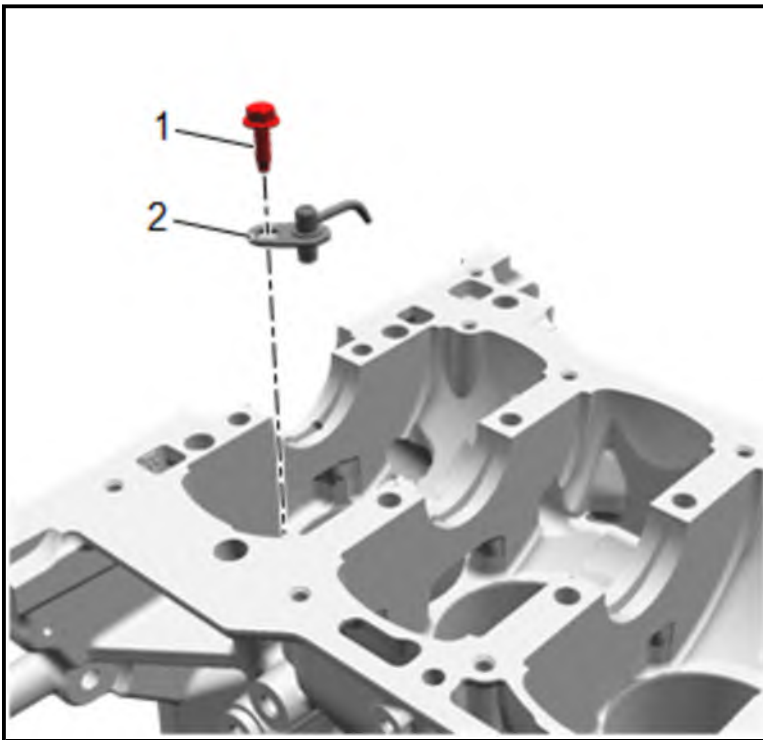
SERVICE PRIOR TO ASSEMBLY

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

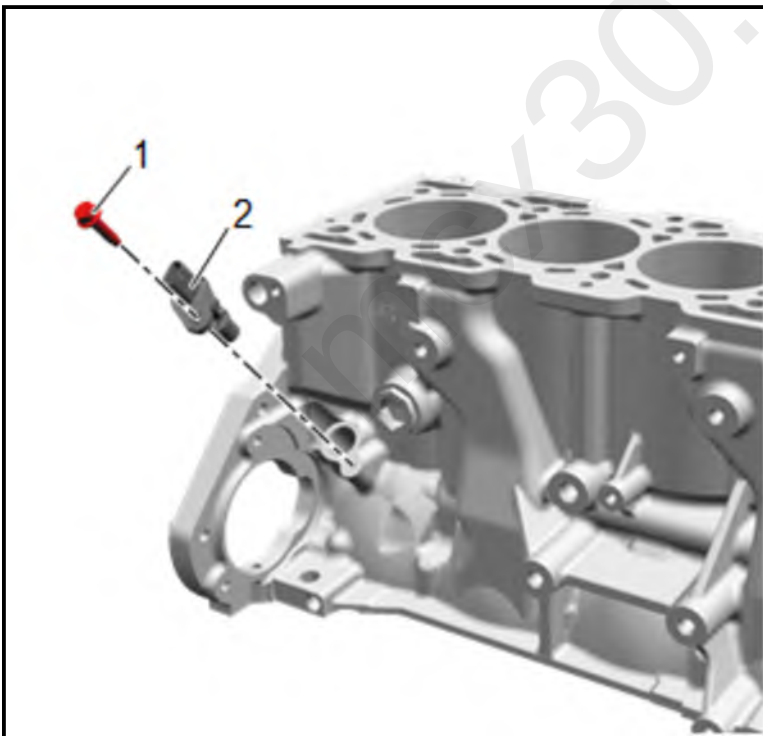
ENGINE BLOCK ASSEMBLY

1. Install the piston oil nozzle assemblies (2), if equipped.



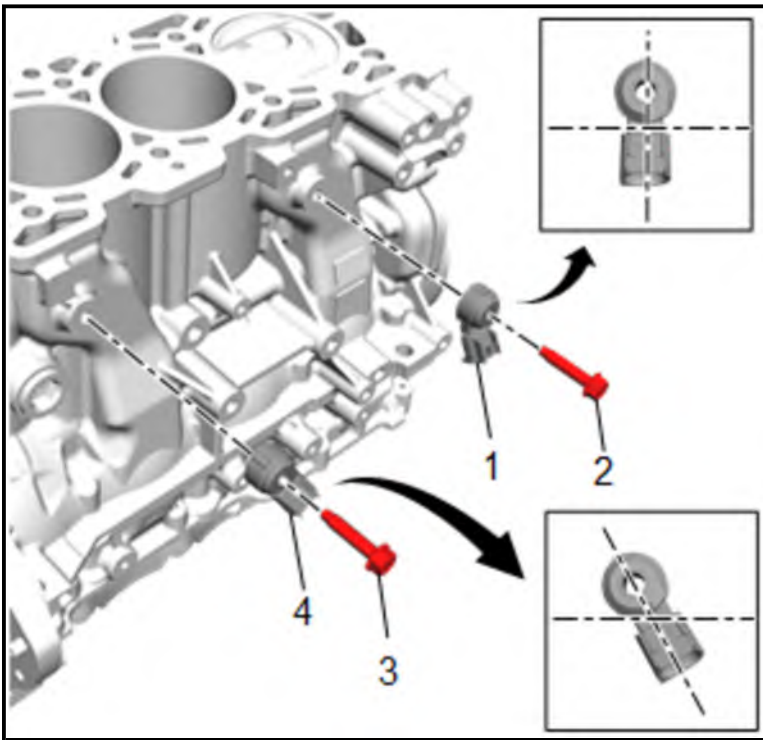
CAUTION: Refer to [Fastener Caution](#) .

2. Install the piston oil nozzle bolts (1) and tighten to 10 N.m (89 lb in).
3. Lubricate the crankshaft position sensor O-ring with engine oil. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



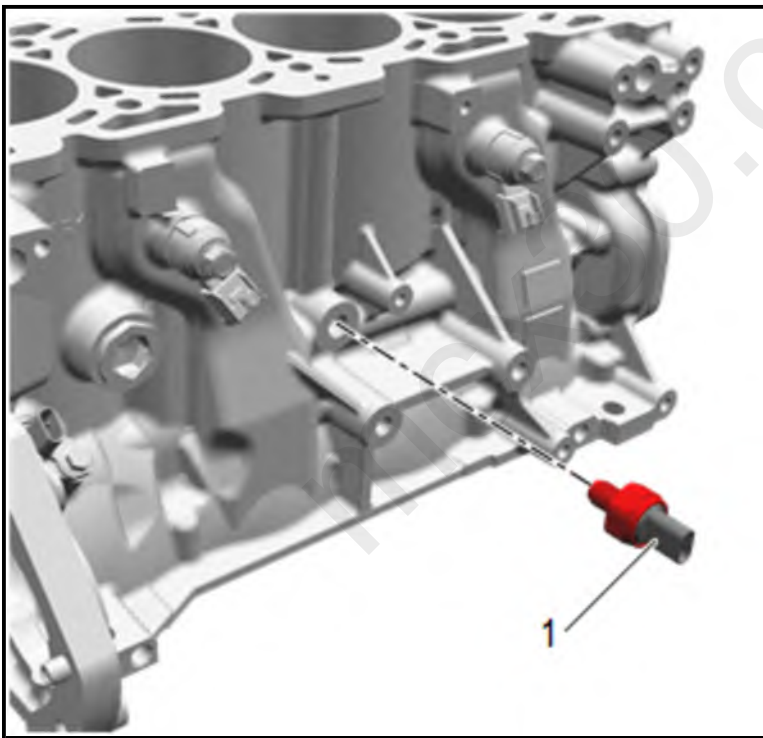
CAUTION: Refer to [Component Fastener Tightening Caution](#) .

4. Install the crankshaft position sensor (2) and bolt (1) and tighten to 10 N.m (89 lb in).
5. Install the knock sensor (1) at 6 O' clock. Install the bolt (2) and tighten to 25 N.m (18 lb ft).

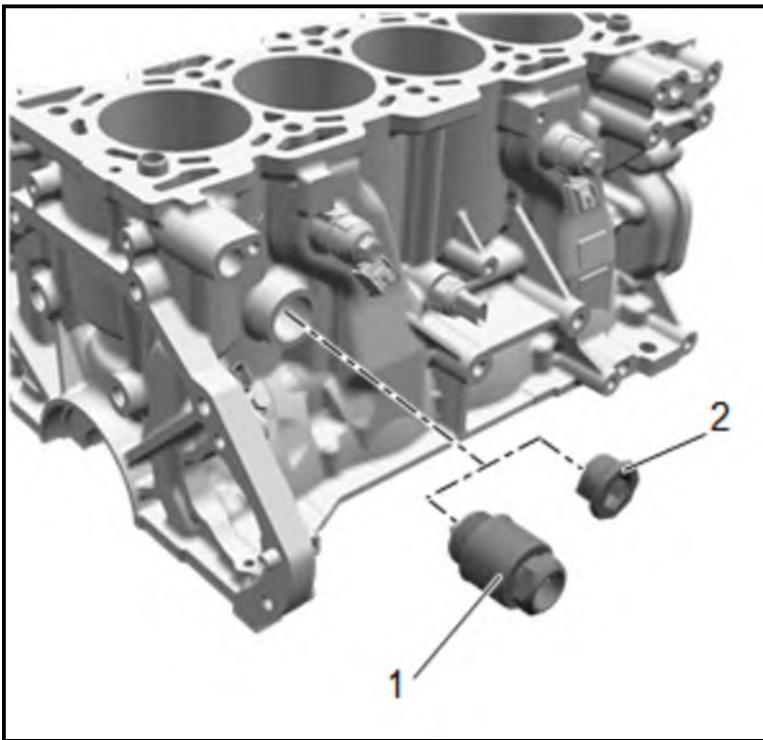


6. Install the knock sensor (4) at 5 O' clock. Install the bolt (3) and tighten to 25 N.m (18 lb ft).

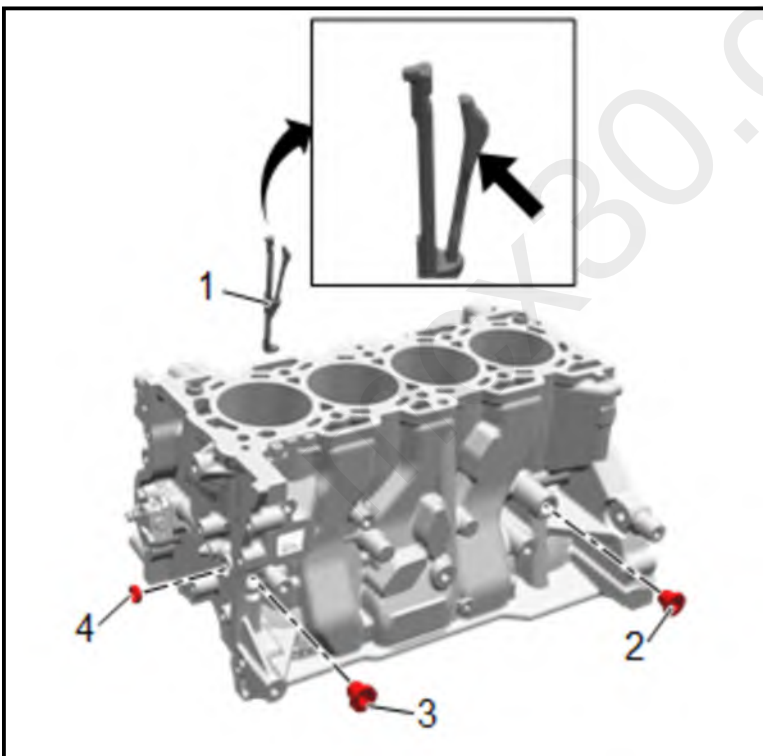
7. Install the engine oil pressure sensor (1) and tighten to 35 N.m (26 lb ft).



8. Install the engine coolant heater assembly (1), if equipped. Tighten the assembly to 50 N.m (37 lb ft).



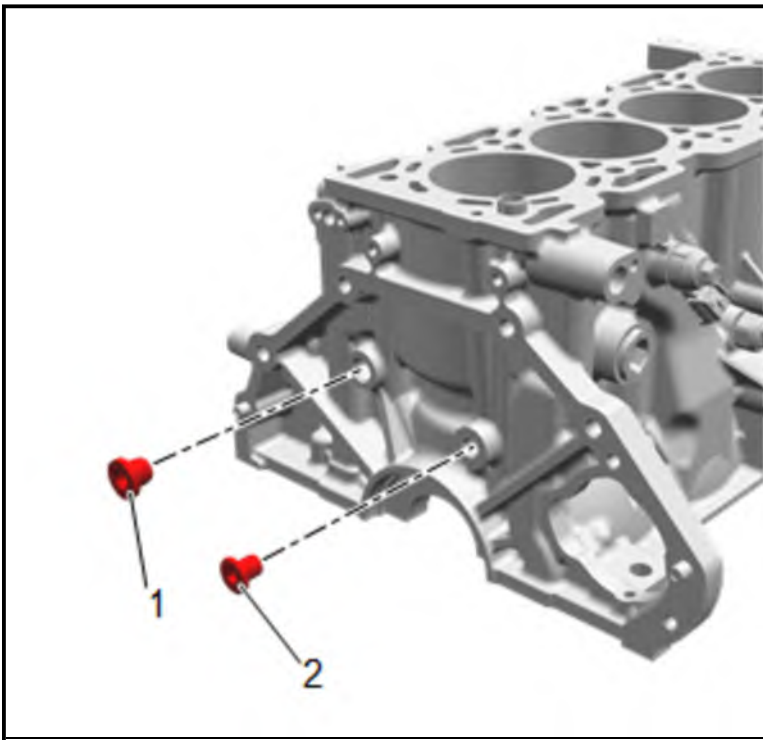
9. If the engine coolant heater assembly is not equipped, install the engine coolant heater hole plug (2). Tighten the plug to 60 N.m (44 lb ft).
10. Apply sealant to all plugs prior to installation. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



11. Install the engine oil gallery cup plug (4).
12. Install the engine oil gallery plugs (2, 3), with sealant, and tighten to 65 N.m (48 lb ft).

NOTE: Always install the baffle with the forked end pointed up. Do not force the baffle into place. Aligning the shape of the orifice and the baffle, and gently depressing the clip will allow the baffle to easily drop into place.

13. Carefully align and install the engine block coolant baffle (1).
14. Install the engine oil gallery plug (1), with sealant, and tighten to 65 N.m (48 lb ft).



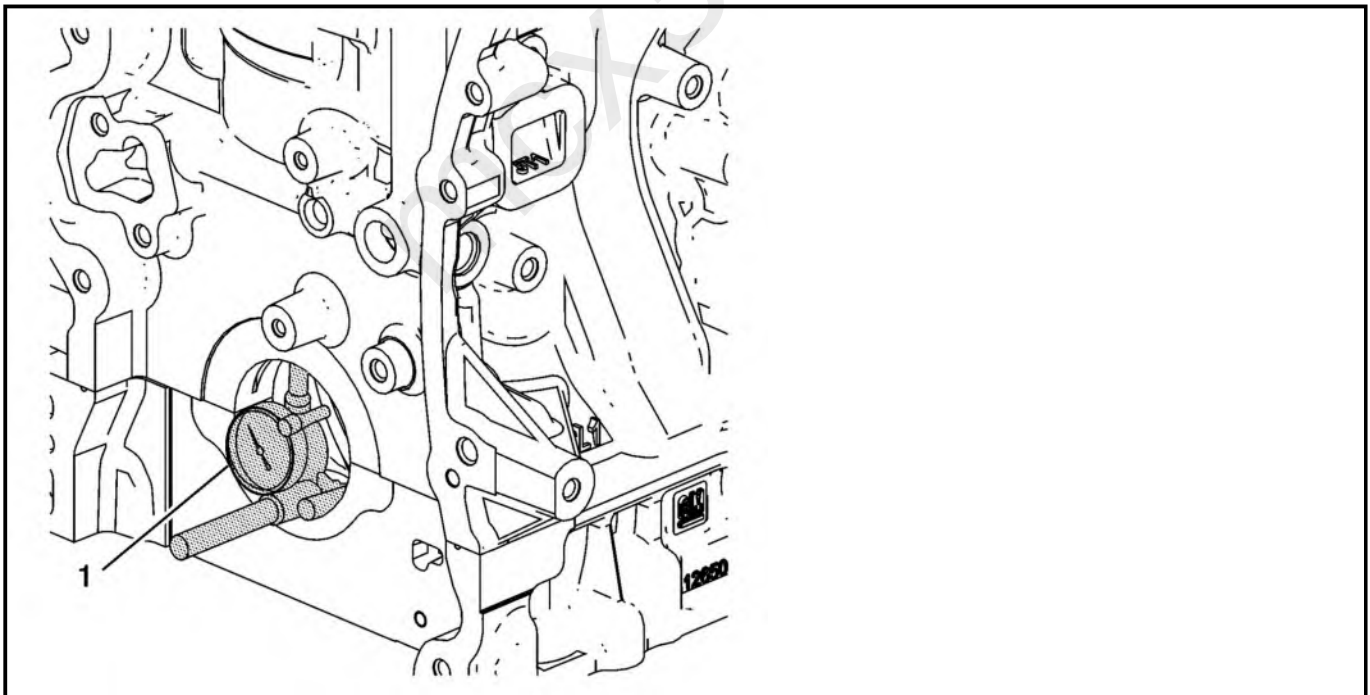
15. Install the engine oil gallery plug (2), with sealant, and tighten to 40 N.m (30 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- EN-8087 Cylinder Bore Checking Gauge
- EN 45059 Angle Meter

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



NOTE:

- Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.
- If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **EN 45059** meter.
- Measure the bearing bore for taper and out-of-round using the **EN-8087** gauge (1).
- No taper or out-of-round should exist.

Bearing Selection

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are two methods to measure bearing clearance. Method A gives more reliable results and is preferred.
 - Method A yields measurement from which the bearing clearance can be computed.
 - Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.
2. To measure bearing clearance for the crankshaft (1) using Method A, use the following procedure:



NOTE: Do not mix inserts of different nominal size in the same bearing bore.

1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
 2. Measure the crankshaft bearing journal taper and runout.
 3. Install the lower crankcase and tighten the bearing cap bolts to specification.
 4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
 5. Subtract journal measurement from bearing ID measurement to determine clearance.
 6. Determine whether clearance is within specification.
 7. If out of specification, choose different inserts.
 8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
 9. Measure the crankshaft main bearing inside diameter with an inside micrometer.
3. To measure bearing clearance using Method B, use the following procedure:
 1. Clean the used bearing inserts.
 2. Install the used bearing inserts.
 3. Place a piece of gaging plastic across the entire bearing width at 90 degrees to block/lower crankcase split line.

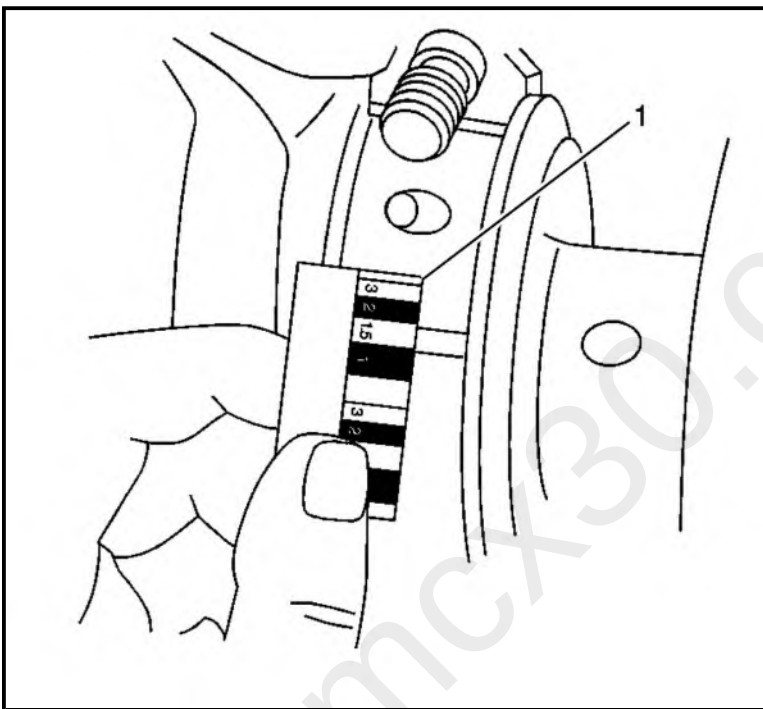
4. Install the bearing caps.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

5. Install the bearing cap bolts to specification.

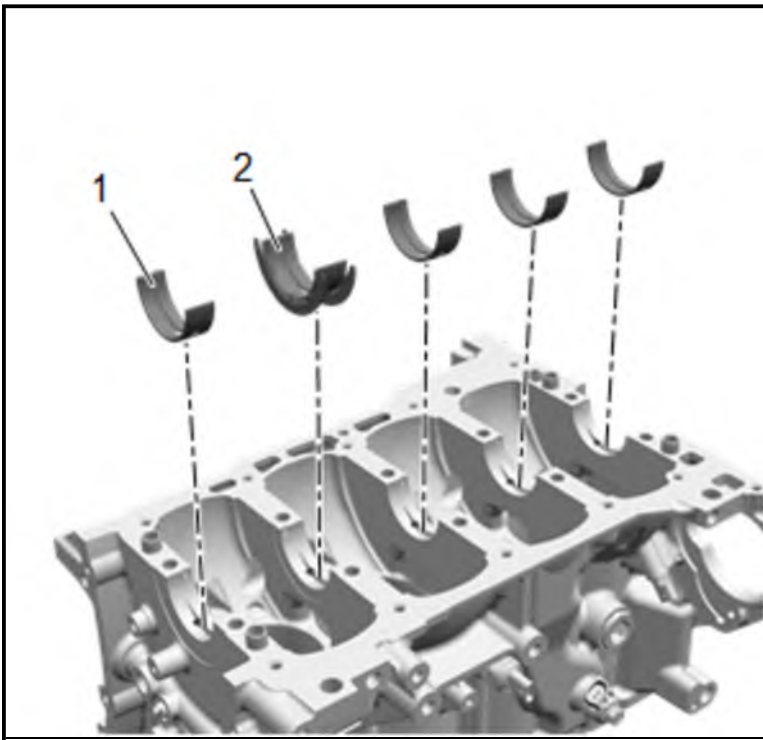
NOTE: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or to the bearing cap.
7. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
8. Remove the gauging plastic.



Crankshaft Installation

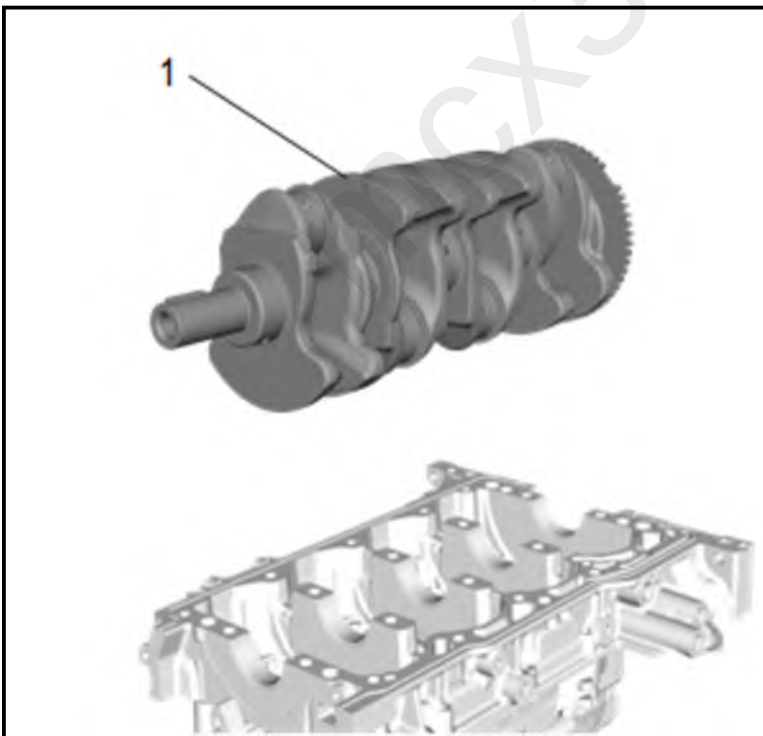
1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.



NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

NOTE: If crankshaft bearing kit has a red bearing in it, install this in the front crankshaft bearing position, closest to the crankshaft balancer.

2. Install the crankshaft upper thrust bearing (2) and lubricate bearing surfaces with engine oil.
3. Install the crankshaft (1) on the journals.



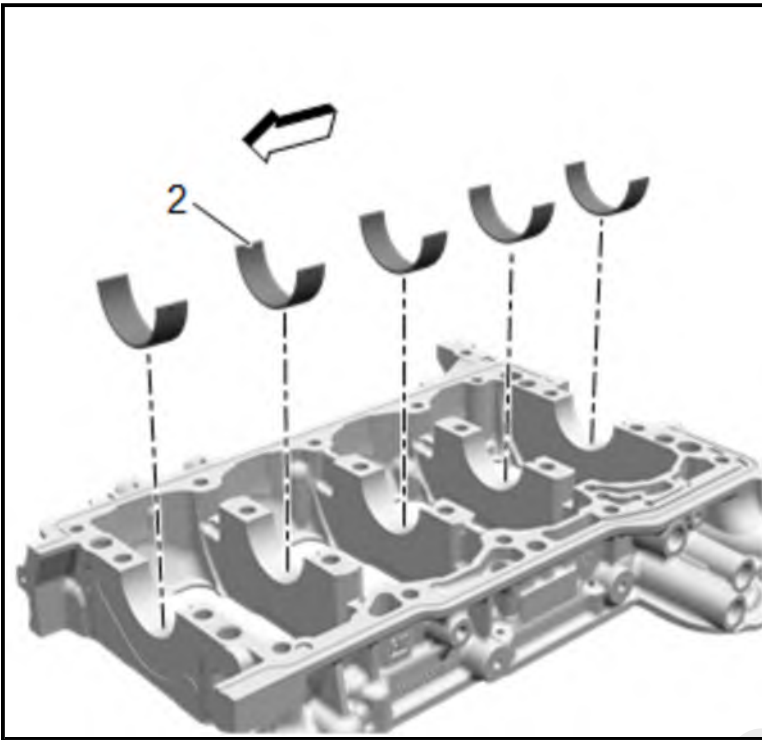
LOWER CRANKCASE INSTALLATION

Special Tools

- EN 45059 Angle Meter
- EN-51380 Seal Installer

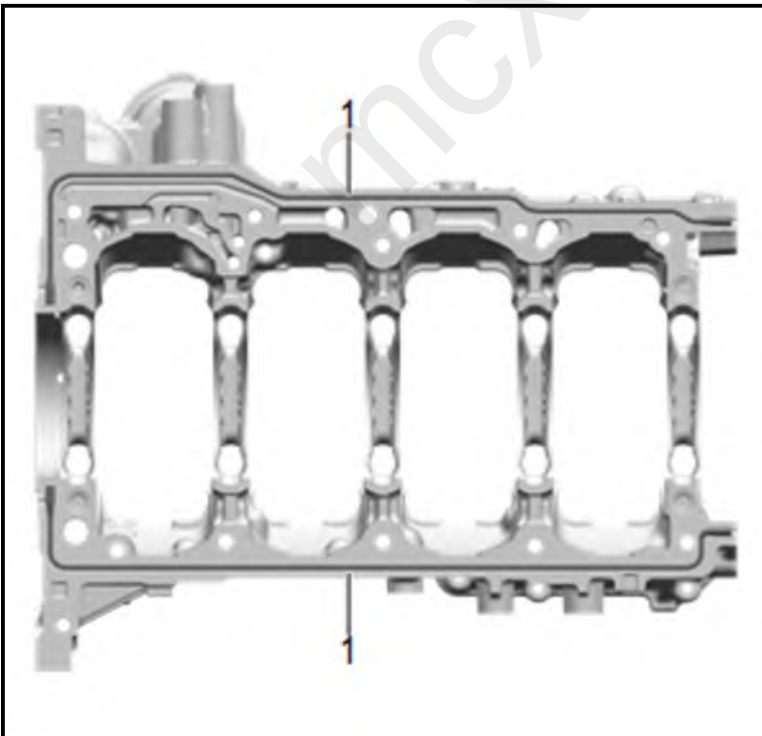
For equivalent regional tools, refer to [Special Tools](#).

1. Install the lower bearing halves (2), without grooves, into the lower crankcase (1). Apply oil to bearing surfaces.



NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

2. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

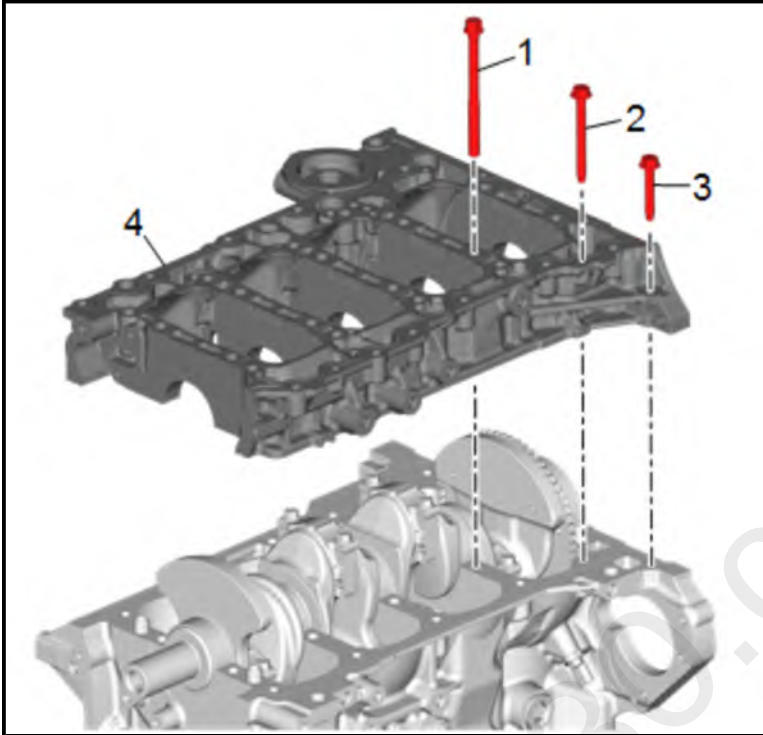


NOTE:

- The block assembly surface must be free of contamination prior to applying the sealer.

- Install and align the bedplate to block within 20 minutes of applying the sealer.
- The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.

3. Apply a 4.25 mm bead of sealer directly in the groove (1) of the block to bedplate mating surfaces. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
4. Install the lower crankcase (4). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.



CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

5. Install the NEW M10 x 2.00 x 116 lower crankcase bolts (1) at the inner bolt locations finger tight.
6. Install the single M8 x 1.25 x 50 lower crankcase bolt (3) finger tight.
7. Install the M8 x 1.25 x 80 lower crankcase bolts (2) at the crankcase perimeter finger tight.
8. Tighten the NEW M10 x 2.00 x 116 lower crankcase bolts in sequence using the following procedure:

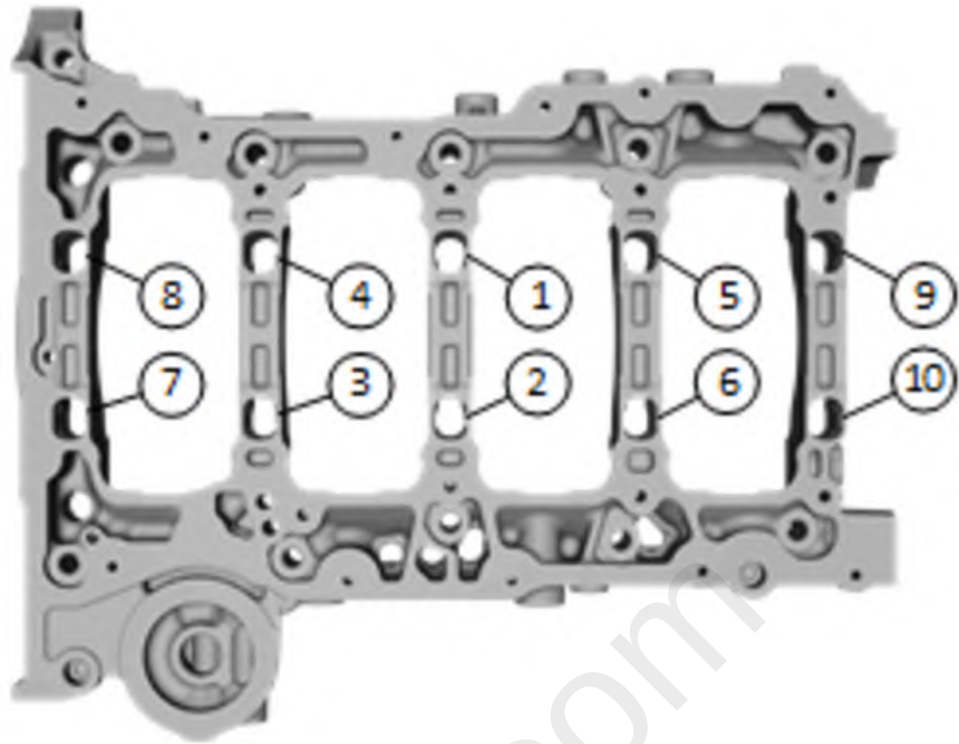


Fig. 19: Crankshaft Bearing Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

1. Tighten the lower crankcase bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the lower crankcase bolts a final pass in sequence using the **EN 45059** meter an additional 140 degrees.
9. Tighten the lower crankcase bolts at the crankcase perimeter in sequence to 25 N.m (18 lb ft).

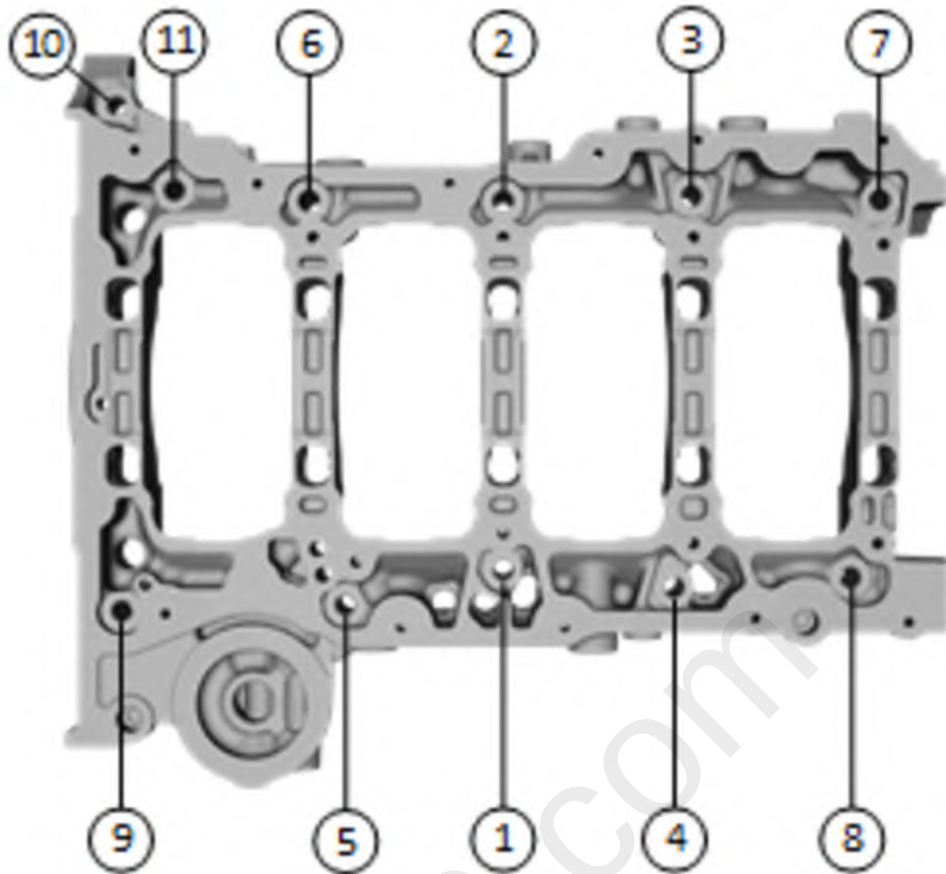
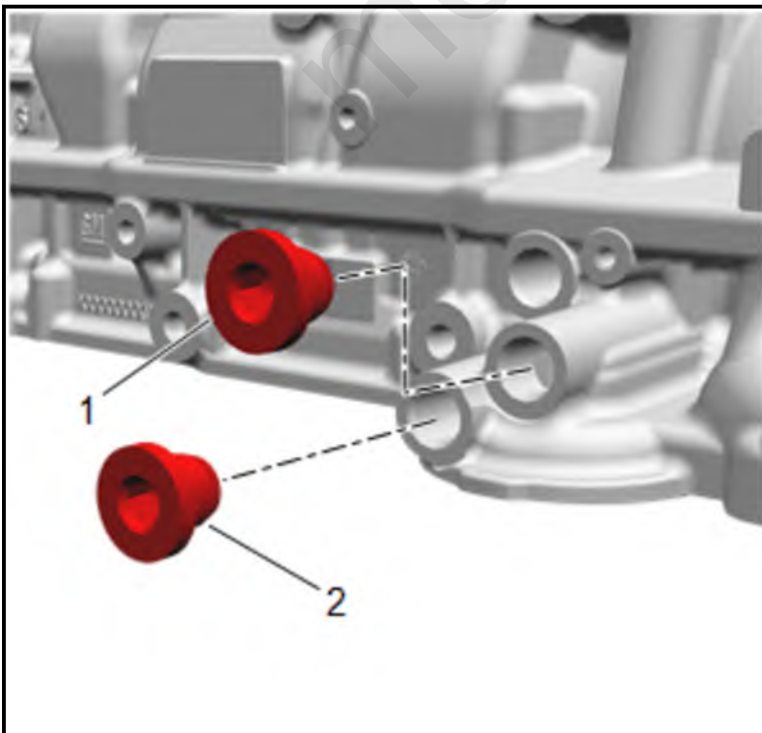


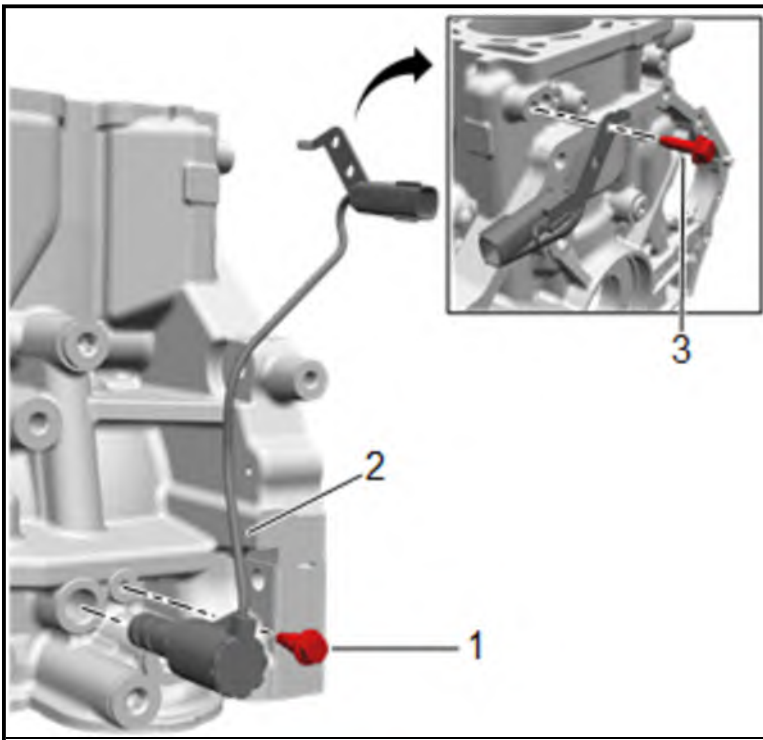
Fig. 20: Lower Crankcase Perimeter Bolts Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

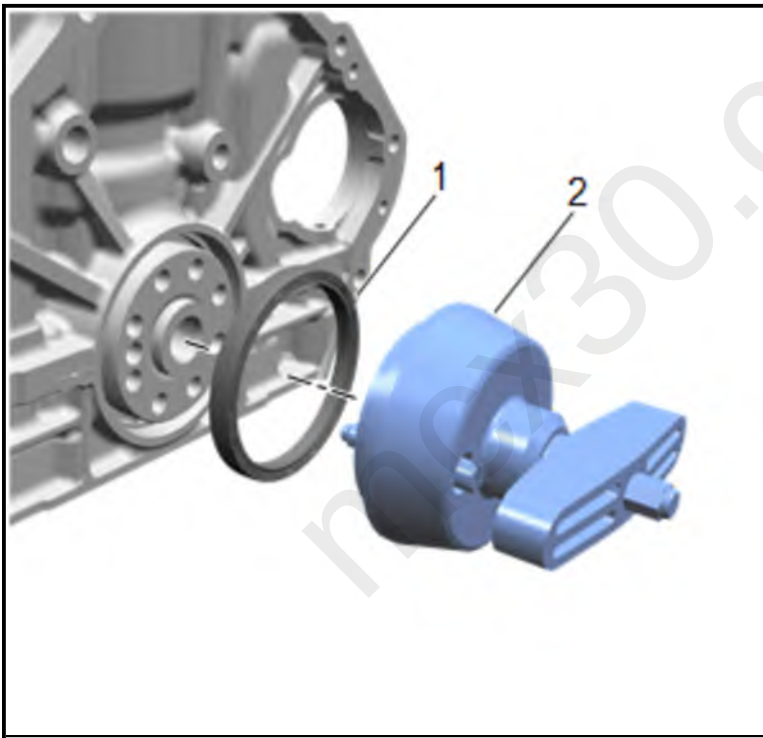
10. Install the engine oil gallery plugs (1, 2). Tighten the plugs to 65 N.m (48 lb ft).



11. Install the oil pump flow control valve (2) and bolts (1, 3). tighten the bolts to 10 N.m (89 lb in).



12. Using **EN-51380** installer (2), install the crankshaft rear oil seal (1) flush or recessed up to 0.5 mm to block.



13. Rotate the crankshaft to ensure that it moves freely and does not bind.

14. Measure and record the crankshaft endplay. Refer to [Engine Mechanical Specifications](#).

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

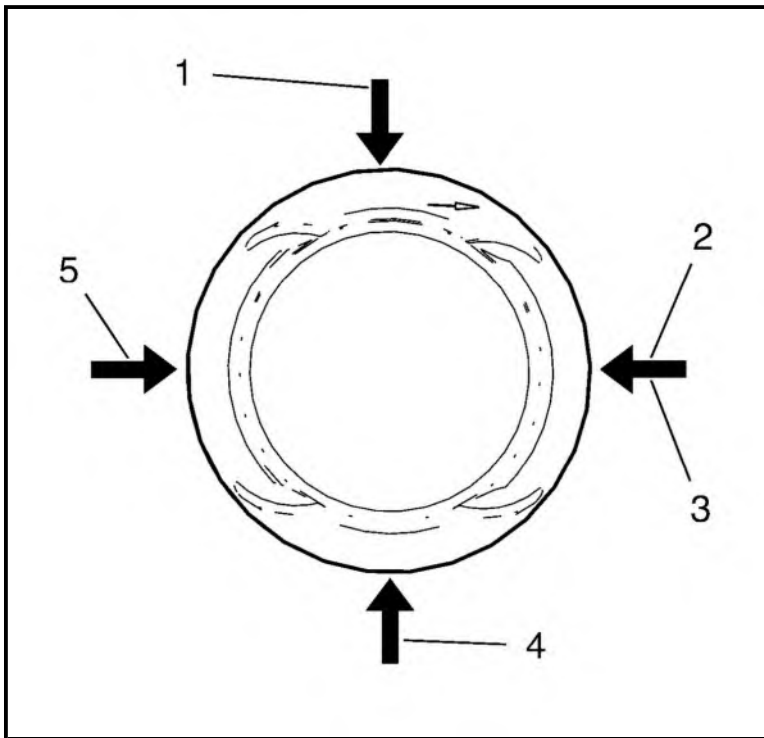
NOTE: This procedure is not used in Europe.

Special Tools

- **EN-47836** Ring Compressor - 88 mm
- **EN-43966** Connecting Rod Guides
- **EN 45059** Angle Meter

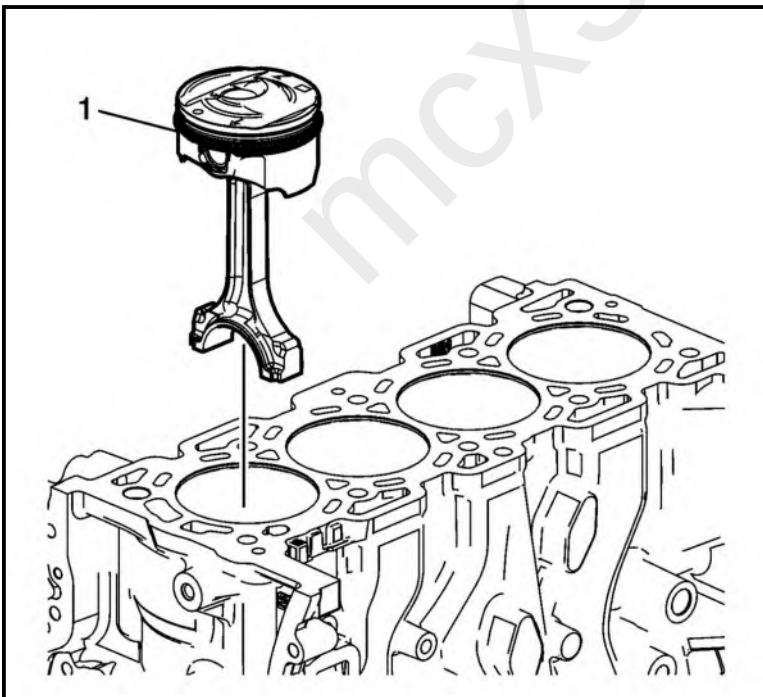
For equivalent regional tools, refer to [Special Tools](#).

1. Ensure the piston ring end gaps are positioned 90 degrees to each other.



- Upper compression ring joint (1)
- Lower compression ring joint (2)
- Upper oil ring rail joint (5)
- Oil ring rail spacer joint (4)
- Lower oil ring rail joint (3)

2. Install the connecting rod bearings. Use NEW bearings.



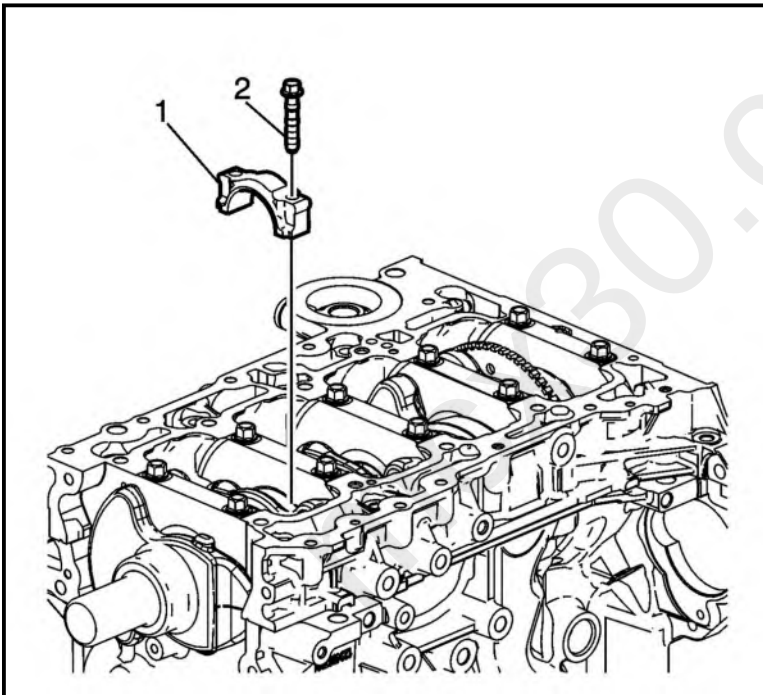
NOTE:

The connecting rods and caps must be installed in the same order and orientation in which they were removed. If new connecting rods are required, the connecting rod is provided as an assembly, and the upper rod will need to be disassembled from the lower cap.

NOTE:

The connecting rod bearing anti-rotation tab grooves are to point toward the right-hand side of the engine.

1. Install the bearing inserts into the connecting rod and the connecting rod cap.
2. Lubricate the connecting rod bearings with engine oil.
3. Install the **EN-43966** guides (2) into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.
4. Install **EN-47836** compressor, piston (1), and the connecting rod to the correct bore.
 1. Lubricate the piston and the piston rings with engine oil.
 2. Do not disturb the piston ring end gap location.
 3. The piston must be installed so that the arrow mark on the top of the piston points to the front of the engine.
 4. Lubricate the engine bore with engine oil, then place the piston in its matching bore.
 5. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
 6. Hold the **EN-47836** compressor against the engine block until all the rings have entered the cylinder bore.
 7. Remove the connecting rod guides from the connecting rod bolt holes.
5. Install the connecting rod cap (1).

**NOTE:**

Ensure that the connecting rod cap is properly oriented on the connecting rod.

CAUTION:

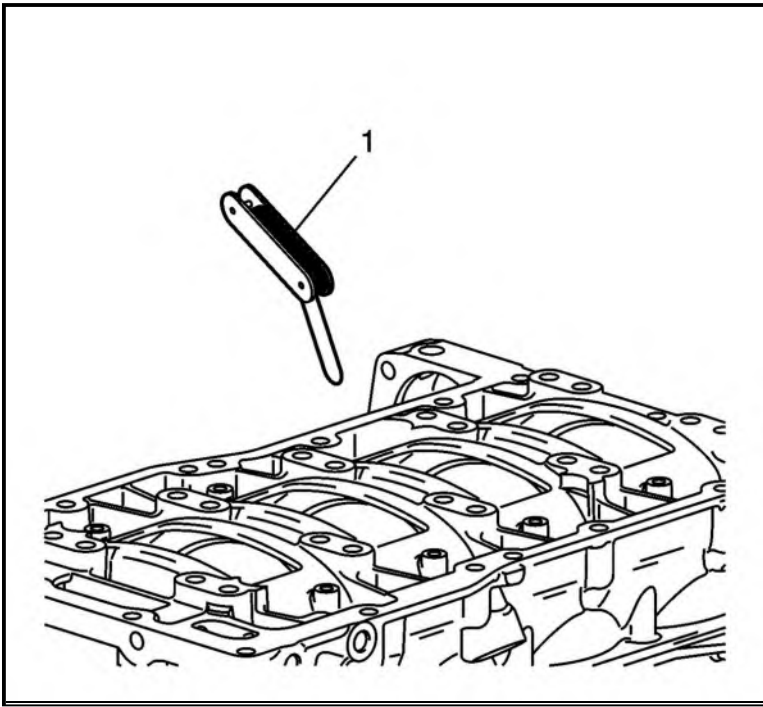
Refer to [Fastener Caution](#) .

CAUTION:

This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

6. Install the NEW connecting rod bolts (2).
 1. Tighten all the connecting rod bolts a first pass to 25 N.m (18 lb ft).
 2. Tighten all the connecting rod bolts a final pass an additional 110 degrees using the **EN 45059** meter.
7. Install the remaining connecting rods and piston assemblies.

8. Measure the connecting rod side clearance with a feeler gauge (1). Refer to [Engine Mechanical Specifications](#).

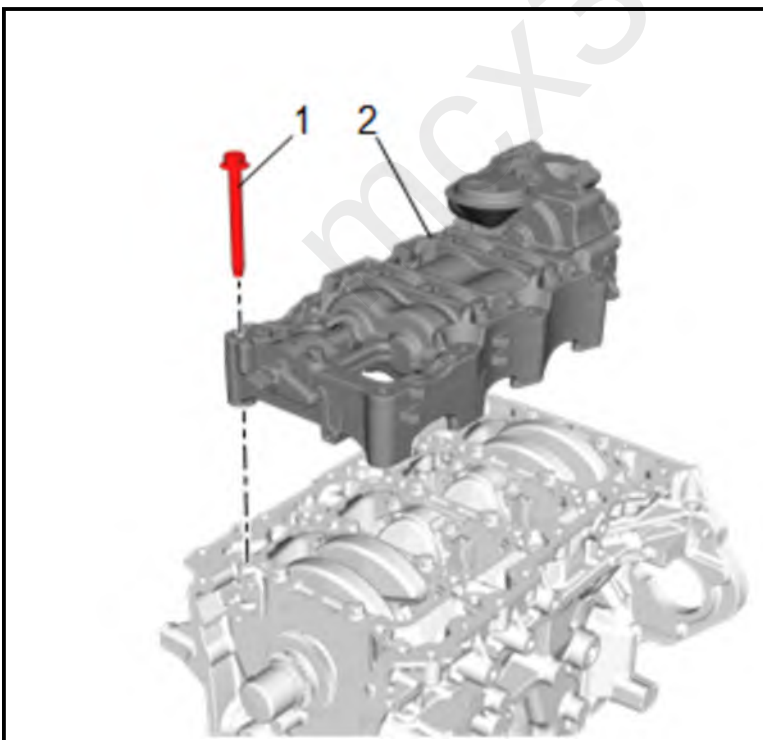


NOTE: Rotate the crankshaft to ensure that it moves freely and does not bind.

9. Measure the piston deck height. Refer to [Engine Mechanical Specifications](#).

BALANCER SHAFT WITH OIL PUMP INSTALLATION

1. Install the balancer and oil pump shaft assembly (2).



2. Install the balancer and oil pump shaft assembly bolts (1) finger tight.
3. Tighten the bolts twice in sequence:

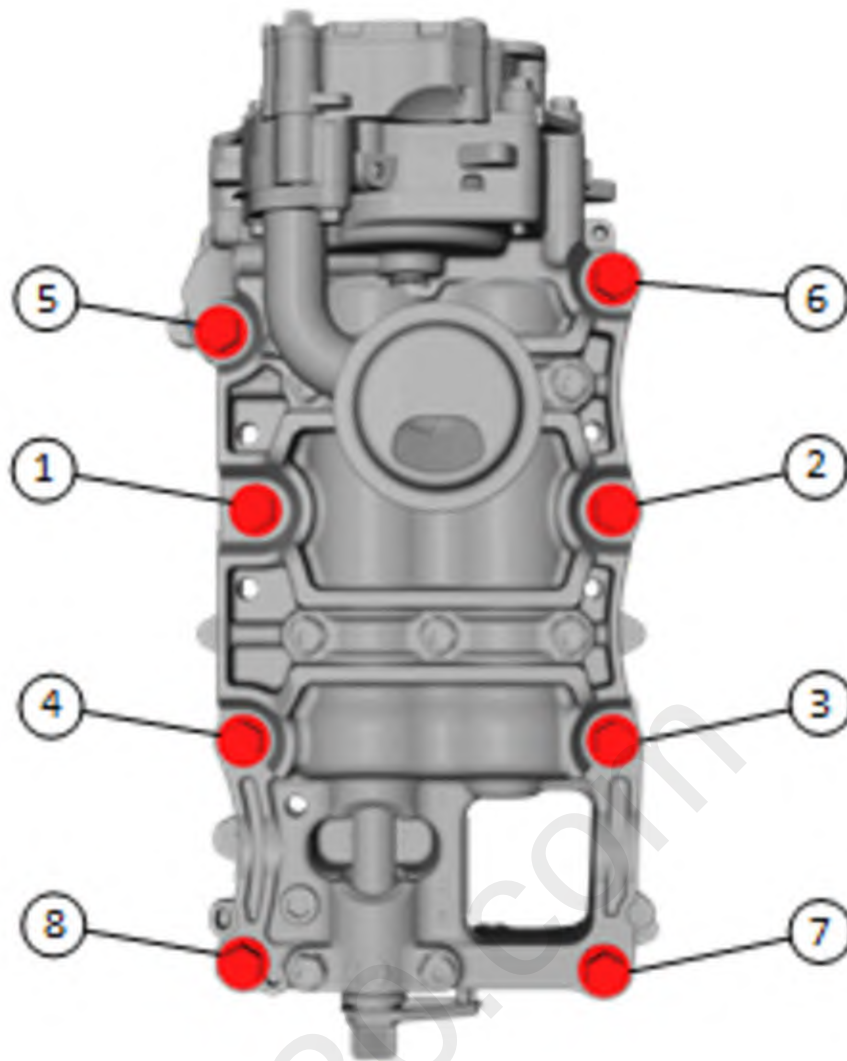


Fig. 21: Balancer And Oil Pump Shaft Assembly Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Tighten the bolts a first pass in sequence to 58 N.m (43 lb ft).
2. Tighten the bolts a final pass in sequence to 58 N.m (43 lb ft).

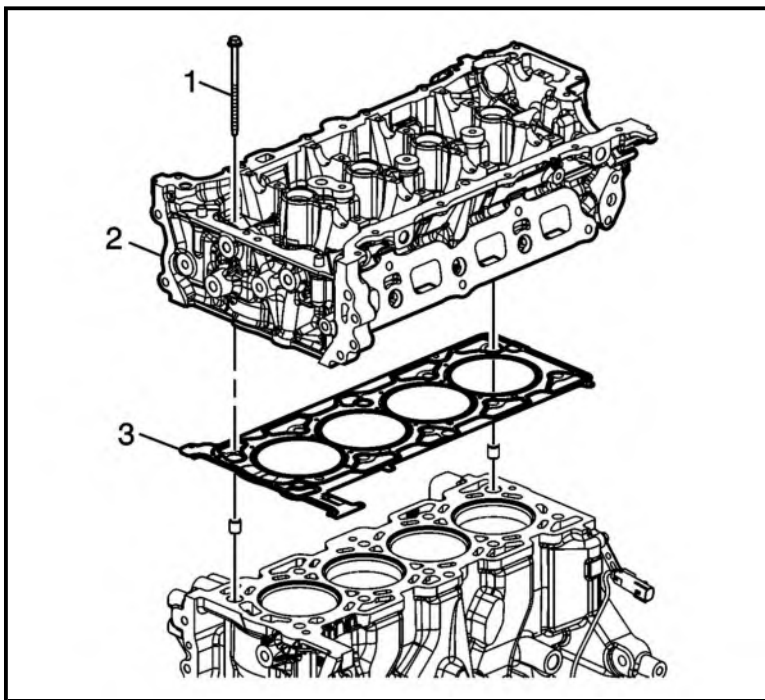
CYLINDER HEAD INSTALLATION

Special Tools

EN 45059 Angle Meter

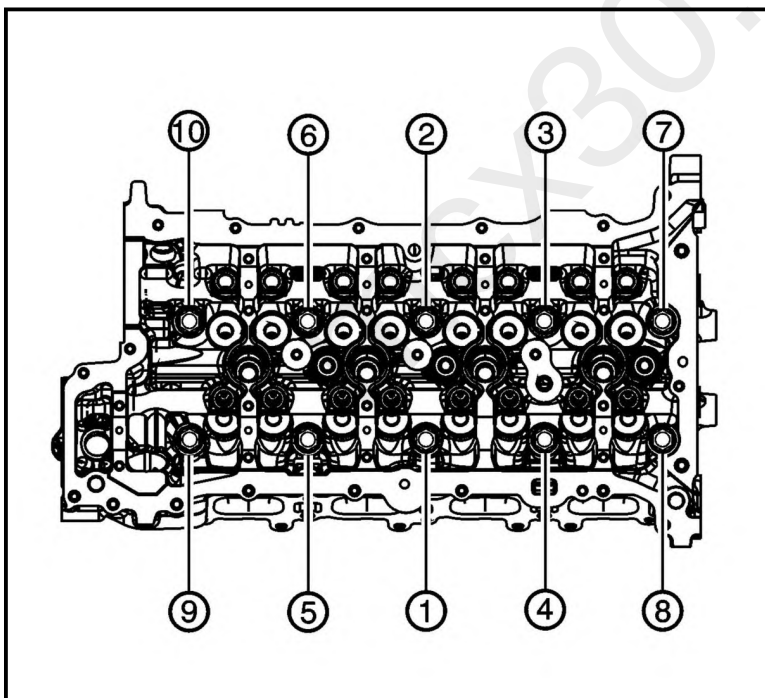
For equivalent regional tools, refer to [Special Tools](#)

1. If necessary, install NEW cylinder head locating pins.



NOTE: Do not use any sealing material. Ensure that all mating surfaces are clean and free of debris.

2. Install the cylinder head gasket (3) to the block.
3. Install the cylinder head (2). Ensure the number 1 cylinder is at top dead center (TDC). The key on the crankshaft should be on top in the 12 o'clock position.
4. Install the NEW cylinder head bolts.



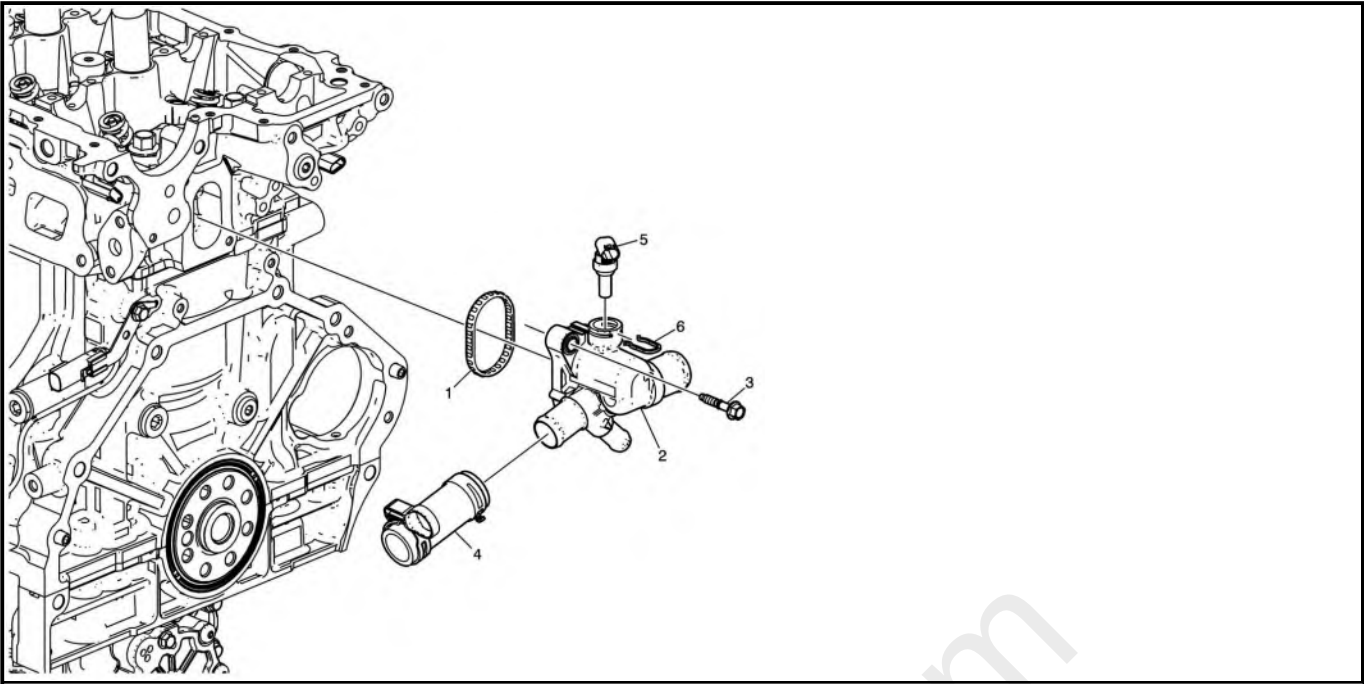
CAUTION: Refer to [Fastener Caution](#) .

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

1. Tighten the bolts in sequence to 30 N.m (22 lb ft).
2. Tighten the bolts an additional 190 degrees in sequence using the **EN 45059** meter.

WATER PUMP INSTALLATION

Water Outlet Installation

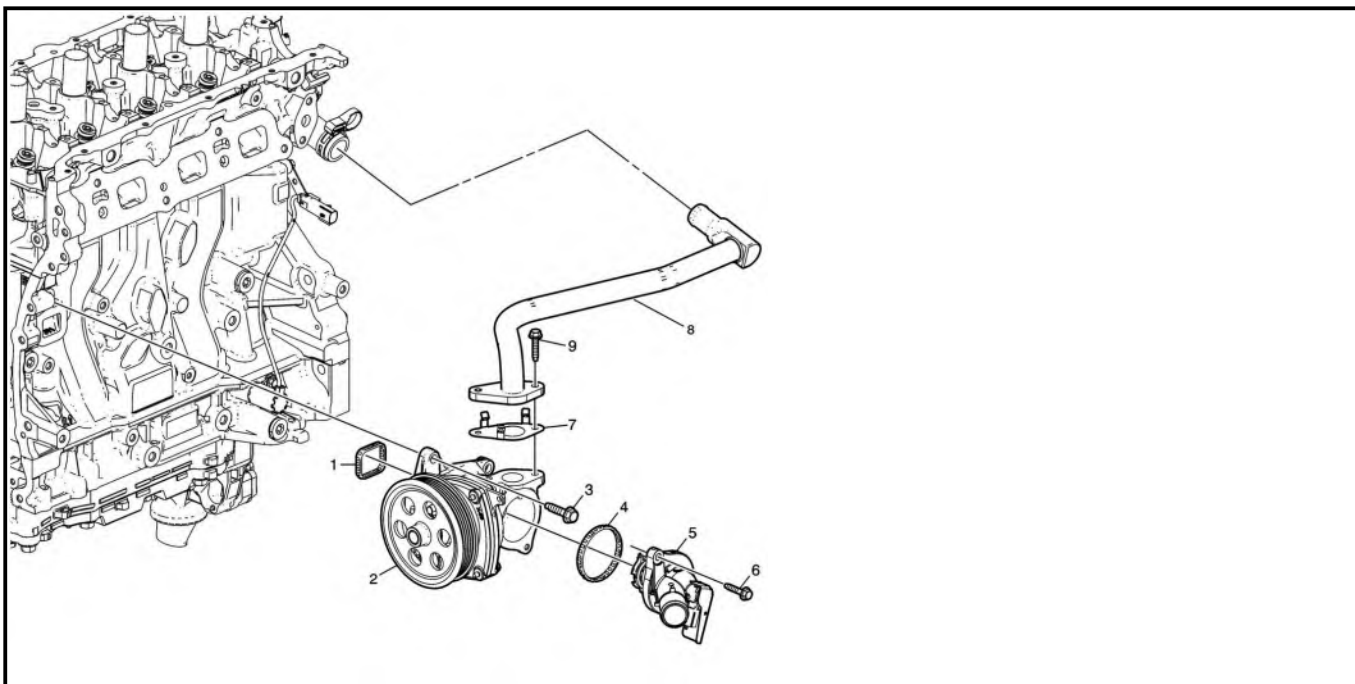


NOTE: Callouts in the following chart represent components shown in graphic above.

Water Outlet Installation

Callout	Component Name
1	Water Outlet Gasket NOTE: Use a NEW gasket.
2	Water Outlet
3	Water Outlet Bolt (Qty: 2) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 10 N.m (89 lb in)
4	Thermostat Bypass Hose
5	Engine Coolant Temperature Sensor
6	Engine Coolant Temperature Sensor Retainer

Thermostat Bypass Pipe and Water Pump Installation



NOTE: Callouts in the following chart represent components shown in graphic above.

Thermostat Bypass Pipe and Water Pump Installation

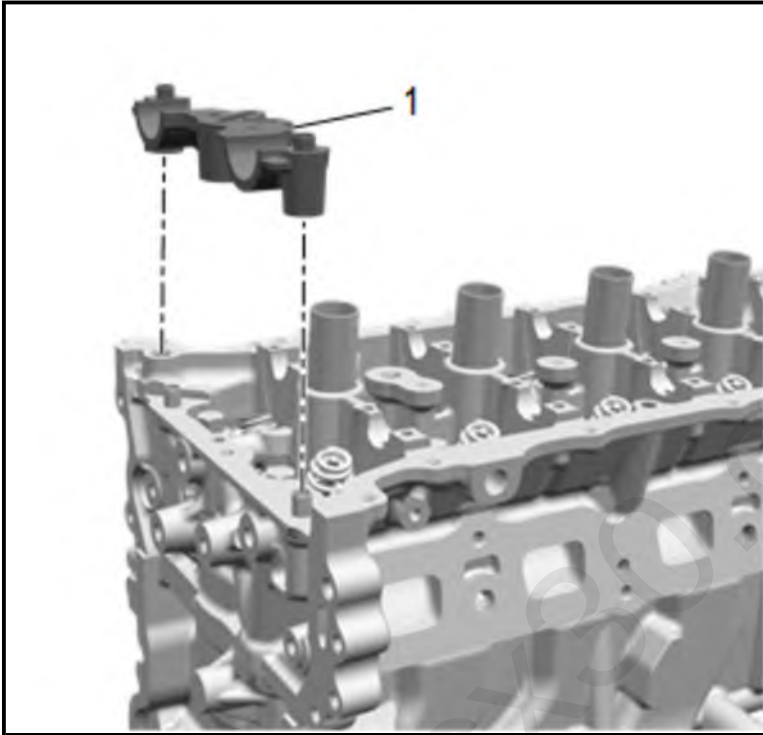
Callout	Component Name
Preliminary Procedure Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to ensure proper sealing.	
1	Water Pump Gasket NOTE: Use a NEW gasket.
2	Water Pump
3	Water Pump Bolts (Qty: 3) CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
4	Engine Coolant Thermostat Housing Gasket NOTE: Use a NEW gasket.
5	Engine Coolant Thermostat
6	Engine Coolant Thermostat Housing Bolt (Qty: 2) Tighten 10 N.m (89 lb in)
7	Thermostat Bypass Pipe Gasket Procedure Install a NEW thermal bypass pipe gasket on the thermal bypass pipe.

Callout	Component Name
8	Thermostat Bypass Pipe Procedure Connect the thermal bypass pipe to the water outlet assembly.
9	Thermostat Bypass Pipe Bolt (Qty: 2) Tighten 10 N.m (89 lb in)

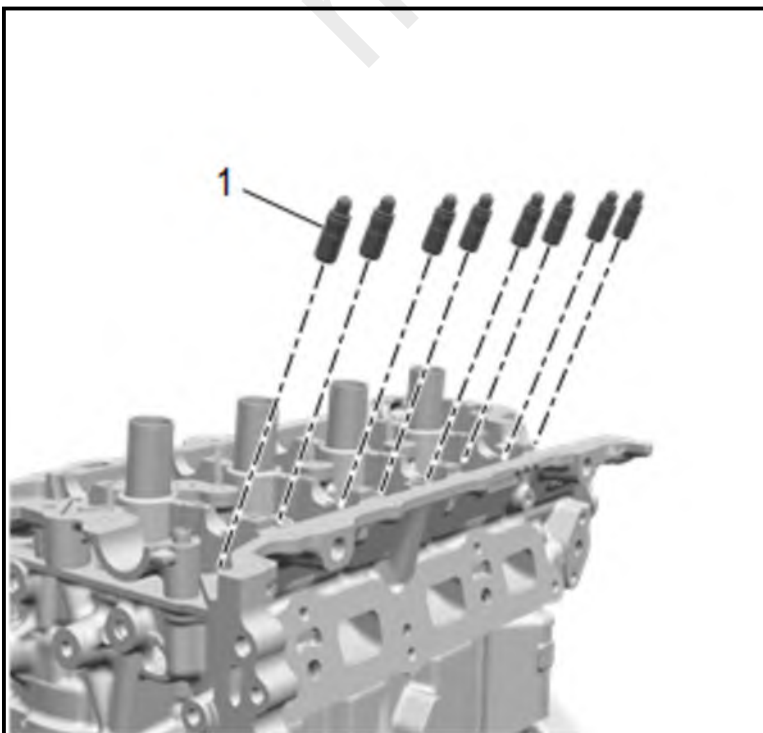
INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

Exhaust Camshaft Installation

1. Install the camshaft bearing lower front cap (1).



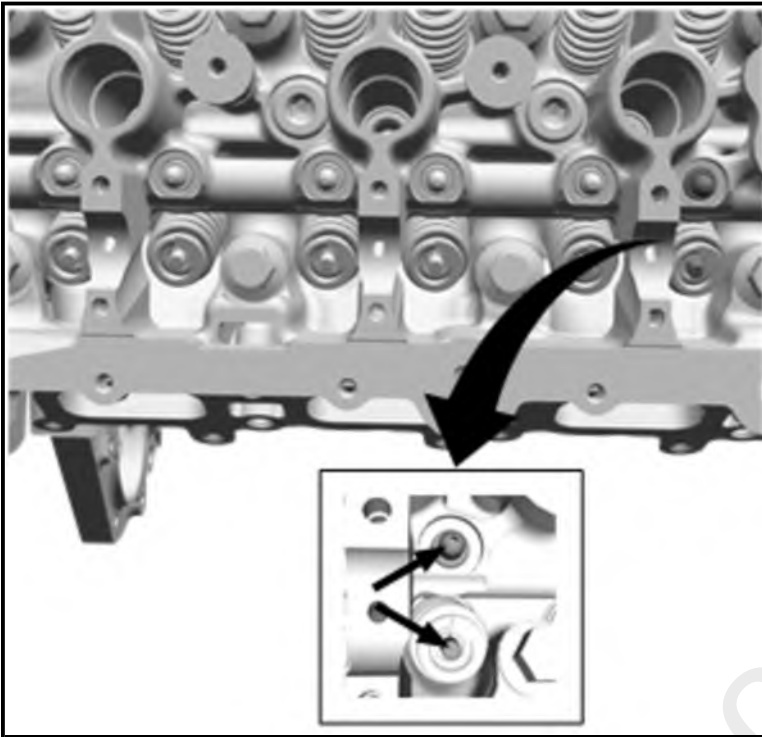
2. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



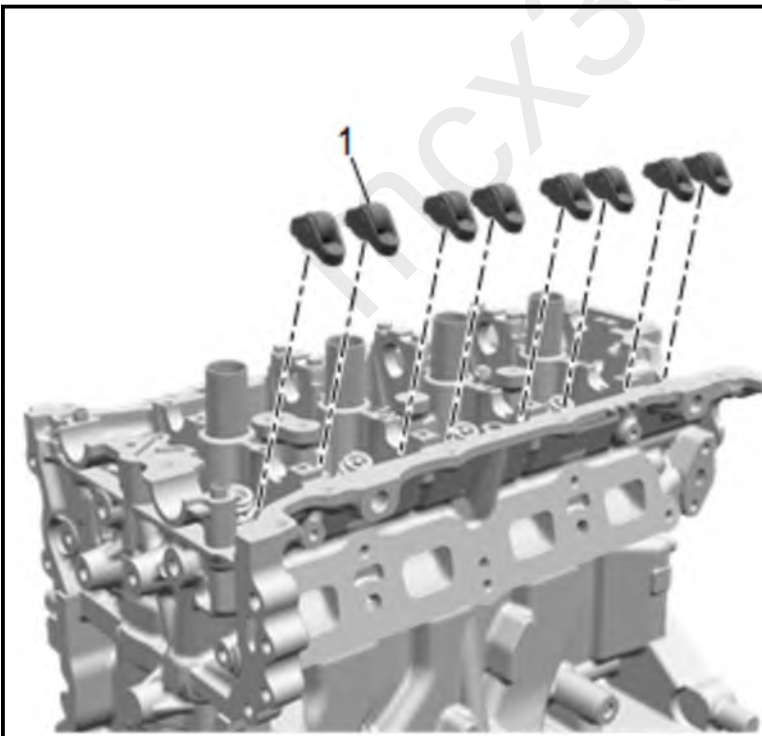
NOTE:

Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

3. Lubricate the valve tips. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



4. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



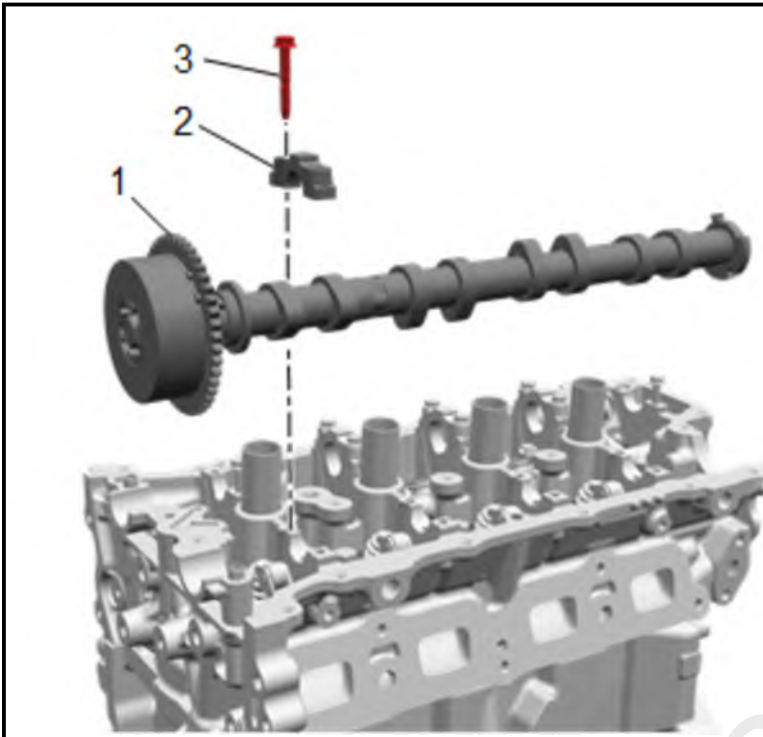
NOTE:

Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.

NOTE:

Pre-oil roller bearings before installation.

5. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
6. Lubricate the exhaust camshaft lobes and journals with camshaft lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

7. Set the exhaust camshaft (1) on top of the rocker arms in the camshaft bearing journals with the actuator timing mark at approximately the 1 O'clock position.

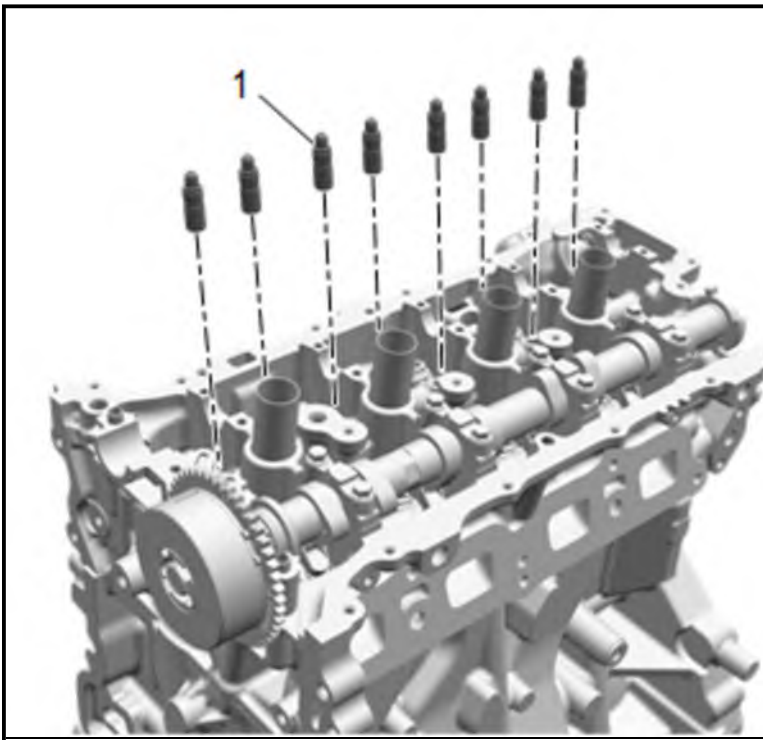
NOTE:

- Do not apply final torque at this time. Camshaft cap final torque is applied in sequence when all caps are installed on both intake and exhaust camshafts.
- To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

8. Install the camshaft cap bolts (3) into the camshaft caps (2).
9. Install the camshaft caps (2) and hand start the camshaft cap bolts (3).

Intake Camshaft Installation

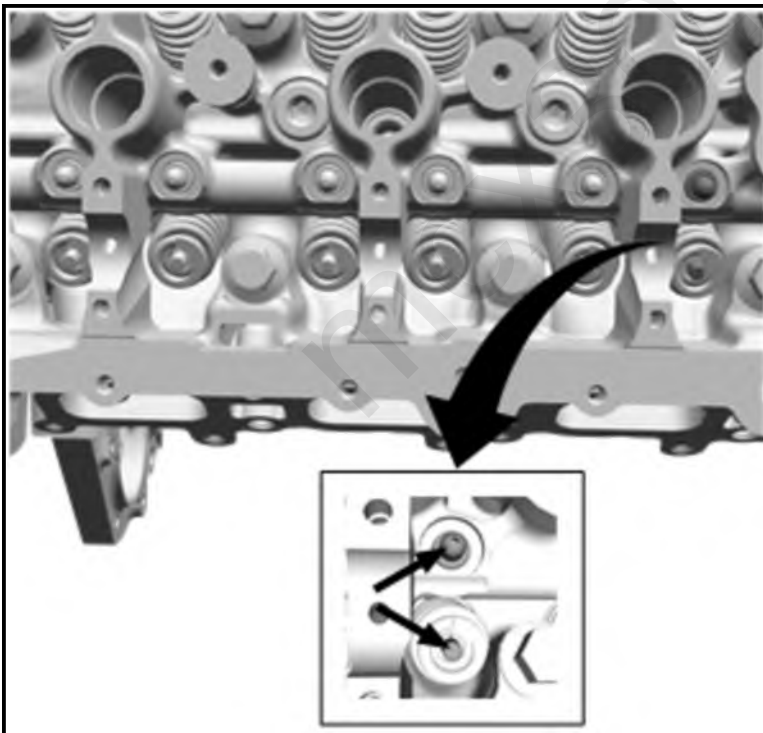
1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



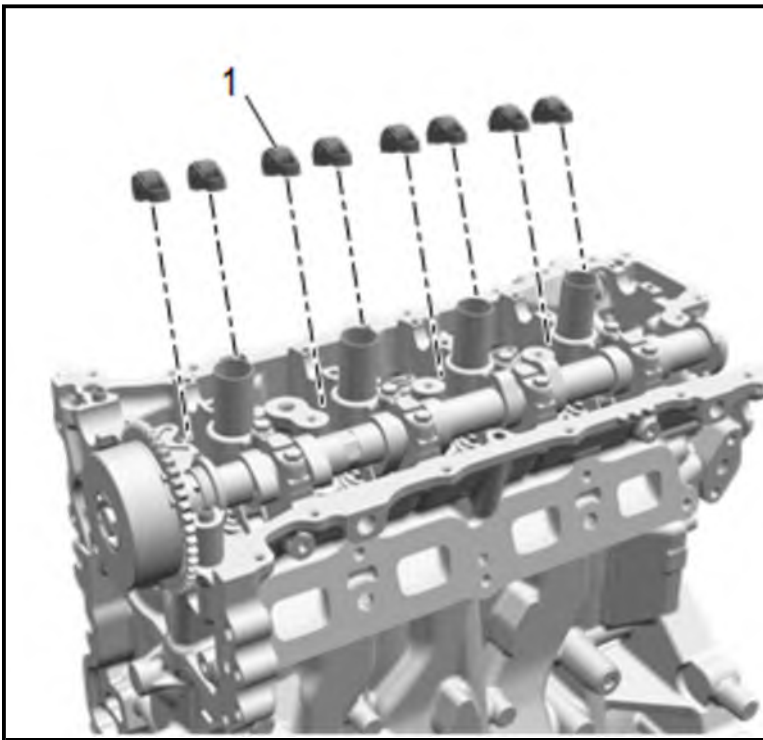
NOTE:

Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

2. Lubricate the valve tips. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



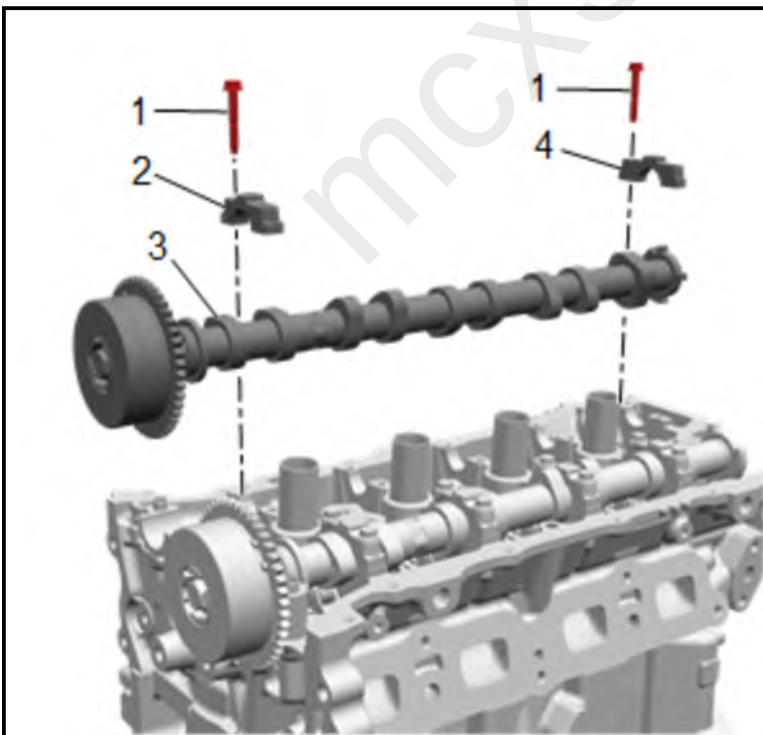
3. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE: Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.

NOTE: Pre-oil roller bearings before installation.

4. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
5. Lubricate the intake camshaft lobes and journals with camshaft lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

Set the intake camshaft (3) on top of the roller followers in the camshaft bearing journals with the intake actuator timing mark at approximately the 11 O'clock position.

NOTE:

To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

6. Install the camshaft cap bolts (1) into the camshaft caps (2, 4).
7. Install the camshaft caps (2) and hand start the camshaft cap bolts (1).
8. Install the camshaft rear cap (4) and hand start the camshaft cap bolts (1).
9. Tighten the camshaft cap bolts in sequence using the following procedure:

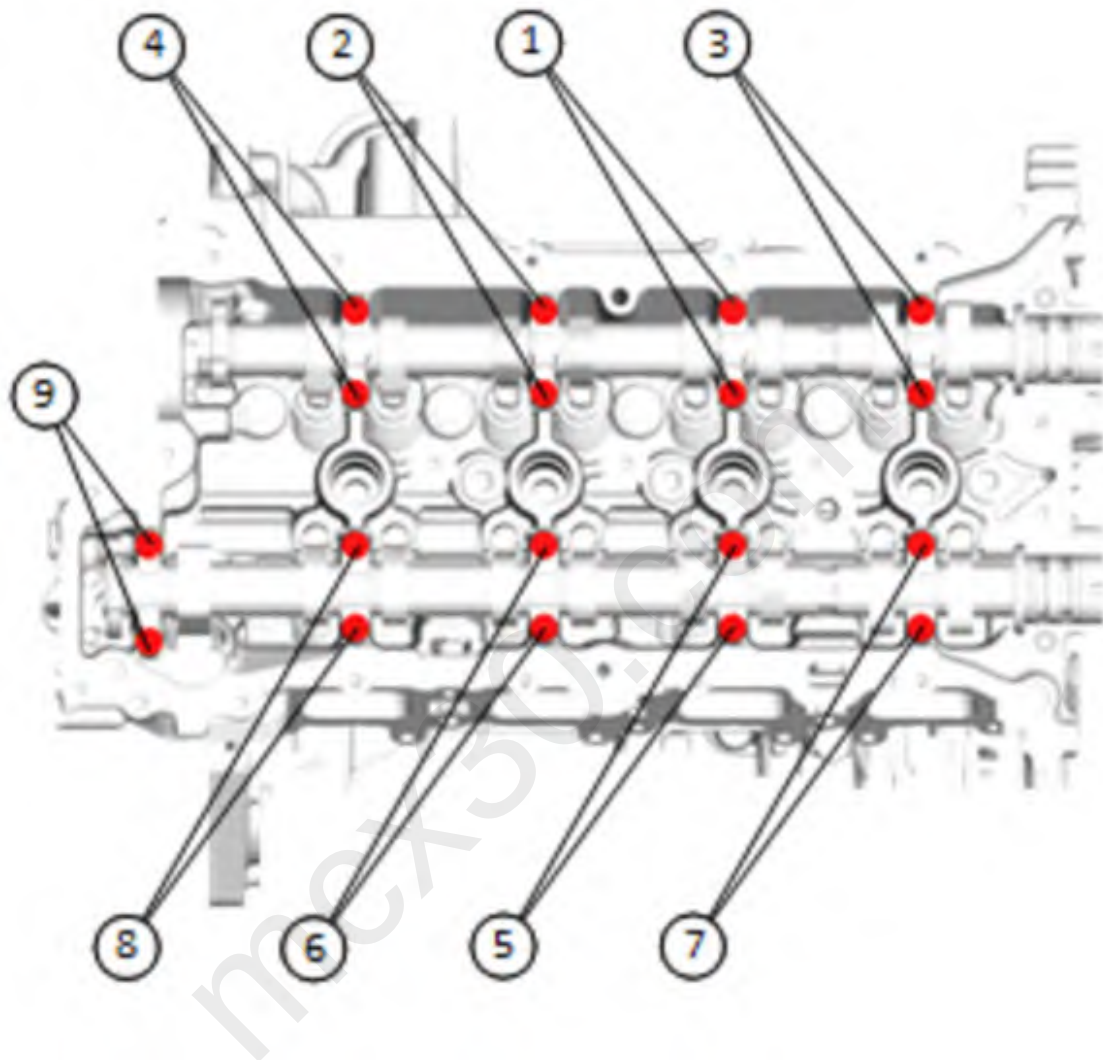


Fig. 22: Camshaft Cap Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

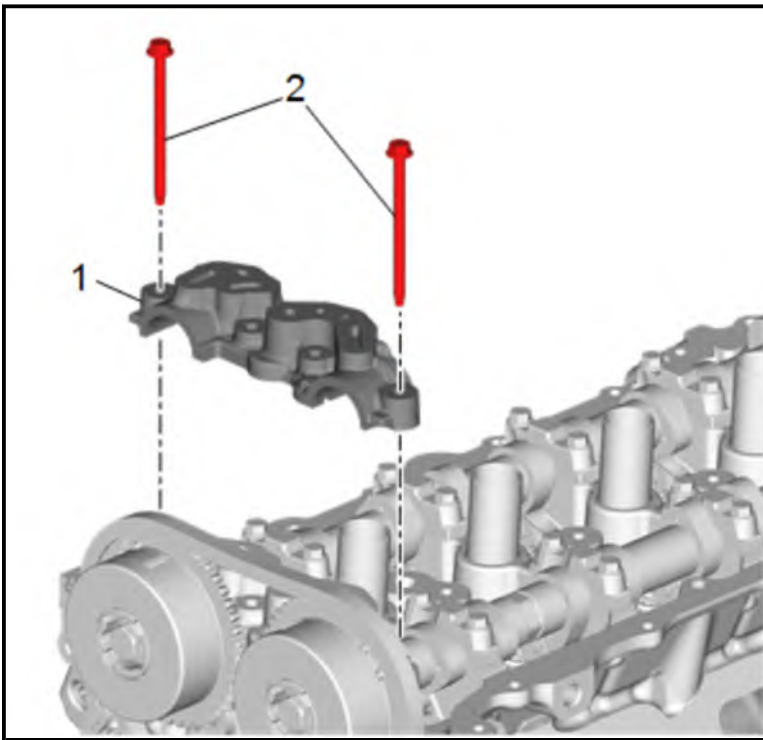
CAUTION:

Refer to [Fastener Caution](#) .

NOTE:

During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

1. Tighten the camshaft cap bolts in sequence to 8 N.m (71 lb in).
2. Loosen both bolts in each cap in sequence to 180 degrees.
3. Tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.
10. Install the front camshaft bearing cap (1). Install the 2 outer bolts (2) for the front camshaft bearing cap finger tight. Installation of the timing chain guide and bolts, and final torque for the front bearing cap is not performed until after the timing chain is installed.



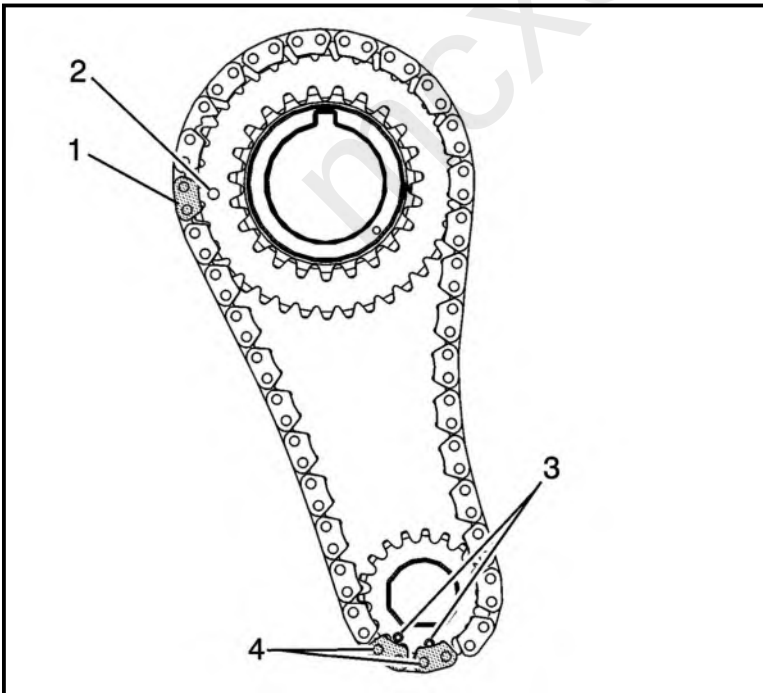
BALANCER CHAIN, SPROCKET, AND TENSIONER INSTALLATION

Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

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

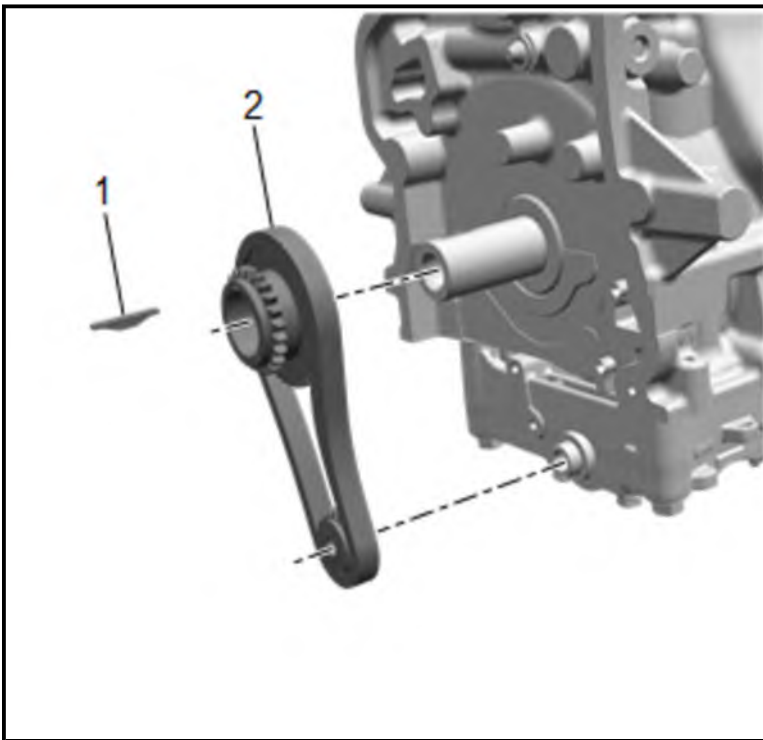
1. Assemble the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain. Ensure the timing link (1) lines up with the timing mark (2) on the crankshaft sprocket. Ensure that both timing teeth (3) on the balancer shaft driven sprocket line up with the timing links (4).



NOTE:

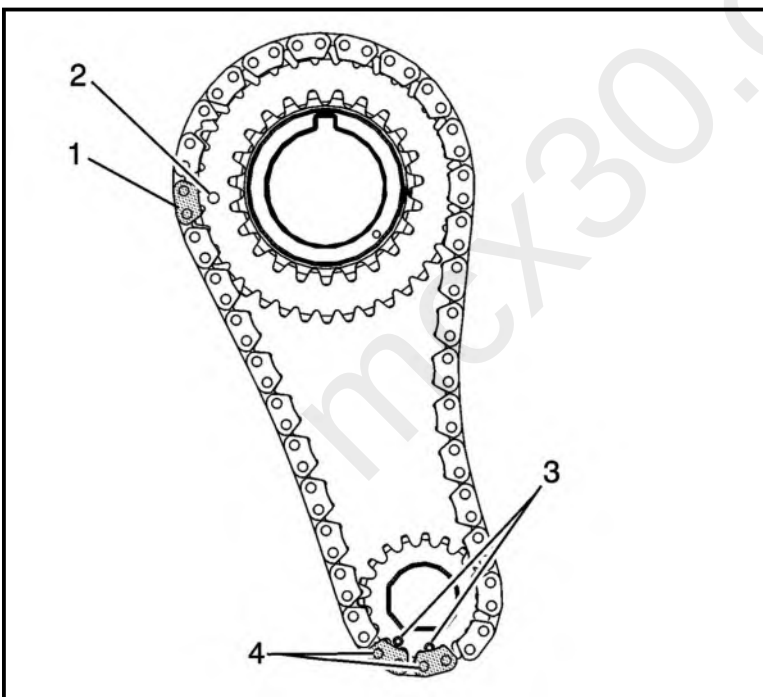
Proper setup is critical to ensure correct timing when installing the sprockets and chain simultaneously onto the shafts. The timing links are heat treated blued steel.

2. Install the sprockets and chain (2) as an assembly to the crankshaft and balancer shaft assembly.

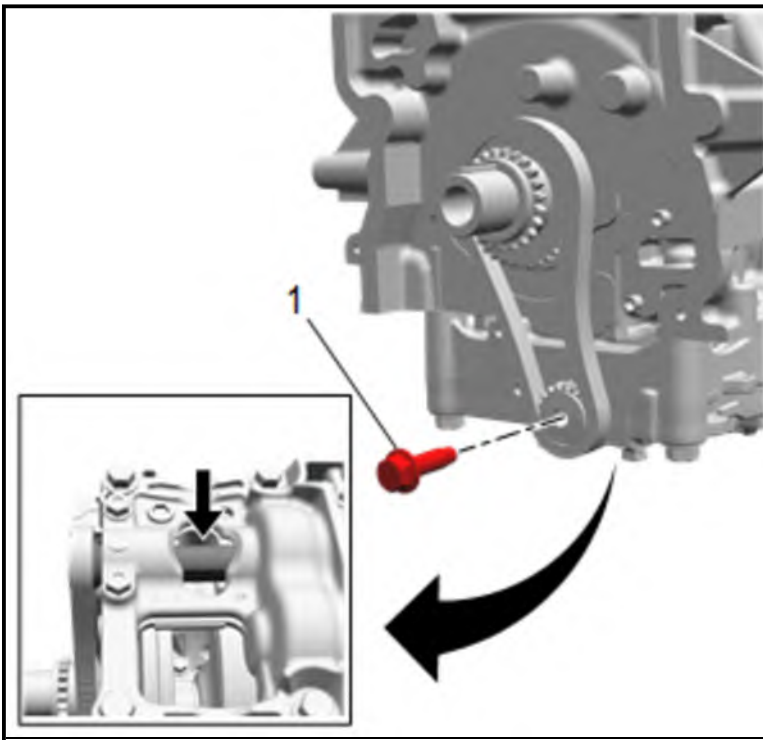


NOTE: The crankshaft keyway should be in the 12 O'clock position.

3. Install the crankshaft key (1).
4. Ensure the timing link (1) is aligned with the crankshaft sprocket timing mark (2).



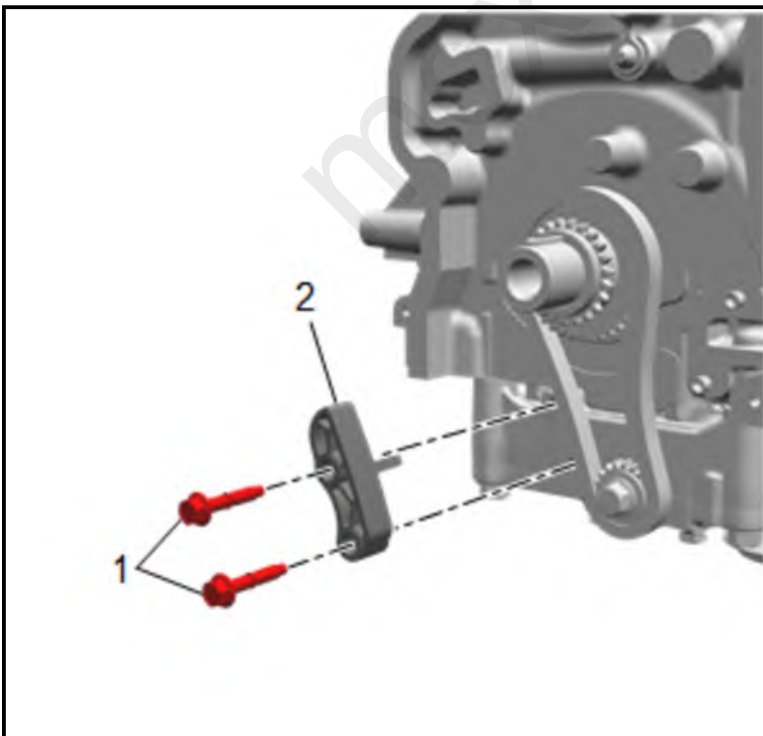
5. Ensure the adjacent timing links (4) are aligned with both of the timing marks (3) on the balancer shaft driven sprocket.
6. Install the NEW balancer shaft driven sprocket bolt (1).



CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

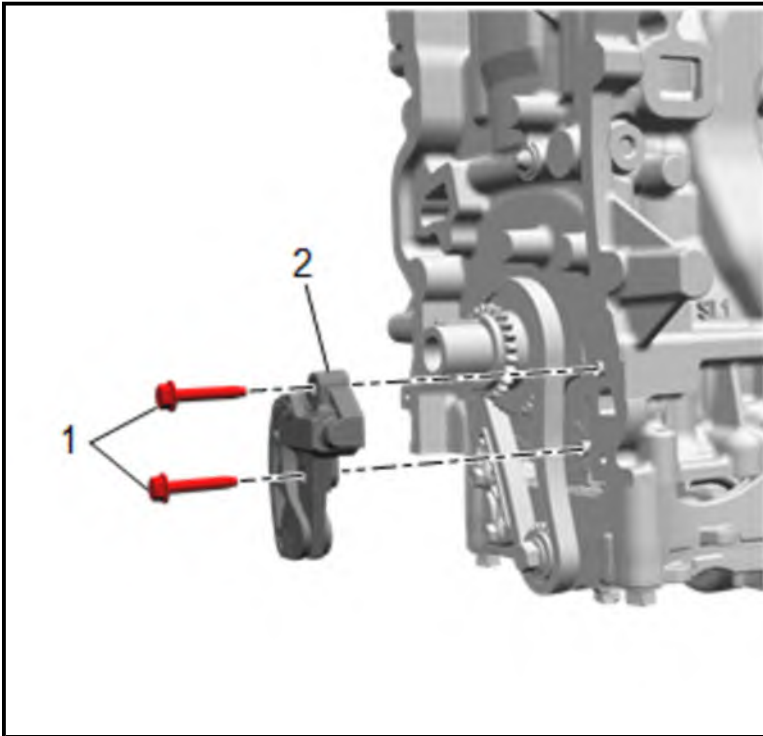
CAUTION: Refer to [Fastener Caution](#) .

7. Use an open end wrench over flat on balance shaft while tightening the balancer shaft sprocket bolt to specification. Tighten the balancer shaft driven sprocket bolt to 40 N.m (30 lb ft) plus 50 degrees.
8. Install the balancer chain guide (2).



NOTE: Ensure the guide is installed in the correct orientation. The long end must point toward the crankshaft and the flat edge must be adjacent to the balance chain.

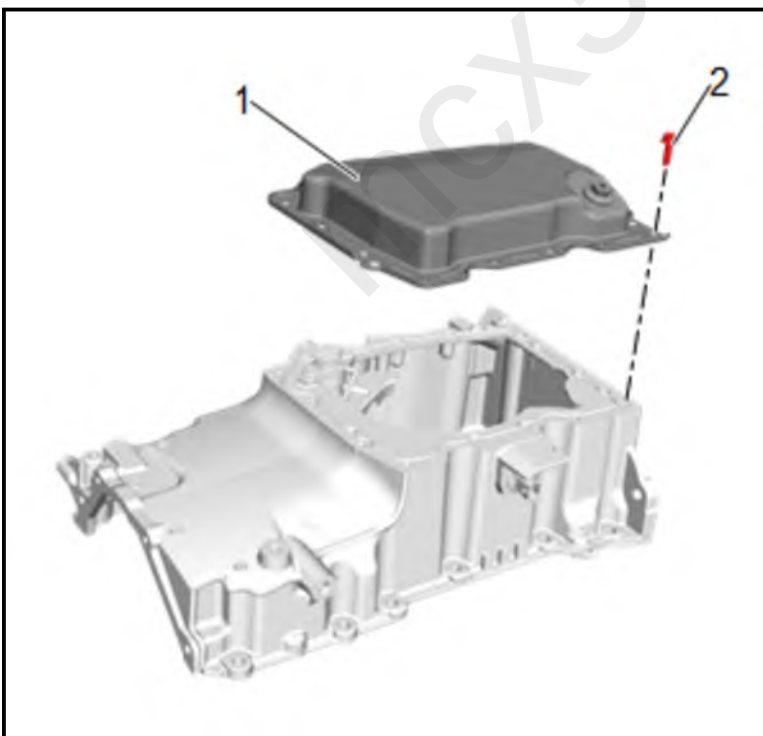
9. Install the balancer chain guide bolts (1). Tighten the bolts to 10 N.m (89 lb in).
10. Install the balancer chain tensioner (2).



11. Install the balancer chain tensioner bolts (1). Tighten the bolts to 10 N.m (89 lb in).
12. Remove **EN-50837** retention tool to restore the tension to the balancer chain.

OIL PAN INSTALLATION (2WD)

1. Apply a bead of RTV sealant to the perimeter of the lower oil pan.



Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

NOTE:

- The oil pan sealing surfaces must be free of contamination prior to applying the sealer.

- Install and align the oil pans within 20 minutes of applying the sealer.
- The oil pans must be fastened to final torque specification within 60 minutes of applying the sealer.

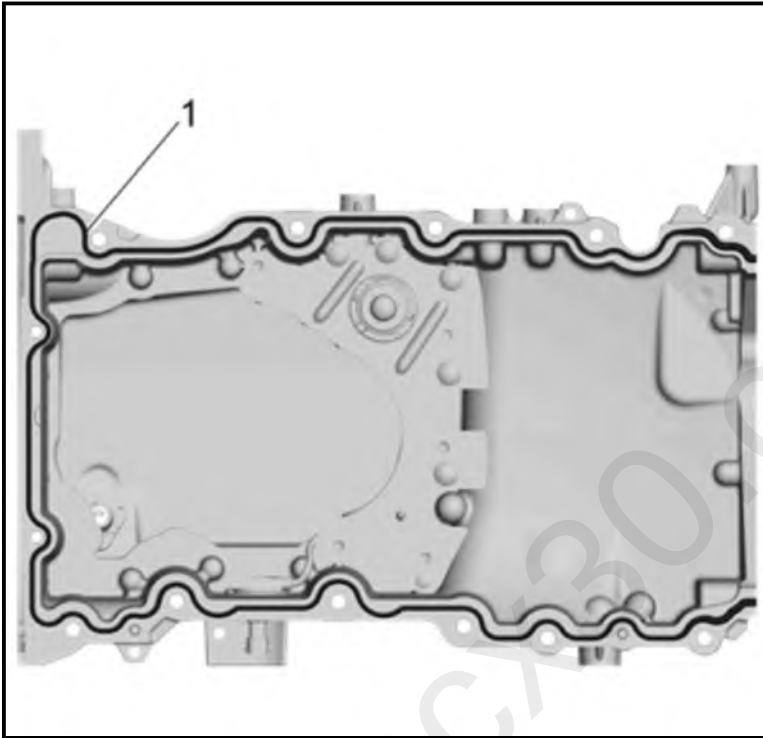
2. Lower Oil Pan (1) - Install NEW

CAUTION: Refer to [Fastener Caution](#) .

NOTE: Two long bolts secure the lower oil pan and upper oil pan together to the lower crankcase.

3. Install the short lower oil pan bolts (2) and tighten to 10 N.m (89 lb in).

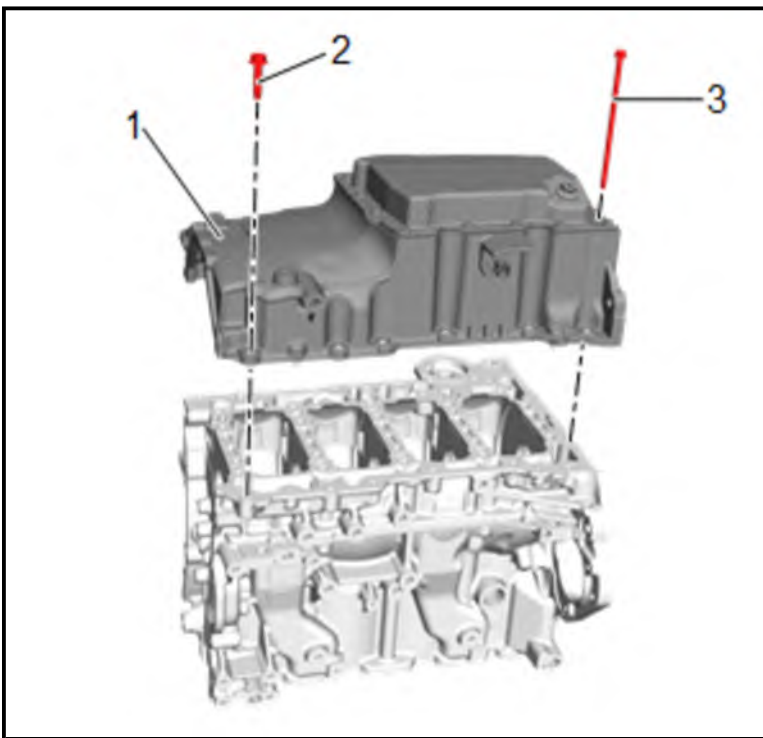
4. Apply a 4.25 mm bead of sealer (1) on the level part of the flange around the perimeter of the oil pan. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 20 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

5. Install the oil pan (1).



6. Install the oil pan bolts (2, 3) finger tight.

7. Tighten the oil pan bolts in sequence to final torque twice using the following procedure:

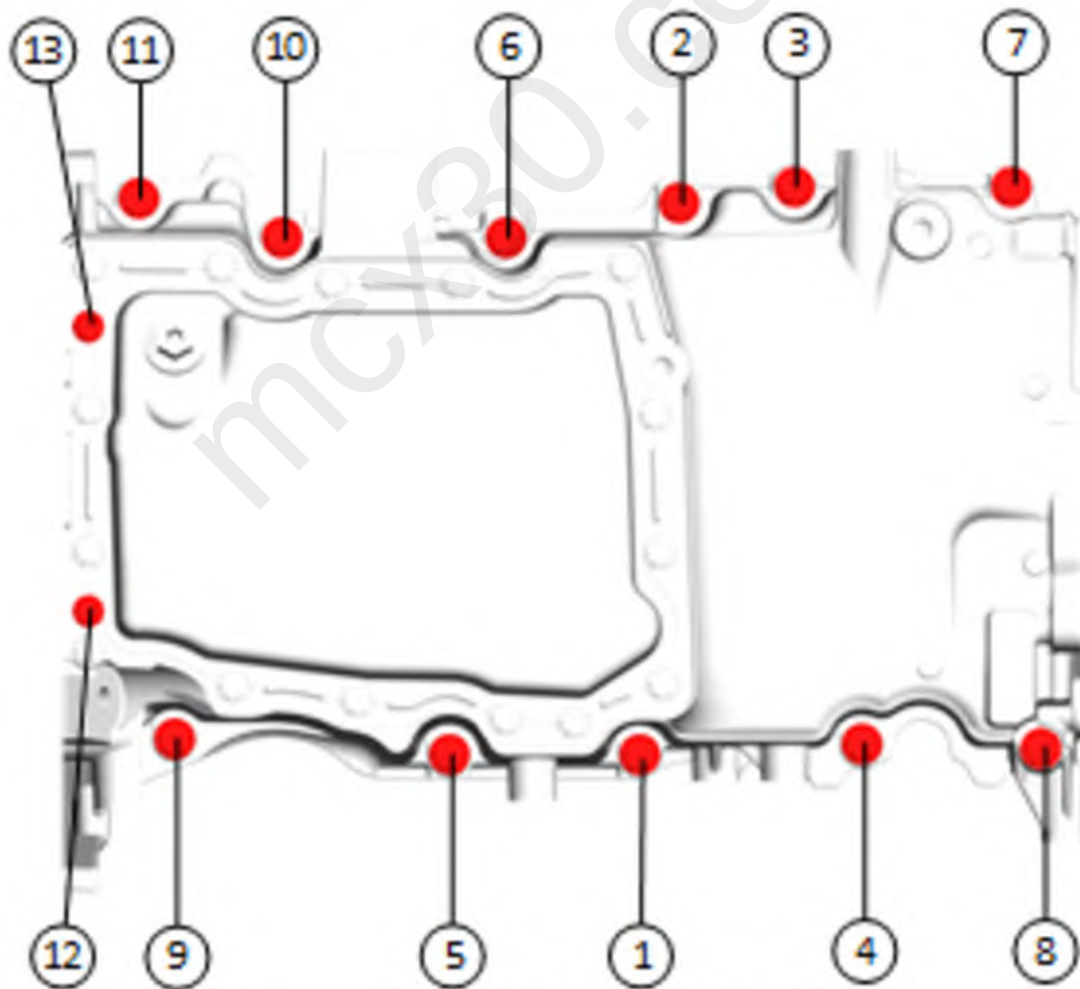
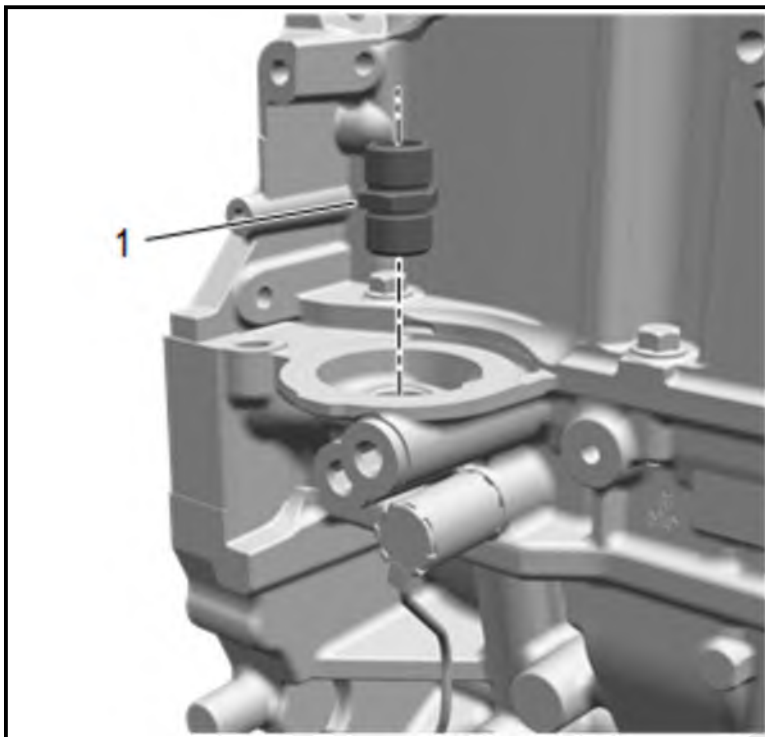
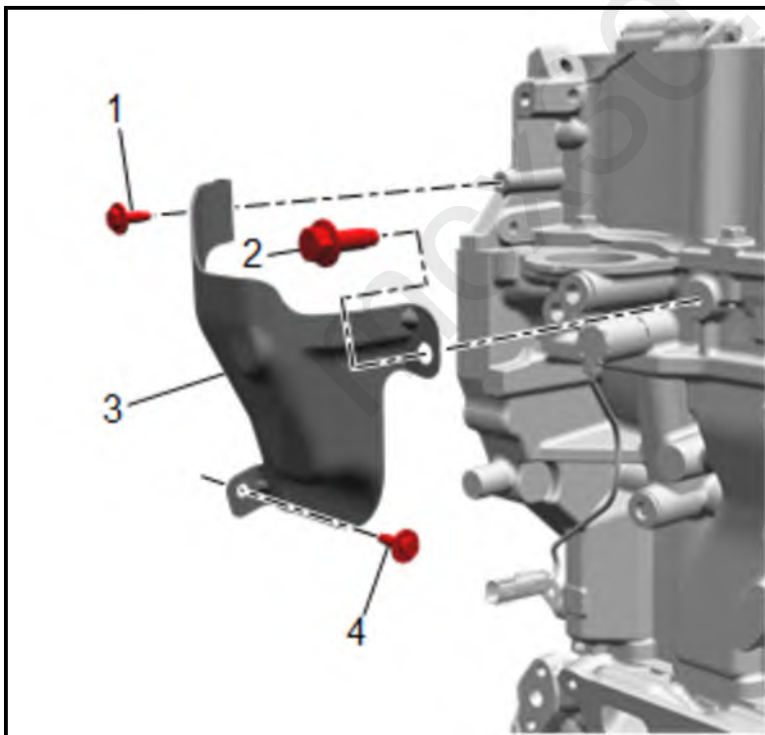


Fig. 23: Engine Oil Pan Bolt Tightening Sequence (2WD).
 Courtesy of GENERAL MOTORS COMPANY

1. Tighten bolts in sequence 1 - 11 to 25 N.m (18 lb ft).
2. Tighten bolts in sequence 12 - 13 to 10 N.m (89 lb in).
8. Insert the oil filter fitting (1). Tighten the fitting to 50 N.m (37 lb ft).



9. Install the oil pump flow control valve cover (3).



10. Install the valve cover bolts (1, 4) and tighten to 9 N.m (80 lb in).
11. Install the valve cover bolt (2) and tighten to 58 N.m (43 lb ft).

OIL PAN INSTALLATION (4WD)

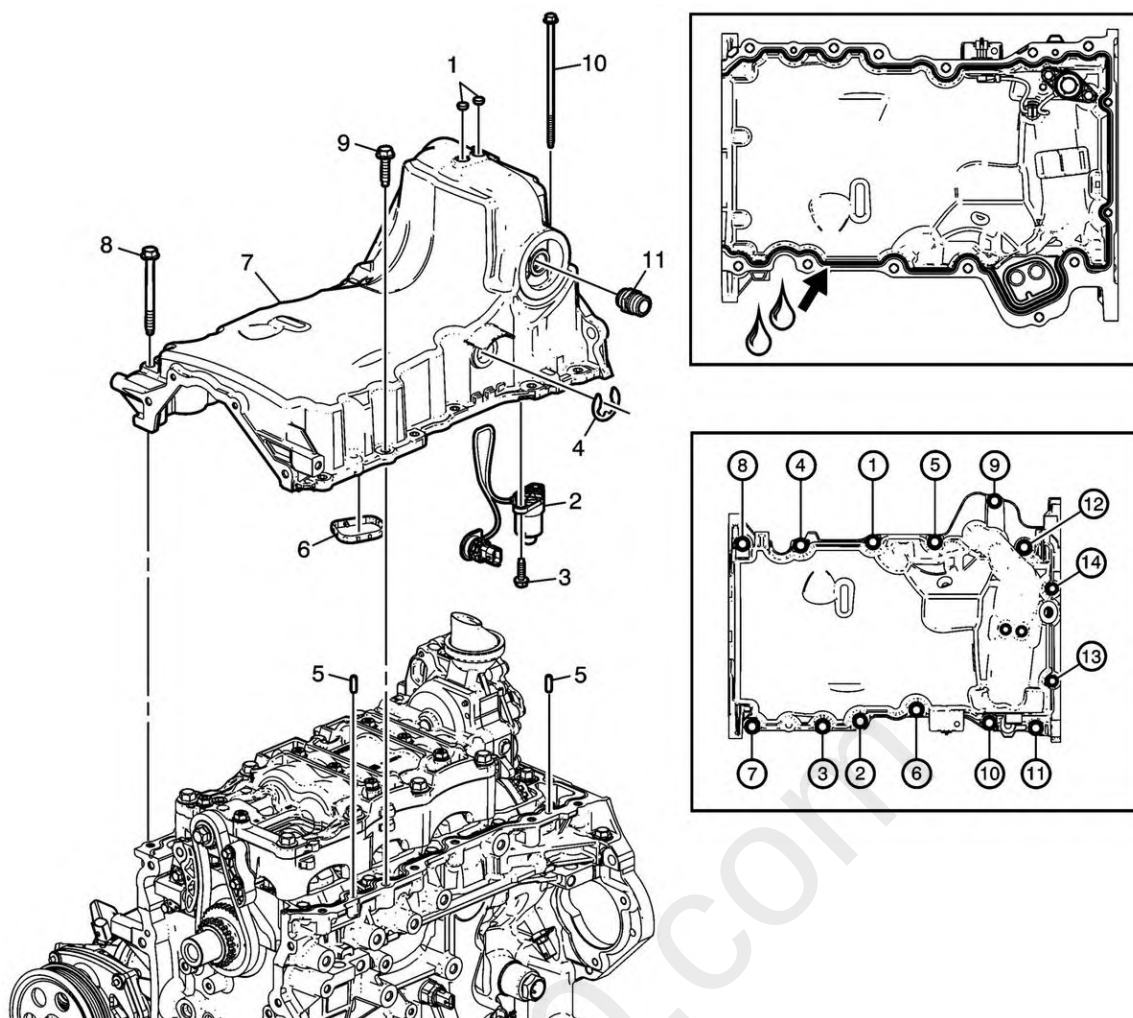


Fig. 24: Oil Pan With Bolt Tightening Sequence (4WD)

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Gallery Plug (Qty: 2)
2	Engine Oil Level Indicator Switch
3	Engine Oil Level Indicator Switch Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
4	Engine Oil Level Sensor Lead Clip Procedure: Install the engine oil level indicator switch connector through the opening in the oil pan, and secure with the clip.
5	Oil Pan Locating Pin (Qty: 2)
6	Oil Pan Gasket NOTE: Use a NEW gasket.

Callout	Component Name
7	Oil Pan Procedure: 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> NOTE: • The lower crankcase surface must be free of contamination prior to applying the sealer. • Install and align the oil pan to block within 10 minutes of applying the sealer. 2. Apply a 4.25 mm bead of sealer on the level part of the flange around the perimeter of the oil pan as shown. Refer to <u>Adhesives, Fluids, Lubricants, and Sealers</u>. 3. Carefully align the oil pan to the locating pins and install the oil pan onto the lower crankcase.
8	Oil Pan Bolt (Qty: 1) NOTE: Install all the oil pan bolts and tighten in the sequence shown.
9	Oil Pan Bolt (Qty: 11) NOTE: Install all the oil pan bolts and tighten in the sequence shown.
10	Oil Pan Bolt (Qty: 2) Procedure: Tighten the oil pan bolts in sequence to final torque twice using the following procedure: 1. Tighten bolts in sequence 1 - 12 to 25 N.m (18 lb ft). 2. Tighten bolts in sequence 13 - 14 to 10 N.m (89 lb in).
11	Oil Filter Fitting Tighten

Callout	Component Name
	50 N.m (37 lb ft)

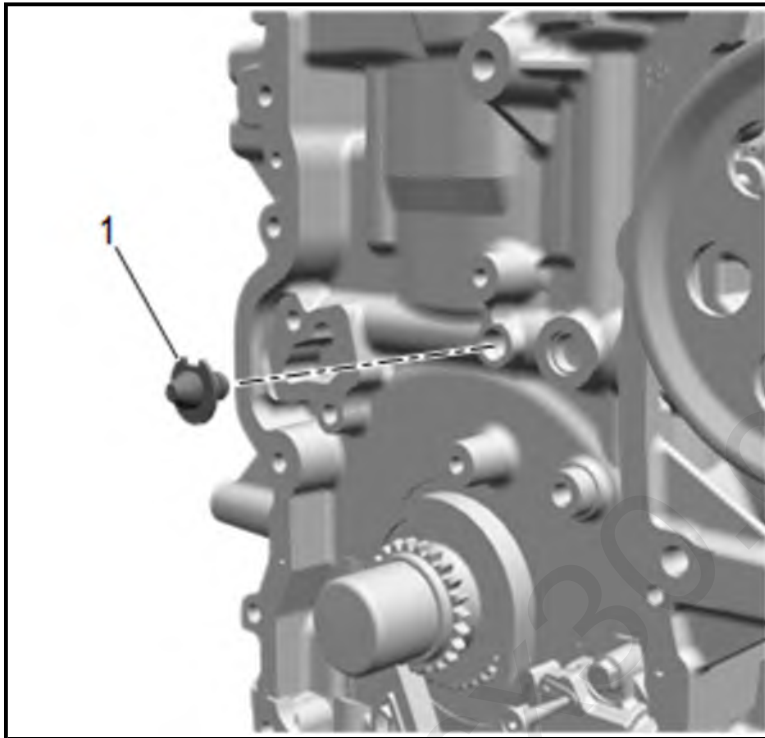
CAMSHAFT TIMING CHAIN AND TENSIONER INSTALLATION

Special Tools

- EN 45059 Angle Meter
- EN 50837 Timing Chain Tensioner Retraction Tool

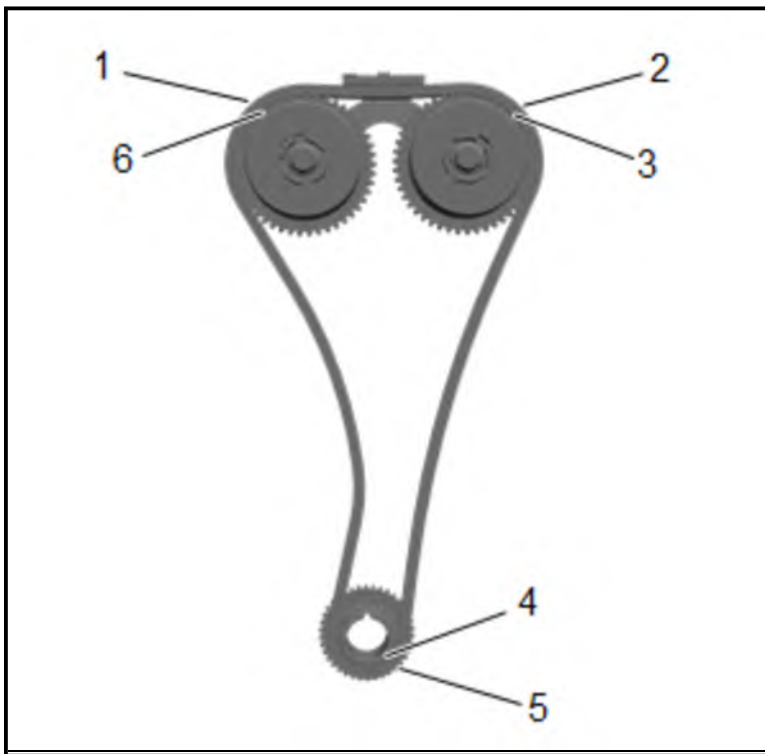
For equivalent regional tools, refer to [Special Tools](#).

1. Install the timing chain oil nozzle (1).



NOTE: Ensure the timing chain oil nozzle is rotated with the notch facing upward, and aligned with the tab on the engine block.

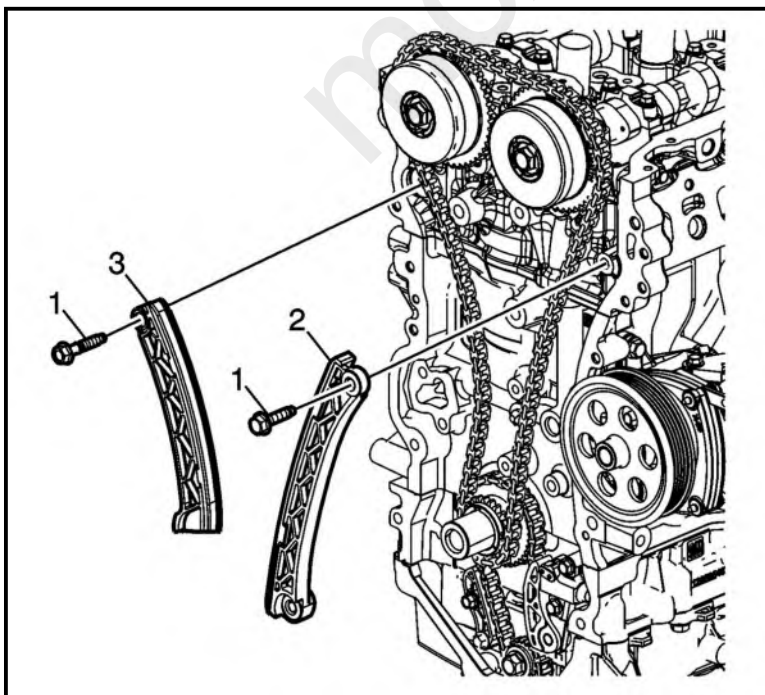
2. Loop the timing chain over the intake and exhaust camshaft actuators, aligning one of the same colored links (2) with the timing mark on the exhaust camshaft actuator (3).



NOTE: There are three colored links on the timing chain. The two links that align to the timing marks on the actuators are the same color. The timing link that aligns with the timing mark on the crankshaft sprocket is a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

NOTE: The same colored link corresponding to the intake actuator will not initially align with the intake actuator timing mark, nor the unique colored timing chain link align with the crankshaft sprocket timing mark.

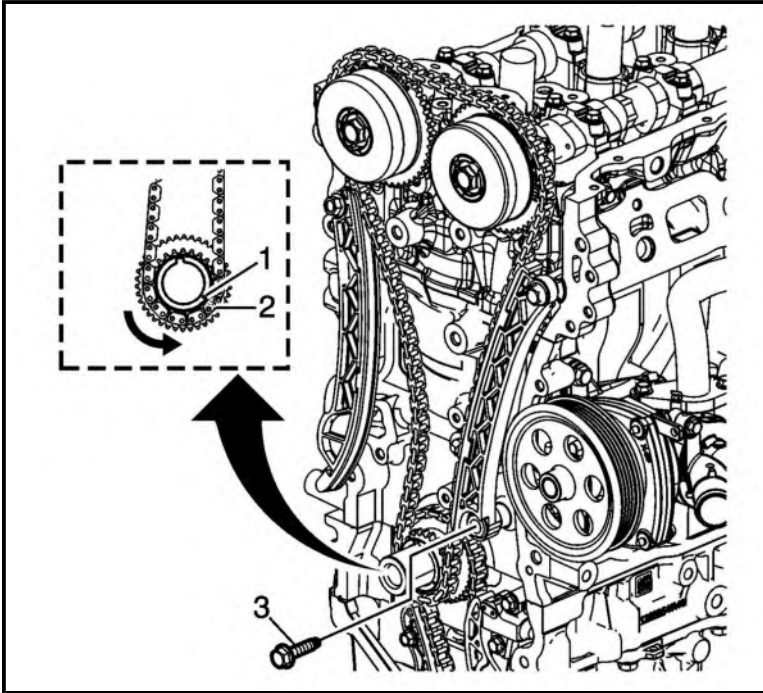
3. Ensure the crankshaft key in the 12 O'clock position. Loop the timing chain onto the crankshaft sprocket.
4. Install the timing chain guide (2) and upper bolt (1) only, finger tight.



NOTE: Timing will be established before the final install and torque of the guide bolts.

5. Install the timing chain tensioner pivot arm (3).

6. Install the pivot arm bolt (1) finger tight.
7. With a suitable tool, rotate the crankshaft counterclockwise to align the timing mark on the crankshaft sprocket (1) with the unique colored timing link (2).



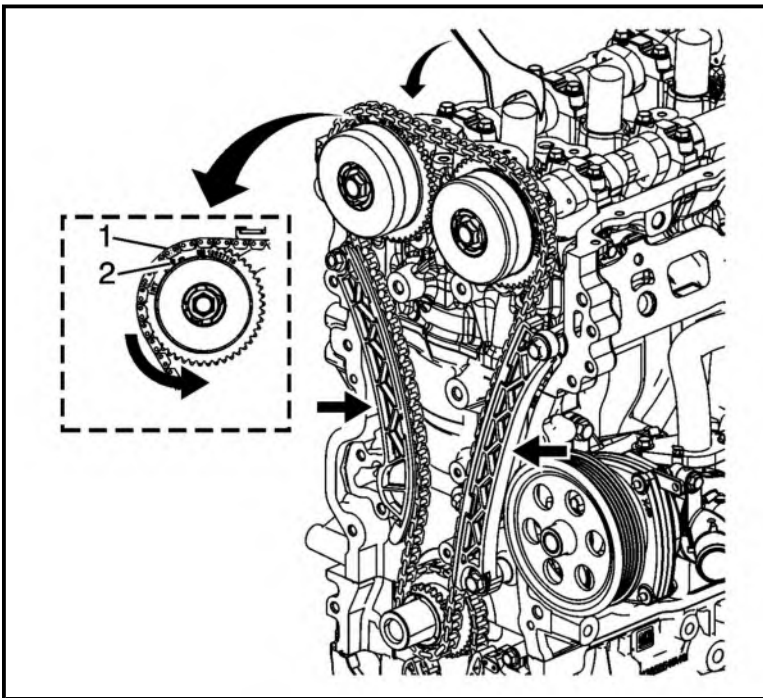
NOTE:

- Continue to rotate the crankshaft counterclockwise as necessary to maintain timing alignment.
- Ensure that the alignment mark on the exhaust camshaft actuator remains aligned with the corresponding same colored timing link.

8. Rotate the lower end of the fixed timing chain guide into installation position and install the lower bolt (3).

CAUTION: Refer to [Fastener Caution](#) .

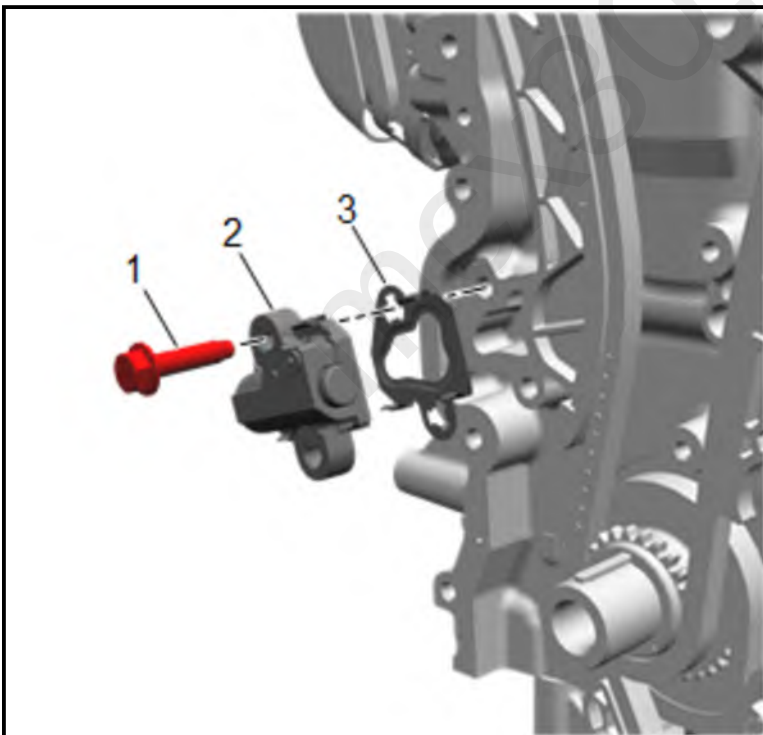
9. Tighten the timing chain guide upper and lower bolts to 25 N.m (18 lb ft).
10. Using a suitable tool, rotate the intake camshaft counterclockwise until the timing mark on the intake actuator (2) is aligned with the corresponding same colored timing link (1). Maintain tension on intake camshaft until the timing chain tensioner can be installed and activated.



NOTE:

- The timing for the exhaust camshaft actuator and the crankshaft sprocket has been established.
- Applying or loosening pressure by hand between the timing chain guides will allow the chain to slip or bind during counterclockwise rotation of the camshaft.

11. Install a NEW timing chain tensioner gasket (3) on the timing chain tensioner (2).

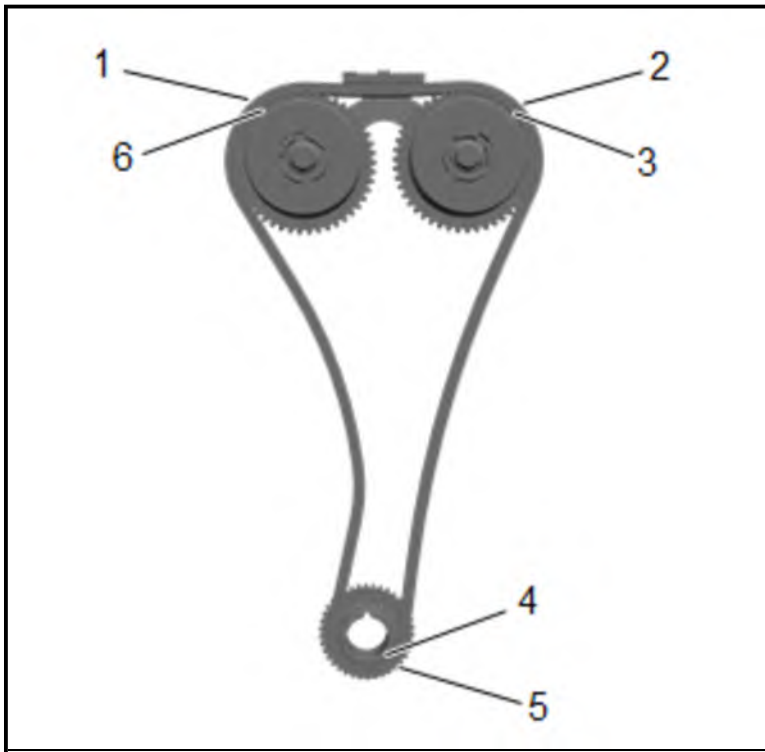


NOTE:

Ensure EN-50837 retraction tool is installed and the tensioner is locked in a compressed state before installing.

12. While maintaining the intake camshaft actuator timing alignment, install the timing chain tensioner (2) and bolts (1) and tighten to 25 N.m (18 lb ft).
13. Tighten the pivot arm bolt to 25 N.m (18 lb ft).
14. Remove **EN-50837** retraction tool.

15. Verify the timing links on the timing chain are properly aligned to the timing marks:

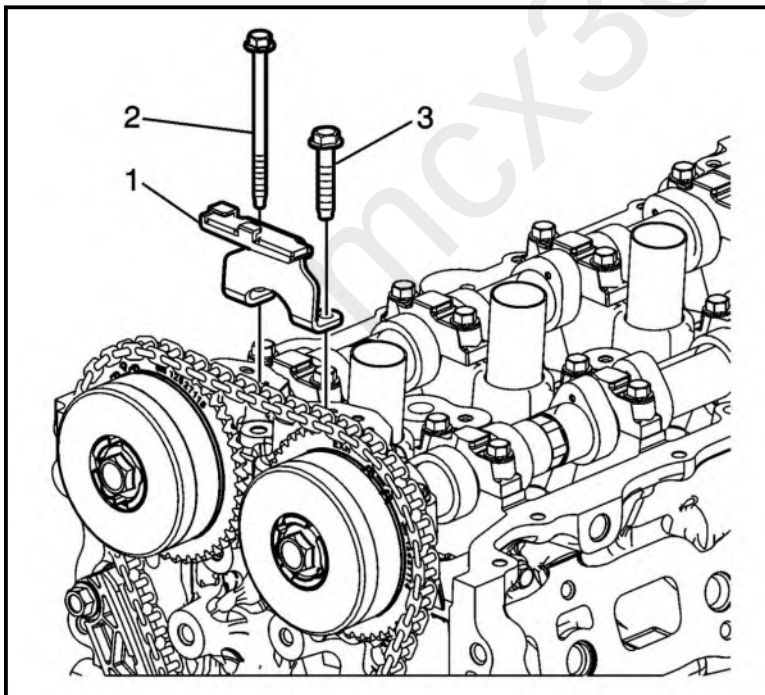


1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).

2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).

16. If they are not, repeat the portion of the procedure necessary to align the timing marks.

17. Install the timing chain guide (1) and bolts (2, 3) finger tight.



18. Tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

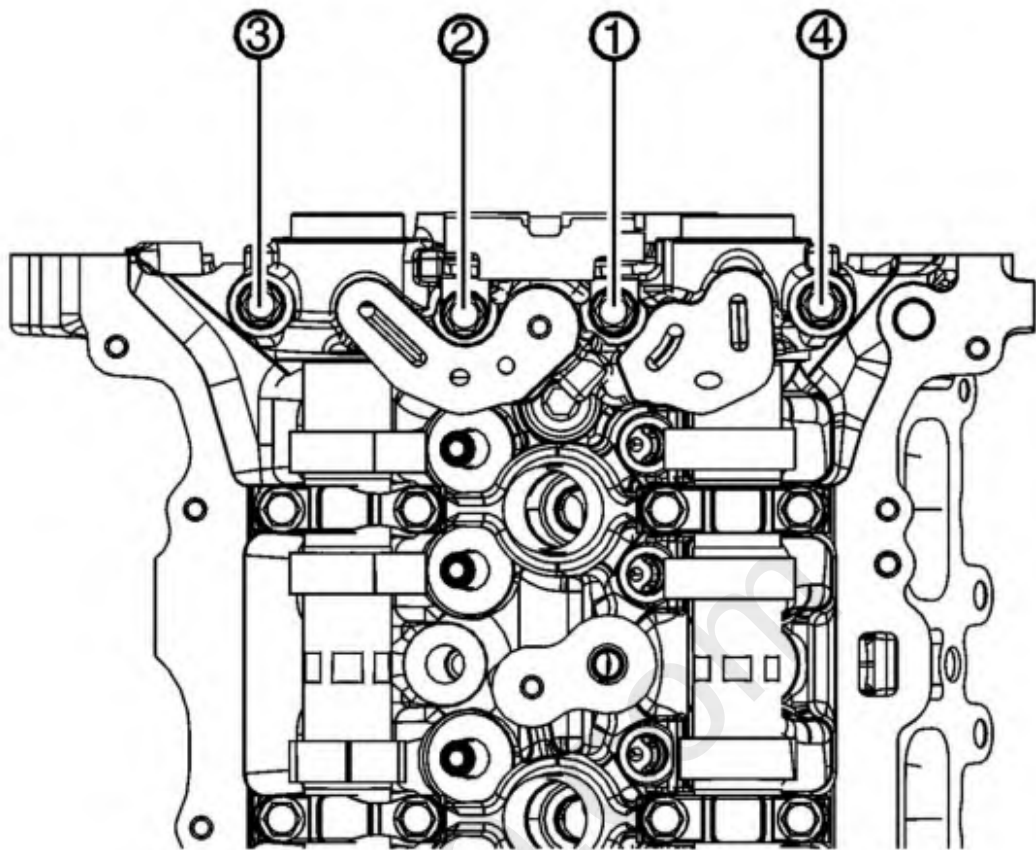
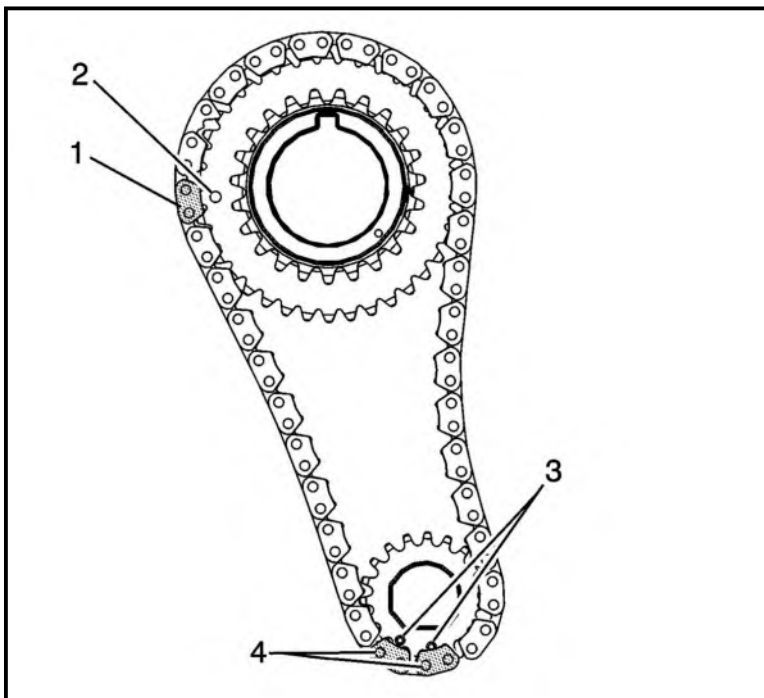


Fig. 25: Front Camshaft Cap Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

NOTE: Rotating the crankshaft will engage the tensioner and remove slack from the timing chain.

19. Rotate the crankshaft slightly in a clockwise direction. If the timing chain jumps actuator teeth, repeat procedure to align the timing marks.
20. Verify the timing links on the balance chain are properly aligned to the timing marks:

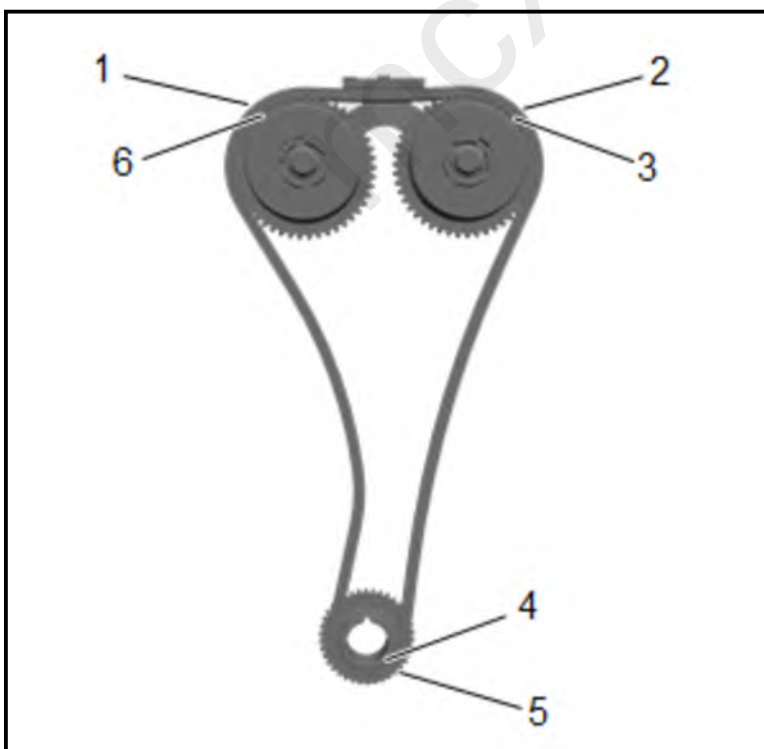


NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

NOTE: Due to size difference of the crankshaft sprocket and the balance shaft sprocket, timing marks on the chain will not match during every crankshaft revolution. Ensure that the marks on the sprockets are aligned appropriately before installing the timing chain.

1. The timing link (1) is aligned to the timing mark on the crankshaft sprocket (2).
2. The adjacent timing links (4) are aligned with both timing marks (3) on the balancer shaft driven sprocket.

21. Verify the timing links on the timing chain are properly aligned to the timing marks:



NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
22. If they are not, repeat the portion of the procedure necessary to align the timing marks.

ENGINE FRONT COVER INSTALLATION

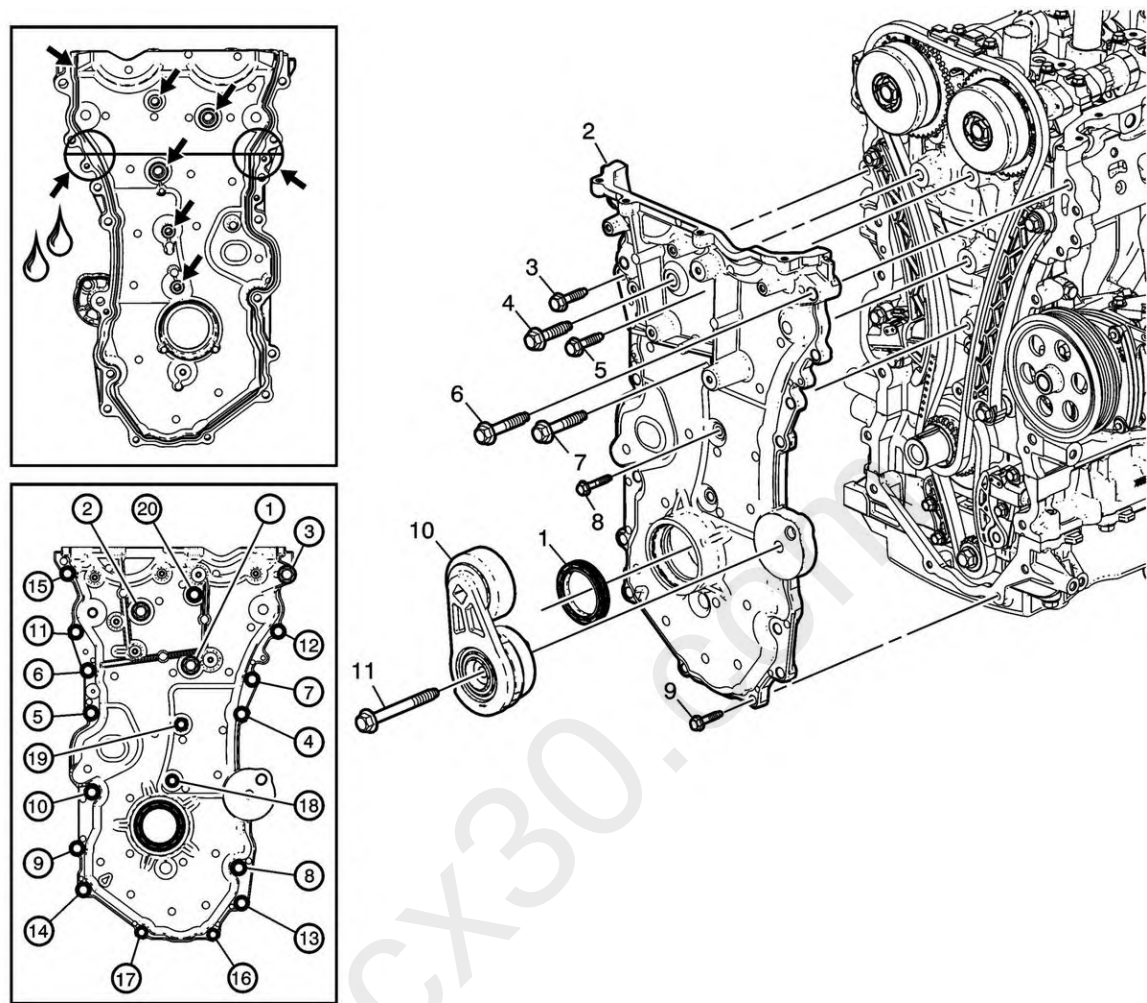


Fig. 26: Engine Front Cover Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Crankshaft Front Oil Seal Special Tools EN-50820 Front Crankshaft Seal Installer For equivalent regional tools, refer to Special Tools .
2	Engine Front Cover Procedure: 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant NOTE: - The engine front cover surface must

Callout	Component Name
	be free of contamination prior to applying the sealer. • Install and align the cover within 10 minutes of applying the sealer. • Additional sealant is necessary to reduce the possibility of leakage where the cylinder head to engine block interface along the bead path flange on the front cover. 2. Apply a 5 mm bead of sealer directly in the flange of the engine front cover perimeter mating surface. Refer to Adhesives, Fluids, Lubricants, and Sealers. 3. Apply a 5 mm bead of sealer directly to the 5 locations as shown. 4. Finally, apply a 14 mm dab of sealant at the point where the cylinder head to engine block interface as shown. 5. Install the engine front cover.
3	Engine Front Cover Bolt (Qty: 12) NOTE: Install the bolts by hand. Tighten all the engine front cover bolts in sequence.
4	Engine Front Cover Bolt CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or

Callout	Component Name
	single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Install a NEW bolt by hand. Tighten all the engine front cover bolts in sequence.
5	Engine Front Cover Bolt NOTE: Install the bolt by hand. Tighten all the engine front cover bolts in sequence.
6	Engine Front Cover Bolt CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the

Callout	Component Name
	torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Install a NEW bolt by hand. Tighten all the engine front cover bolts in sequence.
7	Engine Front Cover Bolt CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Install a NEW bolt by hand. Tighten all the engine front cover

Callout	Component Name
	bolts in sequence.
8	Engine Front Cover Bolt (Qty: 2) NOTE: Install the bolts by hand. Tighten all the engine front cover bolts in sequence.
9	Engine Front Cover Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Procedure: Tighten the engine front cover bolts in sequence to final torque twice: 1. Tighten sequence 1 - 3 bolts a first pass to 15 N.m (11 lb ft). 2. Tighten sequence 1 - 3 bolts a final pass 130 degrees using EN-45059 meter. 3. Tighten sequence 4 - 15 bolts to 25 N.m (18 lb ft). 4. Tighten sequence 16 - 17 bolts to 10 N.m (89 lb in). 5. Tighten sequence 18 - 19 bolts to 10 N.m (89 lb in). 6. Tighten sequence 20 bolt to 25 N.m (18 lb ft). Special Tools EN-45059 Angle Meter For equivalent regional tools, refer to Special Tools.
10	Drive Belt Tensioner
11	Drive Belt Tensioner Bolt Tighten 58 N.m (43 lb ft)

CAMSHAFT COVER INSTALLATION

Camshaft Cover and Components Installation

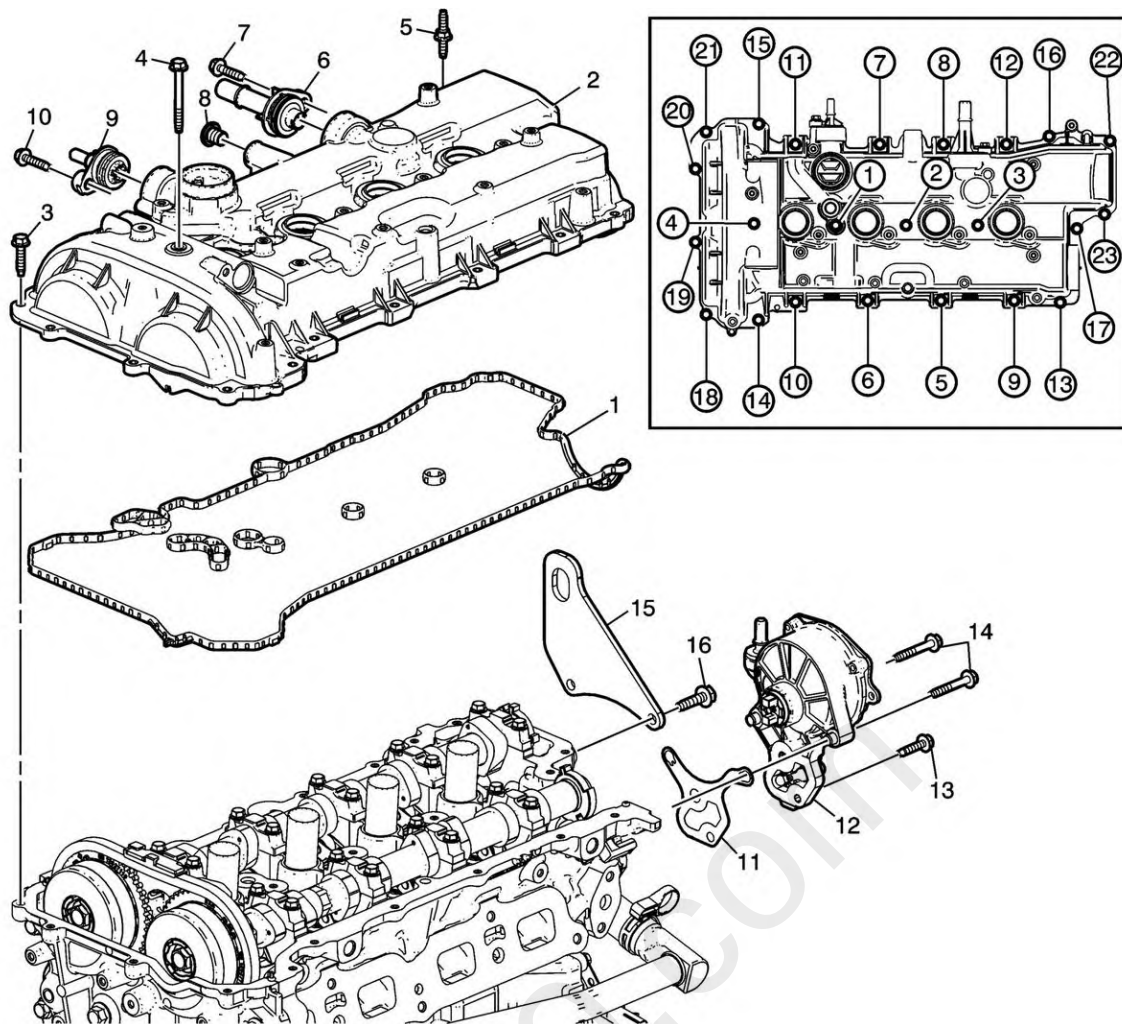


Fig. 27: Exploded View Of Camshaft Cover And Components With Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

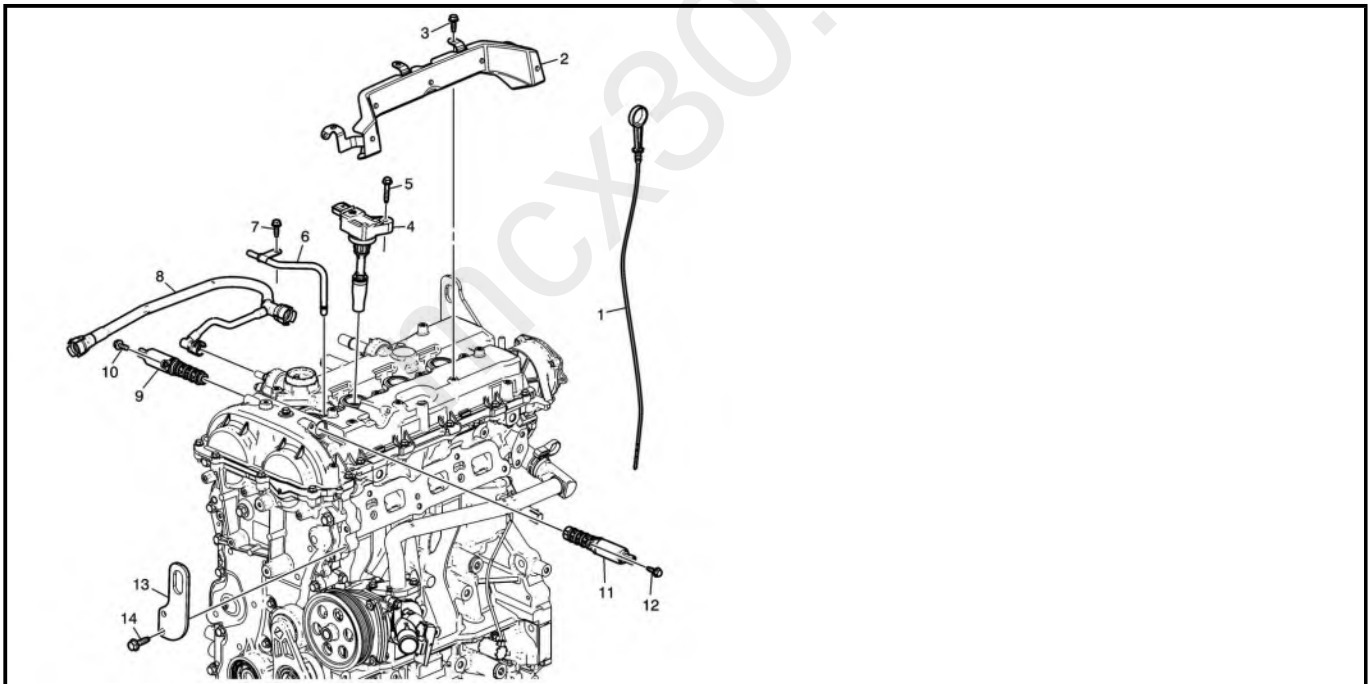
Camshaft Cover and Components Installation

Callout	Component Name
1	Camshaft Cover Gasket Procedure NOTE: Use NEW gaskets. Ensure all camshaft cover gaskets are replaced, including the inner gaskets. Assemble the camshaft cover and gaskets. Ensure each gasket is located in the correct retaining groove in the camshaft cover.
2	Camshaft Cover Procedure

Callout	Component Name
	1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Add a 14 mm bead of sealant at the right and left T-joint where the front cover meets the cylinder head and at the rear of the camshaft cover at the right and left T-joint where the vacuum pump bolts on. Refer to Adhesives, Fluids, Lubricants, and Sealers.
3	Camshaft Cover Bolt (Qty: 19) NOTE: Tighten all 23 camshaft cover bolts in sequence.
4	Camshaft Cover Bolt (Qty: 4) CAUTION: Refer to Fastener Caution . Procedure Tighten the camshaft cover bolts in sequence. Tighten 10 N.m (89 lb in)
5	Camshaft Cover Stud (Qty: 1) Tighten 10 N.m (89 lb in)
6	PCV Valve
7	PCV Valve Bolt Tighten 10 N.m (89 lb in)
8	Camshaft Cover Plug Tighten 35 N.m (26 lb ft)
9	PCV Valve
10	PCV Valve Bolt Tighten 10 N.m (89 lb in)
11	Vacuum Pump Assembly Gasket NOTE: Use a NEW gasket. Ensure the cylinder head sealing surface is clean prior to installing the gasket.
12	Vacuum Pump Assembly NOTE:

Callout	Component Name
	Ensure the vacuum pump seal does not need to be replaced, and the pump housing sealing surface is clean prior to installing the pump.
13	Vacuum Pump Assembly Bolt (Qty: 1) Tighten 10 N.m (89 lb in)
14	Vacuum Pump Assembly Bolt (Qty: 2) Tighten 10 N.m (89 lb in)
15	Rear Lift Bracket
16	Rear Lift Bracket Bolt (Qty: 2) Tighten 25 N.m (18 lb ft)

Camshaft Cover Components Installation



NOTE: Callouts in the following chart represent components shown in graphic above.

Camshaft Cover Components Installation

Callout	Component Name
1	Oil Level Indicator Procedure Inspect the oil level indicator O-ring seals and replace if necessary. Lubricate the O-ring seals with engine oil and install the oil level indicator.
2	Camshaft Cover Heat Shield
3	Camshaft Cover Heat Shield Bolt (Qty: 4)

Callout	Component Name
	CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
4	Ignition Coil (Qty: 4) Procedure 1. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot. 2. Install the ignition coils.
5	Ignition Coil Bolt (Qty: 4) Tighten 10 N.m (89 lb in)
6	Engine Coolant Air Bleed Pipe
7	Engine Coolant Air Bleed Pipe Bolt Tighten 10 N.m (89 lb in)
8	PCV Hose Assembly Procedure Connect the PCV hose at the quick-connect fittings.
9	Intake Camshaft Position Actuator Control Solenoid Valve
10	Camshaft Position Actuator Control Solenoid Valve Bolt Tighten 10 N.m (89 lb in)
11	Exhaust Camshaft Position Actuator Control Solenoid Valve
12	Camshaft Position Actuator Control Solenoid Valve Bolt Tighten 10 N.m (89 lb in)
13	Front Lift Bracket
14	Front Lift Bracket Bolt (Qty: 2) Tighten 25 N.m (18 lb ft)

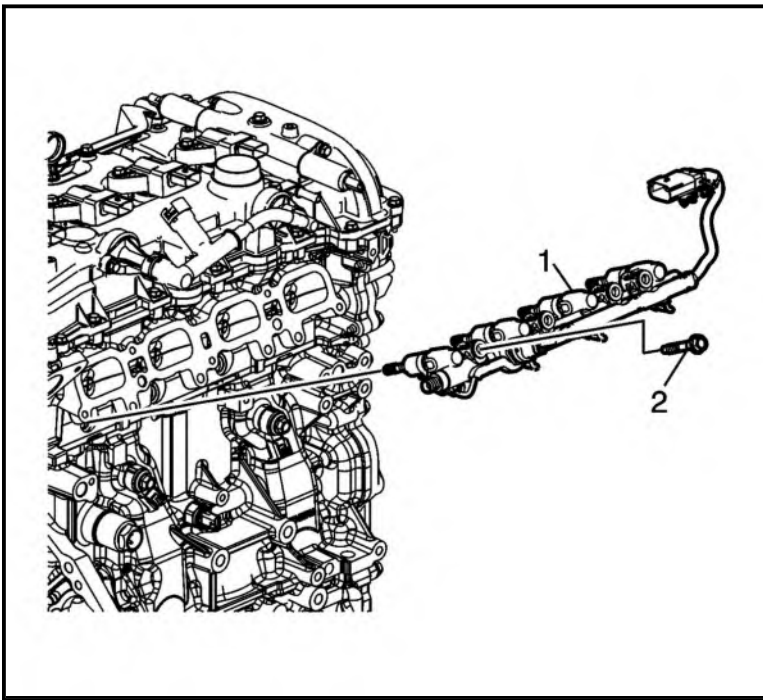
FUEL RAIL AND INJECTORS INSTALLATION

Special Tools

EN-47909 Injector Bore and Sleeve Cleaning Kit

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

1. Clean the fuel injector bore in the cylinder head using the **EN-47909** kit.



2. Replace the fuel rail insulators, if necessary. Refer to [Fuel Rail and Injectors Cleaning and Inspection](#). Replace the fuel rail bolts, if necessary.
3. Replace fuel injector Teflon seals with NEW when transferring fuel rail and injectors on to service engine assembly. Refer to [Fuel Rail and Injectors Cleaning and Inspection](#).
4. Install the fuel rail (1) with injectors into the cylinder head evenly.

NOTE: Mount the bolts evenly to avoid cocking of the fuel injectors during installation.

NOTE: Avoid contamination and contact damage of fuel injectors nozzle tips.

5. Hand start the 2 outer fuel rail bolts (2) to seat the injectors into the injector bores.
6. Hand start the remaining fuel rail bolts.
7. Tighten the fuel rail bolts in sequence to 25 N.m (18 lb ft).

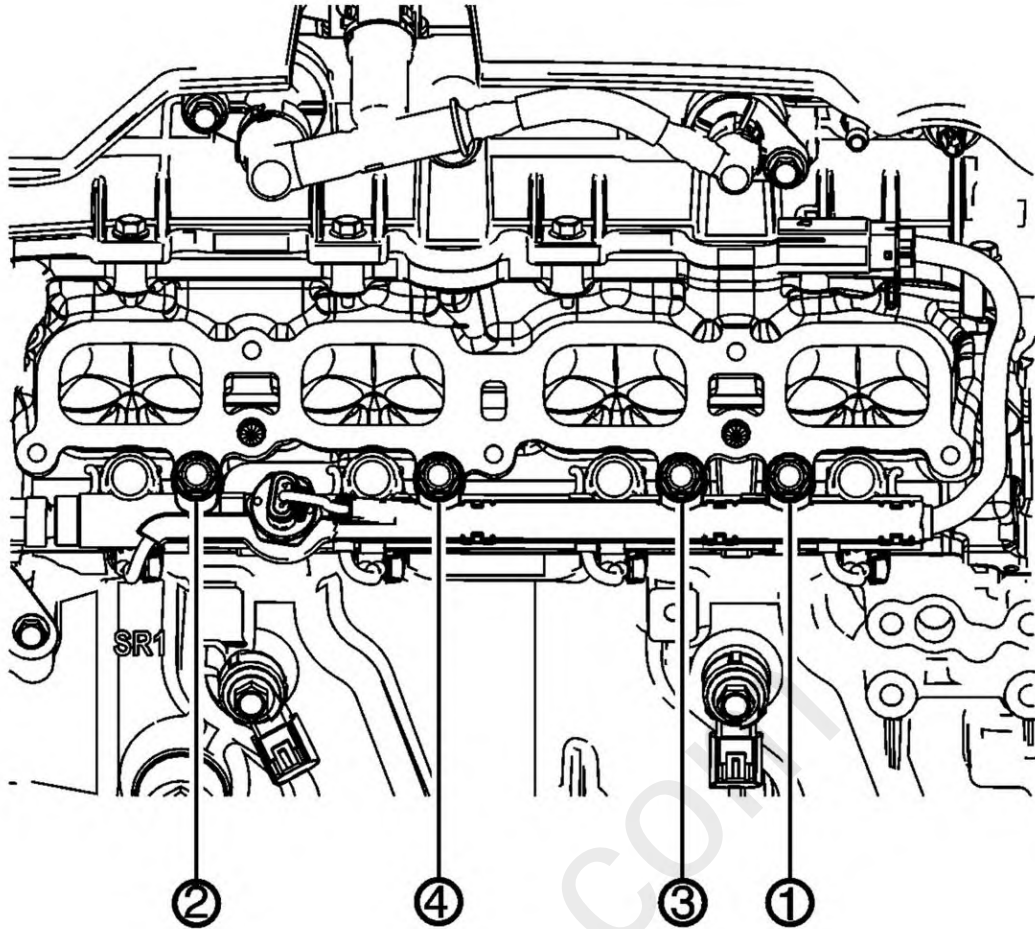
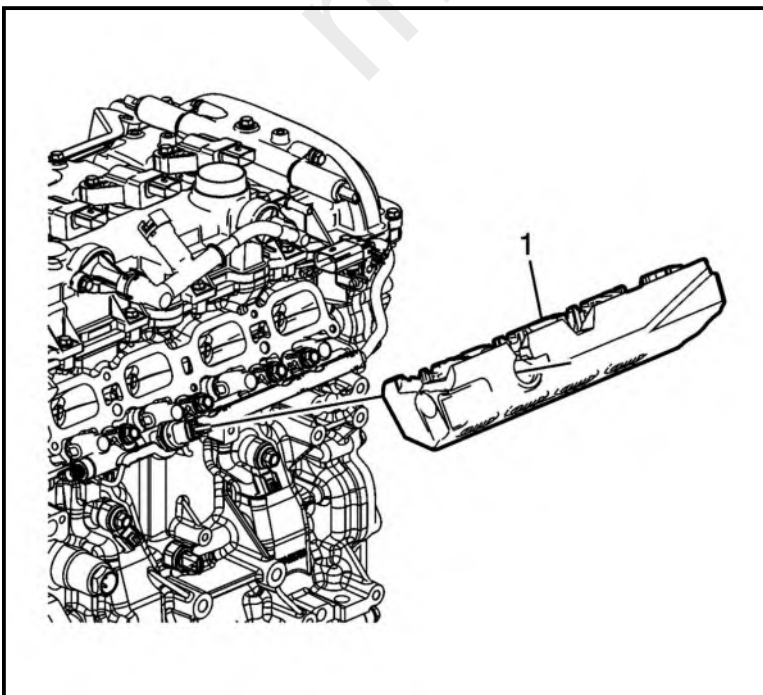


Fig. 28: Fuel Rail Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

8. Connect the electrical harness to the fuel rail harness connections.
9. Install the fuel injection fuel rail noise shield (1).



WARNING:

The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

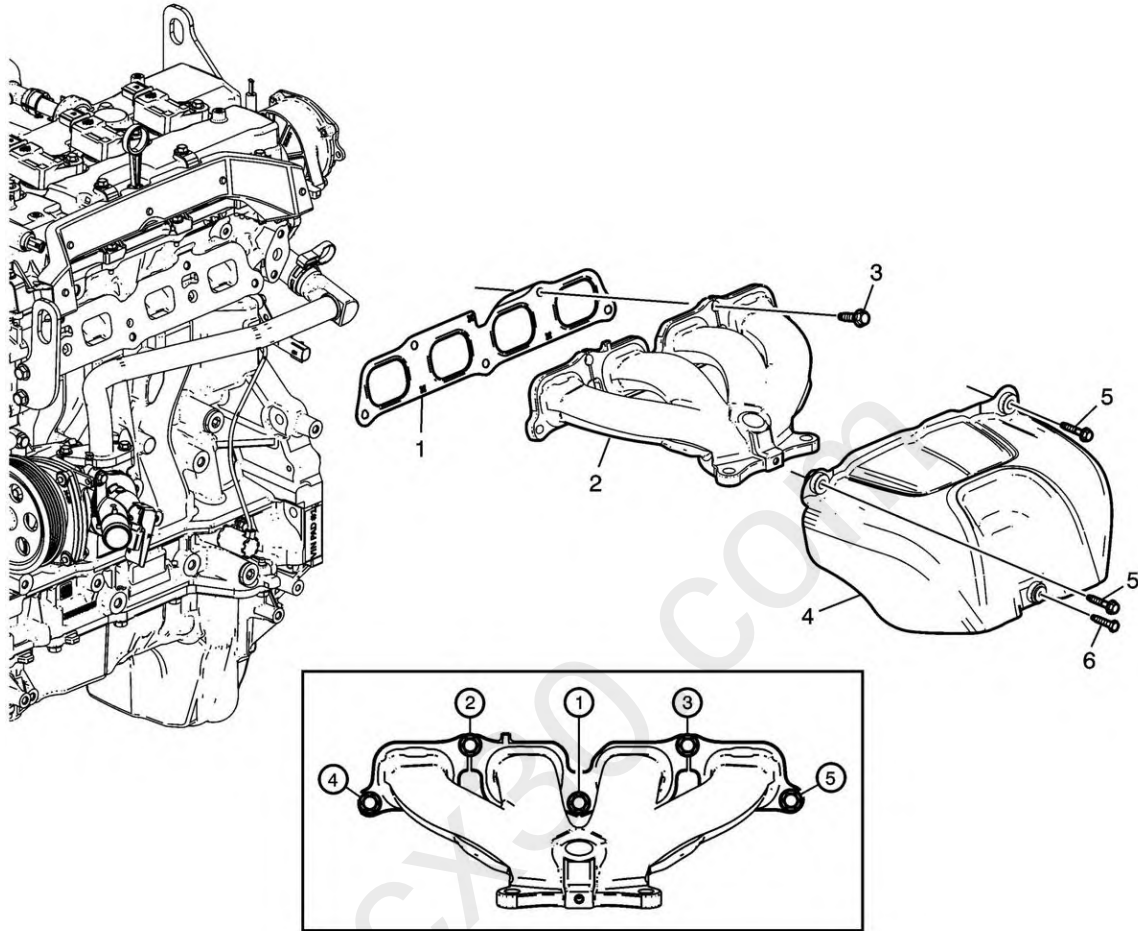
EXHAUST MANIFOLD INSTALLATION

Fig. 29: Exhaust Manifold With Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

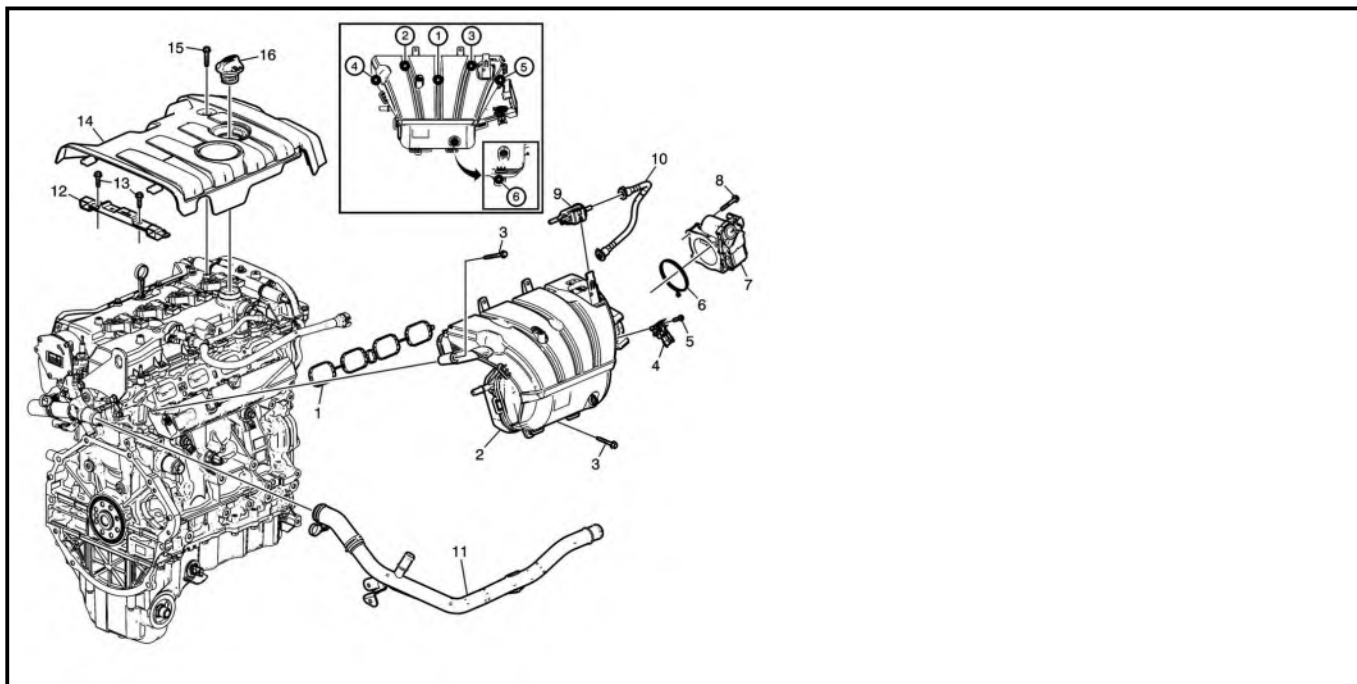
NOTE:

Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Exhaust Manifold Gasket NOTE: Use a NEW gasket.
2	Exhaust Manifold
3	Exhaust Manifold Bolt (Qty: 5) CAUTION: Refer to Fastener Caution . CAUTION:

Callout	Component Name
	This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes. Procedure: Tighten the NEW exhaust manifold to cylinder head bolts three passes in sequence. Tighten 20 N.m (15 lb ft)
4	Exhaust Manifold Heat Shield
5	Exhaust Manifold Heat Shield Bolt (Qty: 2) Tighten 14 N.m (124 lb in)
6	Exhaust Manifold Heat Shield Bolt (Qty: 1) Tighten 14 N.m (124 lb in)

INTAKE MANIFOLD INSTALLATION

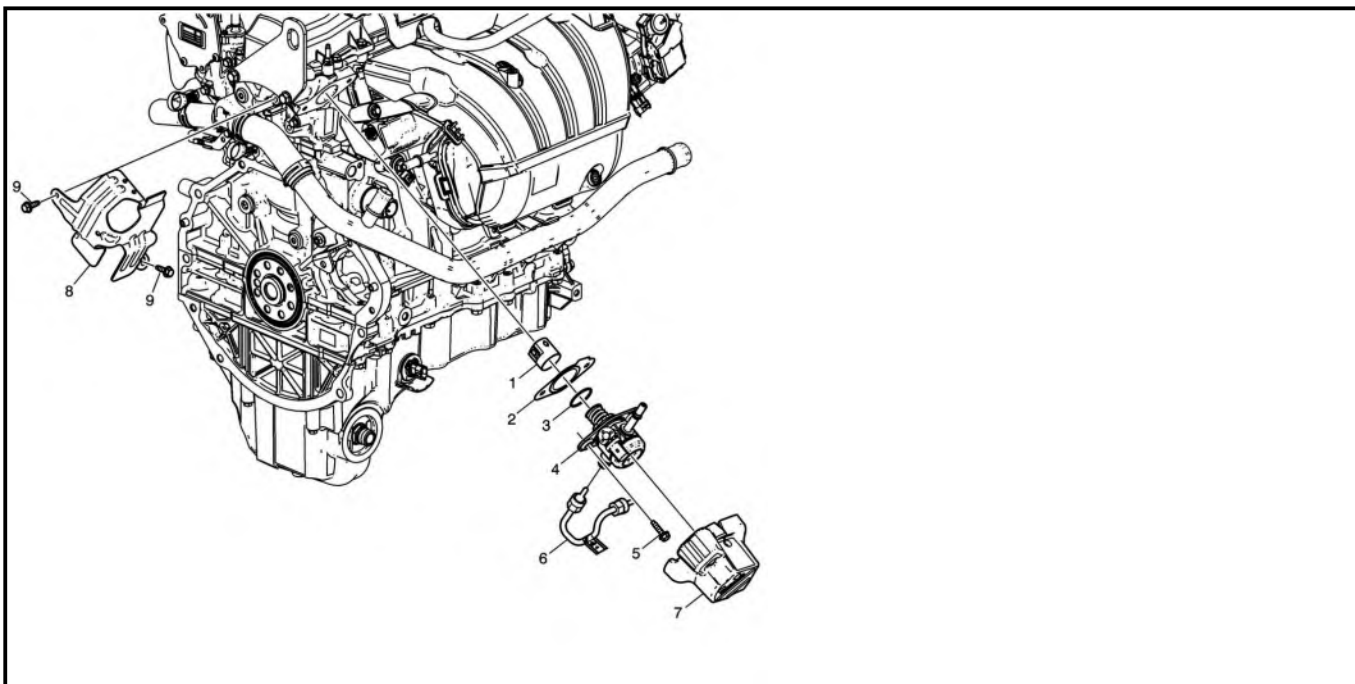


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Intake Manifold Gasket NOTE: Use a NEW gasket.
2	Intake Manifold
3	Intake Manifold Bolt (Qty: 6) CAUTION: Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage. CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Procedure: Tighten the bolts in sequence twice. Tighten 12 N.m (106 lb in)
4	Manifold Absolute Pressure (MAP) Sensor
5	MAP Sensor Bolt Tighten 5 N.m (44 lb in)
6	Throttle Body Gasket NOTE: Use a NEW gasket.
7	Throttle Body
8	Throttle Body Bolt (Qty: 4) Tighten 10 N.m (89 lb in)
9	Evaporative Emission Canister Purge Valve
10	Evaporative Emission Canister Purge Valve Pipe Assembly NOTE: Ensure the quick-connect is clean and free of debris. The latch should move freely prior to installation. Procedure: Connect the valve pipe assembly to the purge valve and intake manifold.
11	Radiator Inlet Pipe And Hose Assembly Procedure: Connect the radiator inlet hose to the water outlet assembly.
12	Upper Intake Manifold Bracket
13	Upper Intake Manifold Bracket Bolt (Qty: 2) Tighten 10 N.m (89 lb in)
14	Intake Manifold Cover
15	Intake Manifold Cover Bolt Tighten 9 N.m (80 lb in)
16	Oil Fill Cap

FUEL INJECTION PUMP INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed. Use the EN-50790 alignment gauge to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head. Special Tools EN 50790 HP Fuel Pump Installation Alignment Gauge For equivalent regional tools, refer to Special Tools .	
1	Valve Lifter Follower Procedure 1. Lubricate the high pressure fuel pump cylinder head bore with 5W30 engine oil. NOTE: Ensure that the valve lifter follower is oriented properly, and the

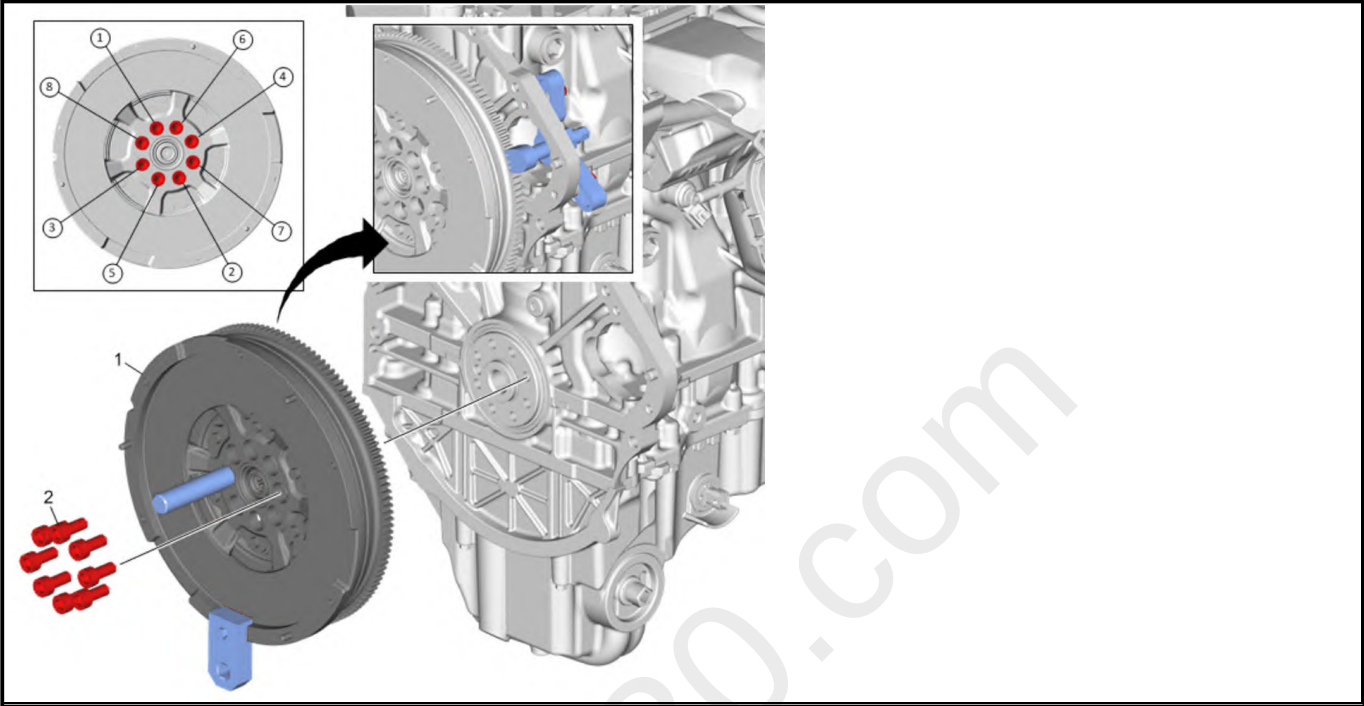
Callout	Component Name
	camshaft is at base circle. 2. Lubricate the valve lifter follower with 5W30 engine oil and install into the cylinder head bore.
2	Fuel Pump Gasket NOTE: Use a NEW gasket. Ensure the fuel pump housing gasket is properly aligned with the tab upward at the 2 O'clock position.
3	Fuel Pump O-Ring NOTE: Use a NEW O-ring. Procedure 1. Lubricate the NEW O-ring with one drop of clean engine oil. 2. Install the NEW O-ring.
4	Fuel Pump
5	Fuel Pump Bolt (Qty: 2) CAUTION: Refer to Fastener Caution. CAUTION: Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in

Callout	Component Name
	pump plunger damage. CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. Procedure Apply threadlocker to the NEW bolts, refer to Adhesives, Fluids, Lubricants, and Sealers. Tighten the NEW bolts evenly using the following procedure: 1. Tighten the bolts a first pass to 8 N.m (71 lb in) 2. Tighten the bolts a final pass 50 degrees using the EN-45059 meter. Special Tools EN-45059 Angle Meter Equivalent Regional Tools: Special Tools
6	Fuel Feed Intermediate Pipe CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener

Callout	Component Name
	when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. Procedure Use a NEW fuel feed intermediate pipe. Tighten the fitting nuts on the pipe using the following sequence: 1. Tighten the fitting nut to the fuel rail to 15 N.m (11 lb ft). 2. Tighten the fitting nut to the fuel pump to 15 N.m (11 lb ft). 3. Tighten the fitting nut to the fuel rail a final pass to 30 N.m (22 lb ft). 4. Tighten the fitting nut to the fuel pump a final pass to 30 N.m (22 lb ft).
7	Fuel Pump Insulator WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible

Callout	Component Name
	injury or death.
8	Fuel Pump Cover
9	Fuel Pump Cover Bolt (Qty: 3) Tighten 10 N.m (89 lb in)

FLYWHEEL INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Engine Flywheel NOTE: EN-51701-2 holder and EN-51701-1 aligner may be installed on the flywheel to maintain alignment of the secondary mass to the primary mass. Special Tools EN-51701 Flywheel Aligner and Holder Equivalent regional tools: Special Tools
2	Engine Flywheel Bolt [8x]

Callout	Component Name
	CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. CAUTION: Refer to Fastener Caution . NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes. Procedure 1. Install the NEW bolts loosely by hand. If necessary, remove EN-51701-2 holder and rotate the secondary mass using EN-51701-1 aligner and a breaker bar to align the holes in the secondary mass with the primary mass. 2. To prevent crankshaft rotation, install EN-51760 holding tool and starter motor bolts at the starter motor location, engaging the flywheel. 3. Tighten the bolts evenly using the following procedure: 1. Tighten the bolts a first pass in sequence to 30 N.m (22 lb ft). 2. Tighten the bolts a final pass in sequence 80 degrees using the EN-45059 meter. 4. Remove EN-51760 holding tool from the starter mount. Remove any remaining special tools, if present.

Callout	Component Name
	Special Tools • EN-45059 Angle Meter • EN-51701 Flywheel Aligner and Holder • EN-51760 Flywheel Holding Tool Equivalent regional tools: Special Tools

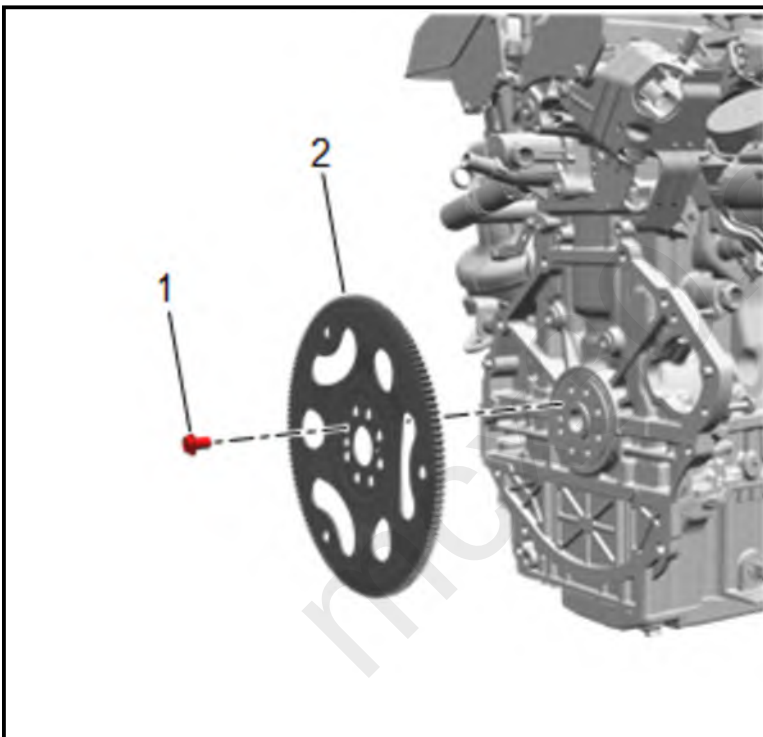
AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

- EN-51760 Flywheel Holding Tool
- EN-45059 Angle Meter

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

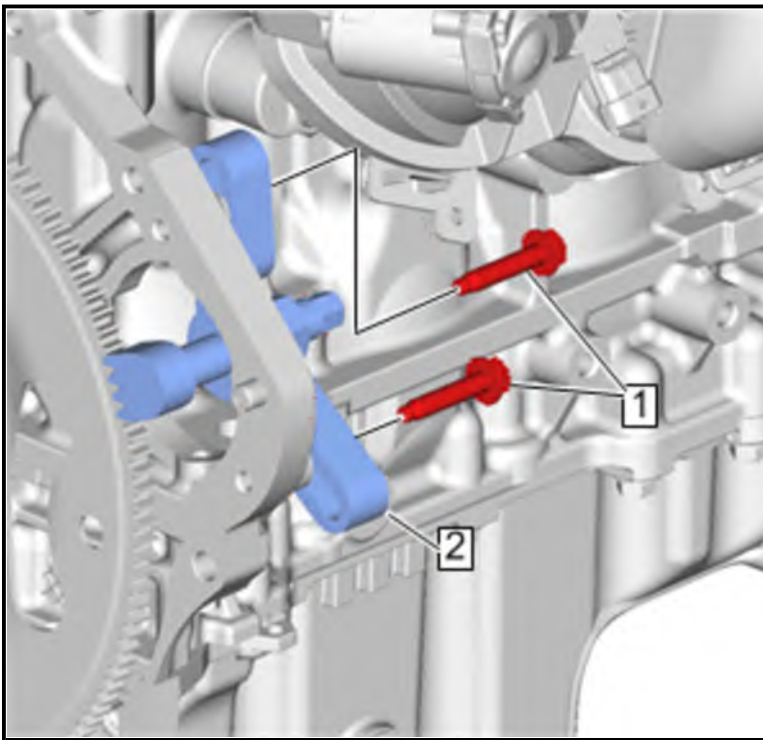
1. Install the flywheel (2) and hand start NEW bolts (1).



CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

2. To prevent crankshaft rotation, install **EN-51760** flywheel holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.



3. Tighten the bolts evenly using the following procedure:

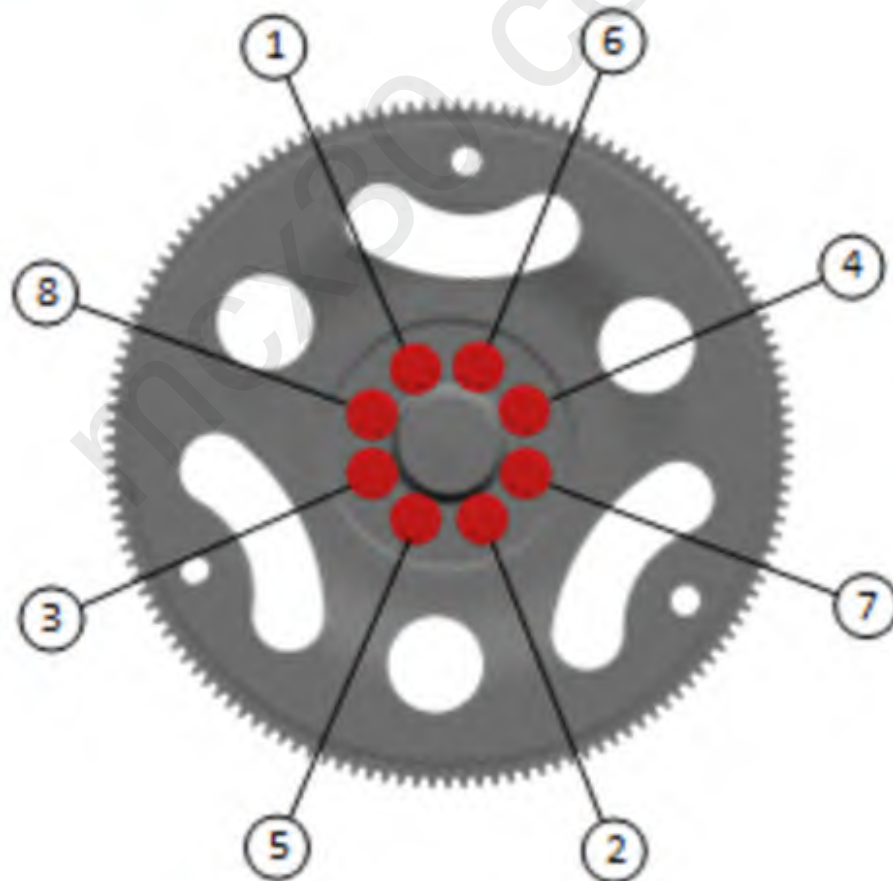
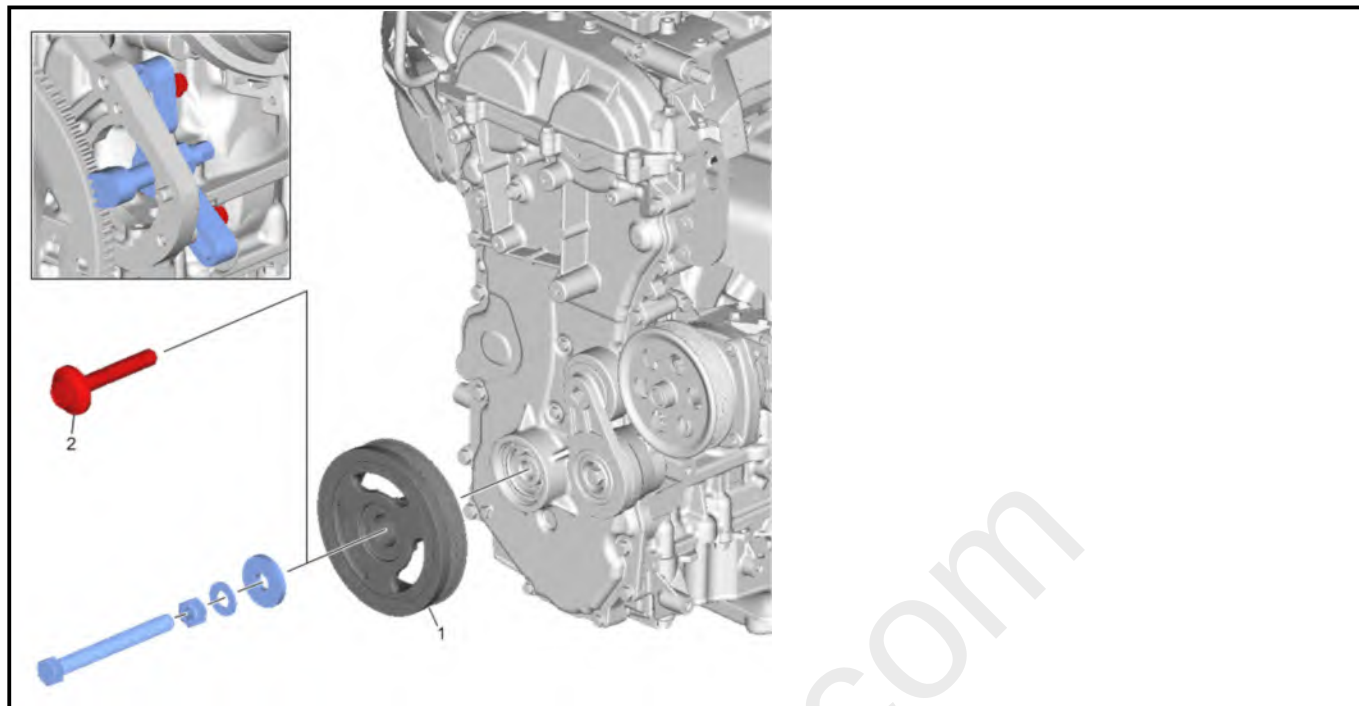


Fig. 30: Flex Plate Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

1. Tighten the bolts a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the bolts a final pass in sequence 40 degrees using the **EN-45059** meter.
4. Remove **EN-51760** flywheel holding tool.

CRANKSHAFT BALANCER INSTALLATION



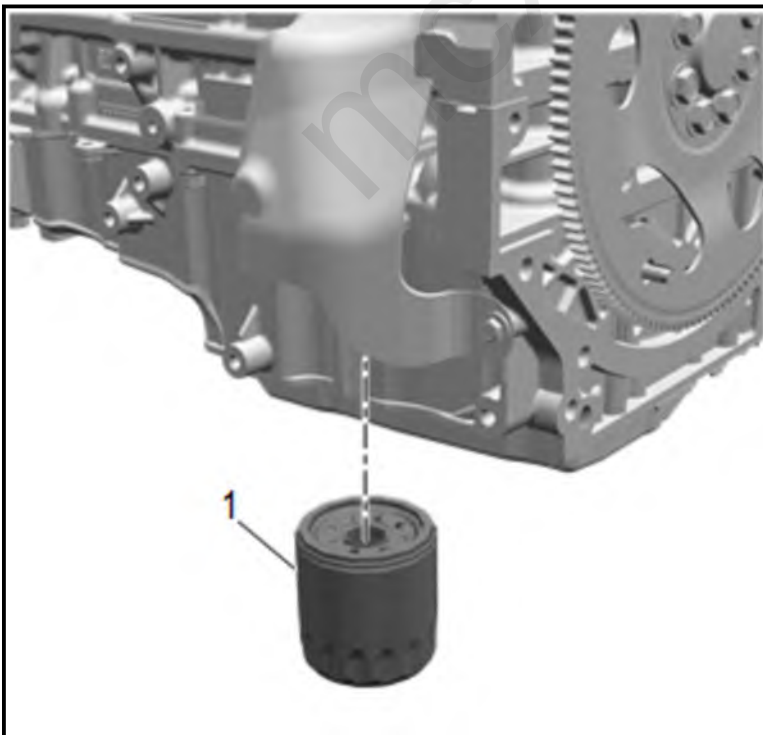
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure To prevent crankshaft rotation, install EN-51760 holding tool at the starter motor location, engaging the flywheel. Special Tools EN-51760 Flywheel Holding Tool For equivalent regional tools, refer to Special Tools .	
1	Crankshaft Balancer Procedure Using EN-48034 installer, install the crankshaft balancer. Special Tools EN-48034 Crankshaft Balancer Installer For equivalent regional tools, refer to Special Tools .
2	Crankshaft Balancer Bolt CAUTION: Refer to Fastener Caution . CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-

Callout	Component Name
	to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. Procedure 1. Install a NEW crankshaft balancer bolt and washer. Tighten the bolt to 150 N.m (111 lb ft) plus 140 degrees using the EN-45059 meter. 2. Remove the flywheel holding tool. Special Tools EN-45059 Angle Meter For equivalent regional tools, refer to Special Tools.

OIL FILTER INSTALLATION (2WD)

1. Lubricate the O-ring on the oil filter with 5W30 engine oil.

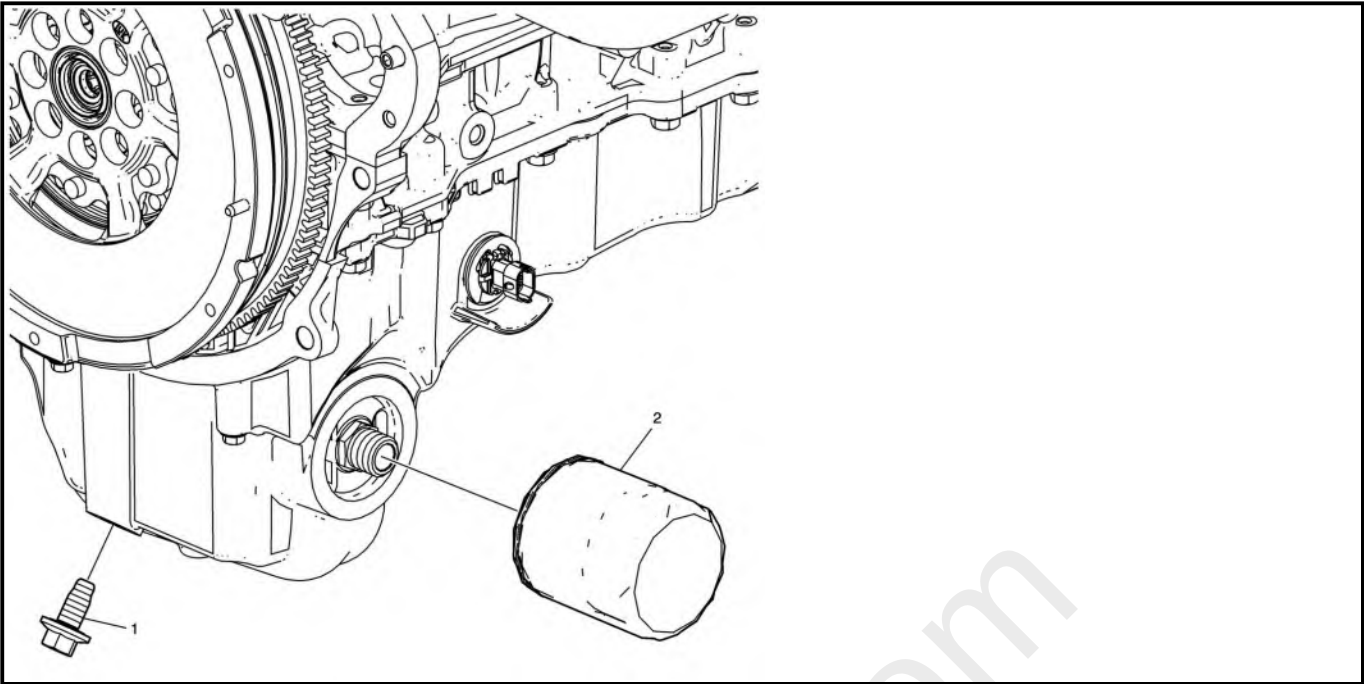


2. Install a new oil filter (1).

CAUTION: Refer to [Fastener Caution](#) .

3. Tighten the oil filter 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.

OIL FILTER INSTALLATION (4WD)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Pan Drain Plug CAUTION: Refer to Component Fastener Tightening Caution . Tighten 25 N.m (18 lb ft)
2	Oil Filter Procedure: 1. Lubricate the O-ring on the oil filter with 5W30 engine oil. 2. Install a new oil filter. Tighten 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange

ENGINE PRELUBING

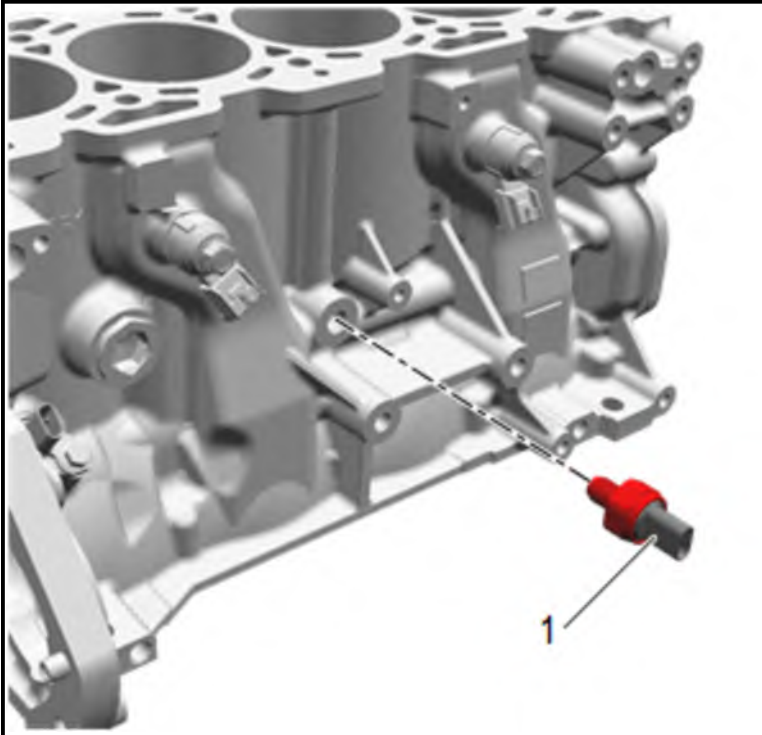
NOTE: This procedure is not used in Europe.

Special Tools

EN-45299 Engine Preluber

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

1. Remove the engine oil pressure sensor (1).



CAUTION: If any malfunction is experienced which may cause debris to enter the oil supply, you must replace the engine oil cooler and hoses if equipped. Debris in the engine oil cooler and oil cooler hoses may be pulled back into the engine causing severe engine damage.

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

2. Install the M12 x 1.75 adapter P/N 509376.
3. Install the flexible hose to the adapter and open the valve.



4. Pump the handle on the **EN-45299** preluber (1) in order to flow a minimum of 1 - 1.9 liters (1 - 2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
5. Close the valve and remove the flexible hose and adapter from the engine.

CAUTION: Refer to **Fastener Caution** .

6. Install the engine oil pressure sensor and tighten to 35 N.m (26 lb ft).
7. Top-off the engine oil to the proper level.

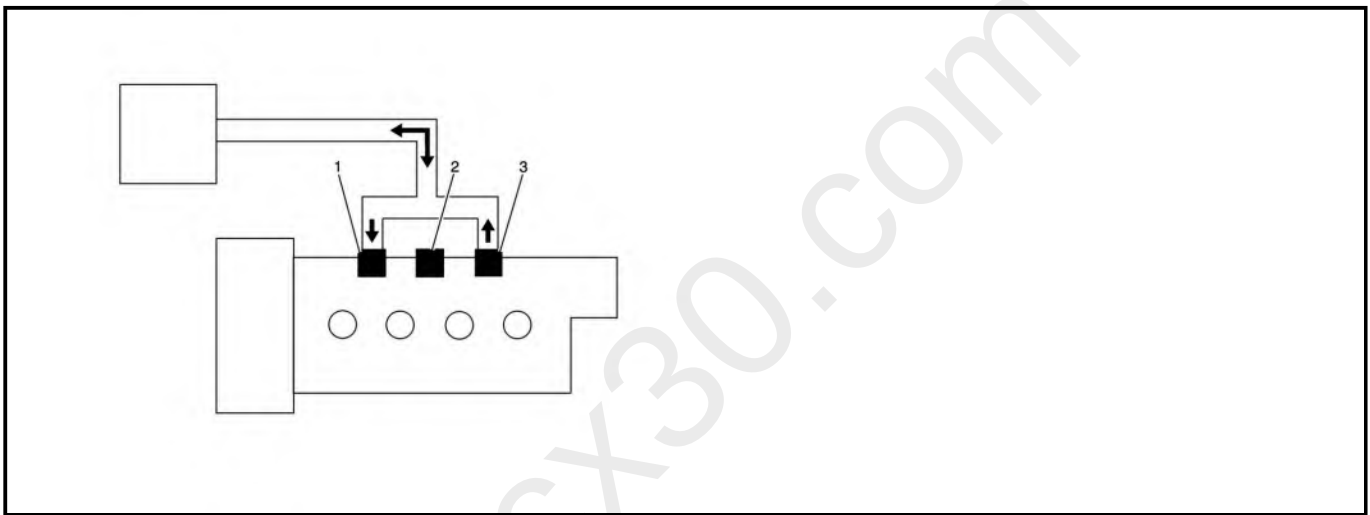
DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation



The primary control is through the positive crankcase ventilation (PCV) valve (2) which meters the flow at a rate depending on intake manifold vacuum. The PCV valve is an integral part of the camshaft cover. Fresh air is introduced to the engine through PVC (1) under normal operating conditions. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent valve (3) into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is constructed of aluminum alloy by precision sand-casting. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the front of the engine. The cylinder block incorporates a bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

Crankshaft

The crankshaft is cast nodular iron with 8 counterweights. The number 8 counterweight is also the ignition system reluctor wheel. The main bearing journals are cross-drilled, and the upper bearings are grooved. The crankshaft has a slip fit balance shaft drive sprocket. Number 2 main bearing is the thrust bearing. The crankshaft balancer is used to control torsional vibration.

Connecting Rod and Piston

The connecting rods are powdered metal. The connecting rod incorporates the floating piston pin. The pistons are cast aluminum. The piston rings are of a low tension type to reduce friction. The top compression ring is ductile steel with a molybdenum facing and phosphate coated sides. The second compression ring is gray iron. The oil ring is a 3-piece spring construction with chromium plating for applications without a turbocharger. For applications with turbocharger, the oil ring is a 3-piece spring construction with nitride plating.

Engine Block Cooling Baffle

The engine block cooling baffle is essential to proper engine coolant flow. The baffle's presence in the engine block is strategic and acts to direct the engine coolant flow around the bores for uniform cooling.

Oil Pan

The oil pan is die cast aluminum. The oil pan includes an attachment to the transmission to provide additional structural support.

Balance Shaft Assembly

The dual balancer shaft assembly is mounted to the lower crankcase located within the oil pan. The balance shafts are driven by a single inverted tooth chain that also drives the oil pump. The chain is tensioned by a hydraulic tensioner that is supplied pressure by the engine oil pump. This design promotes the maximum effectiveness of the balance shaft system and reduces noise and vibration.

Cylinder Head

The cylinder head is a semi-permanent mold. Pressed-in powdered metal valve guides and valve seat insets are used. The cylinder head incorporates camshaft journals and camshaft caps. The fuel injection nozzle is located in the intake port. The high pressure fuel pump is mounted on intake side.

Valves

There are two intake and two exhaust valves per cylinder. The head of the valve is made of a durable alloy. The valve shaft resists wear. Valve stem oil seals control oil consumption. Valve springs, valve spring retainers, and valve keys are assembled to return each valve to a closed position after each actuation of the rotating camshaft assemblies.

Camshaft

Two camshafts are used, one for all intake valves and high pressure fuel pump, the other for all exhaust valves and mechanical vacuum pump. The camshafts are cast iron.

Valve Lash Adjusters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft Drive

A roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

Intake and Exhaust Manifold

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

Electronic Thermostat

The thermostat is positioned between the engine and the radiator. Its purpose is to control the flow of coolant to the radiator. The thermostat will not allow coolant flow through the radiator when cold, coolant flow occurs when the engine has warmed up. Once the engine reaches its operating temperature, generally about 95B°C (203B°F), the thermostat opens. This actuation of the thermostat occurs when the heated wax contained within a cylinder melts and rapidly expands, pushing the rod and valve assembly out of the cylinder, opening the valve. The temperature dependent actuation of the thermostat allows the engine to warm up as quickly as possible, the thermostat reduces engine wear, deposits and emissions. The open thermostat now allows the coolant to flow through the engine cooling circuit to maintain optimal operation temperatures, which is achieved by directing the hot coolant through the radiator for cooling and recirculation. The thermostat is also controlled by an engine calibration program in the ECM. The thermostat receives a signal from the ECM that activates a heater element within the thermostat. This forces the thermostat to an open position when desired for maximum operational efficiencies.

Variable Flow Oil Pump Assembly

The oil pump assembly is located within the oil pan. The oil pump assembly is fastened directly to the rear of the balancer shaft assembly and is driven by the rotation of the balance shaft spline.

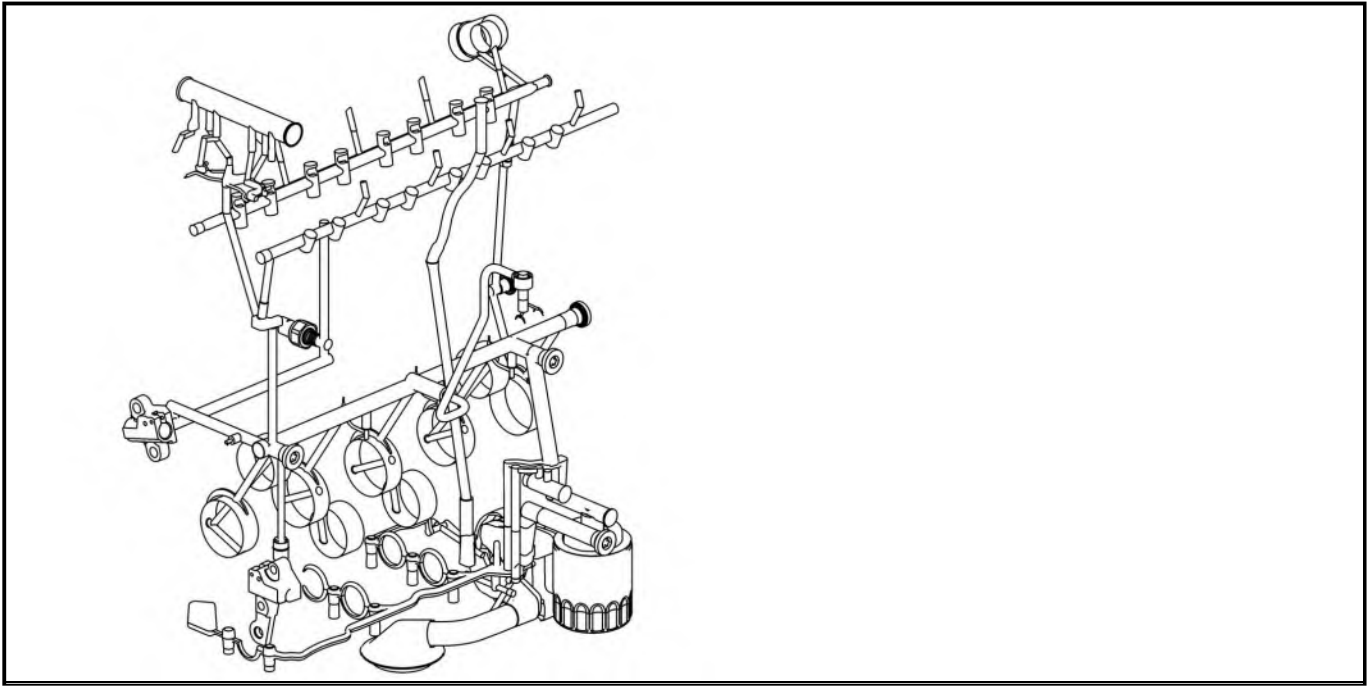
The oil pump assembly possesses variable flow capability which is made possible by a shift of the circular vane arrangement and the actuation of an oil control valve assembly guided by the ECM. The variable flow capability of the pump optimizes oil flow to the engine components when needed. During performance maneuvers and acceleration the oil pump operates in a steady high pressure state. However, during steady low load touring speeds on level terrain the oil pump operates in a steady low pressure state.

The ECM guided "on" and "off" actuation of the oil control valve assembly allows the chamber to be pressurized which takes the switch from high to low pressure mode. The high pressure state of the chamber compressing the spring and shifting the center of the circular vane arrangement nearer to that of the balancer drive shaft, decreasing the difference of the volume of oil contained between each vane. It is this small variation in volume which produces the steady low pressure flow. It is in this mode that the pump behaves as a smaller pump.

Advantages of variable flow oil pumping modes:

- The high performance steady pressure mode is where engine temperatures and friction are reduced because the pump only delivers the oil that the engine requires.
- The low load touring steady pressure mode is where the volume of oil flow is reduced to even more efficient levels when engine requirements allow. This efficiency reduces the resistance on reciprocating component, allowing engine revolutions with less power resulting in fuel economy savings.

LUBRICATION DESCRIPTION



Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, rocker arms, valve lash adjusters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the oil pump through a fixed inlet screen. The oil pump is driven by the balancer shaft assembly's sprocket. The oil pump body is attached to the rear of balancer shaft assembly. The pressurized oil passes through the cylinder head assembly restrictor orifice into the cylinder head's OCV and routed through passages cast into the camshaft cover assembly to each camshaft feed gallery and camshaft drip rail. OCV actuates the 2-Step intake rocker arm assemblies to control valve travel. The oil filter is a metal canister type. A by-pass valve in the filter assembly allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface, rocker arm, and drip rail. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

NOTE:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **Many internal engine components will develop specific wear patterns on their friction surfaces.**
- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location**

and position.

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lash adjusters
- Valve lash adjusters, lash adjuster guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Special Tools

EN-28410 Gasket Remover

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

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **EN-28410** remover or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
 - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.

- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Cleaning Mating Part Surfaces for RTV Joints

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to ensure good adhesion over the life of the product.

CAUTION: When cleaning the sealing surfaces of engine components, **DO NOT** use bristle discs, abrasive pads, wire wheels or surface conditioning discs. These types of devices should not be used because they produce a very fine grit that is abrasive and known to cause internal engine damage. The bristle discs and pads are embedded with abrasive material and wear down as they clean, continually exposing fresh abrasive to the surface of the component.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover, cylinder head, engine block, oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area.

When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1, 600 km (1, 000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

NOTE: After the final cleaning with GM Low VOC Cleaner and before reassembly, DO NOT touch the cleaned surfaces with your hand. Oils from your skin WILL CONTAMINATE the surface and prevent proper bonding of the new RTV sealant.

Typical Applications

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.
- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover/rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/cam covers with press in place gaskets using RTV at corners or T-joints.

Materials Needed

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC - Free Cleaner & Degreaser

Procedure:

1. Identify the surfaces to which the RTV will come into contact in the assembled joint.
2. Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.
3. Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some discoloration of the cloth after wiping however a clean surface should produce the same level of discoloration with successive wiping with a clean cloth and solvent.
4. If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
5. Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
6. Do not touch the cleaned surface with anything prior to RTV application.
7. The surface is now prepared for RTV application.

Sealant Types

NOTE: 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 two major types of sealant are commonly used in engines:

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:
 - Gasket Eliminator
 - Pipe Sealant
 - Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two 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
- Do not use RTV sealant unless the ambient air temperature is at least 18B°C (65B°F) degrees or higher.
- 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.

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

- The surfaces to be sealed must be clean and dry.

NOTE: The bead size is critical and is easier to maintain consistency and application with a RTV dispensing tool. This also helps to eliminate waste.

- 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.

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

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: Do not overtighten the fasteners.

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

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
- The surfaces to be sealed must be clean and dry.

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

- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.
 - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
 - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
 - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between two 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.

NOTE:

- Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.

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

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where two 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.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when

the fastener is tightened, or lead to component failure.

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

NOTE: Do not overtighten the fasteners.

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

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

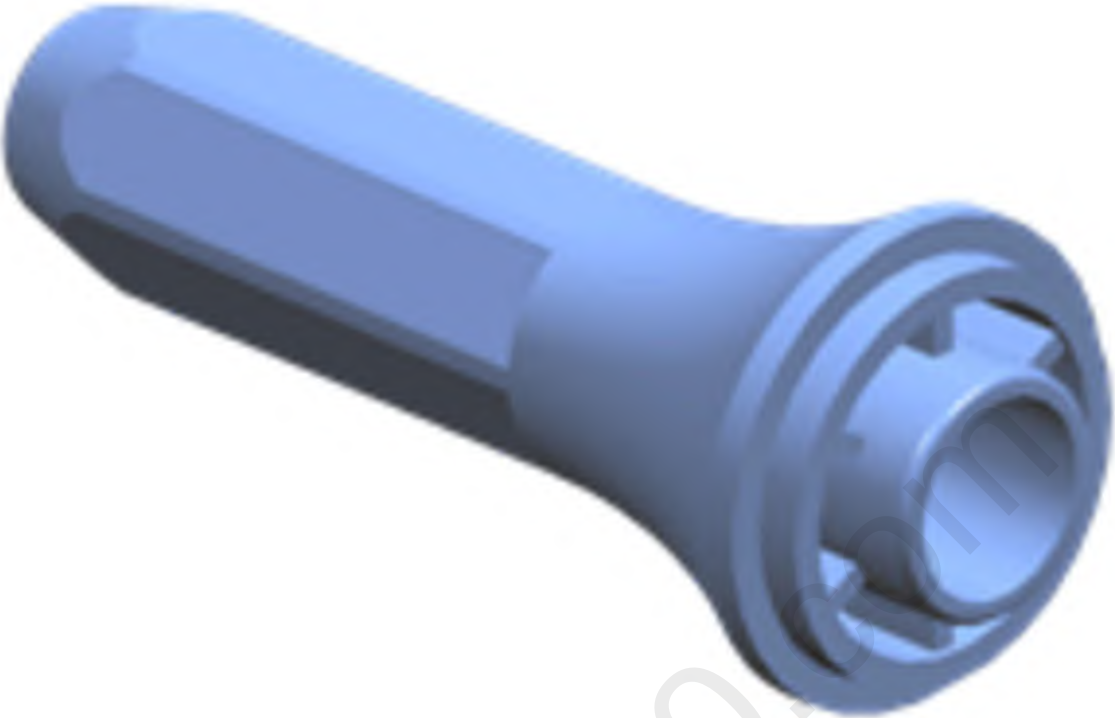
Illustration	Tool Number/Description
	DT-45866 J-45866 Input Shaft Seal Installer

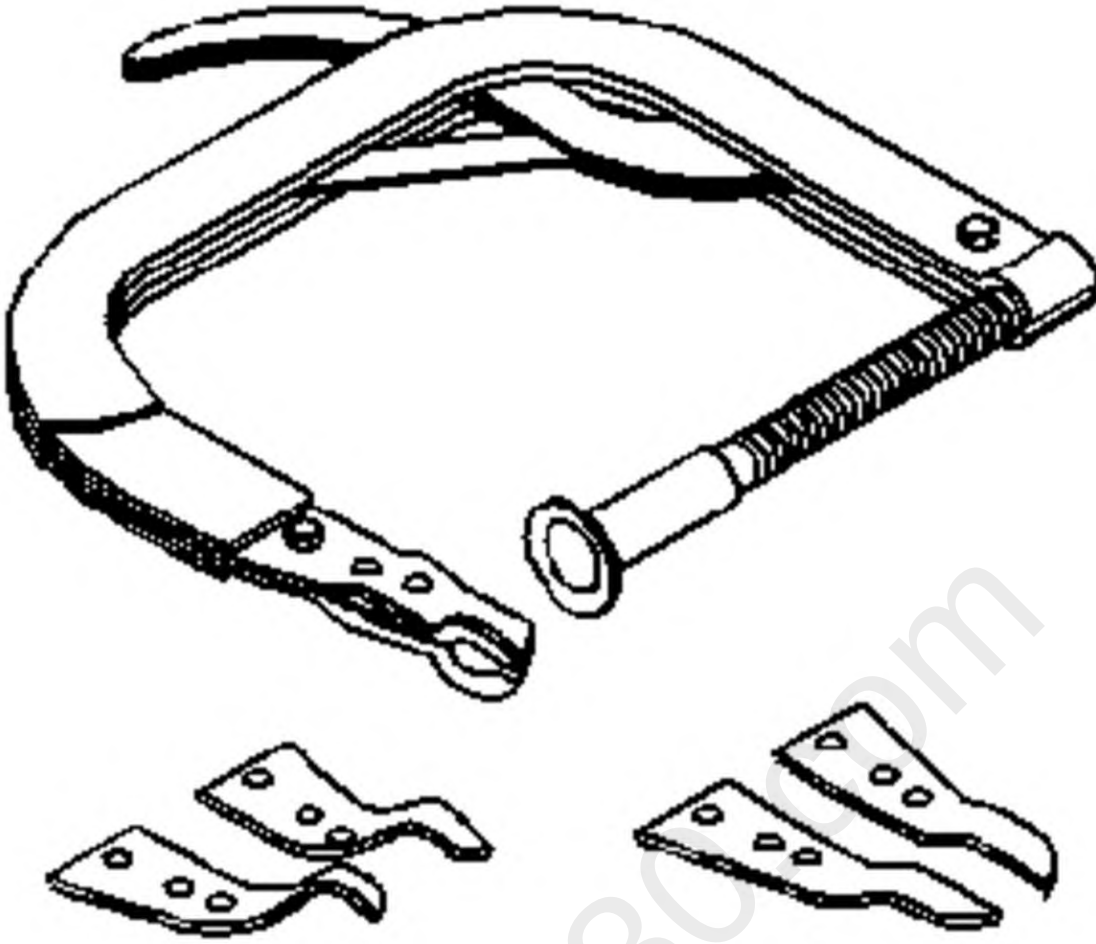
Illustration	Tool Number/Description
	EN-8062 J-8062 KM-348 Valve Spring Compressor - Head Off

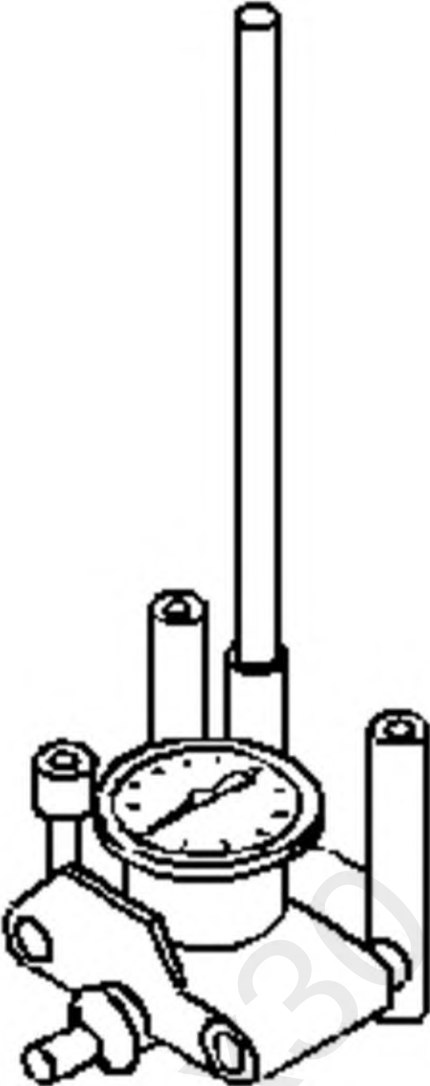
Illustration	Tool Number/Description
	EN-8087 J-8087 Cylinder Bore Gauge

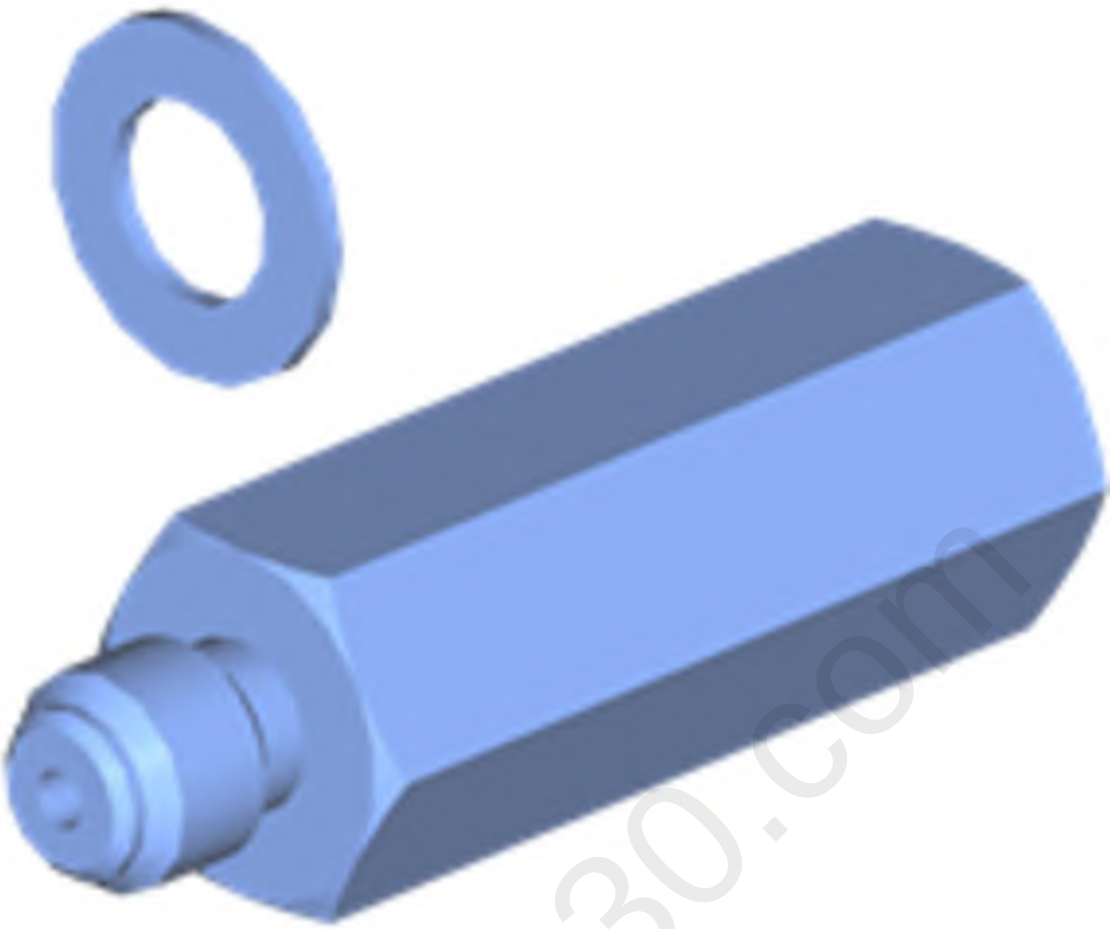
Illustration	Tool Number/Description
	EN-21867-850 J-21867-850 KM-498-B KM-6106 83 93 852 Oil Pressure Gauge Adapter
mcx30.com	

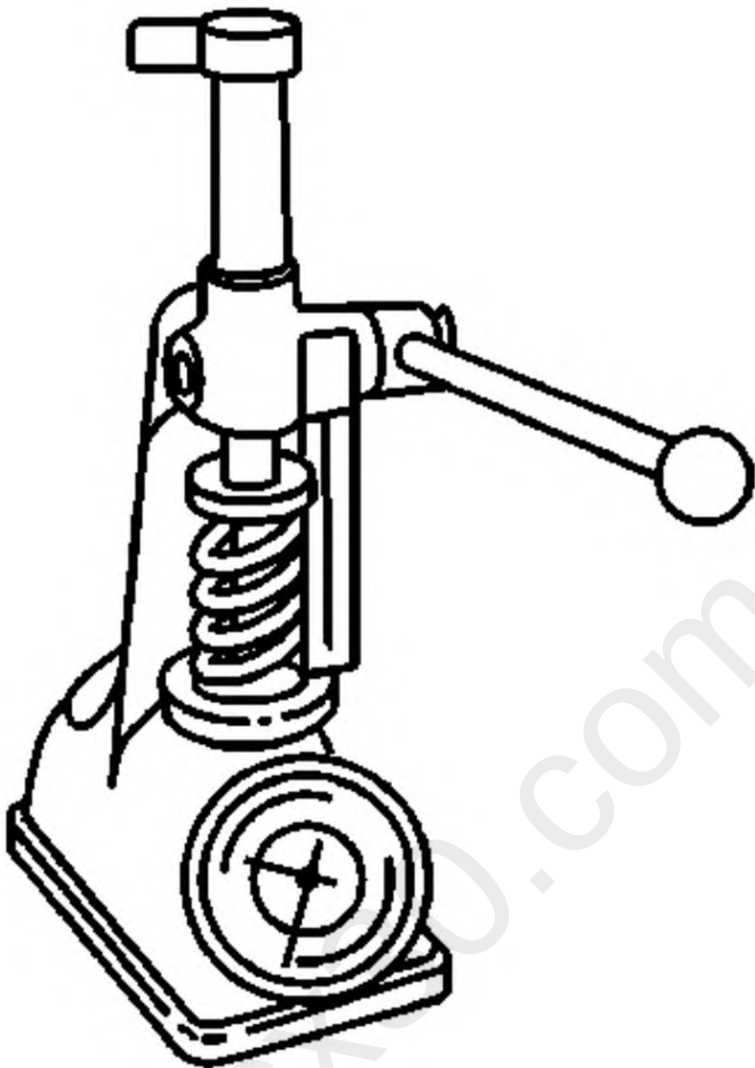
Illustration	Tool Number/Description
	EN-22738-B GE-22738-B J-22738-B J-9666 Valve Spring Tester

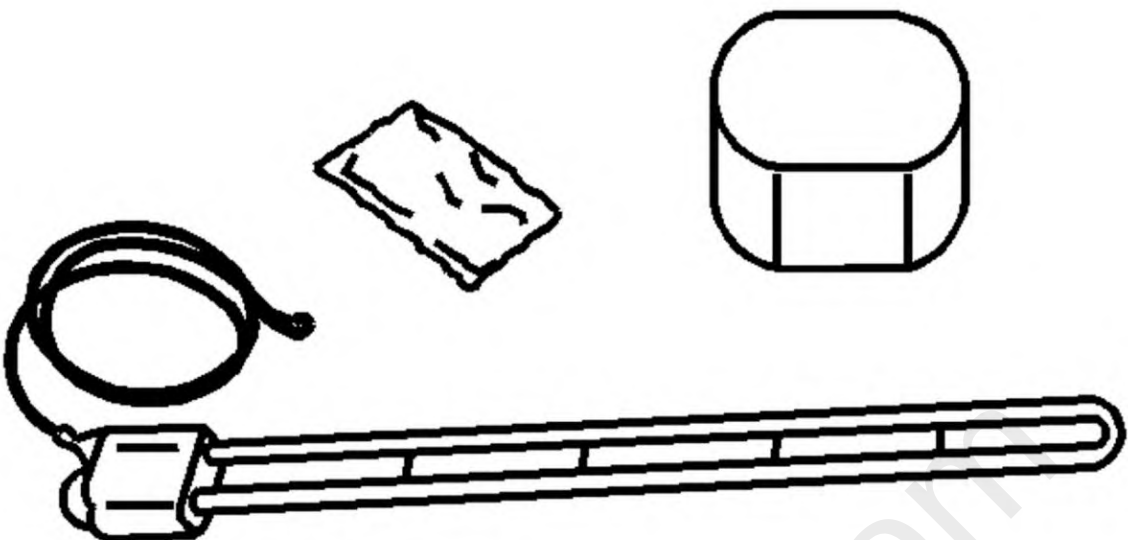
Illustration	Tool Number/Description
 A line drawing of a valve manometer assembly. The main component is a long, horizontal gauge with a scale. Attached to the left end is a coiled hose with a quick-connect fitting. Above the gauge are two smaller components: a small rectangular component and a cylindrical component with a flat top.	EN-23951 J-23951 Valve Manometer

Illustration	Tool Number/Description
	EN-28410 J-28410 Gasket Remover

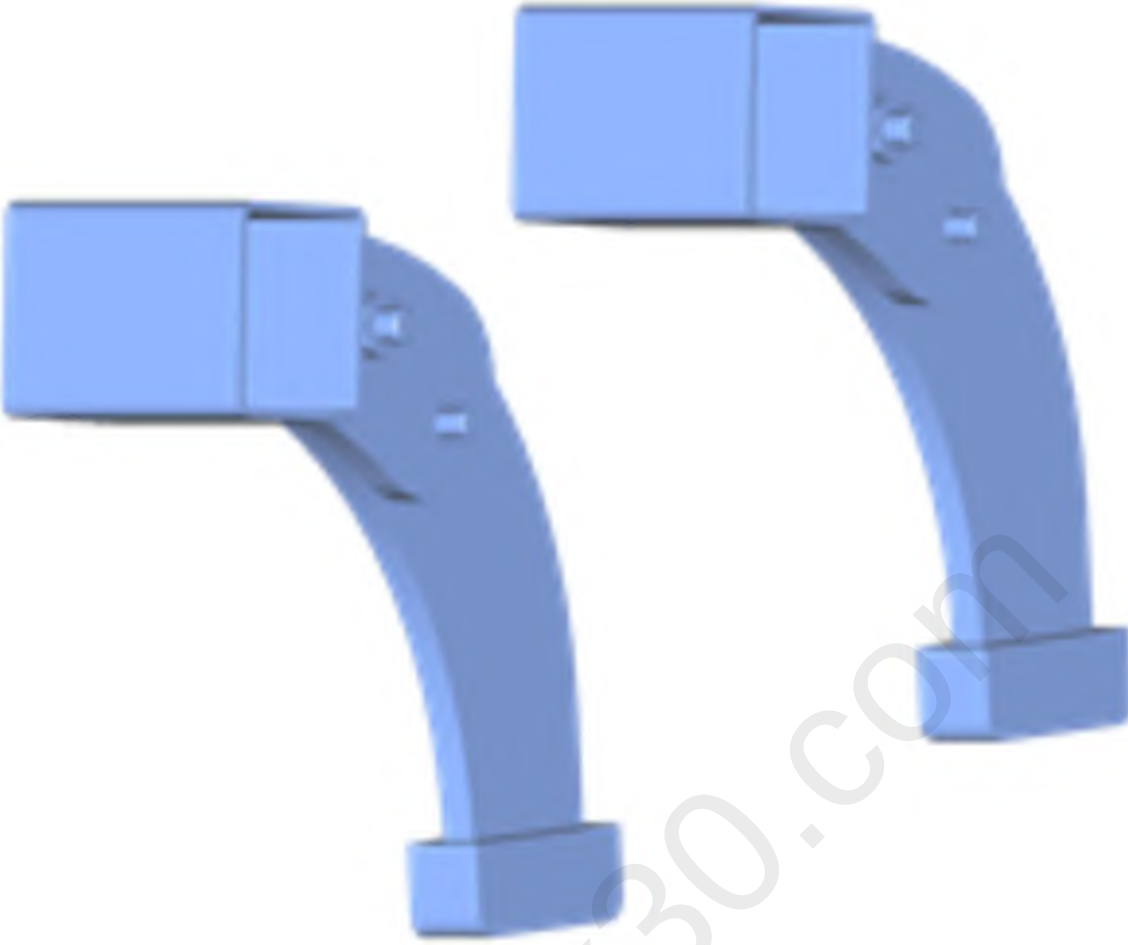
Illustration	Tool Number/Description
	EN-28467-300 EN-51007-5 Engine Support Fixture Adapters

Illustration	Tool Number/Description
	EN-28467-518 J-28467-518 Engine Support Adapter - Main Support Beam

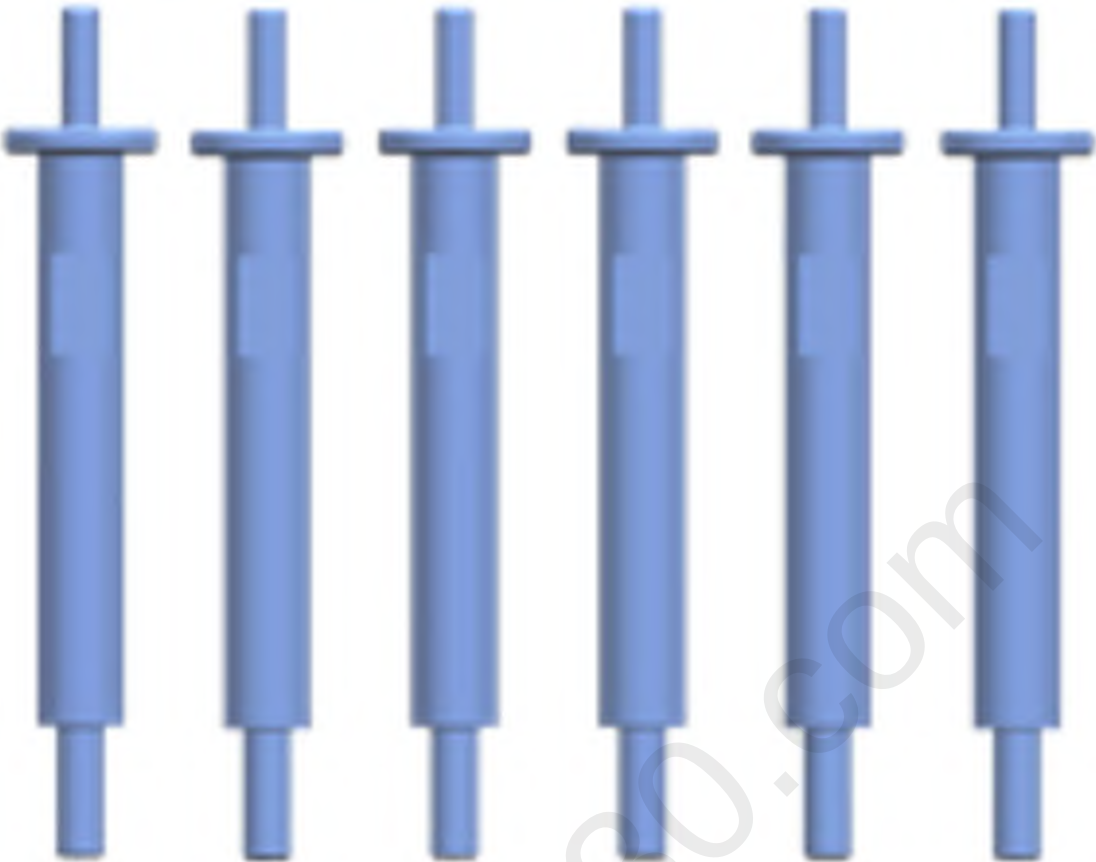
Illustration	Tool Number/Description
 The illustration shows six identical blue 3D models of engine support beam adapters arranged in a horizontal row. Each adapter consists of a long central shaft with a wider flange at the top and a narrower section at the bottom. A large, light gray watermark 'mcx30.com' is diagonally overlaid across the center of the image.	EN-28467-550 J-28467-550 Engine Support Beam Adapter

Illustration	Tool Number/Description
	EN-28467-B J-28467-B EN-51007 Universal Engine Support Fixture
mcx30.com	

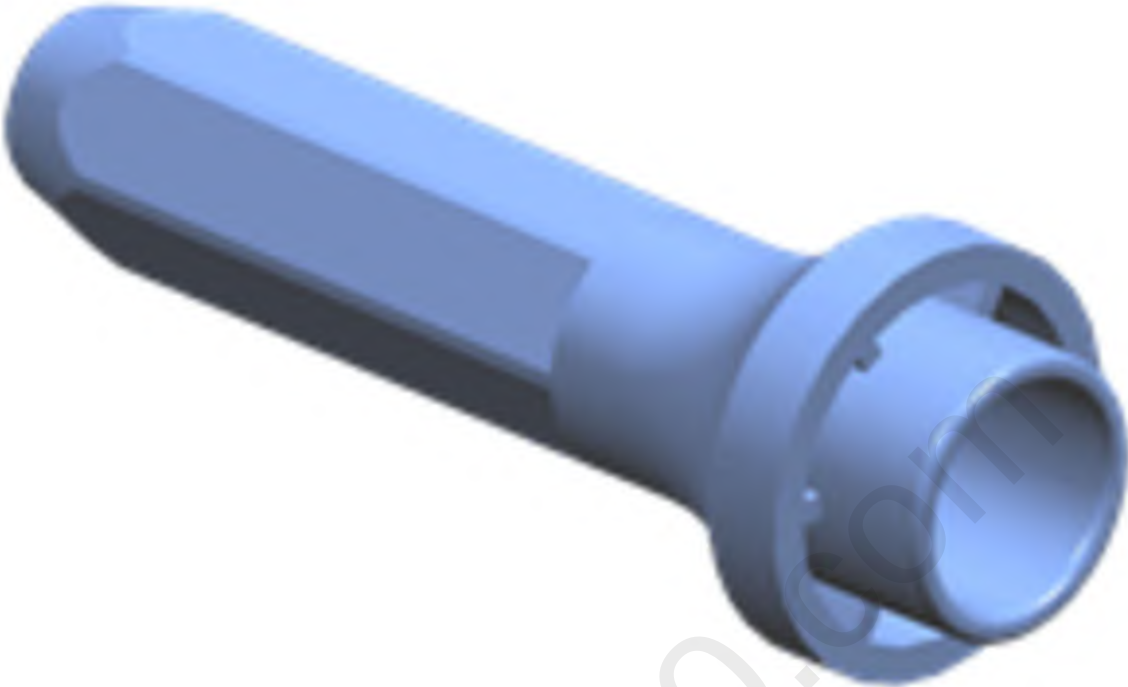
Illustration	Tool Number/Description
	EN-34115 J-34115 Sprocket Bearing Installer

Illustration	Tool Number/Description
	EN-35667-A J-35667-A Cylinder Head Leakdown Tester

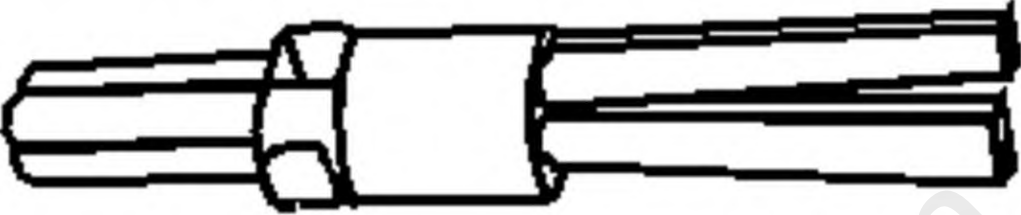
Illustration	Tool Number/Description
	EN-36017 J-36017 KM-840 - Removal KM-6152 - Installation Valve Seal Remover

Illustration	Tool Number/Description
	EN-36857 J-36857 Engine Lift Bracket

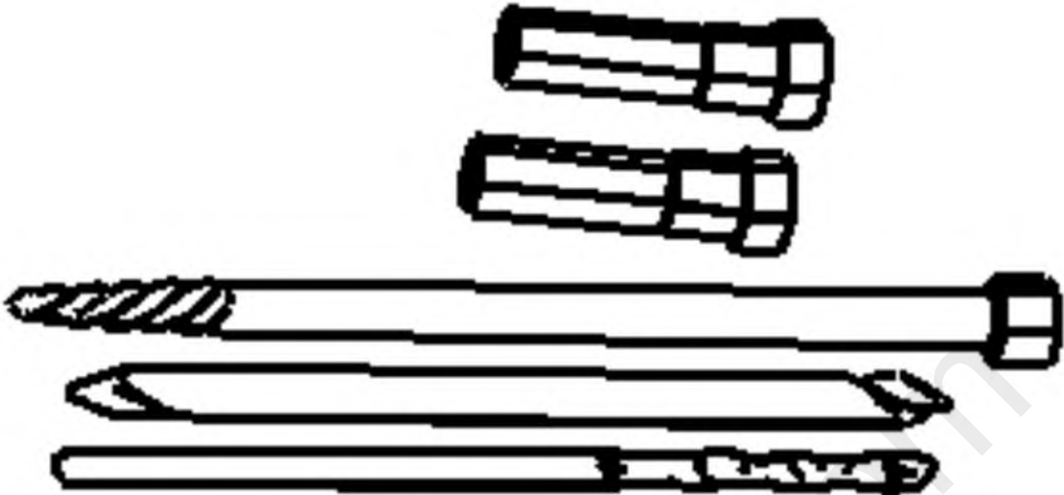
Illustration	Tool Number/Description
	EN-38188 J-38188 Cylinder Head Broken Bolt Extractor Kit

Illustration	Tool Number/Description
	EN-39358 J-39358 83 94 785 Spark Plug Socket

Illustration	Tool Number/Description
	EN-41816 EN-51577 J-41816 Crankshaft Balancer Remover

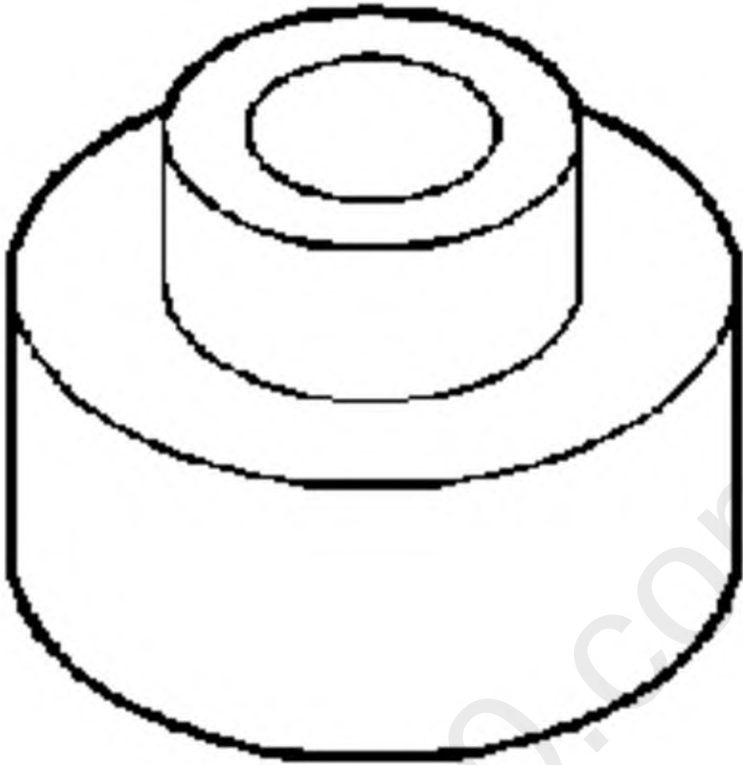
Illustration	Tool Number/Description
	EN-41816-2 J-41816-2 Crankshaft End Protector

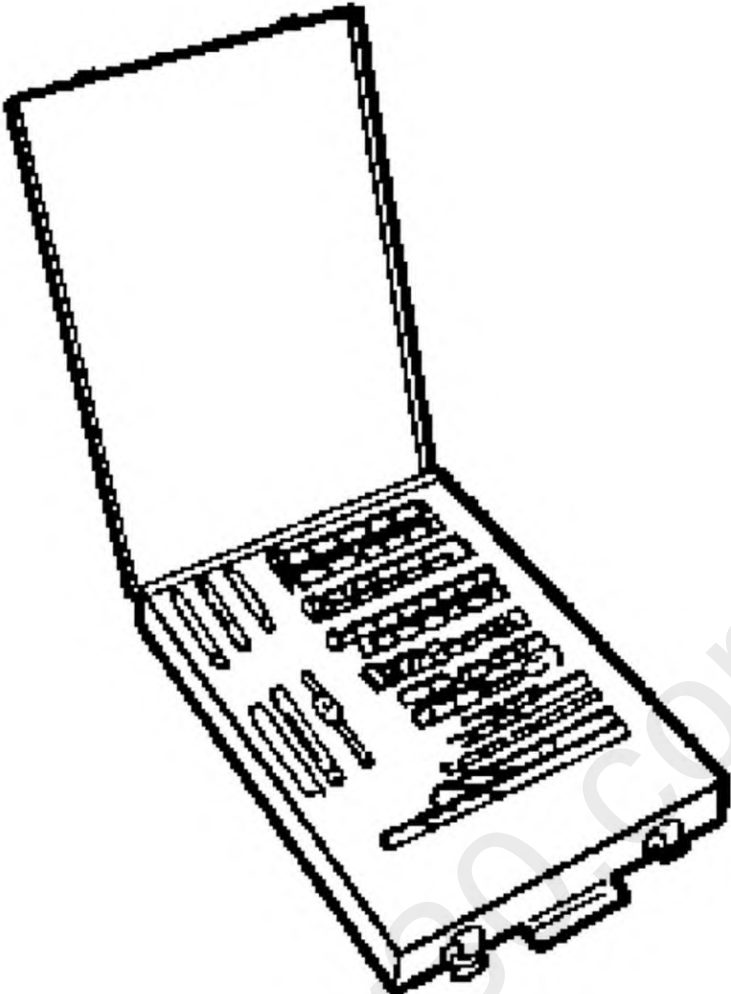
Illustration	Tool Number/Description
	EN-42385-700 J-42385-700 High Feature Thread Repair Kit

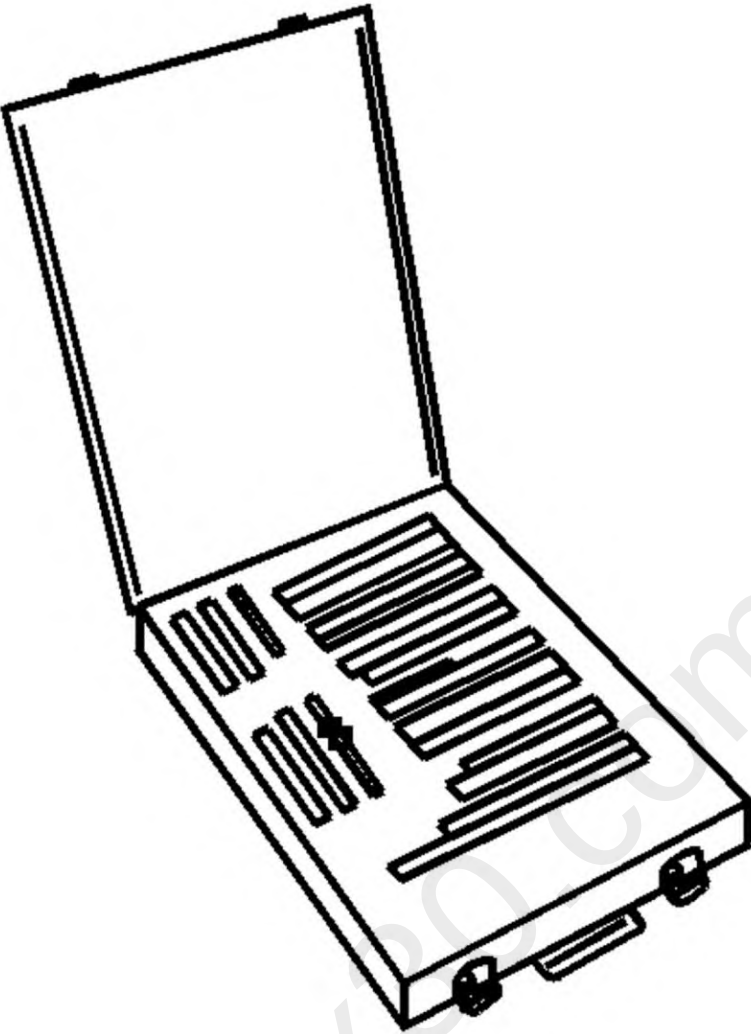
Illustration	Tool Number/Description
	EN-42385-850 J-42385-850 Thread Repair Kit

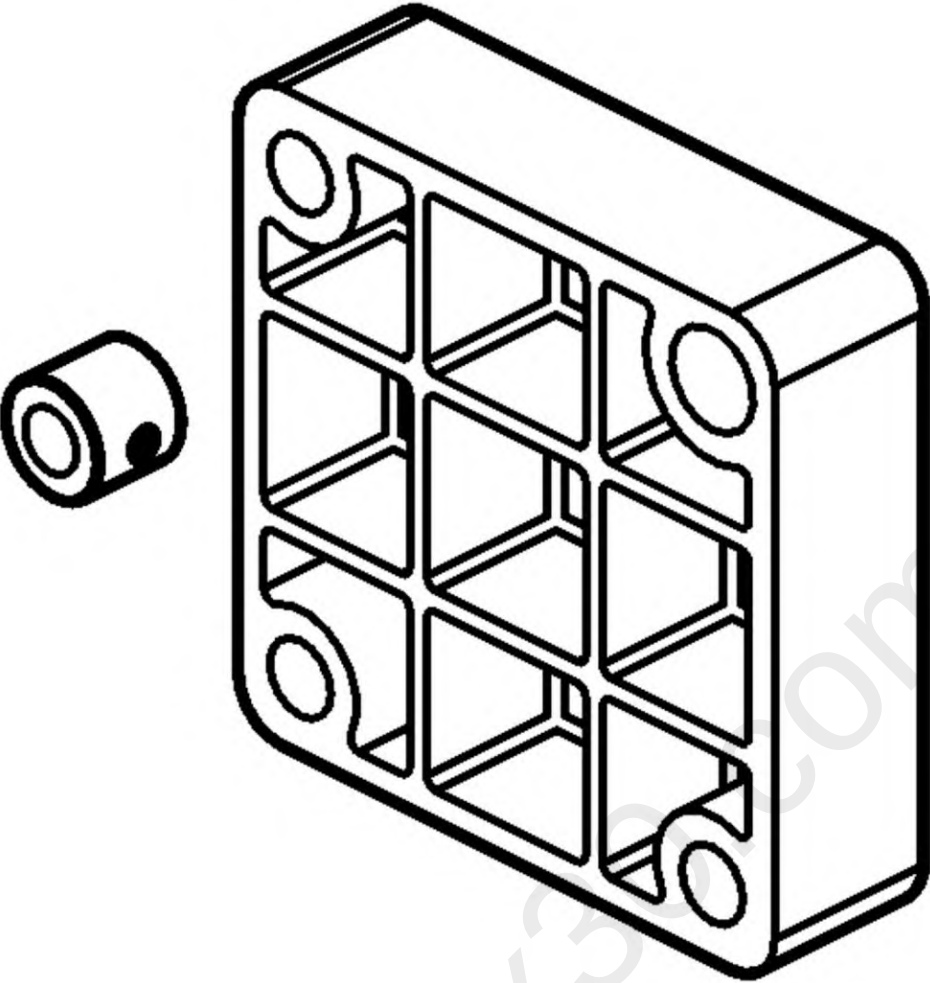
Illustration	Tool Number/Description
 The illustration shows a rectangular repair adapter kit divided into a 3x3 grid of nine square compartments. Each compartment has a raised, circular rim. To the left of the grid is a separate cylindrical component, likely a bolt head, with a central hole and a small circular feature on its side. A faint watermark 'mcx360.com' is visible across the image.	EN-42385-880 Head Bolt Thread Repair Adapter Kit

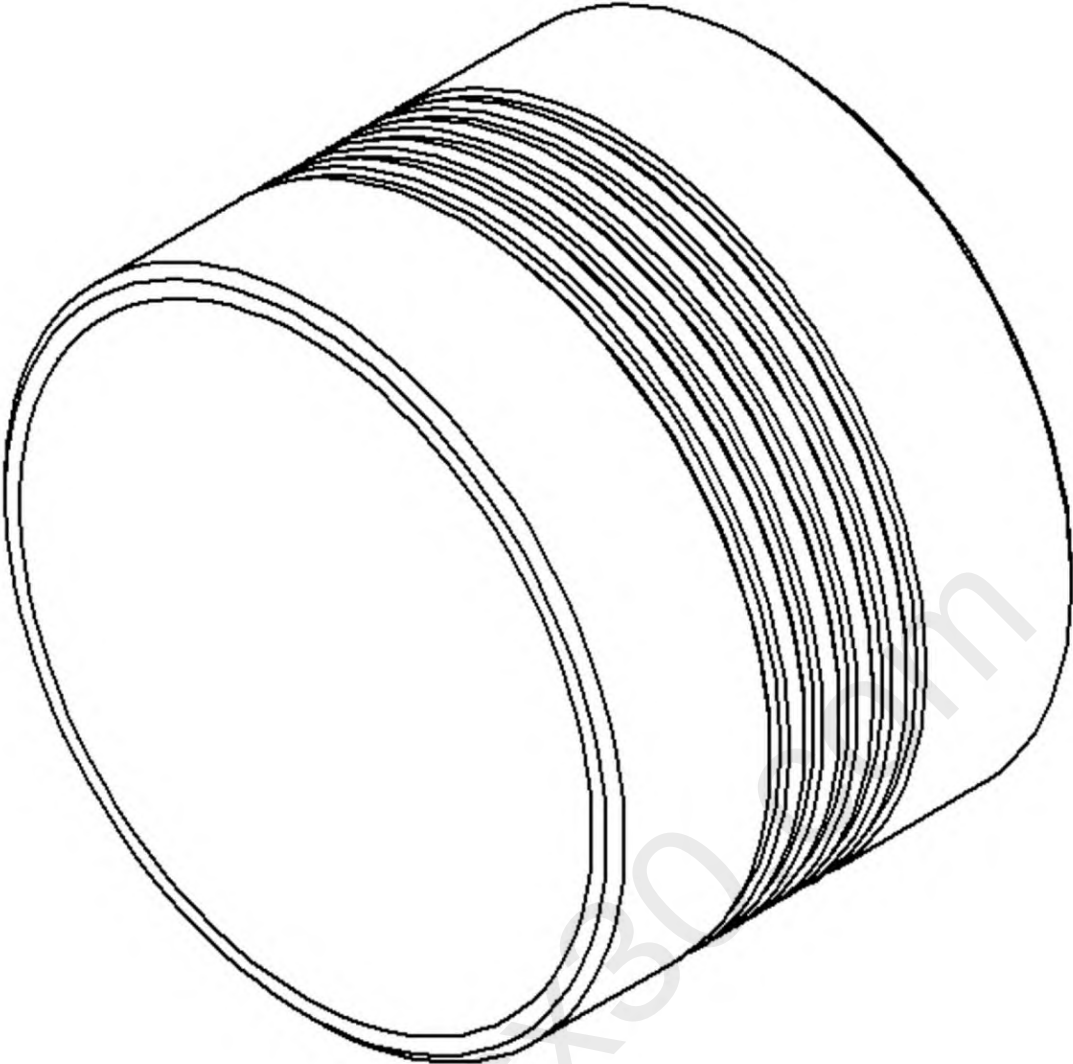
Illustration	Tool Number/Description
 A technical line drawing of a piston ring, shown in a three-quarter perspective. The ring is a toroidal (donut-shaped) component with a smooth outer rim and a series of closely spaced, parallel longitudinal grooves on its inner face. The drawing is oriented diagonally within the cell.	EN-43953 J-43953 Piston Ring Compressor - 86 mm

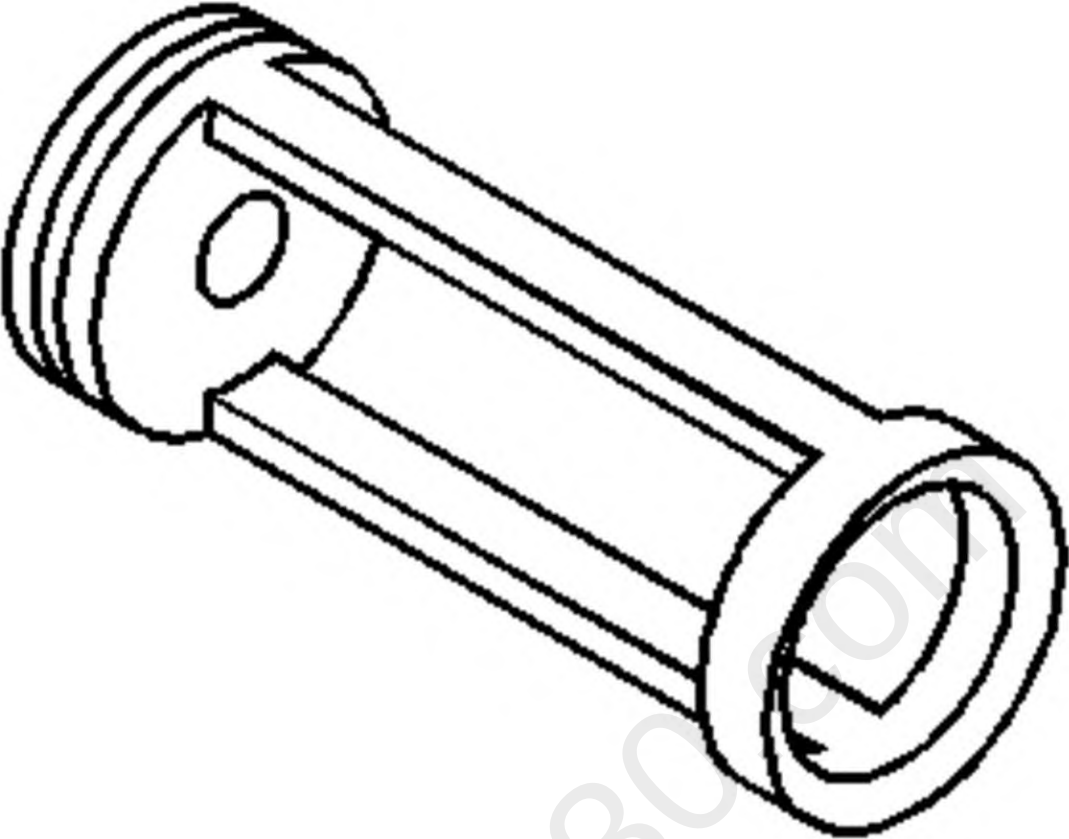
Illustration	Tool Number/Description
	EN-43963 J-43963 KM-6149 Valve Spring Compressor (off car)

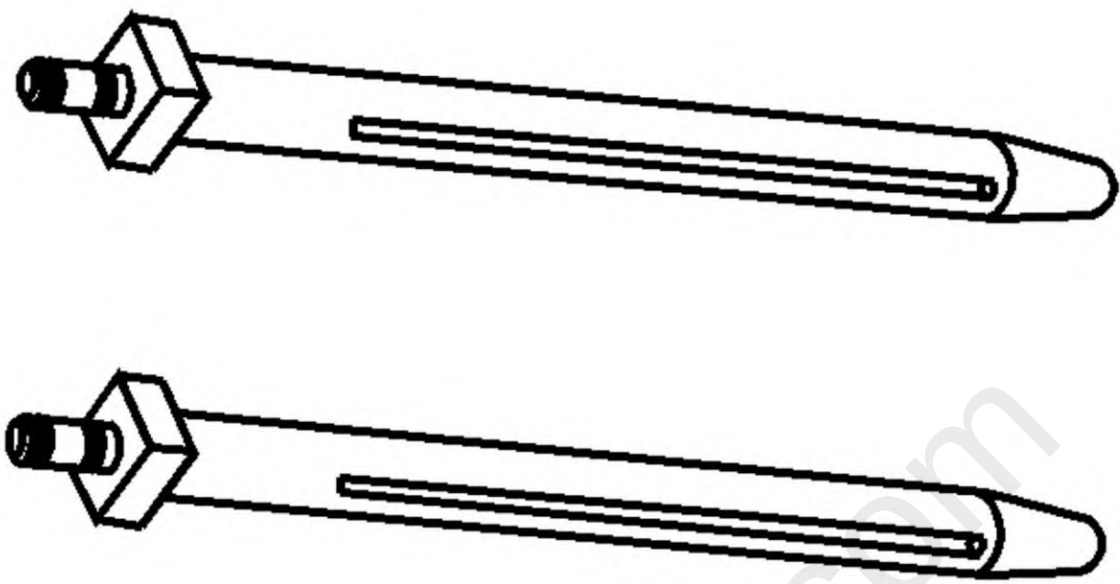
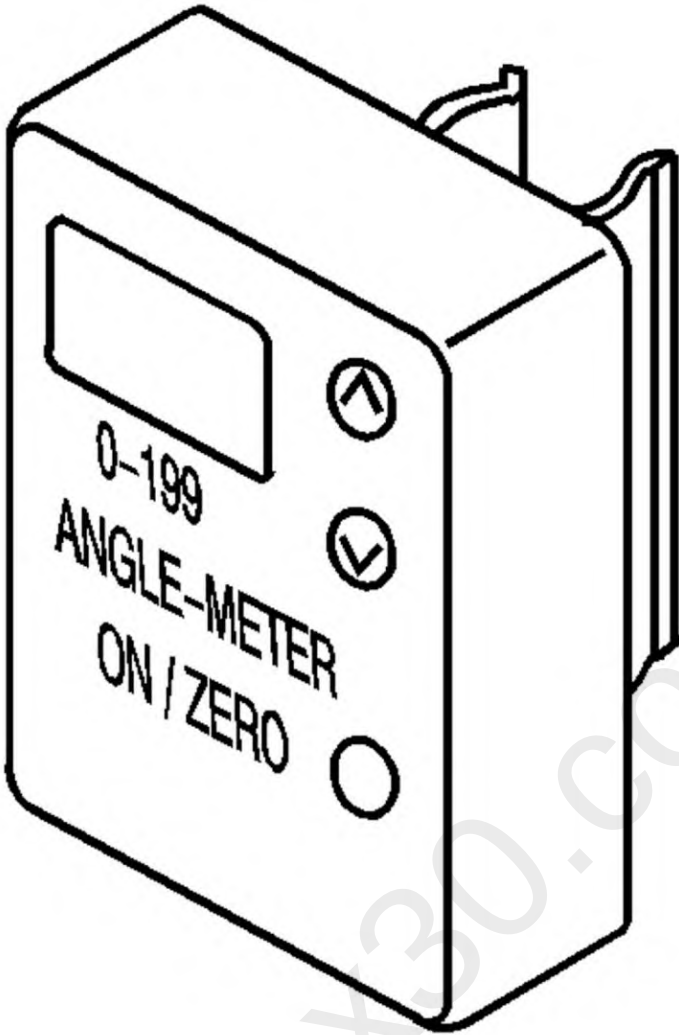
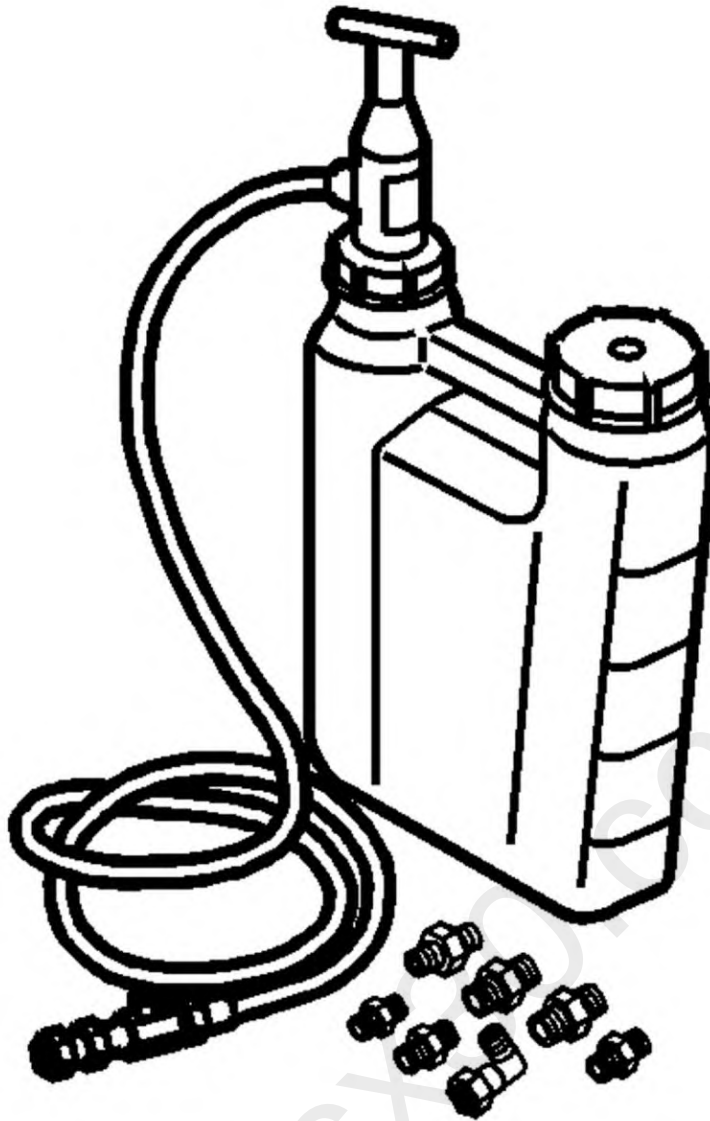
Illustration	Tool Number/Description
	EN-43966-1 J-43966-1 Connecting Rod Guides

Illustration	Tool Number/Description
	EN-45025 J-45025 Belt Tensioner Wrench

Illustration	Tool Number/Description
	EN-45059 J-45059 J-45059-A Angle Meter

Illustration

Tool
Number/Description



EN-45299
J-45299
Engine Pre-Luber

Illustration	Tool Number/Description
	EN-46116 Valve Stem Seal Remover

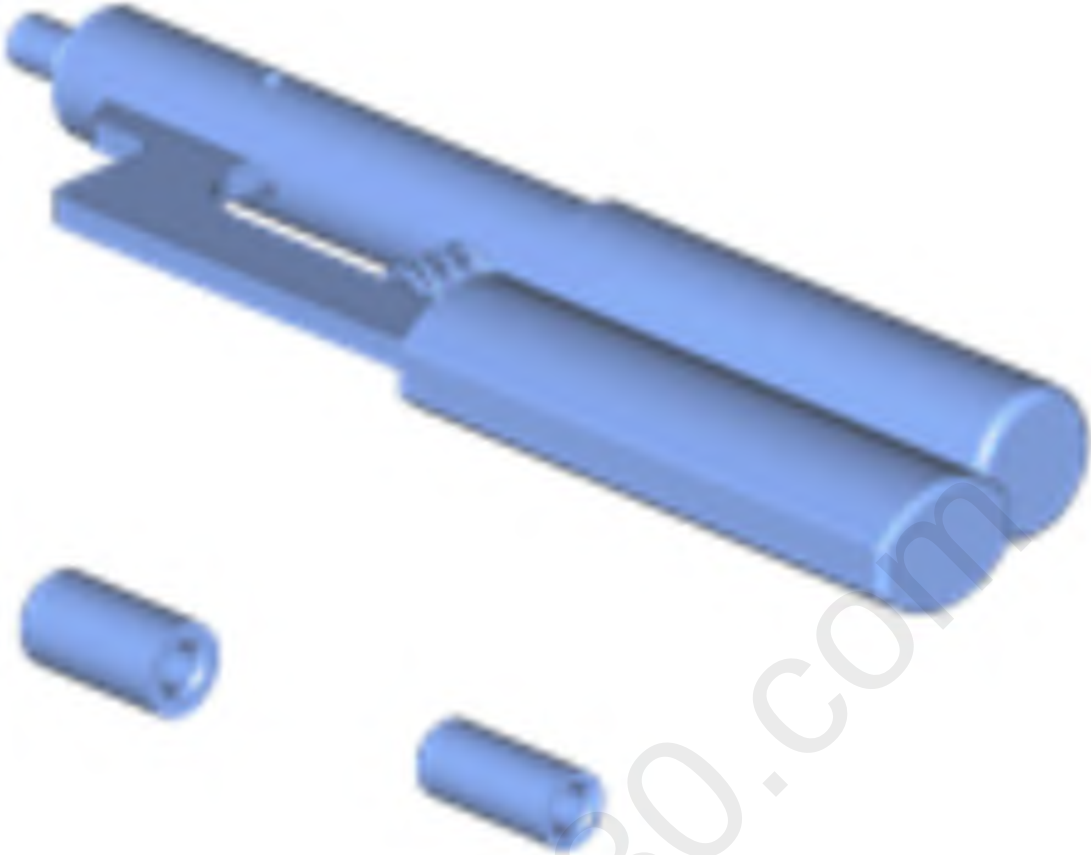
Illustration	Tool Number/Description
	EN-46745 J-43654 Piston Pin Clip Remover/Installer

Illustration	Tool Number/Description
	EN-46745-4 Piston Pin Clip Remover/Installer Adapter
mcx30.com	

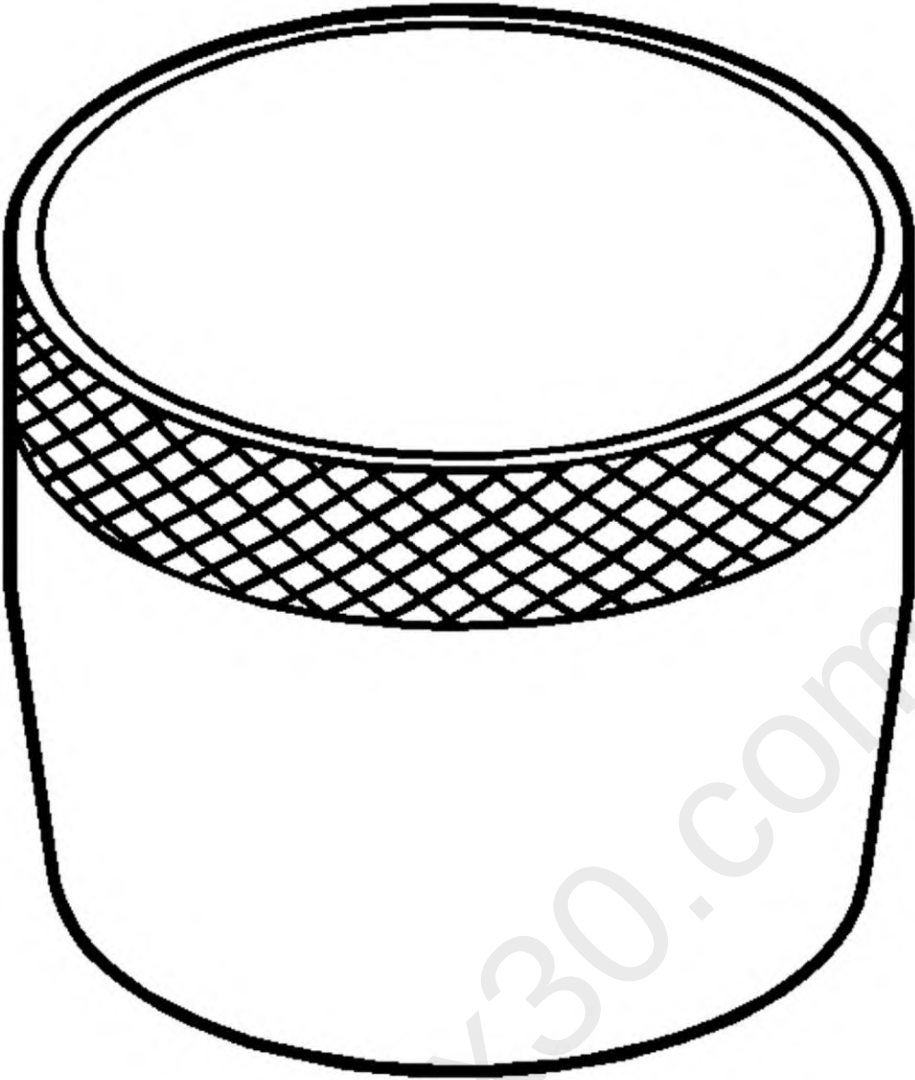
Illustration	Tool Number/Description
	EN-47836 J-47836 Ring Compressor - 88 mm

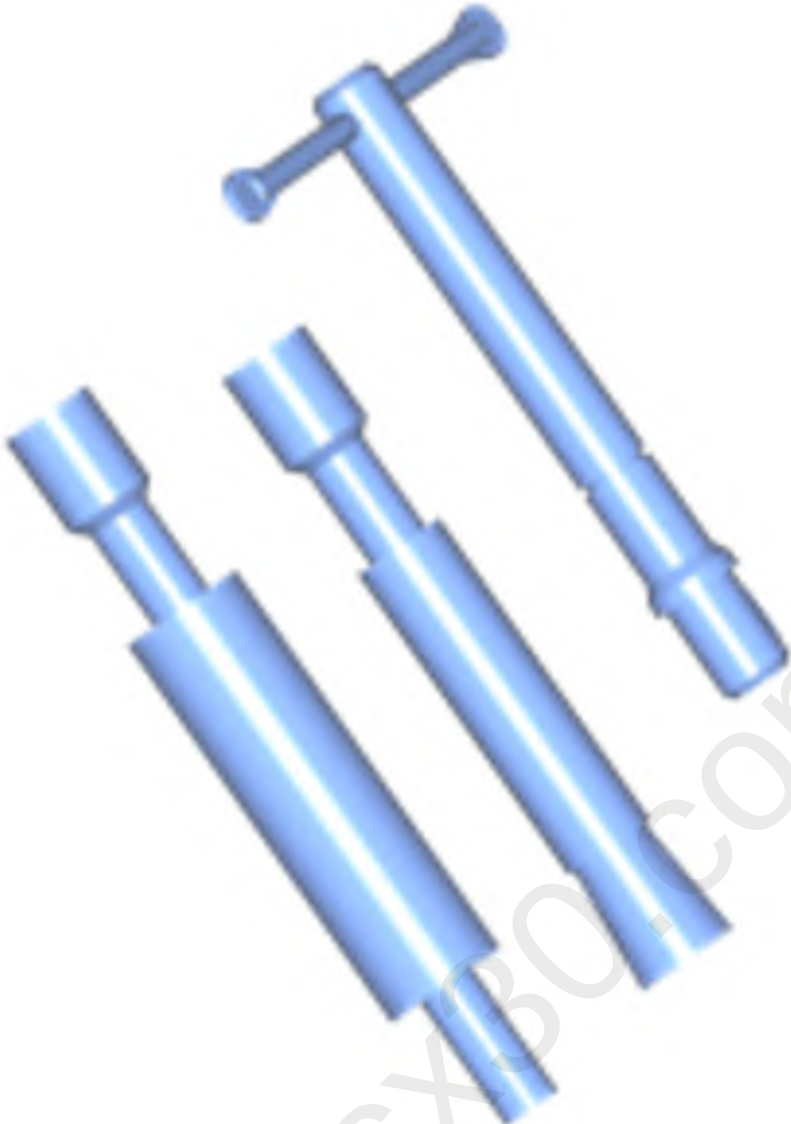
Illustration	Tool Number/Description
	EN-47909 Injector Bore and Sleeve Cleaning Kit

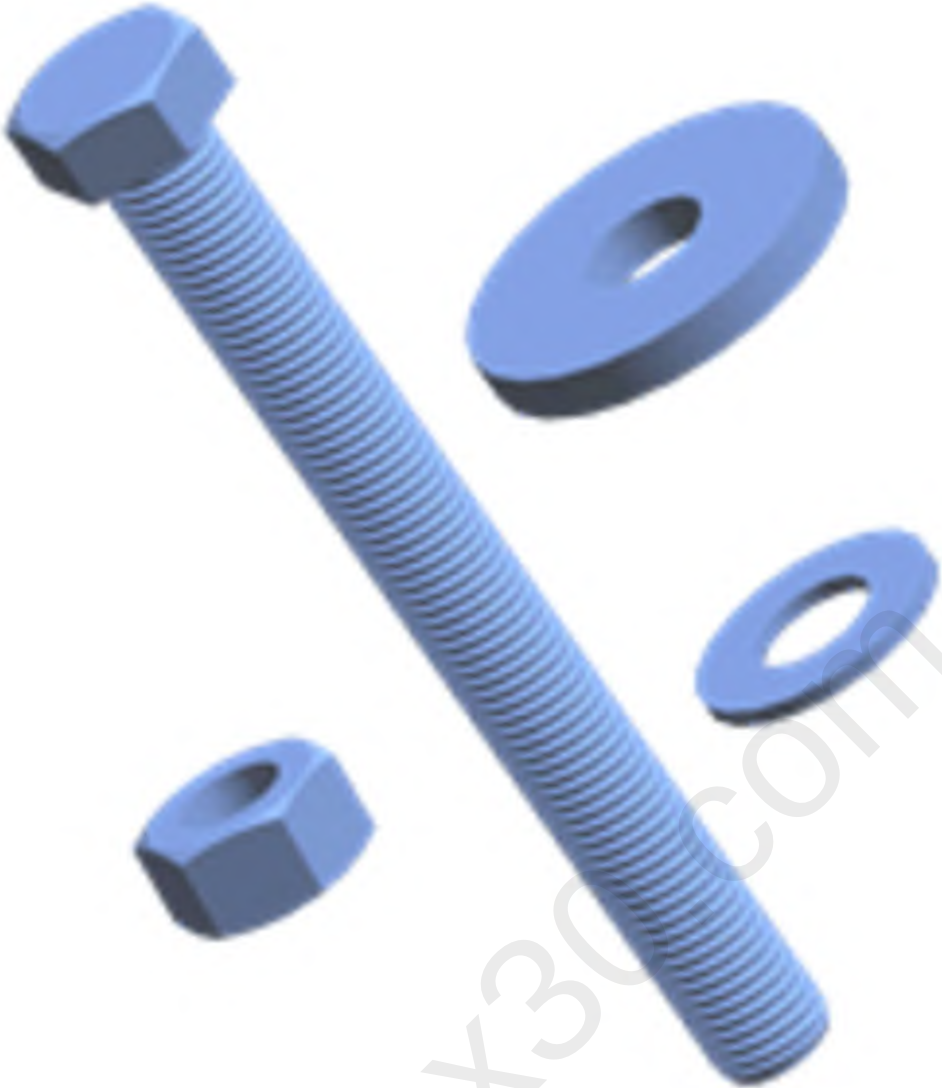
Illustration	Tool Number/Description
	EN-48034 Crankshaft Balancer Installer

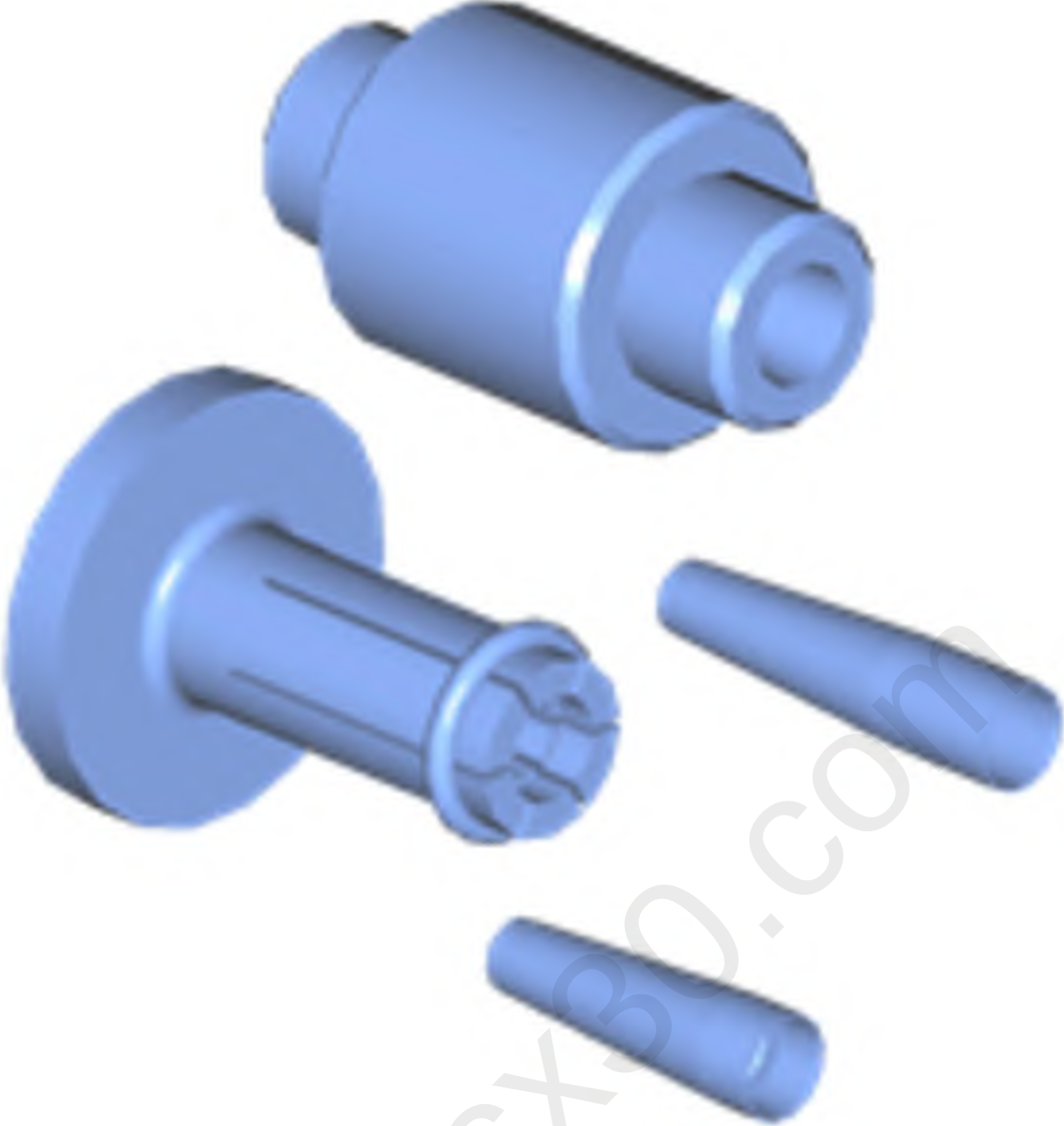
Illustration	Tool Number/Description
	EN-49245 Injector Seal Installer and Sizer

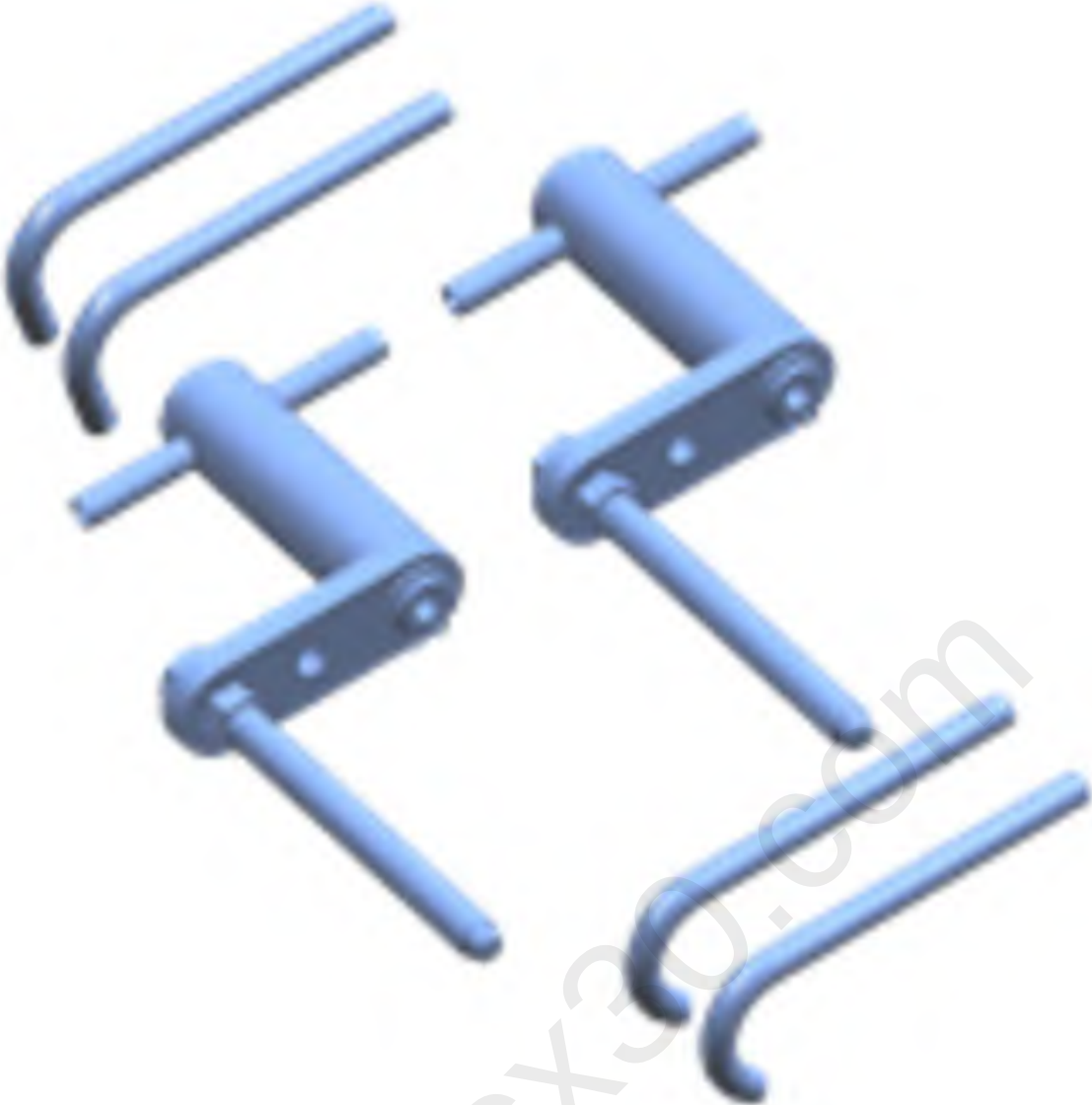
Illustration	Tool Number/Description
	EN-49248 Fuel Rail Assembly Remover

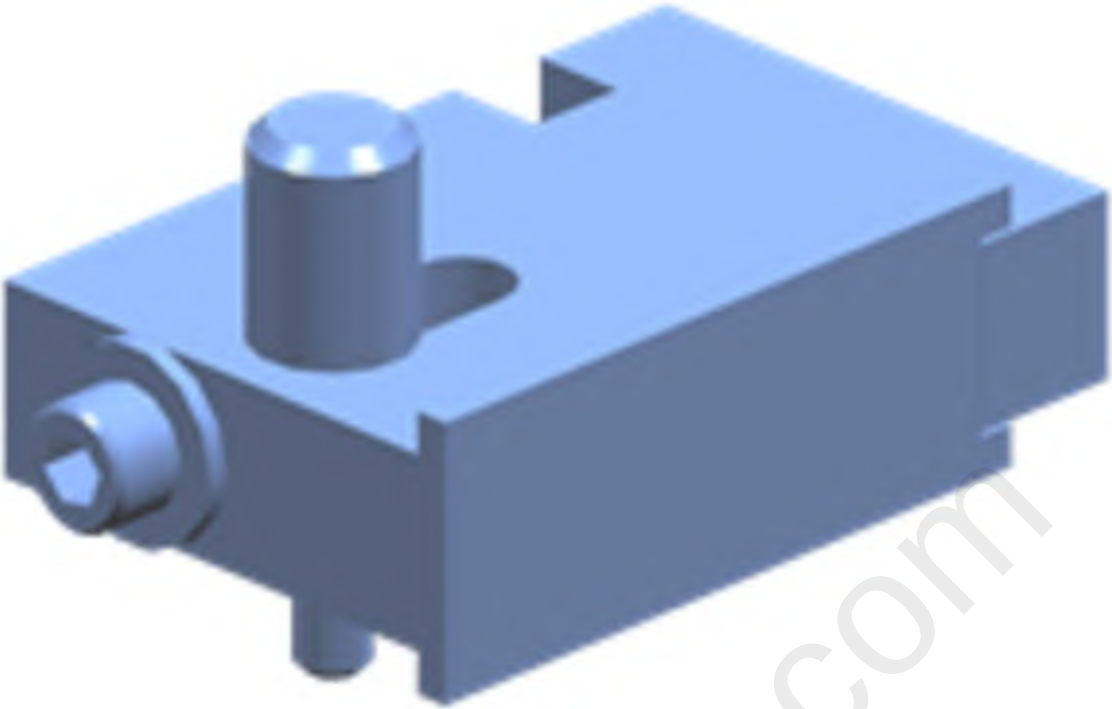
Illustration	Tool Number/Description
	EN-50656 Timing Chain Retention Tool Kit

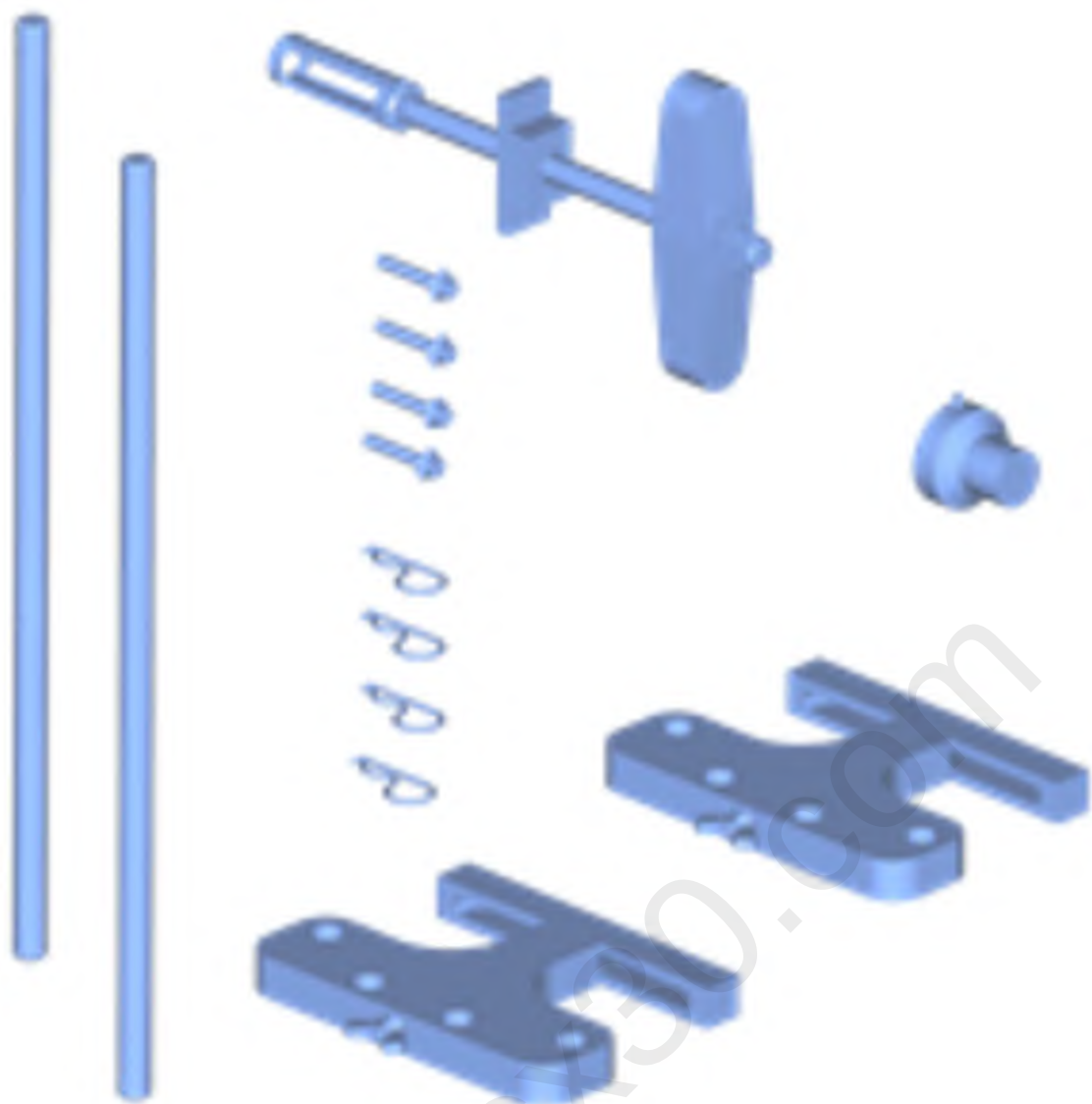
Illustration	Tool Number/Description
 The diagram shows an exploded view of a valve spring compressor tool assembly. The components include: two long vertical rods on the left; a central assembly consisting of a long threaded rod with a square block and a semi-circular handle; a vertical stack of five blue springs; a small circular pin; and two large, symmetrical, U-shaped base blocks with mounting holes. A large, light-blue diagonal watermark reading 'micro30.com' is overlaid across the center of the image.	EN-50717 Valve Spring Compressor

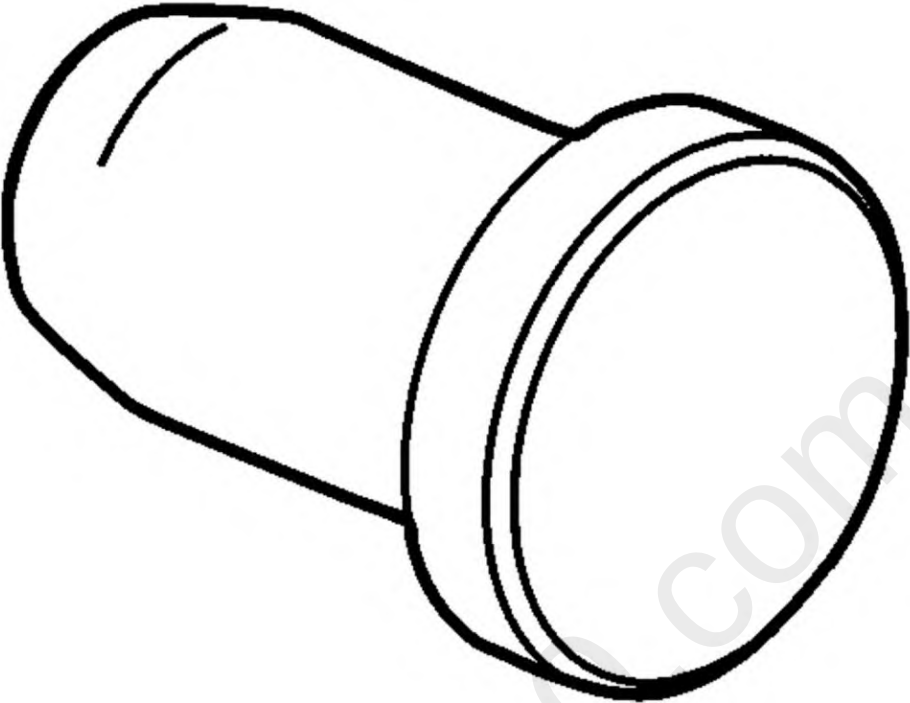
Illustration	Tool Number/Description
	EN-50790 High Pressure Fuel Pump Installation Alignment Gauge

Illustration	Tool Number/Description
	EN-50791 Fuel Injector Nozzle Installer - to Rail

Illustration	Tool Number/Description
	EN-50793 Camshaft Actuator Locking Tool

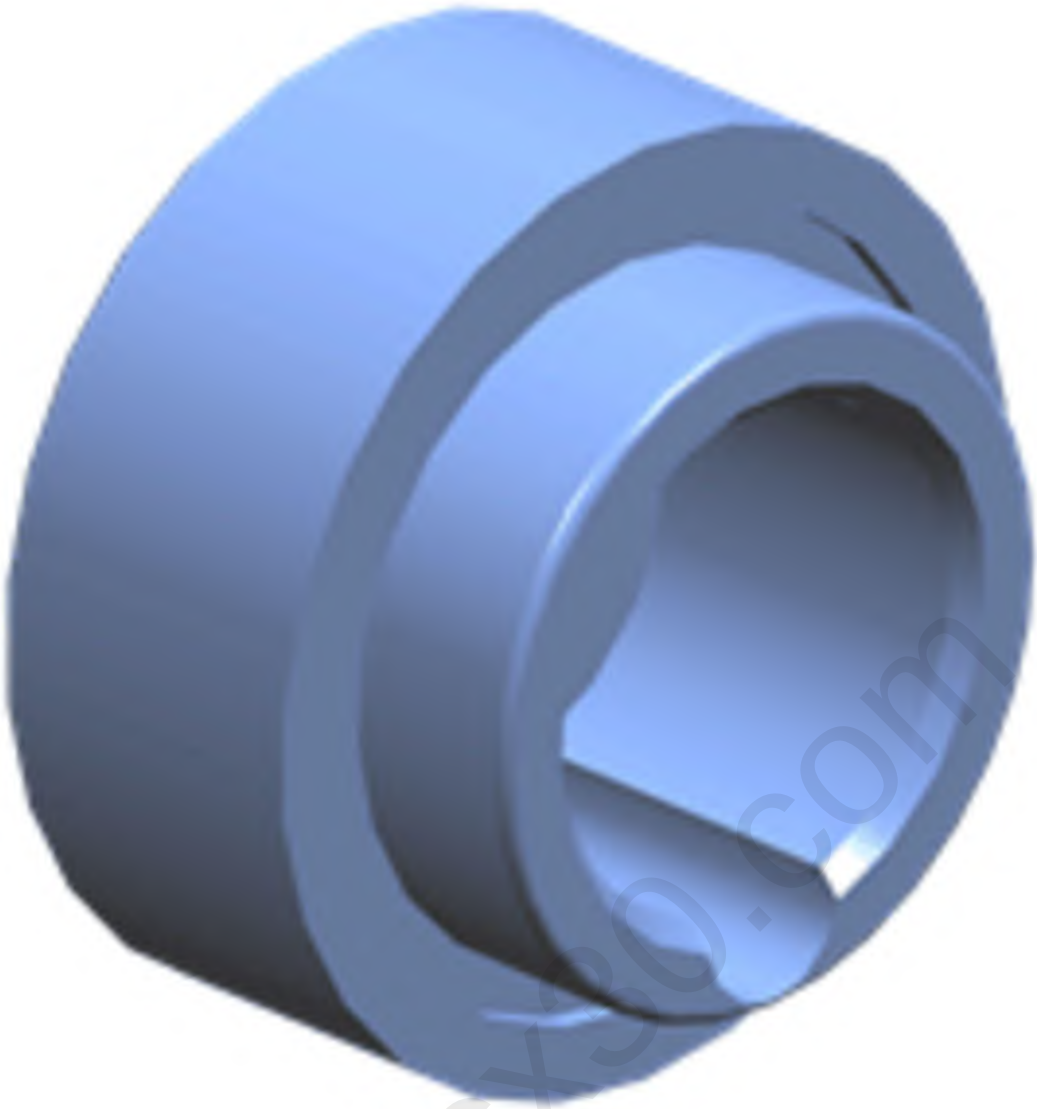
Illustration	Tool Number/Description
	EN-50820 Front Crankshaft Seal Installer

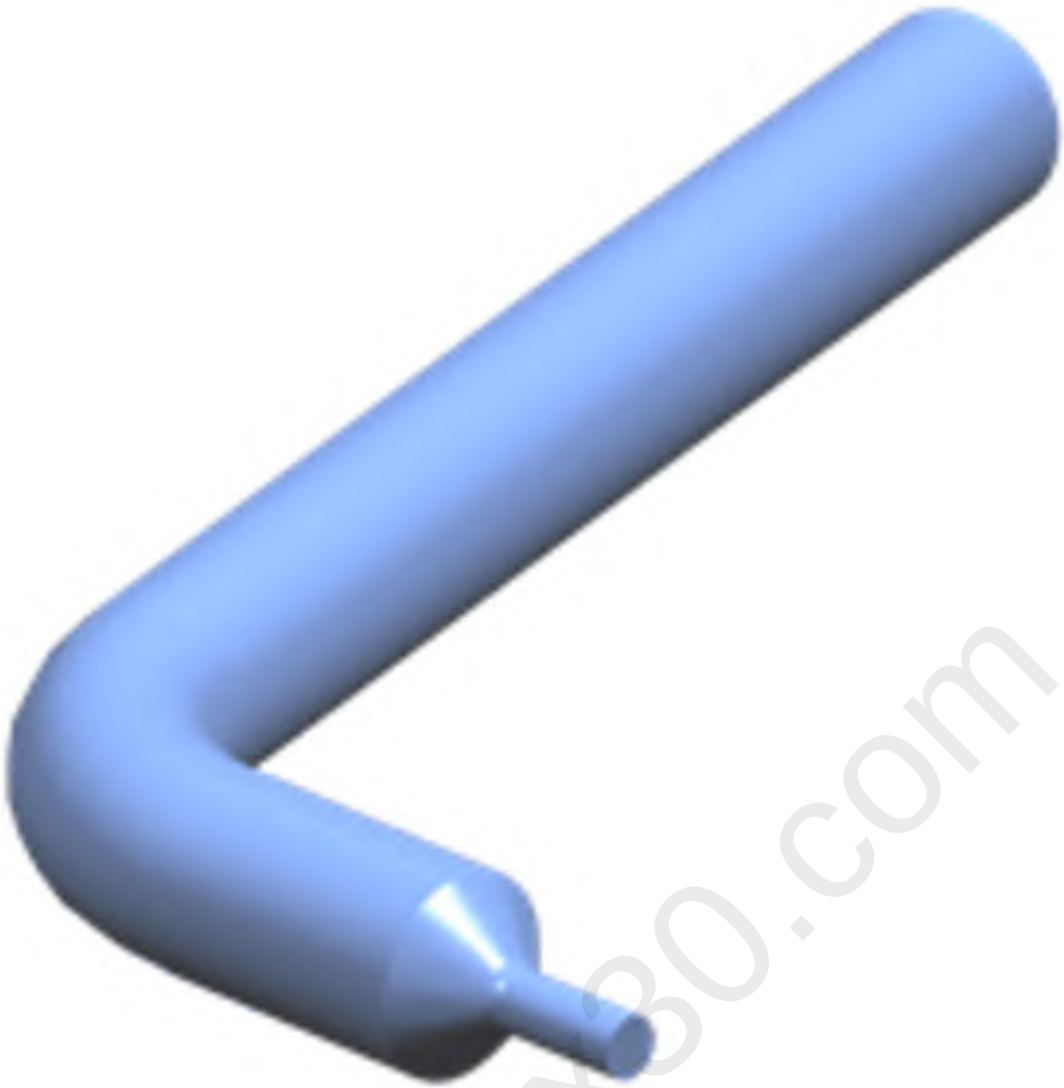
Illustration	Tool Number/Description
	EN-50837 Timing Chain Tensioner Retraction Tool

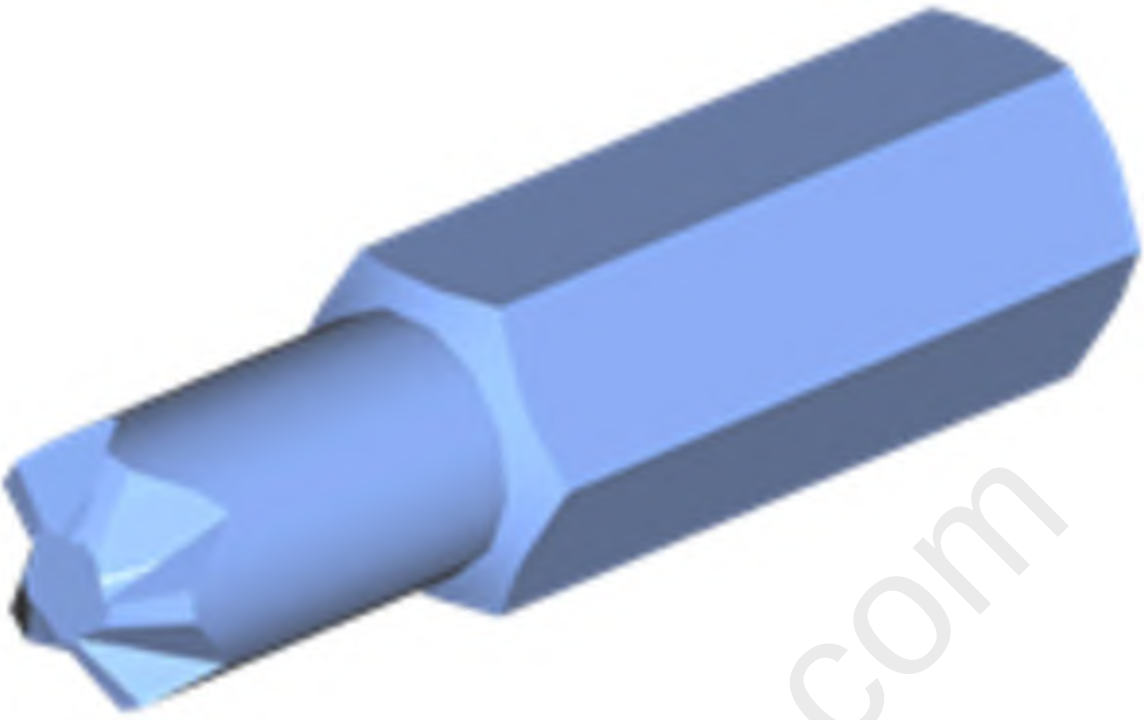
Illustration	Tool Number/Description
	EN-50956 Tamper Proof Drive Bit

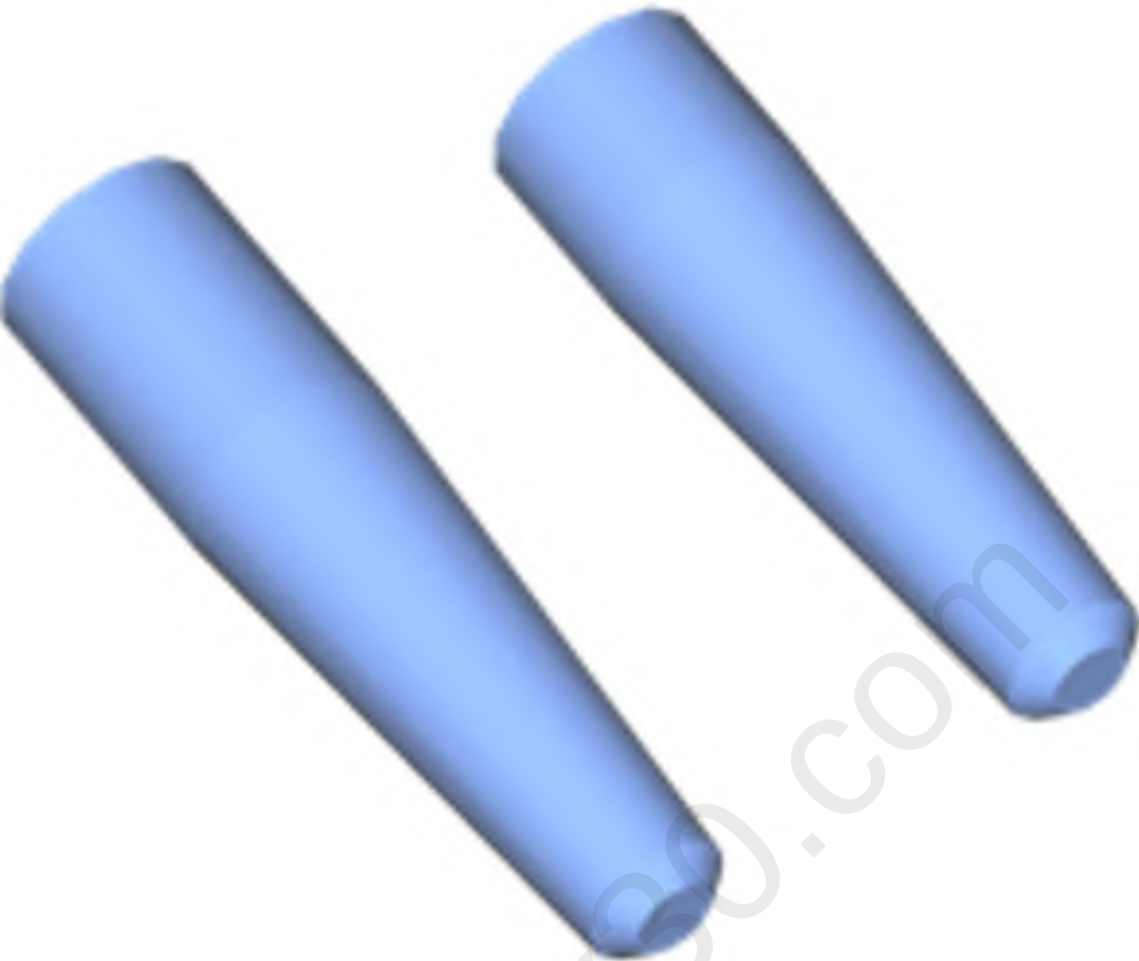
Illustration	Tool Number/Description
 Two blue cylindrical tools, likely injector seal installers, are shown diagonally. They are identical in appearance, with a smooth, slightly tapered surface. A large, light gray watermark 'mcx30.com' is visible across the image.	EN-51105 Injector Seal Installer

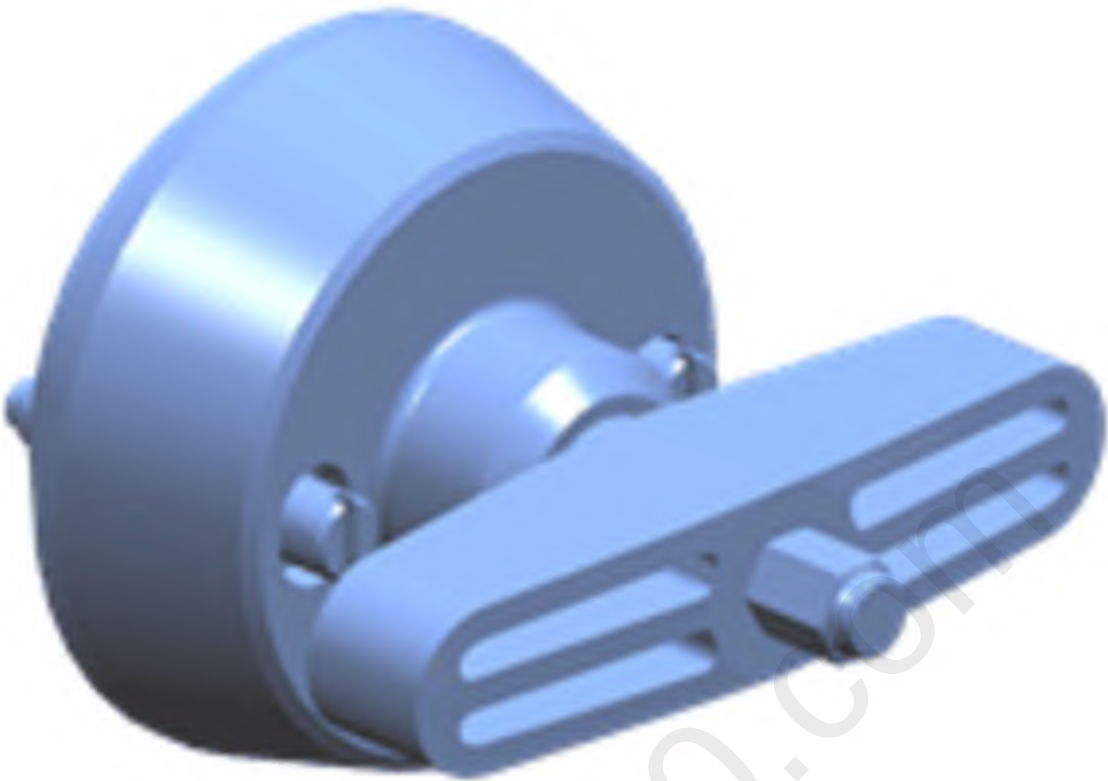
Illustration	Tool Number/Description
	EN-51380 Seal Installer

Illustration	Tool Number/Description
 A 3D rendering of four blue mechanical components. The largest component is a C-clamp with a circular body and a curved arm. A smaller C-clamp is positioned above it. Below the large C-clamp is a circular flange with a central hole and a raised rim. To the left of the flange is a long, cylindrical pin with a hexagonal base. A large, light gray watermark 'mcx30.com' is diagonally across the image.	EN-51577 Balancer Holder and Remover

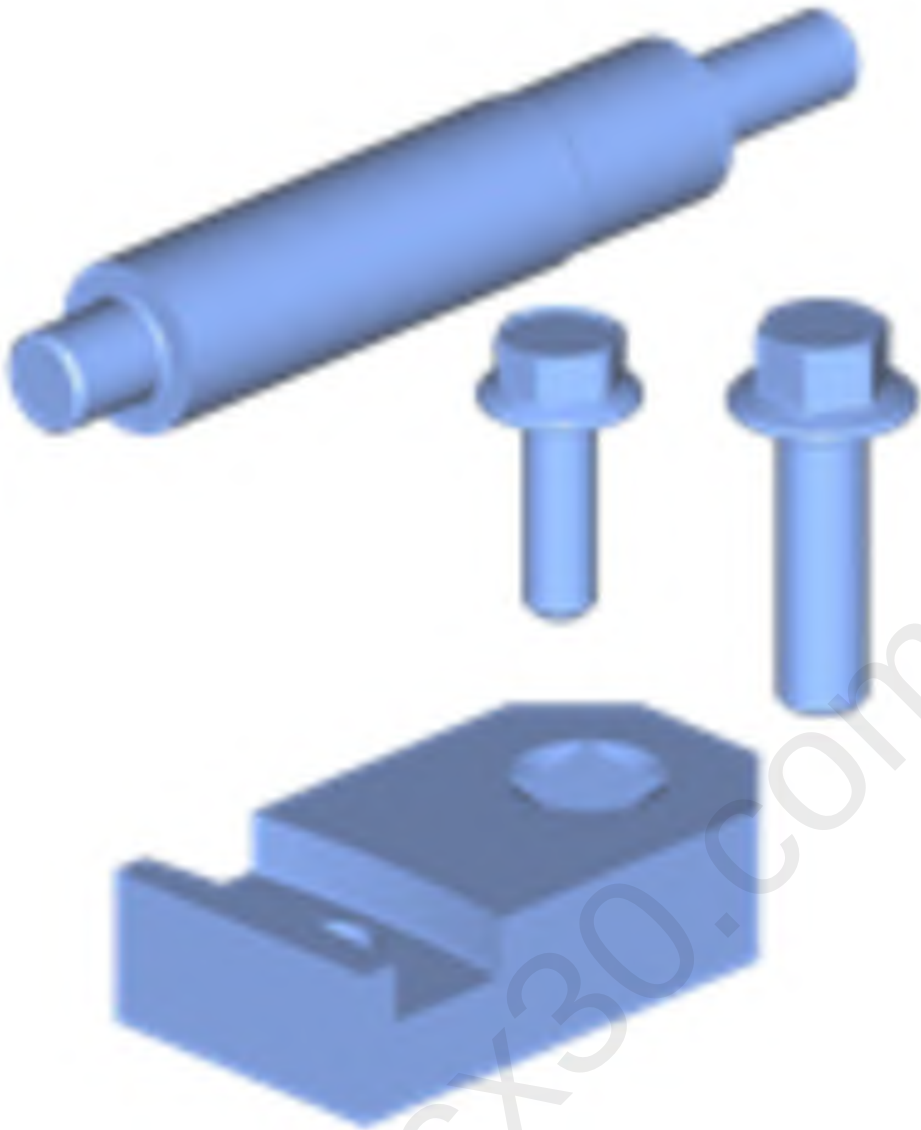
Illustration	Tool Number/Description
 A 3D rendering of a flywheel aligner tool assembly. The assembly consists of a long, cylindrical shaft with a hexagonal base, two hexagonal bolts, and a square base plate with a central hole. The shaft is positioned diagonally across the top left. The two bolts are positioned vertically in the center. The square base plate is positioned at the bottom left. A large, diagonal watermark reading 'mcx30.com' is overlaid across the entire image.	EN-51701 Flywheel Aligner and Holder

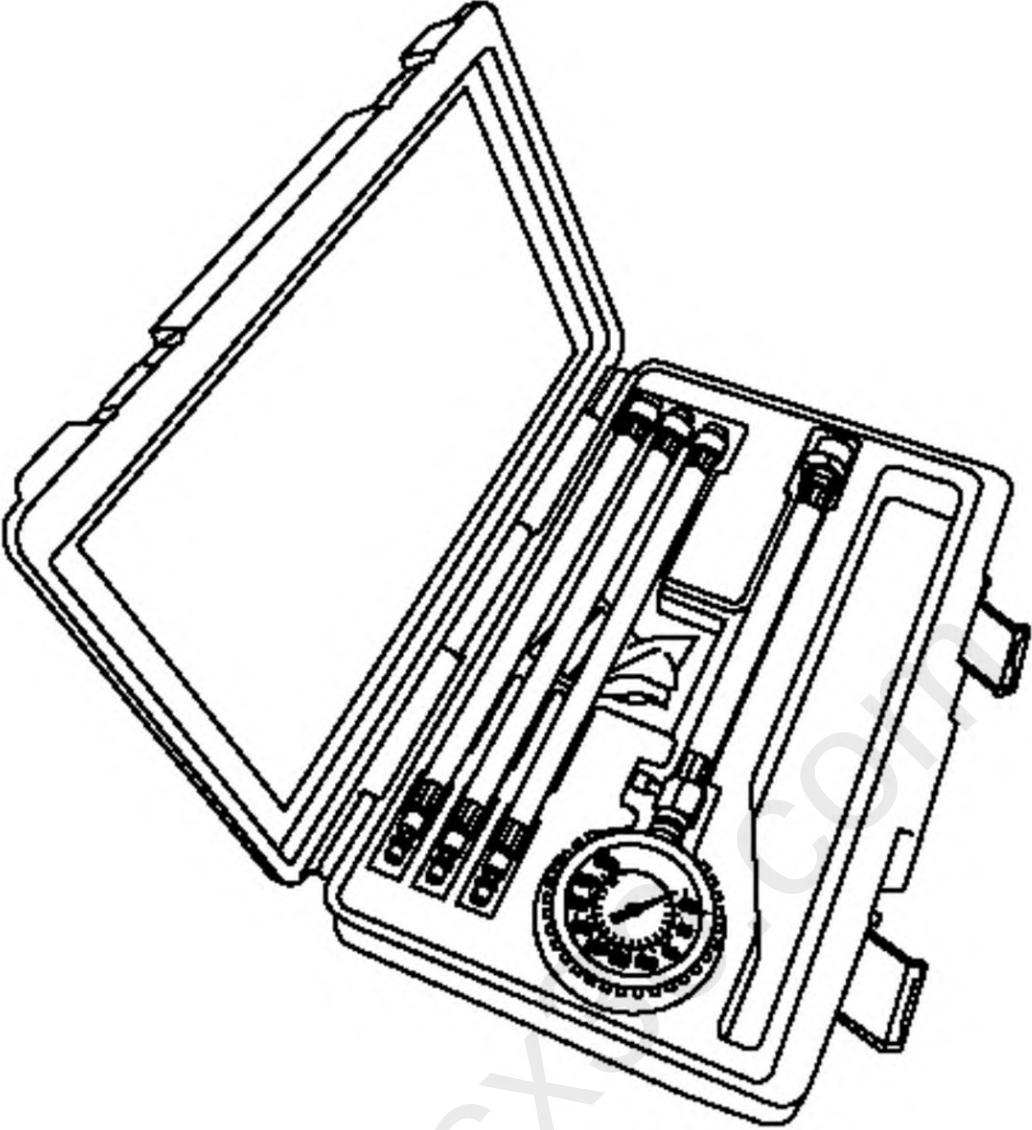
Illustration	Tool Number/Description
	EN-51749 Compression Gauge Tester Kit

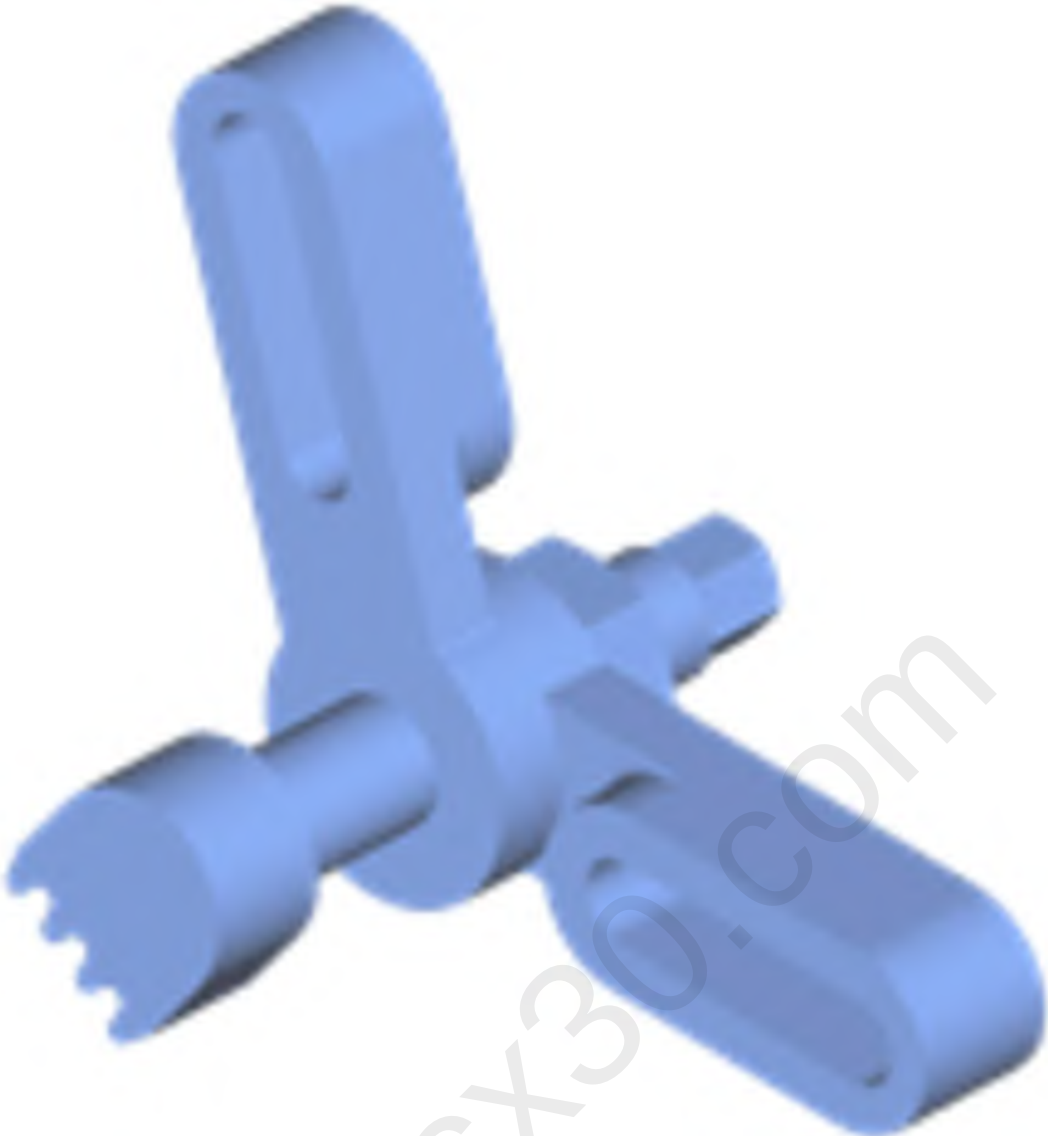
Illustration	Tool Number/Description
	EN-51760 EN-50792 Flywheel Holder

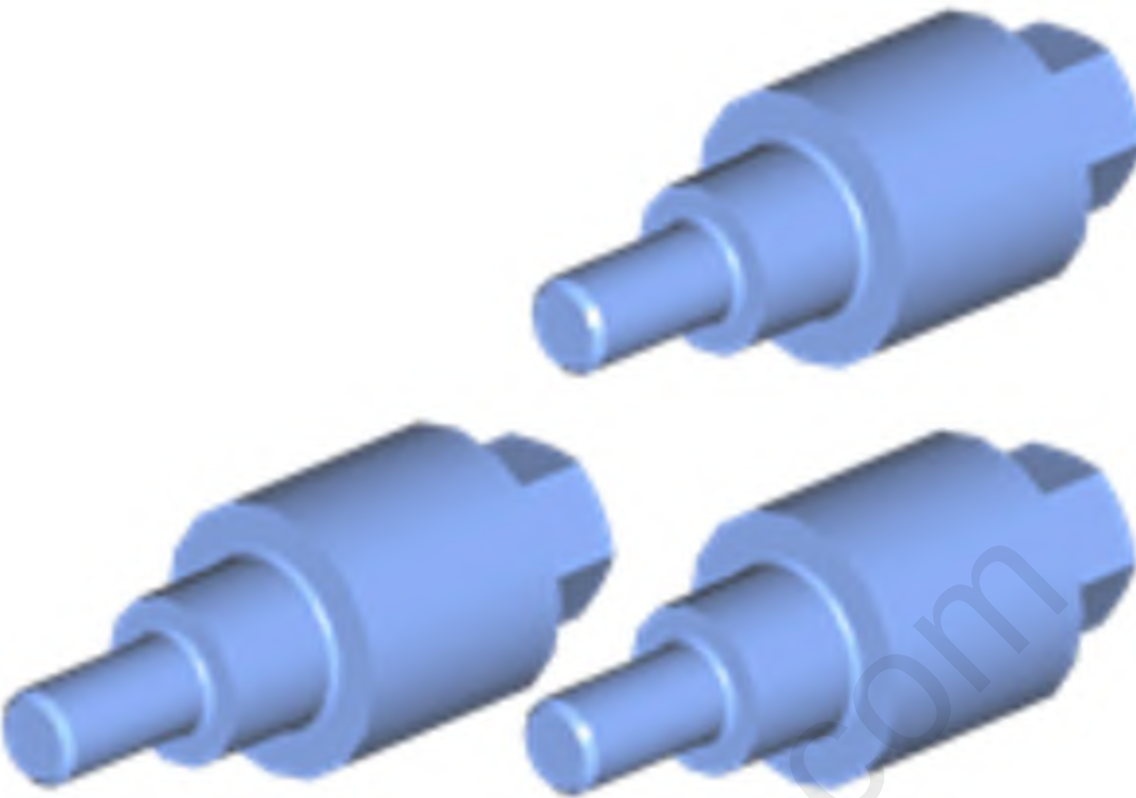
Illustration	Tool Number/Description
	EN-51768 Engine Support Fixture Adapter Bolts M8

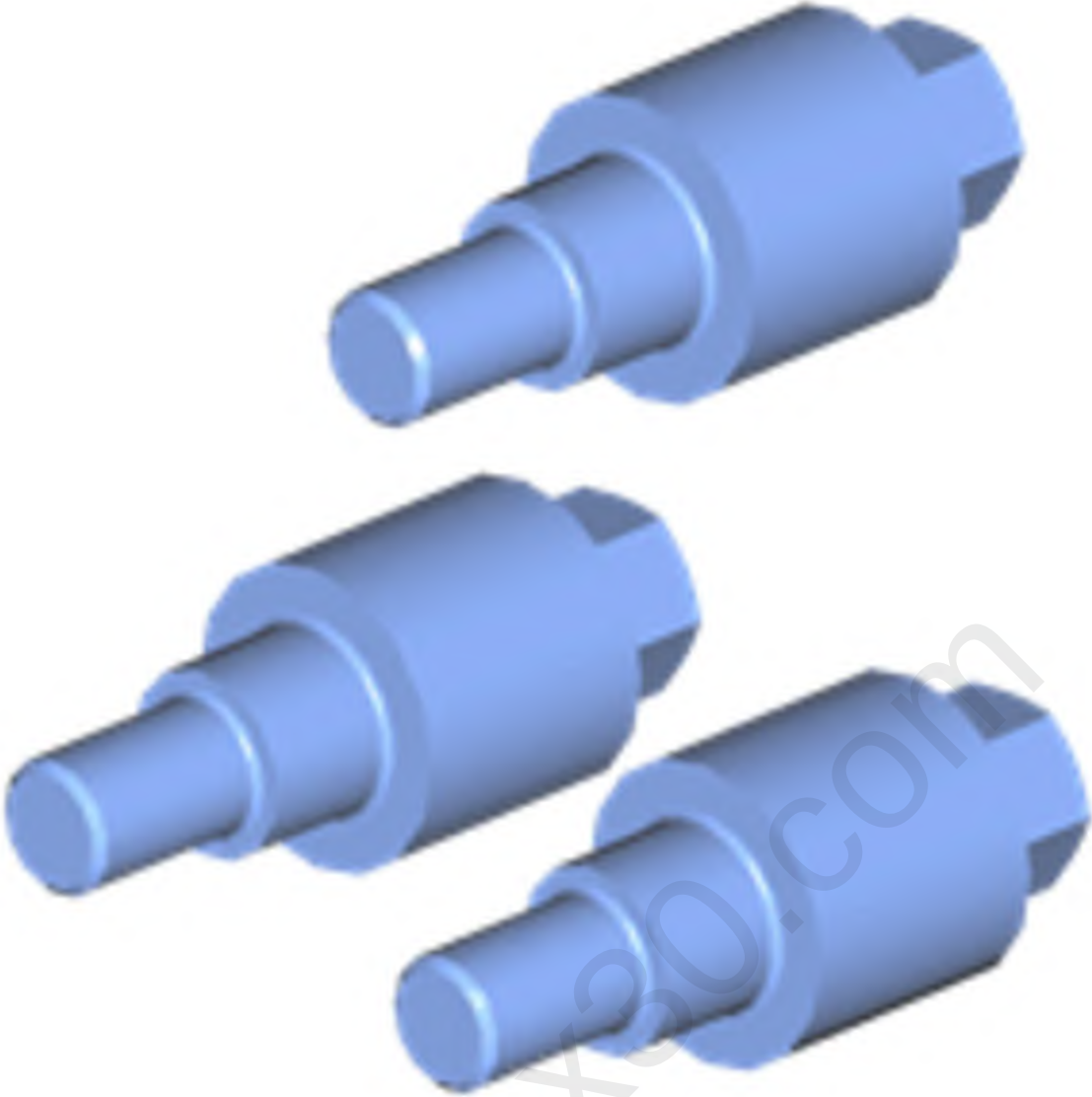
Illustration	Tool Number/Description
	EN-52059 Engine Support Fixture Adapter Bolts M10

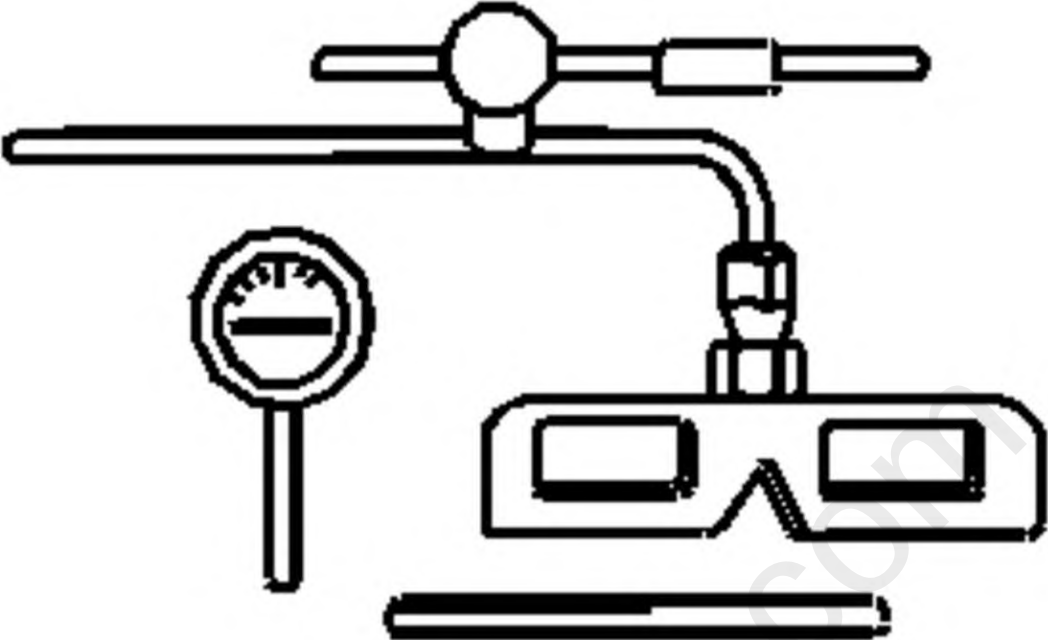
Illustration	Tool Number/Description
	GE-7872 J-7872 Magnetic Base Dial Indicator Set

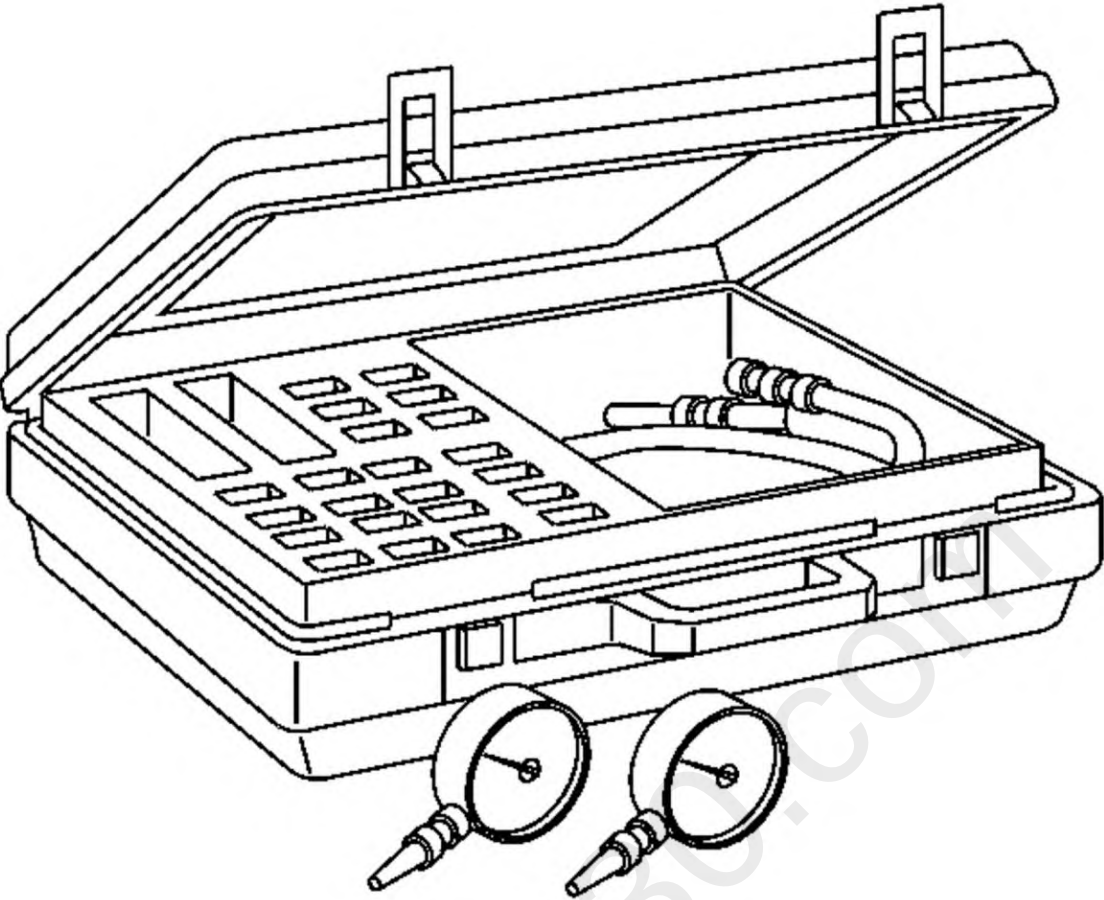
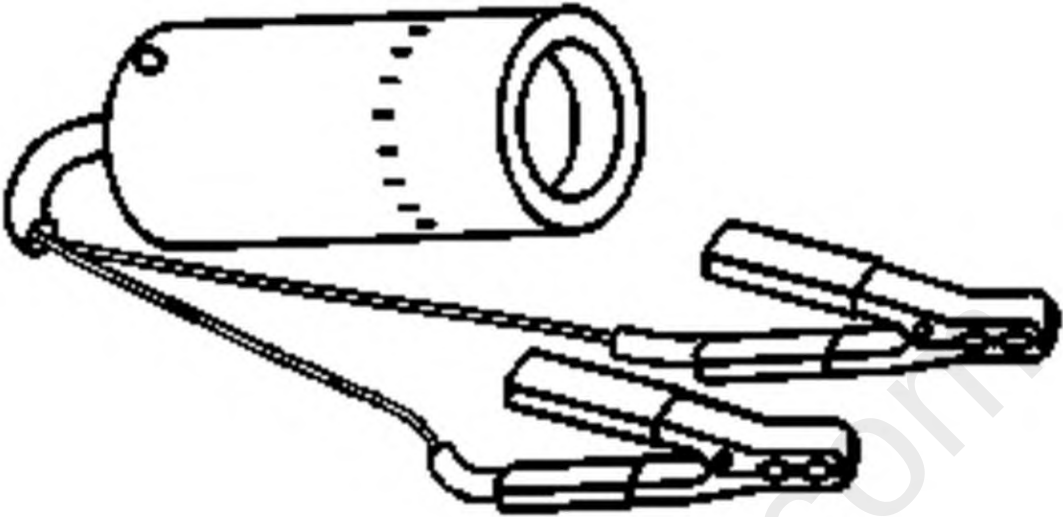
Illustration	Tool Number/Description
	GE-21867-A J-21867-A Oil Pressure Gauge Kit

Illustration	Tool Number/Description
	GE-42220 J-28428-E J-42220 Universal 12V Leak Detection Lamp