Manual Part No. C5456

GENERAC®
POWER SYSTEMS, INC.

7.4 LITER

GM GAS ENGINE

SERVICE MANUAL

P.O. BOX 8 WAUKESHA WI 53187

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ISSUED: 01/30/00

FOREWORD

This manual has been published by GENERAC® POWER SYSTEMS, INC. to aid our dealers' mechanics, company service personnel and general consumers when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products, manufactured and marketed by GENERAC® POWER SYSTEMS, INC. It is also assumed that they have been trained in the recommended servicing procedures for these products, which includes the use of mechanics hand tools and any special tools that might be required.

Proper service and repair is important to the safe, economical and reliable operation of the products described herein. The troubleshooting, testing, service and repair procedures recommended by GENERAC® POWER SYSTEMS, INC. and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

We could not possibly know of and advise the service trade of all conceivable procedures or methods by which a service might be performed, nor of any possible hazards and/or results of each procedure or method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or method not recommended by the manufacturer must first satisfy himself that neither his safety, nor the product's safety, will be endangered by the service or operating procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. However, GENERAC® POWER SYSTEMS, INC. reserves the right to change, alter or otherwise improve the product at any time without prior notice.

Some components or assemblies of the product described in this manual may not be considered repairable. Disassembly, repair and reassembly of such components may not be included in this manual.

The engines described herein may be used to power a wide variety of products. Service and repair instructions relating to any such products are not covered in this manual. For information pertaining to use of these engines with other products, refer to any owner's or service manuals pertaining to said products.

The 7.4 Liter Gas Engine has been engineered for use in Generac Power Systems products. The contents of this manual have been reprinted from the original manufacturer's service and repair manual. The exploded view section at the front of this manual is for reference only.

For a complete listing of engine parts, refer to Generac P/N PB74000G — "Parts Manual, 7.4 Liter Gas Engine"

Notes

SPECIFICATIONS:

CRANKCASE OIL CAPACITY: 8 U.S. QUARTS (7.6 LITERS)
COOLING SYSTEM CAPACITY: 4.5 U.S. GALLONS (28 LITERS)

RECOMMENDED FLUIDS:

COOLANT:

USE A 50/50 MIXTURE OF LOW SILICATE ETHYLENE GLYCOL BASE ANTI-FREEZE AND SOFT WATER. (IF DESIRED, A HIGH QUALITY RUST INHIBITOR MAY BE ADDED TO THE RECOMMENDED COOLANT MIXTURE.) WHEN ADDING COOLANT, ALWAYS ADD THE RECOMMENDED 50/50 MIXTURE.

ENGINE OIL:

USE A HIGH QUALITY DETERGENT OIL CLASSIFIED *FOR SERVICE SC, SD, SE, OR SF.* DETERGENT OILS KEEP THE ENGINE CLEANER AND REDUCE CARBON DEPOSITS. USE OIL HAVING THE FOLLOWING SAE VISCOSITY RATING BASED ON THE AMBIENT TEMPERATURE RANGE ANTICIPATED BEFORE THE NEXT OIL CHANGE.

TEMPERATURE	RECOMMENDED OIL GRADE
ABOVE 86°F (30°C)	SAE 40*
32°F TO 85°F (0° - 29°C)	SAE 30
BELOW 32°F (0°)	SAE 20W
All Seasons	SAE 15W-40*
* Synthetic oil recommended.	

PERIODIC MAINTENANCE SCHEDULE:

A. EVERY THREE MONTHS

1. Check battery state of charge and condition.
2. Inspect and test fuel system.
3. Check transfer switch
4. Inspect exhaust system.
5. Check engine ignition system.
6. Check fan belts.

B. ONCE EVERY SIX MONTHS

1. Test engine safety devices (low oil pressure, low coolant level, high coolant temperature).

C. ONCE ANNUALLY

1. Service fuel filters.
2. Test engine governor; adjust or repair, if needed.
3. Clean and inspect generator.
4. Flush cooling system.
5. Check mechanical governor oil level (if equipped).

D. FIRST 100 OPERATING HOURS

1. Change engine oil and filter (After initial change, service engine oil and filter at 150 operating hours or 6 months, whichever comes first.)
2. Change oil filter.
3. Retorque exhaust manifold.
4. Check mechanical governor oil level (if equipped).

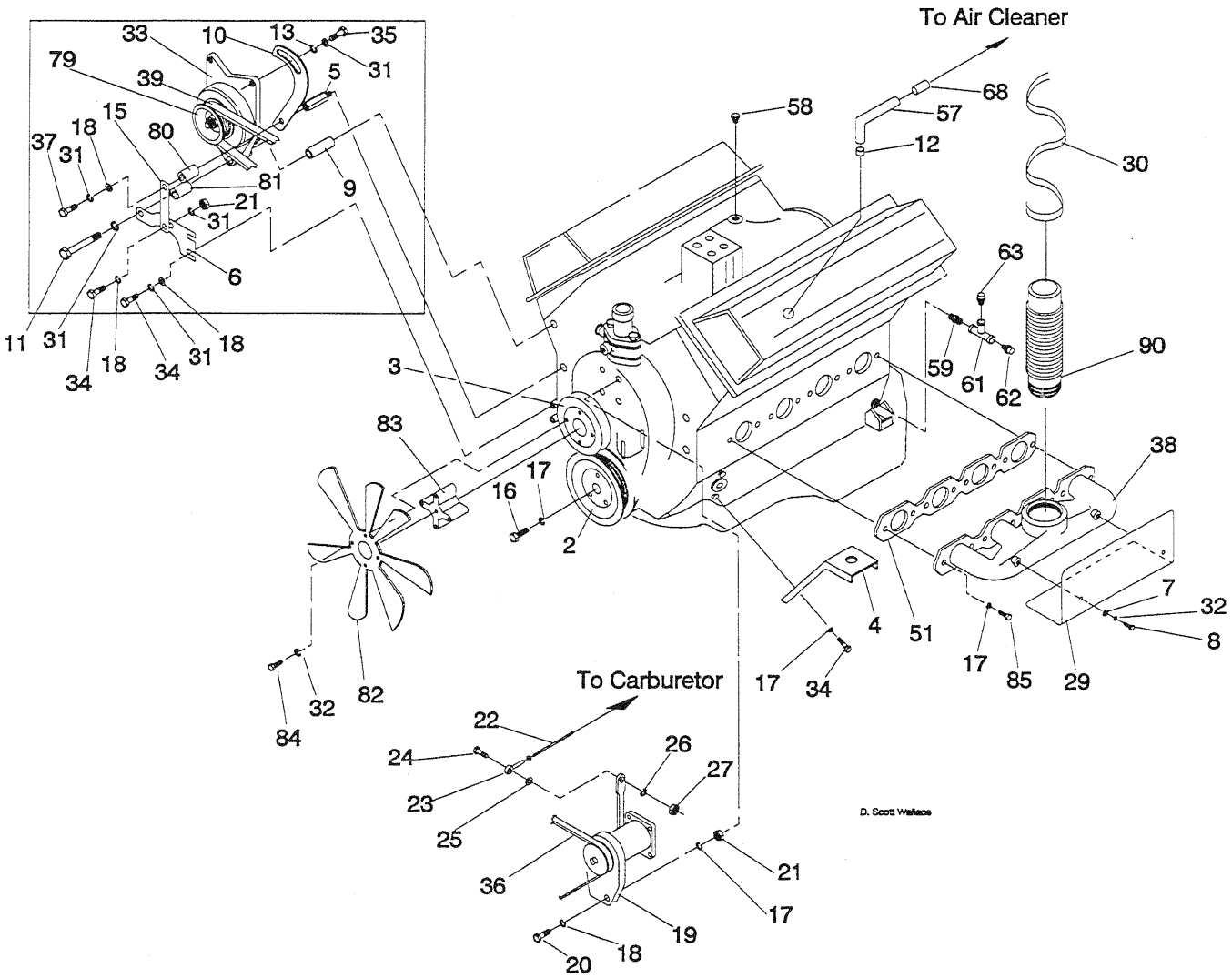
E. EVERY 500 OPERATING HOURS

1. Service air cleaner(s).
2. Check starter.
3. Check engine DC alternator.

E. EVERY 800 OPERATING HOURS

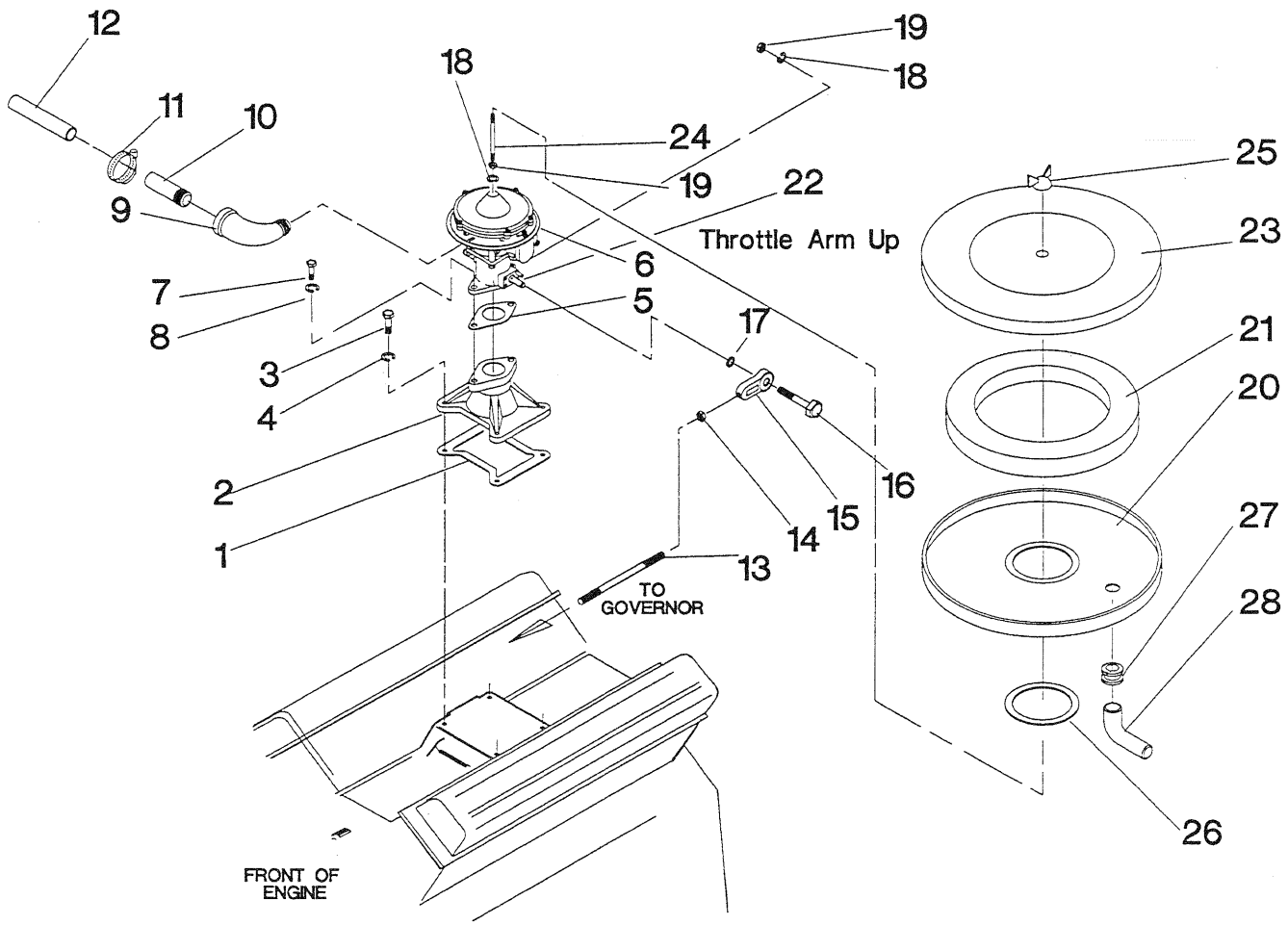
1. Retorque cylinder head.
2. Retorque intake and exhaust manifold.
3. Check engine compression.
4. Check valve clearance.

Exploded View



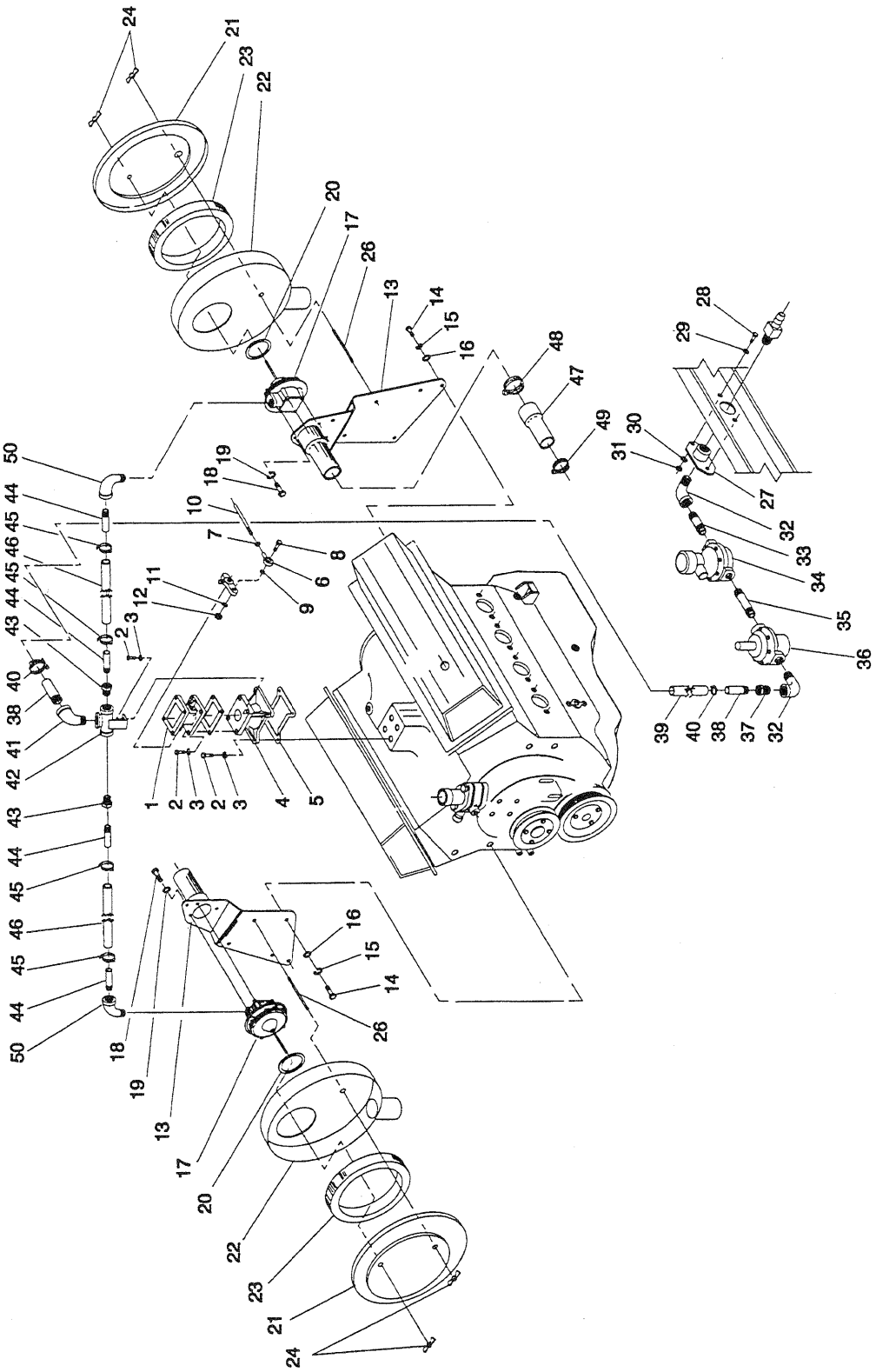
ITEM	DESCRIPTION	QTY
1	ENGINE7.4 LITER V8	1
1	PULLEY, CRANKSHAFT	2
3	PULLEY, WATER PUMP & FAN	1
4	UNIT, MOUNTING	1
5	STANDOFF, ALT. BRACKET	1
6	BRACKET, GENERATOR	1
7	WASHER, FLAT5/16"	2
8	HHCS 5/16"18 X 3/4"	2
9	SPACER, DC ALTERNATOR	1
10	BRACE, DC ALTERNATOR FRONT	1
11	BOLT, 7/16"14 X 61/2"	1
12	GROMMET	1
13	FLAT WASHER, M10	1
14	SUPPORT, GOVERNOR	1
15	BRACKET, ALTERNATOR	1
16	CAPSCREW, SOCKET HD.3/8"24 X 13 4"	3
17	WASHER, LOCK3/8"	40
18	WASHER, FLAT3/8"	10
19	GOVERNOR	1
20	CAPSCREW, HEX HD.3/8"16 X 11/2"	3
21	NUT, HEX3/8"16	9
22	STUD	1
23	END, ROD	1
24	CAPSCREW, HEX HD.1/4"20 X 1"	1
25	WASHER, FLAT1/4"	1
26	WASHER, LOCK1/4"	1
27	NUT, HEX1/4"20	1
28	NUT, HEX1/4"28	1
29	HEAT SHIELD	2
30	EXHAUST WRAP	30
31	WASHER, LOCK7/16"	5
32	WASHER, LOCK5/16"	7
33	ALTERNATOR, ENG. DC	1
34	CAPSCREW, HEX HD.3/8"16 X 1"	12
35	CAPSCREW, HEX HD.M101.5 X 25	1
36	VBELT3/8" X 501/8"	1
37	HHCS3/8"16 X 3"	1
38	MANIFOLDEXHAUST	2
39	VBELT 3/8" X 485/8"	1
57	CONNECTOR, ELBOW	1
58	PLUG, PIPE3/8"	1
59	BUSHING, REDUCER3/8" X 1/8" NPT	1
60	NIPPLE1/8" NPT X 13/4" LONG	1
61	TEE1/8" NPT	1
62	SWITCH, OIL PRESSURE	1
63	SENDER, OIL PRESSURE	1
68	TUBING3/4" I.D. X 12" LONG	1
79	PULLEY (1GROOVE)3.5" DIAMETER	1
80	SPACER, PULLEY	1
81	SPACER, DC ALTERNATOR	1
82	FAN, RADIATOR83	1
83	SPACER1" LONG	1
84	CAPSCREW, HEX HEAD5/16"24 X 13/4"	4
85	SHCS 3/8"16 X 1" LG.	16
89**	HARNESS, ENGINE WIRING1	1
90	EXHAUST, FLEXIBLE21/2" NPT X 175/16" LONG	2
93	CAPSCREW, HEX HEAD3/8"16 X 41/2"	2

Exploded View



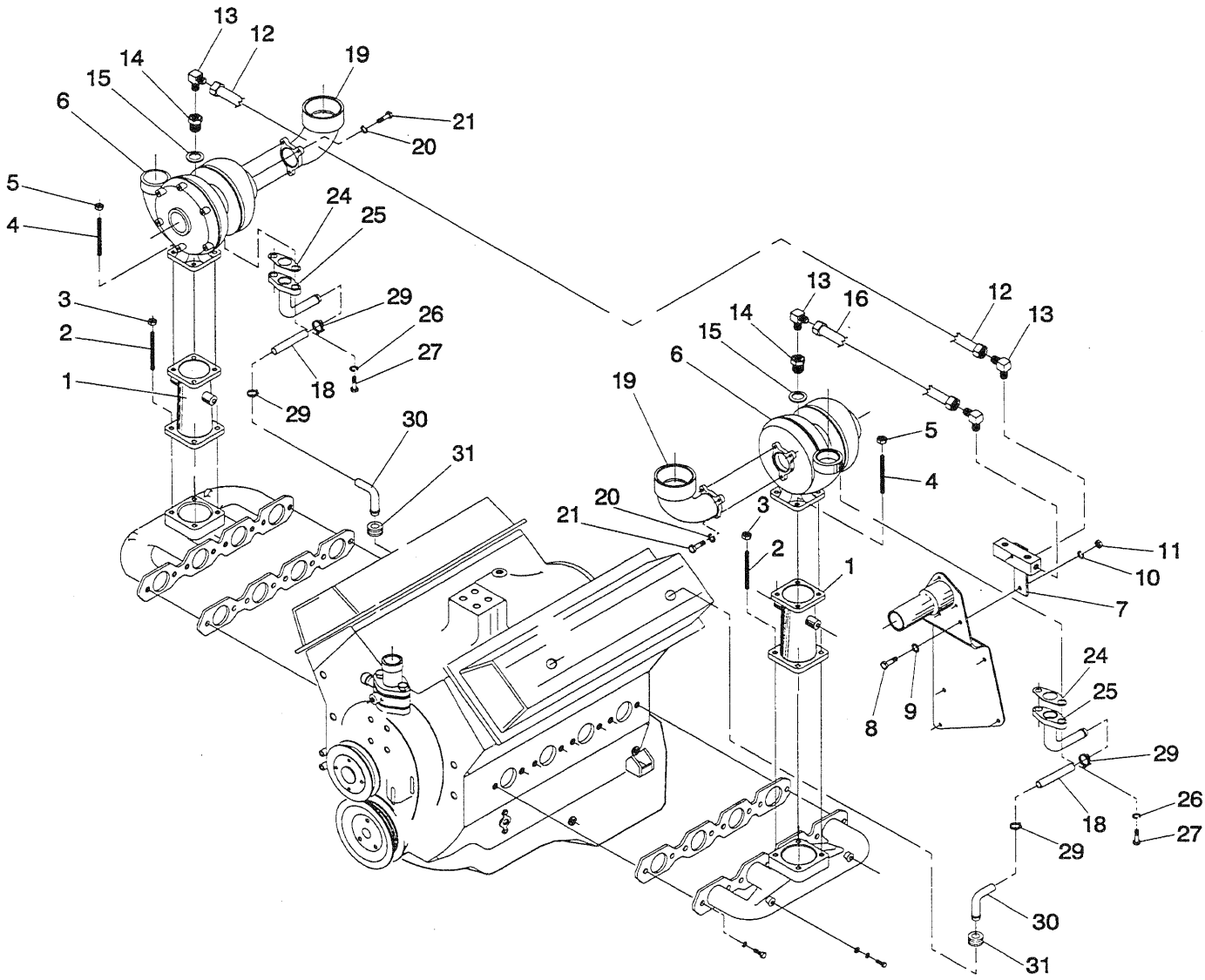
ITEM	DESCRIPTION	QTY
1	GASKET	1
2	ADAPTOR, CARBURETOR	1
3	HHCS5/16"18 X 1"	4
4	WASHER, LOCK5/16"	4
5	GASKET	1
6	CARBURETOR, LP GAS	1
7	HHCS3/8"16 X 1"	2
8	WASHER, LOCK3/8"	2
9	REDUCING STREET ELB. 1" TO 3/4"	1
10	NIPPLE (THREADED ONE END)1"NPT	1
11	CLAMP, HOSE X 11/2"	1
12	HOSE11/4" I.D. X 5" LONG	1
13	ROD, GOVERNOR ADJUSTING	1
14	NUT, HEX1/4"28	1

Exploded View



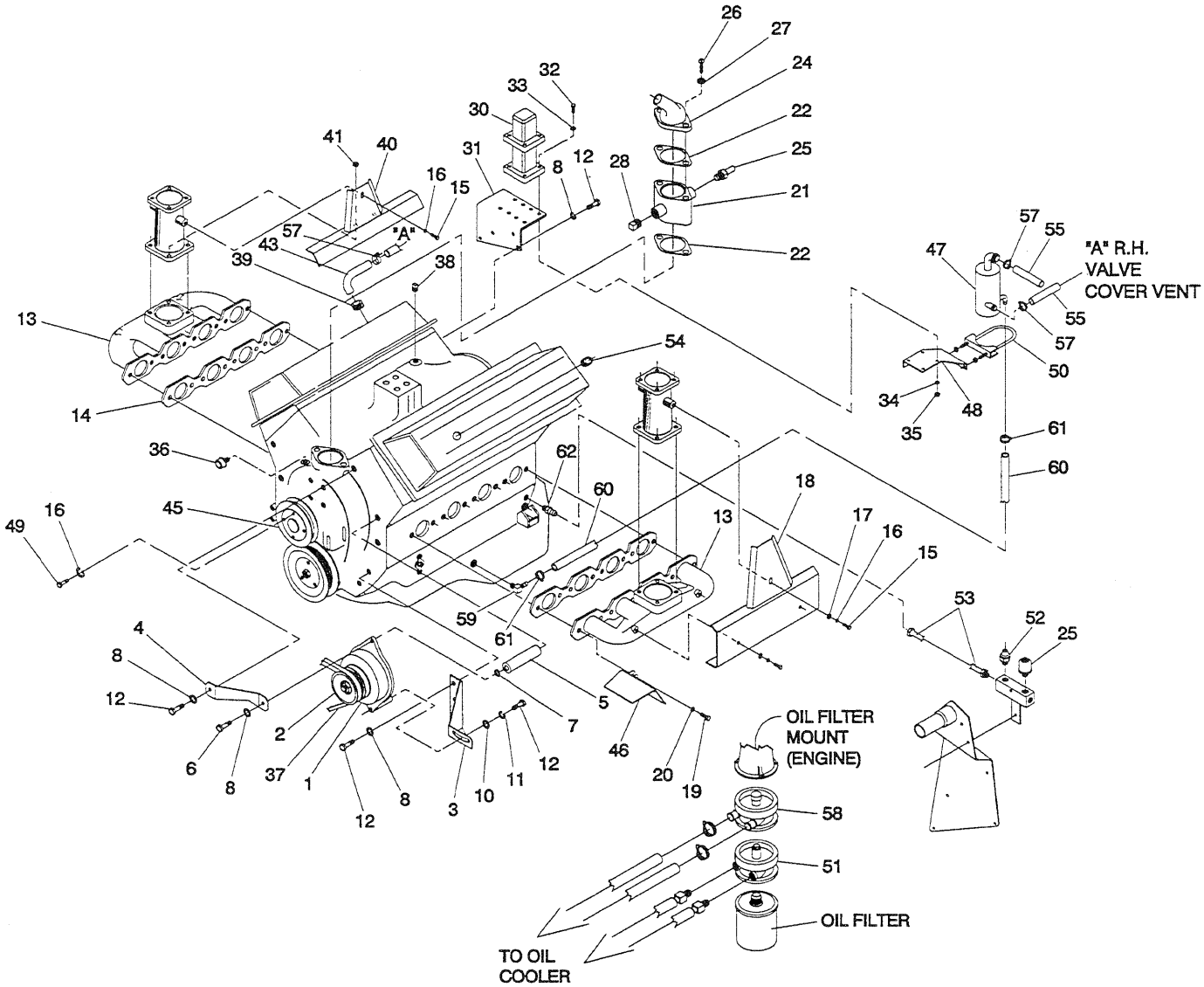
ITEM	DESCRIPTION	QTY
1	THROTTLE BODY, IMPCO	1
2	CAPSCR., HEX HD.-5/16"-18 X 1"	8
3	WASHER, LOCK 5/16"	8
4	ADAPTOR, CARBURETOR	1
5	GASKET	1
6	ROD END-BALL JOINT	1
7	STUD 1/4"-28 X 10-25	1
8	CAPSCR., HEX HD.-1/4"-20 X 1"	1
9	WASHER, FLAT 1/4"	1
10	NUT, HEX 1/4"-28	1
11	WASHER, LOCK 1/4"	1
12	NUT, HEX 1/4"-20	1
13	BRACKET, CARB/TURBO 7.4L	2
14	HHC 7/16"-14 X 3/4"	6
15	WASHER, LOCK-7/16"	6
16	WASHER, FLAT-7/16"	6
17	MIXER, NATURAL GAS	2
18	RHMS #12-24 X 5/8"	8
19	WASHER, LOCK #12	8
20	GASKET	2
21	PLATE, TOP AIR CLEANER	2
22	PLATE, BOTTOM AIR CLEANER	2
23	AIR CLEANER ELEMENT	2
24	NUT, WING4	
26	STUD, THREAD 1/4"-20 X 2" LONG	2
27	NATURAL GAS SOLENOID SUPPORT	1
28	HHCS, M14-2.0 X 25	2
29	WASHER, FLAT M14	2
30	WASHER, LOCK M14	2
31	NUT, HEX M14-2.0	2
32	ELBOW, STRAIGHT 1-1/4" NPT	2
33	NIPPLE, CLOSE 1-1/4" NPT	1
34	SOLENOID	1
35	NIPPLE, PIPE 1-1/4" X 2" LONG	1
36	VALVE, PRESSURE REGULATOR	1
37	BUSHING, REDUCER 1-1/4" NPT TO 1"	1
38	NIPPLE, TOE PIPE 1" NPT X 2-1/2" LONG	2
39	HOSE 1-1/4" I.D. X 51.5" LONG	1
40	CLAMP, HOSE	2
41	ELBOW, 90 DEG. STRAIGHT 1" NPT	1
42	TEE, ASSEM. NATURAL GAS LINE	1
43	REDUCER, BUSHING 1" TO 3/4" NPT	2
44	NIPPLE, TOE 3/4" NPT X 2" LONG	4
45	CLAMP, HOSE #20	4
46	HOSE 1" I.D. X 16" LONG	2
47	CONNECTOR REDUCER 2" X 1-3/4"	2
48	CLAMP #36	2
49	CLAMP #28	2
50	ELBOW, 90 DEG. STRAIGHT 3/4" NPT	2

Exploded View



ITEM	DESCRIPTION	QTY
1	ADAPTOR, EXH. MANIFOLD	2
2	STUD M10-1.5 X 48 S.S.	8
3	NUT, HEX M10-1.5 S.S.	8
4	STUD-M8-1.25 X 40 S.S.	8
5	NUT HEX M8-1.25 S.S.	8
6	TURBO 7.4L 100KW	2
7	MANIFOLD, OIL SENDER	1
8	HHCS, M10-1.5 X 25	1
9	FLAT WASHER-3/8"-M10	1
10	LOCK WASHER M10	1
11	NUT, HEX M10-1.5	1
12	LINE, OIL (R.H. TURBO)	1
13	ELBOW 90DEG. 48 NPT X 1/2"-20	4
14	ADAPTOR, M10 TO 1/8" NPT	2
15	WASHER, COPPER	2
16	LINE, OIL (L.H. TURBO)	1
18	HOSE, 5/8" I.D. X 5" (R.H. TURBO)	2
19	ELBOW, EXH. OUTLET	2
20	LOCK WASHER, M8	2
21	HHCS, M8-1.25 X 30MM	2
24	GASKET	2
25	TUBE, OIL DRAIN TURBO-CHARGER	2
26	LOCK WASHER, M6	4
27	HHCS, M6-1.0 X 16MM	4
29	CLAMP	4
30	ELBOW	2
31	GROMMET	2

Exploded View



ITEM	DESCRIPTION	QTY
1	D.C. ALTERNATOR ASSEMBLY	1
2	PULLEY 3.5" SINGLE	1
3	BRACKET, TENSIONER LOWER	1
4	BRACKET, UPPER TENSIONER	1
5	SPACER, .48 X .75 X 1.87 LONG	1
6	HHCS, 7/16"-14 X 4-1/2"	1
7	FLAT WASHER 7/16"	1
8	LOCK WASHER-7/16"	1
9	HHCS, M10-1.5 X 25	1
10	FLAT WASHER 3/8"-M10	1
11	LOCK WASHER, M10	1
12	HHCS,7/16"-14 X 25	1
13	MANIFOLD-EXHAUST	2
14	GASKET, EXHAUST MANIFOLD	2
15	HHCS, 5/16"-18 X 3/4" S.S.	6
16	WASHER, LOCK-5/16"	6
17	WASHER, FLAT-5/16" S.S.	6
18	HEATSHIELD, EXHAUST MANIFOLD	2
19	SHCS, 3/8"-16 X 1.0" LONG	16
20	LOCK WASHER	16
21	WATER OUTLET ADAPTOR	1
22	GASKET, THERMOSTAT HOUSING	2
23	THERMOSTAT 195 DEGREE	1
24	HOUSING, THERMOSTAT	1
25	SENDER, WATER TEMPERATURE	1
26	SCREW, SELF TAP #6-32 X 3/8" I.D.	1
27	WASHER, SHAKEPROOF	1
28	PIPE PLUG, 3/8" O.D. SQ. HD.	1
29	ACTUATOR, 12V. CCW	1
30	PARTS KIT-ELECT. GOVERNOR	1
31	BRACKET, GOVERNOR MTG.	1
32	HHCS, M6-1.0 X 25	4
33	WASHER, FLAT-M6	4
34	LOCK WASHER-1/4"-M6	4
35	NUT HEX-M6-1.0	4
36	SWITCH, HIGH COOLANT	1
37	V-BELT 7/16" X 44-5/8"	1
38	PIPE PLUG 3/8" SQ.	1
39	GROMMET	1
40	HEATSHIELD, VALVE COVER/MANIFOLD	2
41	HEX NUT-M10-1.5	2
43	CONNECTOR, ELBOW	1
44	HARNESS, 7.4L ENGINE	1
45	PULLEY, WATER PUMP	1
46	HEATSHIELD, SPARK PLUG	6
47	SEPERATOR, OIL/AIR	1
48	BRACKET, OIL SEPERATOR ASSEMBLY1	1
49	HHCS 5/16"-24 X 3/4"4	4
50	CLAMP, FLAT BEND 4.0" I.D.	1
51	ADAPTOR, OIL COOLER	1
52	OIL PRESSURE SW.	1
53	HOSE ASSEMBLY, 22.5" LONG	1
54	GROMMET, VALVE COVER PLUG	1
55	HOSE 3/4" I.D. X 8'	1
56	HOSE 3/4" I.D. X 11"	1
57	HOSE CLAMP SIZE #20	2
58	DONUT, OIL COOLER, MODINE	1
59	BARB 90 DEG. 1/2" X 3/8" NPT	1
60	HOSE, 1/2" I.D. X 48" LONG	1
61	HOSE CLAMP #6	2
62	ADAPTOR, 37 DEGREE 9/16" X 3/8"	1

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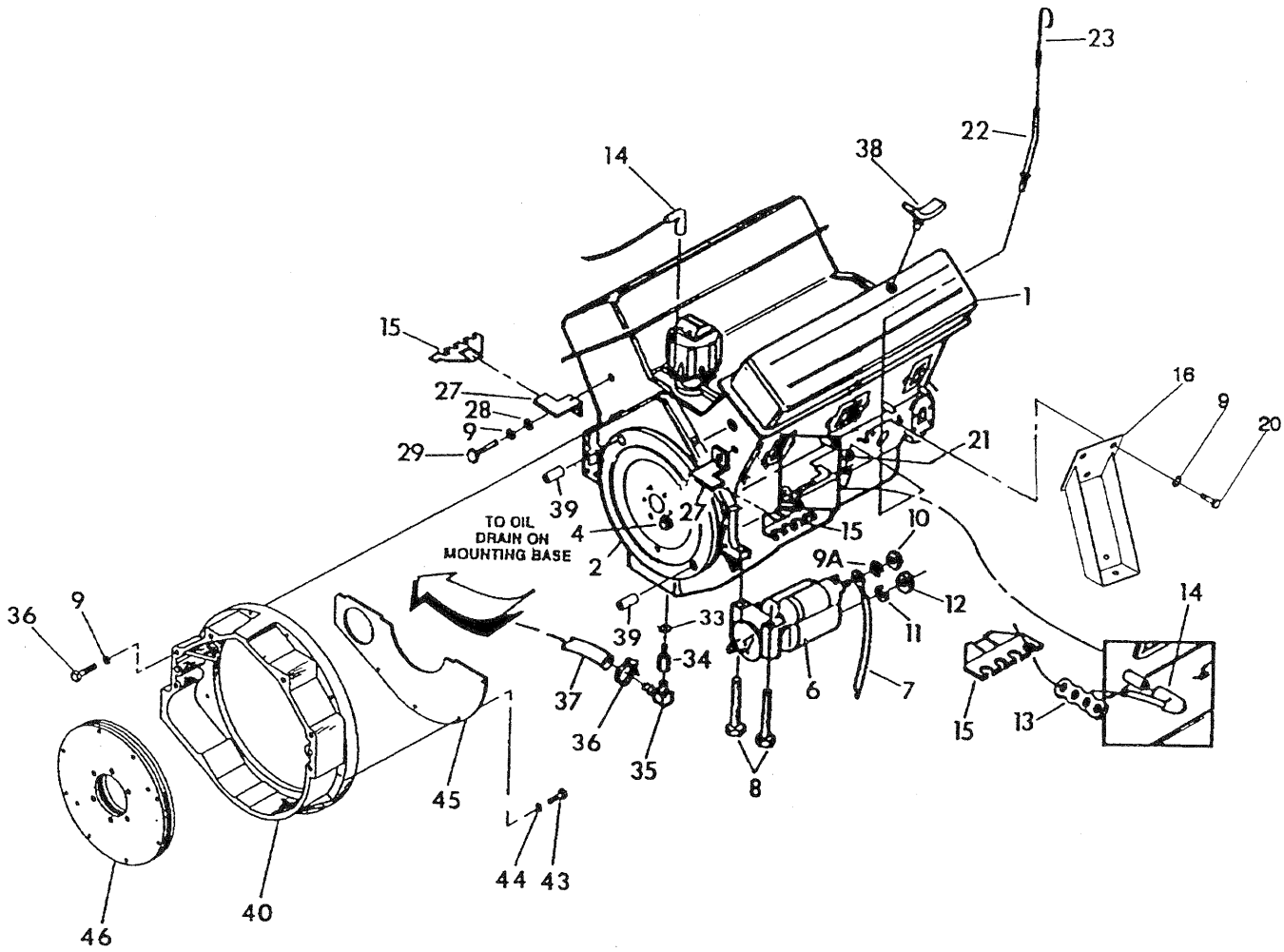


ITEM	DESCRIPTION	QTY
1	ENGINE7.4 LITER V8	1
2	FLYWHEEL	1
4	BOLT, FLYWHEEL	6
6	STARTER	1
7	CABLE, BATTERY(RED)28"	1
8	BOLT, STARTER	2
9	WASHER, LOCK3/8"	10
9A	SHAKEPROOF LOCKWASHERM10	1
10	NUT, HEXM81.25	1
11	WASHER, LOCKM5	1
12	NUT, HEXM50.80	1
13	RETAINER, SPARK PLUG WIRE	2
14	WIRE SET, SPARK PLUG	1
15	RETAINER, SPARK PLUG WIRE	2
16	UNIT MOUNTING	2
20	CAPSCR., HEX HD.3/8"16 X 1"	3
21	SEAL, OIL DIPSTICK TUBE	1
22	TUBE, OIL DIPSTICK	1
23	DIPSTICK, OIL	1
27	BRACKET, SPARK PLUG WIRE SUPPORT	2
28	WASHER, FLAT3/8"	1
29	CAPSCR., HEX HD.3/8"16 X 3/4"	1
33	WASHER (NYLON)	1
34	ADAPTOR, OIL DRAIN	1
35	FITTING, BARBED 90 DEG. 3/8" X 5/8"	1
36	CLAMP, HOSE	1
37	TUBING, 5/8" I.D. X 191/2" LONG	1
38	FILTER, BREATHER(CRANKCASE)	1
39	DOWEL PINM10 X 24	2
40	ADAPTOR CASTING, SAE3	1
43	CAPSCR., HEX HD.M61.0 X 1.0	4
44	WASHER, LOCKM61/4	4
45	COVER, FLYWHEEL	1
46	FLEX PLATE	3

Notes

Engine Mechanical - 7.4L

Specifications

SIE-ID = 361824

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor Bolt	50 N·m	37 lb ft
AIR Pump Mounting Bolt	50 N·m	37 lb ft
Camshaft Retainer Bolt	12 N·m	106 lb in
Camshaft Sprocket Bolt	30 N·m	22 lb ft
Connecting Rod Bolt Nut	64 N·m	47 lb ft
Coolant Outlet Housing Bolt	40 N·m	30 lb ft
Coolant Temperature Gauge Sensor	20 N·m	15 lb ft
Coolant Temperature Sensor	20 N·m	15 lb ft
Crankshaft Balancer Bolt	149 N·m	110 lb ft
Crankshaft Bearing Cap Bolt	138 N·m	102 lb ft
Crankshaft Position Sensor Bolt	12 N·m	106 lb in
Crankshaft Pulley Bolt	40 N·m	30 lb ft
Cylinder Head Bolts First Pass in Sequence		
All Bolts	50 N·m	37 lb ft
Cylinder Head Bolts Final Pass in Sequence		
Bolt #1, 2, 3, 6, 7, 8, 9, 12, 14, 15	150 degrees	
Bolt #13, 16	150 degrees	
Bolt #4, 5, 10, 11	90 degrees	
Distributor Clamp Bolt	33 N·m	24 lb ft
EGR Inlet Pipe Fitting	60 N·m	44 lb ft
EGR Valve Bolt	22 N·m	16 lb ft
Engine Block Coolant Drain Hole Plug	20 N·m	15 lb ft
Engine Block Oil Gallery Plug		
Front	30 N·m	22 lb ft
Left	30 N·m	22 lb ft
Rear	30 N·m	22 lb ft
Top	20 N·m	15 lb ft
Engine Flywheel Bolt	88 N·m	65 lb ft
Engine Flywheel Housing Bolt	40 N·m	30 lb ft
Engine Front Cover Bolt	10 N·m	30 lb ft
Engine Lift Bracket Bolt (Special Tool J 36857)	40 N·m	106 lb in
Engine Mount		
Front Mount Bolt	59 N·m	44 lb ft
Front Mount Nut	45 N·m	33 lb ft
Rear Mount Bolt	47 N·m	35 lb ft
EVAP Purge Solenoid Bolt	12 N·m	106 lb in
Exhaust Manifold		
Adapter	160 N·m	118 lb ft
Center Bolt	54 N·m	40 lb ft
Nut	30 N·m	22 lb ft
Stud	30 N·m	22 lb ft
Fuel Rail		

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Bolt	10 N·m	89 lb in
Stud	25 N·m	18 lb ft
Generator Mounting Bolt	50 N·m	37 lb ft
Generator Mounting Bracket to Engine		
Long Bolt	66 N·m	49 lb ft
Short Bolt	66 N·m	49 lb ft
Nut	66 N·m	49 lb ft
Stud	20 N·m	15 lb ft
Generator Mounting Rear Bracket Bolt	50 N·m	37 lb ft
Idler Pulley Bolt	50 N·m	37 lb ft
Idler Pulley Bracket		
Long Bolt	83 N·m	61 lb ft
Short Bolt	50 N·m	37 lb ft
Ignition Coil		
Bolt	25 N·m	18 lb ft
Stud	25 N·m	18 lb ft
Knock Sensor	19 N·m	14 lb ft
Knock Sensor Heat Shield	12 N·m	106 lb in
Lower Intake Manifold Bolt (in Sequence)		
First Pass	30 N·m	22 lb ft
Final Pass	40 N·m	30 lb ft
MAP Sensor Nut	25 N·m	18 lb ft
Oil Filter	One Turn After Initial Gasket Contact	
Oil Filter Adapter		
Bolt	25 N·m	18 lb ft
Fitting	66 N·m	49 lb ft
Oil Level Indicator Tube Bracket Nut	54 N·m	40 lb ft
Oil Pan Bolt	25 N·m	18 lb ft
Oil Pan Drain Plug	28 N·m	21 lb ft
Oil Pump Bolt	90 N·m	65 lb ft
Oil Pump Cover Bolt	12 N·m	106 lb in
Oil Pressure Gauge Sensor	30 N·m	22 lb ft
Power Steering Pump Mounting Bracket		
Long Bolt	66 N·m	49 lb ft
Nut	66 N·m	49 lb ft
Stud	20 N·m	15 lb ft
Power Steering Pump Rear Bracket Bolt	25 N·m	18 lb ft
Spark Plug (New Cylinder Head)	30 N·m	22 lb ft
Spark Plug (all Subsequent Installations)	20 N·m	15 lb ft
Spark Plug Heat Shield Nut	20 N·m	15 lb ft
Starter Motor Bolt	50 N·m	37 lb ft
Starter Motor Shield		
Bolt	3 N·m	27 lb in
Nut	5 N·m	44 lb in
Throttle Body		
Nut	10 N·m	89 lb in
Stud	12 N·m	106 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Upper Intake Manifold Bolt in Sequence		
First Pass	8 N·m	71 lb in
Final Pass	18 N·m	13 lb ft
Valve Lifter Guide Retainer Bolt	25 N·m	18 lb ft
Valve Rocker Arm Bolt	54 N·m	40 lb ft
Valve Rocker Arm Cover Bolt	12 N·m	106 lb in
Water Pump Bolt	40 N·m	30 lb ft
Water Pump Pulley Bolt	25 N·m	18 lb ft

SIE-ID = 191690

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	V-8	
Displacement	7.4L	454 CID
RPO	L29	
VIN	J	
Bore	107.95 mm	4.25 in
Stroke	101.6 mm	4.00 in
Compression Ratio	9.0:1	
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Gap	0.8890 mm	0.060 in
Cylinder Head		
Surface Flatness	0.0762 mm	0.003 in
Maximum Cylinder Head Block Deck Resurfacing	0.3048 mm	0.012 in
Exhaust Manifold		
Surface Flatness	0.254 mm	0.010 in
Lubrication System		
Oil Capacity without Filter Change	5.7 liters	6.0 qt
Oil Pressure (Fully Warmed Oil not Hot)	68.65 kPa @ 600 RPM 172.37 kPa @ 2,000 RPM	10 psi @ 600 RPM 25 psi @ 2,000 RPM
Oil Filter System	Full Flow	
Oil Pump Type	Gear Driven	
Cylinder Bore		
Diameter	107.950–107.968 mm	4.2500–4.2507 in
Out-of-Round Production	0.0254 mm (Maximum)	0.001 in (Maximum)
Out-of-Round Service	0.051 mm (Maximum)	0.002 in (Maximum)
Taper Production Thrust Side	0.0127 mm (Maximum)	0.0005 in (Maximum)
Taper Production Relief Side	0.0254 mm (Maximum)	0.001 in (Maximum)
Taper Service	0.0254 mm (Maximum)	0.001 in (Maximum)
Piston		

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Piston Diameter	1.07891–1.07904 mm	4.2477–4.2482 in
Clearance Production	0.0457–0.0762 mm	0.0018–0.0030 in
Clearance Service Limit	0.0457–0.219 mm	0.0018–0.0048 in
Piston Ring Compression		
Top Groove Production Clearance	0.031–0.074 mm	0.0012–0.0029 in
Second Groove Production Clearance	0.031–0.074 mm	0.0012–0.0029 in
Service Limit Groove Clearance	0.0991–0.3050 mm	0.0012–0.0039 in
Top Ring Production Gap	0.254–0.457 mm	0.010–0.018 in
Top Ring Service Limit Gap	0.254–0.711 mm	0.010–0.028 in
Second Ring Production Gap	0.406–0.609 mm	0.016–0.024 in
Second Ring Service Limit Gap	0.406–0.863 mm	0.016–0.034 in
Piston Ring Oil Control		
Production Groove Clearance	0.127–0.165 mm	0.0050–0.0065 in
Service Limit Groove Clearance	0.127–0.191 mm	0.0050–0.0075 in
Production Gap	0.254–0.762 mm	0.010–0.030 in
Service Limit Gap	0.254–1.016 mm	0.010–0.040 in
Piston Pin		
Diameter	25.132–25.137 mm	0.98945–0.98965 in
Clearance in Piston Production	0.005–0.017 mm	0.0002–0.0007 in
Clearance in Piston Service Limit	0.005–0.025 mm	0.0002–0.0010 in
Fit in Rod	0.078–0.053 mm Interference	0.0021–0.0031 in Interference
Crankshaft		
Crankshaft Run Out	0.051 mm (Maximum)	0.002 in (Maximum)
Crankshaft Journal Diameter #1, #2, #3, #4, #5	69.804–69.822 mm	2.7482–2.7489 in
Crankshaft Journal Taper Production	0.010 mm (Maximum)	0.0004 in (Maximum)
Crankshaft Journal Taper Service Limit	0.025 mm (Maximum)	0.0010 in (Maximum)
Crankshaft Journal Out-of-Round Production	0.010 mm (Maximum)	0.0004 in (Maximum)
Crankshaft Journal Out-of-Round Service Limit	0.025 mm (Maximum)	0.0010 in (Maximum)
Crankshaft Bearing Clearance #1 Production	0.043–0.076 mm	0.0017–0.0030 in
Crankshaft Bearing Clearance #2, #3, #4 Production	0.028–0.061 mm	0.0011–0.0024 in
Crankshaft Bearing Clearance #5 Production	0.063–0.096 mm	0.0025–0.0038 in
Crankshaft Bearing Clearance #1, #2, #3, #4 Service Limit	0.025–0.076 mm	0.0010–0.0030 in
Crankshaft Bearing Clearance #5 Service Limit	0.063–0.101 mm	0.0025–0.0040 in
Crankshaft End Play	0.127–0.279 mm	0.005–0.011 in
Crankshaft Thrust Wall Width	46.1391–46.2153 mm	1.8165–1.8195 in
Crankshaft Thrust Wall Maximum Runout	0.025 mm	0.001 in
Crankpin Diameter	55.854–55.869 mm	2.1990–2.1996 in
Crankpin Taper Production	0.0127 mm	0.0005 in
Crankpin Taper Service Limit	0.025 mm	0.0010 in
Crankpin Out-of-Round Production	0.013 mm	0.0005 in
Crankpin Out-of-Round Service Limit	0.025 mm	0.0010 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Rod Bearing Clearance Production	0.028–0.074 mm	0.0011–0.0029 in
Rod Bearing Clearance Service Limit	0.028–0.099 mm	0.0011–0.0039 in
Connecting Rod Side Clearance	0.033–0.584 mm	0.0013-0.0230 in
Camshaft		
Camshaft Run Out	0.051 mm (Maximum)	0.002 in (Maximum)
Lobe Lift Intake	7.115–7.216 mm	0.2801–0.2841 in
Lobe Lift Exhaust	7.170–7.272 mm	0.2823–0.2863 in
Journal Diameter	49.471–49.522 mm	1.9477–1.9497 in
Valve System		
Lifter	Hydraulic, Roller Followers	
Rocker Arm Ratio	1.70:1	
Valve Lash Intake	Net Lash	
Valve Lash Exhaust	Net Lash	
Valve Margin	0.79 mm (minimum)	0.031 in (minimum)
Face Angle (Intake & Exhaust)	45 degrees	
Seat Angle (Intake & Exhaust)	46 degrees	
Seat Runout (Intake & Exhaust)	0.051 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	0.762–1.524 mm	0.030–0.060 in
Seat Width Exhaust	1.524–2.413 mm	0.060–0.095 in
Stem Clearance Production Intake	0.025–0.0737 mm	0.0010–0.0029 in
Stem Clearance Production Exhaust	0.030–0.079 mm	0.0012–0.0031 in
Stem Clearance Service Intake	0.025–0.094 mm	0.0010–0.0037 in
Stem Clearance Service Exhaust	0.030–0.124 mm	0.0012–0.0049 in
Valve Spring Pressure Closed	316–351 N @ 46.685 mm	71–79 lb @ 1.838 in
Valve Spring Pressure Open	1059–1165 N @ 34.213 mm	238–262 lb @ 1.347 in
Valve Spring Installed Height	46.685–47.479 mm	1.838–1.869 in
Maximum Valve Spring Installed Height Shim	0.726 mm	0.030 in
Maximum Valve Spring Tension Shim	0.726 mm	0.030 in
Maximum Combined Valve Spring Installed Height and Valve Spring Tension Shim	1.524 mm	0.060 in

SIE-ID = 65721

GM SPO Group Numbers

Application	GM SPO Group Number
Camshaft	0.519
Camshaft Bearing	0.539
Camshaft Bearing Hole Plug	0.553
Camshaft Sprocket	0.736
Camshaft Timing Chain	0.724
Connecting Rod	0.603
Connecting Rod Bearing	0.616
Crankshaft	0.646
Crankshaft Balancer	0.659
Crankshaft Bearing Kit	0.096

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Crankshaft Front Oil Seal	0.213
Crankshaft Rear Oil Seal	0.056
Crankshaft Sprocket	0.728
Cylinder Head	0.269
Cylinder Head Gasket Kit	0.289
Distributor Gasket Kit	2.363
EGR Valve	3.670
EGR Valve Gasket	3.680
Engine Block Core Hole Plug	0.034
Engine Block Oil Galley Plug	8.971
Engine Front Cover	0.206
Engine Front Cover Gasket	0.207
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.270
Exhaust Valve	0.297
Flywheel	0.666
Intake Manifold (With Gasket)	3.265
Intake Valve	0.296
Oil Filter	1.836
Oil Level Indicator	1.516
Oil Pan	1.426
Oil Pan Gasket	1.429
Oil Pump Cover	1.723
Oil Pump Cover Gasket	1.724
Oil Pump (With Gasket)	1.652
Piston	0.629
Piston Ring Kit	0.643
Spark Plug	2.270
Thermostat	1.246
Valve Lifter	0.459
Valve Lifter Guide	0.439
Valve Lifter Guide Retainer	0.056
Valve Pushrod	0.426
Valve Rocker Arm	0.333
Valve Rocker Arm Cover Gasket Kit	0.423
Valve Rotator	0.309
Valve Spring	0.303
Valve Spring Cap	0.309
Valve Stem Key	0.310
Valve Stem Oil Seal	0.308
Water Pump Kit (With Gasket)	1.069

SIE-ID = 210918

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Block Heater O-ring	Lubricant	9985253
Camshaft Rear Bearing Hole Plug	Sealant	12346004
Coolant Sealing Pellets	Sealant	3634621
Coolant Sensor (ETC) Threads	Sealant	12346004
Crankshaft Keyway	Sealant	12345739
Cylinder Head Bolt Threads	Sealant	12346004
Engine Block Coolant Drain Plugs	Sealant	12346004
Engine Block Oil Gallery Plugs	Sealant	12346004
Engine Front Cover	Sealant	12345739
Engine Oil Supplement	Lubricant	1051396
Knock Sensor Threads	Sealant	12346004
Upper Intake Manifold Bolt Threads	Threadlock	12345393
Lower Intake Manifold Bolt Threads	Threadlock	12345382
MAP Sensor Seal	Lubricant	9985770
Oil Pan	Adhesive	12345739
Oil Pressure Sensor Fitting Threads	Sealant	12346004
Oil Pressure Sensor Threads	Sealant	12346004
Oxygen Sensor Thread	Anti-seize Lubricant	12377953
Valve Train Component Prelube	Lubricant	1052367
Water Pump Bolt Threads	Sealant	12346004

Diagnostic Information and Procedures

SIE-ID = 197512

SIO-ID = 197504

Base Engine Misfire Diagnosis

Checks	Action
Engine performance diagnosis procedures are covered in Engine Controls and should be consulted for diagnosis of any Driveability, Emissions, or Malfunctioning Indicator Lamp (MIL) concerns. The following diagnosis covers common concerns and possible causes. When the proper diagnosis is made, the concern should be corrected by adjustment, repair or replacement as required. Refer to the appropriate section of the service manual for each specific procedure. This diagnostic table will assist in engine misfire diagnosis due to a mechanical concern such as a faulty camshaft, worn or damaged bearings or bent pushrod. This table will not isolate a crossed injector wire, faulty injector or any other driveability component failure that may cause a misfire. The Powertrain On-Board Diagnostic System checks must be performed first. When using this table to make a Base Engine Misfire diagnosis, begin with the preliminary information below and then proceed to the specific category.	
Preliminary	1. Perform DTC P0300 engine performance diagnostic procedures found in the diagnostic table before proceeding with Base Engine Misfire Diagnosis information. DTC P0300 will assist in determining which cylinder or cylinders are misfiring. 2. Perform a visual inspection of the following: • A loose or improperly installed engine flywheel or crankshaft balancer • Worn, damaged or misaligned accessory drive system components 3. Listen to the engine for any abnormal internal engine noises. 4. Inspect the engine for acceptable oil pressure. 5. Verify if the engine has excessive oil consumption. 6. Verify if the engine has excessive coolant consumption. 7. Perform a compression test on the engine.
Intake Manifold Leaks	An intake manifold that has a vacuum leak may cause a misfire. Inspect for the following: • Improperly installed or damaged vacuum hoses • Faulty or improperly installed intake manifold and/or gaskets • Cracked or damaged intake manifold Inspect the areas between the intake runners • Improperly installed MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged • Improperly installed throttle body or damaged gasket • Warped intake manifold • Warped or damaged sealing surface on cylinder head
Coolant Consumption	Coolant consumption may or may not cause the engine to overheat. Inspect for the following: • External coolant leaks • Faulty cylinder head gasket • Warped cylinder head • Cracked cylinder head • Damaged engine block • Damaged Intake manifold and/or intake manifold gasket

Base Engine Misfire Diagnosis (cont'd)

Checks	Action
Oil Consumption	1. Remove the spark plugs and inspect for an oil fouled spark plug. Oil consumption may or may not cause the engine to misfire. 2. Perform a cylinder compression test. 3. If the compression test indicates worn valves or valve guides, inspect the following: • Worn, brittle, or improperly installed valve stem oil seals • Worn valve guides • Worn valve stems • Worn or burnt valves or valve seats 4. If the compression test indicates worn or damaged piston rings, inspect the following: • Broken or improperly seated piston rings • Excessive piston ring end gap • Excessive cylinder bore wear or taper • Cylinder damage • Piston damage
Abnormal Internal Engine Noises	**Important:** A slight COLD knock or piston slapping noise could be considered normal if not present after the engine has reached normal operating temperatures. Connect a timing light to the engine and run engine to determine if the noise is timed to camshaft speed or crankshaft speed. Two knocks per flash indicates crankshaft speed and one knock per flash indicates camshaft speed. 1. If the noise is timed to camshaft speed, inspect the following: • Missing or loose valve train components • Worn or loose valve rocker arms • Worn or bent pushrods • Faulty valve springs • Worn or damaged valve rotators • Bent or burnt valves • Worn camshaft lobes • Worn or damaged timing chain and/or sprockets 2. If the knock is timed to crankshaft speed, inspect the following: • Worn crankshaft main or connecting rod bearings • Piston or cylinder damage • Worn piston or piston pin • Faulty connecting rod • Excessive carbon build-up on the top of the piston
No Abnormal Internal Engine Noise	1. Inspect for a worn or improperly installed timing chain and/or sprockets 2. Remove the valve rocker arm cover on the side of the engine with the cylinder that is misfiring. 3. Inspect for the following: • Loose valve rocker arm bolts • Bent push rods • Faulty valve springs • Faulty valve lifters (bleeding down) • Worn or improperly seated valves • Worn camshaft lobes. • Inspect for a chipped or cracked reluctor ring

SIE-ID = 192333
SIO-ID = 192310

Engine Noise Diagnosis

Symptom	Cause
When diagnosing engine noise complaints use the following steps to isolate the source of the engine noise: 1. Determine the type of the noise. This may include a light rattle, tapping or low rumble or knock. 2. Verify the exact operating condition when the noise occurs. This would include ambient engine temperature, engine warm-up time, engine operating temperature, and engine RPM. 3. Isolate the rate when the noise occurs. Generally speaking, engine noises are timed to either engine speed (crankshaft, flywheel, connecting rods, balancer, or pistons and related components) or one-half engine speed (valve train noise such as rocker arms, valve lifters, and timing chain). 4. Compare the engine sounds to a known good engine to prevent trying to fix a noise that is normal.	
Noise on Start-Up but Lasts a Few Seconds	The following condition(s) may produce engine knocks on initial start-up, but only last a few seconds: • Improper oil viscosity. • Install proper oil viscosity for expected temperatures. Refer to Maintenance and Lubrication
Knocks Cold and Continues for 1 to 2 Minutes	• Engine flywheel contacting the splash shield. Reposition the splash shield. • Loose or broken crankshaft balancer or drive pulleys. Tighten or replace as necessary. • Excessive piston to bore clearance. Replace the piston. • Cold engine knock usually disappears when the specific cylinder secondary ignition circuit is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable. • Bent connecting rod.
Intermittent Noise on Idle, Disappearing When Engine Speed is Increased	• Dirt in the lifter. Replace the valve lifter if necessary. • A pitted or damaged valve lifter check ball. Replace the valve lifter if necessary.
Valve Train Noise (Rattle/Tapping)	The following conditions may cause valve train noise: • Low oil pressure. • Loose valve rocker arm attachments • Worn valve rocker arm and/or pushrod. • Broken valve spring. • Worn or damaged valve rotators. • Sticking valves. Inspect the valves. • Worn, dirty or faulty valve lifters. • Worn or faulty camshaft. Replace the camshaft. • Worn or faulty oil pump • Bent, broken, or damaged timing chain sprocket teeth • Worn valve guides. Repair as necessary. • Oil overfull causing foaming of oil.
Knocks at Idle Hot (Rumble/Knocking)	• Inspect the drive belt for wear. Check the tension and/or replace as necessary. • Inspect the A/C compressor or generator bearing. Replace or repair as necessary. • Inspect the valve train. Replace the parts as necessary. • Inspect for improper oil viscosity. Install proper viscosity oil for expected temperature. Refer to Maintenance and Lubrication for engine oil specifications. • Inspect for excessive piston pin clearance. Replace the piston and pin as necessary. • Inspect the connecting rod alignment. Check and replace the rods as necessary. • Inspect for insufficient piston-to bore clearance. • Bore, Hone, and fit the new piston. • Inspect the crankshaft balancer for looseness. Torque and/or replace the worn parts. • Ensure that the piston pin is not offset to the wrong side. Install the correct piston.

Engine Noise Diagnosis (cont'd)

Symptom	Cause
Light Knock Hot	• Detonation or spark knock. Check operation of EST or ESC. Refer to Engine Controls. • Loose torque converter bolts. • Exhaust leak at the manifold. Tighten the bolts and/or replace the gasket. • Excessive rod bearing clearance. Replace bearings as necessary.
Noise at Slow Idle or With Hot Oil; Quiet at Higher Engine Speeds or With Cold Oil	High valve lifter leak down rate may cause noise at slow idle or with hot oil. Replace the valve lifter.
Noise at High Vehicle Speeds, Quiet at Low Speeds	Noise at high vehicle speeds may be caused by the following conditions: • High oil level. Oil levels above the FULL mark allows the crankshaft counterweights to churn the oil into foam. When foam is pumped into the valve lifters, they will become noisy since a solid column of oil is required for proper operation. Drain the oil to the proper level. • A low oil level. Oil below the ADD mark allows the oil pump to pump air at high speeds, which results in noisy valve lifters. Add oil as necessary. • Oil pan bent up against the oil pump pickup screen. • Oil pump pickup screen bent or loose.
Noise Regardless of Engine Speed	• Incorrect valve adjustment leading to noise regardless of engine speed. Check valve lash. • Excessive valve lash may cause engine noise. Check for valve lash by turning the engine so that the piston in that cylinder is on TDC of the firing stroke. If the valve lash is present, the pushrod can be freely moved up and down a certain amount with the valve rocker arm held against the valve. • Excessive valve lash may be caused by the following conditions: – A worn pushrod upper end ball. Replace the pushrod and the valve rocker arm. – A bent pushrod. – Improper lubrication of he pushrod. Replace the pushrod and the valve rocker arm. • Check the lubrication system feed to the pushrod – A loose or damaged valve rocker arm. – If the pushrod and valve rocker are OK, trouble in the valve lifter is indicated. Replace the valve lifter.
Vibrating or Rattling from Exhaust System	Vibration or ratting from the exhaust system may be caused by loose and/or misaligned exhaust components. Align, then tighten the connections. Check for damaged hangers or mounting brackets and clamps.
Exhaust Leakage and/or Noise	Exhaust leakage and/or noise may be caused by the following conditions: • Leakage at the exhaust component joints and couplings. Tighten the clamps or couplings to the specified torque. • Improperly installed or misalignment of the exhaust system. Align, then tighten the exhaust clamps. • A cracked or broken exhaust manifold. Replace the exhaust manifold. • A leak between the exhaust manifold or the cylinder head. Tighten the exhaust manifold to the cylinder head nuts and bolts to specifications. • Damaged or worn exhaust seals. Replace as necessary. • A burned or rusted out exhaust pipe. Replace the exhaust pipe as necessary. • A burned or blown out muffler. Replace the muffler assembly. • A broken or loose exhaust clamp and/or bracket. Replace as necessary.
Heavy Knock with Torque Applied	• Broken balancer or pulley hub. Replace parts as necessary. • Loose torque converter bolts. • Accessory belts too tight or nicked. Replace and/or tension to specifications as necessary. • Flywheel cracked. • Excessive main bearing clearance. Replace as necessary. • Excessive rod bearing clearance. Replace as necessary.

Valve Train Diagnosis

SIE-ID = 362077

General Information

Symptom	Cause
• A light tapping noise at ½ engine speed, or any varying frequency, may indicate a valve train problem. • Tapping noises will typically increase with increased engine speed. • Before attempting to diagnose a valve train noise, check for the proper oil level and allow the engine to obtain normal operating temperature. Following this procedure will bring all engine components to a normal state of expansion. • Sit in the driver's seat, then operate the engine at various speeds and listen for any abnormal engine noise.	
A light tapping noise similar to valve train noise may be caused by the following components:	• Fuel Injectors • Evaporative emissions (EVAP) purge solenoid • Detonation • Loose heat shields
Valve Train Noise	• Low engine oil pressure • A worn or faulty oil pump • A loose or plugged oil pump screen • Loose valve rocker arm attachments (causing excessive valve lash) • A worn or damaged valve rocker arm ball • A worn valve rocker arm and/or pushrod • A broken valve spring • Worn or damaged valve rotators • Sticking valves • Valve lifters worn, dirty, or faulty • a broken valve lifter guide • Camshaft valve lifter lobes worn • Worn valve guides or valve stems • Worn or damaged valve keys • Bent valve pushrods • Excessive play in the camshaft timing chain • Bent, broken, or damaged timing chain sprocket teeth

Diagnostic Table

Step	Action	Value(s)	Yes	No
DEFINITION: A light tapping noise at ½ engine speed, or any varying frequency.				
1	Is there valve train noise?	—	*Go to Step 2*	System OK
2	Check for a high engine oil level. An engine with the engine oil level above the FULL mark allows the crankshaft counterweights to churn the engine oil into foam. When foamy engine oil is pumped into the valve lifters, the valve lifters become noisy. A solid column of engine oil ensures proper valve lifter operation. Is the engine oil level too high?	—	*Go to Step 3*	*Go to Step 4*
3	Drain the engine oil to the proper level. Is the tapping noise gone?	—	System OK	*Go to Step 6*
4	Check for a low engine oil level. An engine with the engine oil level below the ADD mark may allow the oil pump to pump air at high engine RPM. Is the engine oil level too low?	—	*Go to Step 5*	*Go to Step 6*
5	Add engine oil as required. Is the tapping noise gone?	—	System OK	*Go to Step 6*

Diagnostic Table (cont'd)

Step	Action	Value(s)	Yes	No
6	Check for the proper engine oil pressure. Refer to *Engine Mechanical Specifications* and *Oil Pressure Diagnosis and Testing.* Is the engine oil pressure within specifications?	68.65 kPa (10 psi)	*Go to Step 11*	*Go to Step 7*
7	Check the oil pump screen for damage or a loose fit to the oil pump. Is the oil pump screen loose or is the oil pump screen damaged?	—	*Go to Step 8*	*Go to Step 9*
8	Repair as required. Is the tapping noise gone?	—	System OK	*Go to Step 9*
9	Check for a damaged oil pump or loose mounting bolts Refer to *Oil Pump Clean and Inspect.* Is the oil pump damaged or are the mounting bolts loose?	—	*Go to Step 10*	*Go to Step 11*
10	Repair as required. Is the tapping noise gone?	—	System OK	*Go to Step 11*
11	Remove and inspect the valve lifters, valve rocker arms, and valve pushrods. Refer to *Valve Rocker Arm and Push Rods Clean and Inspect* and *Valve Lifters and Guides Clean and Inspect.* Are the components worn or damaged?	—	*Go to Step 12*	*Go to Step 13*
12	Replace the components as required. Is the tapping noise gone?	—	System OK	*Go to Step 13*
13	Perform a camshaft lobe lift test. Refer to *Camshaft and Bearings Clean and Inspect* Is the test within *Engine Mechanical Specifications* ?	—	*Go to Step 15*	*Go to Step 14*
14	Replace the camshaft and valve lifters. Is the tapping noise gone?	—	System OK	*Go to Step 15*
15	Remove the engine front cover and inspect the camshaft timing chain and sprockets for excessive wear or damage. Refer to *Timing Chain and Sprockets Clean and Inspect.* Are the components worn or damaged?	—	*Go to Step 17*	*Go to Step 16*
16	Replace the components as required. Is the tapping noise gone?	—	System OK	*Go to Step 17*
17	Perform a complete disassembly of the engine and inspect all components. Are the components worn or damaged?	—	*Go to Step 18*	System OK
18	Replace the components as required. Did you complete the worn and damaged component replacement?	—	System OK	—

Oil Consumption Diagnosis

SIE-ID = 294973

Excessive oil consumption (not due to leaks) is the use of more than 0.95 liter (1 quart) of engine oil within 100 gallons of fuel used. However, during initial engine break-in periods 5,000–6,500 kilometers (3,000–4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or more per 100 gallons of fuel used. 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 check 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 miss-fitted.

Oil Pressure Diagnosis and Testing

SIE-ID = 42493

SIO-ID = 18963

1. With the vehicle on a level surface, allow adequate drain down time (2–3 minutes) and measure for a low engine oil level.

   Add the recommended grade engine oil GM P/N 12345610 or equivalent, and fill the crankcase until the oil level measures FULL on the oil level indicator.
2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gauge or oil indicator light.

   Listen for a noisy valve train or knocking noise.
3. Inspect for the following:
   - Engine oil diluted by moisture or unburned fuel mixtures
   - Improper engine oil viscosity for the expected temperature
   - Incorrect or faulty oil pressure gauge sensor
   - Incorrect or faulty oil pressure gauge
   - Plugged oil filter
   - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gauge sensor or another engine block oil gallery plug.
5. Install an oil pressure gauge and measure the engine oil pressure.
6. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
   - Oil pump worn or dirty
   - Malfunctioning oil pump pressure relief valve
   - Oil pump screen loose, plugged, or damaged
   - Excessive bearing clearance
   - Cracked, porous or restricted oil galleries
   - Engine block oil gallery plugs missing or incorrectly installed
   - Broken valve lifters

SIE-ID = 204344

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.				
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait (15 minutes). 4. Check for drippings. Are drippings present?	—	Go to *Step 2*	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 3*
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 4*
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait (15 minutes). 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 5*

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 6*
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 7*
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 8*
8	Use *J 28428-E*, 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

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	—	Go to *Step 11*	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	—	Go to *Step 1*	—

Symptoms - Drive Belt

SIE-ID = 591994

Important: Review the system operation in order to familiarize yourself with the system functions. Refer to *Drive Belt System Description*.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the drive belts.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect the drive belt for excessive wear, shredding, or missing sections.
- Inspect the drive belt for contamination of excessive dirt, oil, coolant or other substances that may affect the drive belt operation.

Intermittent

- Drive belt symptoms may be from intermittent failure of an accessory drive component.
- Drive belt symptoms may occur from changes in load of the accessory drive components.
- Ambient temperatures, moisture, or engine operating temperature can affect the drive belt operation.

Symptom List

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

- *Drive Belt Chirping Diagnosis*
- *Drive Belt Squeal Diagnosis*
- *Drive Belt Whine Diagnosis*
- *Drive Belt Rumbling Diagnosis*
- *Drive Belt Vibration Diagnosis*
- *Drive Belt Falls Off Diagnosis*
- *Drive Belt Excessive Wear Diagnosis*

Drive Belt Chirping Diagnosis

SIE-ID = 506358

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt(s) or the pulleys. It may be necessary to spray a small amount of water on the drive belt(s) in order to duplicate the customers concern. If spraying water on the drive belt(s) duplicates the symptom, cleaning the belt pulleys may be the probable solution.

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the chirping noise.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt(s) the water pump may not be operating and the

engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it may 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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. 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. • It usually occurs on cold damp mornings.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to *Engine Noise Diagnosis*	Go to *Step 4*
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	Go to *Step 5*	Go to *Step 6*
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to*Step 15*	Go to*Step 6*
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to *Step 7*	Go to *Step 8*
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to *Step 15*	Go to *Step 8*
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to *Step 9*	Go to *Step 10*
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to *Step 15*	Go to *Step 10*
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to *Step 11*	Go to *Step 12*
11	Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to *Fastener Tightening Specifications* Did you complete the repair?	Go to *Step 15*	Go to *Step 12*
12	Inspect for a bent pulley. Did you find the condition?	Go to *Step 13*	Go to *Step 14*
13	Replace the bent pulley. Did you complete the repair?	Go to *Step 15*	Go to *Step 14*
	Replace the drive belt. Refer to *Drive Belt Replacement* Did you complete the repair?	Go to *Step 15*	Go to Diagnostic Aids

Drive Belt Chirping Diagnosis (cont'd)

Step	Action	Yes	No
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Squeal Diagnosis

SIE-ID = 506361

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the squeal noise.

If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table
3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the squeal noise is the drive belt(s) or an accessory drive component. 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 belt removed.
4. This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.
5. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
6. This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
7. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
8. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt (this is unusual for a drive belt with multiple ribs) • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to *Engine Noise Diagnosis*	Go to *Step 4*
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 5*
5	Test the drive belt tensioner for proper operation. Refer to *Drive Belt Tensioner Diagnosis* Did you find and correct the condition?	Go to *Step 9*	Go to *Step 6*

Drive Belt Squeal Diagnosis (cont'd)

Step	Action	Yes	No
6	Inspect for the correct drive belt length. Refer to *Drive Belt Replacement* Did you find and correct the condition?	Go to *Step 9*	Go to *Step 7*
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to *Step 9*	Go to *Step 8*
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to *Step 9*	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Whine Diagnosis

SIE-ID = 506364

Diagnostic Aids

The drive belt(s) will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

3. This test is to verify that the noise is being caused by the drive belt(s) or the accessory drive components. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt(s) may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to *Engine Noise Diagnosis*	Go to *Step 4*
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to *Step 5*	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	—

Drive Belt Rumbling Diagnosis

SIE-ID = 506367

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise.

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

If replacing the drive belt(s), completing the diagnostic table, and the noise is only heard when the drive belt(s) is 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 number(s) below refer to the step number(s) on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that the drive belt(s) is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only

one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4. Inspecting the drive belt(s) is to ensure that it is not causing a the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.
5. Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: • 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		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to *Engine Noise Diagnosis*	Go to *Step 4*
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. 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 belt. Refer to *Drive Belt Replacement* Did you complete the repair?	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*	—
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

Drive Belt Vibration Diagnosis

SIE-ID = 506368

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as 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.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
3. This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. The drive belt(s) may cause a vibration. While the drive belt(s) is removed this is the best time to inspect the condition of the belt.
6. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
8. This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.

9. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known good water pump.
10. Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. 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 - Drive Belt*
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to *Step 3*	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to *Engine Noise Diagnosis*	Go to *Step 4*
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to *Step 5*	Go to *Step 6*
5	Install a new drive belt. Refer to *Drive Belt Replacement* Did you complete the replacement?	Go to *Step 11*	—
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to *Step 7*	Go to *Step 8*
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to *Fastener Tightening Specifications* Did you complete the repair?	Go to *Step 11*	—
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to *Fan Clutch Replacement (7.4L)* Did you find and correct the condition?	Go to *Step 11*	Go to *Step 9*
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to *Water Pump Replacement (Gasoline)* Did you find and correct the condition?	Go to *Step 11*	Go to *Step 10*
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to *Step 11*	Go to Diagnostic Aids
11	Operate the system in order to verify the repair Did you correct the condition?	System OK	Go to *Step 3*

Drive Belt Falls Off Diagnosis

SIE-ID - 506370

Diagnostic Aids

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

An extra load that is quickly applied 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(s) is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may 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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a

misalign pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
7. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing. loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
Notice: Refer to *Belt Dressing Notice* in Cautiions and Notices. DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Inspect for a damaged drive belt. Did you find the condition?	Go to *Step 3*	Go to *Step 4*
3	Install a new drive belt. Refer to *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	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to *Fastener Tightening Specifications* Does the drive belt continue to fall off?	Go to *Step 9*	System OK
9	Test the drive belt tensioner for operating correctly. Refer to *Drive Belt Tensioner Diagnosis* Does the drive belt tensioner operate correctly?	Go to *Step 11*	Go to *Step 10*
10	Replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement* Does the drive belt continue to fall off?	Go to *Step 11*	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to *Step 12*	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to *Step 2*

Drive Belt Excessive Wear Diagnosis

SIE-ID = 506373

Diagnostic Aids

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

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

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

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The inspection is to verify the drive belt(s) is correctly installed on all of the drive belt pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one groove on a pulley.
3. The installation of a drive belt that is two wide or two narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

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

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
	Notice: Refer to *Belt Dressing Notice* in Cautions and Notices. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to *Step 2*	Go to *Symptoms - Drive Belt*
2	Inspect the drive belt(s) for the proper installation. Refer to *Drive Belt Replacement* Did you find this condition?	Go to *Step 5*	Go to *Step 3*
3	Inspect for the proper drive belt. Did you find this condition?	Go to *Step 5*	Go to *Step 4*
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to *Step 6*	Go to Diagnostic Aids
5	Replace the drive belt. Refer to *Drive Belt Replacement* Did you complete the replacement?	Go to *Step 6*	—
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	—

Drive Belt Tensioner Diagnosis

SIE-ID = 506374

Inspection Procedure

Notice: SIO-ID = 3753 Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

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

Engine Compression Test

SIE-ID = 201715

1. Disconnect the positive ignition coil wire plug from ignition coil.
2. Disconnect the fuel injector electrical connector.
3. Remove all the spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery if the battery is not fully charged.
6. Start with the compression gauge at zero. Then crank the engine through four compression strokes (four puffs).
7. Make the compression check the same for each cylinder. Record the reading.

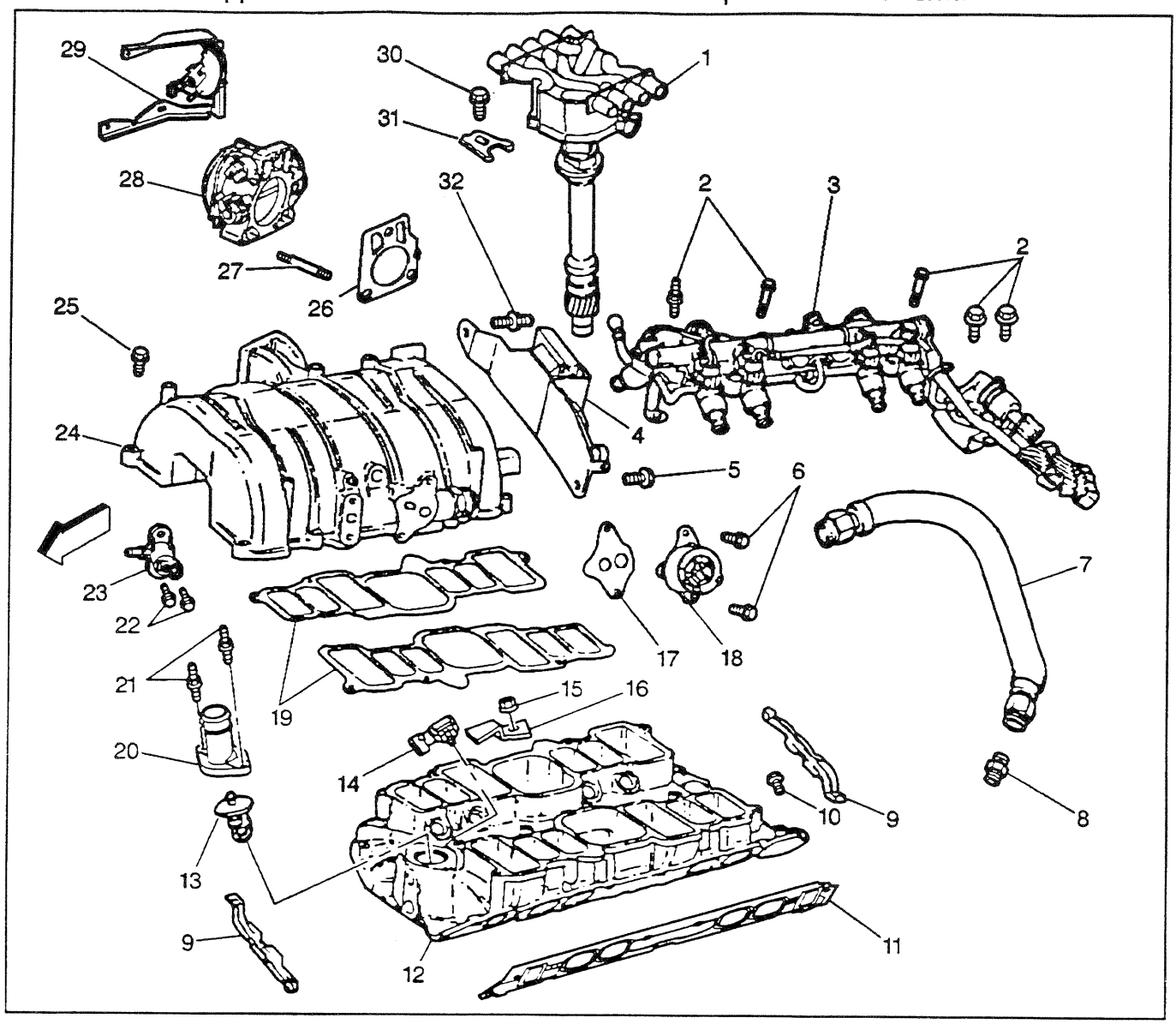
   The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1035 x 70% = 725) (150 x 70% = 105).
8. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
   - Normal — Compression builds up quickly and evenly to the specified compression for each cylinder.
   - Piston Rings Leaking — Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.
   - Valves Leaking — Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
   - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the two cylinders.
9. Install the removed parts.
10. Connect the disconnected components.

Visual Identification

Disassembled Views

SIE-ID = 201613

Upper and Lower Intake Manifolds and Components SIO-ID = 201487



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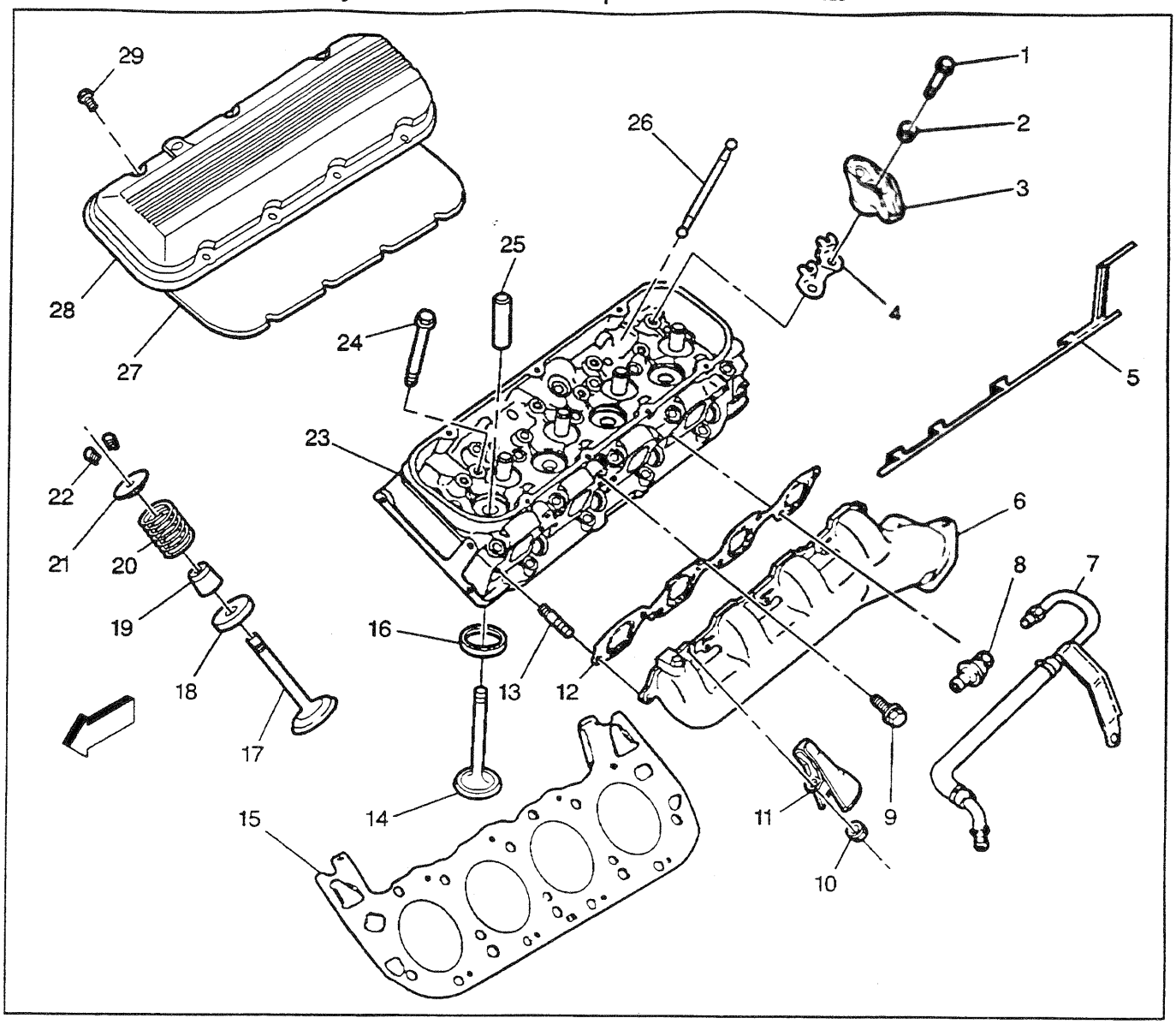
Legend

(1) High Voltage Distributor
(2) Fuel Rail Bolt
(3) Fuel Rail Assembly
(4) Ignition Coil
(5) Ignition Coil Bolt
(6) EGR Valve Bolt
(7) EGR Inlet Pipe
(8) EGR Inlet Pipe Fitting
(9) Lower Intake Manifold End Gaskets
(10) Lower Intake Manifold Bolt
(11) Lower Intake Manifold Side Gasket
(12) Lower Intake Manifold
(13) Thermostat
(14) MAP Sensor
(15) MAP Sensor Bracket
(16) MAP Sensor Bracket Nut
(17) EGR Valve Gasket
(18) EGR Valve
(19) Upper Intake Manifold Gaskets
(20) Water Outlet Housing
(21) Water Outlet Housing Studs
(22) EVAP Purge Valve Bolts

(23) EVAP Purge Valve
(24) Upper Intake Manifold
(25) Upper Intake Manifold Bolt
(26) Throttle Body Gasket
(27) Throttle Body Stud
(28) Throttle Body
(29) Governor Bracket (RPO 9C2 only)
(30) Distributor Clamp Bolt
(31) Distributor Clamp
(32) Ignition Coil Stud

Cylinder Head and Components SIO-ID = 201528



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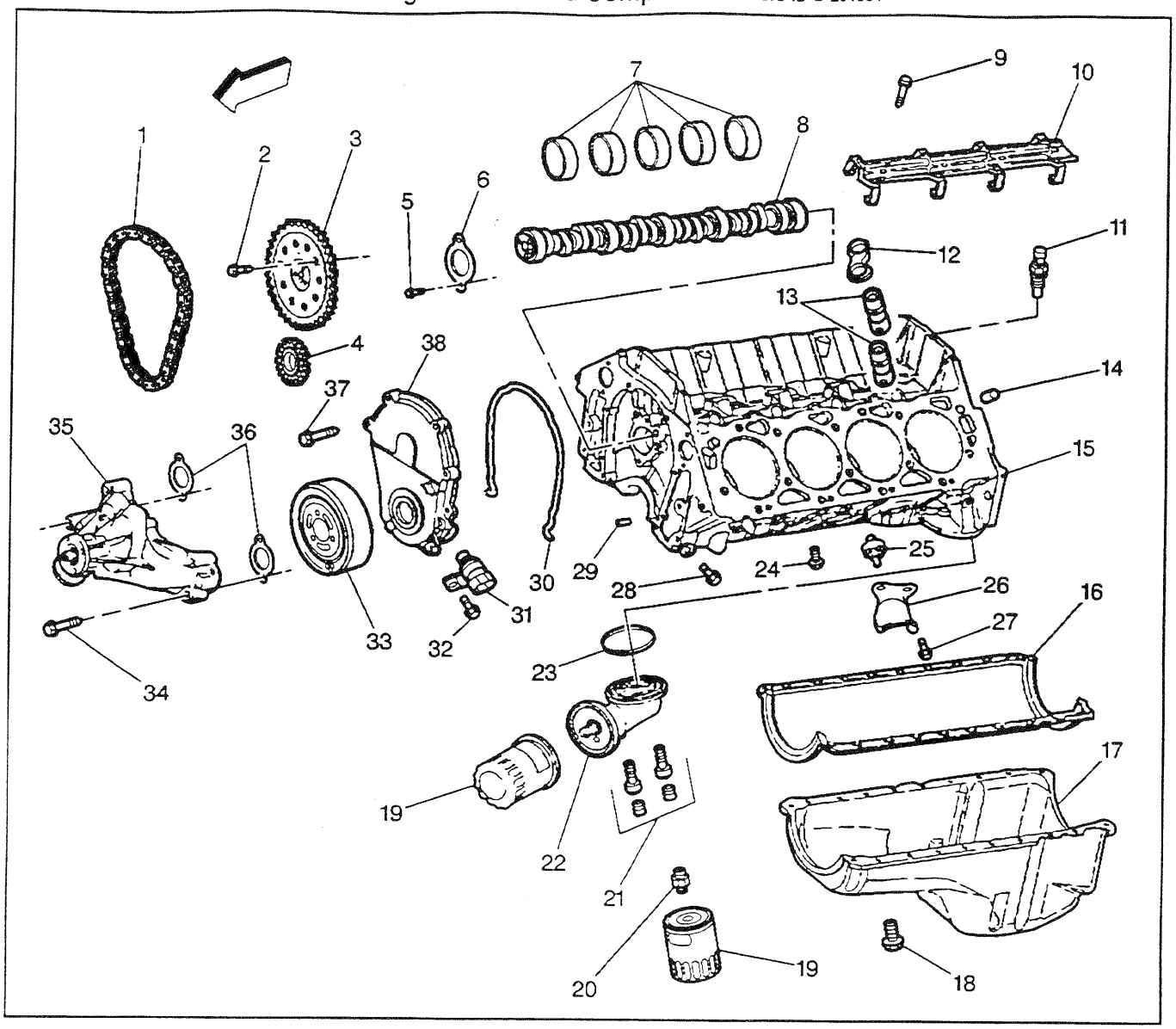
Legend

(1) Valve Rocker Arm Bolt
(2) Valve Rocker Arm Ball
(3) Valve Rocker Arm
(4) Pushrod Guide
(5) Spark Plug Wire Bracket
(6) Exhaust Manifold
(7) AIR Tube (California Only)
(8) AIR Tube Check Valve (California Only)
(9) Exhaust Manifold Center Bolt
(10) Heat Shield Nut
(11) Heat Shield
(12) Exhaust Manifold Gasket
(13) Exhaust Manifold Stud
(14) Valve
(15) Cylinder Head Gasket
(16) Valve Seat
(17) Valve
(18) Valve Rotator
(19) Valve Stem Oil Seal
(20) Valve Spring
(21) Valve Cap
(22) Valve Keys
(23) Cylinder Head
(24) Cylinder Head Bolt
(25) Valve Guides
(26) Valve Pushrod
(27) Valve Rocker Arm Cover Gasket
(28) Valve Rocker Arm Cover
(29) Valve Rocker Arm Cover Bolt

Lower Engine Block and Components SIO-ID = 201531

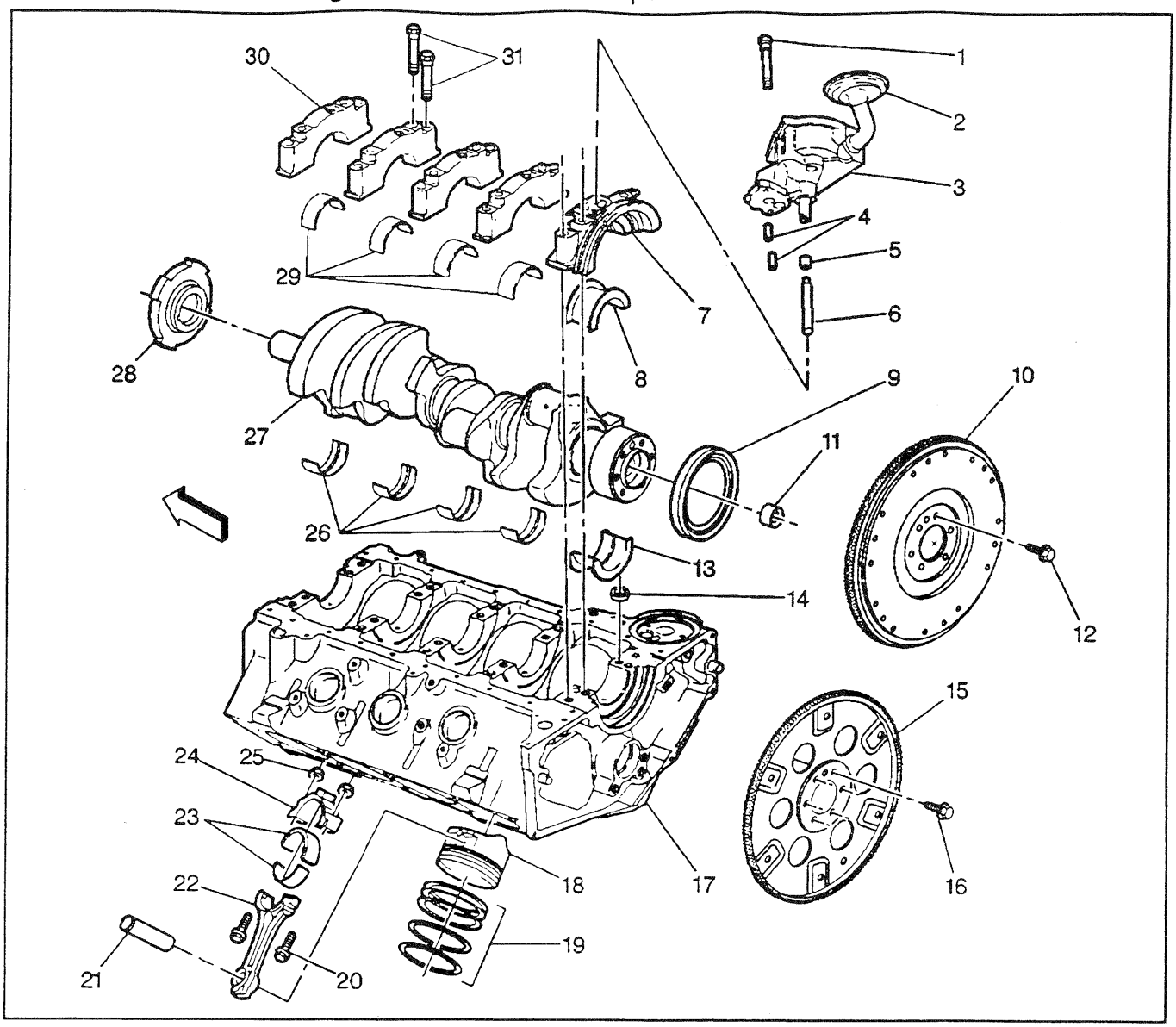


Legend

(1) Timing Chain
(2) Camshaft Sprocket Bolt
(3) Camshaft Sprocket
(4) Crankshaft Sprocket
(5) Camshaft Retainer Bolt
(6) Camshaft Retainer
(7) Camshaft Bearings
(8) Camshaft
(9) Valve Lifter Guide Retainer Bolt
(10) Valve Lifter Guide Retainer
(11) Oil Pressure Sensor
(12) Valve Lifter Guide
(13) Valve Lifter
(14) Cylinder Head Locating Pin
(15) Engine Block
(16) Oil Pan Gasket
(17) Oil Pan
(18) Oil Pan Bolt
(19) Oil Filter
(20) Oil Filter Fitting
(21) Oil Filter Adapter Bolts and Plugs
(22) Oil Filter Adapter Assembly
(23) Oil Filter Adapter O-Ring
(24) Engine Block Coolant Drain Hole Plug
(25) Knock Sensor
(26) Knock Sensor Heat Shield
(27) Knock Sensor Heat Shield Bolt
(28) Engine Block Oil Gallery Plug
(29) Engine Front Cover Locating Pin
(30) Engine Front Cover Gasket
(31) Crankshaft Position Sensor
(32) Crankshaft Position Sensor Bolt

(33) Crankshaft Balancer
(34) Water Pump Bolt
(35) Water Pump
(36) Water Pump Gaskets
(37) Engine Front Cover Bolt
(38) Engine Front Cover

Engine Crankshaft and Components SIO-ID = 201534



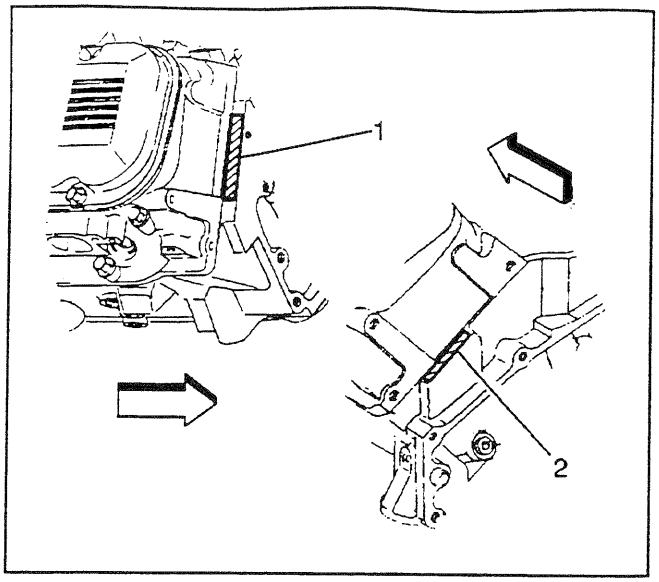
180860

Legend

(1) Oil Pump Bolt
(2) Oil Pump Screen
(3) Oil Pump
(4) Oil Pump Locating Pins
(5) Oil Pump Driveshaft Retainer
(6) Oil Pump Driveshaft
(7) Crankshaft Thrust Bearing Cap
(8) Crankshaft Lower Thrust Bearing
(9) Crankshaft Rear Oil Seal
(10) Engine Flywheel (Manual Transmission)
(11) Clutch Pilot Bearing
(12) Engine Flywheel Bolt
(13) Crankshaft Upper Thrust Bearing
(14) Crankshaft Bearing Cap Oil Seal
(15) Engine Flywheel (Automatic Transmission)
(16) Engine Flywheel Bolt
(17) Engine Block
(18) Piston
(19) Piston Ring Assembly
(20) Connecting Rod Bolt
(21) Piston Pin
(22) Connecting Rod
(23) Connecting Rod Bearings
(24) Connecting Rod Cap
(25) Connecting Rod Nut
(26) Crankshaft Upper Bearings
(27) Crankshaft
(28) Crankshaft Position Sensor Reluctor Ring
(29) Crankshaft Lower Bearings
(30) Crankshaft Bearing Cap
(31) Crankshaft Bearing Cap Bolts

Engine Identification

SIE-ID = 511715



180875

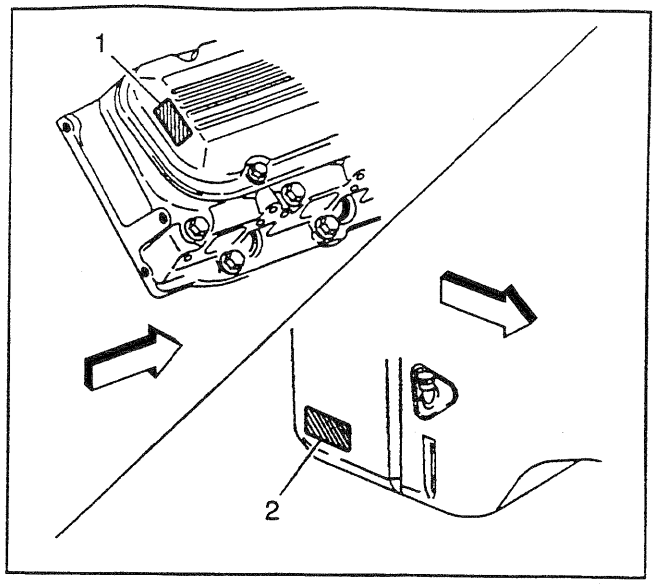
The engine identification number is located on the right front side of the engine block (1). The engine identification number gives specific information about the assembly of the engine. If reading the identification number from the left the following information can be obtained:

- The first digit identifies the plant code.
- The second and third digits give the month of the engine build.
- The fourth and fifth digits describe the date of engine build.
- The sixth, seventh, eighth digits give the engine broadcast code.

The Vehicle Identification Number (VIN) Derivative is located on the left rear side of the engine block (2) and is a nine digit number stamped or laser etched onto the engine at the vehicle assembly plant. If reading the identification number from the left the following information can be obtained:

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

Engine Verification Label



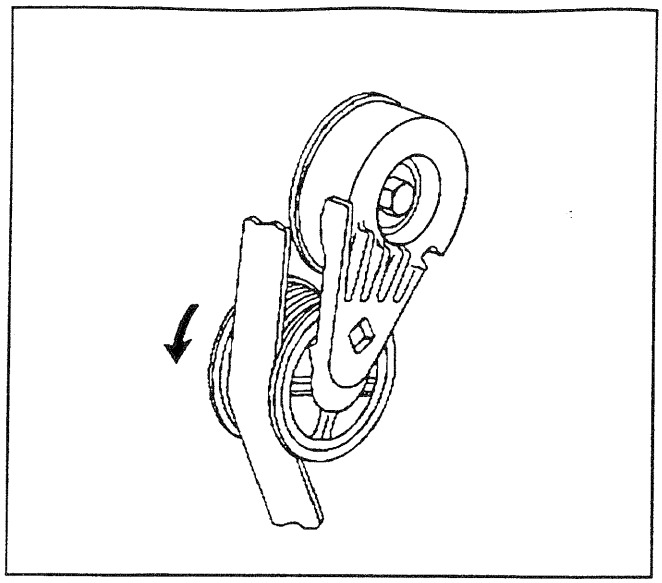
492039

The engine verification label is placed in two locations on the right side of the engine.

- On the back of the valve rocker arm cover (1)
- On the side of the oil pan (2)

The engine verification label displays the bar code and the broadcast code that identifies the engine RPO, transmission RPO and other component RPOs that the engine includes and excludes.

Repair Instructions



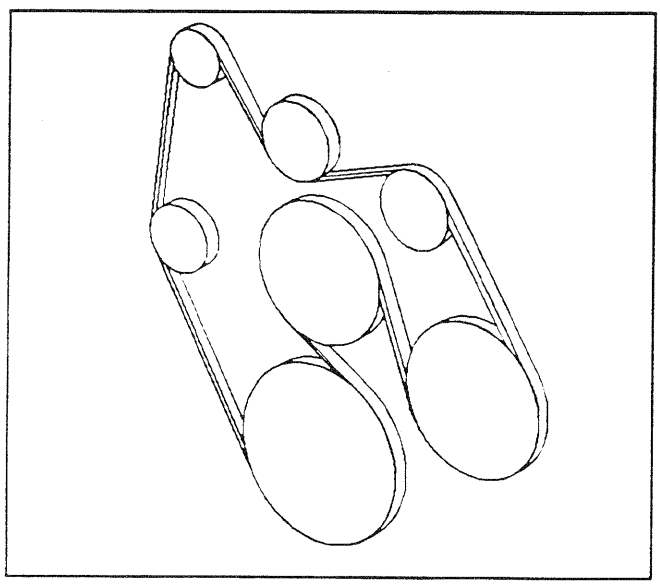
177620

Drive Belt Replacement

SIE-ID = 506377

Removal Procedure

1. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm counterclockwise.
2. Remove the drive belt.
3. Slowly release the tension on the tensioner arm.

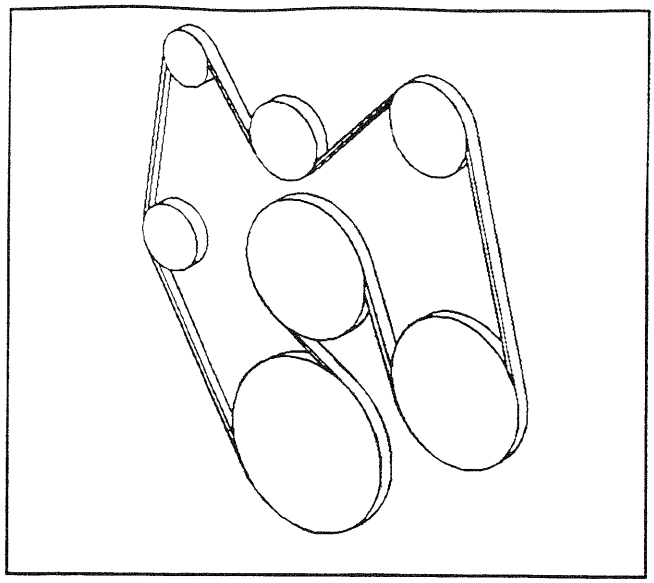


43858

Installation Procedure

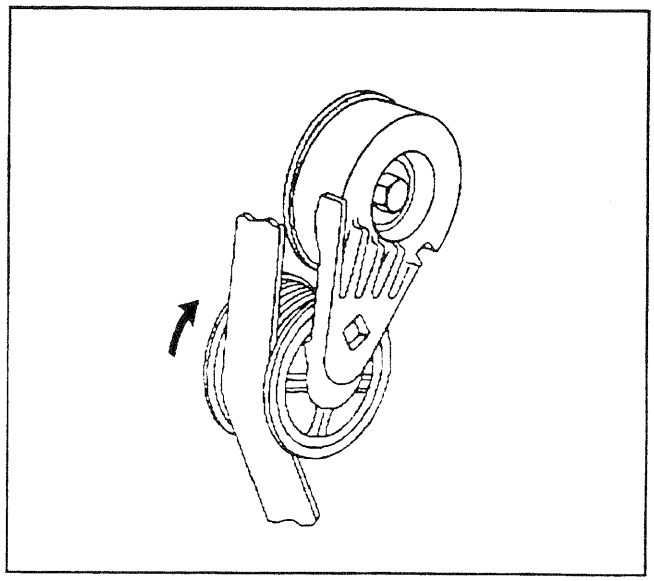
1. Route the belt over all the pulleys except the tensioner arm.
2. Observe belt routing for vehicles without air conditioning.

3. Observe belt routing for vehicles with air conditioning.



43859

4. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm counterclockwise.
5. Install the belt over the tensioner arm pulley.
6. Slowly release the tension on the tensioner arm.
7. Confirm that the belt is properly routed.



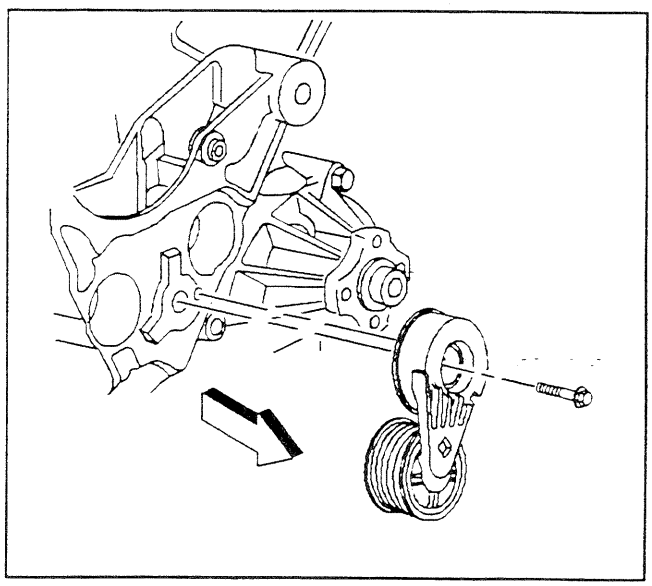
177622

Drive Belt Tensioner Replacement

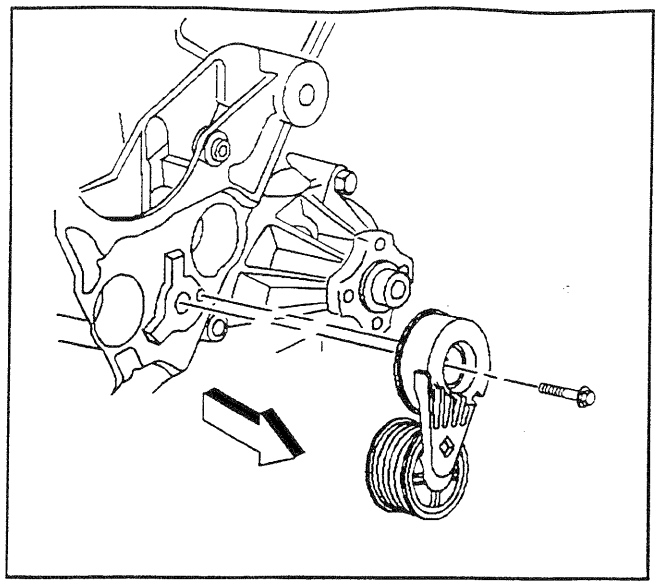
SIE-ID - 50639C

Removal Procedure

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



43854



43854

Installation Procedure

1. Install the drive belt tensioner assembly.

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

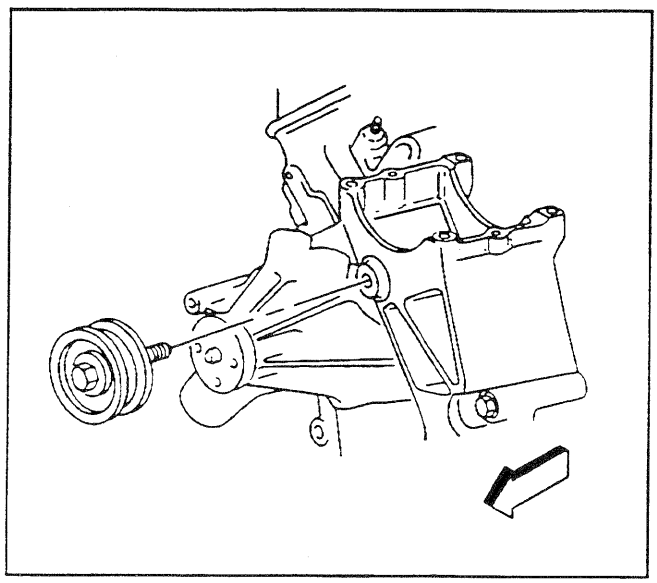
2. Install the attaching bolt.

   Tighten

   Tighten the tensioner assembly bolt to 50 N·m (37 lb ft).

3. Install the drive belt.

   Refer to *Drive Belt Replacement.*



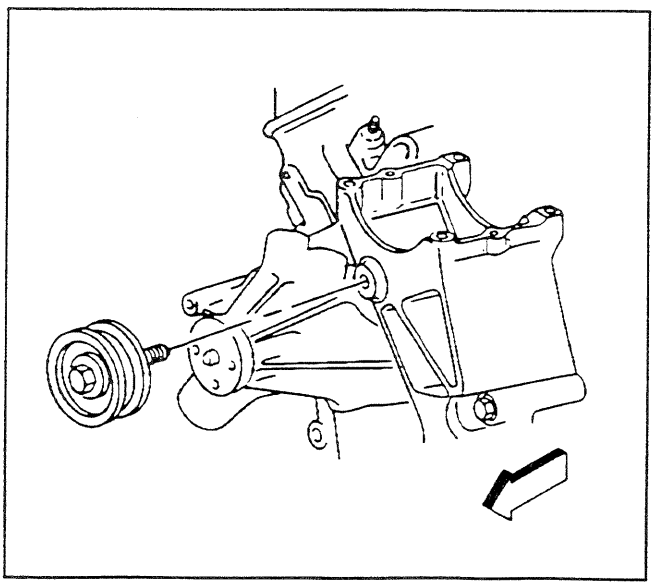
188927

Drive Belt Idler Pulley Replacement

SIE-ID = 506384

Removal Procedure

1. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in engine cooling.
2. Remove the drive belt from the vehicle. Refer to *Drive Belt Replacement.*
3. Remove the drive belt idler pulley from the engine.



188927

Installation Procedure

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

1. Install the drive belt idler pulley to the engine assembly..

   Tighten

   Tighten the bolt to 50 N·m (37 lb ft).

2. Install the drive belt to the vehicle. Refer to *Drive Belt Replacement.*
3. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)* in engine cooling.

Accessory Mounting Brackets Replacement (AC)

SIE-ID = 506388

Removal Procedure

1. **Tools Required**

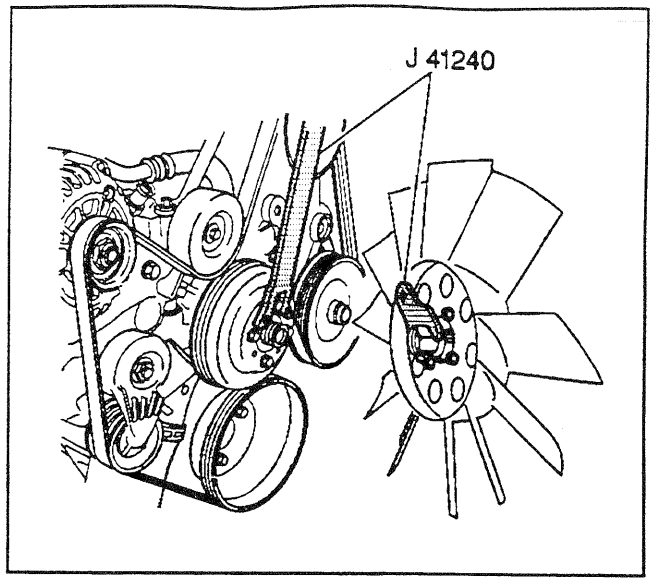
Use *J 41240* to remove fan.

2. Remove the engine cooling fan. Refer to *Fan Clutch Replacement (7.4L)* in Engine Cooling.
3. Remove the drive belt. Refer to *Drive Belt Replacement.*

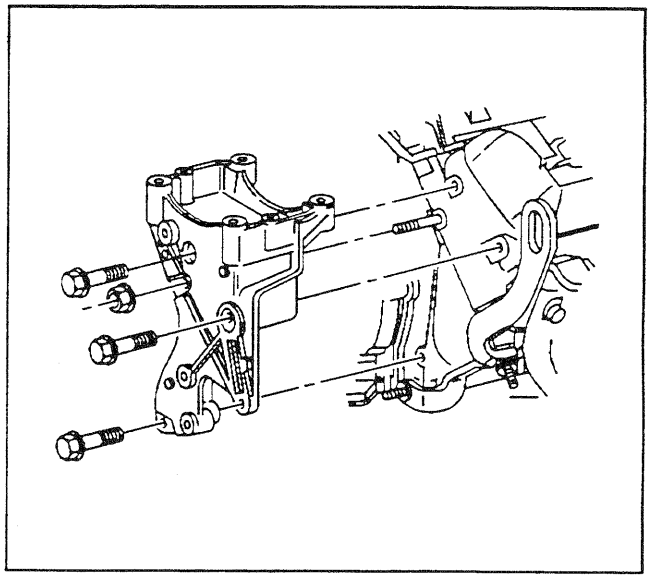
Important: Do not evacuate the air conditioning system.

Remove the mounting bolts for the air conditioning compressor, if equipped. Refer to *Compressor Replacement (7.4L)* in HVAC.

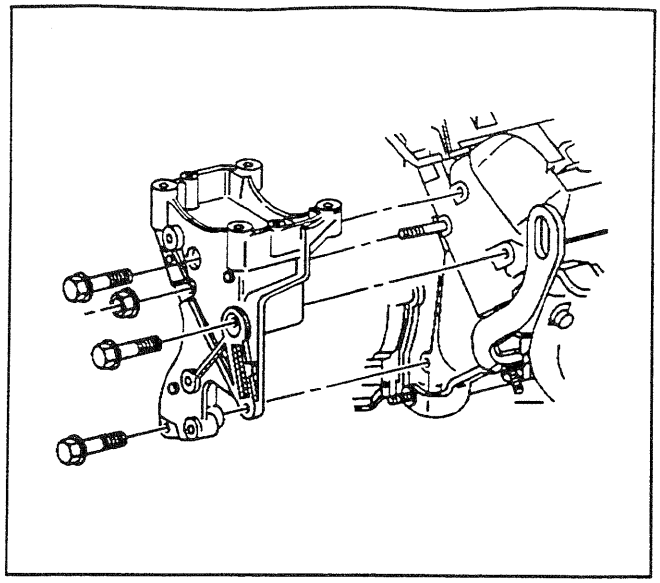
4. Move the compressor aside and support.
5. Remove the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement* in Engine Mechanical.
6. Remove the power steering pump pulley. Refer to *Power Steering Pump Replacement (7.4L)* in Power Steering Systems.
7. Remove the three bolts and nut holding the accessory mounting bracket to the engine.
8. Slide the bracket off the stud and power steering pump.



42910



188295



188295

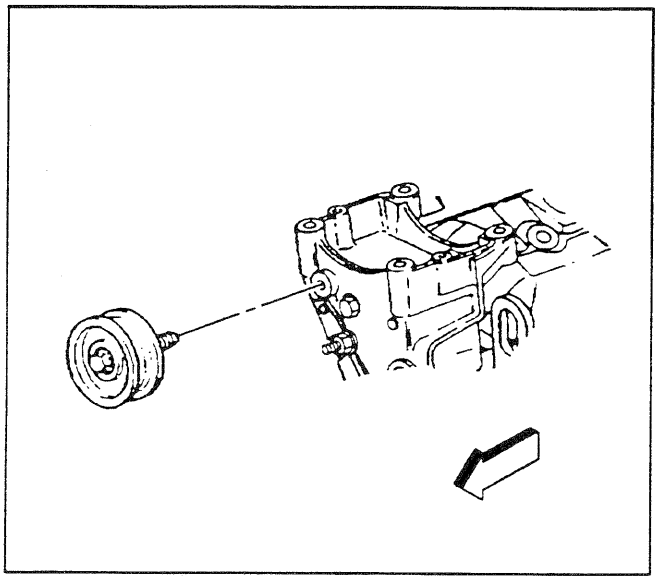
Installation Procedure

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

1. Slide the bracket on the stud and the power steering pump.
2. Install the three bolts and the nut.

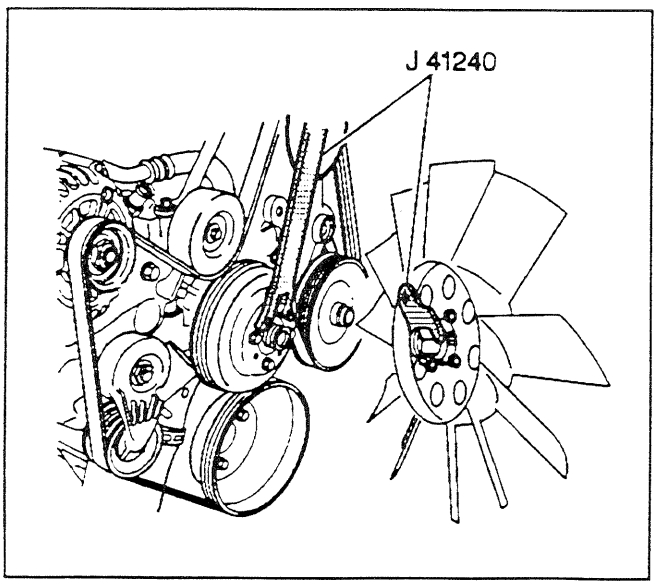
   Tighten

   Tighten the bolts and nut to 44 N·m (32 lb ft).
3. Install the power steering pump. Refer to *Power Steering Pump Replacement (7.4L)* in Power Steering Systems.
4. Install the air conditioning compressor, if equipped. Refer to *Compressor Replacement (7.4L)* in HVAC systems with A/C-Manual.



338506

5. Install the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement* in Engine Mechanical.
6. Install the drive belt. Refer to *Drive Belt Replacement* in Engine Mechanical.
7. Install the engine cooling fan. Refer to *Fan Clutch Replacement (7.4L)* in Engine Cooling.



42910

Accessory Mounting Brackets Replacement (Generator)

SIE-ID - 506393

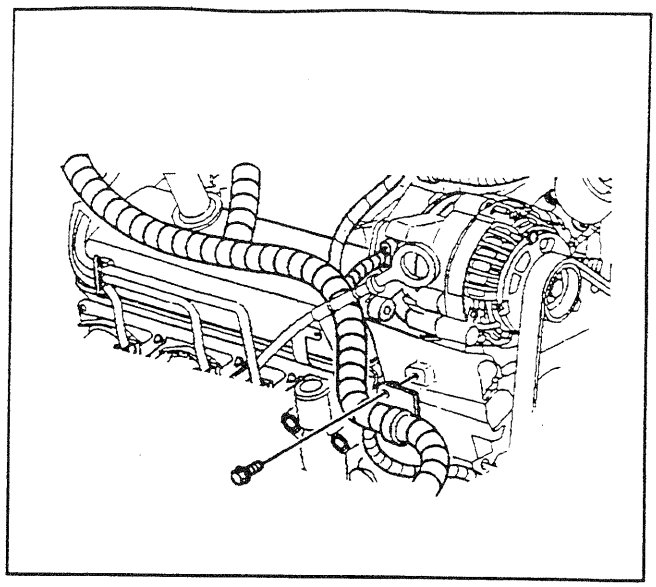
Removal Procedure

1. **Special Tools**

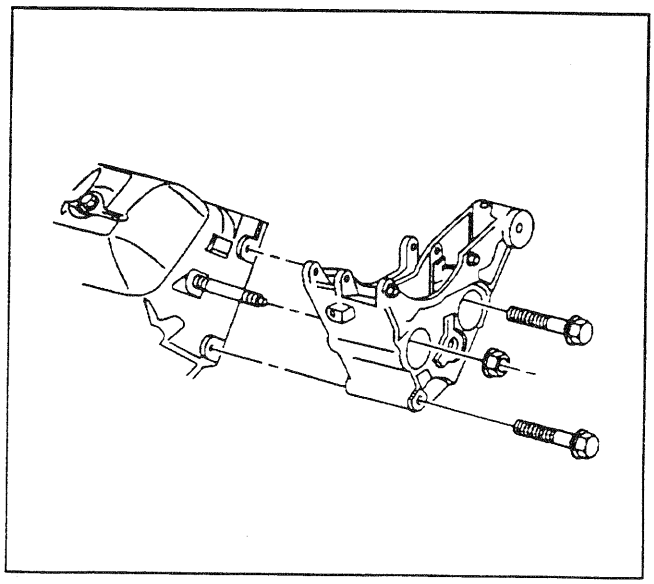
Use *J 41240* to remove fan.

2. Remove the engine cooling fan. Refer to *Fan Clutch Replacement (7.4L)* in Engine Cooling.
3. Disconnect the battery negative cable. Refer to *Battery Cable* in Engine Electrical.
4. Remove the drive belt. Refer to *Drive Belt Replacement.*
5. Remove the generator. Refer to *Generator Replacement (Gas, CS 144)* in Engine Electrical.

6. Remove the wire harness bracket from the generator mounting bracket.
7. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement.*
8. Remove the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement.*


340790

9. Remove the three bolts and nut holding the generator bracket to the engine.
10. Slide the bracket off of the stud.


196643

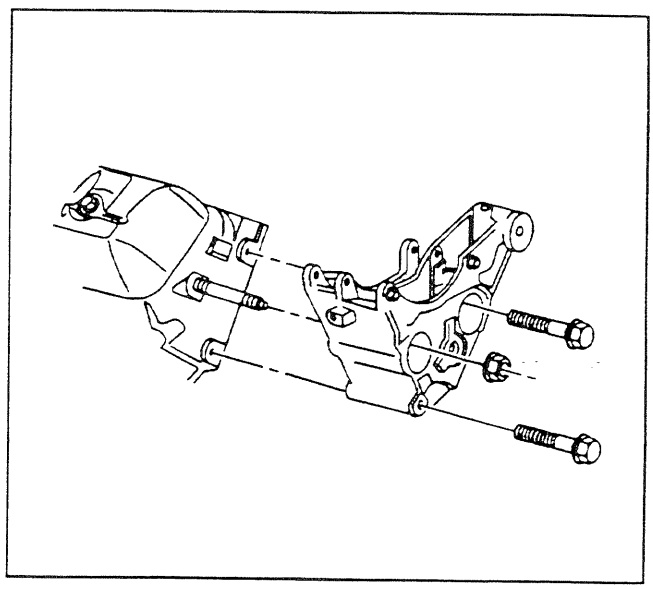
Installation Procedure

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

1. Slide the bracket on the stud.
2. Install the three bolts and the nut.

   Tighten

   Tighten the bolts and nut to 41 N·m (30 lb ft).
3. Install the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement.*
4. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement.*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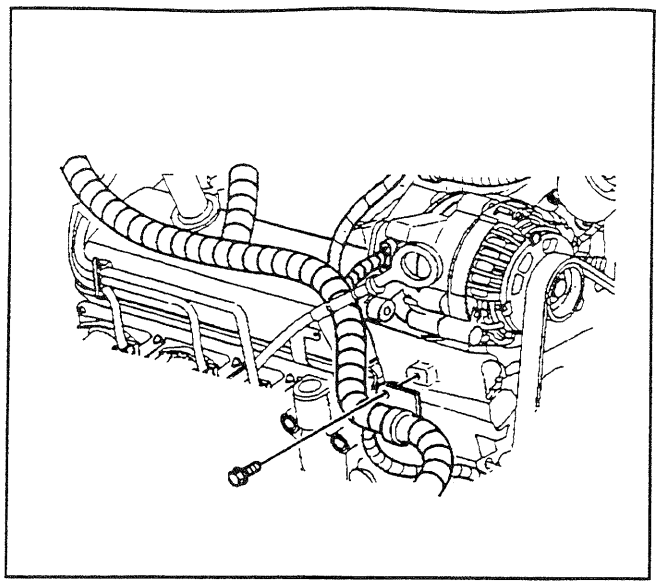

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5. Install the wire harness bracket to the generator mounting bracket.

   Tighten

   Tighten the bolt to 24 N·m (18 lb ft).
6. Install the generator. Refer to *Generator Replacement (Gas, CS 144)* in Engine Electrical.
7. Install the drive belt. Refer to *Drive Belt Replacement.*
8. Connect the battery negative cable. Refer to *Battery Cable* in Engine Electrical.
9. Install the engine cooling fan. Refer to *Fan Clutch Replacement (7.4L)* in Engine Cooling.

Engine Mount Inspection

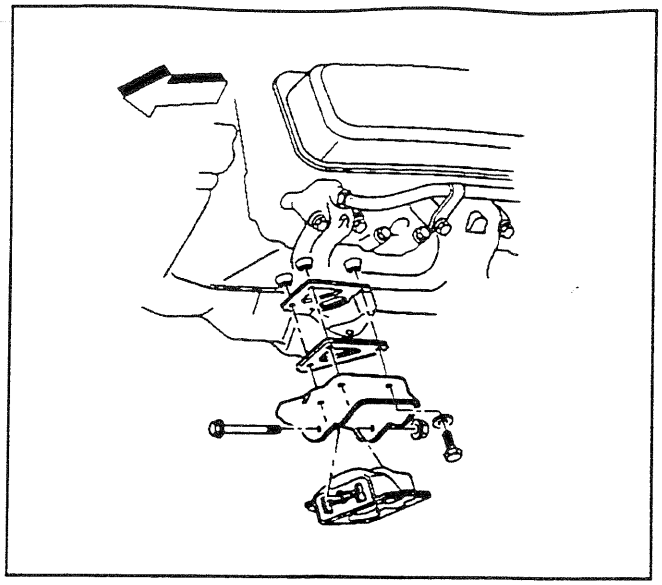
SIE-ID = 600655

Front Engine Mount

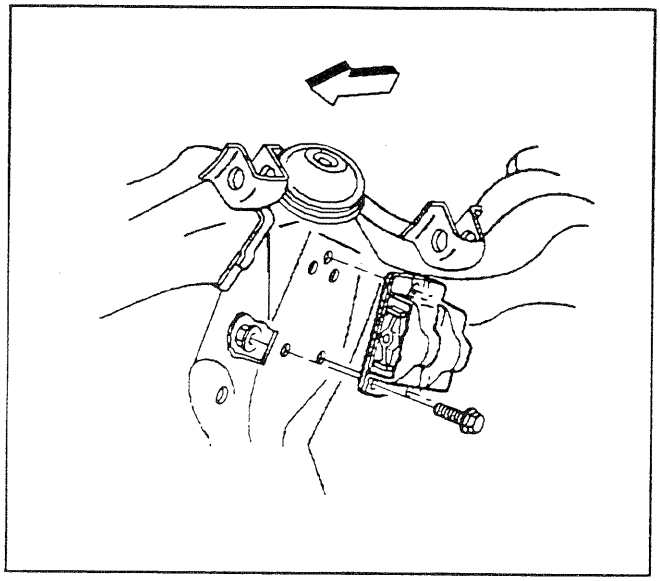
Notice: SIO-ID = 5167 Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Notice: SIO-ID = 5168 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.

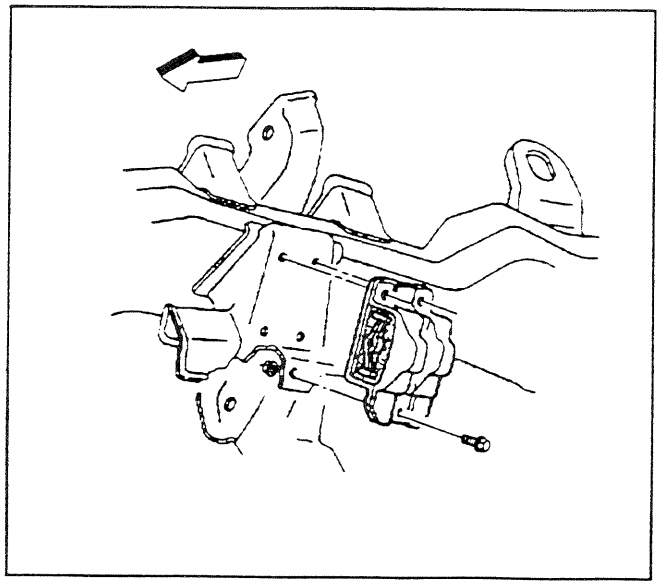
1. Raise the engine in order to remove the weight from the mount and to place a slight tension on the rubber cushion. Observe both mount while raising the engine.
2. Replace the mount if any of the following conditions exist:
   - Hard rubber surface covered with heat check cracks
   - The rubber cushion separated from the metal plate of the mount
   - The rubber cushion is split through the center
3. If there is movement between a metal plate of the mount and its attaching points, lower the engine and tighten the bolts or nuts attaching the mount to the engine, the frame or the bracket.



66191



66189



66190

Engine Mount Replacement

SIE-ID = 506406

Removal Procedure

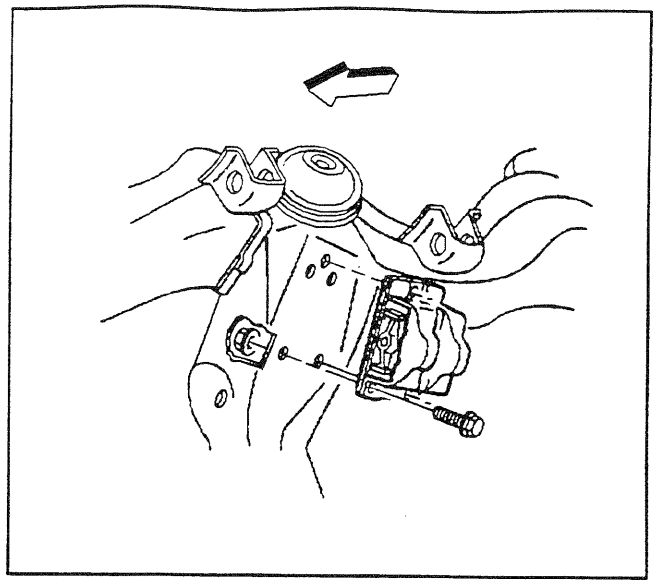
1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.

Notice: SIO-ID = 5168 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.

2. Support the engine with a suitable jack. Do not load the engine mounts.
3. Remove the engine mount through bolt and the nut.
4. Raise the engine only enough to permit removal of the engine mount.
5. If servicing a 2 wheel drive model truck, remove the engine mount assembly bolts, nuts, and washers.
6. Remove the engine mount assembly.
7. If servicing a 4 wheel drive model truck, remove the engine mount assembly bolts, nuts, and washers.
8. Remove the engine mount assembly.

Installation Procedure

1. If servicing a 2 wheel drive model truck, install the engine mount assembly.



66189

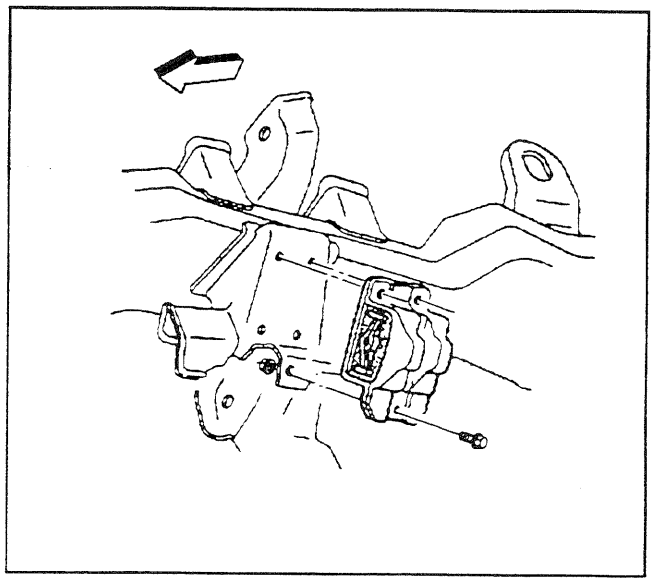
2. If servicing a 4 wheel drive model truck, install the engine mount assembly.

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

3. Install the engine mount assembly bolts, nuts, and washers.

   Tighten

   - Tighten the bolts to 59 N·m (44 lb ft).
   - Tighten the nuts to 45 N·m (33 lb ft).

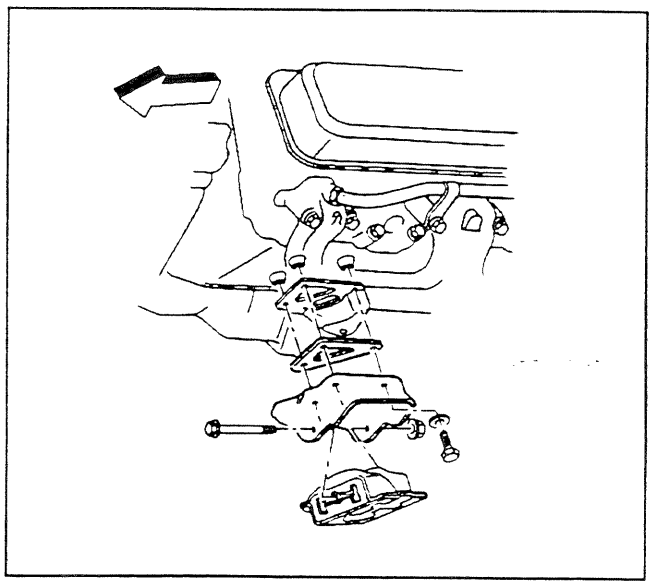


66190

4. Lower the engine until the engine mount through bolt can be inserted.
5. Install the engine mount through bolt and the nut.

   Tighten

   Tighten the through bolt nut to 68 N·m (50 lb ft).
6. Connect the battery negative cable. Refer to *Battery Cable* in Engine Electrical.



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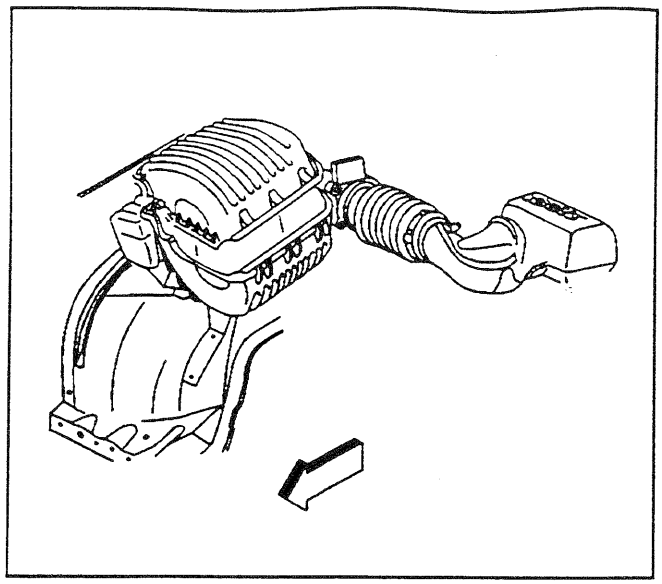


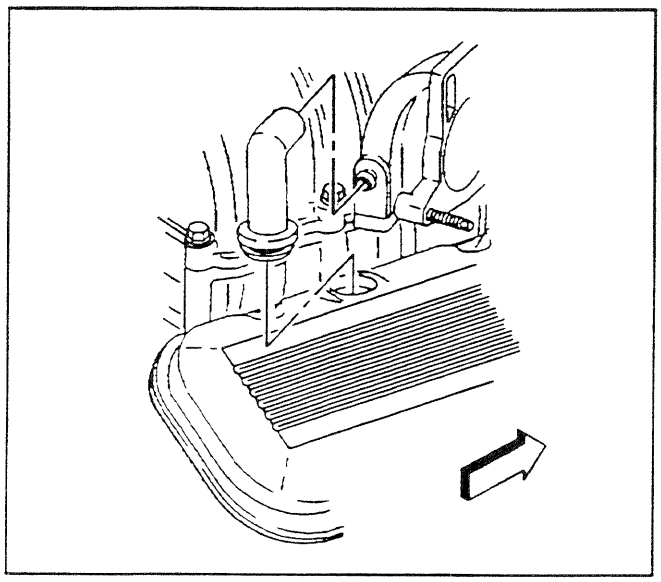
308291

Intake Manifold Replacement (Upper Intake Manifold)

SIE-ID = 506410

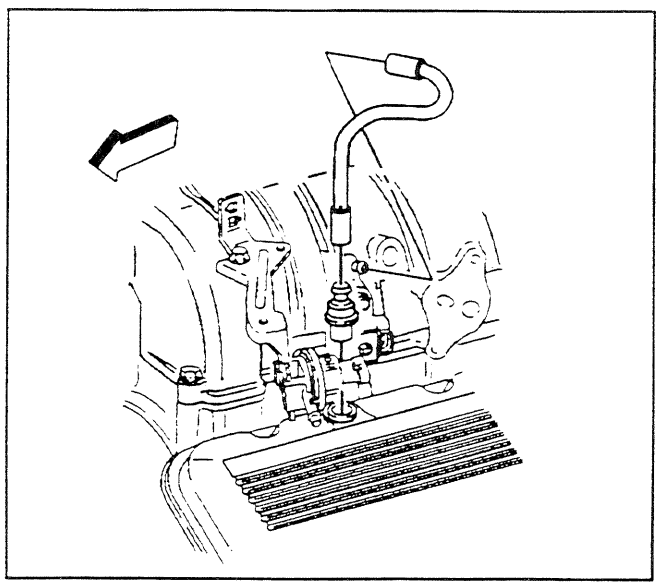
Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the intake air resonator from the throttle body. Refer to *Air Cleaner Element Replacement* in Engine Controls–7.4L.
3. Remove the air cleaner intake duct from the throttle body. Refer to Air *Air Cleaner Assembly Replacement* in Engine Controls–7.4L.



173189

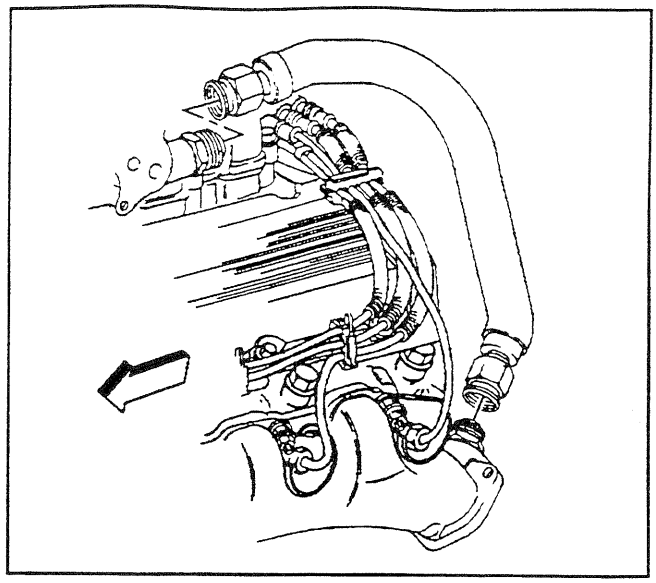
4. Remove the crankcase vent tube from the throttle body.



173187

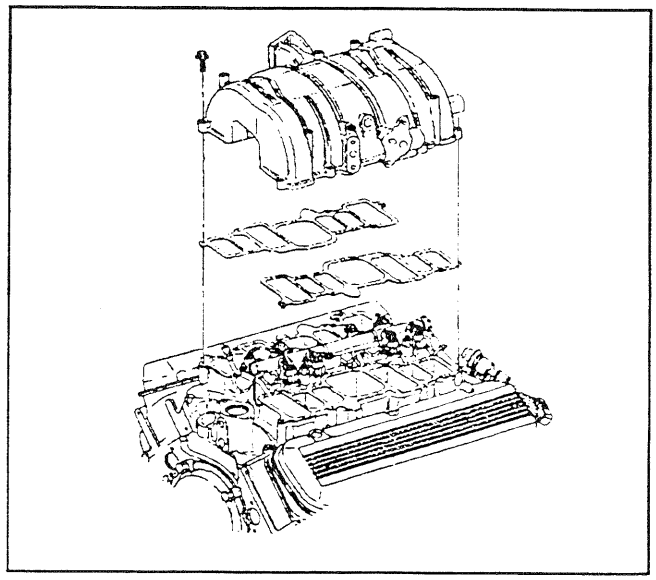
5. Remove the PCV valve from the valve rocker arm cover.

6. Remove the EGR pipe from the upper intake manifold. Refer to *EGR Pipe Replacement* in Engine Controls.
7. Remove Left and Right Side Secondary AIR Injection Pipe. If so Equipped. Refer to *Sec Air Injection Check Valve/Pipe Replacement* in engine controls.
8. Remove the ignition coil from the intake manifold. Refer to *Ignition Coil and ICM Replacement (HVS 7.4L)* in Engine Electrical.
9. Remove the throttle body from the upper intake manifold. Refer to *Throttle Body Assembly Replacement.*
10. Remove the EVAP canister solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls–7.4L.
11. Remove the number 8 spark plug wire from the distributor. Refer to *Spark Plug Wire Harness Replacement (7.4 L)* in Engine Electrical.



173284

12. Remove the upper intake manifold bolts.
13. Remove the upper intake manifold and gaskets.
14. Clean the excessive carbon deposit from the exhaust and the EGR valve passages. Refer to *Cylinder Head Clean and Inspect.*



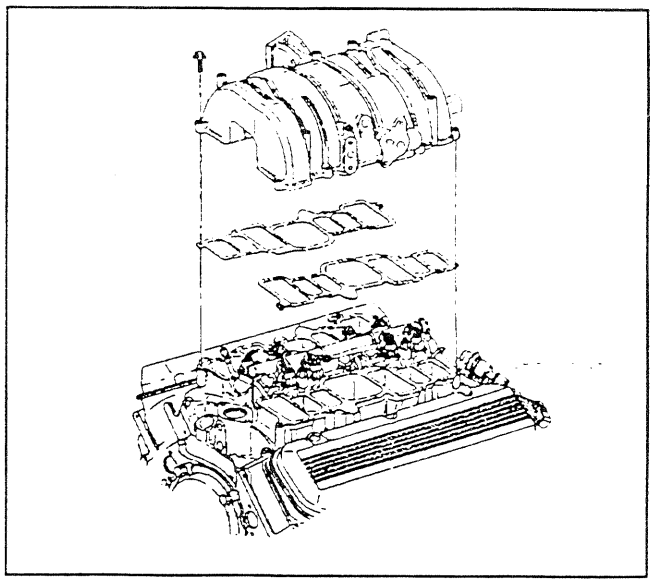
64529

Installation Procedure

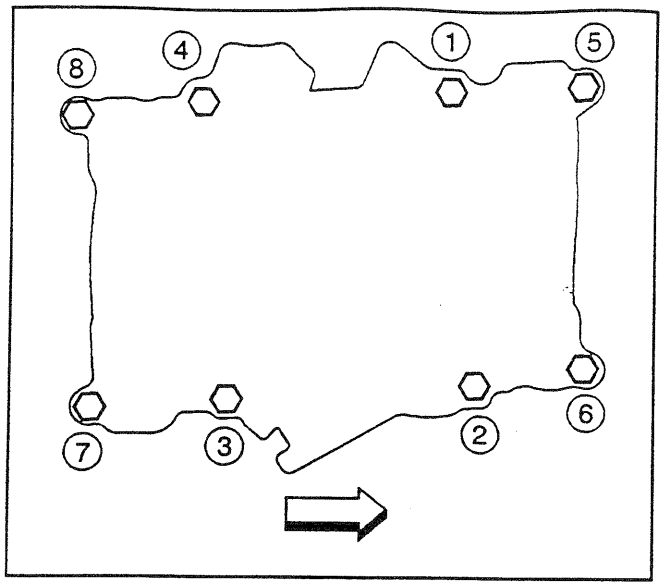
1. Install the upper intake manifold gaskets.
2. Install the upper intake manifold.

Important: Failure to follow the procedure listed, could cause a driveability problem.

3. Coat a minimum of eight threads of the bolts with thread locking sealant.



64529



67778

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

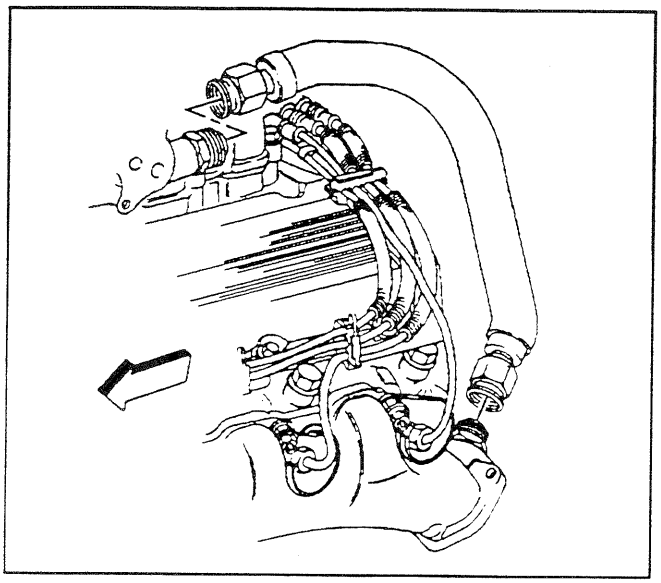
4. Install the upper intake manifold bolts.

   Tighten

   4.1. Tighten the bolts in sequence to 30 N·m (22 lb ft).

   4.2. Re tighten the bolts in sequence to 40 N·m (30 lb ft).

5. Install the number 8 spark plug wire. Refer to *Spark Plug Wire Harness Replacement (7.4 L)* in Engine Electrical.
6. Install the ignition coil to the upper intake manifold. Refer to *Ignition Coil and ICM Replacement (HVS 7.4L)* in Engine Electrical.
7. Install the EGR valve if necessary. Refer to *Sec Air Injection Check Valve/Pipe Replacement* in Engine Controls.



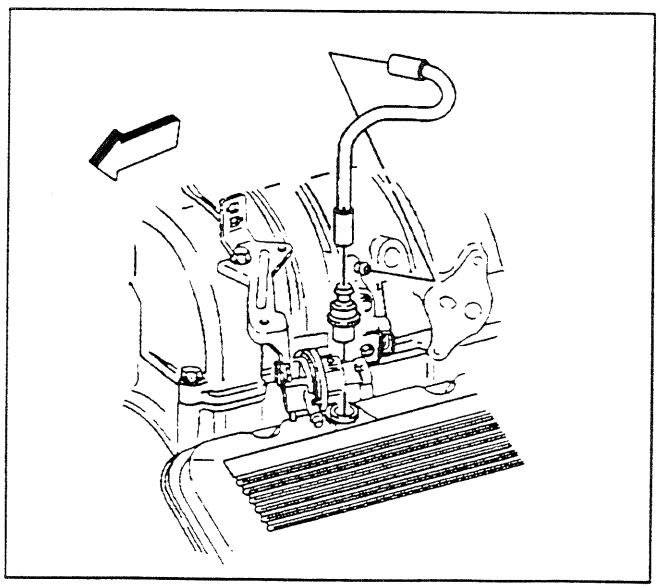
173284

8. Install the EGR pipe to the upper intake manifold.

   Tighten

   Tighten EGR valve fittings to 60 N·m (46 lb ft).

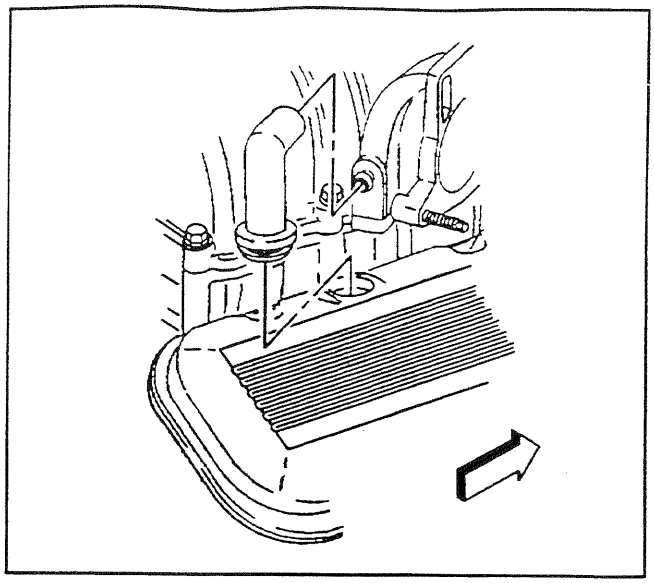
9. Install Left and Right Side Secondary AIR Injection Pipes. If so equipped. Refer to *Sec Air Injection Check Valve/Pipe Replacement* in Engine Controls.
10. Install the EVAP canister solenoid valve to the intake manifold. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls
11. Install the throttle body to the upper intake manifold. Refer to *Throttle Body Assembly Replacement.*



173187

12. Install the PCV valve to the valve rocker arm cover to the cylinder head.

13. Install the crankcase vent tube to the valve rocker arm cover.
14. Install the air cleaner intake duct to the throttle body. Refer to *Air Cleaner Assembly Replacement* in Engine Controls.
15. Install the intake air resonator to the throttle body. Refer to *Air Cleaner Element Replacement* in Engine Controls.
16. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.



173189

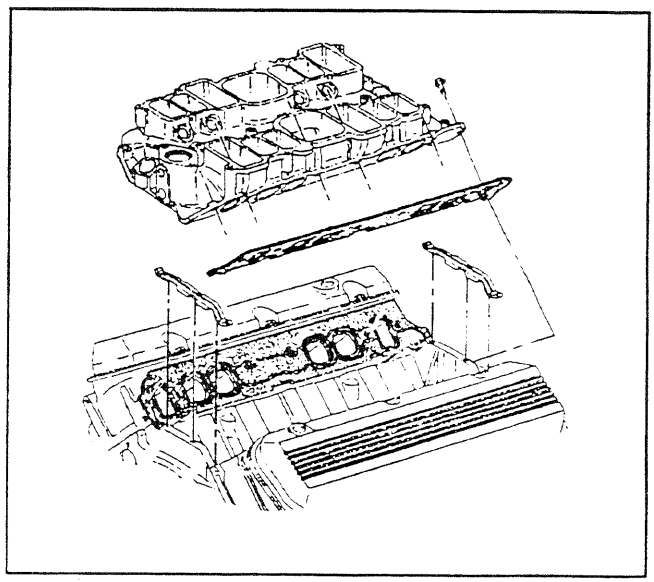
Intake Manifold Replacement (Lower Intake Manifold)

SIE-ID = 506415

Removal Procedure

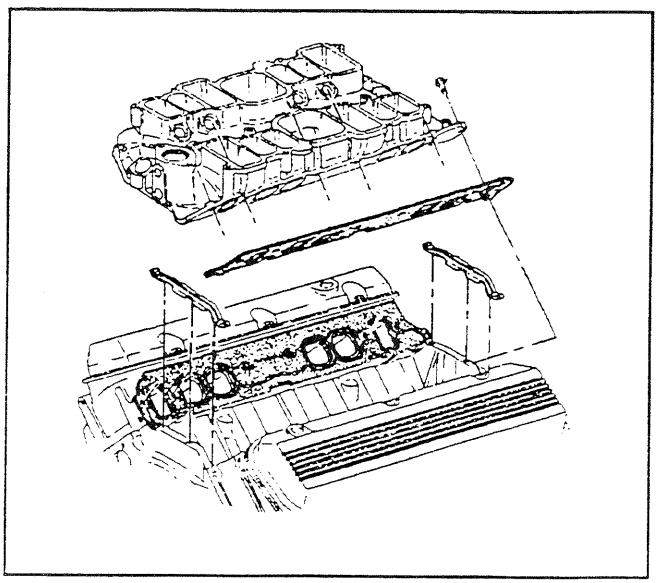
Important: The lower intake manifold gaskets and seals are reusable. Replace only the gaskets and seals if they are damaged.

1. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
2. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
3. Remove the upper intake manifold from the lower intake manifold.
4. Remove the suction line from Air Conditioning from the A/C compressor. Refer to *Heater Hoses Replacement (Inlet Hose - 5.7L, 7.4L)* in HVAC.
5. Remove the distributor from the lower intake manifold. Refer to *Distributor Replacement (7.4L)* in Engine Electrical.
6. Remove the MAP sensor from the lower intake manifold. Refer to *MAP Sensor Replacement* in Engine Controls.
7. Remove the radiator hose from the thermostat. Refer to *Radiator Hose Replacement (7.4L)* in Engine Cooling.
8. Remove the thermostat housing from the lower intake manifold from the engine block. Refer to *Thermostat Replacement (Gas)* in Engine Cooling.
9. Remove the heater hoses from the heater core. Refer to *Heater Hoses Replacement (Inlet Hose - 5.7L, 7.4L)* and *Heater Hoses Replacement (Outlet Hose - 7.4L)* in Engine Cooling.
10. Remove the coolant bypass hose from the lower intake manifold and the water pump.



64532

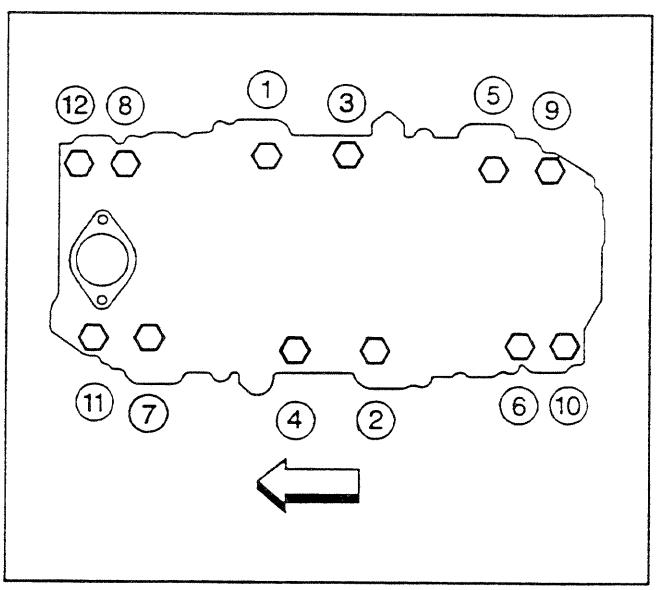
11. Remove the retaining bolts for the fuel rail. Refer to *Fuel Rail Assembly Replacement* in Engine Controls.
12. Remove the fuel rail from the lower intake manifold. Refer to *Fuel Rail Assembly Replacement* in Engine Controls.
13. Remove the lower intake manifold bolts from the engine head.
14. Remove the lower intake manifold from the cylinder head.
15. Remove the lower intake manifold gaskets and seals from the cylinder head.
16. Clean all sealing surfaces of oil and grease. Refer to *Intake Manifold Clean and Inspect (Lower)*.



64532

Installation Procedure

1. Install the lower intake manifold gaskets to the cylinder head with THIS SIDE UP stamped facing up.
2. Install the lower intake manifold to the engine block.
3. Apply bolt thread locking material to the lower intake manifold bolts.



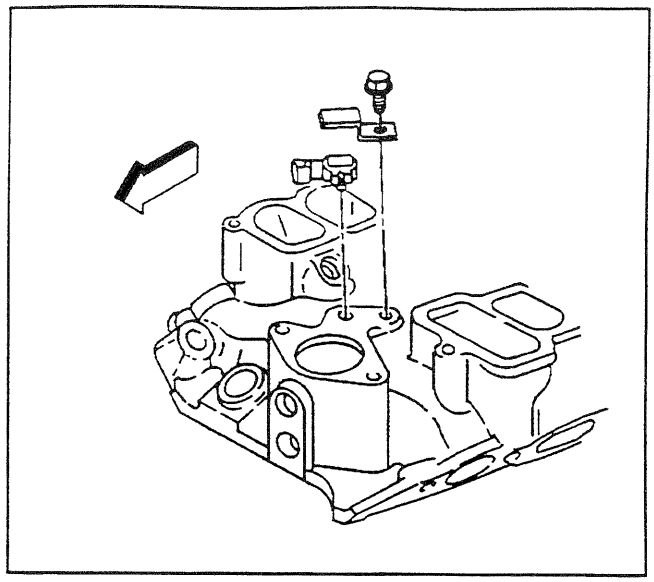
67780

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

4. Install the lower intake manifold bolts to the engine head.
   - **Tigthen**

     Tighten the bolts in sequence to 30 N·m (22 lb ft).
   - Re-tighten the bolts in sequence to 40 N·m (30 lb ft).
5. Install the fuel rail to the lower intake manifold. Refer to *Fuel Rail Assembly Replacement* in Engine Controls.
6. Install the fuel rail retaining bolts. Refer to *Fuel Rail Assembly Replacement* in Engine Controls.
7. Install the coolant bypass hose to the water pump.
8. Install the heater hoses to the lower intake manifold. Refer to *Heater Hoses Replacement (Inlet Hose - 5.7L, 7.4L)* and *Heater Hoses Replacement (Outlet Hose - 7.4L)* in Engine Cooling.
9. Install the thermostat housing to the lower intake manifold from the engine block. Refer to *Thermostat Replacement (Gas)* in Engine Cooling.

10. Install the MAP sensor to the lower intake manifold. Refer to *MAP Sensor Replacement* in Engine Controls.
11. Install the radiator hose to the thermostat housing. Refer to *Heater Hoses Replacement (Inlet Hose - 5.7L, 7.4L)* or *Heater Hoses Replacement (Outlet Hose - 7.4L)* in Engine Cooling.
12. Install the distributor to the engine block. Refer to *Distributor Replacement (7.4L).*
13. Install the suction hose to the A/C compressor. Refer to *Heater Hoses Replacement (Inlet Hose - 5.7L, 7.4L)* in HVAC.
14. Install the upper intake manifold to the lower intake manifold. Refer to *Intake Manifold Installation.*
15. Install the discharge line to the A/C compressor. Refer to *Compressor Hose Assembly Replacement (Gasoline Engines)* in HVAC.
16. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
17. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



19673

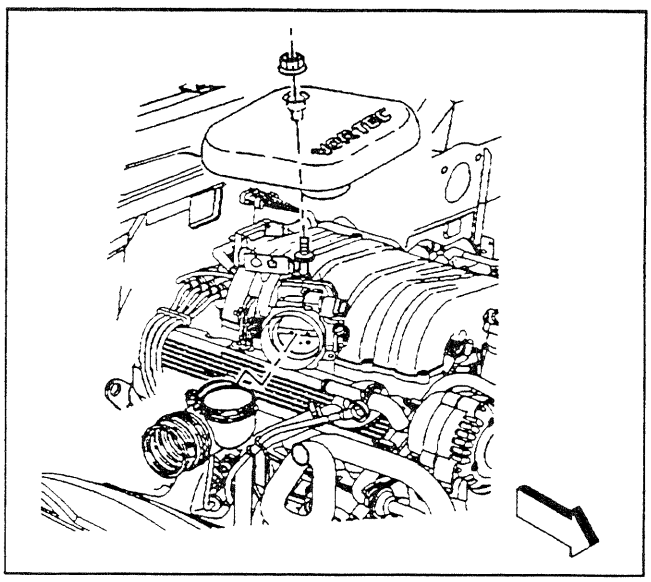
Valve Rocker Arm Cover Replacement

SIE-ID = 506422

Removal Procedure

Important: Valve rocker arm cover gaskets are reusable. Replace the valve rocker arm cover gasket only if damaged.

1. Remove the intake air resonator. Refer to *Air Cleaner Assembly Replacement* in Engine Controls 7.4L.
2. Remove the air cleaner intake duct from the throttle body. Refer to *Air Cleaner Assembly Replacement* in Engine Controls 7.4L.
3. Remove the spark plug wires from the spark plugs. Refer to *Spark Plug Replacement* in Engine Electrical.



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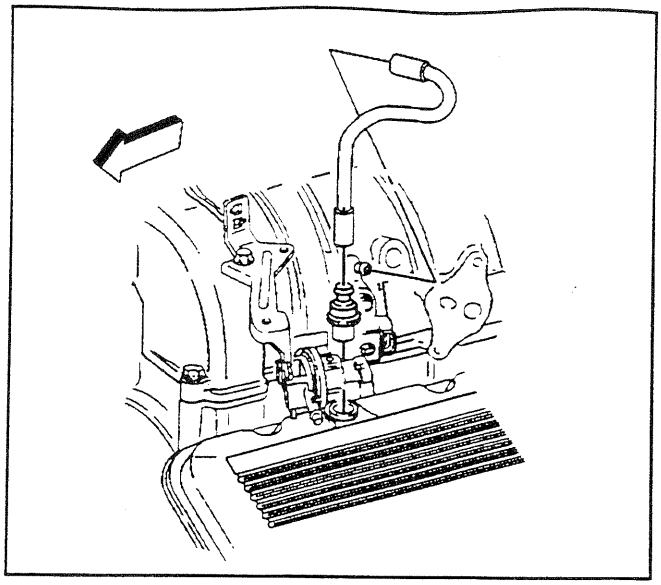
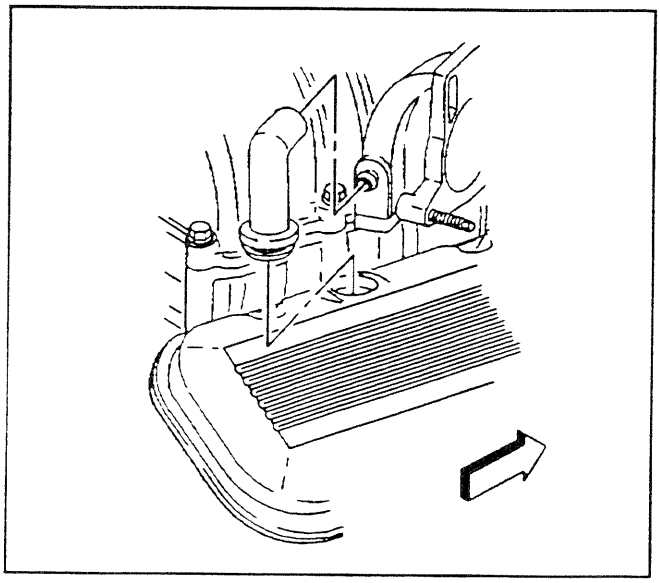


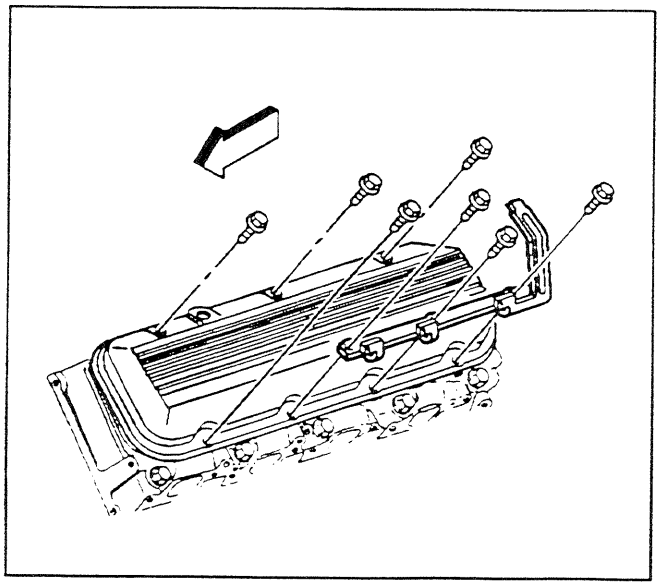
173187

4. Remove the PVC valve from then valve rocker arm cover if necessary.



173189

5. Remove the engine vent tube from the throttle body if necessary.
6. Remove the throttle body from the intake manifold if necessary. Refer to *Throttle Body Assembly Replacement.*



354009

7. Remove the valve rocker arm cover bolts.
8. Remove the valve rocker arm cover from the cylinder head.

Installation Procedure

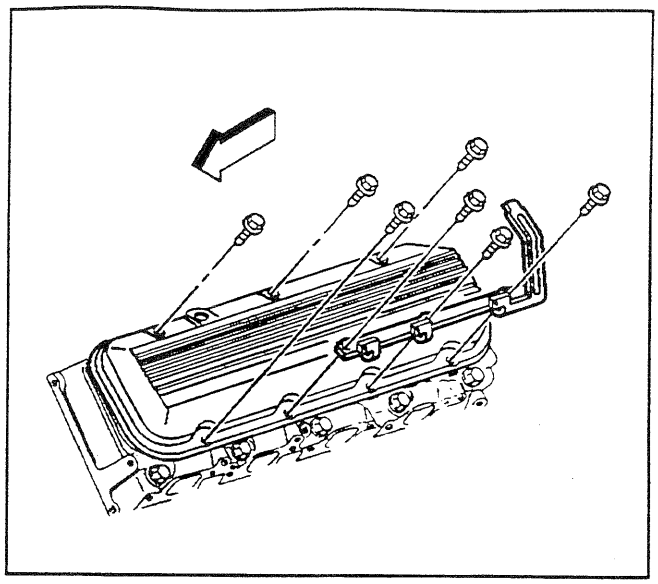
1. Install the valve rocker cover gasket to the cylinder head.
2. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Installation (Left)* and *Valve Rocker Arm Cover Installation (Right).*

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

3. Install the valve rocker arm cover bolts.

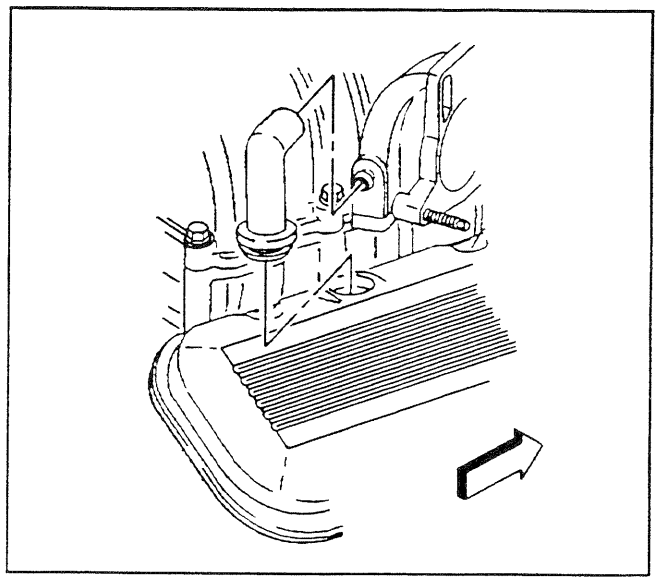
   Tighten

   Tighten the bolts to 8 N·m (71 lb in).
4. Install the throttle body to the upper intake manifold. Refer to *Throttle Body Assembly Replacement.*



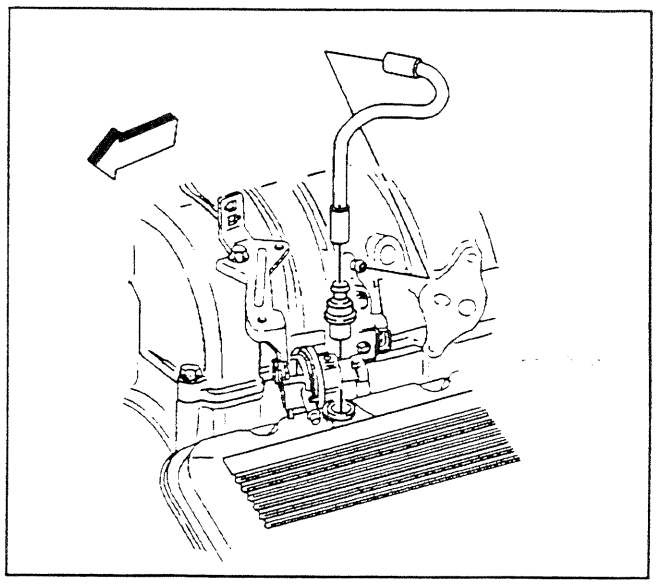
354009

5. Install the engine vent tube to the throttle body if necessary.



173189

6. Install the PVC valve to the valve rocker arm cover if necessary.
7. Install the spark plug wires to the spark plugs. Refer to *Spark Plug Replacement* in Engine Electrical.
8. Install the intake air resonator to the throttle body. Refer to *Air Cleaner Assembly Replacement* in Engine Controls.
9. Install the air cleaner intake duct. Refer to *Air Cleaner Assembly Replacement* in Engine Controls.



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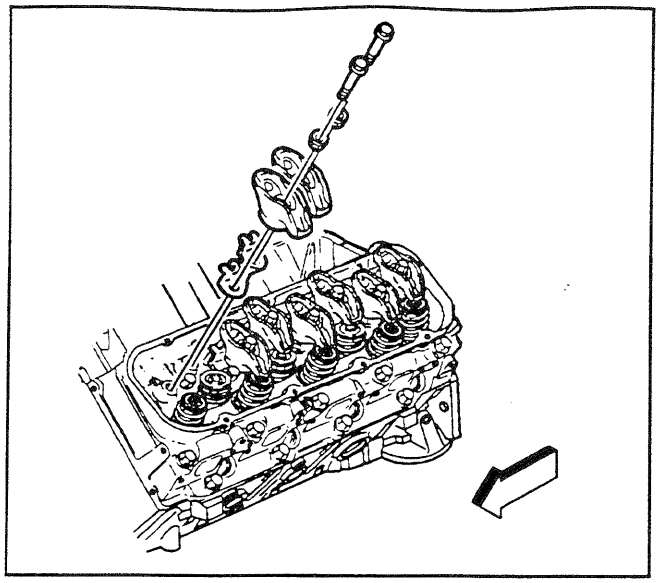
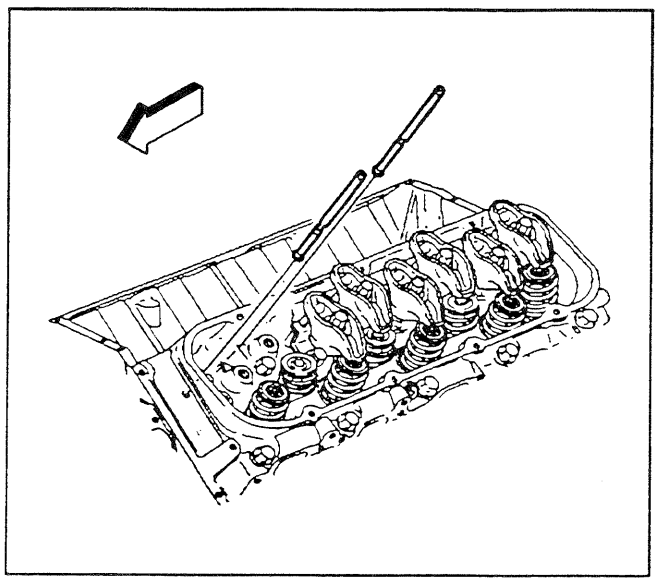


354070



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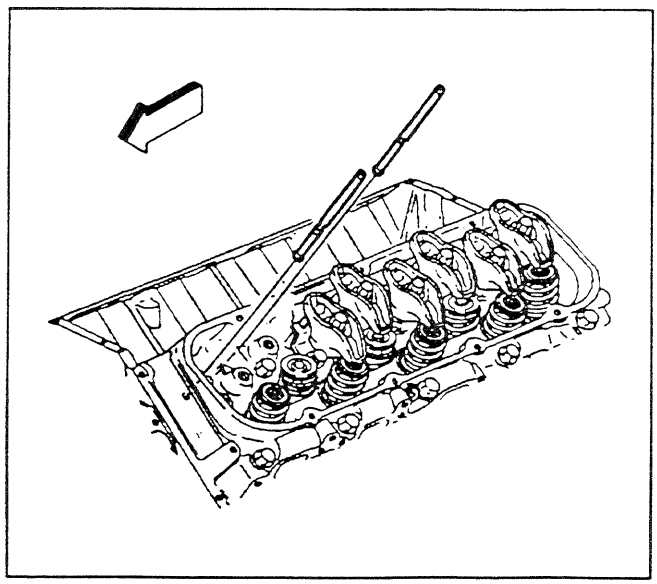


202196

Valve Rocker Arm and Push Rod Replacement

SIE-ID = 506426

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*

Important: If the push rod is the only item to be replaced, loosen the valve rocker arm bolt until the valve rocker arm can be rotated so the push rod can be removed.

3. Remove the valve rocker arm bolt from the cylinder head.
4. Remove the valve rocker arm and guide from the cylinder head.
5. Remove the pushrod from the engine block.

Installation Procedure

Important: Make sure that the pushrod is properly seated in the valve lifter.

1. Install the pushrod into the engine block.

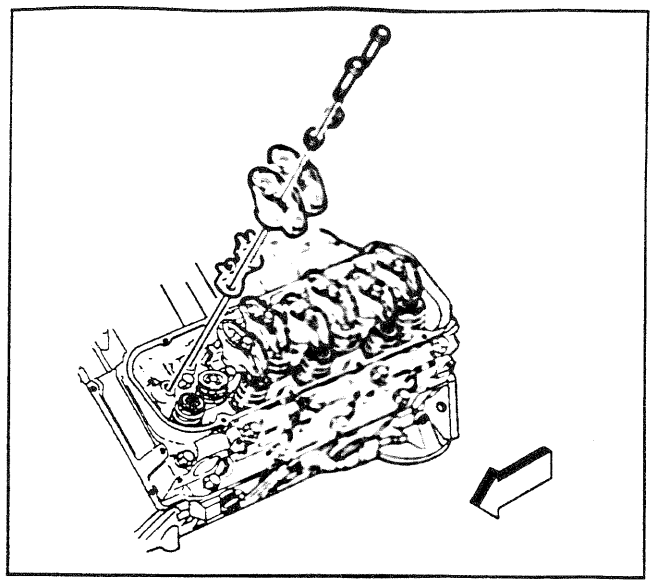
Important: When a new valve rocker arm and balls are installed, coat the bearing surfaces with clean engine oil.

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

2. Install the valve rocker arm bolt to the cylinder head.

   Tighten

   Tighten The bolts to 54 N·m (40 lb ft).
3. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
4. Connect the battery negative to the battery. Refer to *Battery Cable* in Engine Electrical.



354070

Valve Stem Oil Seal and Valve Spring Replacement

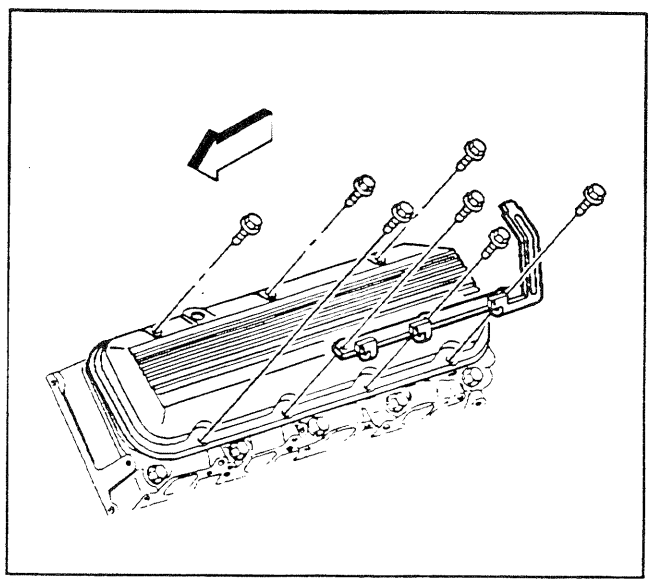
SIE-ID = 506430

Removal Procedure

Tools Required

- *J 5892-C* Valve Spring Compressor
- *J 22794* Spark Plug Port Adapter

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in engine electrical.
2. Remove the valve rocker arm cover from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
3. Rotate the crankshaft until both valves are closed before installing the compressed air into the cylinder being serviced.



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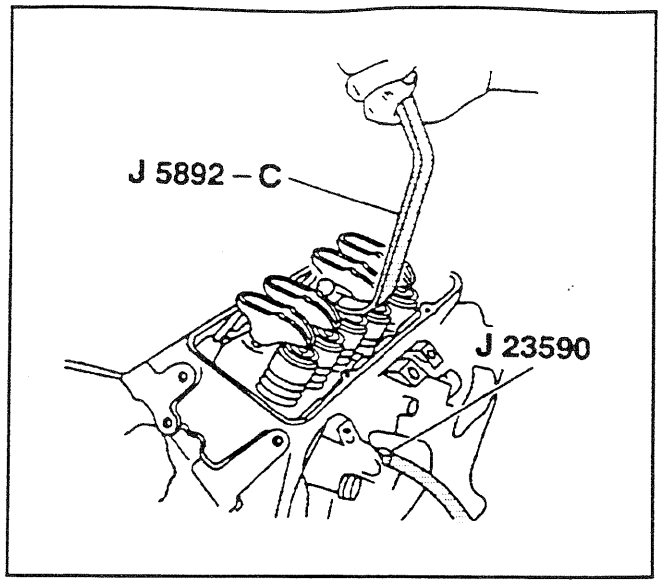
Important: Rotate the cylinder being serviced to the bottom of the stroke, to ensure that the engine does not rotate when the compressed air is applied to the cylinder being serviced.

4. Remove the valve rocker arm from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
5. Remove the valve push rod from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
6. Remove the spark plugs from the cylinder head. Refer to *Spark Plug Wire Harness Replacement (7.4 L)* in Engine Electrical.



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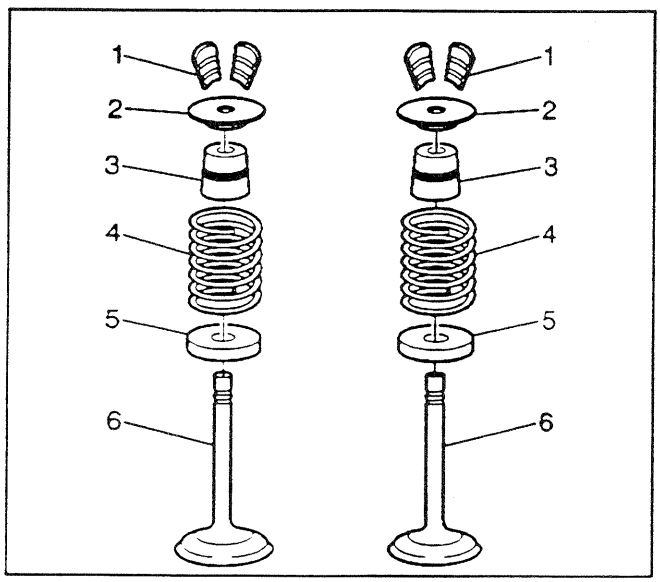


35216

7. Remove the valve keepers as followed:
   7.1. Install the *J 22794* into the spark plug hole.
   7.2. Apply compressed air into the cylinders in order to hold the valves closed.
   7.3. Lightly tap the valve spring retainer to loosen the valve keepers.
   7.4. Install the *J 5892-C* to the cylinder head.
   7.5. Install the valve rocker arm bolt.

Important: Tighten the valve rocker arm bolt enough to hold *J 5892-C* in place while compressing the valve and valve spring assembly.

   7.6. Use the *J 5892-C* to compress the valve spring assembly.
   7.7. Remove the valve keepers.

Important: Do not release the compressed air from the cylinder being worked on. The valve will fall into the cylinder bore.

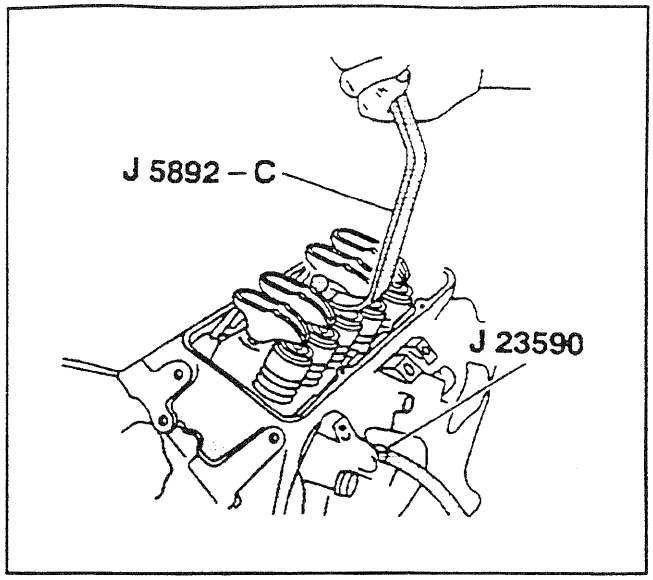
   7.8. Carefully release the spring tension and remove the *J 5892-C*.
   7.9. Remove the *J 5892-C* from the cylinder head.
8. Remove the valve spring retainer (2) and the valve spring (4) from the cylinder head.
9. Remove the valve stem oil seal from the valve guide.

Installation Procedure

Tools Required

- *J 5892-C* Valve Spring Compressor
- *J 22794* Spark Plug Port Adapter

1. Install the valve stem oil seal to the valve guide.
2. Install the valve spring retainer and the spring.
3. Use the *J 5892-C* to install the valve springs and keepers to the cylinder head.
4. Install the valve keepers to the valve as follows:
   4.1. With the compressed air still applied, use the *J 5892-C* to compress the valve spring assembly.
   4.2. Install the valve keepers to the valve being worked on. Apply a small amount of clean grease to hold the valve keepers in place.
   4.3. Carefully release the tension on the valve spring assembly. Make sure the valve keepers do not move while releasing the tension.
   4.4. Remove the *J 5892-C* from the valve assembly.
   4.5. Carefully release the compressed air from the cylinder being worked on.
5. Install the spark plugs to the cylinder head into the cylinder being serviced. Refer to *Spark Plug Wire Harness Replacement (7.4 L)* in Engine Electrical.
6. Install the valve rocker arms to the cylinder head to the cylinder being serviced. Refer to *Valve Rocker Arm and Push Rod Replacement.*
7. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
8. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.



66450

Valve Lifter Replacement

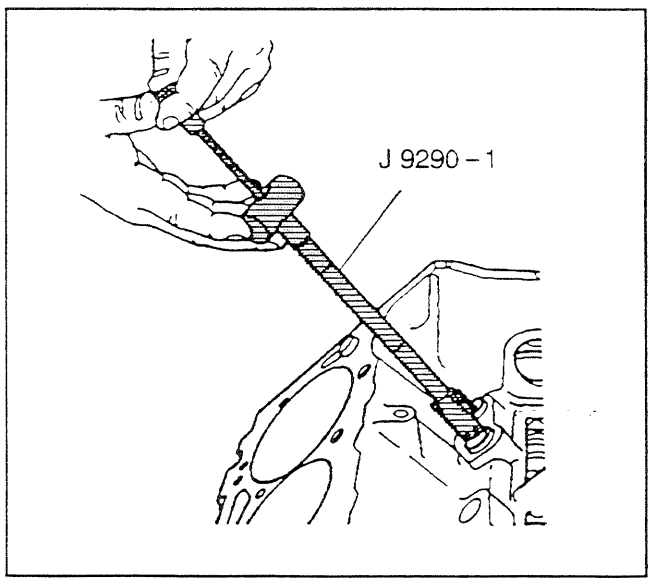
SIE-ID = 506435

Removal Procedure

Tools Required

J 3049-A Valve Lifter Remover (Slide Hammer Type)

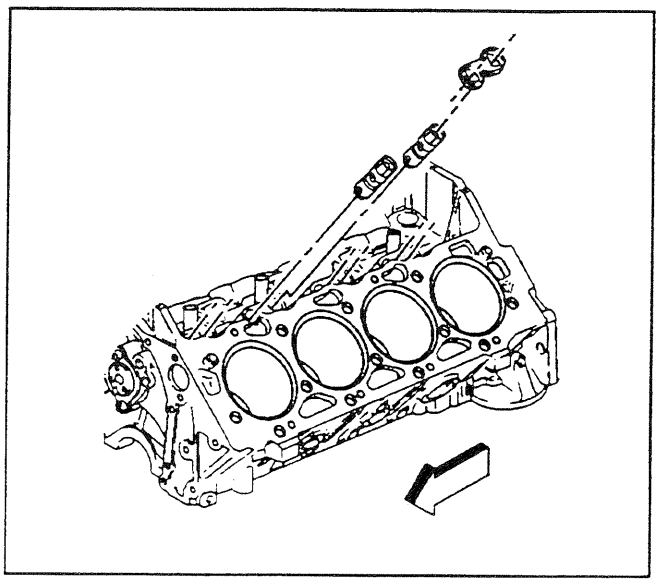
1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*
3. Remove the lower intake manifold from the cylinder heads. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
4. Remove the valve rocker arm cover from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*



34571

5. Remove the valve rocker arm from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
6. Remove the push rod from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
7. Remove the valve lifters one at a time. Place the valve lifters in an organizer rack in order to ensure that the valve lifters are later returned to the original bore during installation.

   A stuck valve lifter can be removed using *J 3049-A.*

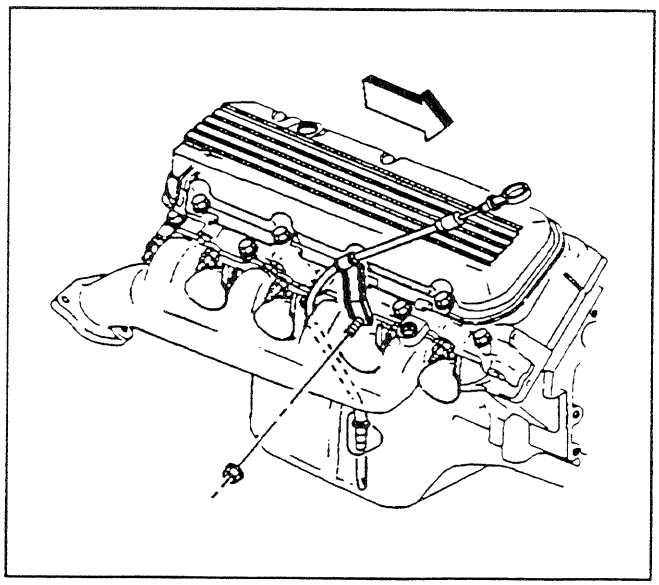


173176

Installation Procedure

Important: Replace the engine oil and oil filter if new valve lifters or a new camshaft is installed.

1. Install the valve lifters and guide into the engine block. Lubricate the valve lifter and the body with clean engine oil.
2. Install the push rods into the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
3. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
4. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
5. Install the lower intake manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
6. Install the upper intake manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*
7. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



173184

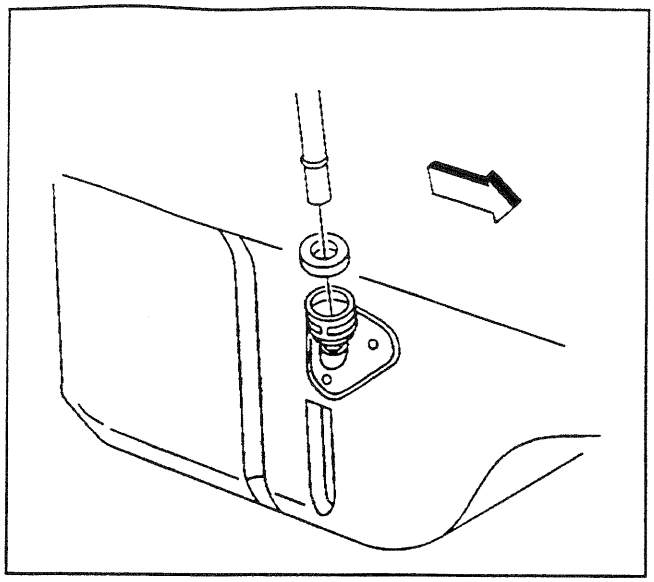
Oil Level Indicator and Tube Replacement

SIE-ID = 506436

Removal Procedure

1. Remove the retaining nut for the oil level indicator tube.
2. Remove the oil level indicator and tube from the engine block.

3. Remove the O-ring from the oil level indicator tube.

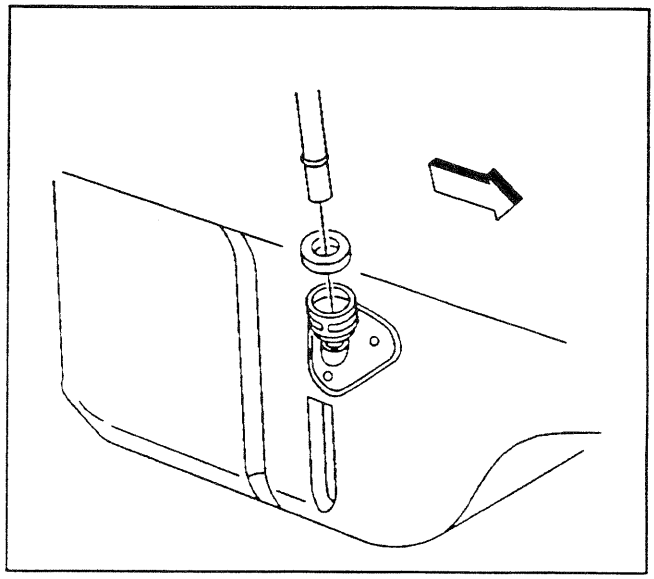


173185

Installation Procedure

Important: When installing the oil level indicator tube to the engine, always use a new O-ring.

1. Install the new O-ring on the oil level indicator tube.
2. Apply clean engine oil to the oil level indicator tube O-ring.



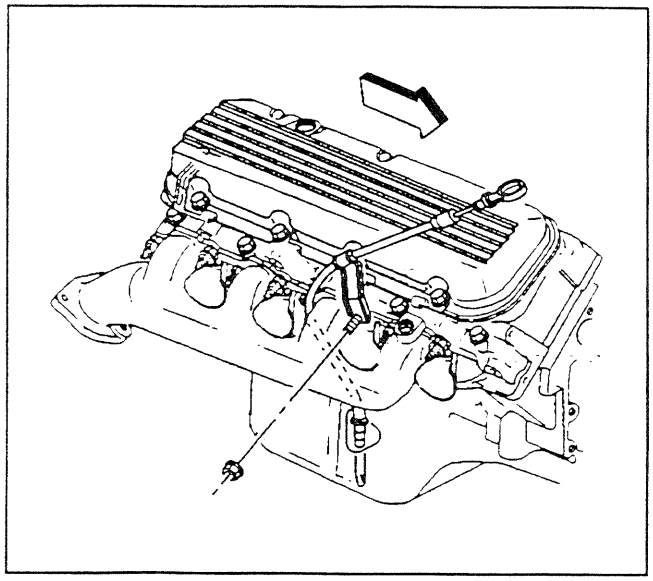
173185

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

3. Install the oil level indicator tube and retaining nut to the engine.

   Tighten

   Tighten the oil level indicator tube nut to 54 N·m (40 lb ft).



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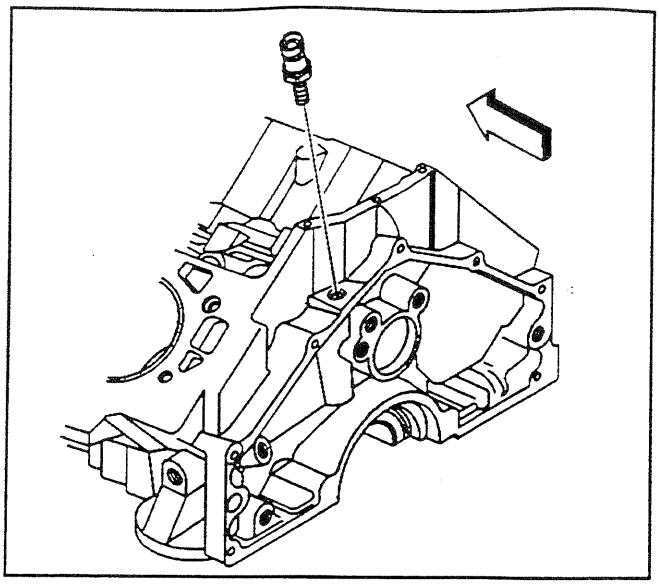


351829

Engine Oil Pressure Sensor/Switch Replacement

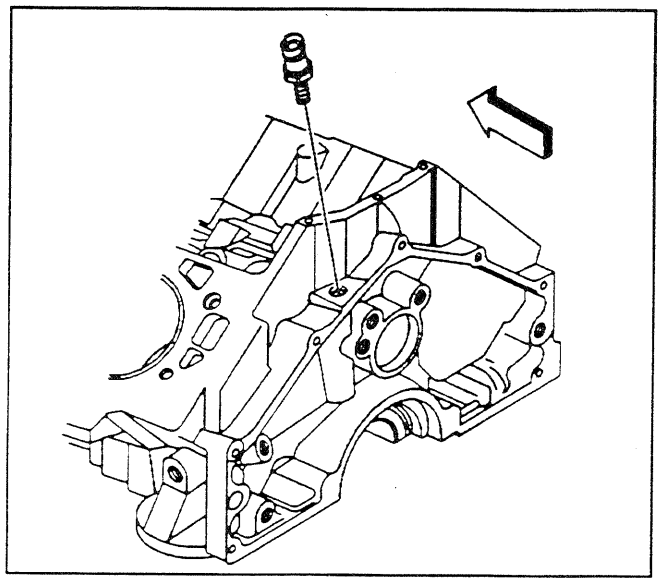
SIE-ID = 506443

Removal Procedure

Tools Required

J 25254-10 A Oil Pressure Sensor Socket

1. Disconnect the electrical connector from the engine pressure sensor / switch.
2. Remove the oil pressure sensor using *J 25254-10 A*.



351829

Installation Procedure

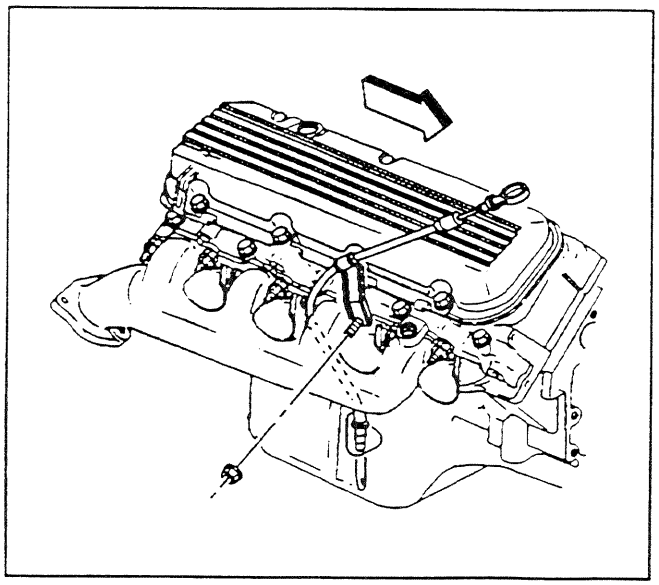
Tools Required

J 25254-10 A Oil Pressure Sensor Socket.

1. Install the oil pressure sensor.
2. Hold the oil pressure sensor fitting with a wrench to prevent from turning.

   Tighten

   Using *J 25254-10 A* tighten the oil pressure sensor to 30 N·m (22 lb ft).
3. Install the electrical connector.



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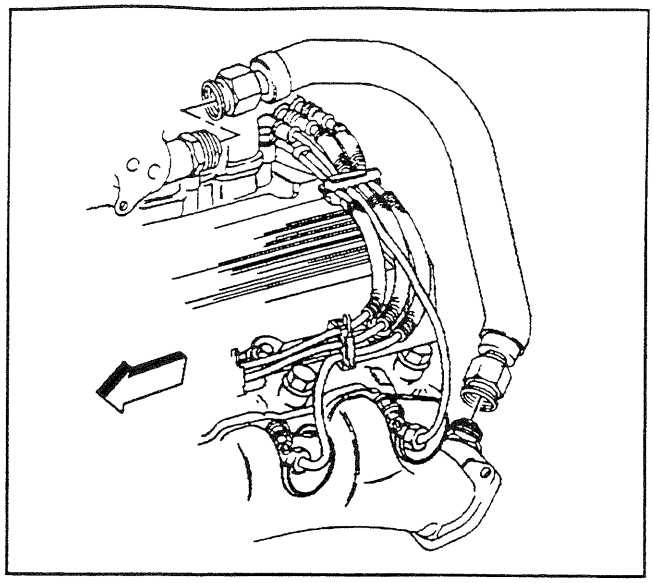
Exhaust Manifold Replacement

SIE-ID = 506447

Removal Procedure

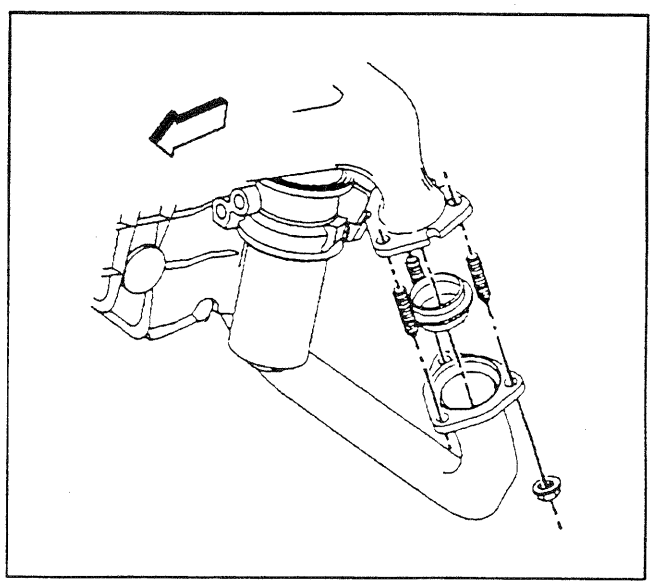
1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the oil level indicator and tube from the engine block. Refer to *Oil Level Indicator and Tube Replacement*.

3. Remove the EGR valve pipe from the left exhaust manifold.
4. Remove the spark plugs cylinder head. Refer to *Spark Plug Replacement* in Engine Electrical.
5. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.



173284

6. Remove the exhaust pipe from the exhaust manifold.
   - For vehicles under 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, Below 8600 lb (GVWR))* in Engine Controls.
   - For vehicles above 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, 8600 lb and Above)* in Engine Controls.
7. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
8. Remove the left side exhaust manifold. Refer to *Exhaust Manifold Removal (Left)* and *Exhaust Manifold Removal (Left with RPO K19).*
9. Remove the right side exhaust manifold. Refer to *Exhaust Manifold Removal (Right)* and *Exhaust Manifold Removal (Right with RPO K19).*
10. Remove the exhaust manifold gasket from the cylinder head.
11. Clean and check the gasket mating surface and the cylinder head. Refer to *Exhaust Manifold Clean and Inspect (without RPO K19)* or *Exhaust Manifold Clean and Inspect (with RPO K19).*



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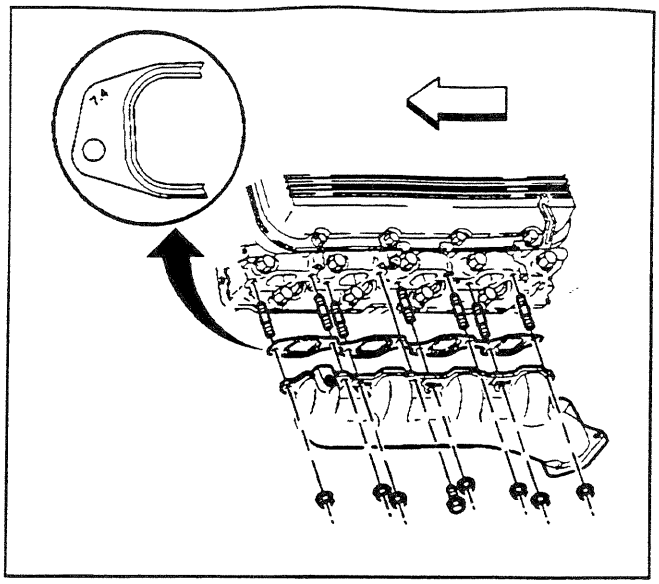

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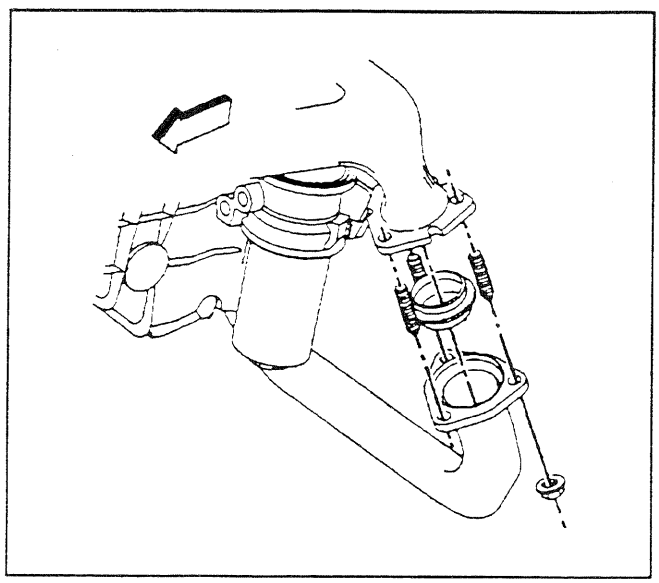

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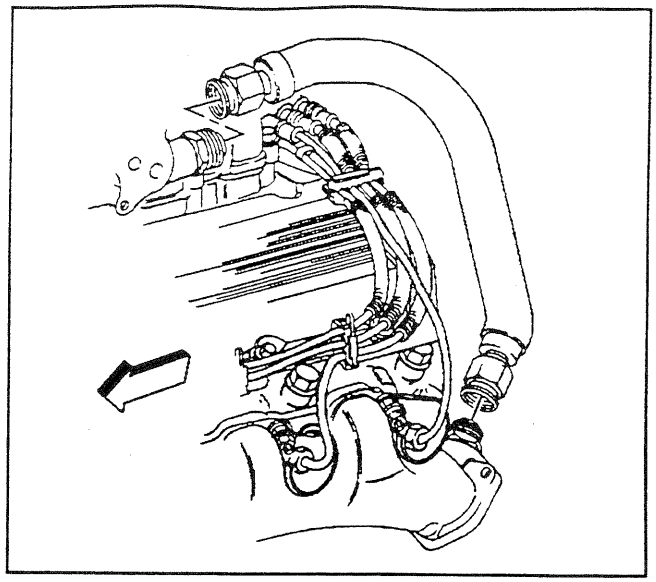
Installation Procedure

Important: Install the exhaust manifold gasket with the stamped 7.4 facing away from the cylinder head.

1. Install the exhaust manifold gaskets to the cylinder heads.
2. Install the left side exhaust manifold to the cylinder head. Refer to *Exhaust Manifold Installation (Left)* or *Exhaust Manifold Installation (Left Side with RPO K19).*
3. Install the right side exhaust manifold to the cylinder head. Refer to *Exhaust Manifold Installation (Right)* or *Exhaust Manifold Installation (Right Side with RPO K19).*
4. Install the left side spark plug heat shields.
5. Install the right side spartk plug heat shields.
6. Install the oil level indicator tube to the exhaust manifold. Refer to *Oil Level Indicator and Tube Replacement.*
7. Install the spark plugs to the cylinder head. Refer to *Spark Plug Replacement* in Engine Electrical.
8. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
9. Install the exhaust pipes to the exhaust manifolds.
   - For vehicle under 8600 GVWR, refer to *Catalytic Converter Replacement (Gas, Below 8600 lb (GVWR))* in Engine Controls.
   - For vehicles above 8600 GVWR, refer to *Catalytic Converter Replacement (Gas, 8600 lb and Above)* in Engine Controls.
10. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

11. Install the EGR pipe to the intake manifold and the exhaust manifold.
12. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



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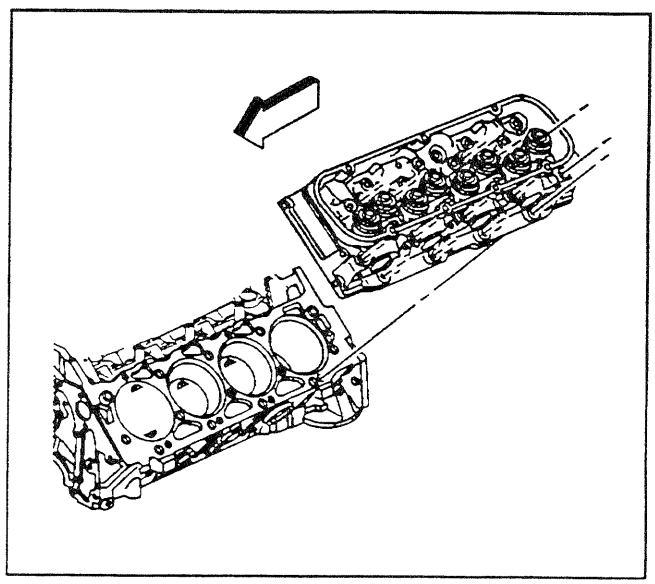
Cylinder Head Replacement

SIE-ID = 506451

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the engine electrical wiring harness and lay to the side.
4. Disconnect the engine ground straps. Refer to *Ground Strap Replacement* in Engine Electrical.
5. Remove the air conditioning compressor from the accessory mounting bracket. Refer to *Compressor Replacement (7.4L)* Air Conditioning Replacement in HVAC.
6. Remove the air conditioning accessory mounting bracket from the engine block head. Refer to *Accessory Mounting Brackets Replacement (AC)* in Engine Mechanical.
7. Remove the generator from the accessory mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator)* in Engine Electrical.
8. Remove the accessory mounting bracket from the engine block. Refer to *Generator Brace Replacement (CS 144).*
9. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*
10. Remove the lower intake manifold from the engine block. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
11. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*



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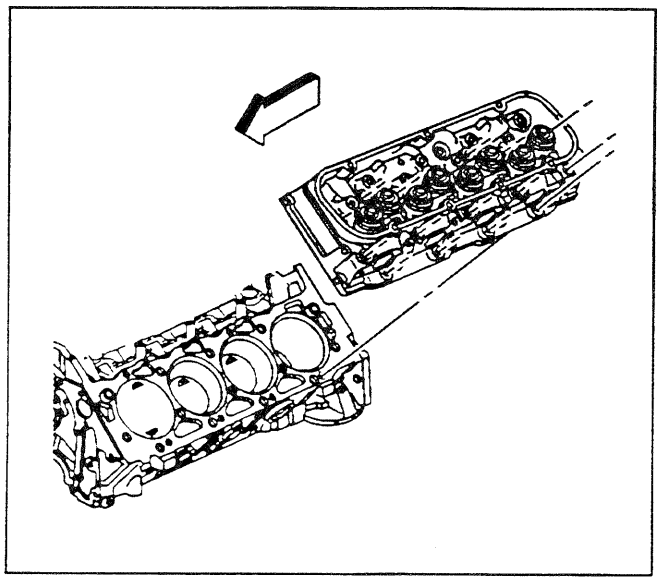
12. Remove the valve rocker arm from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
13. Remove the pushrod from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
14. Remove the spark plugs from the cylinder heads. Refer to *Spark Plug Replacement* in Engine Electrical.
15. Remove the exhaust manifolds from the cylinder head. Refer to *Exhaust Manifold Replacement.*
16. Remove cylinder head bolts from the engine block.
17. Remove the cylinder heads and gaskets from the engine block.
18. Clean and inspect the sealing surfaces on the cylinder heads. Refer to *Cylinder Head Clean and Inspect.*
19. Discard the cylinder head bolts.



452378

Installation Procedure

Important: Do not use sealer on the composition gaskets, and make sure that the punch code (7.4L) on the cylinder head gasket is facing up. Refer to *Replacing Engine Gaskets.*

Important: When servicing the right cylinder head, use a rubber band to secure the cylinder head bolts to the valve spring to hold cylinder bolt for ease of cylinder head removal.

1. Assemble the cylinder head. Refer to *Cylinder Head Assemble.*
2. Install the cylinder head gaskets to the engine block.
3. Install the cylinder heads to the engine block.

Important: Make sure that the threads on the cylinder head bolts are clean as well as the threaded holes in the engine block.

4. Install New cylinder head bolts. Refer to *Cylinder Head Installation (Left)* and *Cylinder Head Installation (Right).*
5. Install the push rod into the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
6. Install the valve rocker arm to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
7. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
8. Install the exhaust manifolds to the cylinder heads. Refer to *Exhaust Manifold Replacement.*
9. Install the spark plugs to the cylinder head. Refer to *Spark Plug Replacement* in Engine Electrical.
10. Install the lower intake manifold to the cylinder head. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
11. Install the upper intake manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*

12. Install the engine ground straps to the engine block. Refer to *Ground Strap Replacement* in Engine Electrical.
13. Install the generator mounting bracket to the engine block. Refer to *Generator Brace Replacement (CS 144).*
14. Install the generator to the mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator)* in Engine Electrical.
15. Install the air conditioning mounting bracket to the cylinder head. Refer to *Accessory Mounting Brackets Replacement (AC).*
16. Install the air conditioning compressor to the mounting bracket. Refer to *Compressor Replacement (7.4L)* in Air Conditioning Compressor Replacement in HVAC.
17. Connect the engine electrical wiring harness.
18. Fill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
19. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.

Crankshaft Balancer Replacement

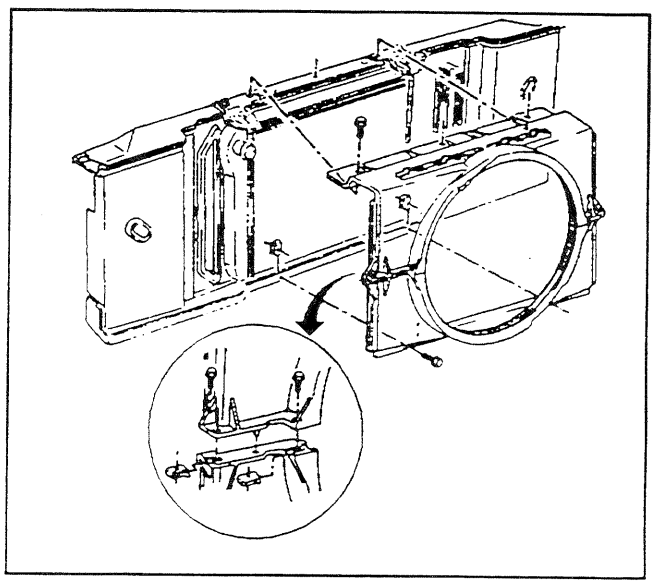
SIE-ID = 506457

Removal Procedure

Tools Required

J 23523-F Crankshaft Balancer Puller and Installer

1. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
2. Remove the drive belt from the vehicle. Refer to *Drive Belt Replacement.*
3. Raise the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower).*



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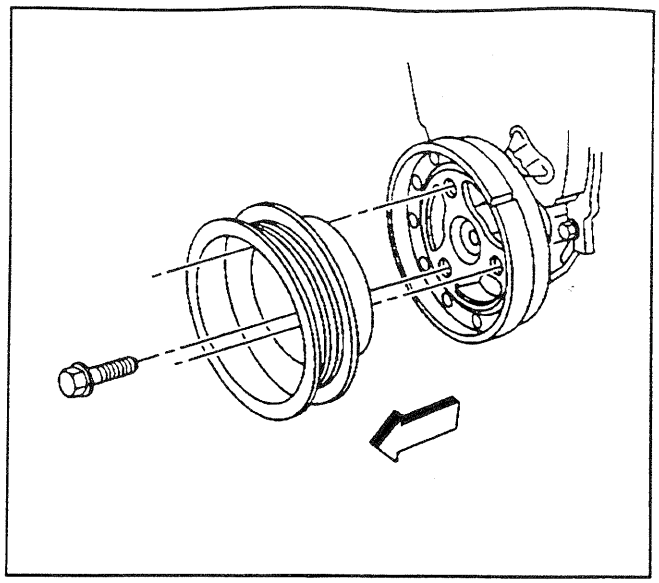

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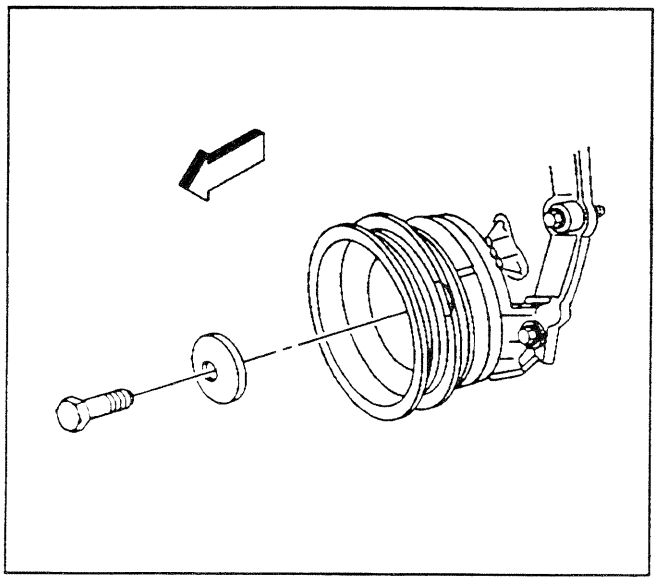
5. Remove the crankshaft pulley from the crankshaft balancer.



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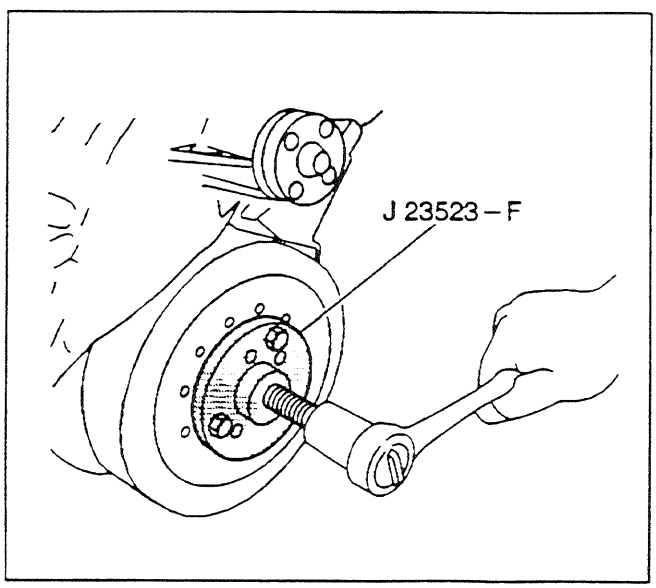
6. Remove the crankshaft bolt and washer from the crankshaft.



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7. Use the *J 23523-F* to remove the crankshaft balancer
8. Remove the *J 23523-F* from the crankshaft balancer.

Installation Procedure

Tools Required

- *J 23523-F* Crankshaft Balancer Puller and Installer
- *J 22102* Oil Seal Installer

Important: The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tools) must be followed or movement of the inertial weight section of the crankshaft balancer will destroy the balance and will have to be replaced.

1. Install the crankshaft balancer end of the crankshaft.
2. Install *J 23523-F* to the crankshaft balancer.
3. Use the *J 23523-F* and install the crankshaft balancer to the crankshaft.
4. Remove the tool from the crankshaft balancer.

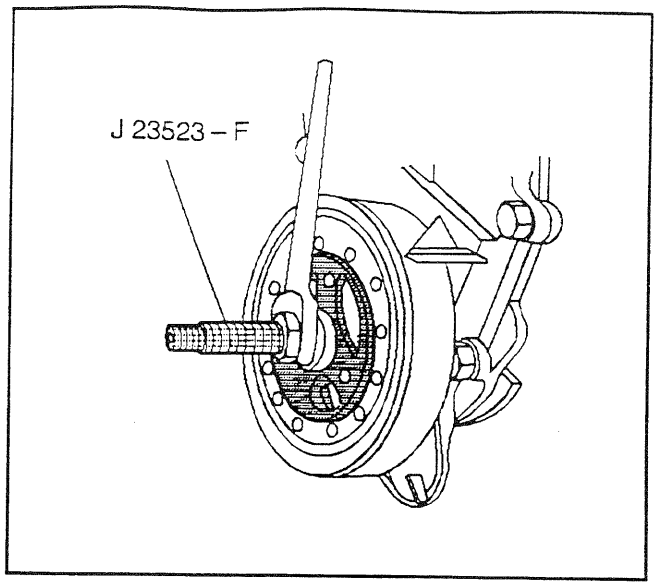
Important: Make sure that when installing the crankshaft bolt and washer, the curve part of the washer is facing away from the engine block.

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

5. Install the crankshaft bolt and washer to the crankshaft.

   Tighten

   Tighten the crankshaft bolt to 149 N·m (110 lb ft).



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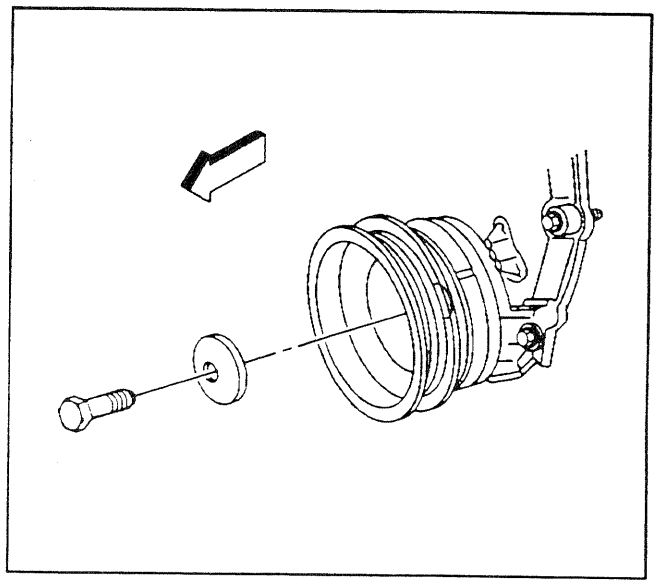
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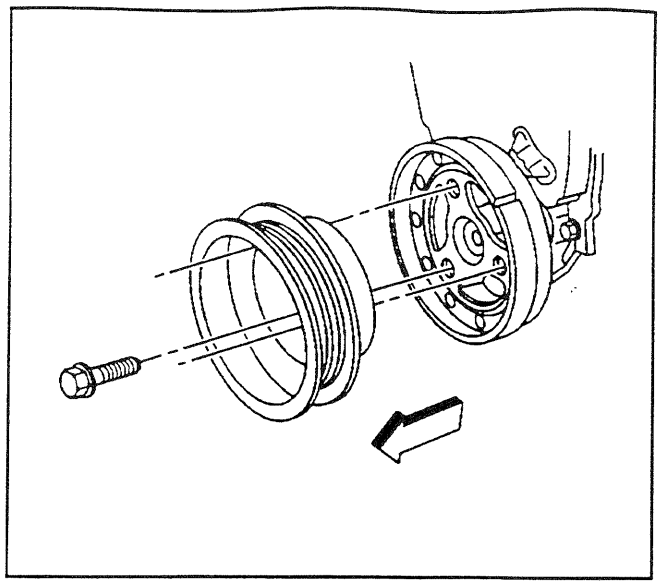

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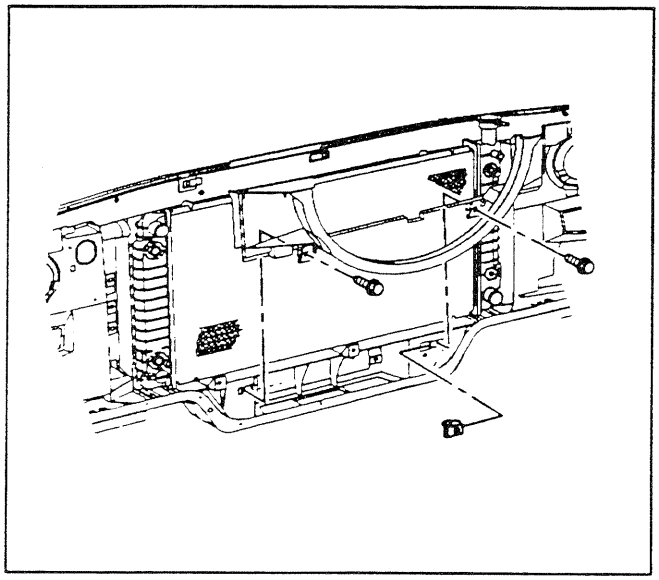
6. Install the crankshaft pulley to the crankshaft.
7. Install the crankshaft pulley bolts.

   Tighten

   Tighten the bolts to 40 N·m (30 lb ft).



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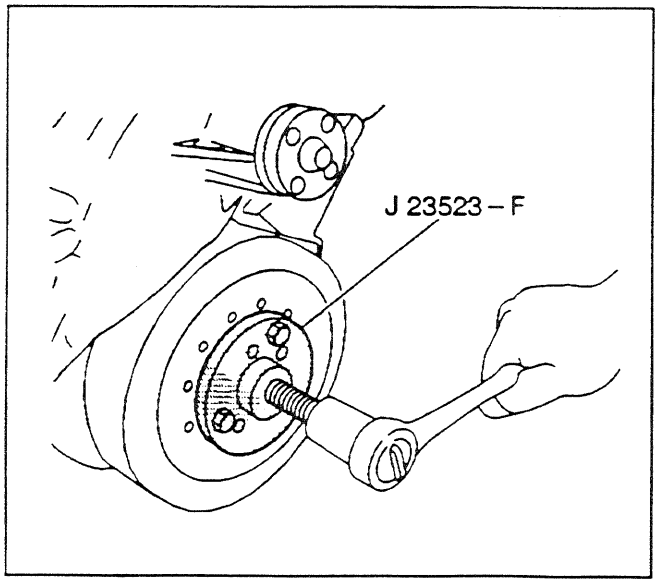
8. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
9. Lower the vehicle.
10. Install the drive belt on the pulley. Refer to *Drive Belt Replacement.*
11. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.



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Crankshaft Front Cover Oil Seal Replacement

SIE-ID - 506460

Removal Procedure

Tools Required

J 22102 Seal Installer

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the drive belt form the vehicles drive pulleys. Refer to *Drive Belt Replacement.*
4. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.

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

Important: Use care as not to damage the engine front cover or the crankshaft sealing area when removing the crankshaft front cover oil seal.

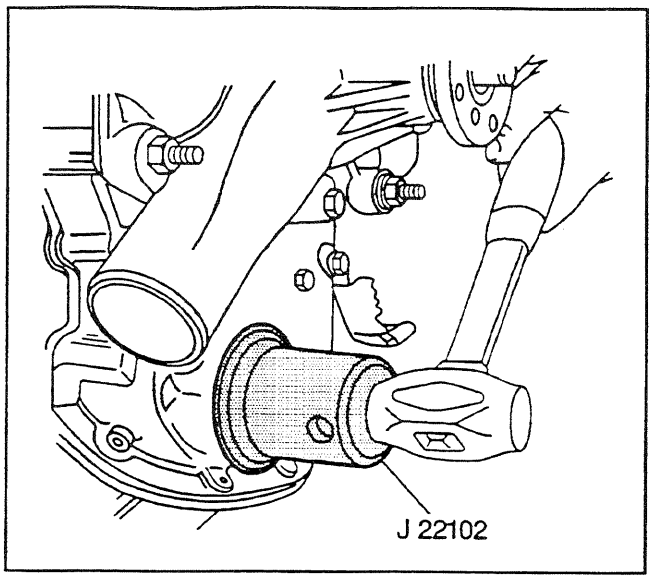
6. Remove the crankshaft front cover oil seal from the engine front cover.

Installation Procedure

Tools Required

J 22102 Seal Installer

1. Coat the crankshaft front cover oil seal with clean engine oil.
2. Use the *J 22102* to install the crankshaft front cover oil seal.
3. Remove the *J 22102* from the crankshaft front cover oil seal.



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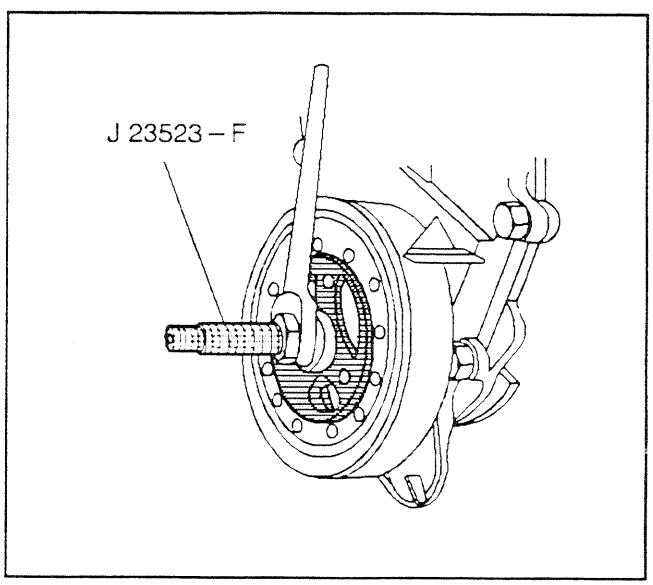
4. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement.*
5. Install the drive belt on the vehicle drive pulleys. Refer to *Drive Belt Replacement.*



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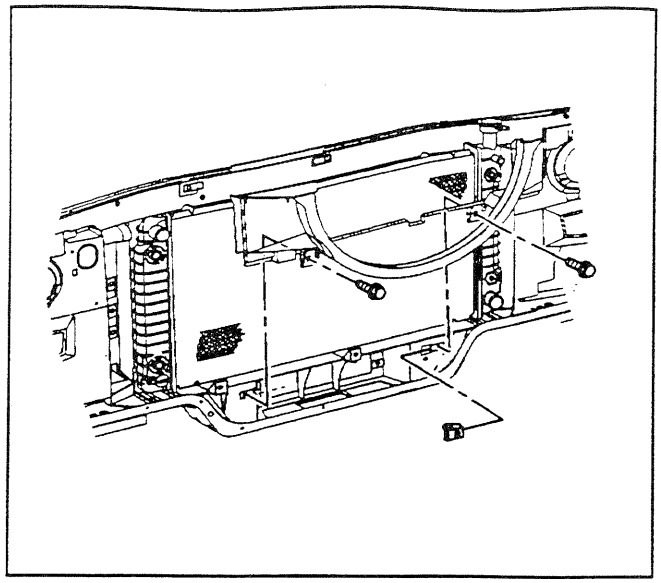

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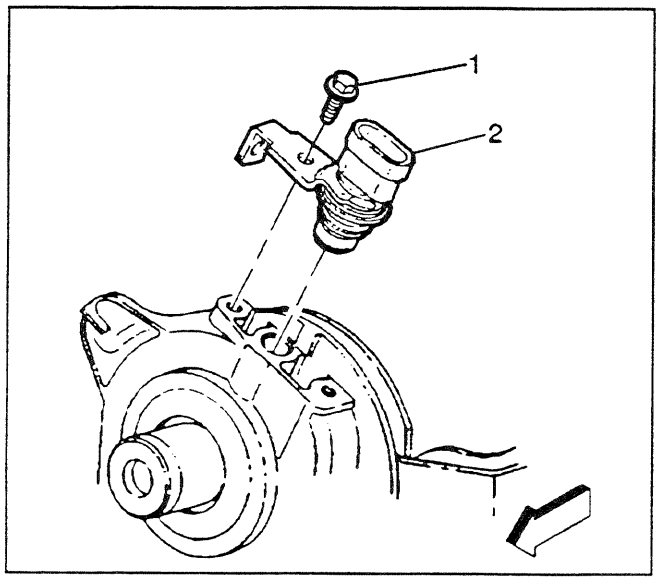
6. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
7. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
8. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



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Engine Front Cover Replacement

SIE-ID = 506463

Removal Procedure

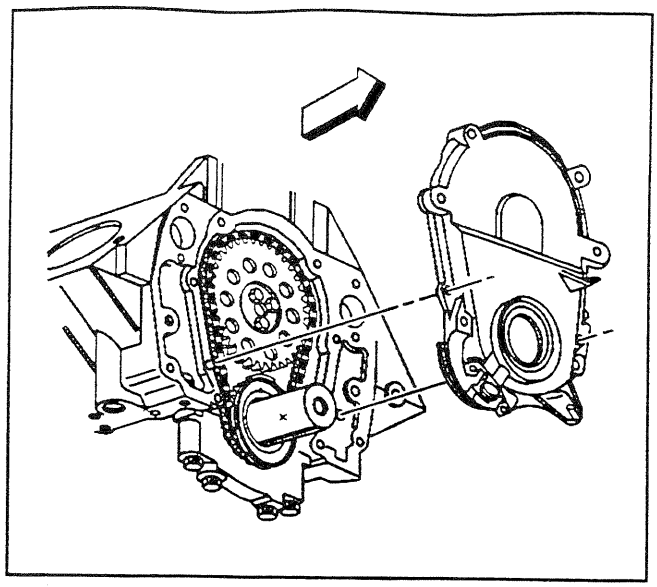
Important: The engine front cover gasket is reusable. Replace only if gasket is damaged.

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the drive belt from the drive pulleys. Refer to *Drive Belt Replacement.*
3. Remove the crankshaft position sensor (1) from the engine front cover. Refer to *Crankshaft Position Sensor (CKP) Replacement* in Engine Controls.
4. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement.*
5. Remove the water pump from the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.

Important: Do not remove the oil pan, allow the oil pan to hang by the rear mounting bolts.

Remove the bolts from the oil pan to the engine block. Refer to *Oil Pan Replacement.*

6. Remove the engine front cover mounting bolts.
7. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Removal*.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Installation Procedure

Important: The engine front cover gasket is reusable. Replace only if gasket is damaged.

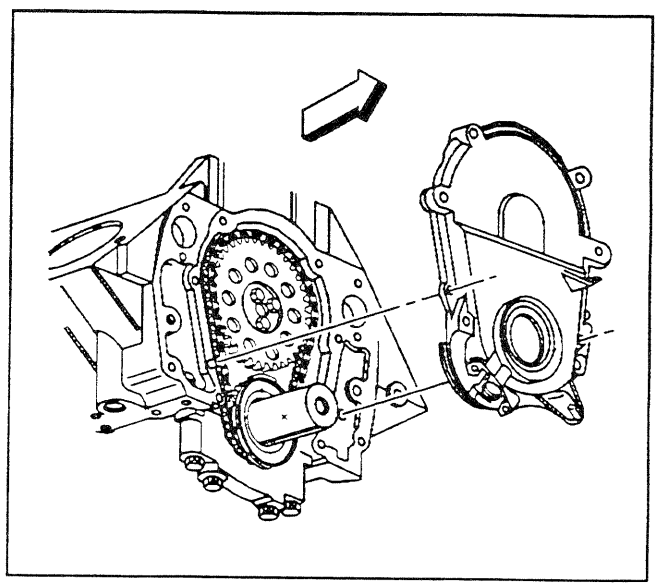
1. Install the engine front cover to the engine block. Refer to *Engine Front Cover Installation*.

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

2. Install the engine front cover bolts

   Tighten

   Tighten the bolts to 10 N·m (89 lb in).
3. Install the oil pan to the engine block. Refer to *Oil Pan Replacement*.
4. Install the crankshaft position sensor to the engine front cover. Refer to *Crankshaft Position Sensor (CKP) Replacement* in Engine Controls.
5. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement*
6. Connect the battery cable to the battery. Refer to *Battery Cable* in Engine Electrical.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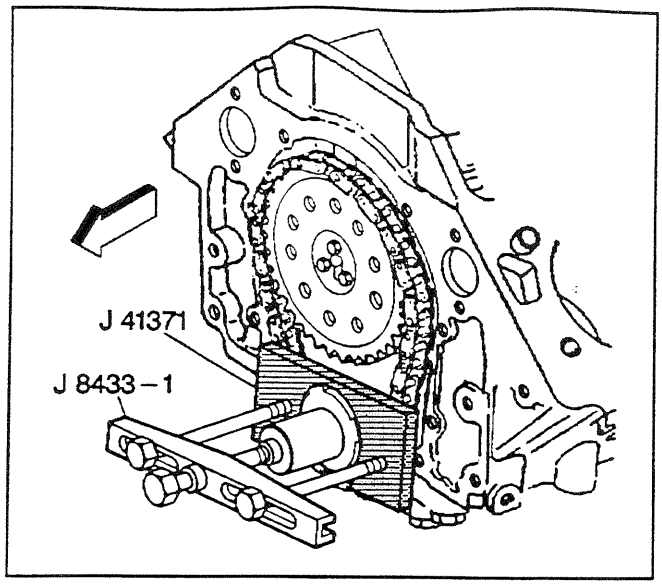

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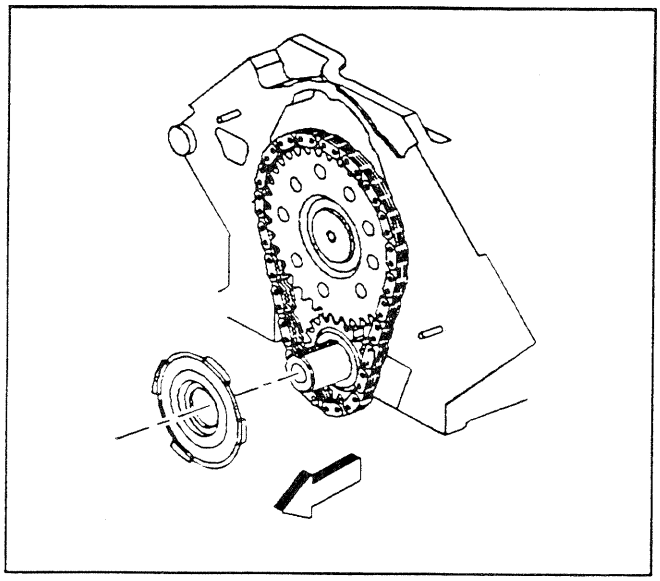

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Crankshaft Position (CKP) Reluctor Ring Replacement

SIE-ID = 506466

Removal Procedure

Tools Required

J 41371 Reluctor Wheel Remover

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement.*
3. Remove the water pump from the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
4. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Replacement.*
5. Use the *J 41371* to remove the reluctor ring from the crankshaft.

Installation Procedure

Important: Replace the crankshaft position sensor whenever the crankshaft position reluctor ring is replacement.

1. Install the crankshaft position reluctor ring on to the crankshaft.
2. Install the engine front cover to the engine block. Refer to *Engine Front Cover Replacement.*
3. Install the water pump to the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
4. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement.*
5. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.

Timing Chain and Sprockets Replacement

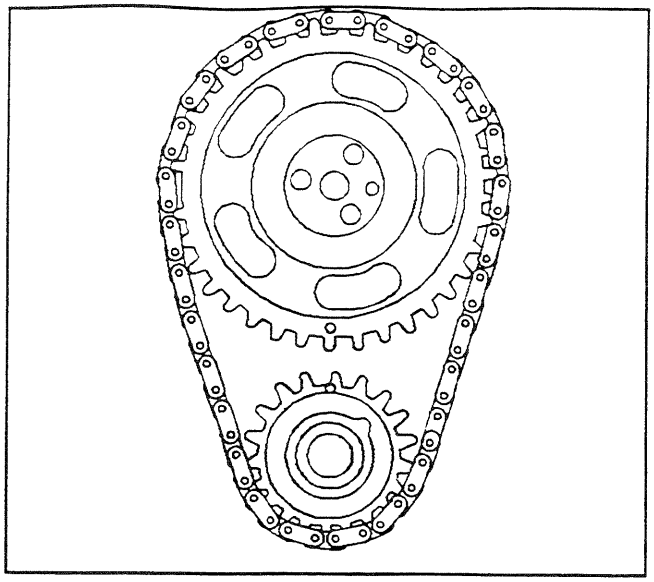
SIE-ID = 506473

Removal Procedure

Tools Required

- *J 28509-A* Crankshaft Sprocket Remover
- *J 41371* Reluctor Wheel Remover

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
3. Rotate the engine until the timing marks on the crankshaft balancer and the engine front cover are on TDC.
4. Remove the drive belt from the vehicles drive pulleys. Refer to *Drive Belt Replacement.*
5. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
6. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
7. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement.*
8. Remove the water pump from the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
9. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Replacement.*

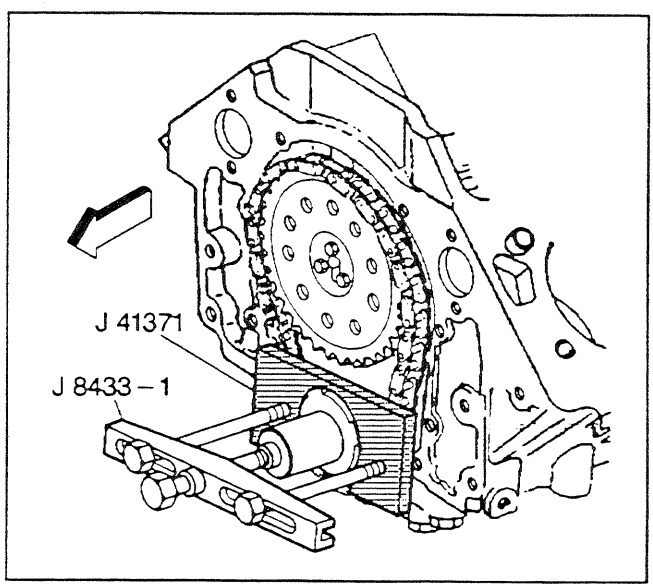


11503

Important: If the crankshaft position reluctor ring is removed, a new crankshaft position reluctor ring sensor must be installed.

Aligned the timing marks on the camshaft and crankshaft gears.

10. Use the *J 41371* to remove the crankshaft reluctor ring from the crankshaft. Refer to *Crankshaft Position (CKP) Reluctor Ring Replacement.*



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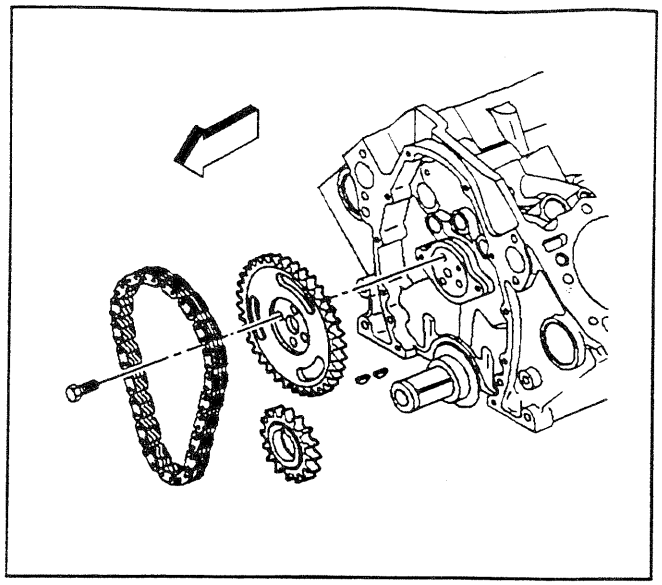
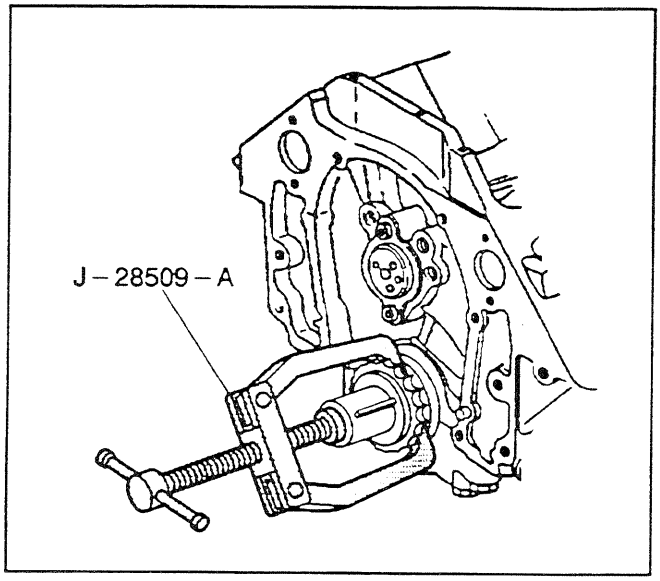


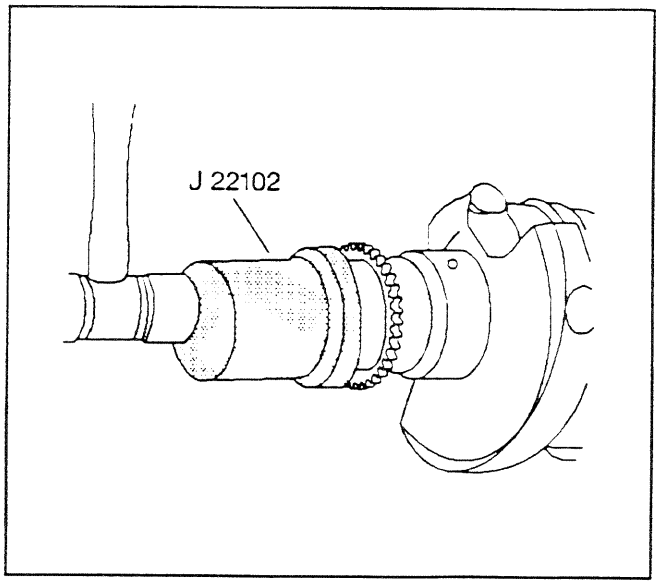
65453

11. Remove the camshaft sprocket retaining bolts.
12. Remove the timing chain and camshaft sprocket.



65848

13. Use the *J 28509-A* to remove the crankshaft sprocket.



65850

Installation Procedure

Tools Required

J 22102 Crankshaft Sprocket Installer

Important: Ensure the following conditions exist:

- The camshaft and the crankshaft timing marks are aligned
- The camshaft dowel pin and the camshaft sprocket holes are properly aligned
- The gears and the chain mesh properly

Use the *J 22102* to install the crankshaft sprocket.

Notice: Refer to *Camsaft Sprocket/Camshaft Notice* in Cautions and Notices.

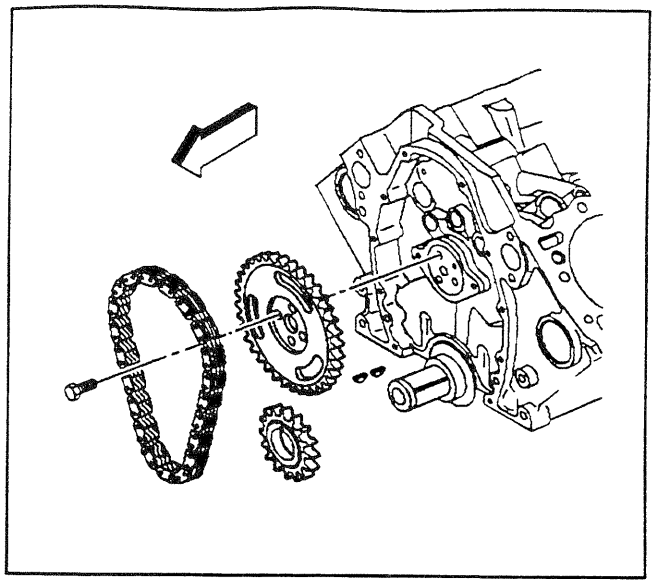
1. Install the timing chain and sprocket to the camshaft.

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

2. Install the camshaft retaining bolts to the camshaft.

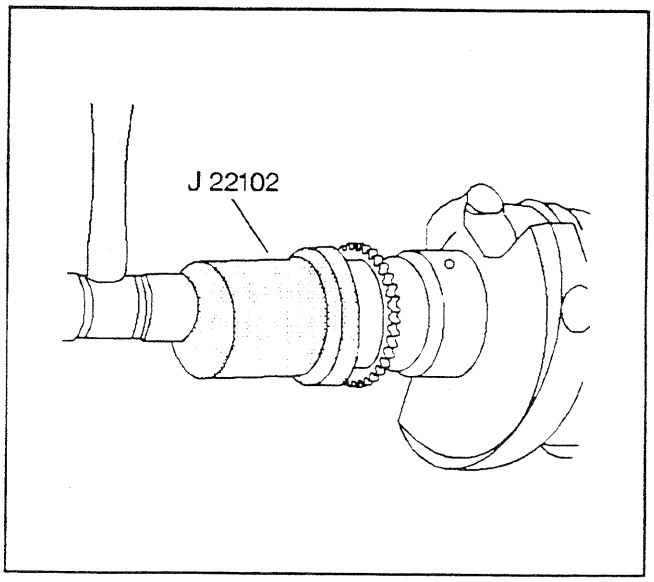
   Tighten

   Tighten the retaining bolts to 30 N·m (22 lb ft).
3. Install the timing chain and sprocket to the camshaft.
4. Install the engine front cover to the engine block. Refer to *Engine Front Cover Replacement.*



65453

5. Install a new crankshaft position reluctor ring to the crankshaft. Refer to *Crankshaft Position (CKP) Reluctor Ring Replacement* in Engine Mechanical.
6. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement.*
7. Install the water pump to the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
8. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
9. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
10. Install the drive belt on the vehicle drive pulleys. Refer to *Drive Belt Replacement.*
11. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
12. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



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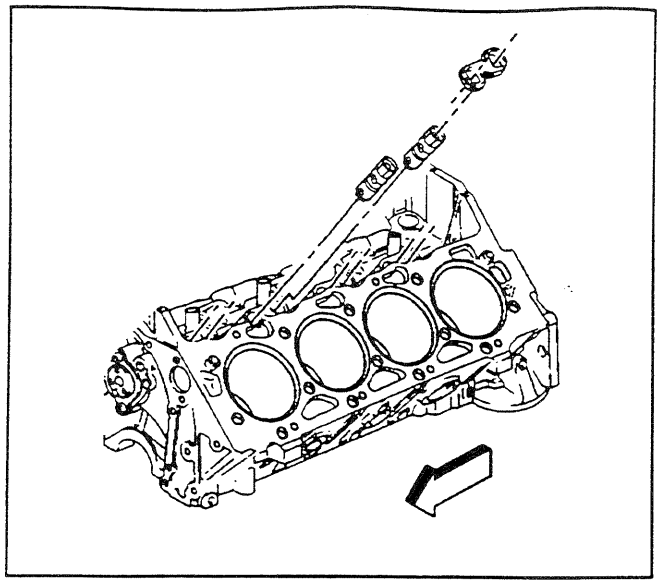


173176

Camshaft Replacement

SIE-ID = 506477

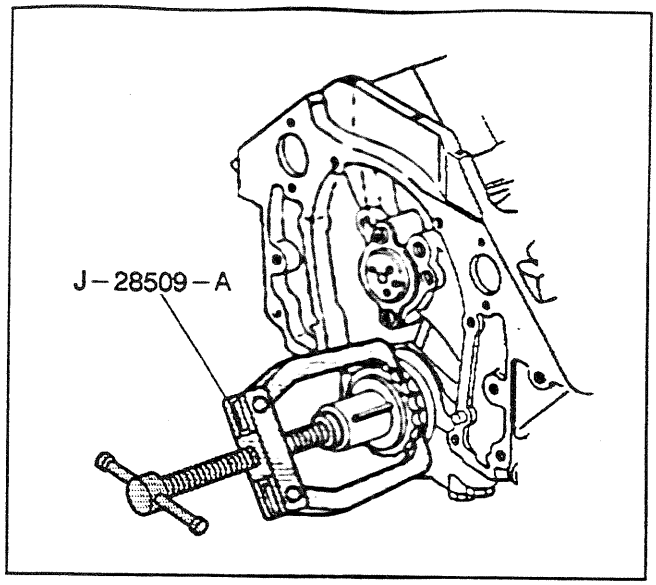
Removal Procedure

Tools Required

J 28509-A Sprocket Remover

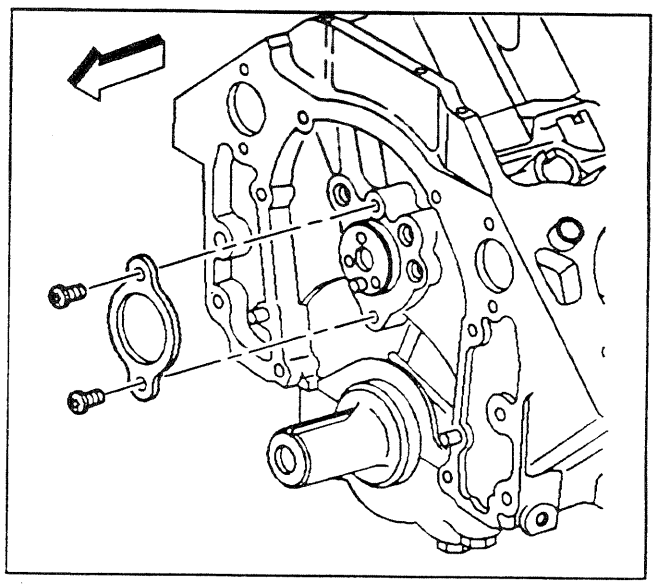
1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the air intake duct from the throttle body.
3. Remove the grille from the vehicle. Refer to *Grille Replacement (Base)* or *Grille Replacement (C3500HD)* in Exterior Trim.
4. Remove the radiator assembly from the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
5. Remove the air conditioning condenser. Refer to *Condenser Replacement* in HVAC.
6. Remove the upper intake manifold from the engine block. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*
7. Remove the lower intake manifold from the engine block. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
8. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
9. Remove the valve rocker arms from the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
10. Remove the valve push rods from the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
11. Remove the valve lifters from the engine block.
12. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement.*
13. Remove the water pump from the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
14. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Replacement.*
15. Remove the crankshaft position reluctor ring from the crankshaft. Refer to *Crankshaft Position (CKP) Reluctor Ring Replacement.*
16. Remove the timing chain and sprockets from the engine block. Refer to *Timing Chain and Sprockets Replacement.*

17. Use the *J 28509-A* to remove the camshaft sprocket.



65848

18. Remove the camshaft retainer bolt and retainer from the engine block.
19. Install three 5/16 18 bolts 4 to 5 inches long into the camshaft threaded bolt holes. Use these bolts as a handle for the camshaft removal.
20. Pull the camshaft from the engine block. Use care as not to damage the camshaft bearing. Refer to *Camshaft Removal*.
21. Remove the three 5/16 18 bolts from the camshaft.

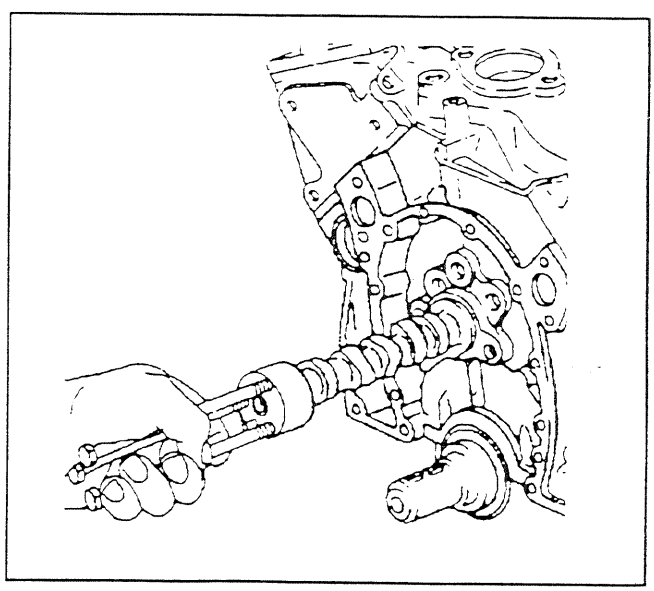

193223

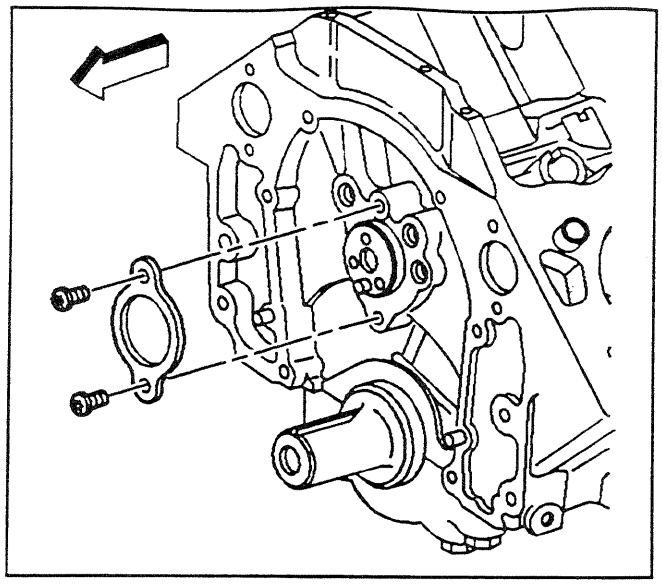
Installation Procedure

Tools Required

J 22101 Seal Installer

1. Install the three 5/16 18 bolts 4 to 5 inches long into the camshaft threaded bolt holes. Use these bolts as a handle to install the camshaft in the engine block.
2. Coat the camshaft lobes and journals with engine oil supplement GM P/N 1052367 before installing the camshaft into the cylinder block.
3. Install the camshaft into the engine block. Refer to *Camshaft Installation* in Engine Mechancial.
4. Remove the three 5/16 18 bolts from the camshaft.


66262



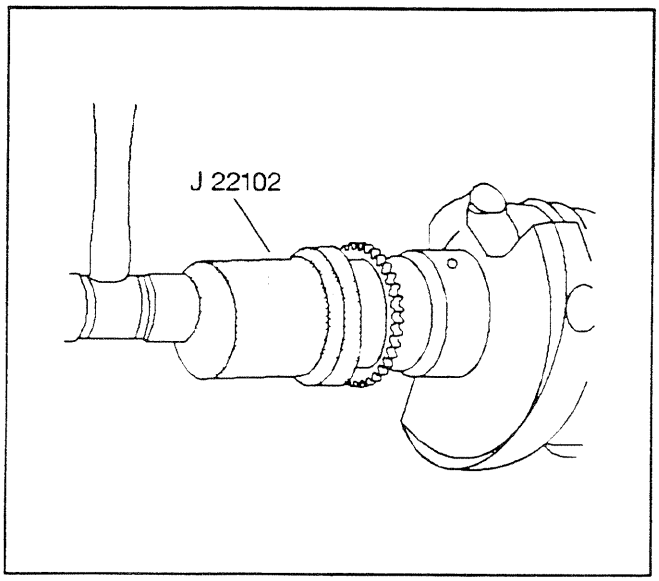
193223

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

5. Install the camshaft retainer and bolts in the engine block.

   Tighten

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



65850

6. Use the *J 22101* to install the crankshaft sprocket.
7. Install the timing chain and camshaft sprocket to the camshaft. Refer to *Timing Chain and Sprockets Installation.*
8. Install the camshaft sprocket bolts to the camshaft.

   Tighten

   Tighten the bolts to 30 N·m (22 lb ft).
9. Install the crankshaft position reluctor ring on the crankshaft. Refer to *Timing Chain and Sprockets Replacement.*
10. Install the engine front cover to the engine block. Refer to *Engine Front Cover Replacement.*
11. Install the water pump to the engine block. Refer to *Water Pump Replacement (Gasoline)* in Engine Cooling.
12. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement.*
13. Install the valve lifters to the engine block. Refer to *Valve Lifter Replacement.*
14. Install the push rods into the engine block. Refer to *Valve Rocker Arm and Push Rod Replacement.*
15. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement.*
16. Install the lower intake manifold to the engine block. Refer to *Intake Manifold Replacement (Lower Intake Manifold).*
17. Install the upper intake manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Upper Intake Manifold).*
18. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
19. Install the air cleaner duct to the throttle body.
20. Install the radiator in the vehicle. Refer to *Radiator Replacement* in Engine Cooling.

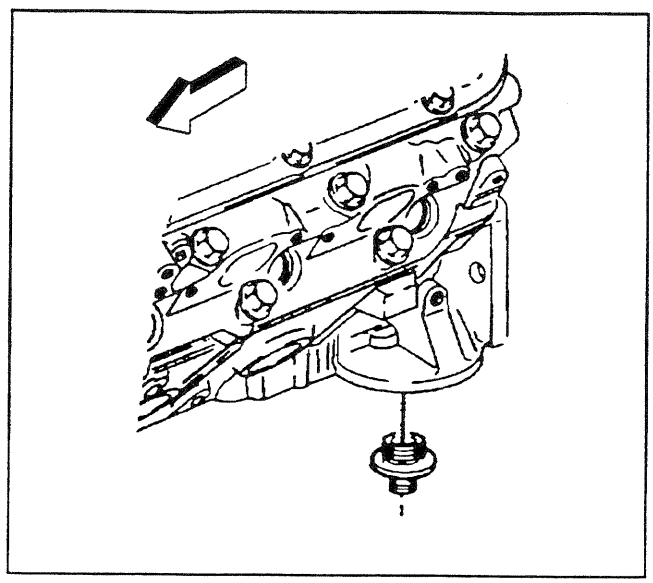
21. Install the air conditioning condenser to the vehicle. Refer to *Condenser Replacement* in HVAC.
22. Install the grille on the vehicle. Refer to *Grille Replacement (Base)* or *Grille Replacement (C3500HD)* in Exterior Trim.
23. Install the drive belt on the drive pulleys. Refer to *Drive Belt Replacement.*
24. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.

Oil Filter Adapter and Valve Assembly Replacement

SIE-ID - 506483

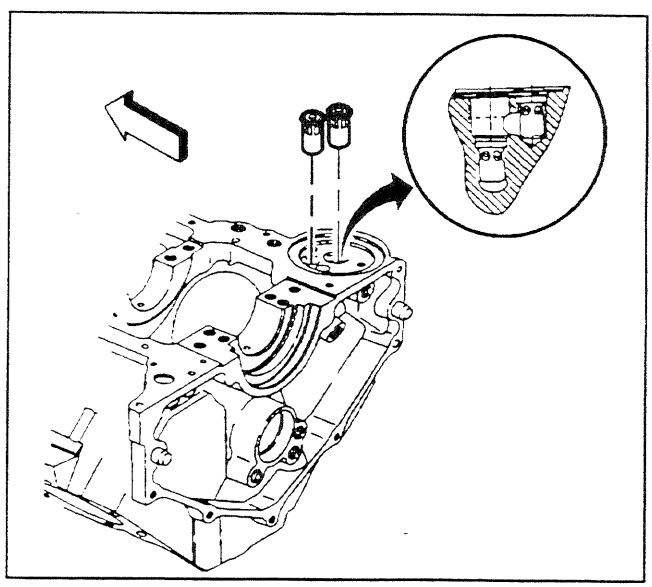
Removal Procedure

1. Raise the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the oil filter from the adapter from the engine block. Refer to *Engine Oil and Oil Filter Replacement.*
3. Remove the oil filter adapter fittings from the engine block. Refer to *Oil Filter Adapter Removal (2WD).*

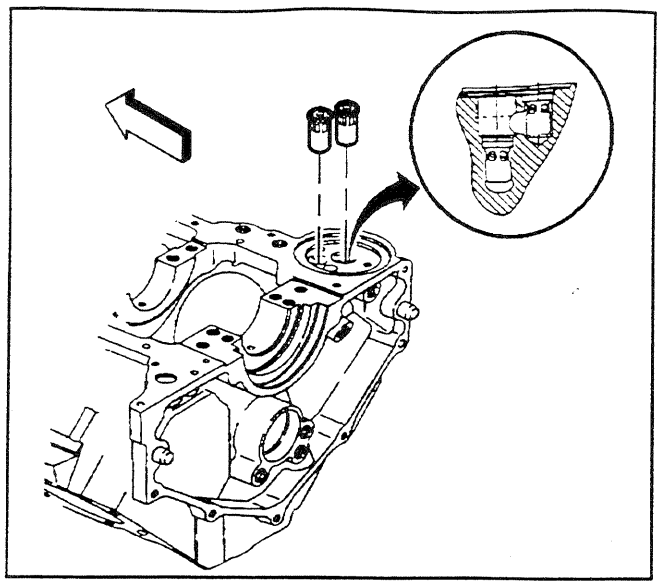


70416

4. Remove the oil filter bypass valve from the engine block. Refer to *Oil Filter Adapter Removal (2WD).*



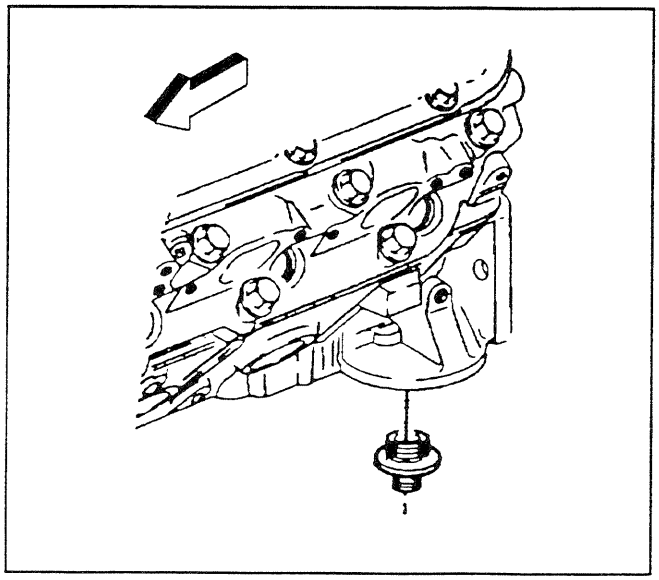
180862



180862

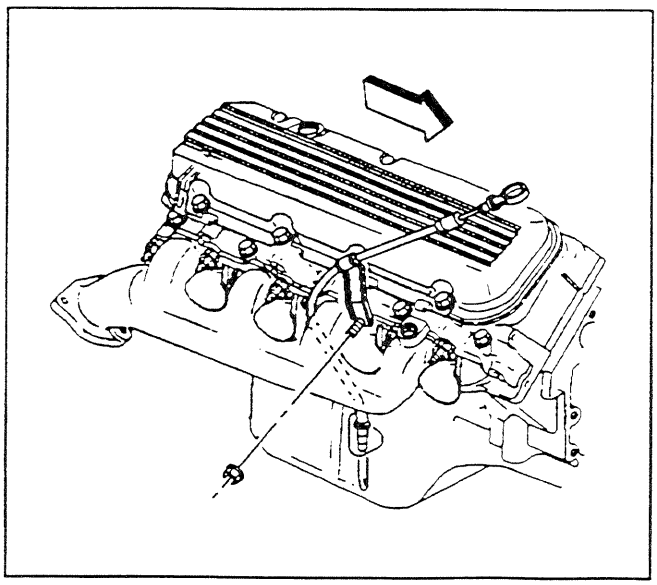
Installation Procedure

1. Install the bypass valve in the engine block. Refer to *Oil Filter Adapter Installation (2WD).*



70416

2. Install the oil filter adapter to the engine block. Refer to *Oil Filter Adapter Installation (2WD).*
3. Install the oil filter to the adapter. Refer to *Engine Oil and Oil Filter Replacement.*
4. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.



173184

Oil Pan Replacement

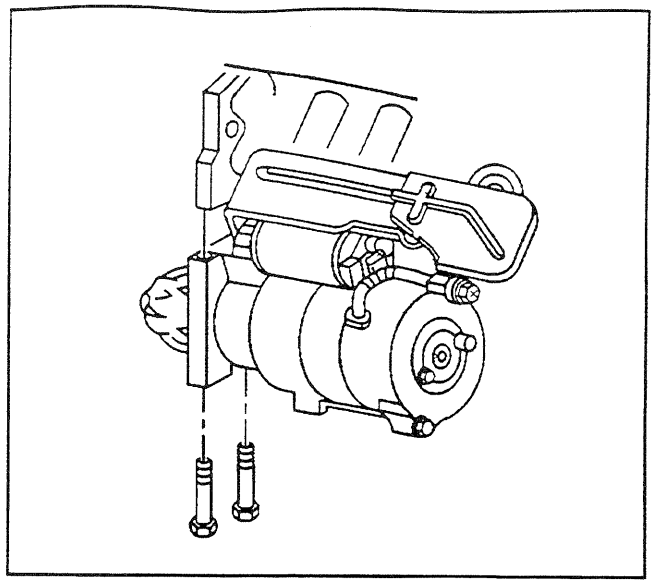
SIE-ID = 506487

Removal Procedure

Important: Do not raise the engine by the crankshaft balancer to perform this service procedure. Damage to the crankshaft balancer or the crankshaft may occur.

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the oil level indicator and tube from the engine. Refer to *Oil Level Indicator and Tube Replacement* in Engine Mechanical.
3. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Drain the crankcase. Refer to *Engine Oil and Oil Filter Replacement* in Engine Mechanical–7.4L.

5. Remove the starter from the engine block. Refer to *Starter Motor Replacement (Gas, 7.4L)* in Engine Electrical.
6. Roll the front drive axle if servicing a 4 wheel drive truck. Refer to *Wheel Drive Shafts Replacement* in Halfshaft Assmebly Replacement.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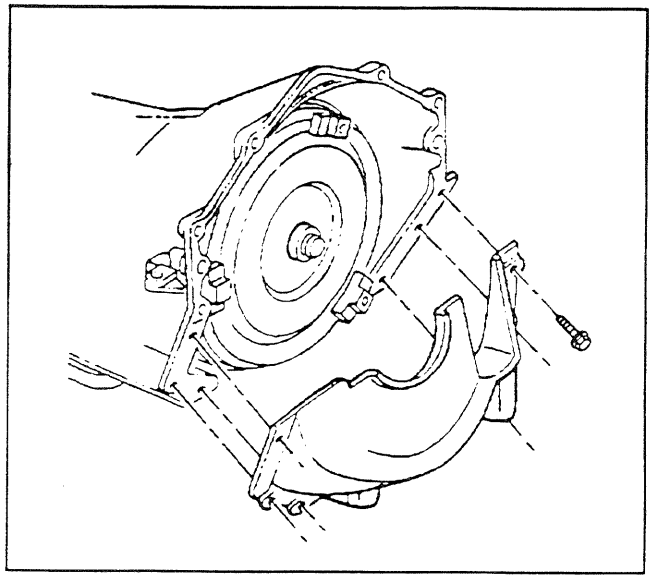
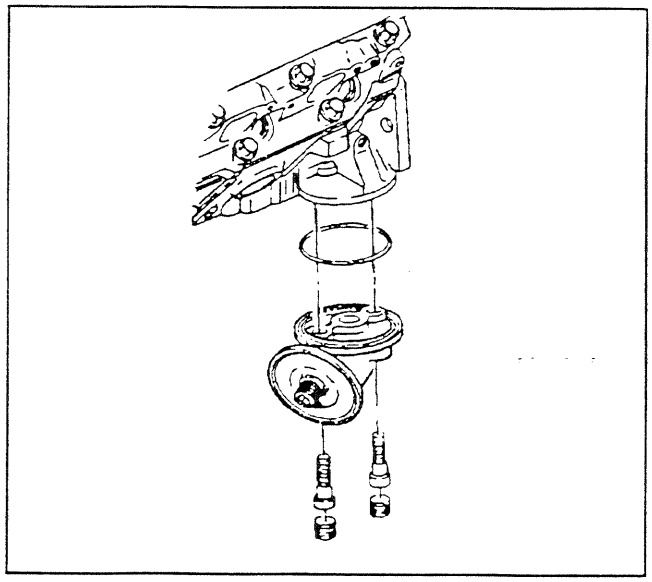
7. Remove the flywheel inspection cover if equipped.


32688

8. Remove the oil filter and adapter (4 wheel drive) if equipped. Refer to *Oil Filter Adapter and Valve Assembly Replacement.*
9. Remove the oil cooler line retainer from the retaining bracket. Refer to *Engine Oil Cooler Line Replacement* in Engine Cooling.

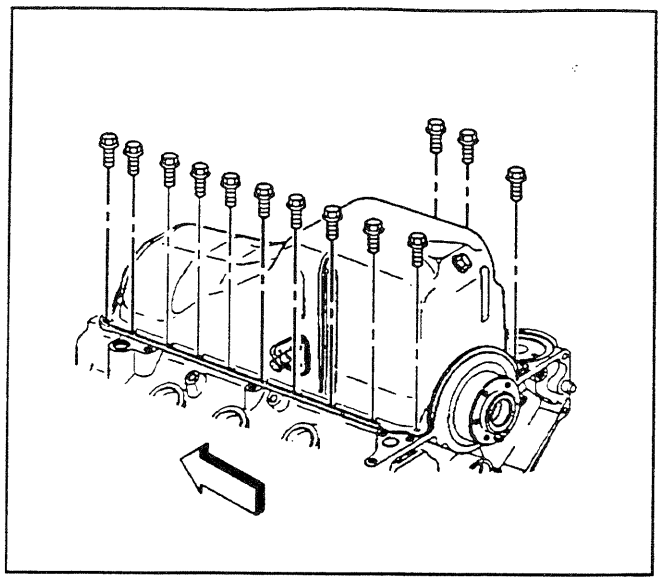
Important: DO NOT lift the engine by the crankshaft balancer to aide in removing the oil pan from the engine block. Damage to crankshaft balancer or crankshaft could occur.

10. Remove the transmission from the vehicle.
    - For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
    - For the automatic transmission. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.

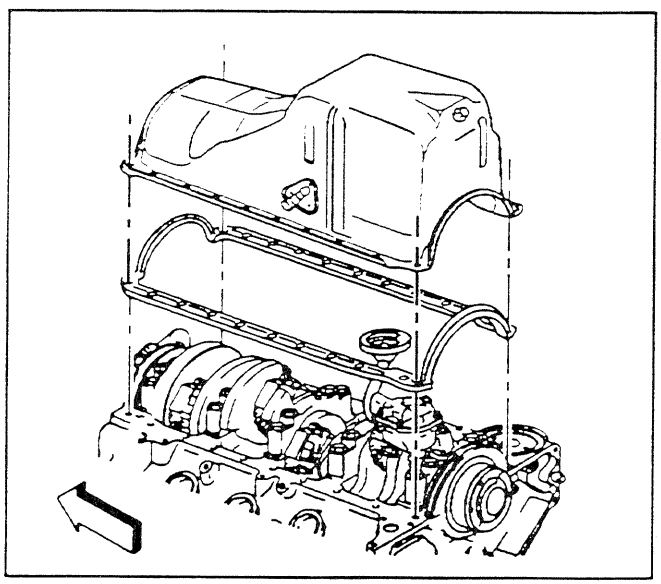

70415

- Remove the clutch from the flywheel (if equipped). Refer to *Clutch Assembly Replacement* in Clutch.
- Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Removal (MT1 Automatic Transmission)* or *Engine Flywheel Removal (MW3 Manual Transmission)*.

11. Remove the oil pan bolts from the engine block.



173182



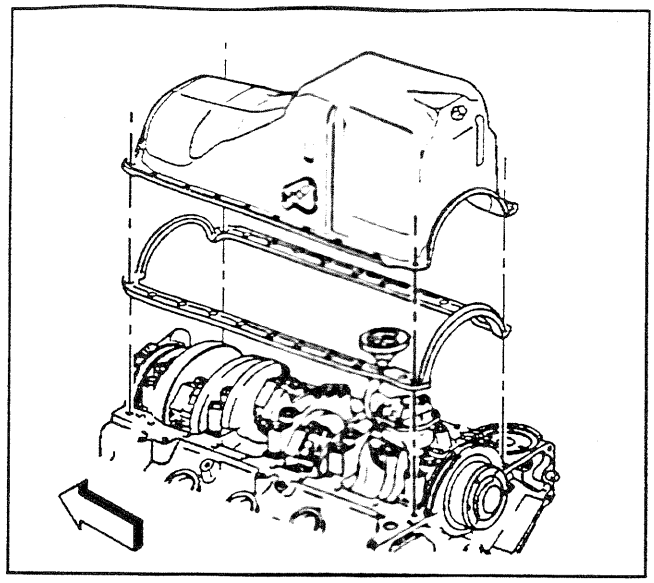
173179

12. Remove the oil pan from the vehicle.
13. Remove the oil pan gasket from the engine block.
14. Remove the oil from the sealing surfaces. Refer to *Oil Pan Clean and Inspect*.

Installation Procedure

Important: The oil pan gasket is reusable. Replace only if the gasket is damaged.

1. Install the oil pan gasket on the oil pan.
2. Install the oil pan gasket and oil pan to the engine block.



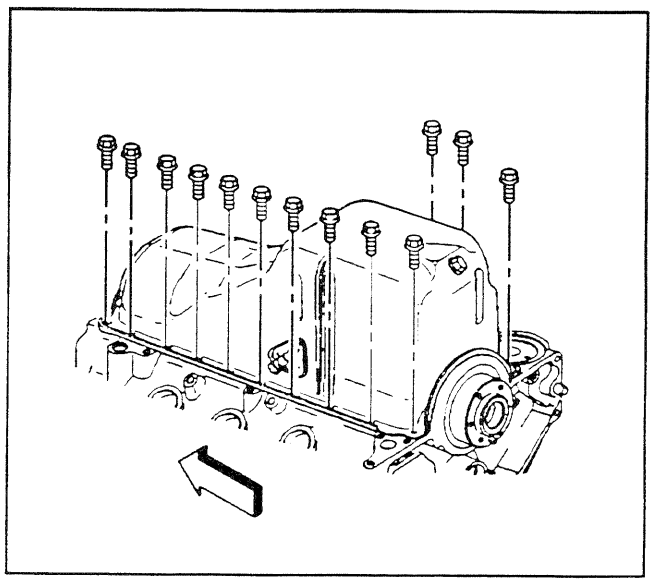
173179

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

3. Install the oil pan bolts to the engine block.

   Tighten

   Tighten the bolts to 25 N·m (18 lb ft).
4. Install the clutch assembly to the flywheel. Refer to *Clutch Assembly Replacement* in Clutch.
5. Install the flywheel to the crankshaft. Refer to *Engine Flywheel Removal (MT1 Automatic Transmission)* and *Engine Flywheel Removal (MW3 Manual Transmission)*.
6. Install flywheel inspection cover to the transmission.
7. Install the transmission in the vehicle.
8. For the automatic transmission. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.
9. For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.



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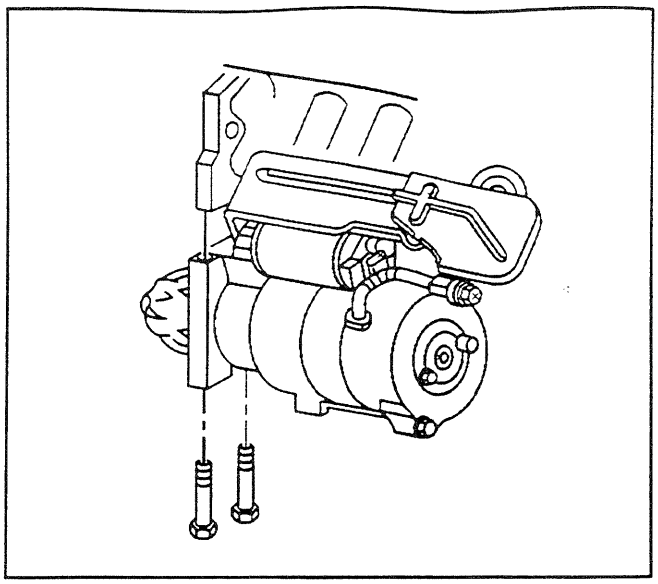
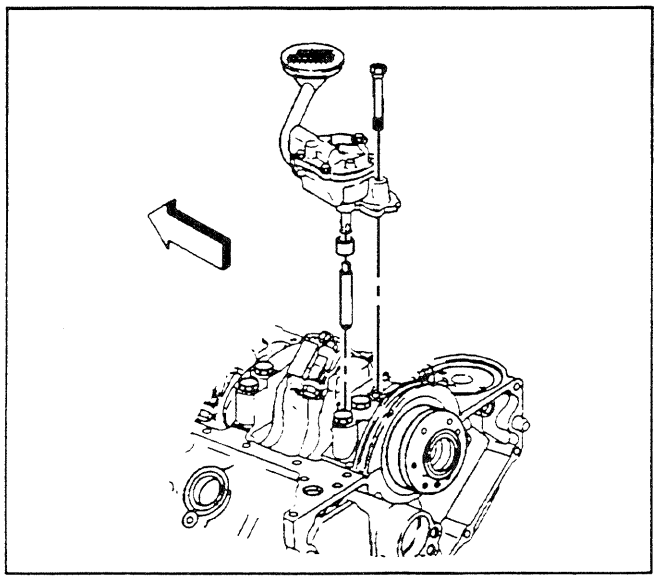


84599

10. Install the starter to the engine block. Refer to *Starter Motor Replacement (Gas, 7.4L)* in Engine Electrical.
11. Install oil cooler line to the retainers. Refer to *Engine Oil Cooler Line Replacement* in Engine Cooling.
12. Install the oil filter adapter (4 wheel drive) to the cylinder block if equipped. Refer to *Oil Filter Adapter Installation (4WD)* or *Oil Filter Adapter Installation (2WD)*.
13. Install the front drive axle if servicing a 4 wheel drive truck. Refer to *Wheel Drive Shafts Replacement* in Halfshaft Assembly Replacement.
14. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
15. Install the oil level indicator and tube. Refer to *Oil Level Indicator and Tube Replacement*.
16. Fill the crankcase with new engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
17. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.



73183

Oil Pump Replacement

SIE-ID = 506489

Removal Procedure

1. Disconnect the negative battery cable from the battery. Refer to *Battery Cable* in Engine Electrical
2. Drain the crankcase. Refer to *Engine Oil and Oil Filter Replacement*.
3. Remove the oil pan from the engine block. Refer to *Oil Pan Replacement*.
4. Remove the oil pump retaining bolts from the oil pump. Refer to *Oil Pump, Pump Screen and Deflector Removal*.
5. Remove the oil pump assembly from the engine block.

Installation Procedure

Important: When installing the oil pump, always replace the retainer between the oil pump and the shaft.

1. Install the oil pump to the engine block. Refer to *Oil Pump, Pump Screen and Deflector Installation.*

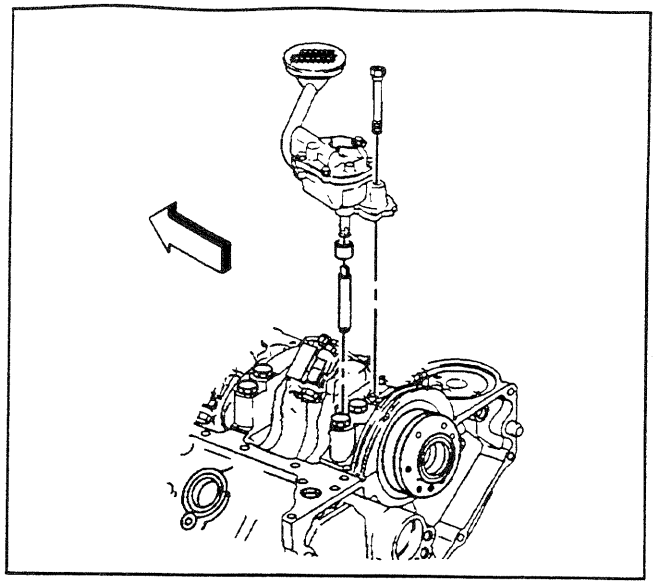
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the oil pump mounting bolts.

   Tighten

   Tighten the bolts to 90 N·m (65 lb ft).

3. Install the oil pan to the engine block. Refer to *Oil Pan Replacement.*
4. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.



173183

Crankshaft Rear Oil Seal Replacement

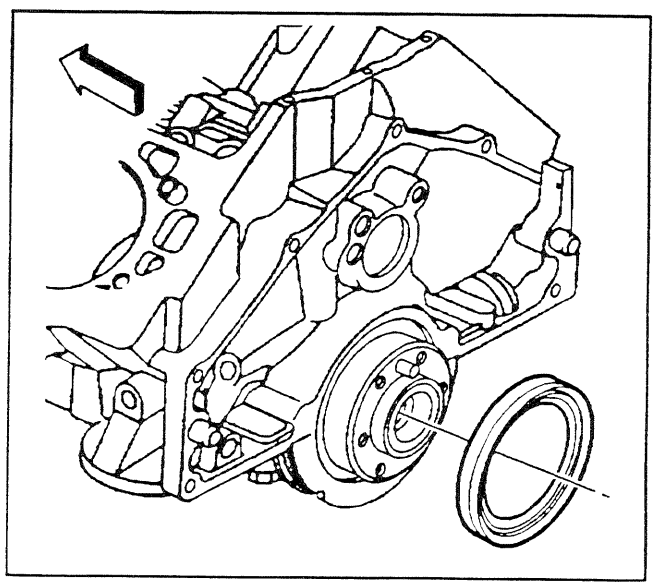
SIE-ID = 506493

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the transmission from the vehicle.
   - For the automatic transmission. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.
   - For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
4. Remove the clutch from the crankshaft if equipped. Refer to *Clutch Assembly Replacement* in Clutch.
5. Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Replacement.*

Important: When removing the crankshaft rear oil seal from the cylinder block be careful not to nick the crankshaft sealing surface.

6. Remove the crankshaft rear oil seal from the engine block.



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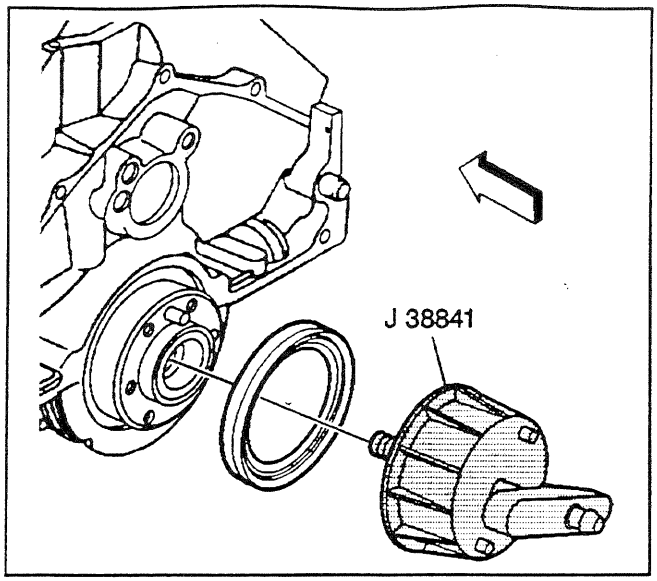


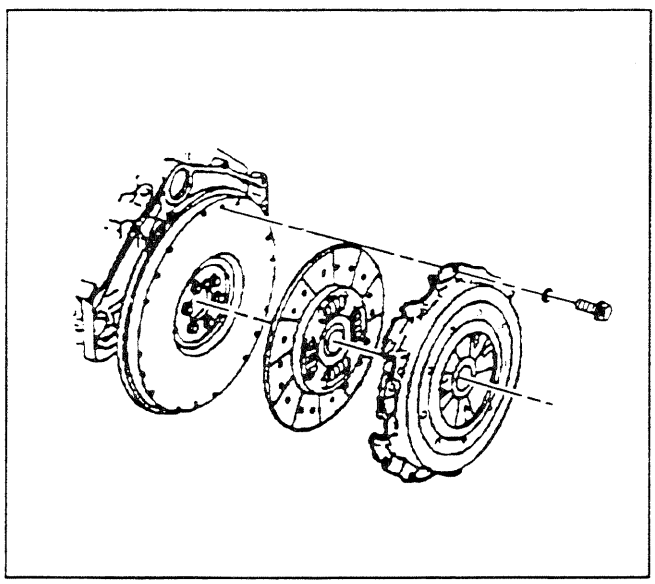
290961

Installation Procedure

Tools Required

J 38841 Rear Oil Seal Installer

1. Install the crankshaft rear oil seal as follows:
   1.1. Lubricate the inner and outer diameter of the crankshaft rear oil seal with clean engine oil.
   1.2. Install the crankshaft rear oil seal the *J 38841*.
   1.3. Use the *J 38841* to install the crankshaft rear oil seal on the crankshaft.
   1.4. Remove the *J 38841* from the crankshaft.
2. Install the flywheel to the crankshaft. Refer to *Engine Flywheel Replacement*
3. Install the clutch to the crankshaft if equipped. Refer to *Clutch Assembly Replacement* in Clutch.
4. Install the transmission to the engine block.
   4.1. For the automatic transmission. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.
   4.2. For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
5. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
6. Connect the battery negative cables to the battery. Refer to *Battery Cable* in Engine Electrical.


34060

Engine Flywheel Replacement

SIE-ID - 506495

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the transmission from the vehicle.
   - For the automatic transmissions,. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.
   - For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
   - Remove the clutch assembly from the crankshaft if equipped. Refer to *Clutch Assembly Replacement* in Transmission/Transaxle.
   - Remove the flywheel from the crankshaft.
   - Remove any burrs from the end of the crankshaft.

Installation Procedure

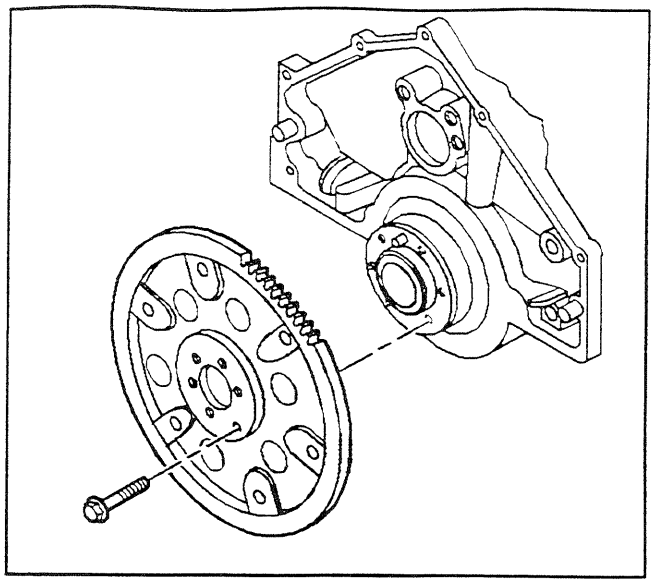
1. Install the flywheel to the crankshaft.

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

2. Install the flywheel mounting bolts.

   Tighten

   Tighten the bolts to 90 N·m (65 lb ft).



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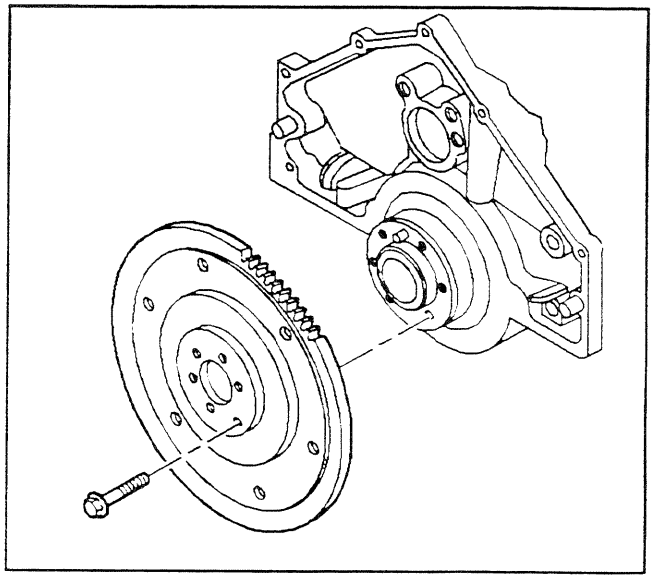
3. Install the flywheel (manual) to the crankshaft.

   Tighten

   Tighten the bolts to 90 N·m (65 lb ft).



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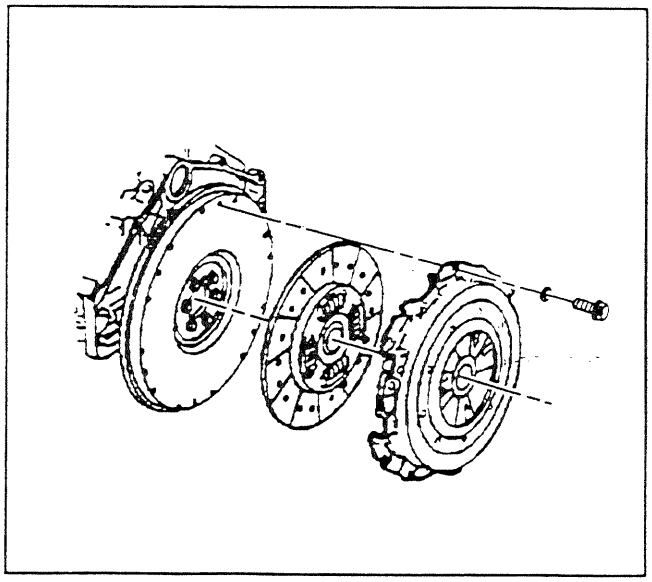
4. Install the Clutch to the flywheel. Refer to *Clutch Assembly Replacement* in Clutch.
5. Install the transmission to the vehicle.
   - For the automatic transmission. Refer to *Transmission Replacement* and *Transmission Replacement* in Transmission/Transaxle.
   - For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
6. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.



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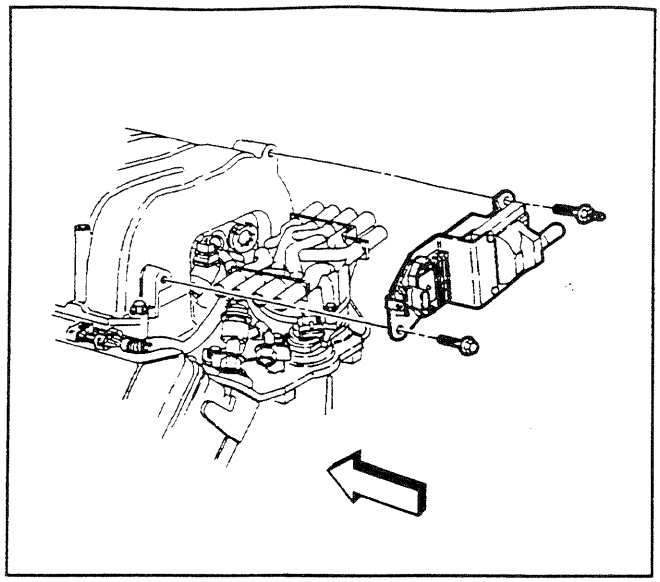

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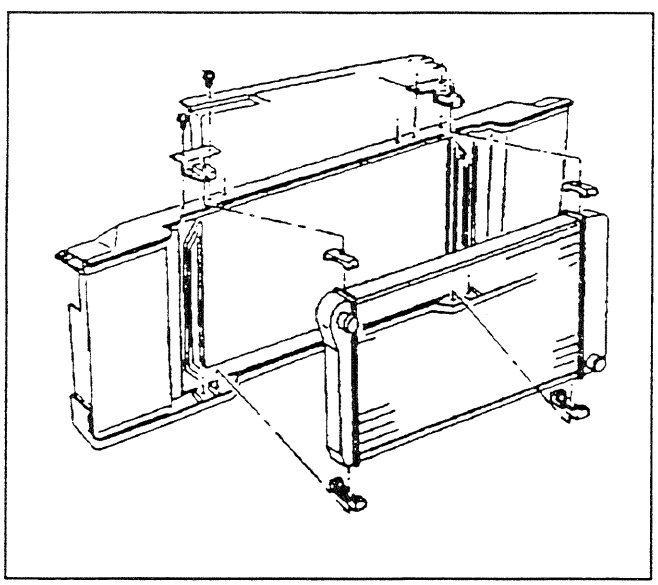


72749

Engine Replacement

SIE-ID = 506496

Removal Procedure

Tools Required

J 36857 Engine Lift Brackets

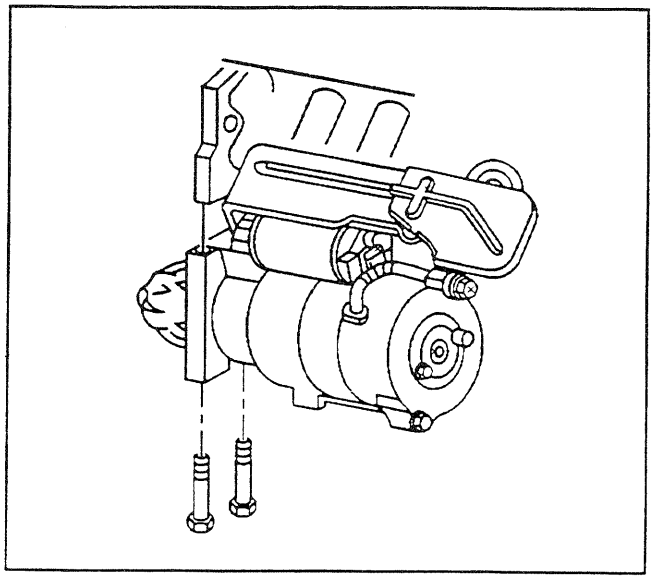
1. Remove the hood.
2. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
3. Remove the air cleaner duct and resonator from the throttle body.
4. Remove the ignition coil from the intake manifold. Refer to *Ignition Coil and ICM Replacement (HVS 7.4L)* in Engine Electrical.
5. Remove the electrical connector at the distributor. Refer to *Distributor Replacement (7.4L)* in Engine Electrical.
6. Remove the fuel supply lines from the fuel rail. Refer to *Fuel Rail Assembly Replacement* in Engine Controls.
7. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
8. Discharge to AC system. Refer to *Refrigerant Recovery and Recharging* in HVAC.
9. Remove the air conditioning compressor from the engine block. Refer to *Compressor Replacement (7.4L)* in HVAC.
10. Remove the radiator from the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
11. Disconnect the electrical connectors on the throttle body. Refer to *Throttle Body Assembly Replacement.*

Caution: SIO-ID = 352518 ***In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a NEW cable whenever you remove the engine from the vehicle.***

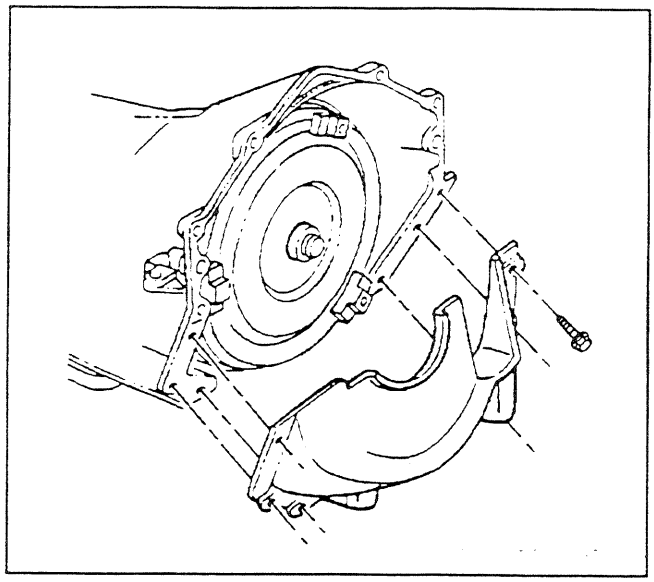
In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

12. Remove the accelerator control cable from the throttle body. Refer to *Accelerator Controls Cable Replacement.*
13. Remove the cruise control cables from the throttle body if equipped. Refer to *Accelerator Controls Cable Replacement.*
14. Remove the vacuum lines from the engine.
15. Remove the electrical connector from the EGR valve. Refer to *EGR Valve Replacement* in Engine Controls.
16. Remove the generator from the generator mounting bracket. Refer to *Generator Replacement (Gas, CS 144)* in Engine Electrical.
17. Remove the engine electrical harness and tie out of the way.

18. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
19. Remove the hoses from the power steering pump. Refer to *Power Steering Hoses Replacement* in Power Steering.
20. Remove the front propeller shaft if equipped. Refer to *Propeller Shaft Replacement - One Piece* or *Propeller Shaft Replacement - Two Piece* or *Propeller Shaft Replacement - Three Piece* in Driveline and Axle.
21. Remove the ground wires from the engine block. Refer to *Ground Strap Replacement* in Engine Electrical.
22. Remove the starter motor from the engine block. Refer to *Starter Motor Replacement (Gas, 7.4L)* in Engine Electrical.


84599

23. Remove the flywheel inspection cover from the transmission if equipped.
24. Remove the bolts from the torque convertor to the flywheel if equipped. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.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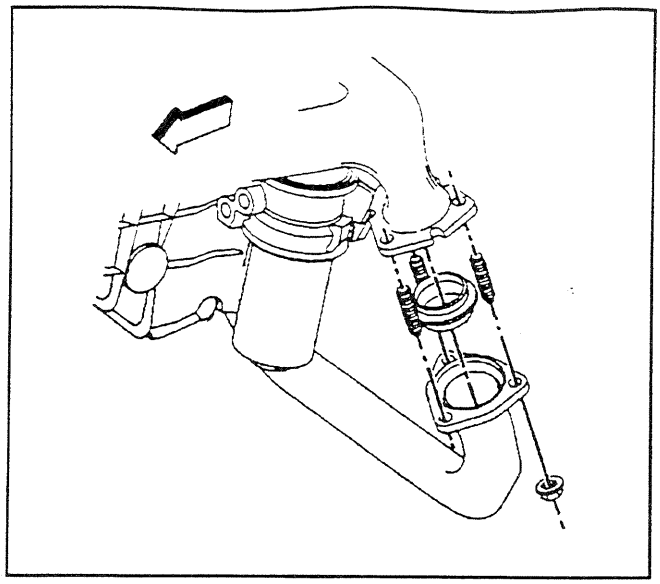
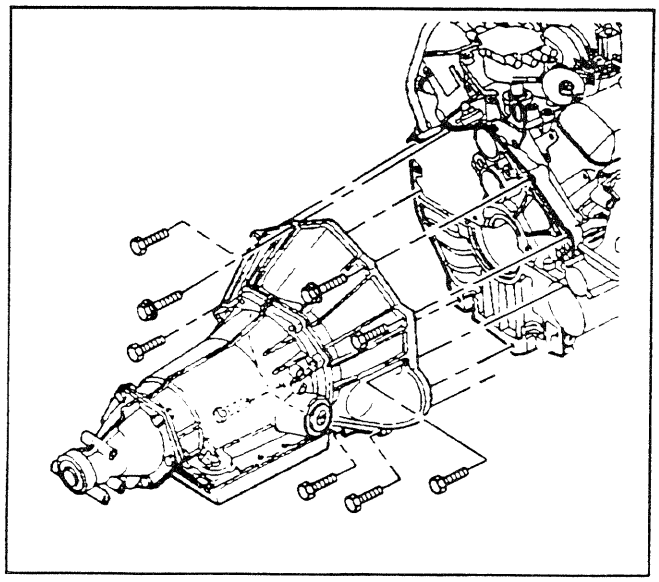


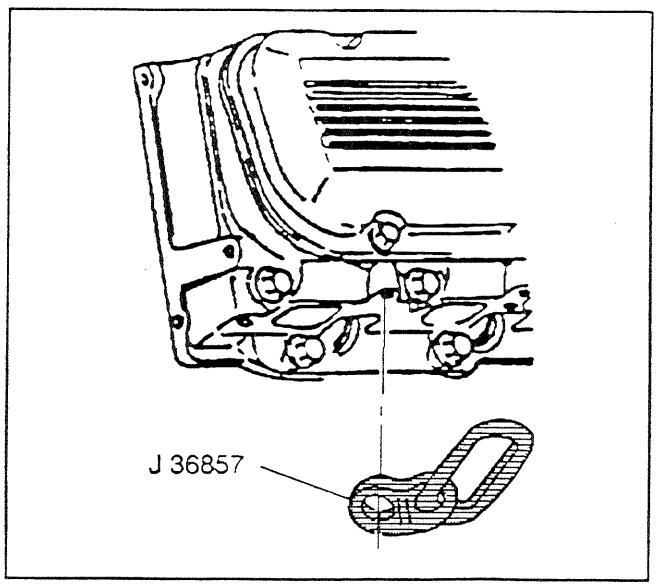
78428

25. Remove the exhaust pipes from the exhaust manifolds.
    - For vehicles under 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, Below 8600 lb (GVWR))* in Engine Controls.
    - For vehicles over 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, 8600 lb and Above)* in Engine Controls.



32774

26. Remove the bolts from the transmission to the engine block.
    - For the automatic transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
    - For the manual transmission Refer to *Transmission Replacement* in Transmission/Transaxle.
27. Remove the engine auxiliary oil cooler lines from the engine block. Refer to *Engine Oil Cooler Line Replacement.*
28. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
29. Support the transmission with a suitable jack.



66457

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

30. Attach *J 36857* to the rear of the right cylinder head.
31. Install the attaching bolt and washer. Use GM P/N 9428217 with GM P/N 15650963.
32. **Tighten**

Tighten the lift bracket bolts to 40 N·m (30 lb ft).

33. Remove the front engine mount through bolts.
34. Remove the engine with a suitable lifting devise.
35. Remove the generator mounting bracket from the engine block. Refer to *Accessory Mounting Brackets Replacement (Generator).*
36. Remove the air conditioning compressor/power steering mounting bracket from the cylinder head. Refer to *Accessory Mounting Brackets Replacement (AC).*

37. Remove the lift brackets from the cylinder head.

Installation Procedure

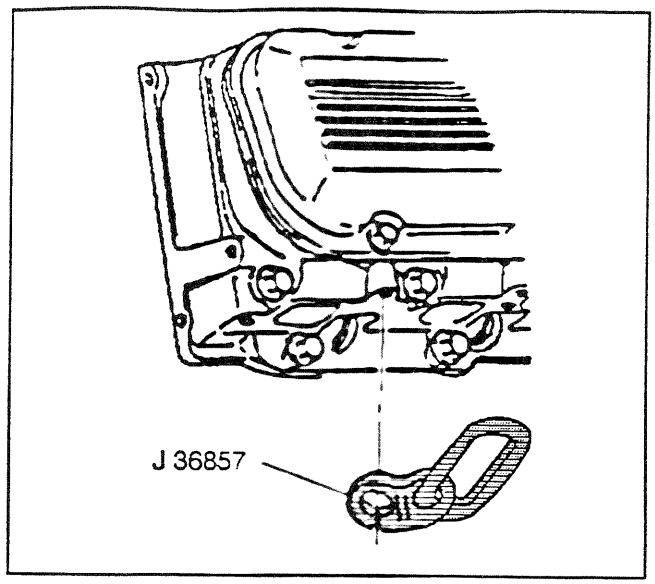
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Attach *J 36857* to the rear of the right cylinder head.

   Install the attaching bolt and washer. Use GM P/N 9428217 with GM P/N 15650963.

   Tighten

   Tighten the lift bracket bolts to 40 N·m (30 lb ft).



66457

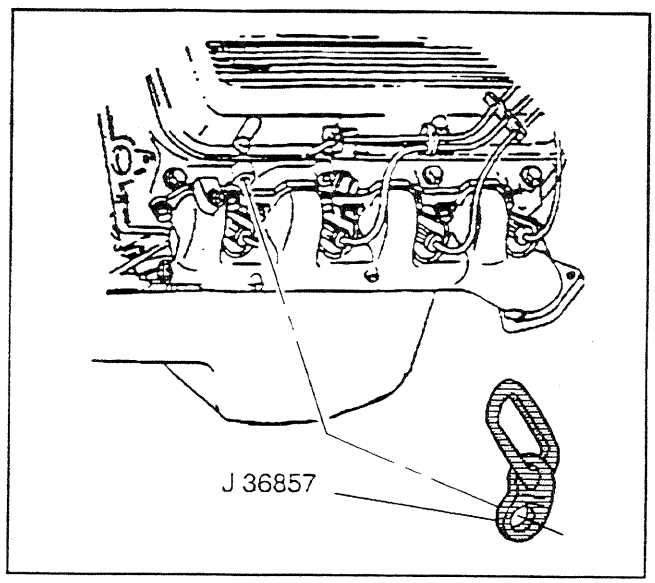
2. Attach *J 36857* to the left front cylinder head.

   Install the attaching bolt and washer. Use GM P/N 9428217 with GM P/N 15650963.

   Tighten

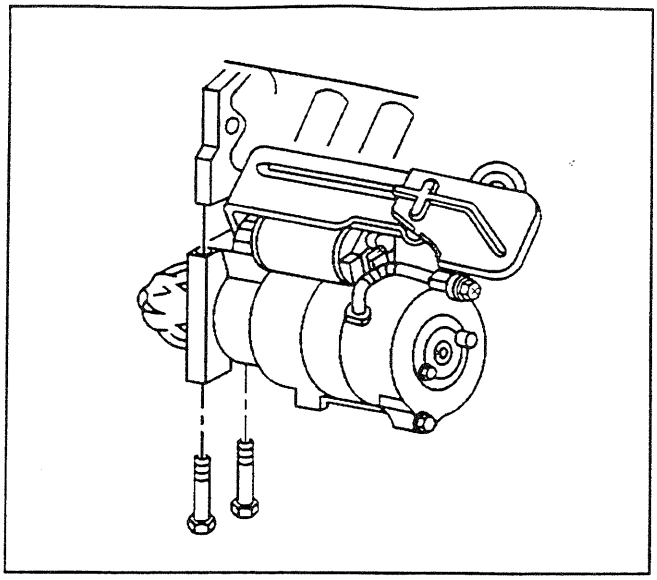
   Tighten the lift bracket bolts to 40 N·m (30 lb ft).

3. Install the engine into the vehicle.
4. Install the engine mounting through bolts.
5. Remove the engine lift hooks from the cylinder head.
6. Install the air compressor/power steering mounting bracket to the engine block. Refer to *Accessory Mounting Brackets Replacement (AC)*.
7. Install the generator mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator)* in Engine Electrical.
8. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
9. Install the bolts from the transmission to the engine block.
   - For the automatic transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
   - For the manual transmission. Refer to *Transmission Replacement* in Transmission/Transaxle.
10. Install the ground straps to the engine block. Refer to *Ground Strap Replacement* in Engine Electrical.
11. Install the hoses to the power steering pump. Refer to *Power Steering Hoses Replacement* in Power Steering.
12. Install the torque converter bolts. Refer to *Transmission Replacement* in Transmission/Transaxle.



66456

13. Install the convertor pan cover to the transmission. Refer to *Transmission Replacement* or *Transmission Replacement* in Transmission/Transaxle.
14. Install the starter to the engine block. Refer to *Starter Motor Replacement (Gas, 7.4L)* in Engine Electrical.
15. Install the oil cooler lines to the engine block if equipped. Refer to *Engine Oil Cooler Line Replacement* in Engine Cooling.



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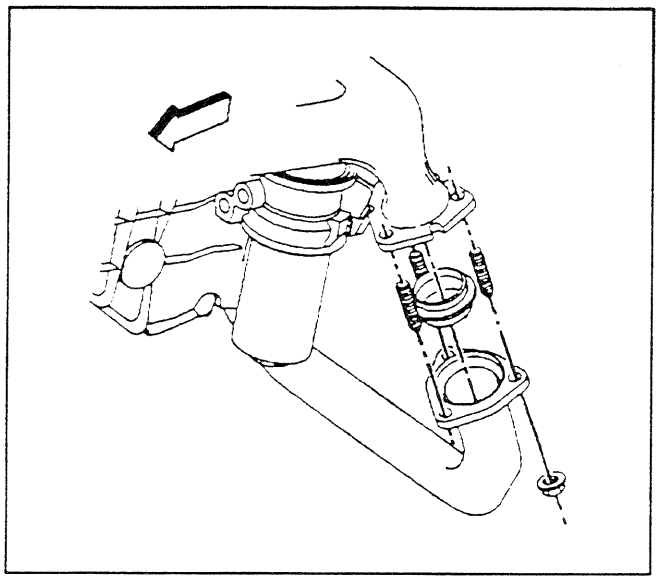


78428

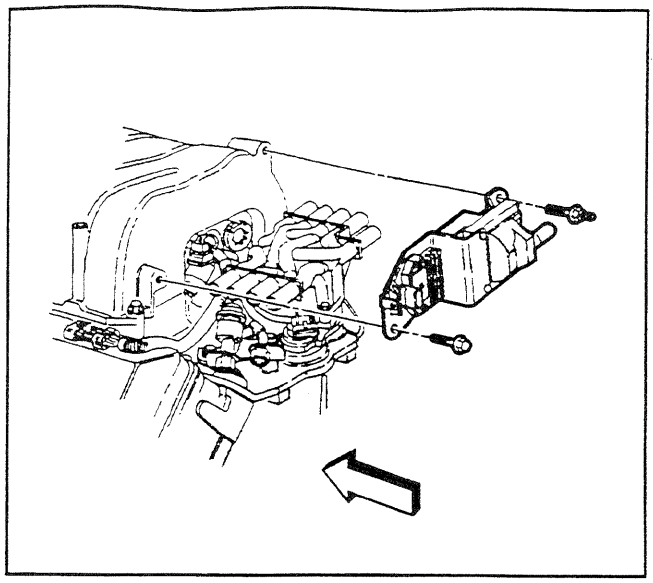
16. Install the exhaust pipes to the exhaust manifold.
    - For vehicles under 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, Below 8600 lb (GVWR))*
    - For vehicles over 8600 lb GVWR, refer to *Catalytic Converter Replacement (Gas, 8600 lb and Above)*.
17. Install the front propeller shaft (4WD). Refer to *Propeller Shaft Replacement - One Piece* or *Propeller Shaft Replacement - Two Piece* in Driveline and Axle.
18. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
19. Install the fuel lines to the fuel rail. Refer to *Fuel Rail Assembly Replacement*.

20. Install the ignition coil to the upper intake manifold. Refer to *Ignition Coil and ICM Replacement (HVS 7.4L)* in Engine Electrical.
21. Install the electrical connector to the distributor. Refer to *Distributor Replacement (7.4L)* in Engine Electrical.
22. Install the electrical connector to the EGR valve. Refer to *EGR Valve Replacement* in Engine Controls.
23. Install the electrical connectors to the throttle body. Refer to *Throttle Body Assembly Replacement.*

Caution: *SIO-ID = 352518* ***In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a NEW cable whenever you remove the engine from the vehicle.***

In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

24. Install the NEW accelerator control cable to the Throttle Body. Refer to *Accelerator Controls Cable Replacement.*
25. Install the vacuum lines to the engine.
26. Install the generator to the generator mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator)* in Engine Electrical.
27. Install the air conditioning compressor to the air conditioning/power steering mounting bracket. Refer to *Compressor Replacement (7.4L)* in HVAC.
28. Install the engine electrical wiring harness to the engine.
29. Install the radiator to the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
30. Install the Air Cleaner Duct and Resonator to the throttle body.
31. Fill the radiator with coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
32. Recharge the air conditioning system. Refer to *Refrigerant Recovery and Recharging* in HVAC.
33. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.
34. Install the hood.
35. Before starting a new engine or one that has been repaired. Refer to *Engine Set-Up and Testing.*
36. The final step is to perform the CKP System Variation Learn Procedure. Refer to *CKP System Variation Learn Procedure.*



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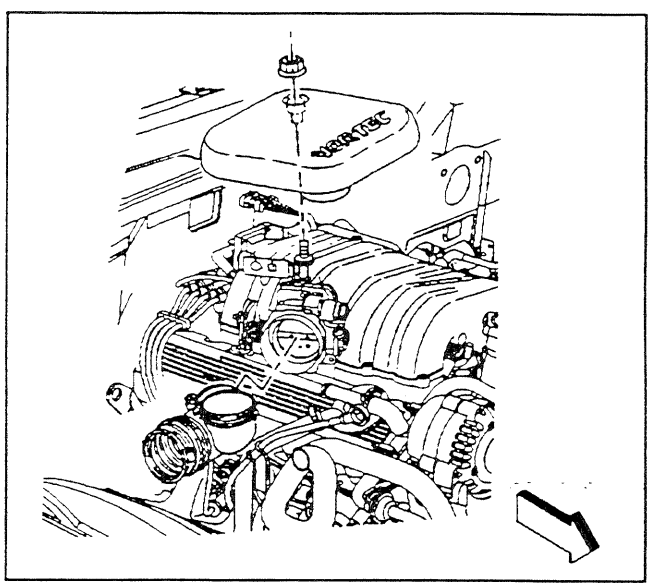

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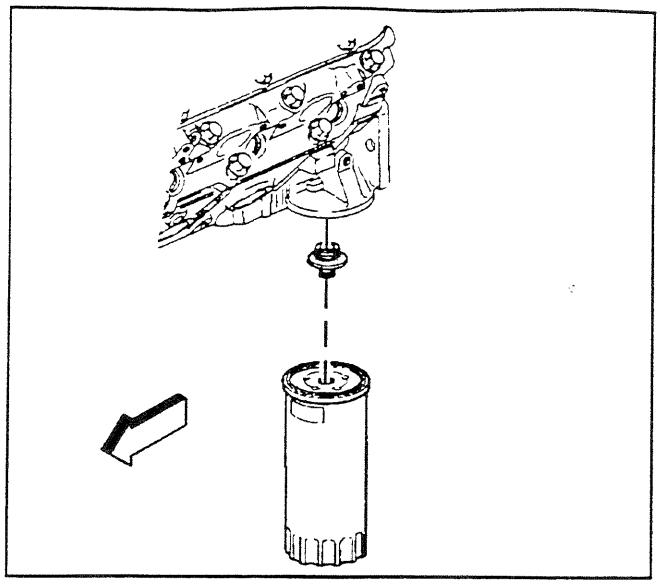


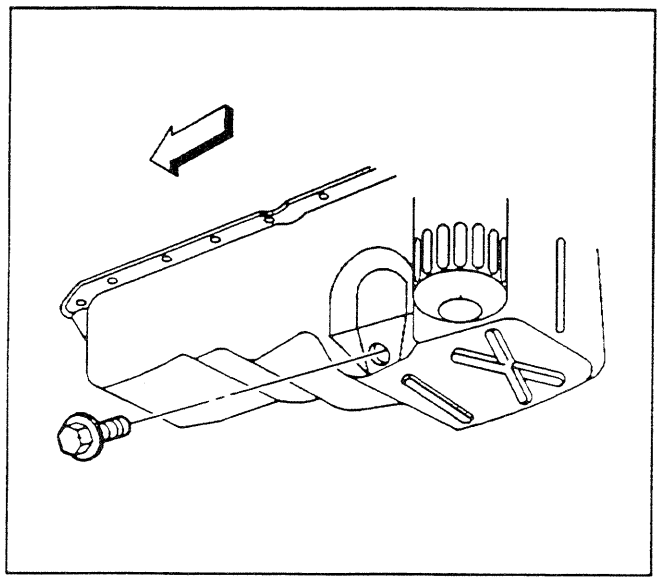
181988

Engine Oil and Oil Filter Replacement

SIE-ID = 506498

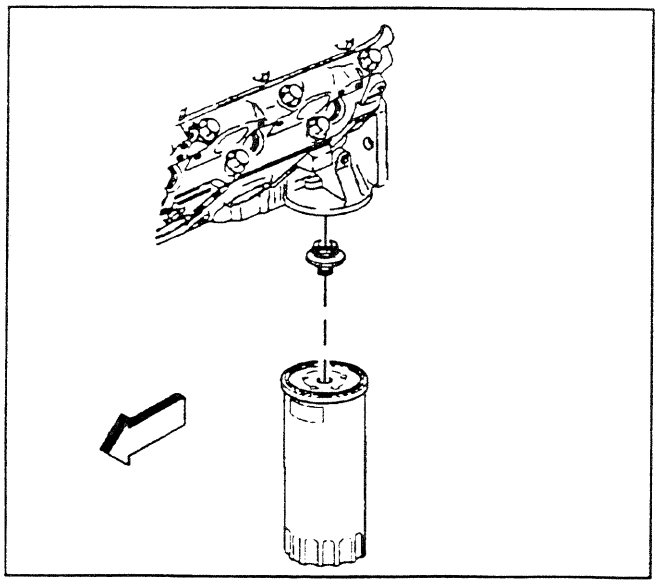
Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the oil filter from the engine block.



182850

3. Remove the oil pan drain plug and drain the engine oil.



181988

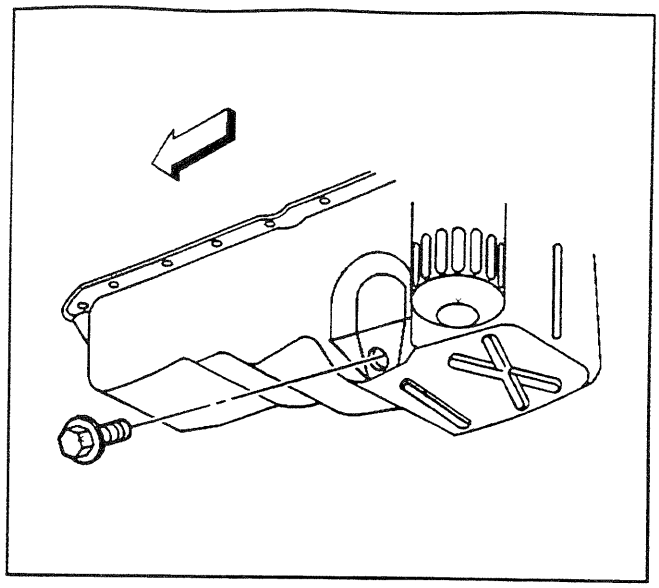
Installation Procedure

1. Install the oil filter to the engine block. Tighten the oil filter per the oil filter manufacturers instruction printed on the oil filter bax.

2. Install the drain plug to the oil pan.

   Tighten

   Tighten the drain plug to 28 Nm 21 lb ft
3. Lower the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Fill the crankcase with oil. Refer to *Capacities - Approximate Fluid* in General Information.



182850

Engine Set-Up and Testing

SIE-ID = 298634

After overhaul, test the engine before it is installed in the vehicle. If a suitable test stand is not available, the following procedure can be used after the engine is installed in the vehicle.

1. Fill the crankcase with the proper quantity and grade of oil.
2. Add engine oil supplement GM P/N 1052367 or equivalent to the engine oil.
3. Fill the cooling system with engine coolant GM Goodwrench DEX-COOL (GM Specification 6277M).
4. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any of the parts are binding.
5. Start the engine and listen for unusual noises.
6. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.

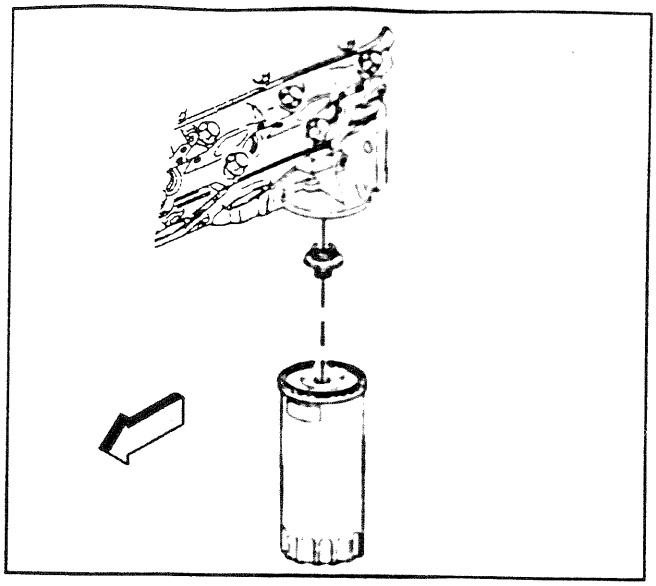
   If necessary, install an oil pressure gauge and measure the engine oil pressure.
7. Run the engine at about 1000 RPM until the engine has reached normal operating temperature.
8. Listen for improperly adjusted or sticking valves, sticking lifters, or other unusual noises.
9. Inspect for oil and/or coolant leaks while the engine is running.
10. Verify that the distributor is properly positioned/adjusted.
11. Perform a final inspection for the proper engine oil and coolant levels.

Draining Fluids and Oil Filter Removal

SIE-ID = 197962

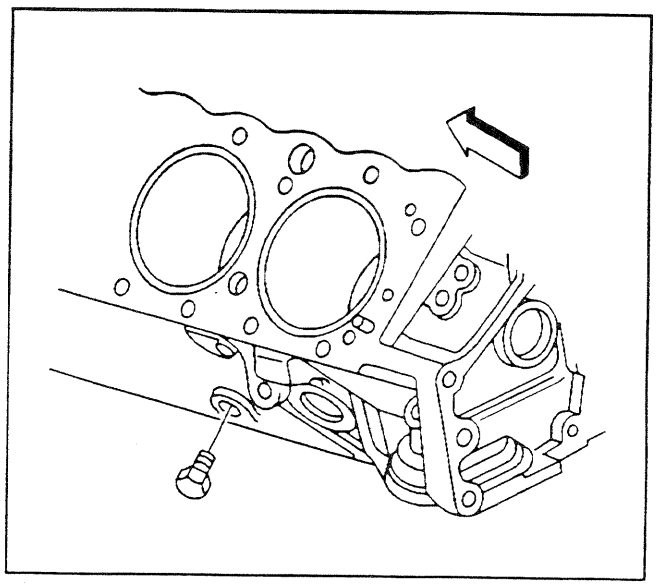
SIO-ID = 197937

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



181988

4. Remove the coolant drain hole plugs.
5. Drain the coolant.

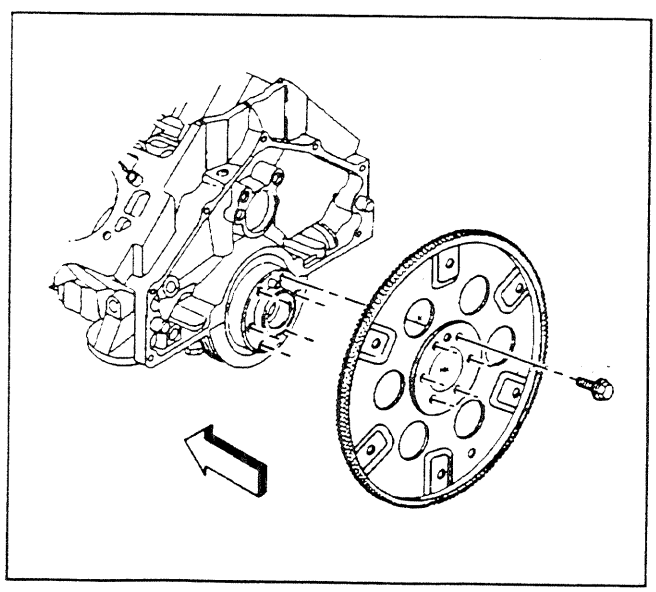


69033

Engine Flywheel Removal (MT1 Automatic Transmission)

SIE-ID = 36342

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



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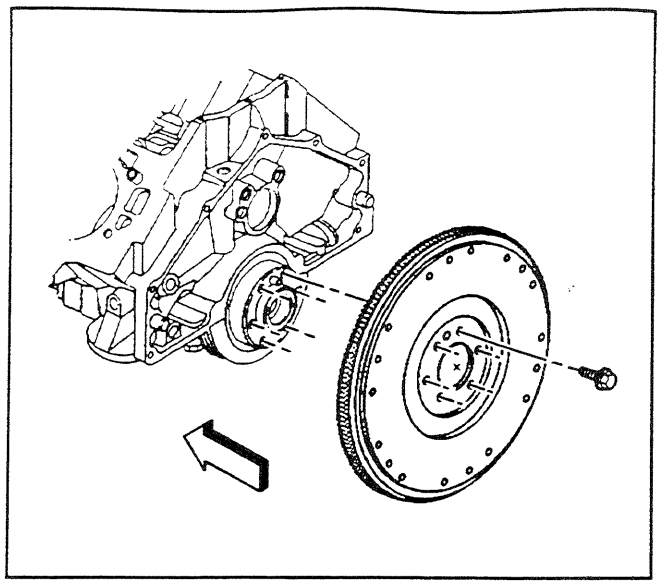
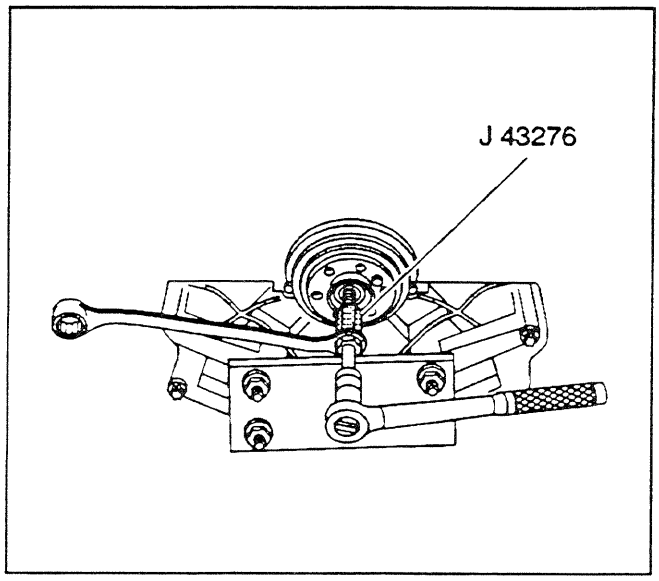


363409

Engine Flywheel Removal (MW3 Manual Transmission)

SIE-ID = 363426

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



373133

Clutch Pilot Bearing Removal

SIE-ID = 378499

Tools Required

J 43276 Clutch Pilot Bearing Remover

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

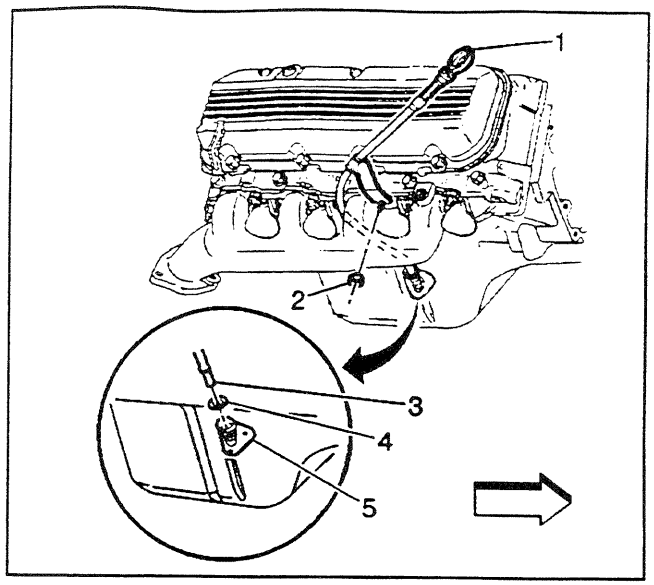
Notice: SIO-ID = 352829 When using the J 43276 Clutch Pilot Bearing Remover always secure the J 43276-1 Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the J 43276-1 Clutch Pilot Bearing Remover tool body to rotate. Failing to do so will cause damage to the J 43276-1 Clutch Pilot Bearing Remover tool body.

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

Oil Level Indicator and Tube Removal

SIE-ID = 500284

1. Remove the oil level indicator (1) from the oil level indicator tube (3).
2. Remove the oil level indicator tube bracket nut (2) from the right exhaust manifold stud.
3. Remove the oil level indicator tube (3) from the oil pan (5).
4. Remove the oil level indicator O-ring seal (4) (if required).

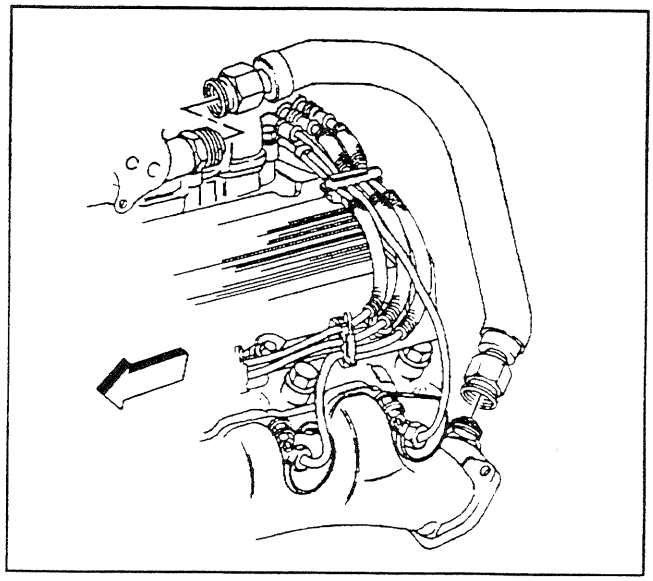


180884

Exhaust Manifold Removal (Left)

SIE-ID = 364040

1. Remove the exhaust gas recirculation (EGR) valve inlet pipe from the intake manifold.
2. Remove the EGR valve inlet pipe from the left exhaust manifold.

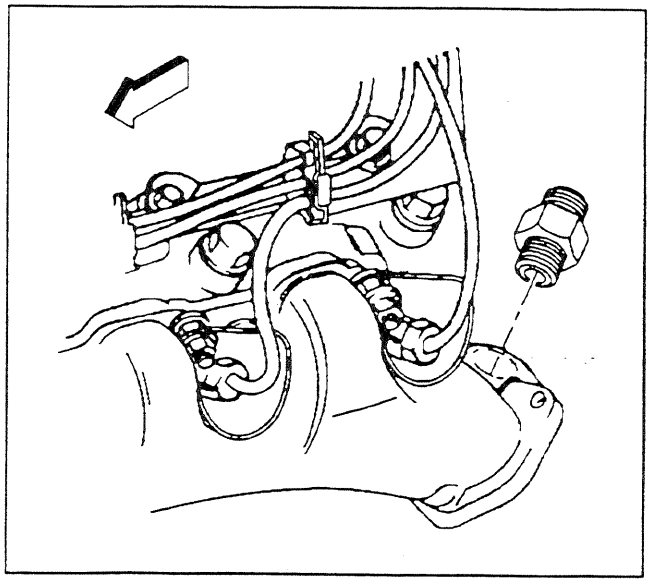


173284

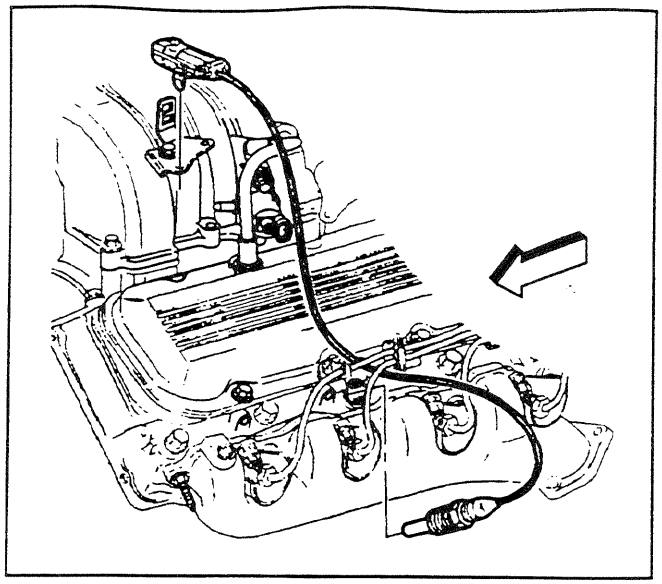
3. Remove the exhaust manifold adapter, if required.

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

4. Remove the spark plug wire boots from spark plugs.

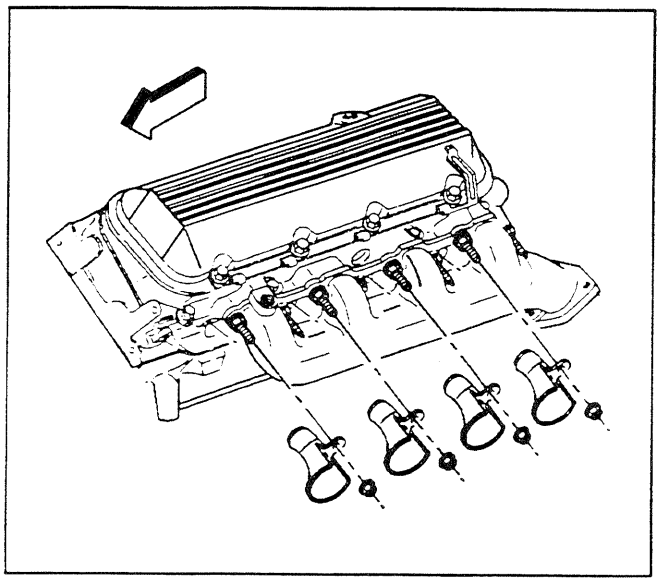


354034



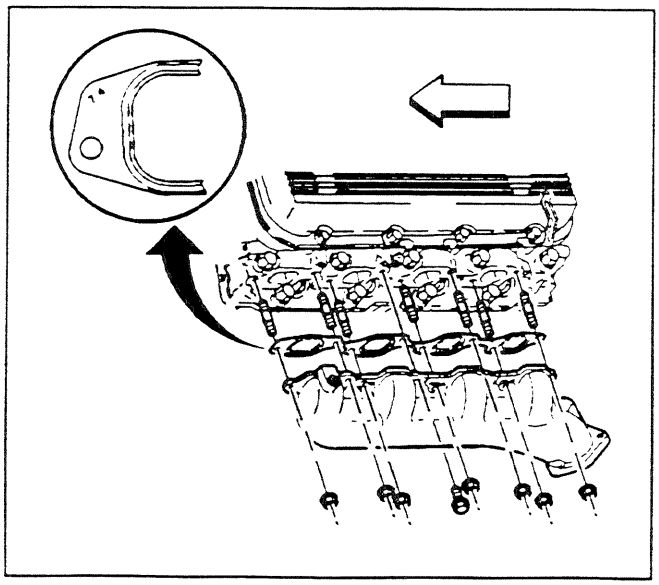
492025

5. Disconnect the ECT sensor wiring harness connector from the bracket on the upper intake manifold.
6. Remove the ECT sensor from the left cylinder head.



354056

7. Remove the spark plug heat shield nuts.
8. Remove the spark plug heat shields.



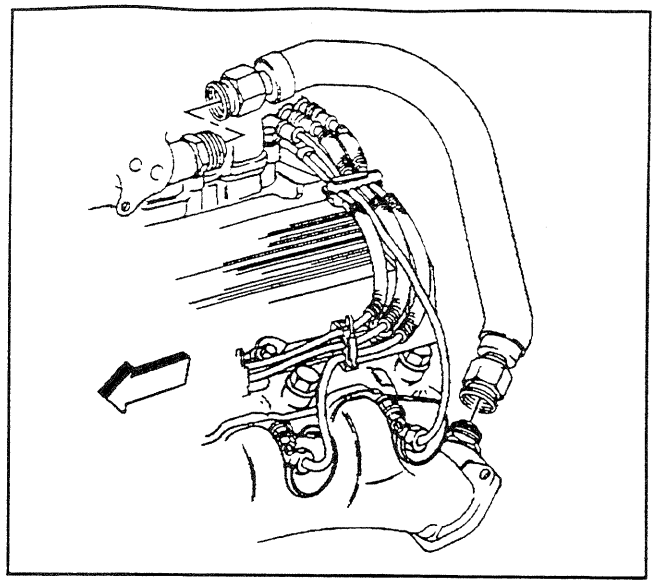
180888

9. Remove the exhaust manifold nuts and center bolt.
10. Remove the exhaust manifold.
11. Remove the exhaust manifold gasket. Discard the exhaust manifold gasket.
12. Remove the exhaust manifold studs, if required.

Exhaust Manifold Removal (Left with RPO K19)

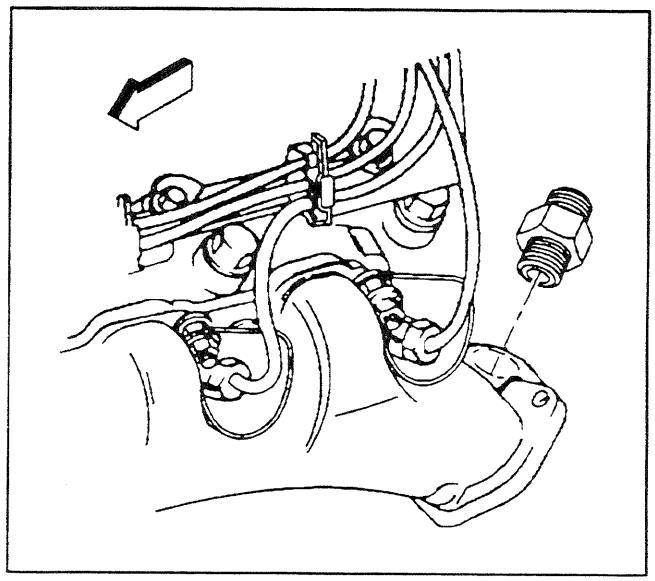
SIE-ID = 204023

1. Remove the exhaust gas recirculation (EGR) valve inlet pipe from the intake manifold.
2. Remove the EGR valve inlet pipe from the left exhaust manifold.



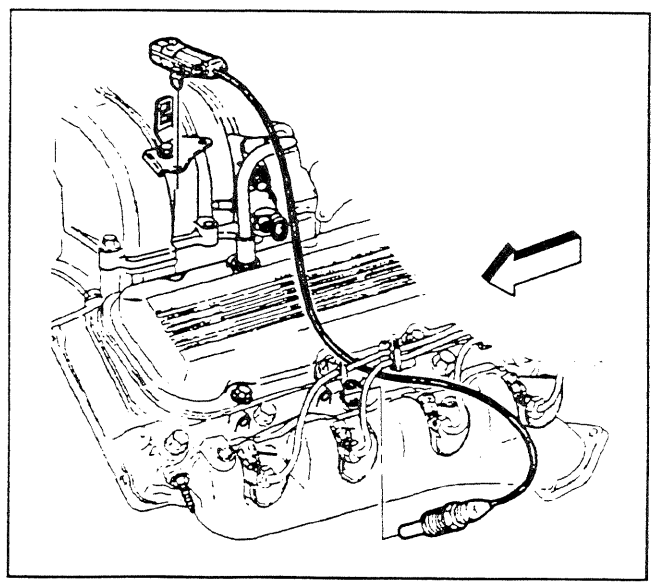
173284

3. Remove the exhaust adapter, if required.

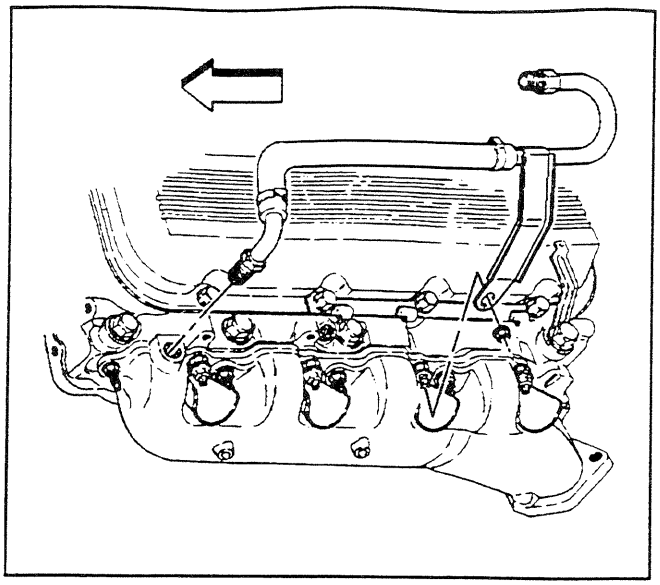


354034

4. Disconnect the ECT sensor wiring harness connector from the bracket on the upper intake manifold.
5. Remove the ECT sensor from the left cylinder head.



492025

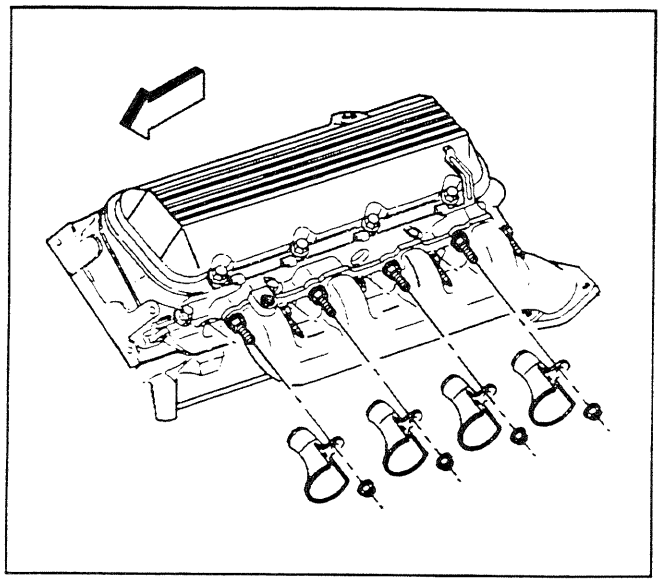


180942

6. Remove the AIR tube assembly pipe fitting from the exhaust manifold, if required.
7. Remove the AIR tube assembly pipe bracket nut from the exhaust manifold stud.

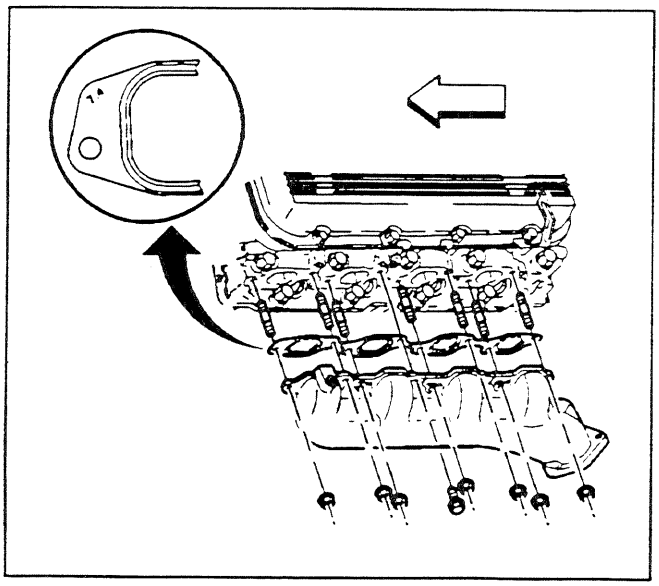
Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

8. Remove the spark plug wire boots from spark plugs.



354056

9. Remove the spark plug heat shield nuts.
10. Remove the spark plug heat shields.



180888

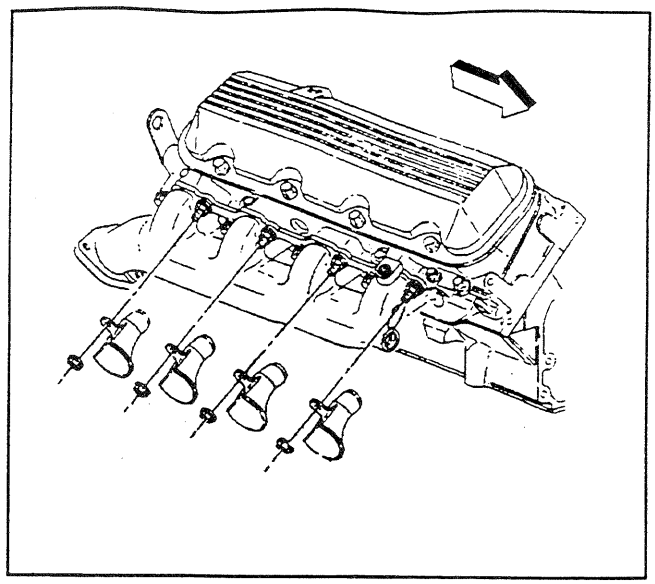
11. Remove the exhaust manifold nuts and center bolt.
12. Remove the exhaust manifold.
13. Remove the exhaust manifold gasket. Discard the exhaust manifold gasket.
14. Remove the exhaust manifold studs, if required.

Exhaust Manifold Removal (Right)

SIE-ID = 364043

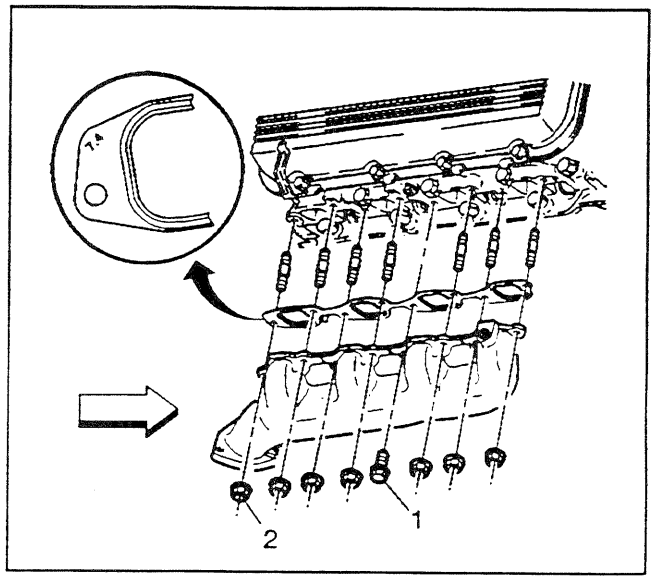
Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wire boots from the spark plugs
2. Remove the spark plug heat shields nuts.
3. Remove the spark plug heat shields.



65852

4. Remove the exhaust manifold nuts (2) and center bolt (1).
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket. Discard the exhaust manifold gasket.
7. Remove the exhaust manifold studs, if required.



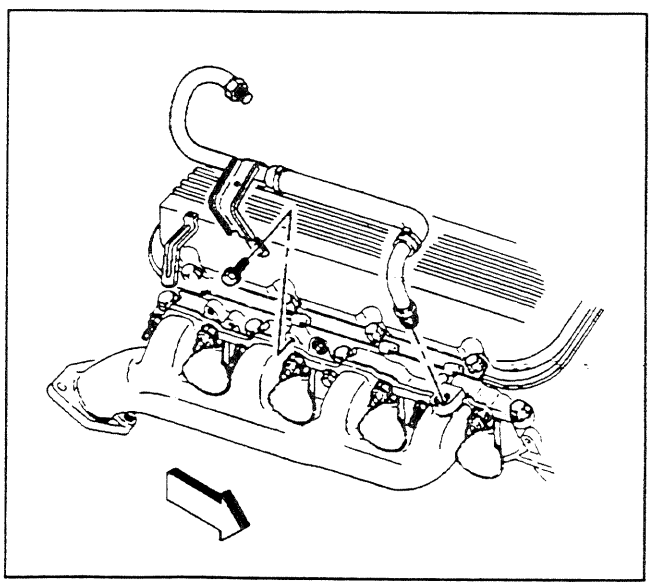
180881

Exhaust Manifold Removal (Right with RPO K19)

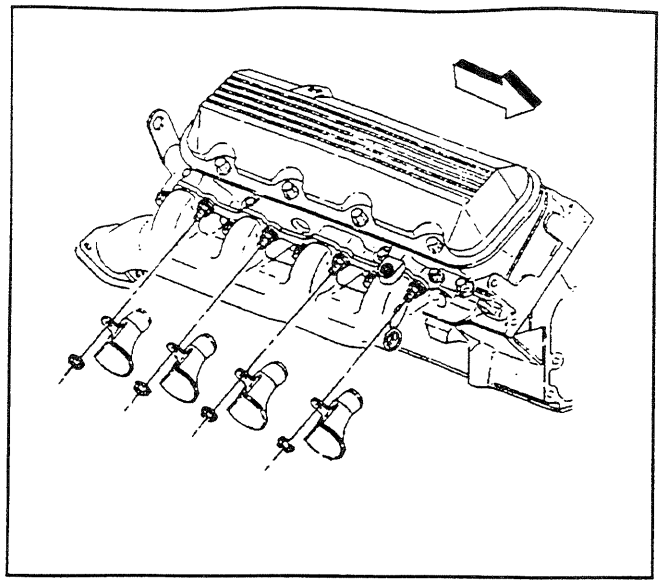
SIE-ID = 192874

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wire boots from the spark plugs
2. Remove the AIR tube assembly pipe fitting from the exhaust manifold, if required.
3. Remove the AIR tube assembly pipe bracket bolt from the cylinder head.

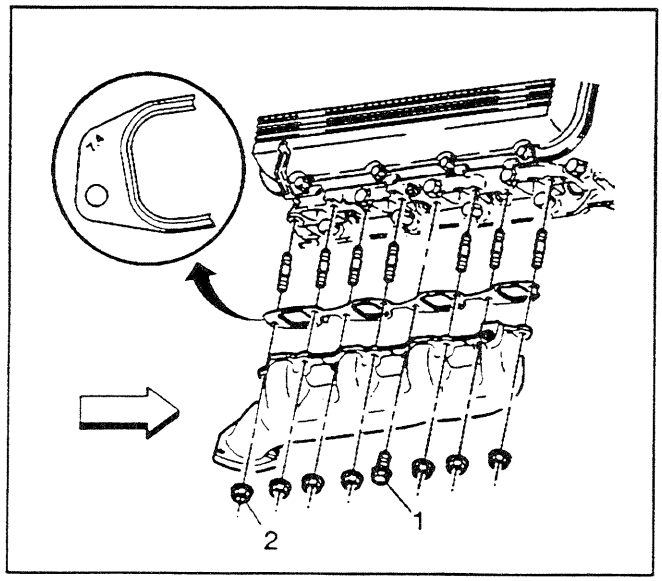


354054



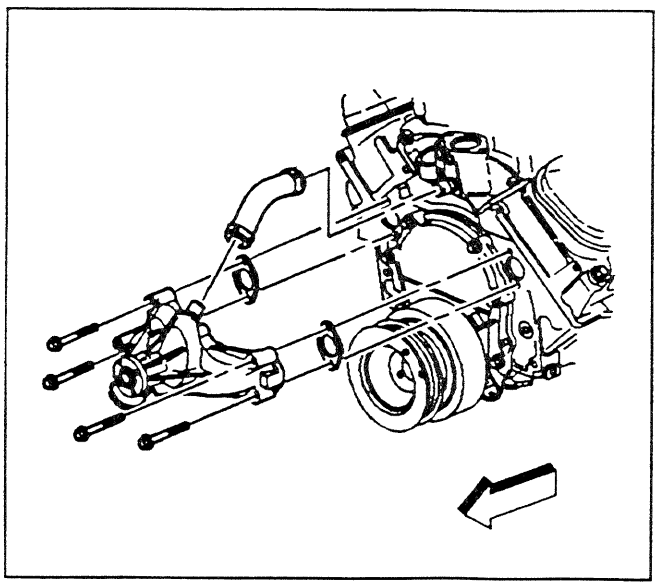
65852

4. Remove the spark plug heat shields nuts.
5. Remove the spark plug heat shields.



180881

6. Remove the exhaust manifold nuts (2) and center bolt (1).
7. Remove the exhaust manifold.
8. Remove the exhaust manifold gasket. Discard the exhaust manifold gasket.
9. Remove the exhaust manifold studs, if required.



66263

Water Pump Removal

SIE-ID - 66377

1. Loosen the water pump bypass hose clamps.
2. Remove the water pump bolts.
3. Remove the water pump.
4. Remove the water pump gaskets.
5. Remove the water pump bypass hose and clamps.

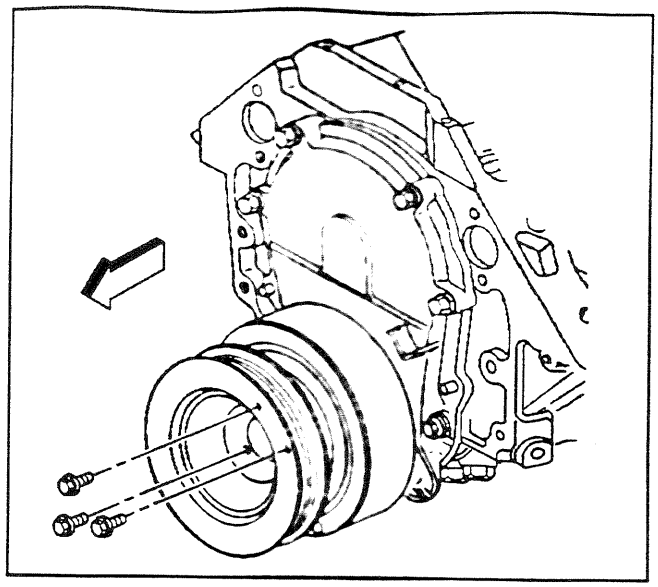
Crankshaft Balancer Removal

SIE-ID = 311315

Tools Required

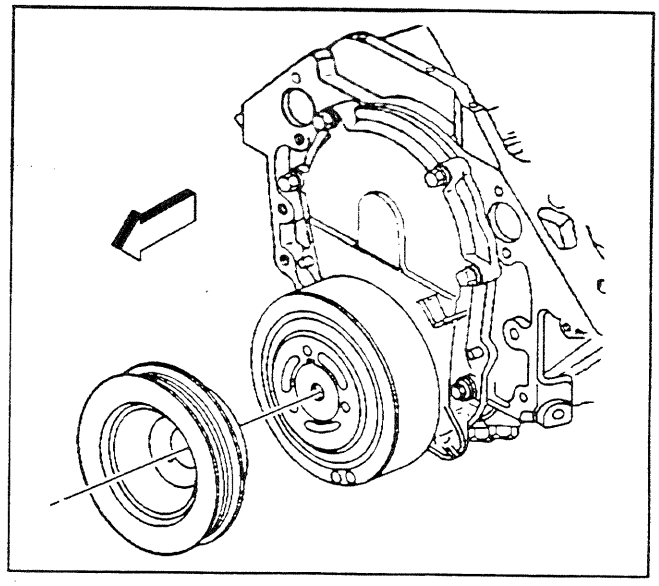
J 23523-F Crankshaft Balancer Remover and Installer

1. Remove the crankshaft pulley bolts.



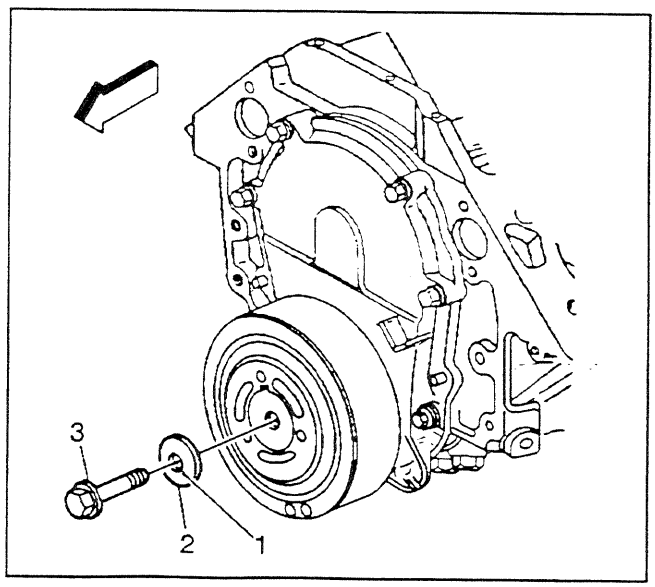
354014

2. Remove the crankshaft pulley.

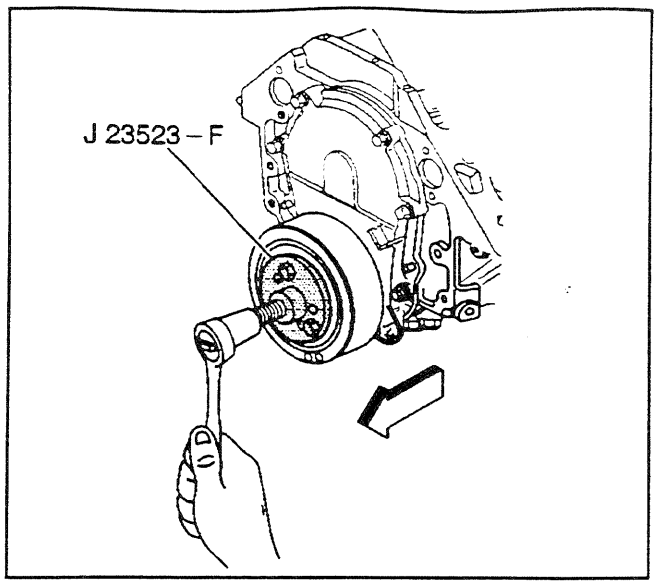


354015

3. Remove the crankshaft balancer bolt (3) and washer (2).



354016



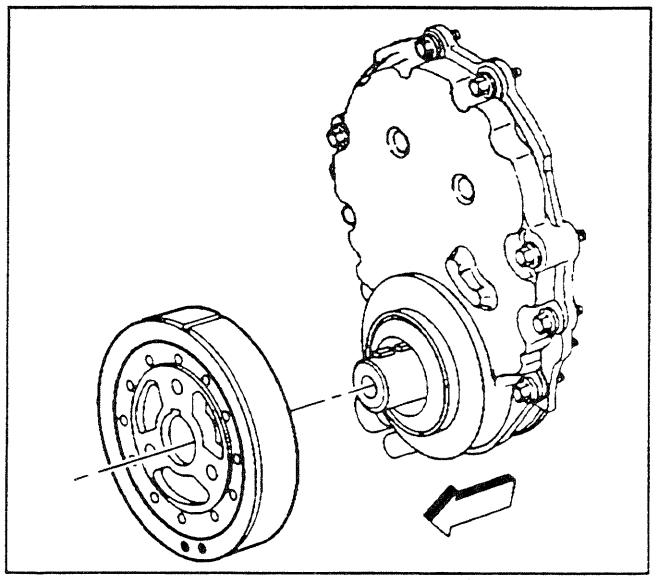
354023

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

4. Use the *J 23523-F* in order to remove the crankshaft balancer.
   4.1. Install the *J 23523-F* plate and bolts.

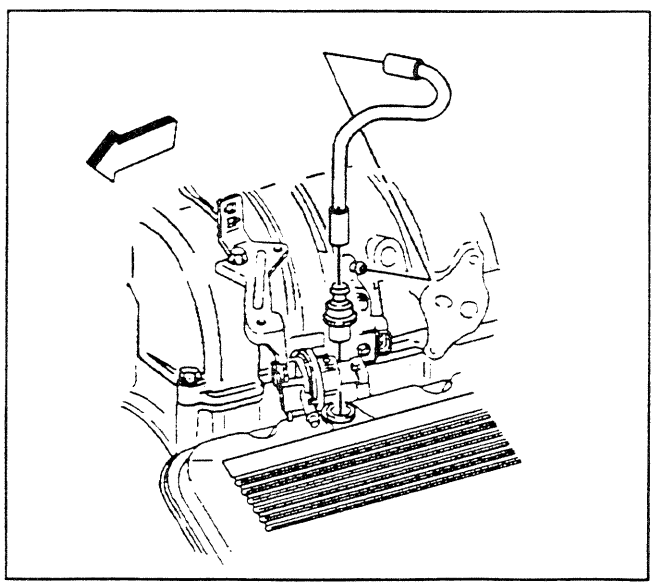
   Tighten

   Tighten the *J 23523-F* bolts to 25 N·m (18 lb ft).
   4.2. Install the *J 23523-F* forcing screw.
   4.3. Rotate the *J 23523-F* forcing screw clockwise in order to remove the crankshaft balancer.



182832

5. Remove the crankshaft balancer.
6. Remove the *J 23523-F* from the crankshaft balancer.



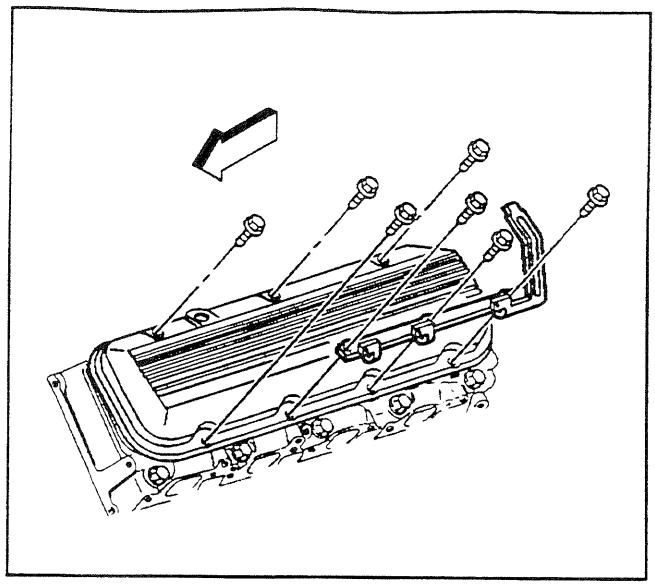
173187

Valve Rocker Arm Cover Removal (Left)

SIE-ID - 204204

1. Remove the Positive Crankcase Ventilation Valve (PCV) and crankcase ventilation tube.

2. Remove the valve rocker arm cover bolts.
3. Remove the spark plug wiring harness bracket(s).

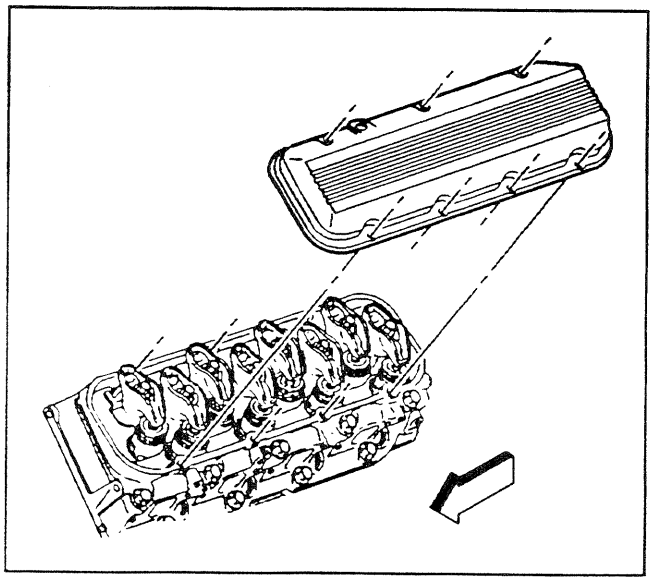


354009

4. Remove the valve rocker arm cover.

Important: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

Remove the valve rocker arm cover gasket if it is cut or damaged.

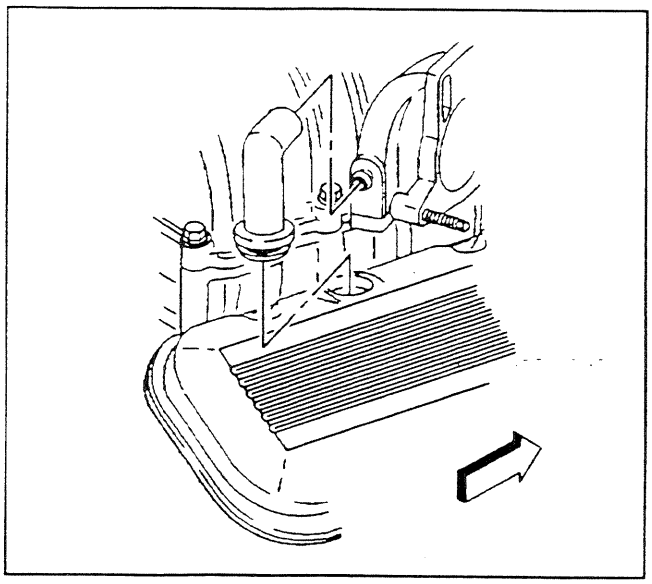


354006

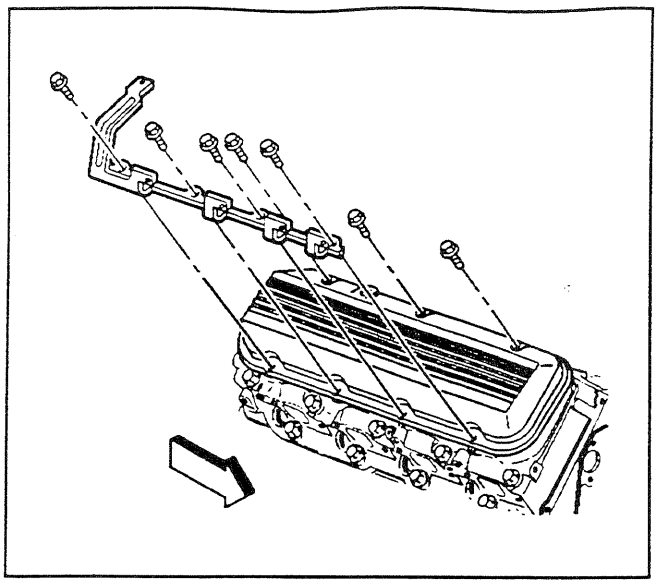
Valve Rocker Arm Cover Removal (Right)

SIE-ID = 204206

1. Remove the crankcase ventilation tube.

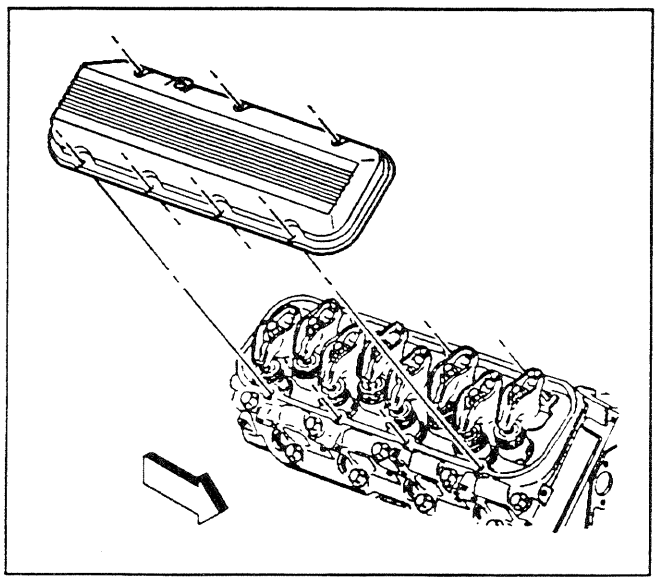


173189



354012

2. Remove the valve rocker arm cover bolts.
3. Remove the spark plug wiring harness bracket(s).

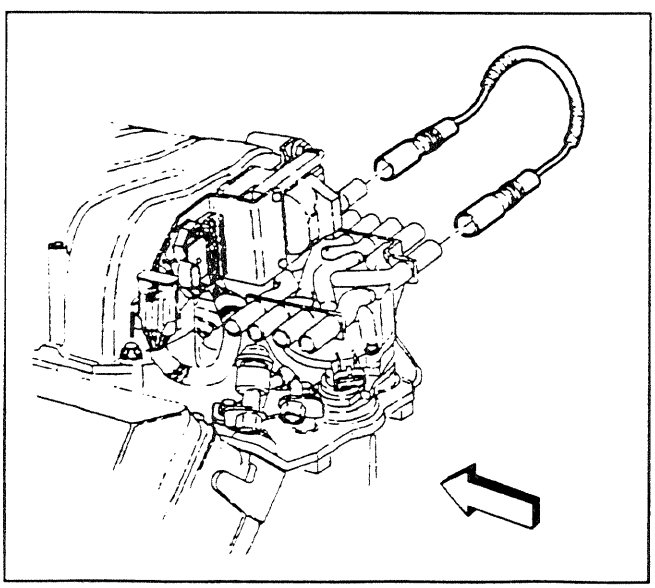


354010

4. Remove the valve rocker arm cover.

Important: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

Remove the valve rocker arm cover gasket if it is cut or damaged.



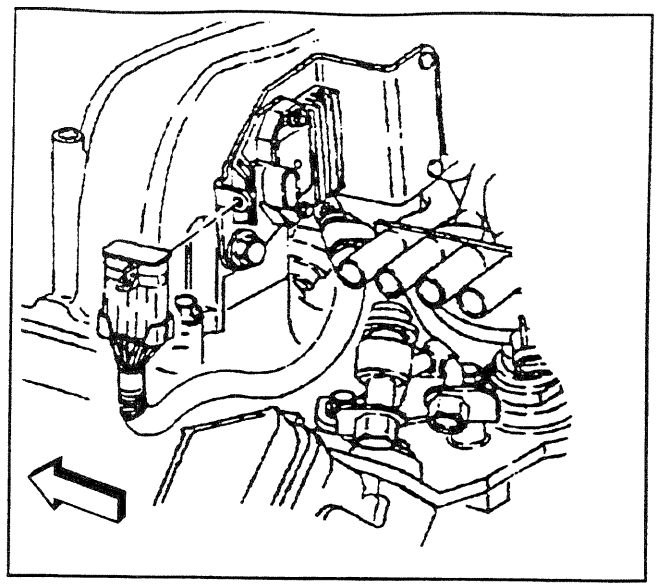
492041

Distributor Removal

SIE-ID - 500297

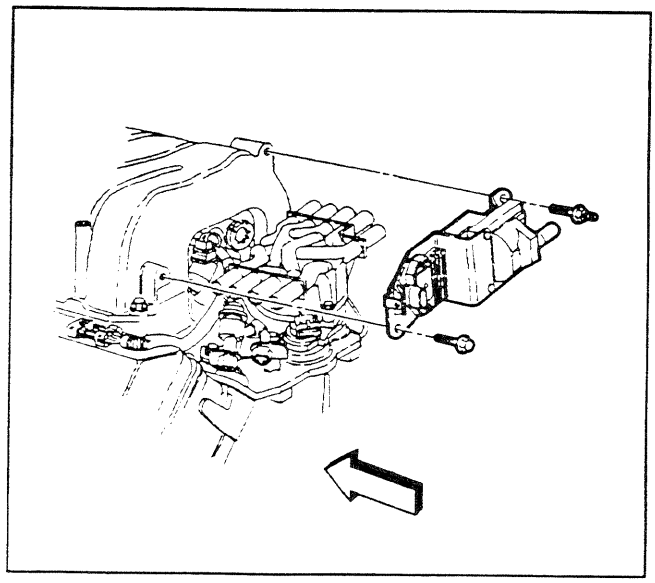
1. Remove the spark plug wire clips from the spark plug wire brackets.
2. Disconnect the ignition coil wire from the distributor and ignition coil.

3. Disconnect the fuel injector wiring harness connector from the ignition coil bracket.



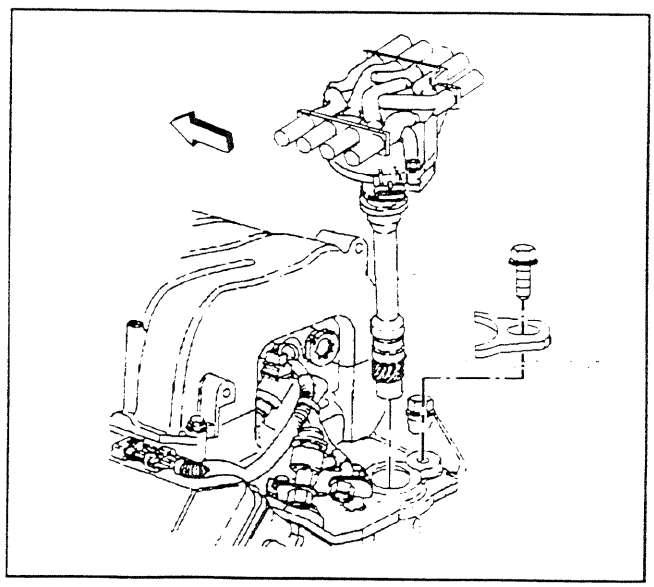
501421

4. Remove the ignition coil bracket bolt and stud from the upper intake manifold.
5. Remove the ignition coil from the upper intake manifold.

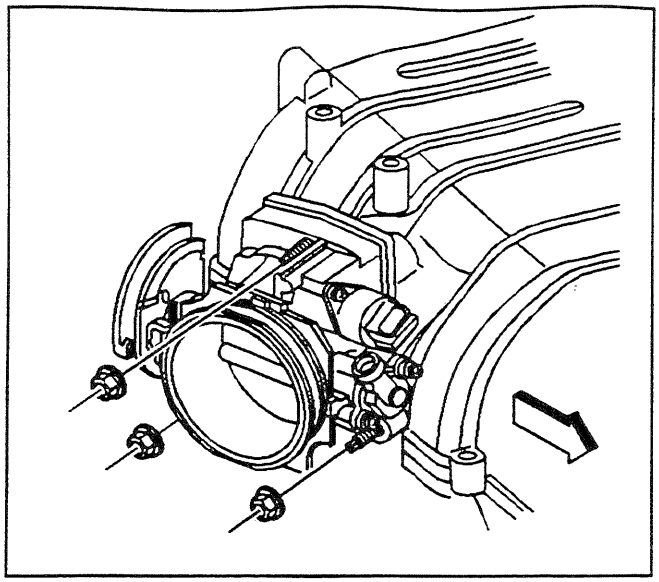


68506

6. Remove the distributor hold down clamp bolt from the lower intake manifold.
7. Remove the distributor.



68504

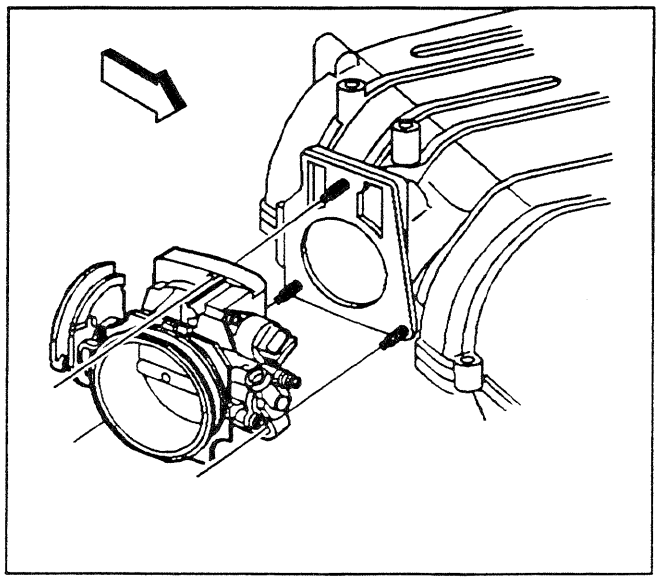


18299

Throttle Body Removal

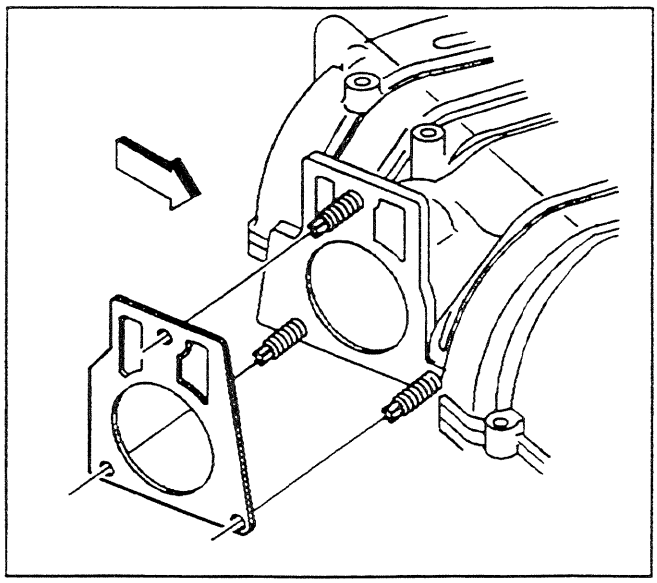
SIE-ID = 563861

1. Remove the throttle body nuts.



18302

2. Remove the throttle body.



18303

3. Remove the throttle body gasket.
4. Remove the throttle body studs, if required.

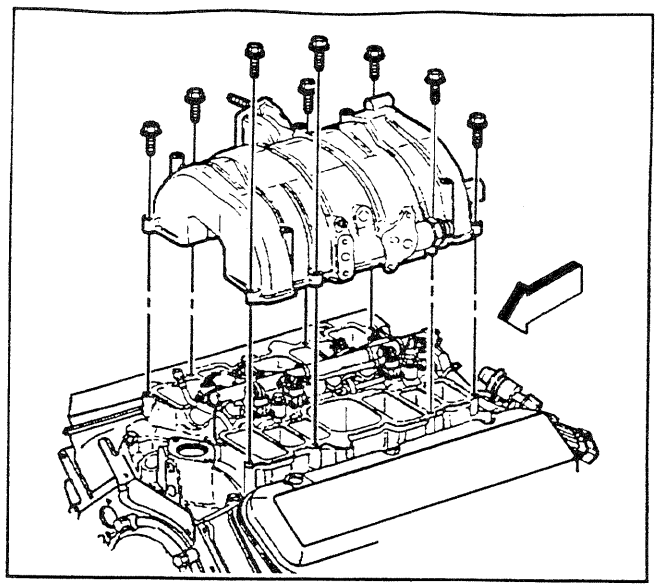
Intake Manifold Removal

SIE-ID = 500302

1. Remove the upper intake manifold bolts.

Important: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

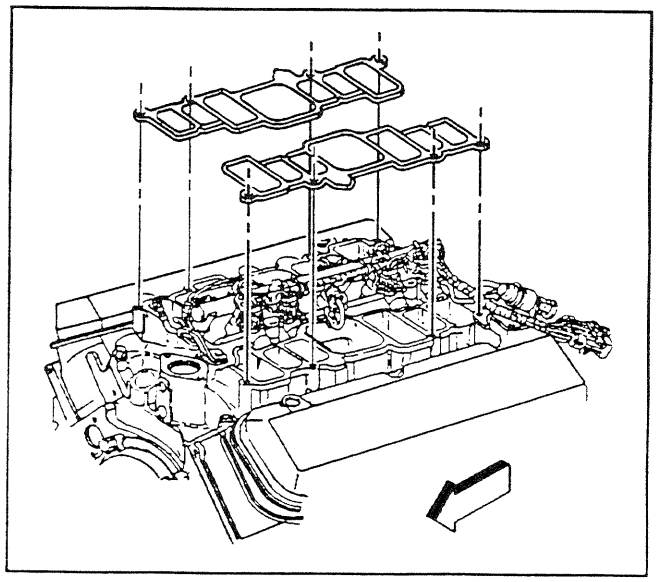
Remove the upper intake manifold.



351769

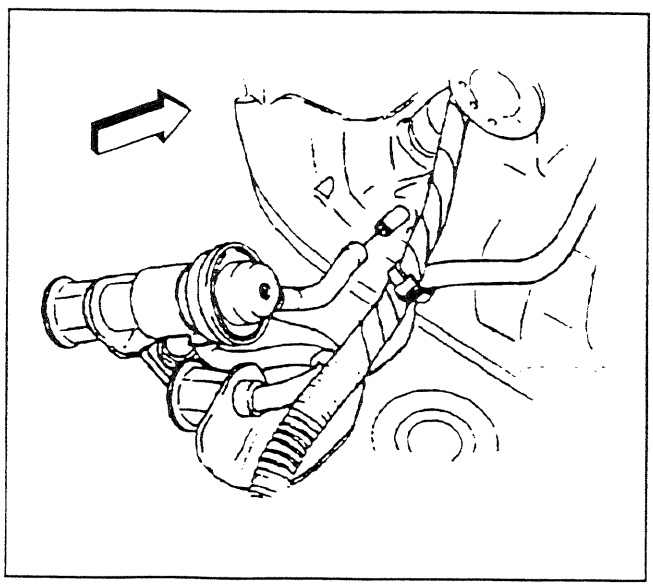
Important: The upper intake manifold gaskets are not reusable.

Remove and discard the upper intake manifold gaskets.

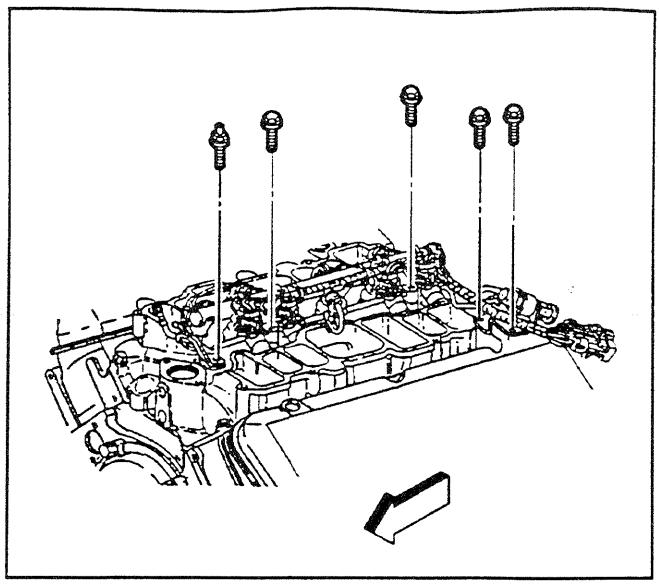


351764

2. Disconnect the fuel injector regulator vacuum hose connection from the intake manifold fitting.

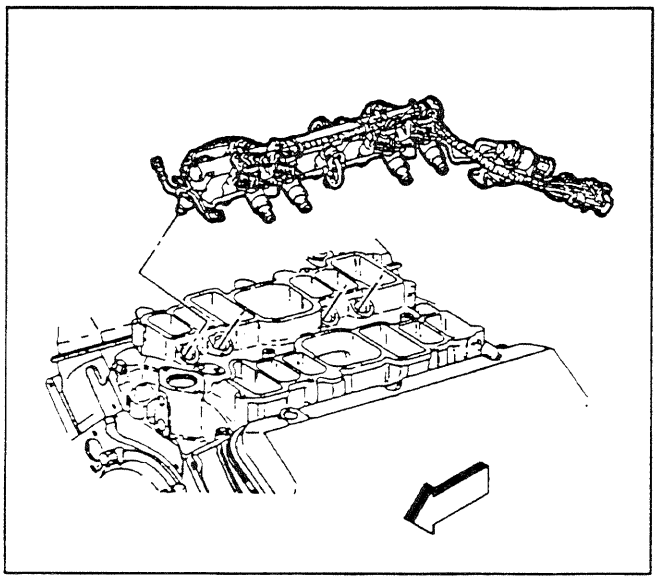


501422



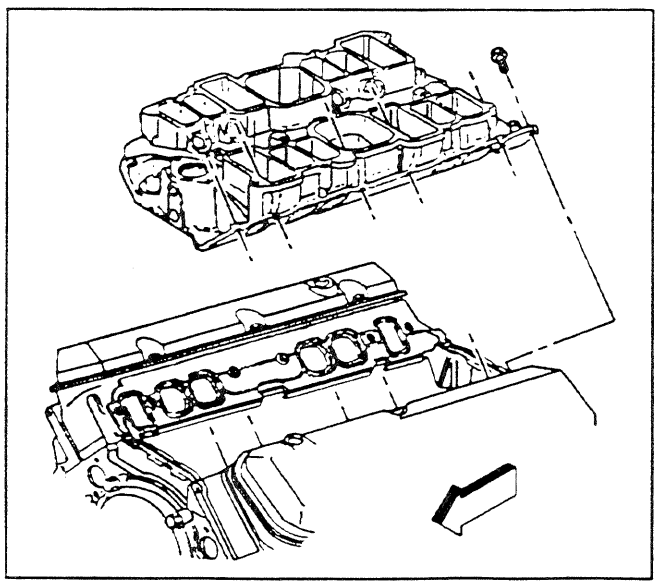
276370

3. Remove the fuel rail bolts.



276369

4. Remove the fuel rail assembly.
   Lift evenly on both sides of the assembly until all the injectors have left their bores.



351763

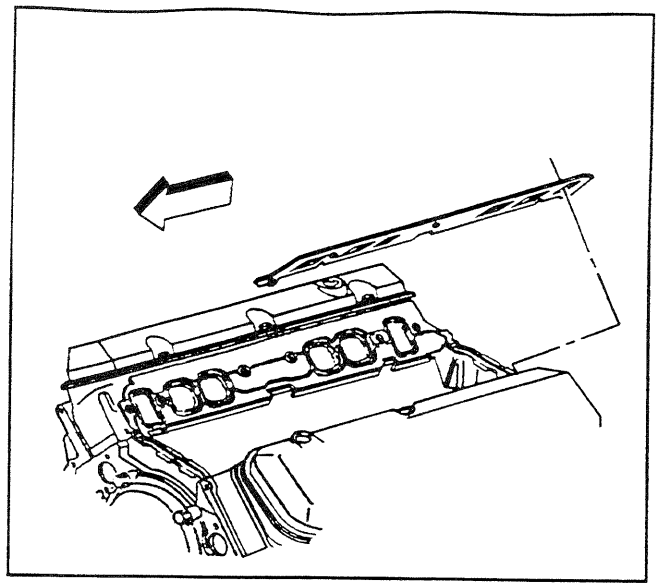
5. Remove the lower intake manifold bolts.

Important: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

Remove the lower intake manifold.

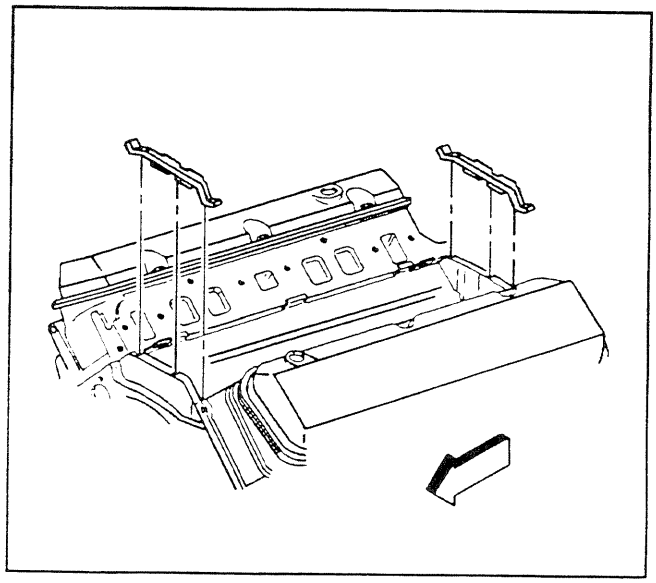
Lift the lower intake manifold up evenly until removed from the engine.

6. Remove and discard the lower intake manifold gaskets.



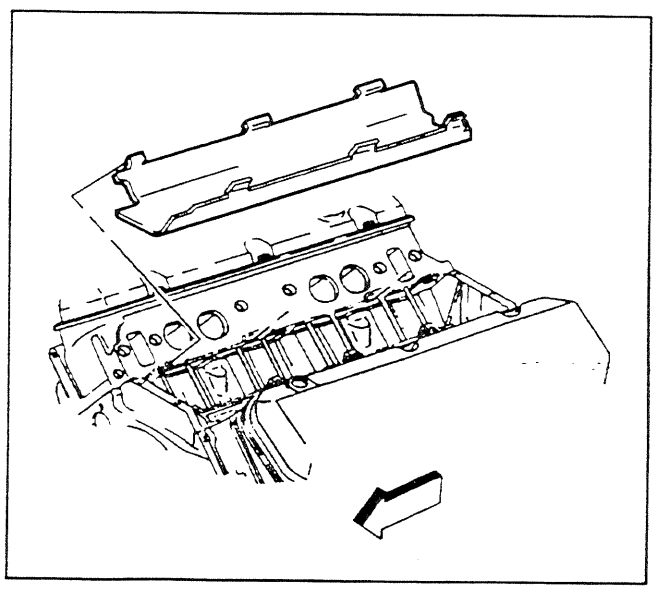
351760

7. Remove and discard the lower intake manifold seals.

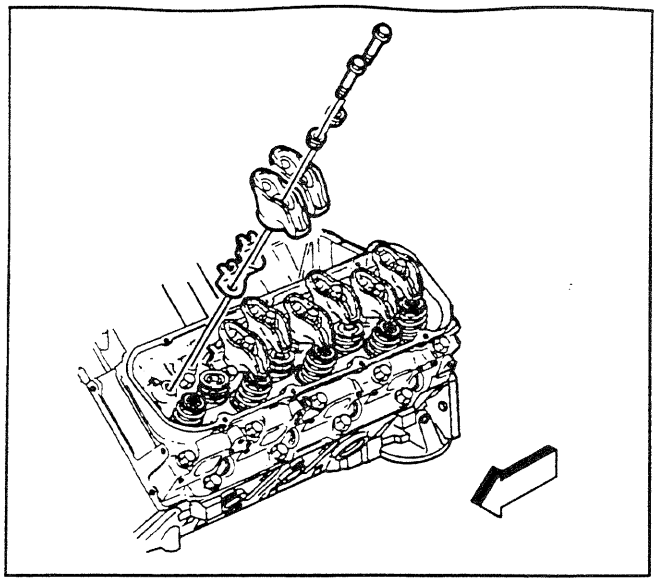


351757

8. Remove the splash shield.



276364



354070

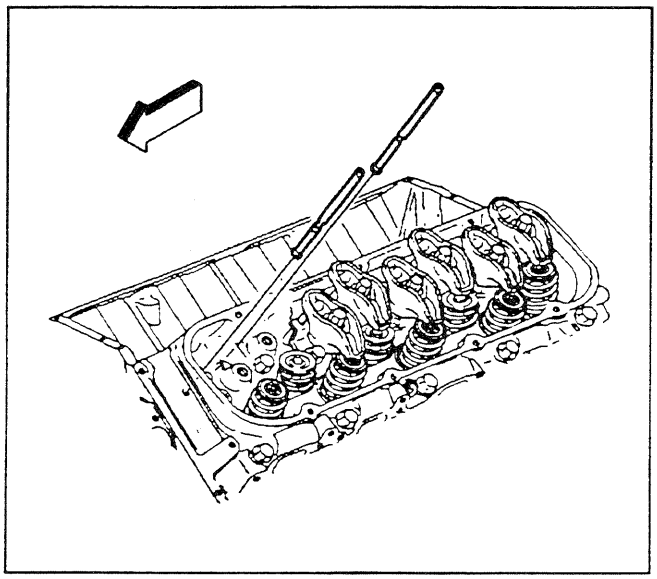
Valve Rocker Arm and Push Rod Removal

SIE-ID = 195760

Important: Mark and organize all valve train components. Return the components to their original location during reassembly. Make an organizer rack from a piece of wood.

Remove the following parts:

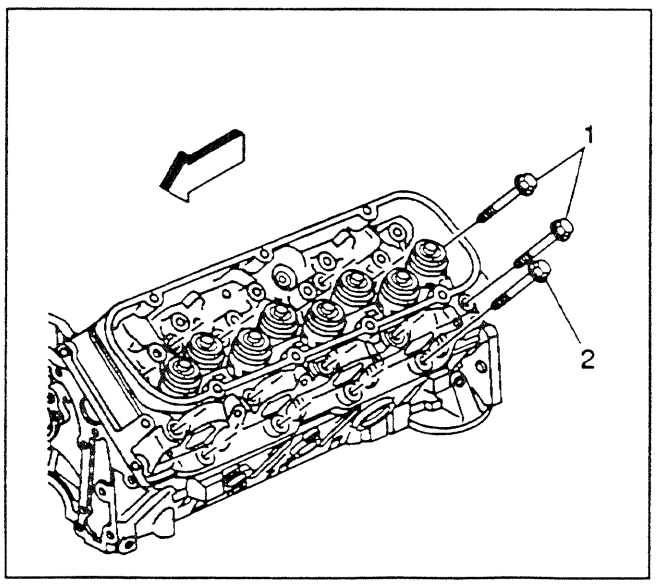
1. The valve rocker arm bolts
2. The valve rocker balls
3. The valve rocker arms
4. The valve pushrod guides



202196

Important: The exhaust valve pushrods are longer than the intake valve pushrods.

Remove the valve pushrods.



354041

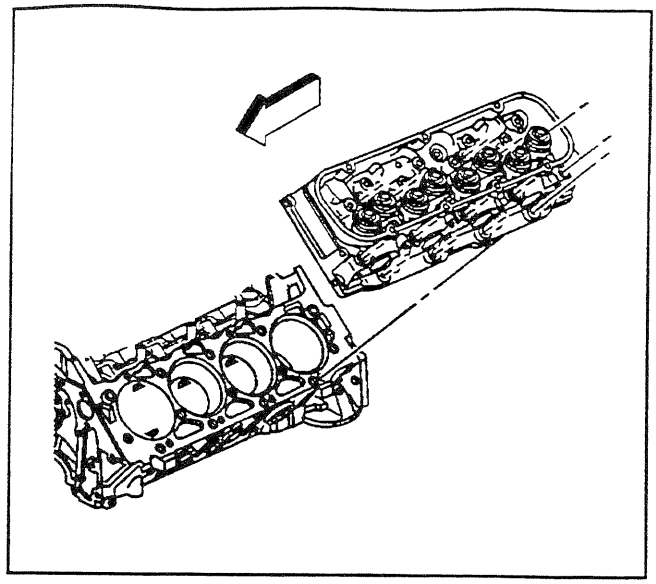
Cylinder Head Removal (Left)

SIE-ID = 195900

1. Remove the spark plugs from the cylinder head.
2. Remove and discard the cylinder head bolts (1, 2).

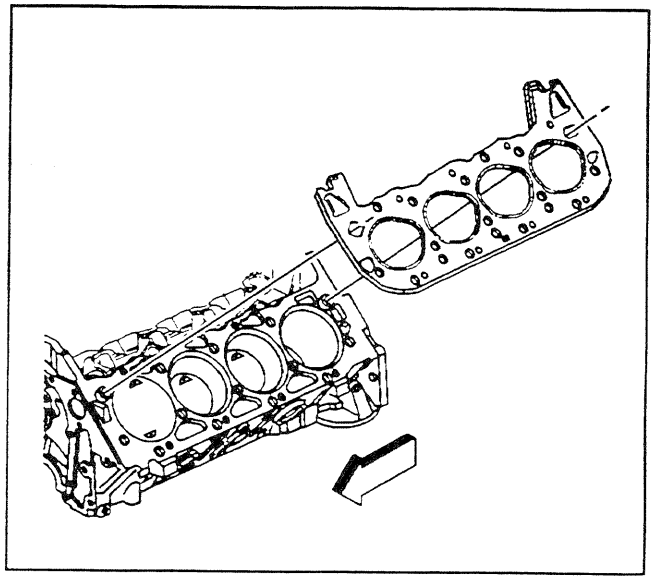
Important: Place cylinder head on two wood blocks to prevent damage to the sealing surfaces.

Remove the cylinder head.



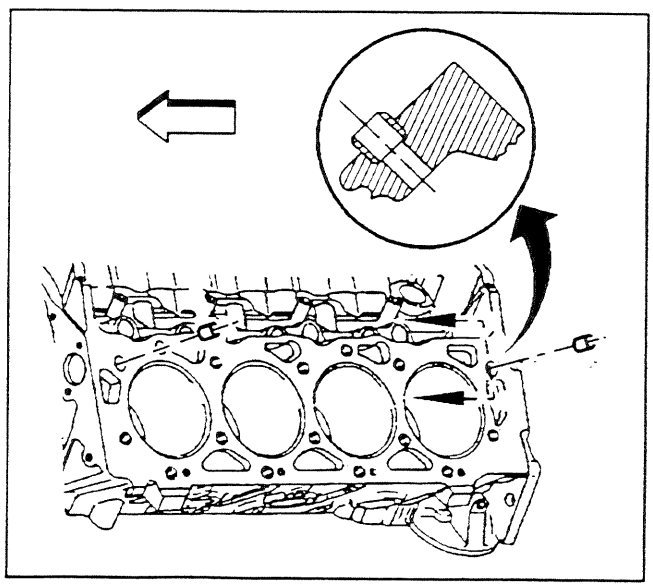
452378

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.

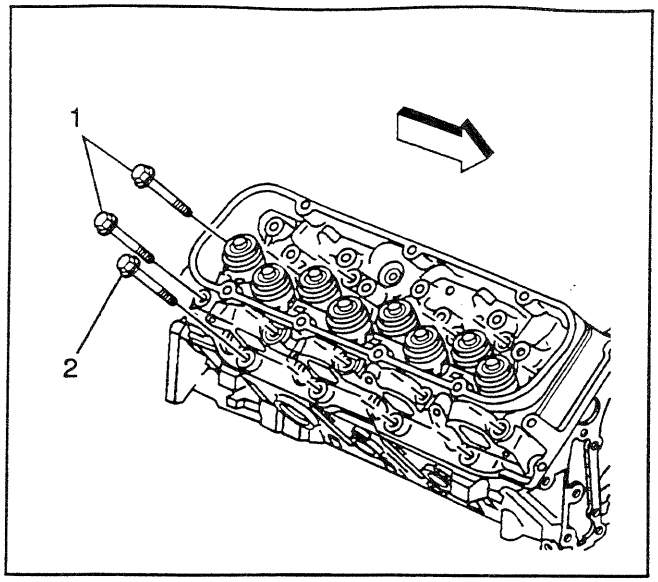


452377

5. Remove the cylinder head locating pins, if required.



180904

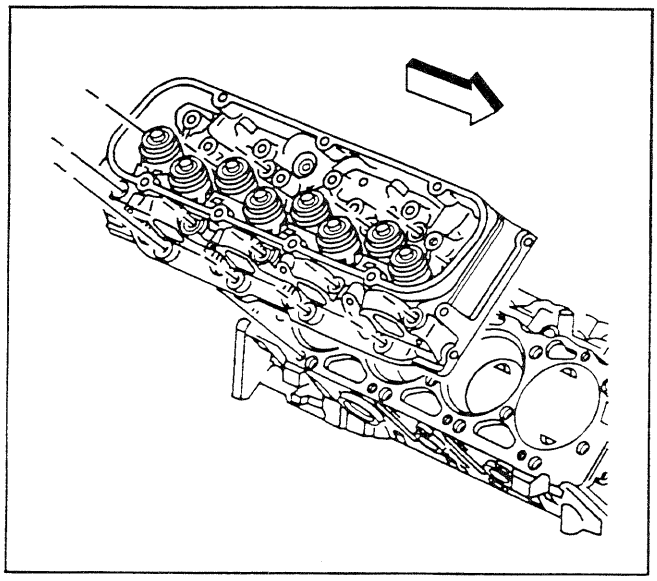


562687

Cylinder Head Removal (Right)

SIE-ID = 195903

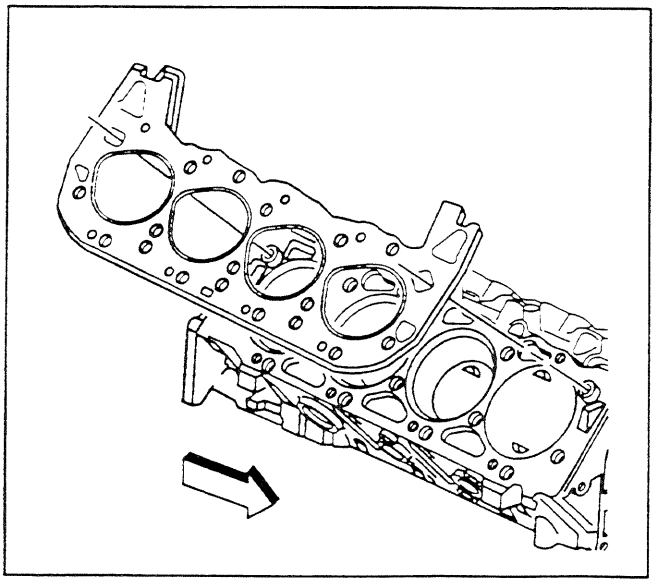
1. Remove the spark plugs from the cylinder head.
2. Remove and discard the cylinder head bolts (1, 2).



562710

Important: Place cylinder head on two wood blocks to prevent damage to the sealing surfaces.

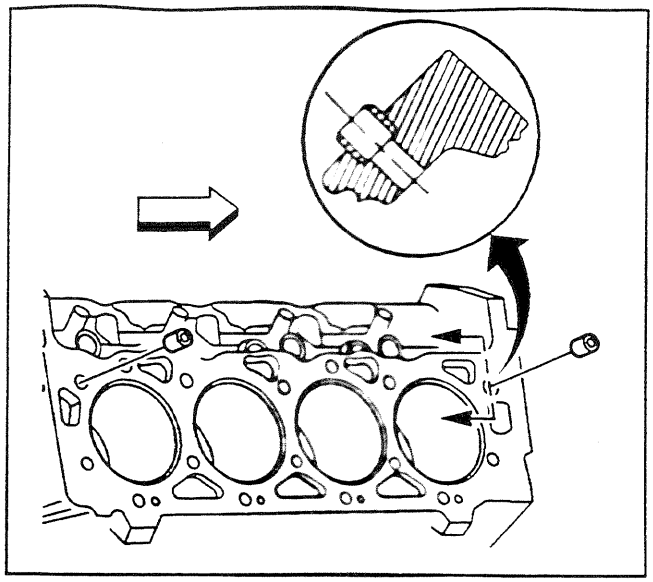
Remove the cylinder head.



562717

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.

5. Remove the cylinder head locating pins, if required.



562727

Valve Lifter Removal

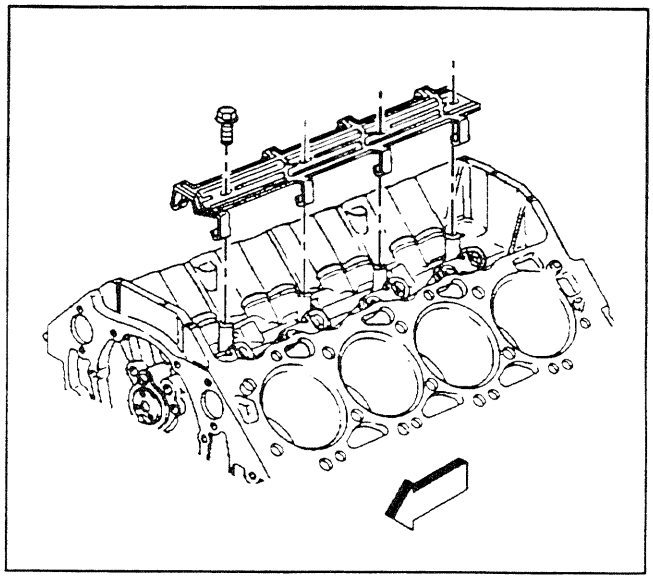
SIE-ID = 500304

Tools Required

J 3049-A Valve Lifter Remover

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

Remove the valve lifter guide retainer bolts and retainer.

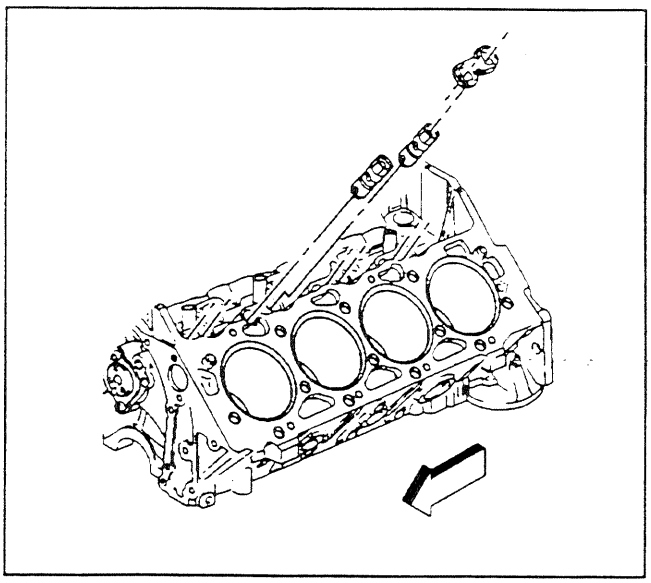


173193

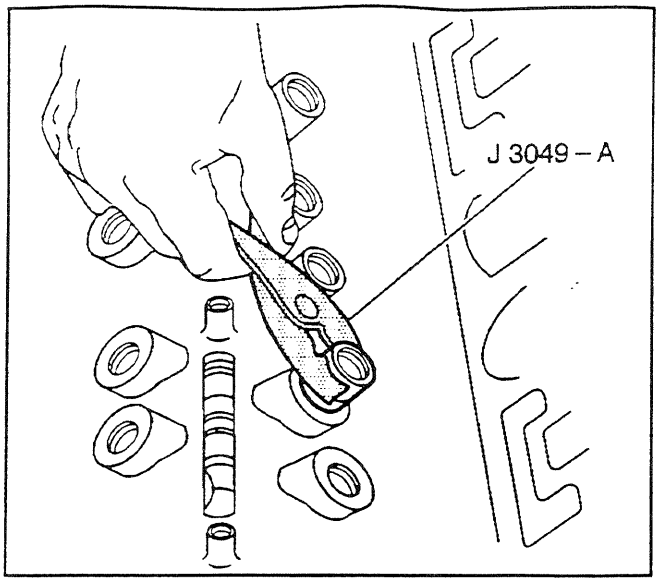
1. Remove the valve lifter guides.

Important: Place the valve lifters in the organizer rack or tag them in a way to ensure they can be returned to the valve lifter bore from which they were removed.

Remove the valve lifters.

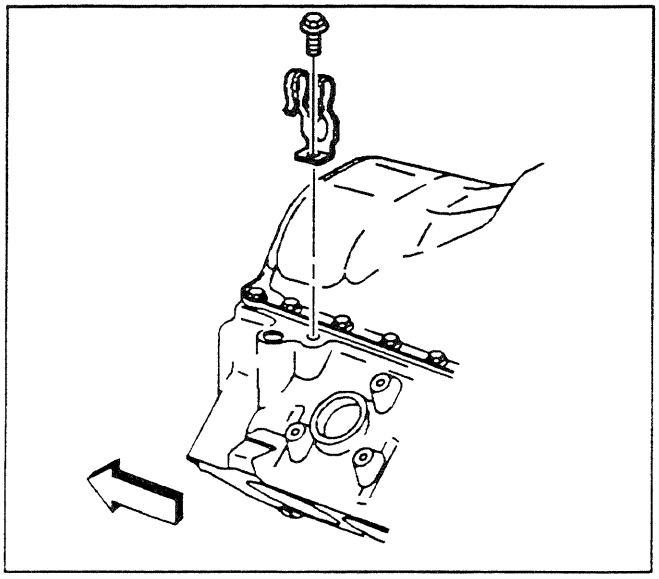


173176



31350

2. Some valve lifters may be stuck in their bore due to gum or varnish deposits. These valve lifters can be removed using *J 3049-A*.

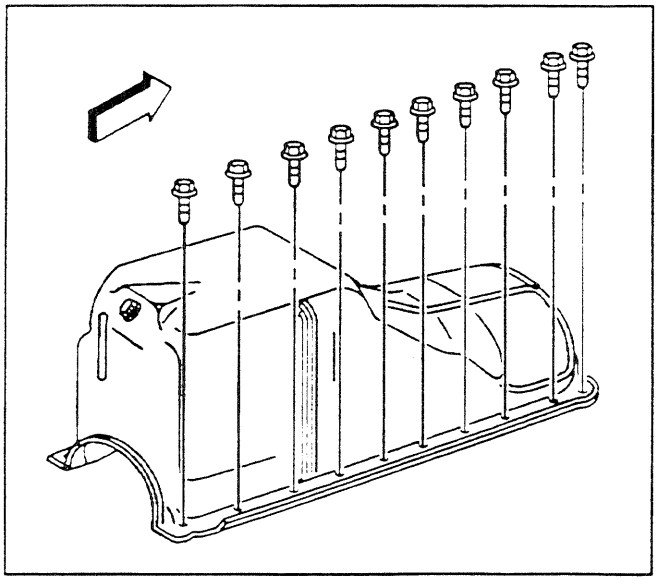


492038

Oil Pan Removal

SIE-ID = 489050

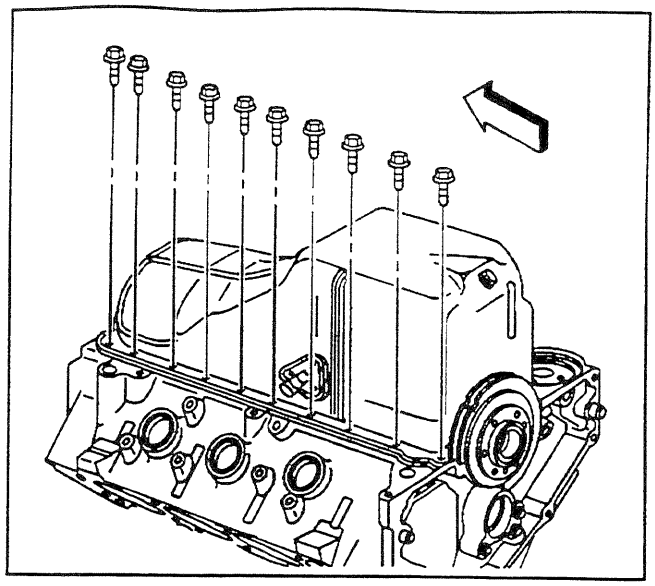
1. Remove the transmission oil cooler pipe clip bolt (RPO MT1).
2. Remove the transmission oil cooler pipe clip (RPO MT1).



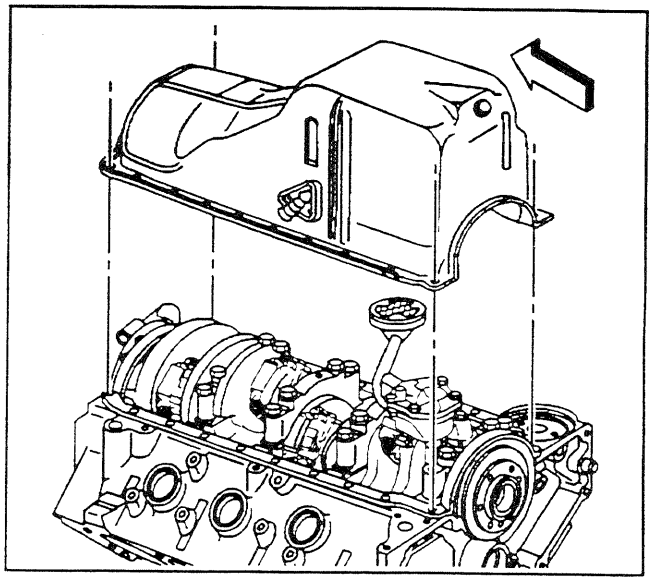
351809

3. Remove the left side oil pan bolts.

4. Remove the right side oil pan bolts.

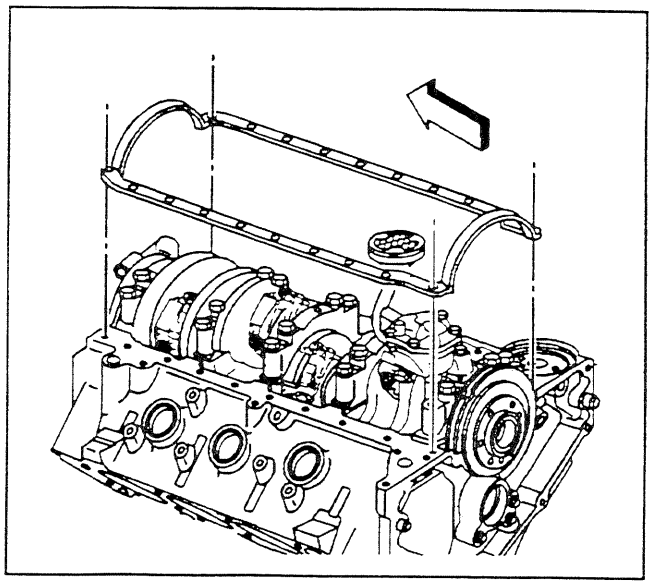

351806

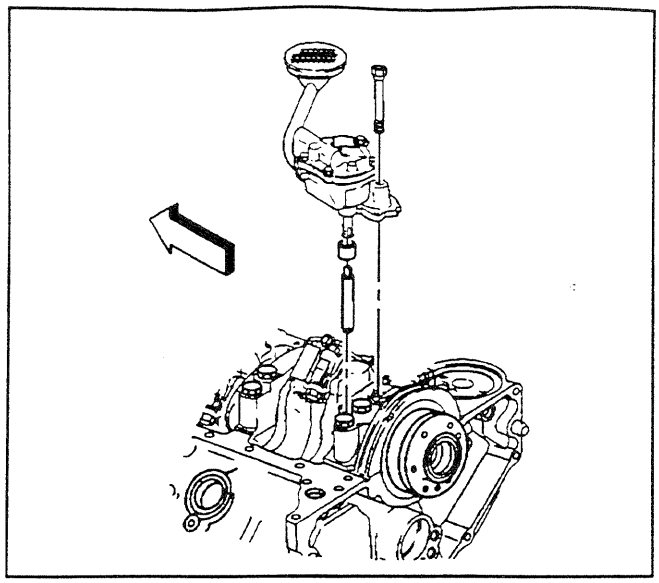
5. Remove the oil pan.


351803

Important: The oil pan gasket is reusable if not cut or damaged.

Remove the oil pan gasket.


351800

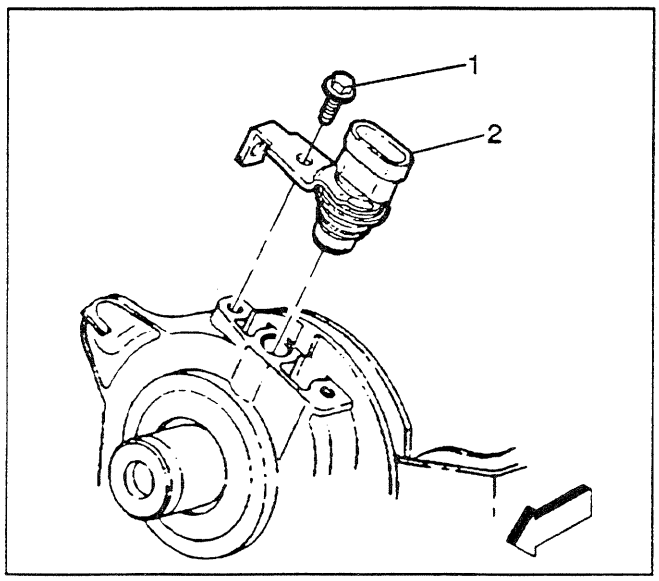


173183

Oil Pump, Pump Screen and Deflector Removal

SIE-ID = 500307

1. Remove the bolt that attaches the oil pump to the rear crankshaft bearing cap.
2. Remove the oil pump, driveshaft, and retainer from the rear crankshaft bearing cap.
3. Separate the oil pump, driveshaft, and retainer.
4. Discard the driveshaft retainer.

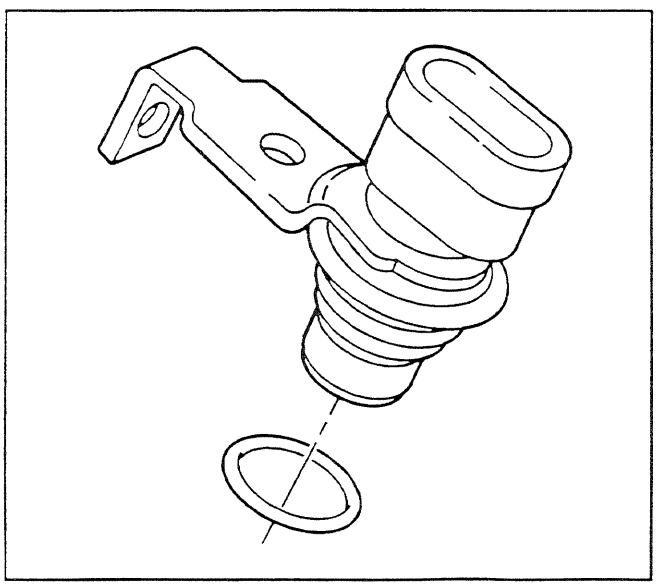


180901

Engine Front Cover Removal

SIE-ID = 196184

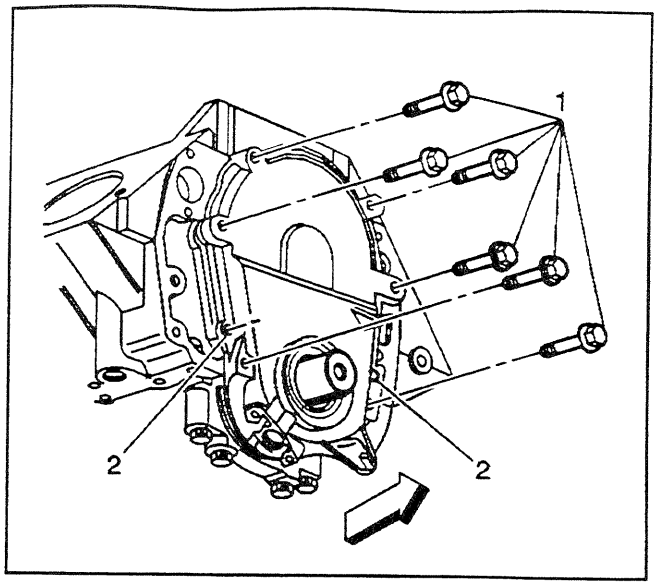
1. Remove the crankshaft position sensor bolt (1).
2. Remove the crankshaft position sensor (2).



562733

3. Remove the O-ring seal from the crankshaft position sensor.
4. Discard the O-ring seal.

5. Remove the engine front cover bolts (1).

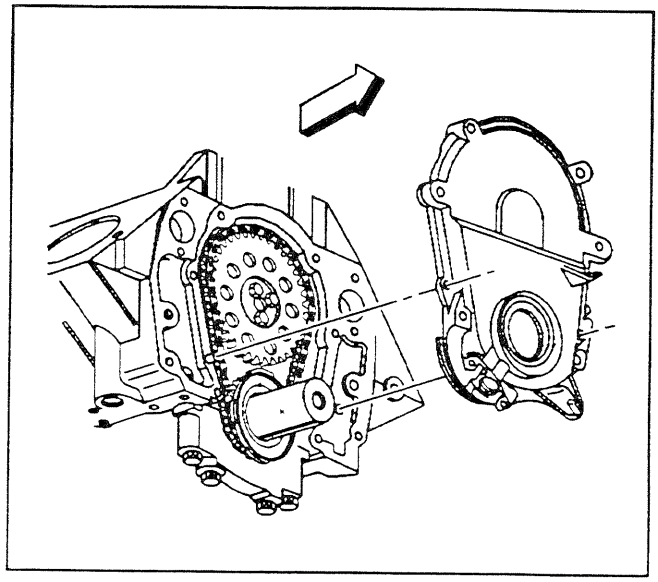


342207

Important: The engine front cover gasket is reusable.

Remove the engine front cover.

6. Remove the engine front cover gasket.
7. Remove the crankshaft front oil seal from the engine front cover.



64547

Timing Chain and Sprockets Removal

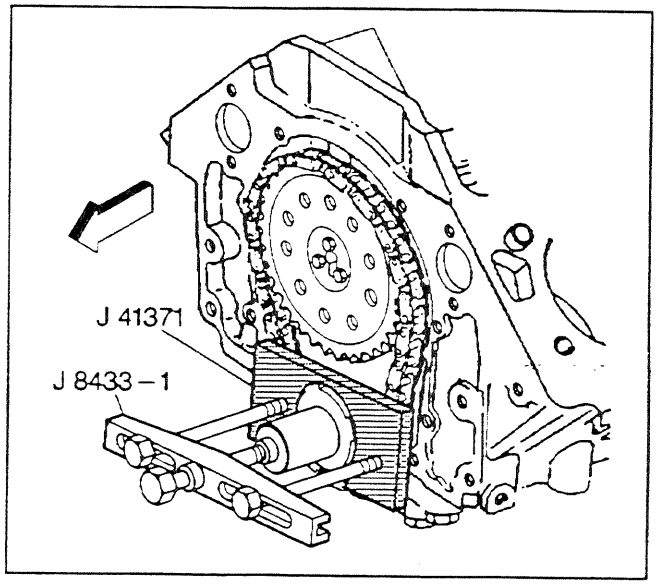
SIE-ID = 196185

Tools Required

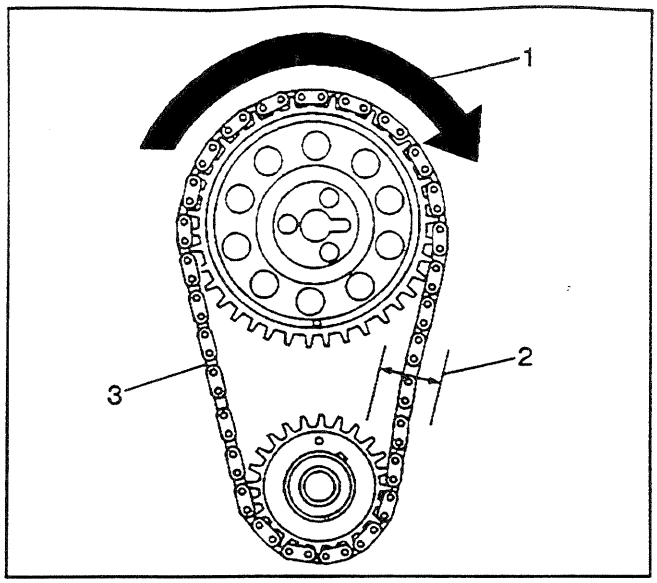
- *J 28509-A* Crankshaft Sprocket Remover
- *J 41371* Reluctor Wheel Remover
- *J 8433* Pulley Puller

Important: If the crankshaft sensor reluctor ring is removed from the crankshaft, a new crankshaft sensor reluctor ring must be installed.

Remove the reluctor ring from the crankshaft using *J 41371* and the *J 8433*.



181777

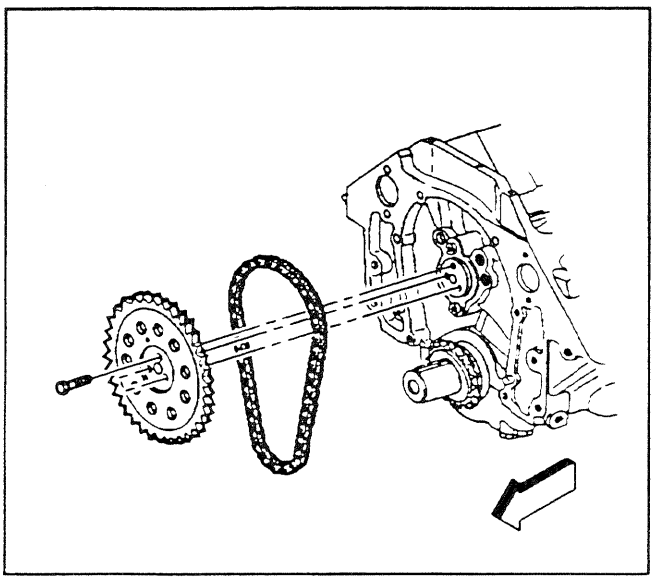


354026

Important: If the sprocket(s) must be replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

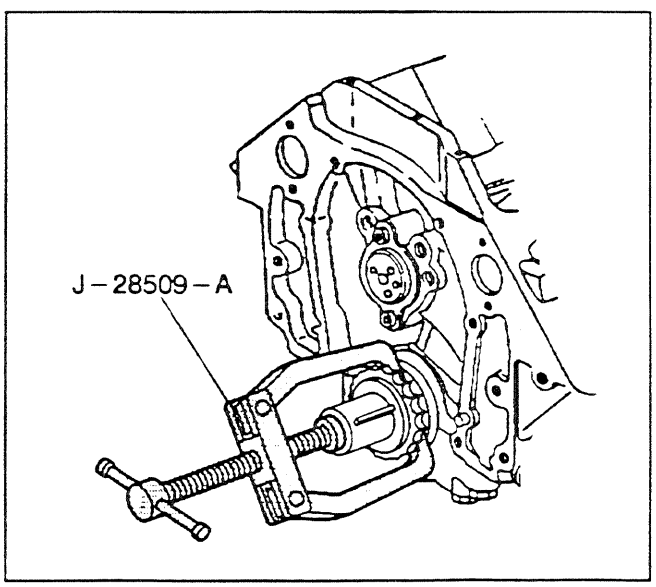
Measure the camshaft timing chain free play (2)

1. Align the camshaft timing chain marks.
2. Rotate the camshaft sprocket clockwise (1) in order to eliminate any slack (3).
3. Measure the camshaft timing chain free play (2). If the chain can be moved back and forth in excess of 16 mm (0.625 in) the camshaft timing chain and the sprockets must be replaced during assembly.



196671

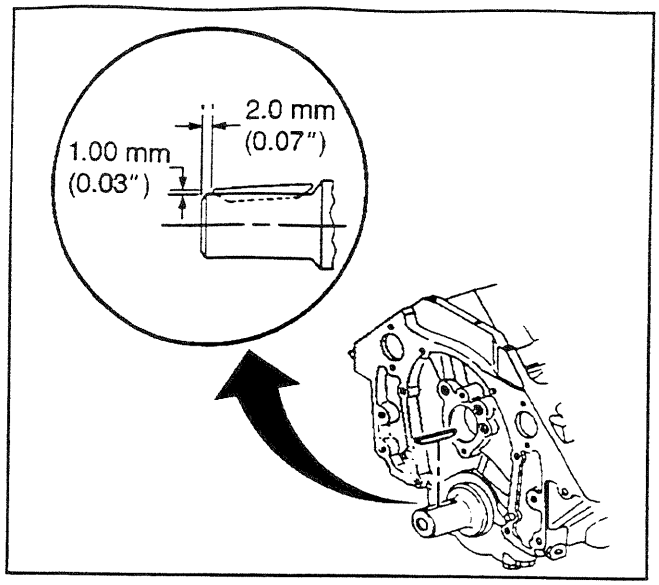
1. Remove the camshaft sprocket bolts.
2. Remove the camshaft sprocket and the camshaft timing chain.



65848

3. Remove the crankshaft sprocket using *J 28509-A*.

4. Remove the crankshaft key from the crankshaft keyway, if required.

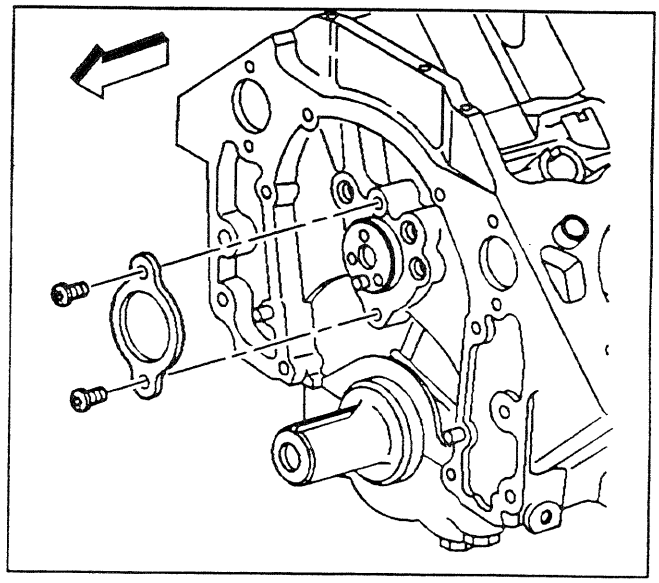


180902

Camshaft Removal

SIE-ID = 197514

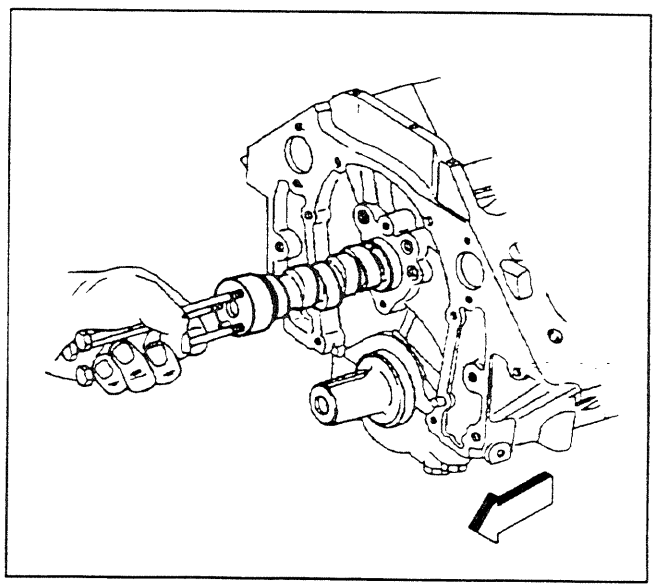
1. Remove the camshaft retainer bolts.
2. Remove the camshaft retainer.

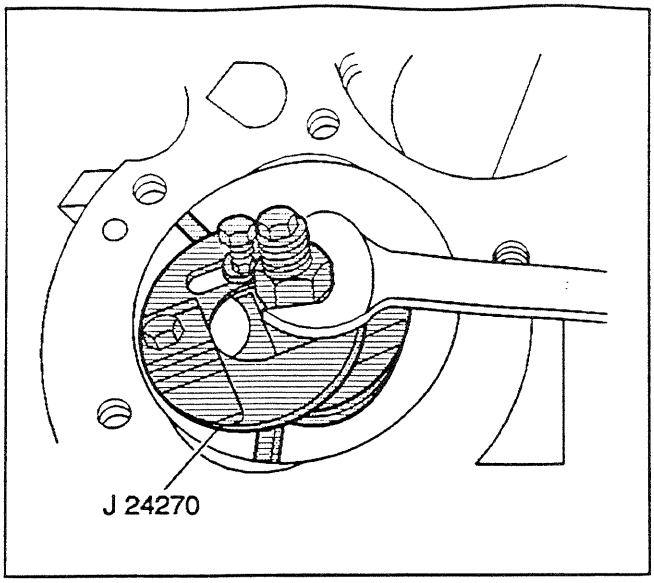

193223

3. Install three 5/16-18 x 4.0 inch bolts in the camshaft front bolt holes.

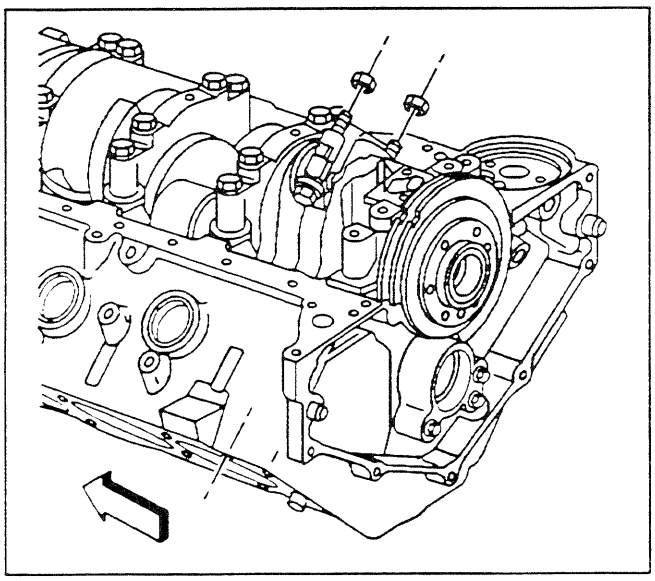
Notice: SIO-ID = 13833 All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

4. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
5. Remove the bolts from the front of the camshaft.


196588



11497



35403

Piston, Connecting Rod, and Bearing Removal

SIE-ID = 65407

Tools Required

- *J 24270* Ridge Reamer
- *J 5239* Connecting Rod Guide Tool

Important: Do not remove the excessive material from the cylinder bore. Excessive removal of material may require cylinder boring to the next oversize.

Remove the cylinder bore ridge as necessary.

1. Rotate the crankshaft until the piston is at the bottom of the stroke (BDC).
2. Place a cloth on top of the piston.
3. Perform the cutting operation with a *J 24270*. Refer to the manufacturer's instructions before using the *J 24270*.
4. Remove the *J 24270*.
5. Rotate the crankshaft until the piston is at top dead center (TDC).
6. Remove the cloth and the cuttings.
7. Repeat the procedure for each piston.

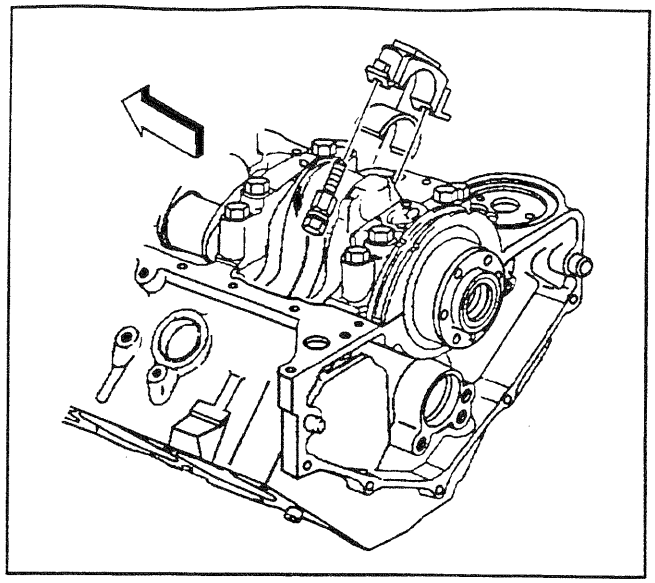
Important: Place the matching marks or numbers on the connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

Remove the connecting rod nuts.

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

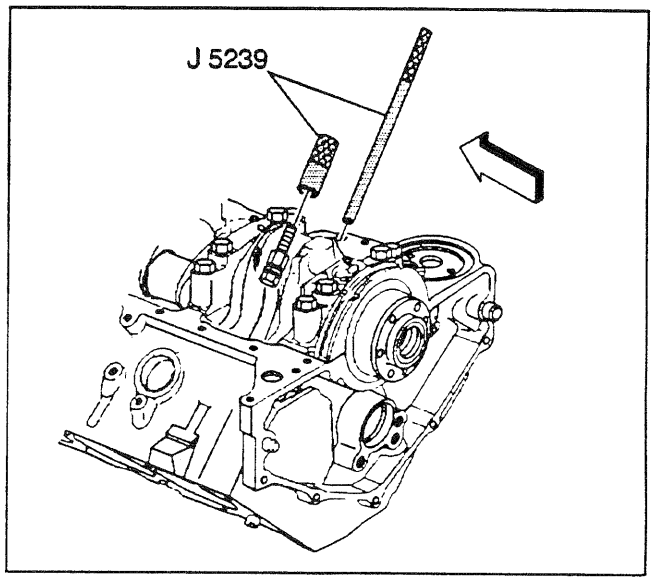
Important: If reusing bearings, keep the bearings with their original connecting rod and connecting rod cap.

Remove the connecting rod cap and the lower connecting rod bearing.



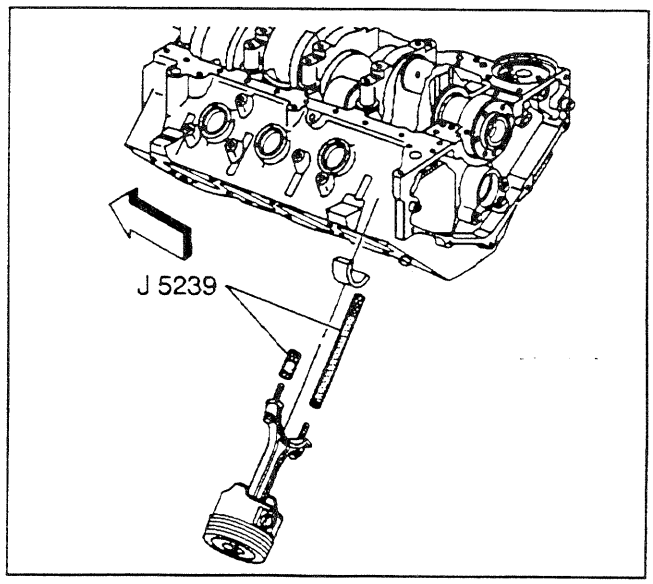
354030

1. Install the *J 5239* on the connecting rod bolts.

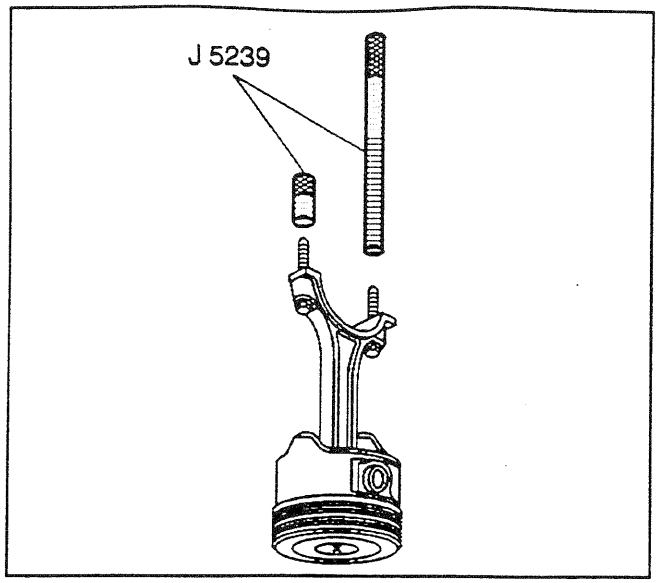


354029

2. Remove the piston, connecting rod and upper connecting rod bearing out of the top of the engine block using the *J 5239*.

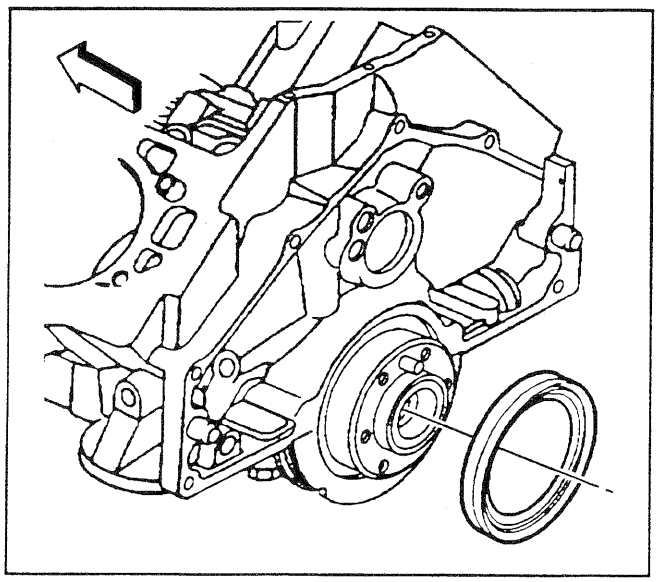


354028



354027

3. Remove the *J 5239* from the connecting rod bolts.
4. Remove the remaining piston and the connecting rod assemblies.
5. Wipe the oil from the bearings and the crankpins.



290963

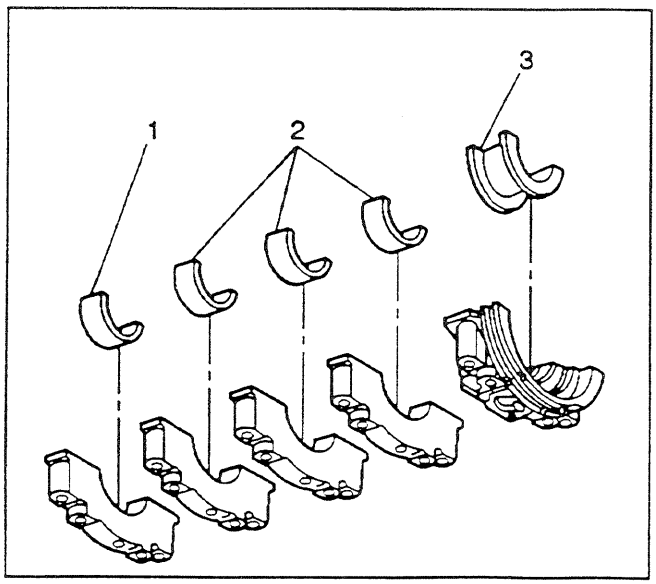
Crankshaft Rear Oil Seal Removal

SIE-ID = 314525

1. Loosen the crankshaft bearing cap bolts.

Notice: SIO-ID = 2773 Do not damage the crankshaft surface when prying out the crankshaft rear oil seal.

2. Pry the crankshaft rear oil seal from the bore.



351781

Crankshaft and Bearings Removal

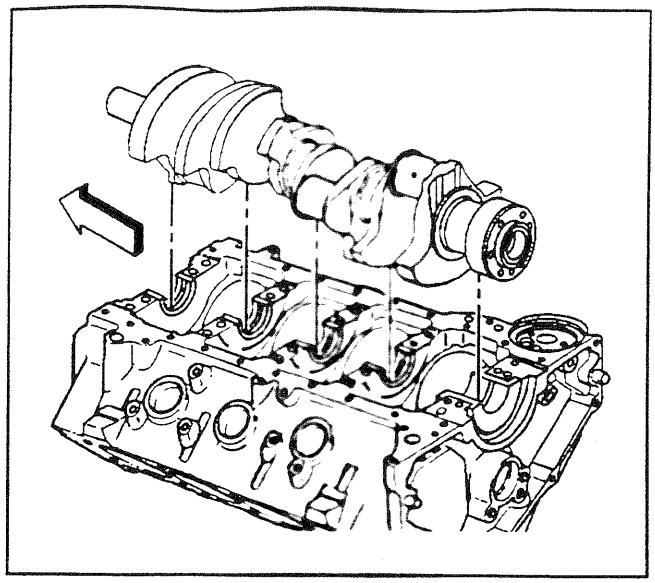
SIE-ID = 197028

Important: Crankshaft bearing caps are machined with the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. Crankshaft bearing caps must be installed in their original locations.

Remove the crankshaft bearing cap bolts.

1. Remove the crankshaft bearing caps.
2. Remove the crankshaft lower bearings (1–3) from the crankshaft bearing caps.

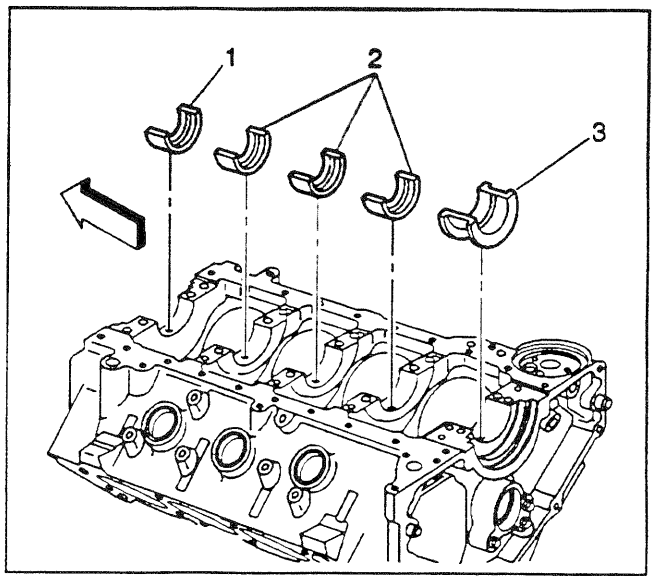
3. Remove the crankshaft.



351779

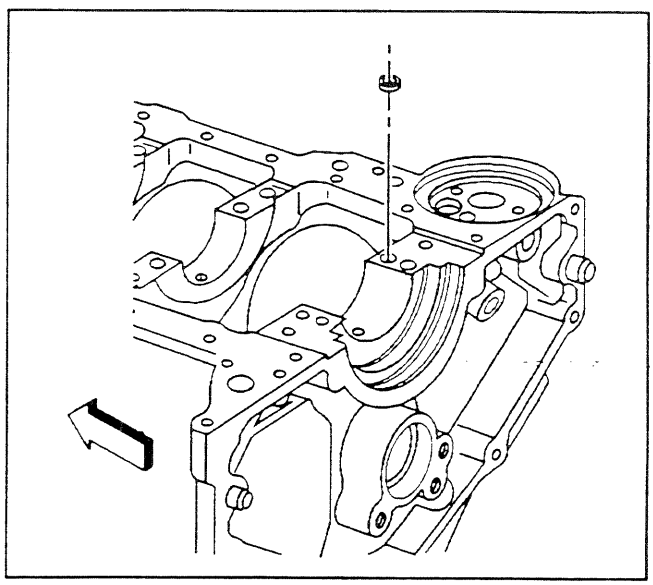
Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

4. Remove the crankshaft upper bearings (1–3) from the engine block.

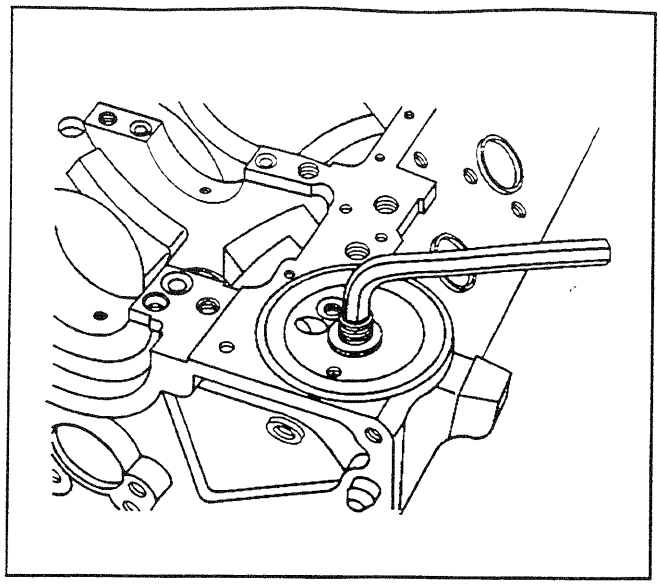


351777

5. Remove the crankshaft bearing cap oil seal.



351825

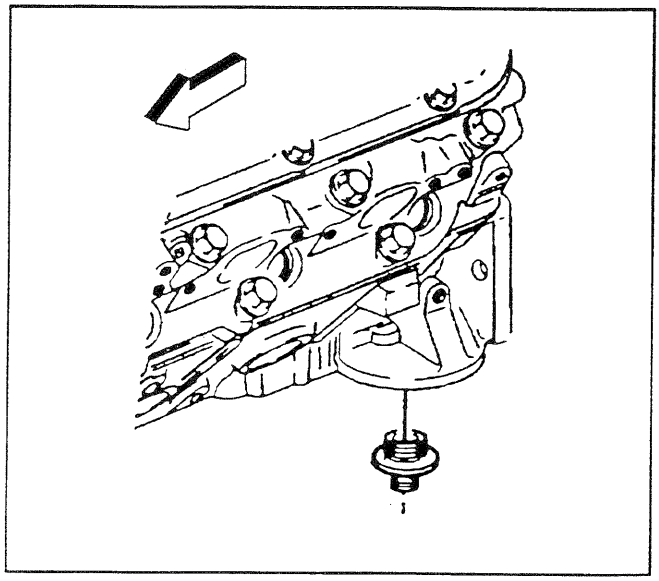


452375

Oil Filter Adapter Removal (2WD)

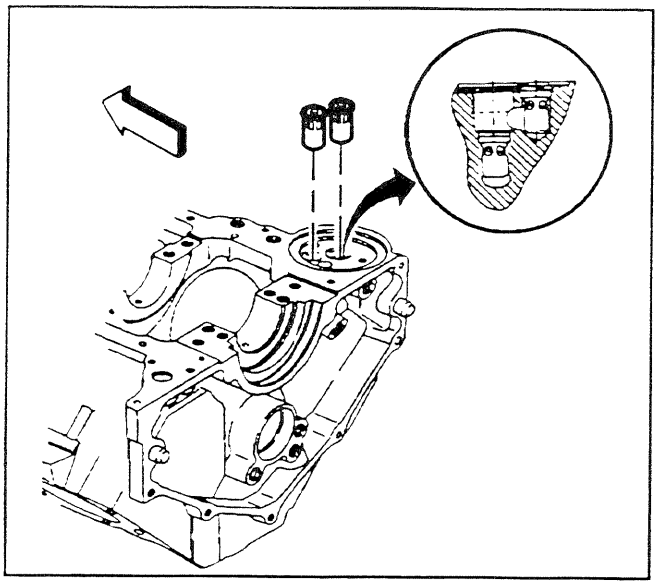
SIE-ID = 500309

1. Loosen the oil filter fitting, using a hex wrench.



70416

2. Remove the oil filter fitting.
3. Remove the oil bypass valves (if required). Unstake the tangs on oil bypass valves and remove with long nose pliers.



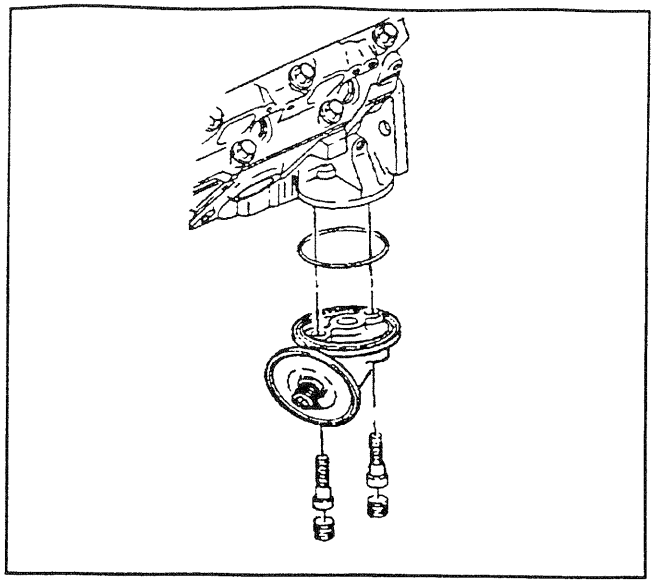
180862

4. Inspect the oil filter fitting, replace if necessary.
5. Discard the oil bypass valves, if removed.

Oil Filter Adapter Removal (4WD)

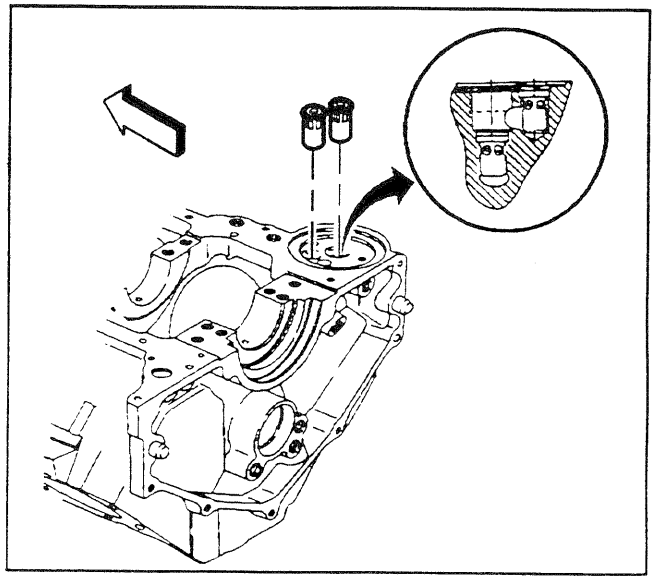
SIE-ID = 500311

1. Remove the oil filter adapter using the following procedure:
   1.1. Remove the plugs from the oil filter adapter.
   1.2. Remove the bolts from the oil filter adapter.
   1.3. Remove the oil filter adapter and the O-ring seal.



70415

2. Remove the oil bypass valves (if required). Unstake the tangs on oil bypass valves and remove with long nose pliers.
3. Inspect the oil filter adapter.
4. Discard the oil bypass valves, if removed.



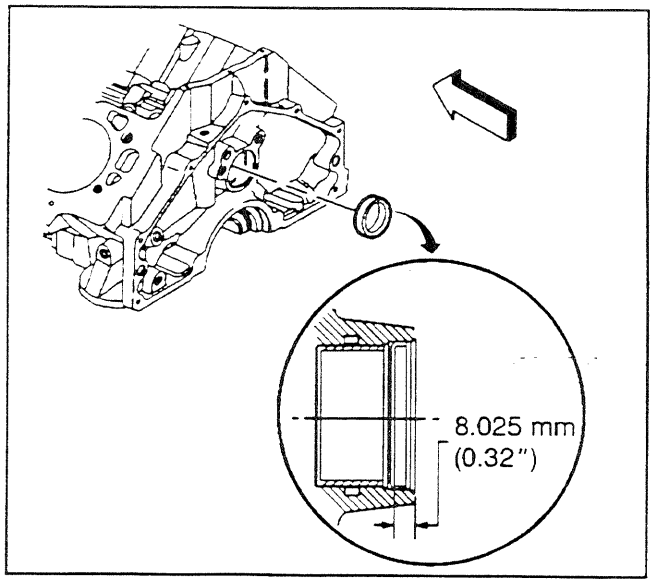
180862

Engine Block Plug Removal

SIE-ID = 197532

Notice: SIO-ID = 564831 Do not damage the camshaft bearings.

1. Remove the camshaft rear bearing hole plug:
   1.1. Obtain a suitable self-threading screw.
   1.2. Drill a hole into the plug.
   1.3. Install the self-threading screw.
   1.4. Pull on the plug until it has left the bore.
   1.5. An alternate method to remove the plug would be to insert a long shaft or bar through the front of the engine and drive the plug from the bore.



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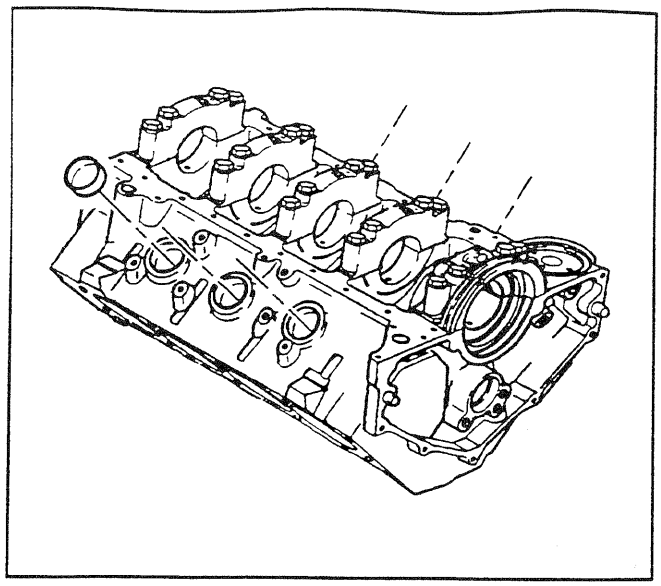
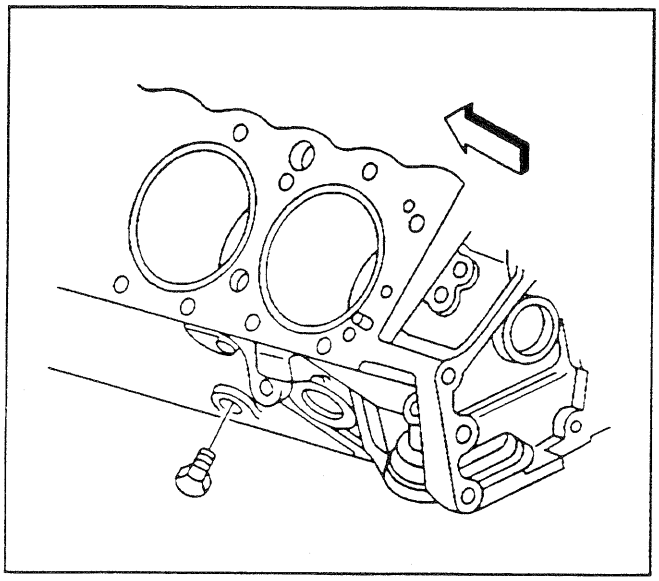


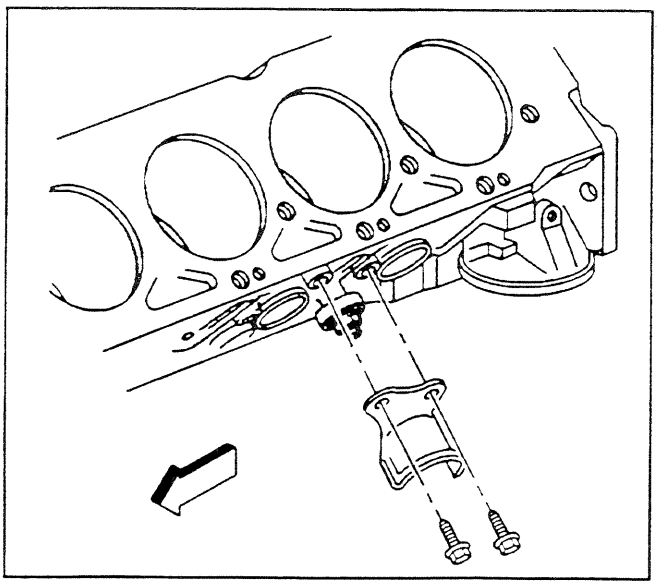
562737

2. Remove the engine block expansion plugs from both sides of block.
   2.1. Obtain a suitable self-threading screw.
   2.2. Drill a hole into the plug.
   2.3. Install the self-threading screw.
   2.4. Pull on the plug until it has left the bore.



69033

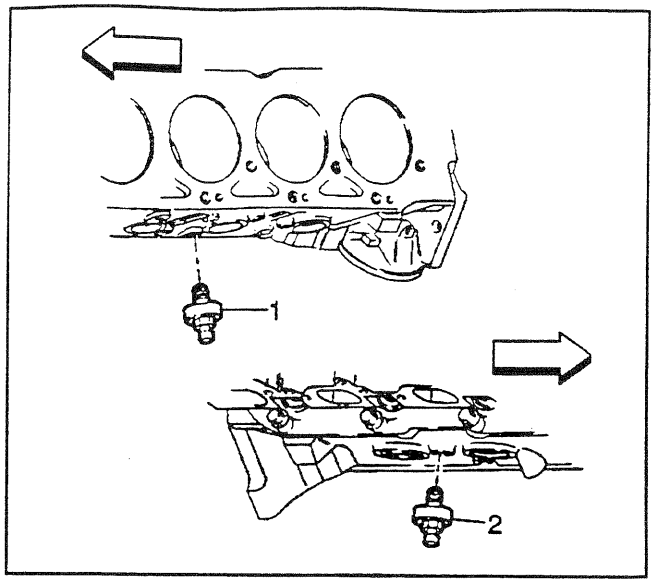
3. Remove the engine block coolant drain hole plugs.



354072

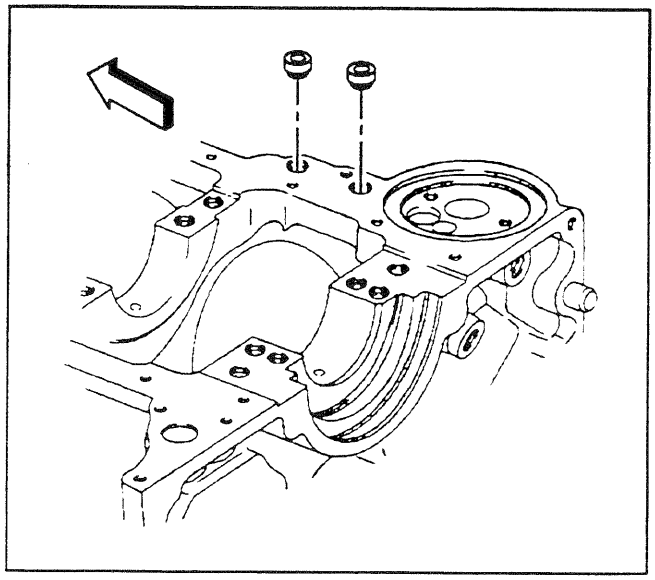
4. Remove the left side knock sensor shield bolts.
5. Remove the left side knock sensor shield.

6. Remove the left side knock sensor (1).
7. Remove the right side knock sensor (2).



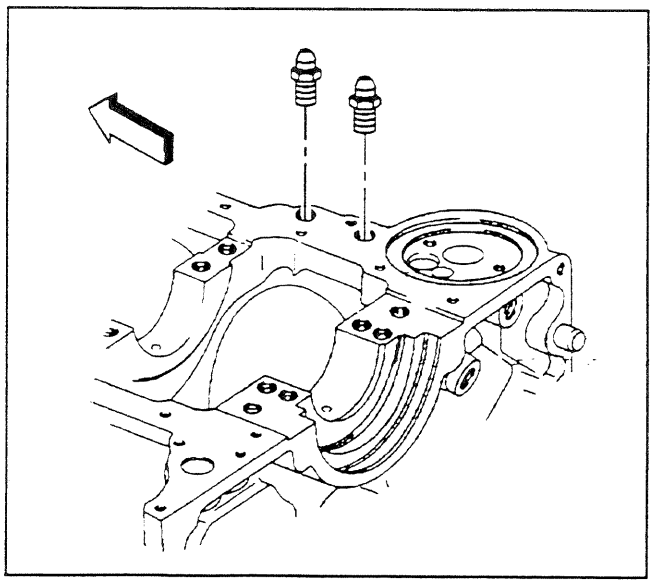
181034

8. Remove the engine block oil cooler plugs (without oil cooler).



354082

9. Remove the engine block oil cooler hose fittings (with oil cooler).



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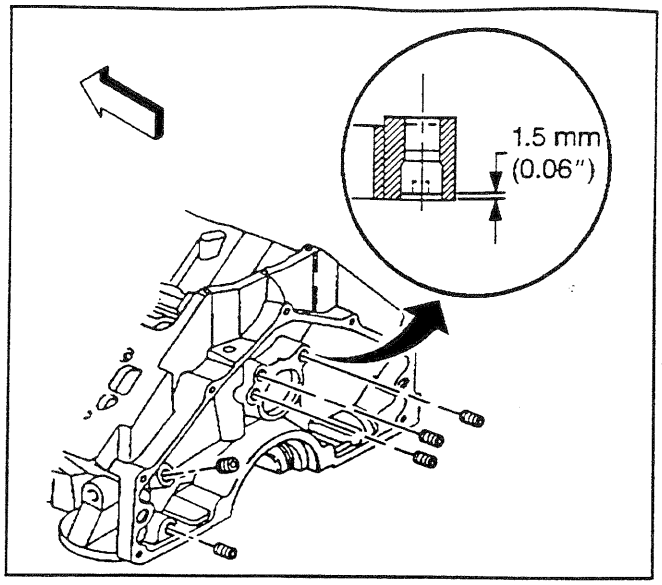
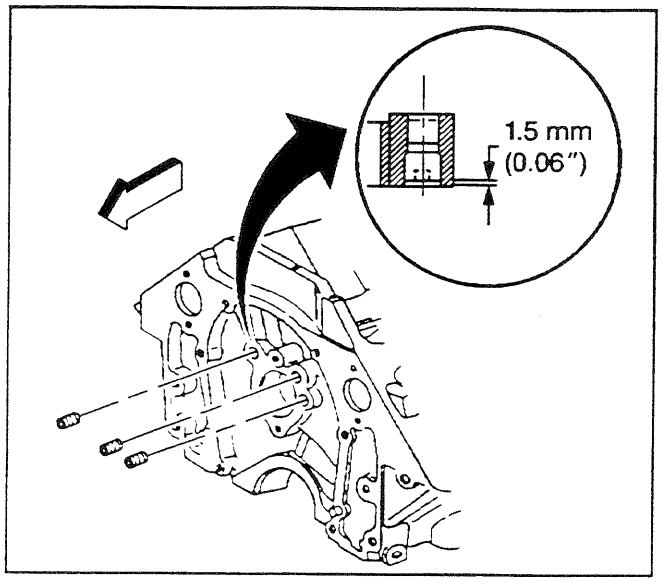


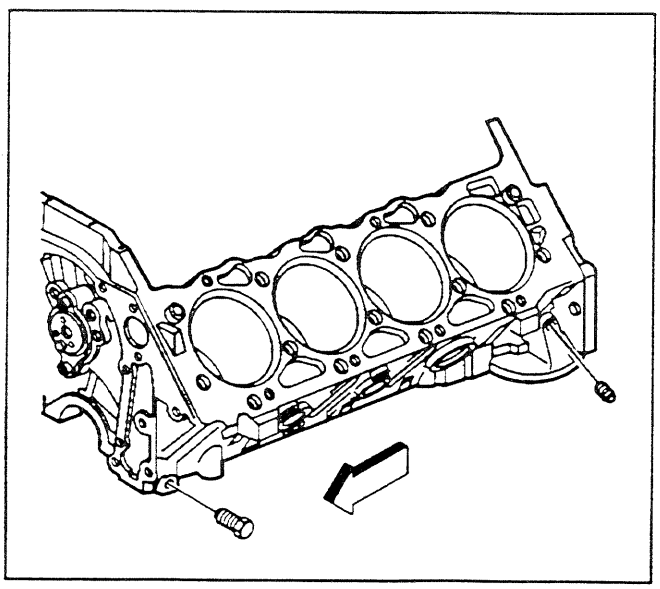
180866

10. Remove the rear oil gallery plugs.



180871

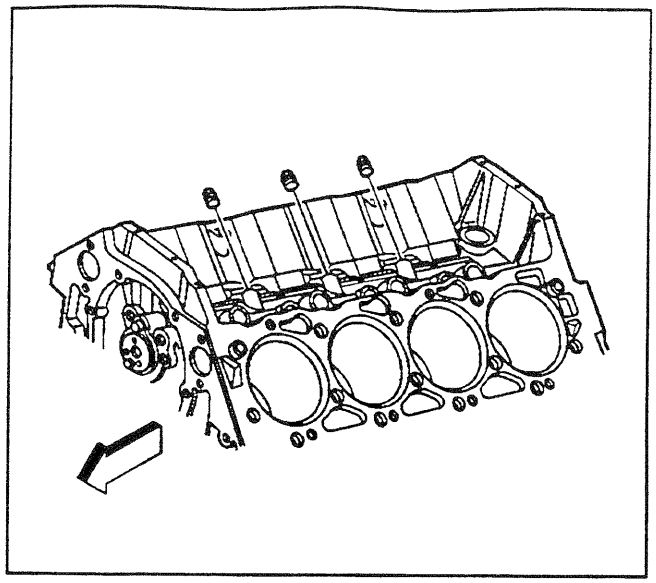
11. Remove the front oil gallery plugs.



180869

12. Remove the left side oil gallery plugs.

13. Remove the top oil gallery plugs.



180870

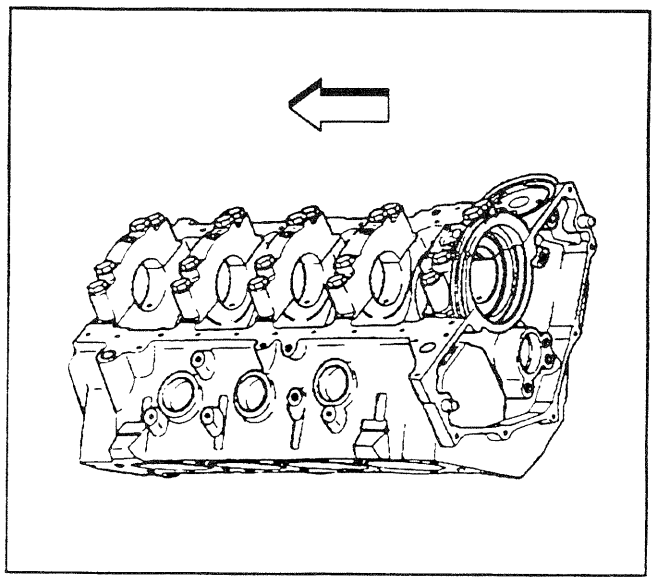
Engine Block Clean and Inspect

SIE-ID = 500317

1. Boil the cylinder block in caustic solution.
2. Flush the cylinder block with clean water or steam.
3. Clean the following areas:
   - All gasket surfaces; Refer to *Replacing Engine Gaskets*
   - Cylinder bores, remove excessive cylinder ring ridge as required
   - Main bearing caps
   - Oil galleries, remove all sludge or restrictions
   - Scale deposits from the coolant passages
   - All dirt or debris from threaded bolt holes

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

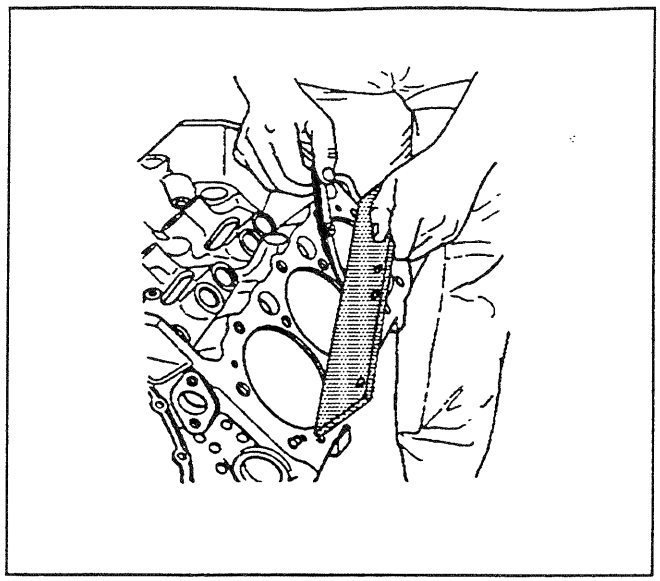
4. Dry the block with compressed air.
5. Lubricate the cylinder bores with clean engine oil to prevent rusting.
6. Inspect the engine block for the following conditions:
   - Gasket surfaces for deep gouges or other damage
   - Crankshaft bearing bores for wear
     - The surfaces where the crankshaft bearings contact the crankshaft bearing bore must be smooth.
     - All crankshaft bearing bores must be round and uniform in inside diameter (ID) at all the bearing supports.
     - If a crankshaft bearing cap is damaged and requires replacement, refer to *Crankshaft and Bearings Clean and Inspect*
   - Camshaft bearing bores for wear or damage
   - Valve lifter bores for scuffing or wear
   - Engine block for cracks or other damage
   - Cylinder walls for scoring or gouges



183593

- Coolant jackets for cracks
- Crankshaft bearing webs for cracks
- Engine mount bosses for damage
- The oil passages for restrictions

7. Inspect the engine block cylinder head deck for flatness using a straight edge and a feeler gauge.
   The surface must be flat within 0.10 mm (0.004 in).



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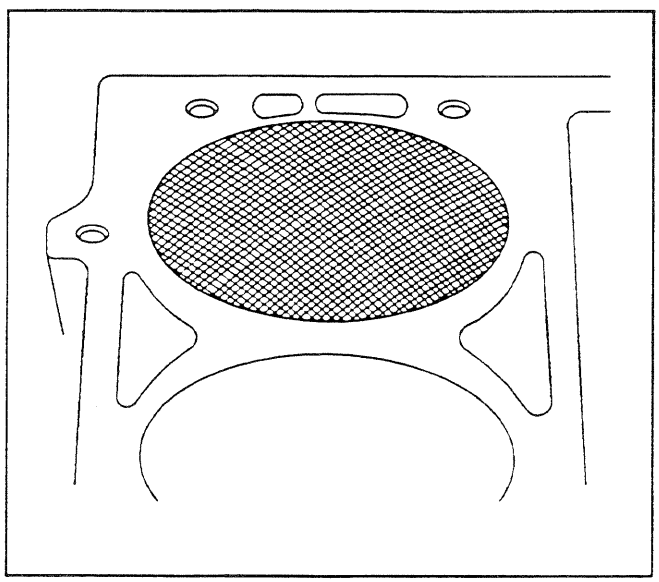


186747

Cylinder Boring and Honing

SIE-ID = 197787

Honing Procedure

Notice: SIO-ID = 311282 Always remove all bearings and components from engine block before cleaning, boring or honing the engine block.

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
   - Use only clean, sharp stones of the proper grade for the amount of material you remove.
   - Dull, dirty stones cut unevenly and generate excessive heat.
   - Do not hone to a final grade with a coarse or medium-grade stone.
   - Leave sufficient metal so that all stone marks may be removed with fine grade stones.
   - Perform final honing with a fine-grade stone and hone the cylinder in a cross hatch pattern at 45 to 65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore.
   - Repeatedly check the cylinder bore for fit with the selected piston.
   - All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle, and the bottom of the bore.
   - The finish marks should be clean but not sharp.

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

4. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the cylinder honing dimension required. Refer to *Engine Mechanical Specifications*
5. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round or taper requirements.
6. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent.
   6.1. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of new piston rings and cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
   6.2. After washing the cylinder bore, dry the bore with a clean shop towel.
7. Perform final measurements of the piston and cylinder bore.
8. Permanently mark the piston for the specific cylinder to which it has been fitted.
9. Apply clean engine oil to each cylinder bore in order to prevent rusting.

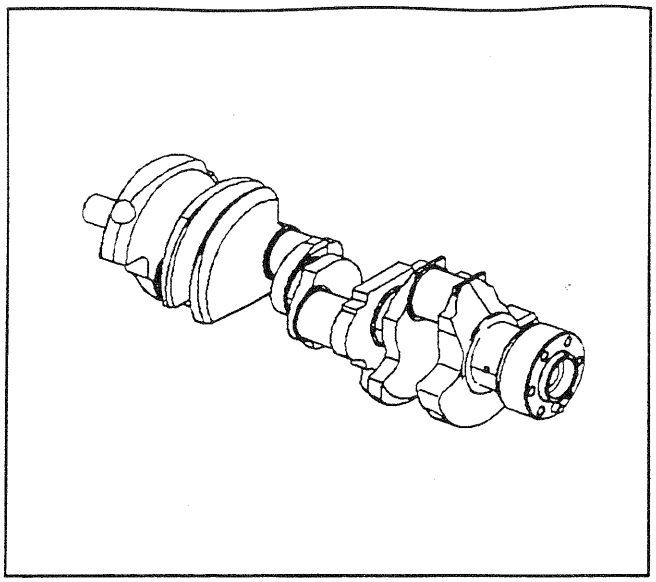
Boring Procedure

1. Before you start the honing or boring operation, measure all new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.

Important: If you do not check the cylinder block, the boring bar may be tilted, this may result in incorrect rebored cylinder wall to crankshaft angle.

Before you use any type of boring bar, file the top of the cylinder block in order to remove any dirt or burrs.

2. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
3. When you rebore cylinders, make sure all crankshaft bearing caps are in place.
   - Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly.
   - The crankshaft must be clear of the boring cutter when you bore each cylinder.
4. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between pistons, rings, and cylinder bores).



59918

Crankshaft and Bearings Clean and Inspect

SIE-ID = 199078

Crankshaft Inspection

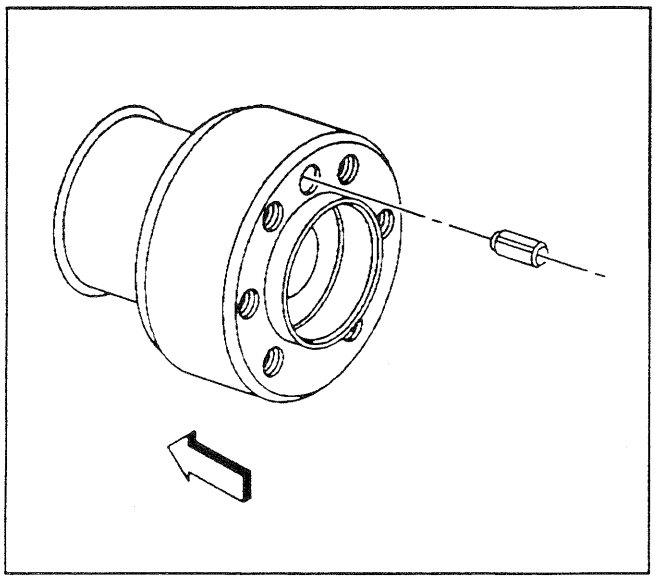
Tools Required

J 7872 Magnetic Base Dial Indicator

Notice: SIO-ID = 564827 Do not damage the bearing surfaces when handling the crankshaft.

Replace loose or damaged crankshaft rear oil gallery plug.

1. Clean the crankshaft in solvent. Remove all sludge or restrictions from the oil passages.



374743

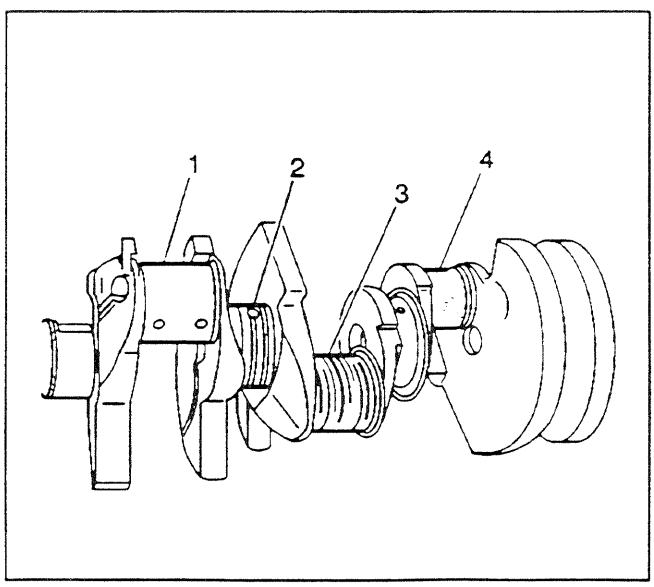
2. Remove the engine flywheel locator pin, if damaged.

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

3. Clean the crankshaft bearings in solvent. Wipe the bearings clean with a soft cloth, do not scratch the bearing surfaces.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

4. Dry the crankshaft and bearings with compressed air.



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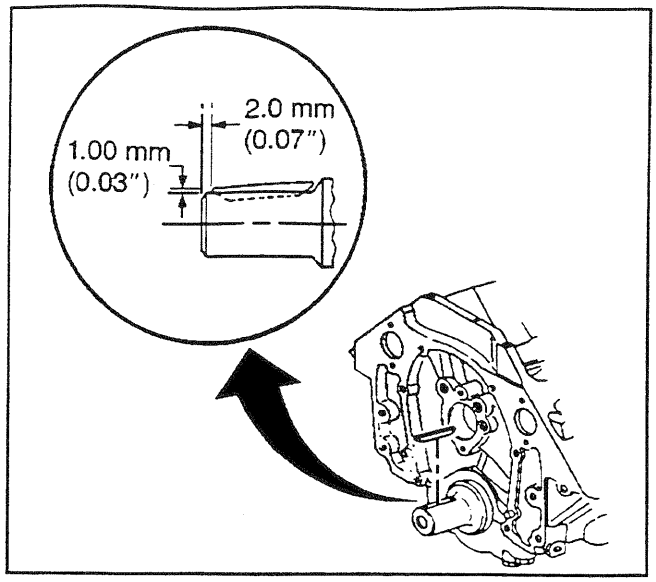
5. Inspect the crankshaft for the following conditions:
   - Crankshaft journals (1) should be smooth with no evidence of scoring or damage
   - Deep grooves (2)
   - Scratches or uneven wear (3)
   - Pitted surfaces (4)
   - Wear of damage to the thrust journal surfaces
   - Scoring or damage to the rear seal surface
   - Restrictions to oil passages
   - A loose or damaged rear oil gallery plug
   - Damage to threaded bolt holes

6. Inspect the crankshaft key and the keyway for damage.



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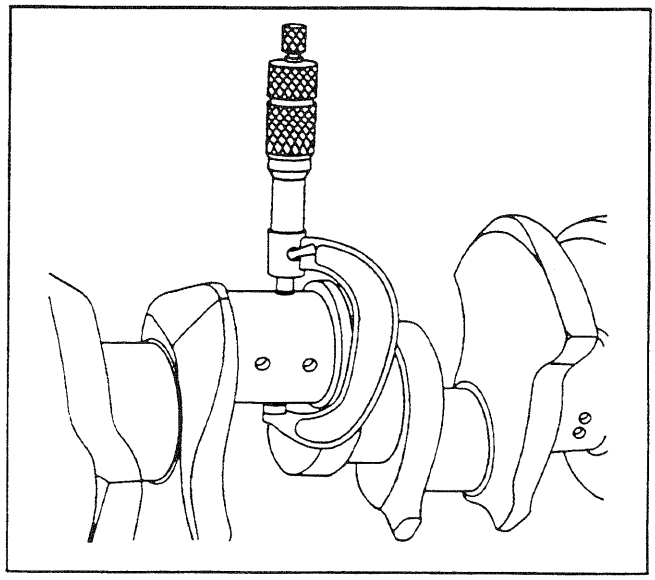
7. Measure the crankshaft main journals and the crankpins for out-of-round and taper.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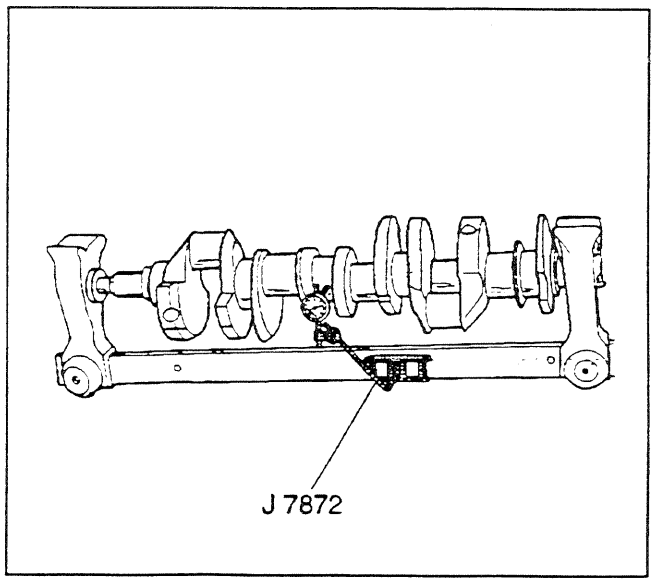
8. Using a suitable fixture, support the crankshaft.
   8.1. Measure the crankshaft runout using *J 7872*.
   8.2. Crankshaft runout should not exceed 0.051 mm (0.002 in).



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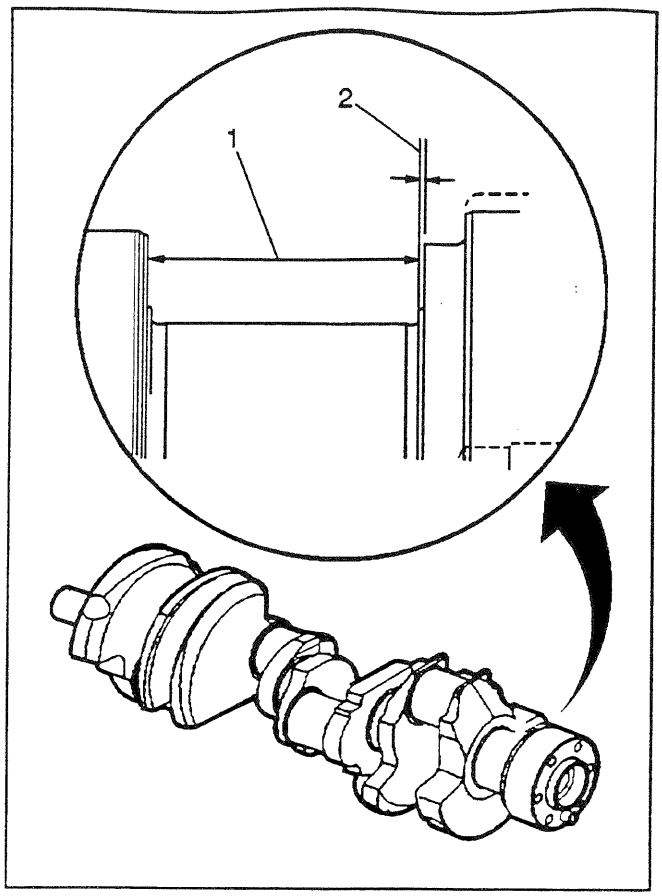

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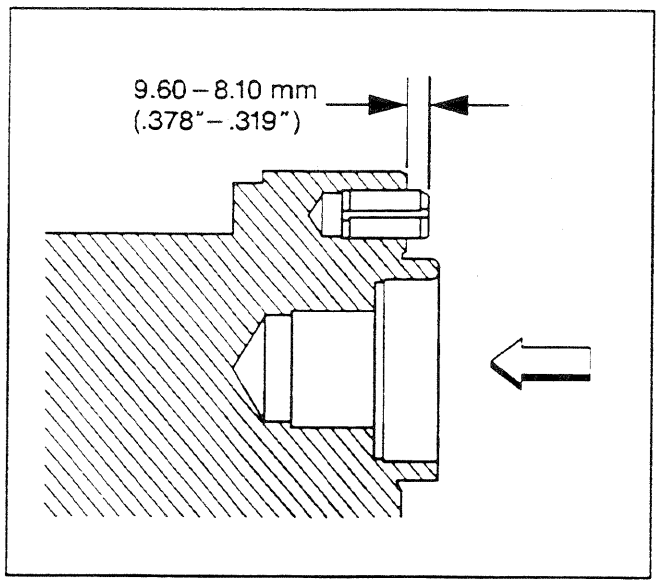
9. Inspect the crankshaft thrust wall surface for wear (1) and/or excessive runout (2). Refer to *Engine Mechanical Specifications*.



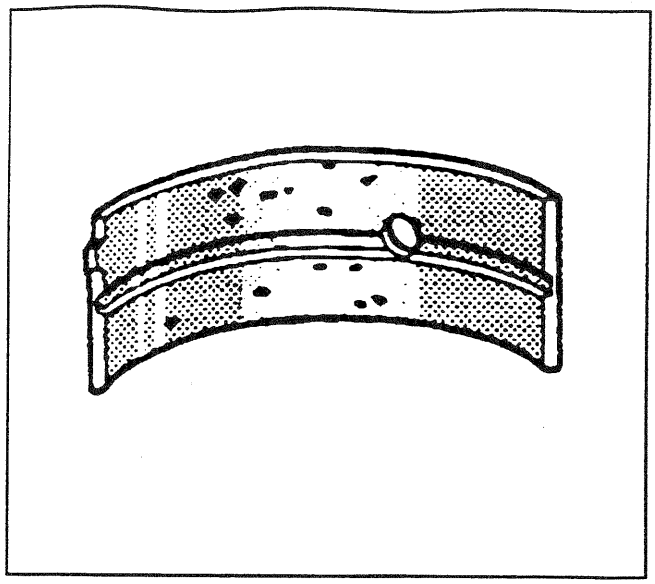
374746

10. Install the engine flywheel locator pin, if removed.

Crankshaft and Connecting Rod Bearing Inspection

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

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



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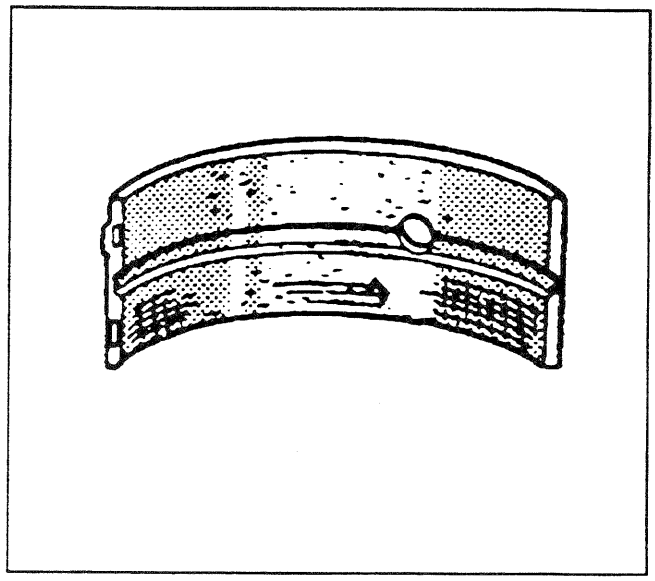
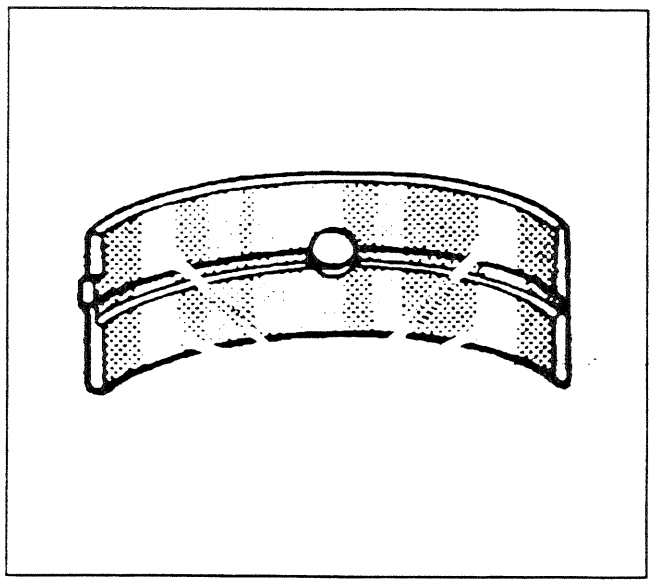
2. Inspect the bearings for excessive scoring or discoloration.
3. Inspect the bearings for dirt or debris imbedded into the bearing material.



52053

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



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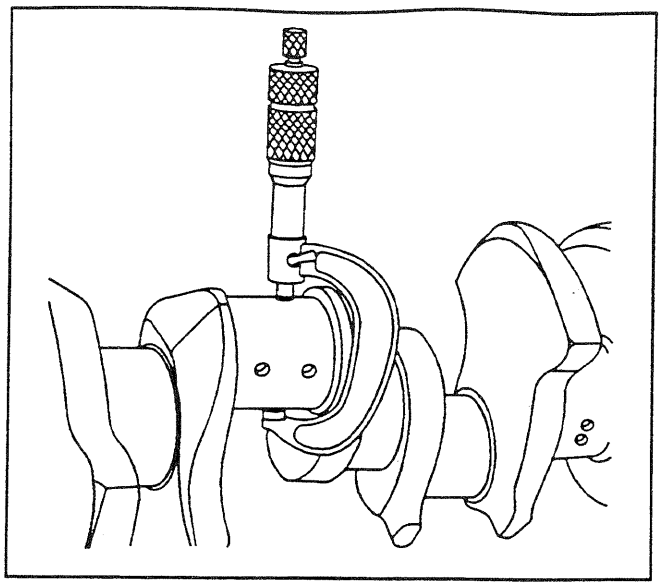

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Crankshaft and Connecting Rod Bearing Clearance Measurement

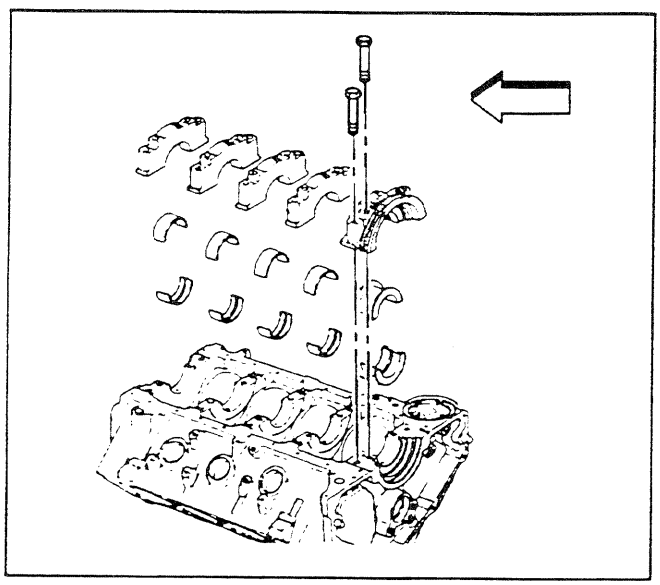
The crankshaft and connecting rod bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, the new upper and the lower bearings will be required. The service bearings are available in the standard size and an undersize.

The selective fitting of the bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard bearing with one-half of a undersize bearing.

In order to determine the correct replacement bearing size, the bearing clearance must be measured accurately. Either the micrometer or plastic gauge method may be used, however, the micrometer method gives more reliable results and is preferred.

Micrometer Method for Crankshaft Bearings

1. Measure the crankshaft main journal diameter with a micrometer in several places along the length approximately 90 degrees apart, (minimum of 4 places), and average the measurements.
2. Determine the taper and the out of round. Refer to *Engine Mechanical Specifications*.



452370

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

3. Install the crankshaft bearings into the crankshaft bearing caps and the engine block.

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

Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap bolts.

Install the crankshaft bearing caps and the crankshaft bearing cap bolts.

Tighten

3.1. Tighten the crankshaft bearing cap inner bolts to 138 N·m (102 lb ft).

3.2. Tighten the crankshaft bearing cap outer bolts to 138 N·m (102 lb ft).

4. Measure the crankshaft bearing inside diameter (ID) using an inside micrometer.

   Measure at a minimum of 4 places and average the measurements.

5. In order to determine the crankshaft bearing clearance, subtract the crankshaft journal diameter from the crankshaft bearing ID.
6. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
7. If the crankshaft bearing clearances exceeds specifications, install the new crankshaft bearings.

8. Measure the new crankshaft bearing inside diameter (ID) using an inside micrometer.
9. Replace or repair the crankshaft if the proper clearances cannot be obtained.

Micrometer Method for Connecting Rod Bearings

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

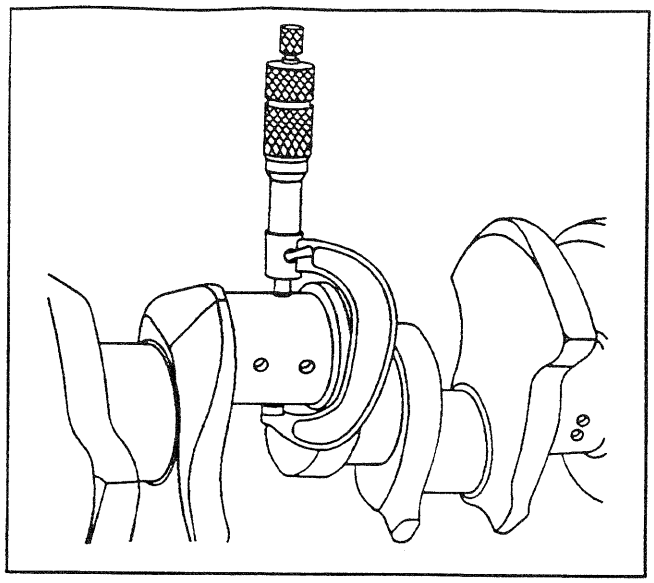
1. Measure the crankpin diameter with a micrometer in several places along the length, approximately 90 degrees apart (minimum of 4 places), and average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications*.
3. Install the connecting rod bearings into the connecting rod cap and the connecting rod.

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

4. Install the connecting rod cap and the nuts.

   Tighten

   Tighten the connecting rod nuts to 64 N·m (47 lb ft).
5. Measure the connecting rod bearing inside diameter (ID) using an inside micrometer.
6. Compare the connecting rod bearing clearance specifications. Refer to *Engine Mechanical Specifications*.
7. If the connecting rod bearing clearance is within specifications, the connecting rod bearing is satisfactory.
   - If the clearance is not within specifications, replace the connecting rod bearing.
   - Always replace both the upper and the lower connecting rod bearings as an assembly.
8. A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it will be necessary to replace or repair the crankshaft.



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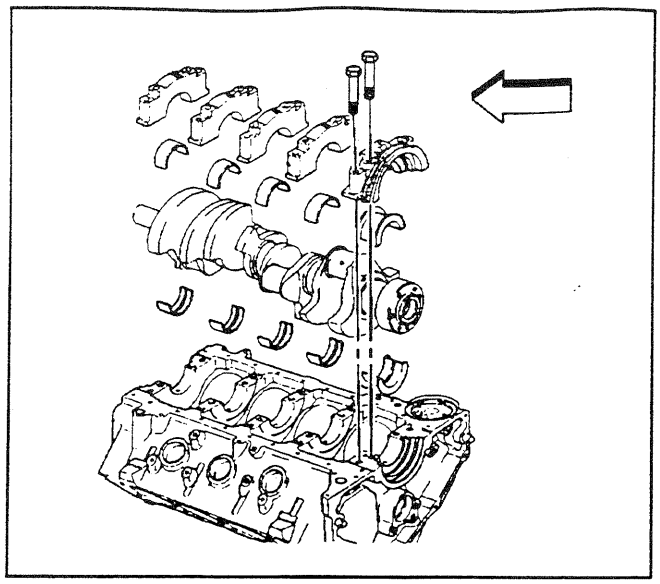

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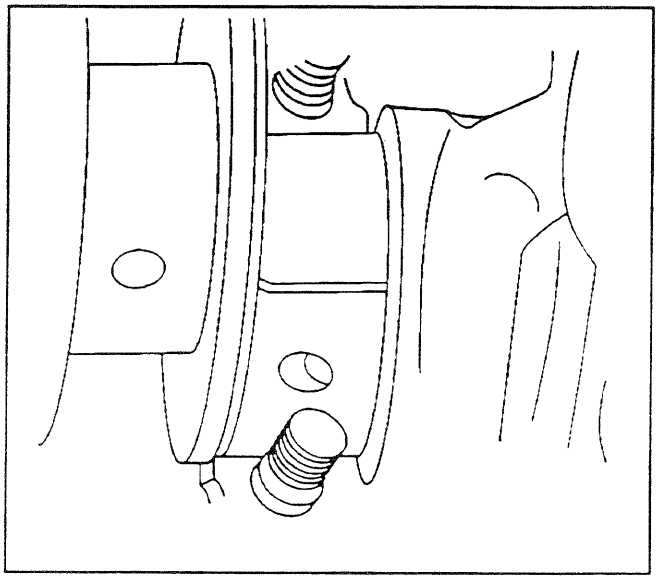
Plastic Gauge Method for Main Bearings

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

1. Install the crankshaft and crankshaft bearings into the block.



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2. Install the gauging plastic the full width of the crankshaft journal.

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

Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap bolts.

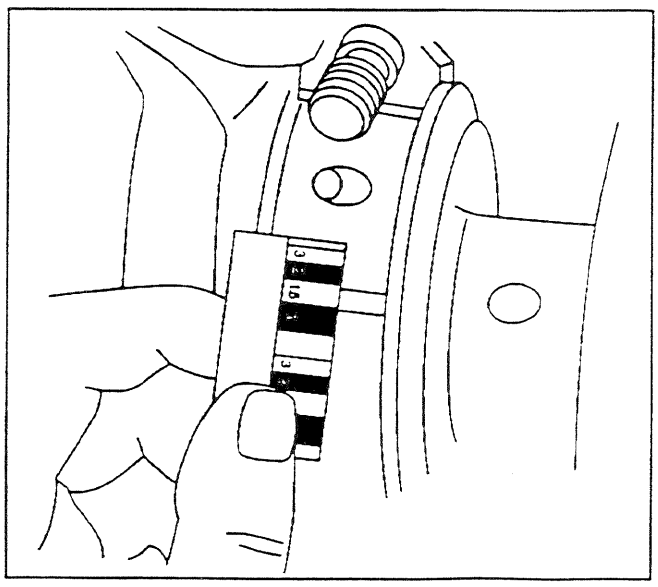
Install the crankshaft bearing caps and the crankshaft bearing cap bolts.

Tighten

2.1. Tighten the crankshaft bearing cap inner bolts to 138 N·m (102 lb ft).

2.2. Tighten the crankshaft bearing cap outer bolts to 138 N·m (102 lb ft).

3. Remove the crankshaft bearing cap bolts and crankshaft bearing caps. The gauging plastic may adhere to either the crankshaft journal or the crankshaft bearing surface.



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4. On the edge of the gauging plastic envelope there is a graduated scale. Without removing the gauging plastic, measure the compressed width at the widest point.
5. If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft journal.
   - Normally the crankshaft journals wear evenly and are not out of round. However, if a crankshaft bearing is being fitted to an out of round 0.0254 mm (0.001 in maximum) crankshaft journal, be sure to fit to the maximum diameter of the crankshaft journal.
   - If the crankshaft bearing is fitted to the minimum diameter and the crankshaft journal is excessively out of round, the interference

between the crankshaft bearing and the crankshaft journal will result in rapid crankshaft bearing failure.

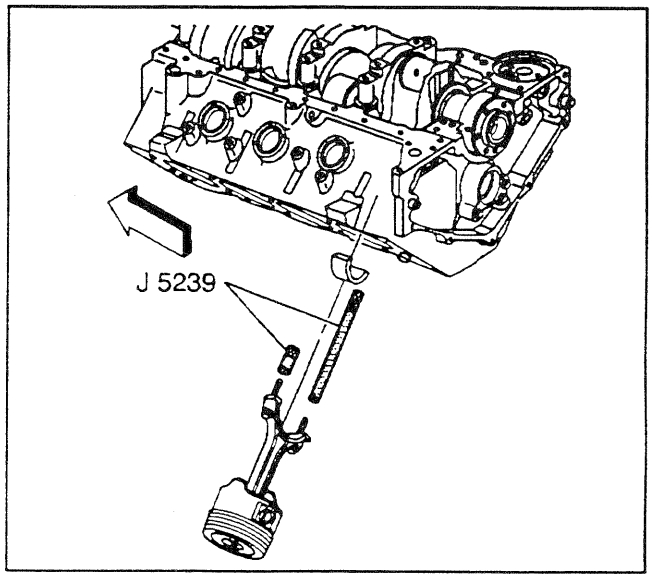
Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

6. If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory.
   - If the clearance is not within specifications, replace the crankshaft bearing.
   - Always replace both the upper and lower crankshaft bearings as a unit.
   - A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.
7. Remove the flattened gauging plastic.
8. Measure the remaining crankshaft journals.

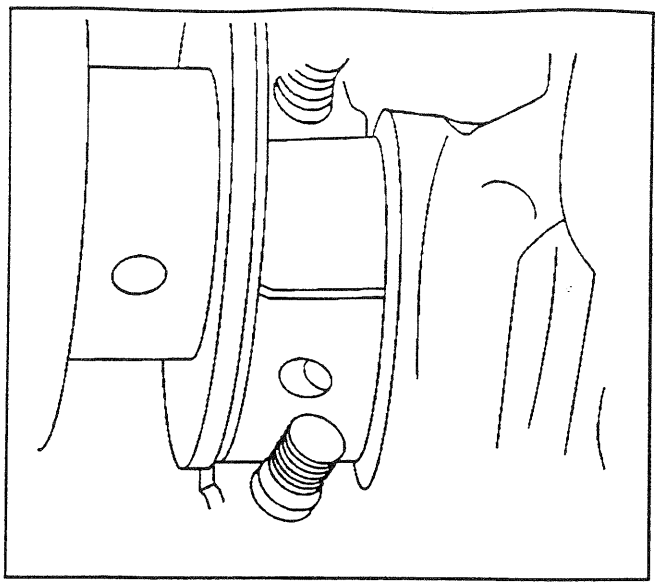
Plastic Gauge Method for Connecting Rod Bearings

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

1. Install the connecting rod bearing into the connecting rod.
2. Install the piston and connecting rod assembly onto the crankpin journal using the *J 5239*.

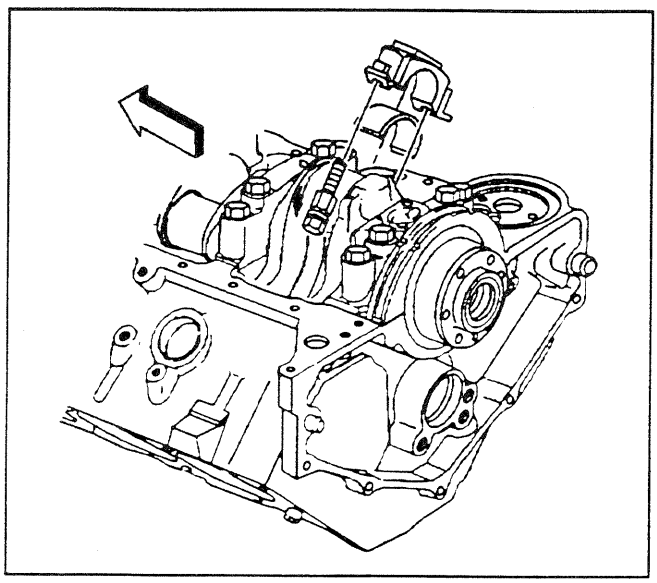


354028



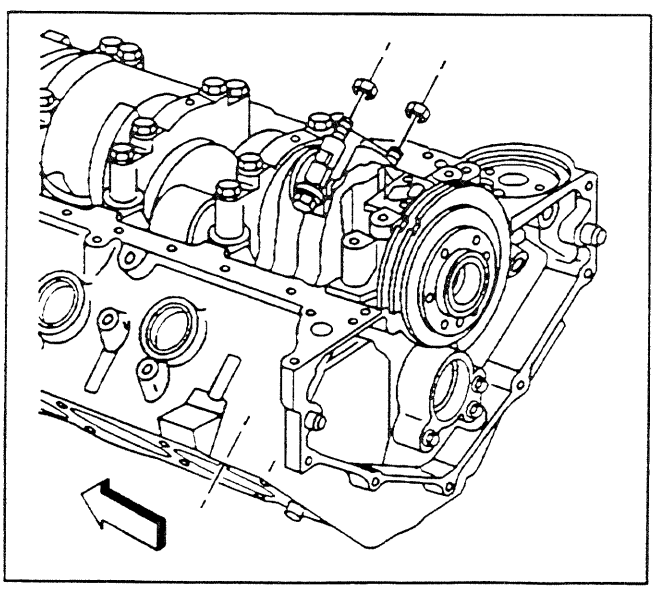
4980

3. Install the gauging plastic the full width of the crankpin journal.



354030

4. Install the connecting rod cap with the connecting rod bearing.



354031

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

5. Install the connecting rod nuts.

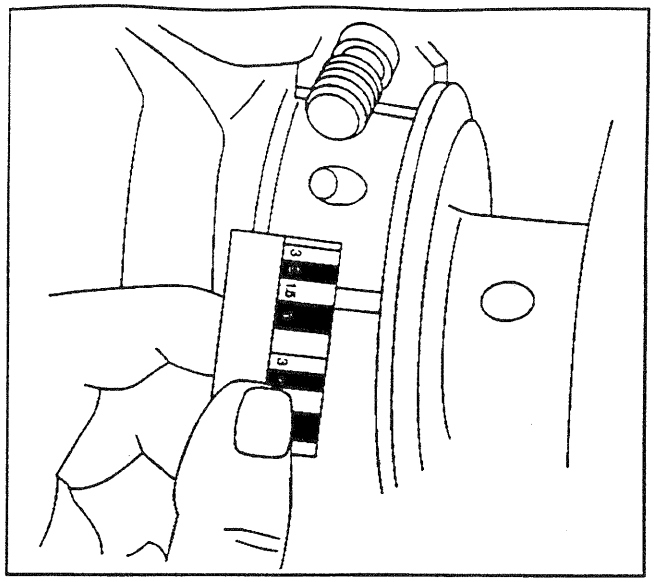
   Tighten

   Tighten the connecting rod cap nuts to 64 N·m (47 lb ft).

6. Remove the connecting rod nuts and cap. The gauging plastic may adhere to either the crankpin journal or the connecting rod bearing surface.

7. On the edge of the gauging plastic envelope there is a graduated scale. Without removing the gauging plastic, measure the compressed width at the widest point.

   If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the connecting rod bearing or the crankpin journal.



4981

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

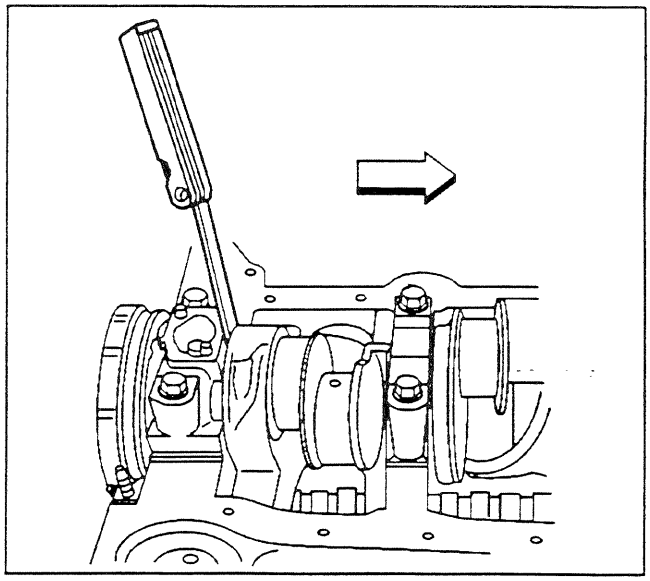
8. Normally the crankpin journals wear evenly and are not out of round. However, if a connecting rod bearing is being fitted to an out-of-round 0.0254 mm (0.001 in. maximum) crankpin journal, be sure to fit to the maximum diameter of the crankpin journal. If the connecting rod bearing is fitted to the minimum diameter and the crankpin journal is excessively out-of-round, the interference between the connecting rod bearing and the crankpin journal will result in rapid connecting rod bearing failure.
9. If the connecting rod bearing clearance is within specifications, the connecting rod bearing is satisfactory.
   - If the clearance is not within specifications, replace the connecting rod bearing.
   - Always replace both the upper and lower connecting rod bearings as a unit.
   - A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it may be necessary to repair or replace the crankshaft or connecting rod.
10. Remove the flattened gauging plastic.
11. Measure the remaining crankpin journals.

Measuring Crankshaft End Play

Important: In order to properly measure the crankshaft end play, the crankshaft, bearings, bearing caps, and fasteners must be installed into the engine block and the bolts tightened to specifications.

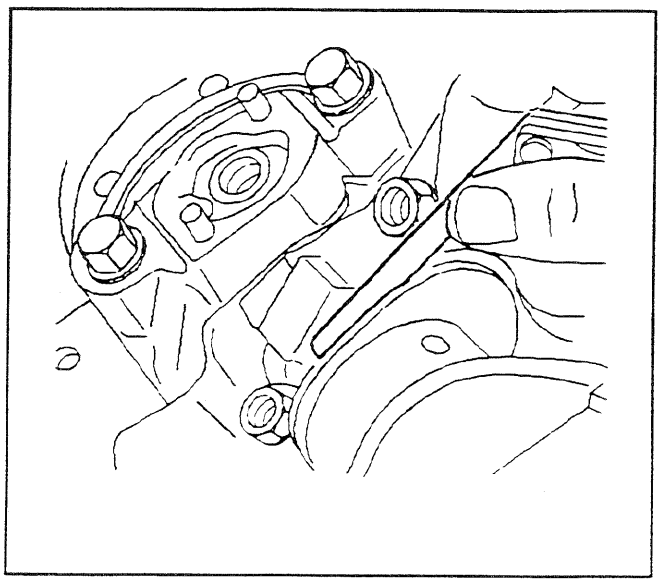
Measure the crankshaft end play.

1. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
2. With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the bearing surface and measure the clearance. Refer to *Engine Mechanical Specifications*.
3. If the correct end play cannot be obtained, inspect for the following conditions:
   - Verify that the correct size crankshaft bearing has been installed, refer to *Engine Mechanical Specifications*


35199

- Inspect the crankshaft thrust wall surface(s) for wear and/or excessive runout, refer to *Engine Mechanical Specifications*

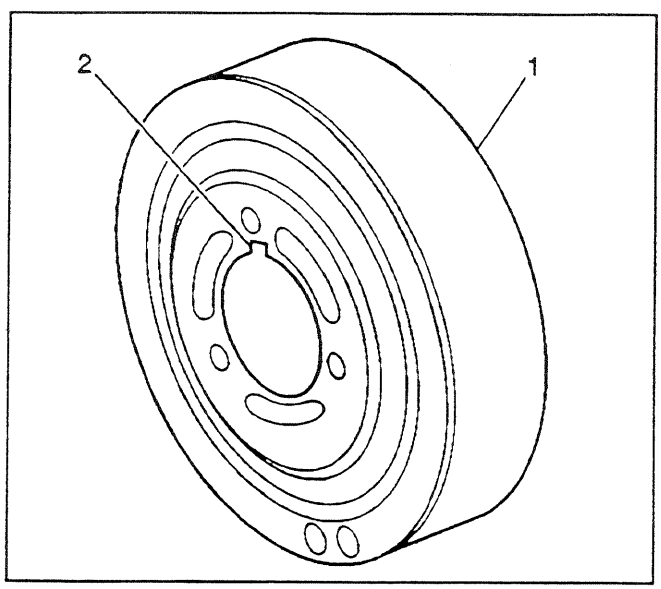
1. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts, one cap at a time, until the tight bearing is located. The following condition(s) could cause a lack of clearance at the bearing:
   - Burrs on the crankshaft bearing cap
   - Foreign matter between the crankshaft bearing and the block or the crankshaft bearing cap
   - A faulty crankshaft bearing



5163

Measuring Connecting Rod Side Clearance

1. Insert a feeler gauge between the connecting rod caps and measure the connecting rod side clearance. Refer to *Engine Mechanical Specifications*.
2. Connecting rod clearances may also be measured with a dial indicator set.



354018

Crankshaft Balancer Clean and Inspect

SIE-ID = 311319

1. Clean the crankshaft balancer (1) in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
   - Worn or damaged bolt hole thread(s)
   - Worn, grooved, or damaged hub seal surface
     - Minor imperfections on the hub seal surface may be removed with a polishing compound or fine grade emery cloth.
     - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust, or other damage must be replaced.
   - Worn, chunking, or deteriorated rubber between the hub and pulley
   - Worn or damaged keyway (2)
4. Repair or replace the crankshaft balancer as necessary.

Engine Flywheel Clean and Inspect

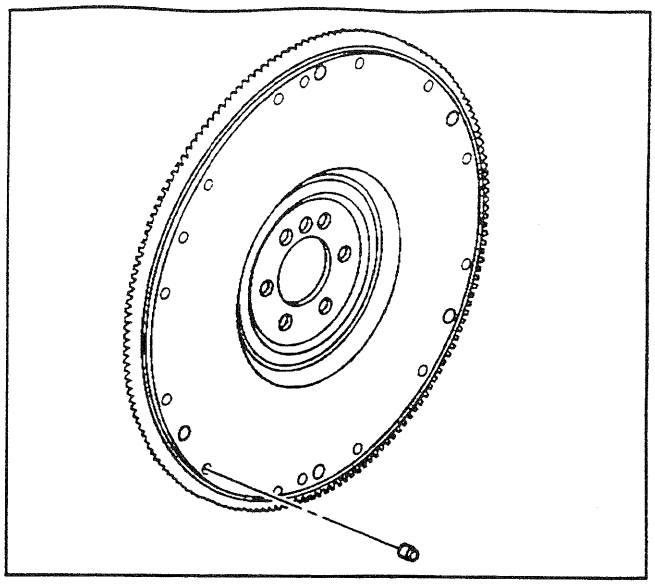
SIE-ID = 198447

1. Clean the engine flywheel in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

2. Dry the engine flywheel with compressed air.
3. Inspect the manual transmission engine flywheel for loose or improperly installed balance weights.

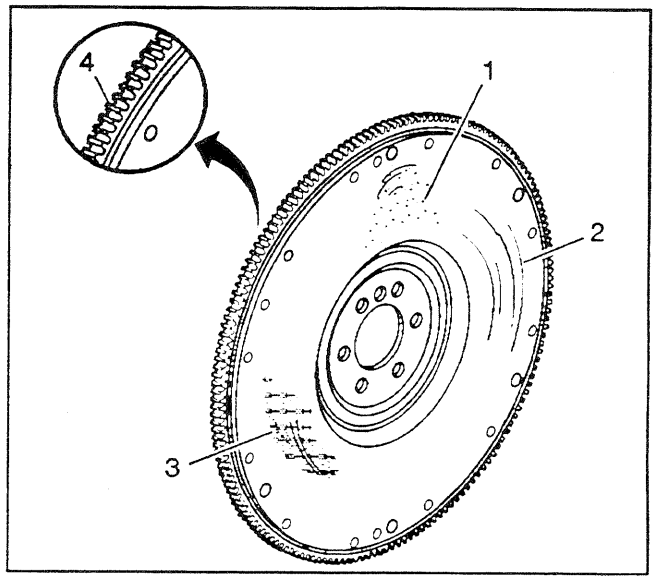
   A properly installed balance weight should be installed until flush or below flush with the face of the engine flywheel.



64126

4. Inspect the manual transmission engine flywheel for the following conditions:
   - Pitted surface (1)
   - Scoring or grooves (2)
   - Rust or other surface damage (3)
   - Damaged ring gear teeth (4)
   - Loose or improperly positioned ring gear

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



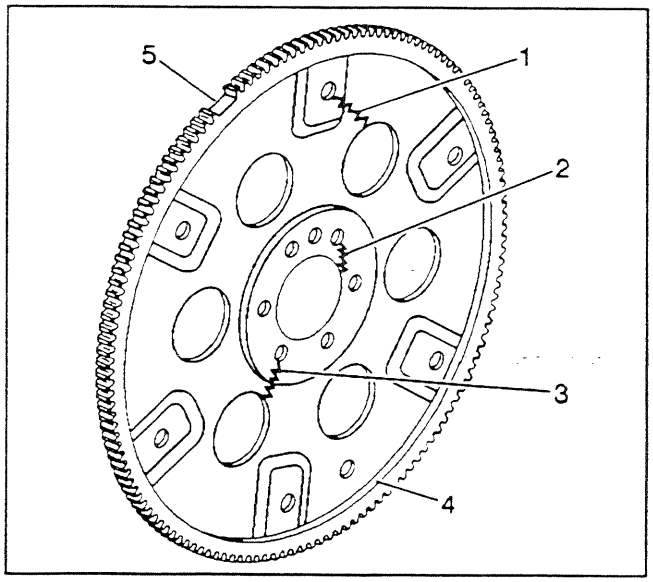
188086

5. Inspect the automatic transmission engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 3)

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

Cracks at welded areas that retain the ring gear onto the engine flywheel (4)

- Damaged or missing ring gear teeth (5)



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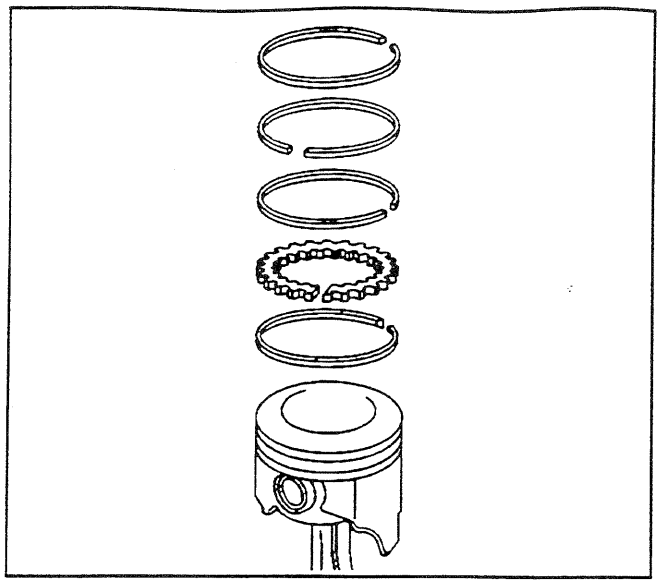


4967

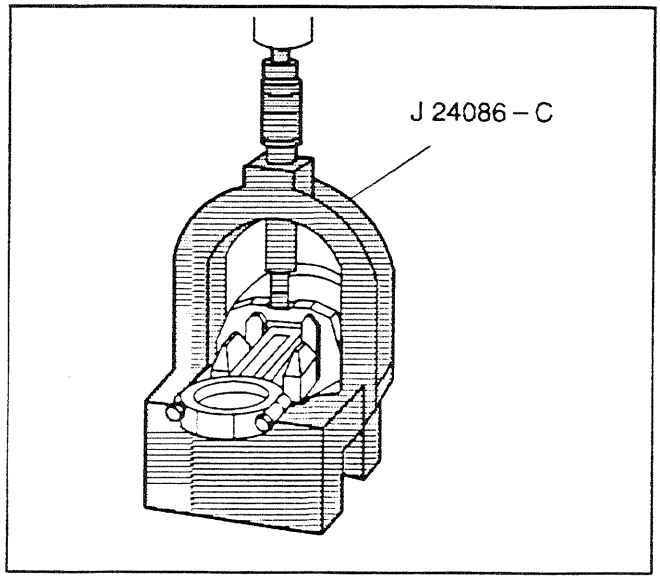
Piston and Connecting Rod Disassemble

SIE-ID = 198478

Tools Required

J 24086-C Piston Pin Remover and Installer

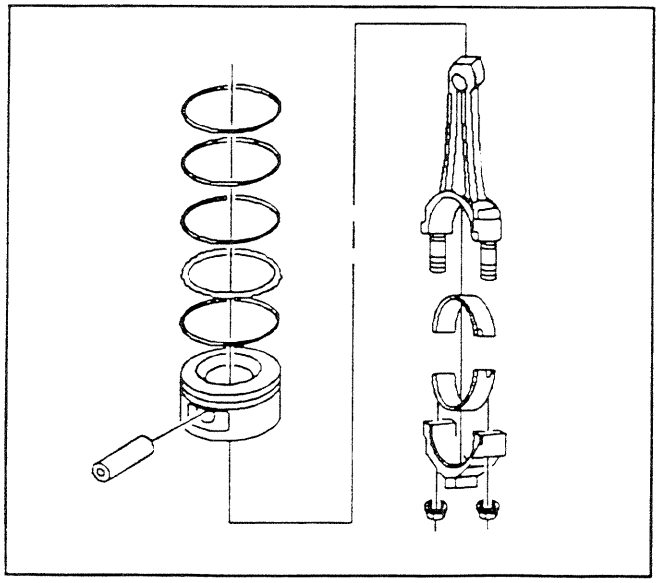
1. Remove the piston rings from the pistons.



4965

2. Press the pin from the connecting rod by using *J 24086-C*.

   The piston pin has an interference fit into the connecting rod and is full floating in the piston.



34671

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

3. If the bearings will be reused, place the bearings in a rack in order to ensure reinstallation with the original connecting rod and the cap.

Piston, Connecting Rod and Bearings Clean/Inspect

SIE-ID = 198525

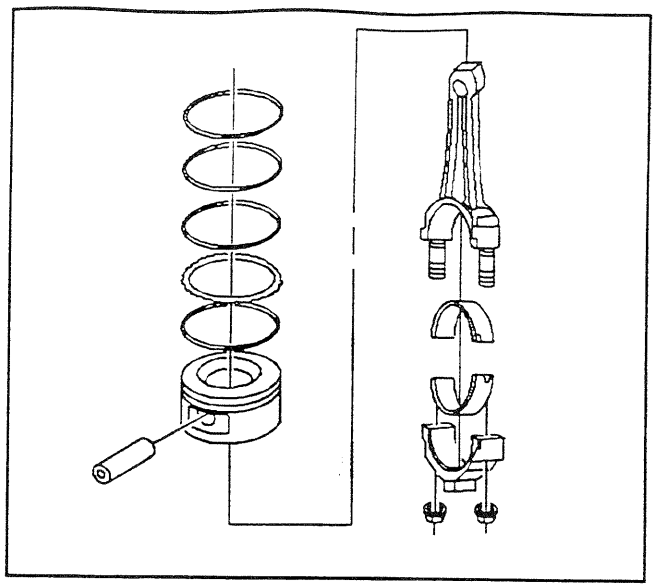
Important: Measurement of all components should be taken with the components at room temperature.

Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston and connecting rod in solvent.

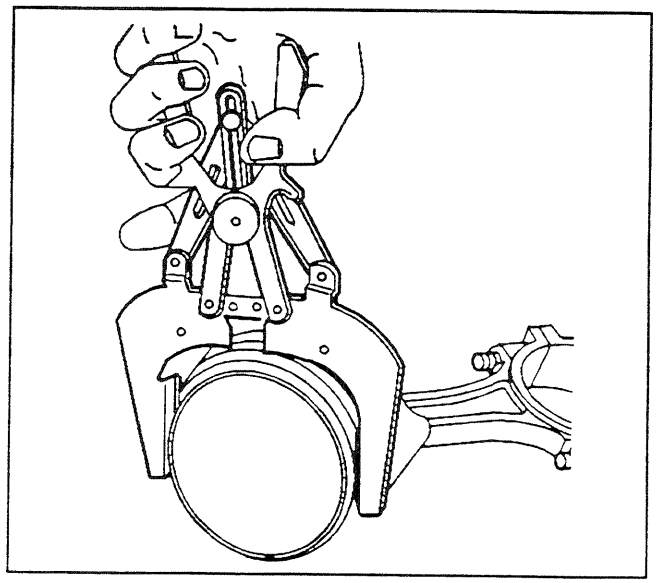
Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

2. Dry the components with compressed air.



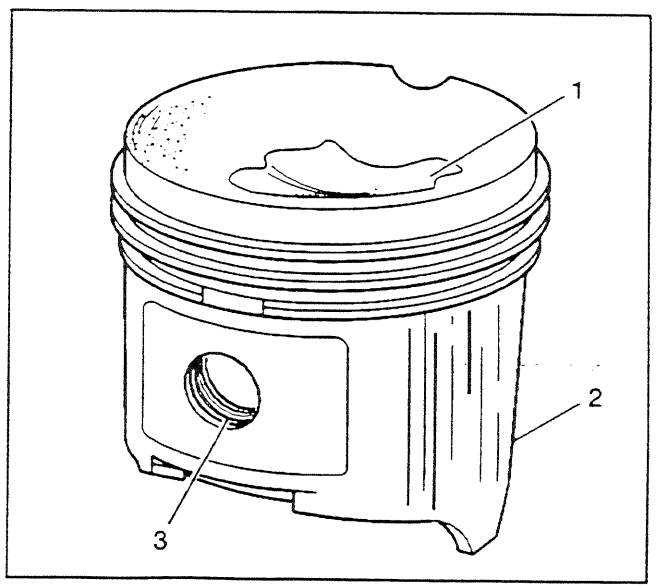
34671

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.

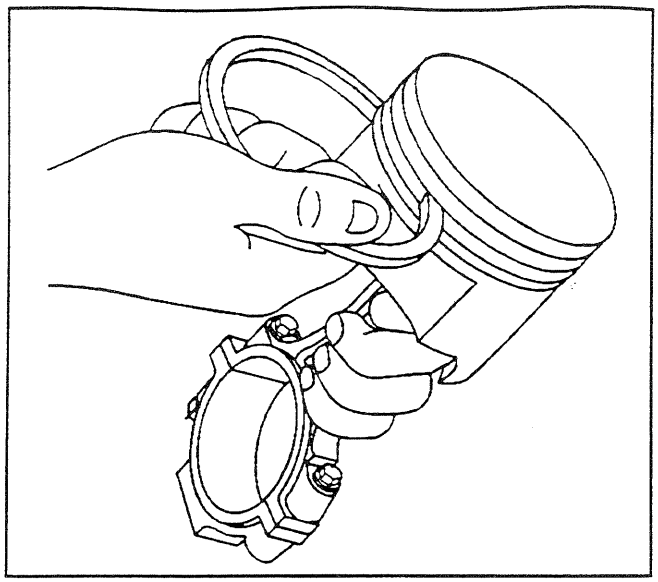


4977

4. Clean the piston oil lubrication holes and slots.
5. Inspect the piston for the following conditions:
   - Eroded areas (1) on the top of the piston
   - Scuffed or damaged skirt (2)
   - Damage to the pin bore (3)
   - Cracks in the piston ring lands, the piston skirt, or the pin bosses
   - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind.
6. Inspect the piston pin for scoring, wear or other damage.

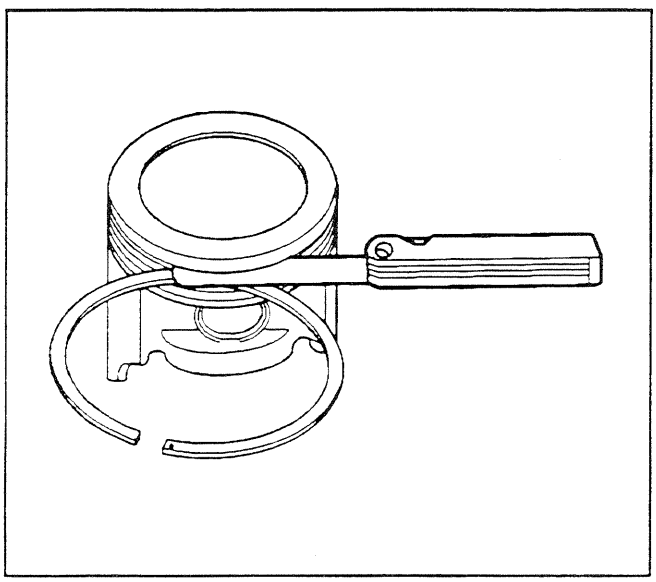


156168



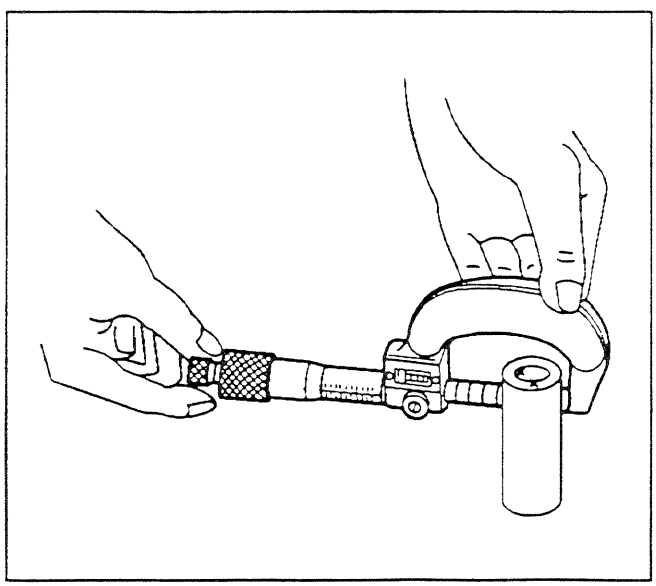
4969

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



22934

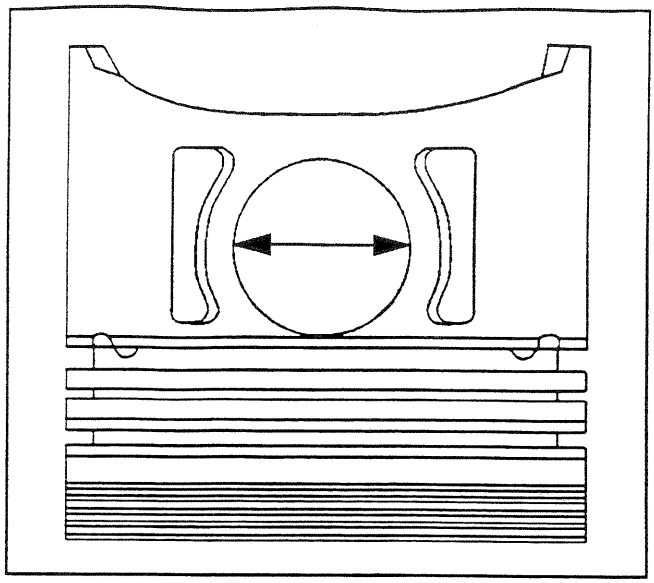
8. Measure the piston ring side clearance with a feeler gauge.
9. If the side clearance is too small, try another piston ring set. Refer to *Engine Mechanical Specifications*.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.



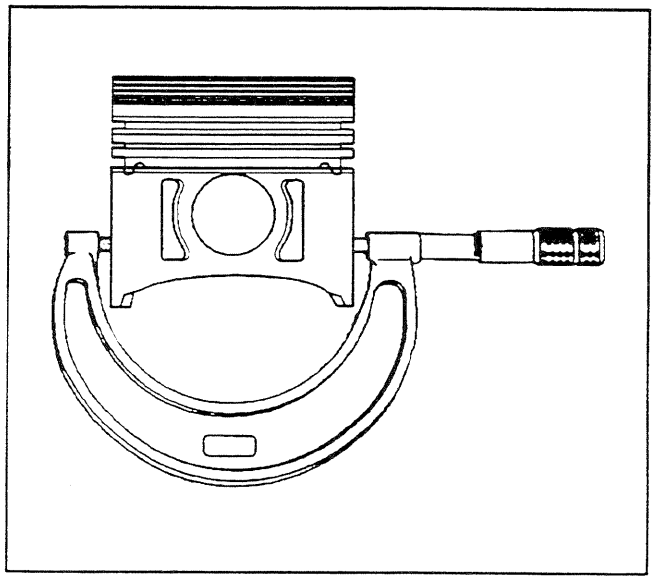
4976

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

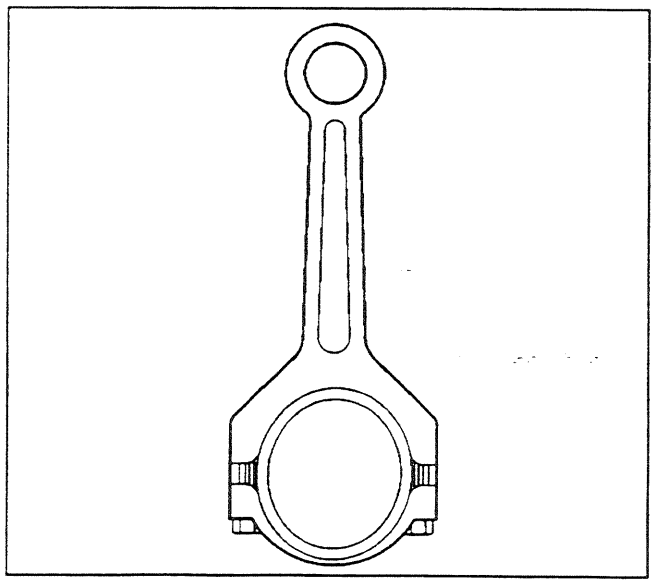
12. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
13. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter.

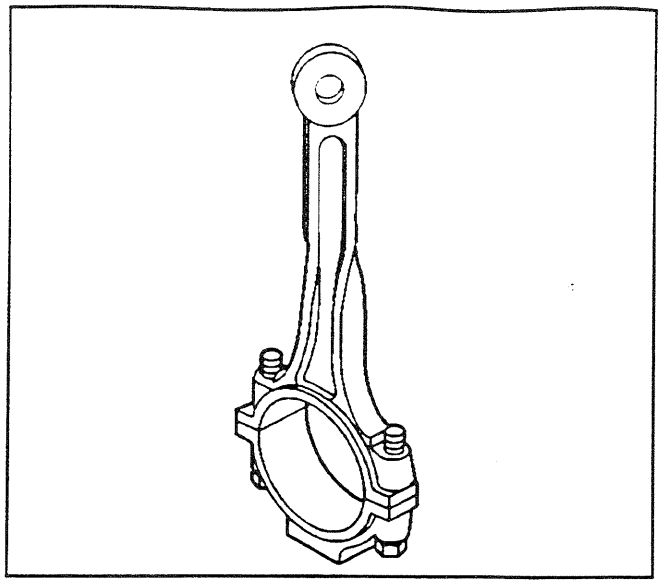

4975

14. Measure the piston for out-of-round.
    14.1. With a micrometer at a right angle to the piston, measure the piston at 11 mm (0.433 in) from the bottom of the skirt.
    14.2. Measure the piston at three different points 120 degrees apart and compare the readings. Refer to *Engine Mechanical Specifications*.
    14.3. If the clearance is not within specifications, replace the piston and pin as an assembly.


4988

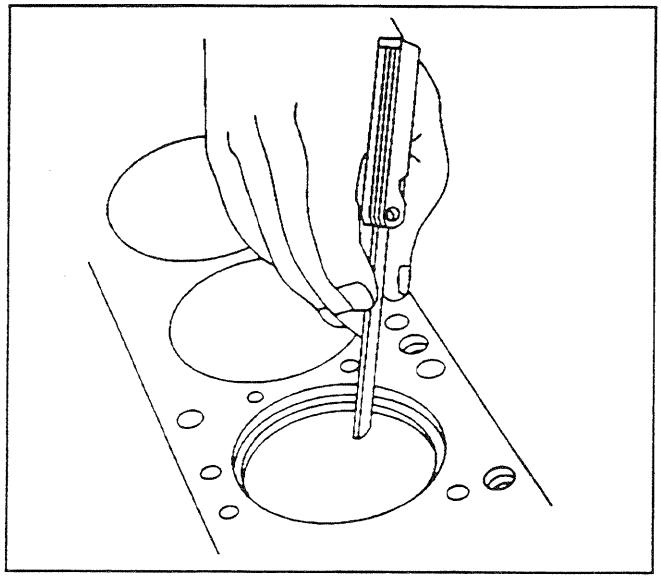
15. Inspect the connecting rod for an out-of-round bearing bore.


156167



156169

16. Inspect the connecting rod for twisting.
17. Inspect the connecting rod for damage the to the connecting rod bolt threads.



4968

Important: Fit each compression ring to the cylinder in which it will be used.

Measure the piston compression ring end gap.

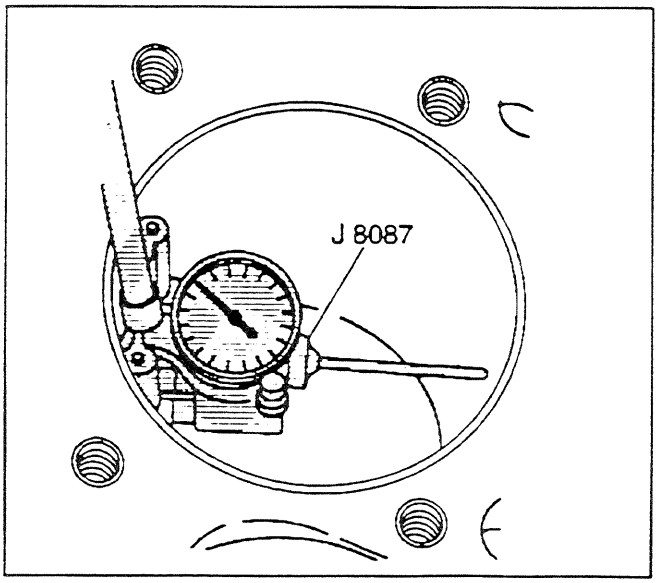
17.1. Place the compression ring into the cylinder bore.

17.2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.

The ring must be square to the cylinder wall.

17.3. Use a feeler gage in order to measure the end gap.

17.4. Select another size ring set if the end gap exceeds specifications.



4972

Piston Selection

SIE-ID - 198614

Tools Required

J 8087 Cylinder Bore Checking Gauge

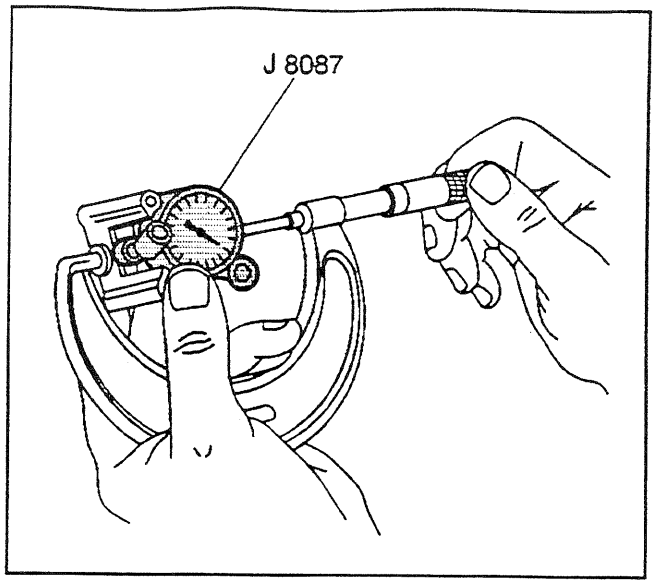
Important: Measurements of all components should be taken with the components at normal room temperature.

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

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

1. Inspect the engine block cylinder bore. Refer to *Cylinder Boring and Honing.*
2. Inspect the piston and pin. Refer to *Piston, Connecting Rod and Bearings Clean/Inspect.*

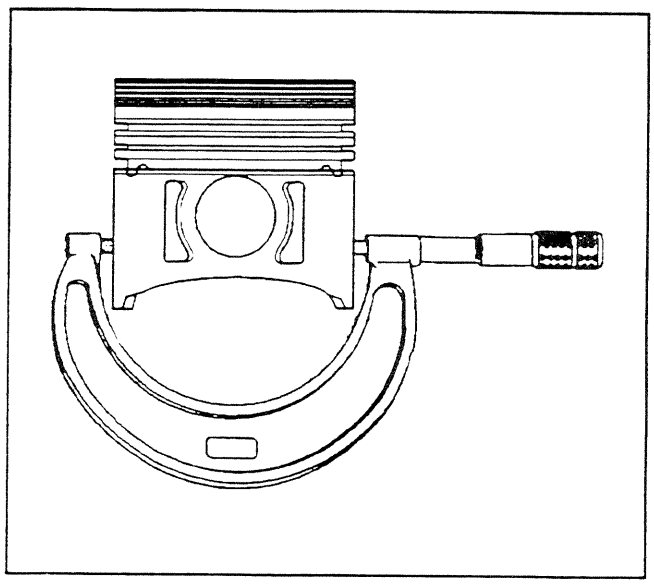
3. Use the *J 8087* and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.
4. Measure the *J 8087* with a micrometer and record the reading.



4974

5. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 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. Refer to *Engine Mechanical Specifications*.
7. If the proper clearance cannot be obtained, select another piston and measure the clearances.

   If the proper fit cannot be obtained, the cylinder bore may require honing or boring.
8. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.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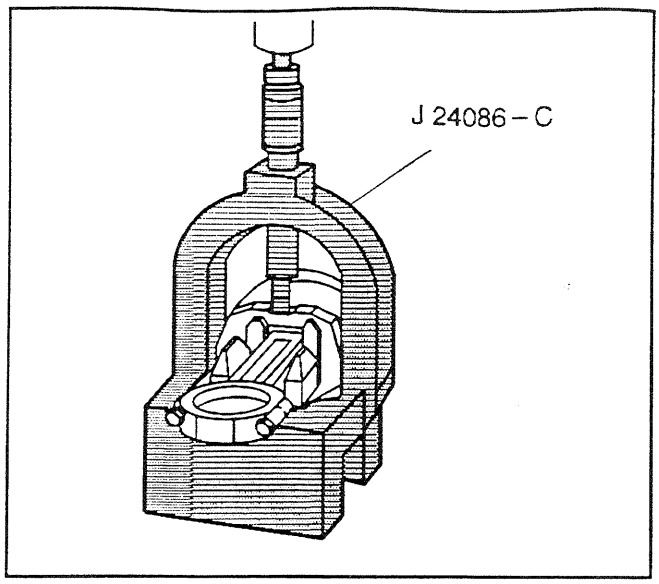


4965

Piston and Connecting Rod Assemble

SIE-ID = 577128

Tools Required

J 24086-C Piston Pin Remover/Installer

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Notice: SIO-ID = 38775 After the J 24086-C installer hub bottoms on the support assembly, DO NOT exceed 35 000 kPa (5,000 psi) or the tool may be damaged.

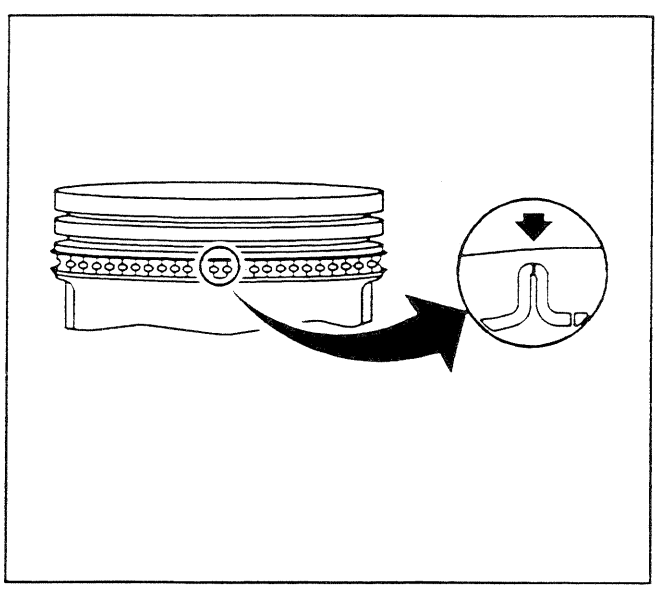
Important: When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.

The piston pin has an interference fit into the connecting rod and is full floating in the piston.

Install the piston pin and connecting rod assembly.

1. Lubricate the piston and connecting rod pin bores with clean engine oil.
2. Use the *J 24086-C* in order to press the piston pin into the piston and connecting rod assembly.
3. Inspect for the proper installation of the piston and piston pin.

   The piston should move freely on the piston pin with no binding or interference.

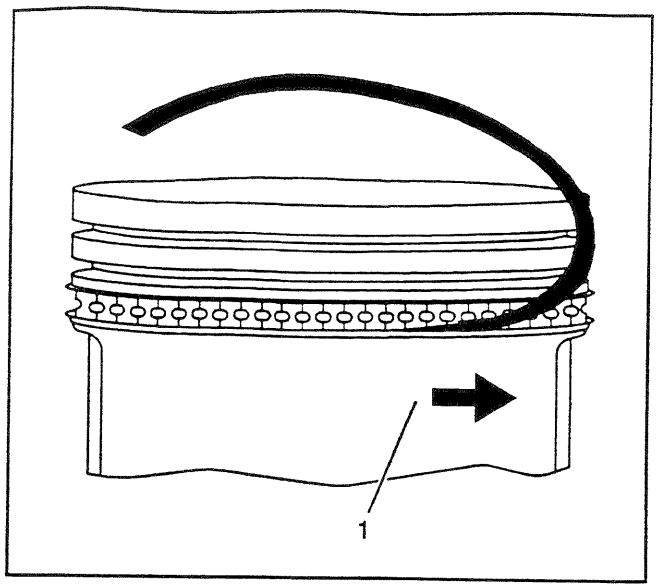


562836

Notice: SIO-ID = 16608 Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the oil control piston ring spacer onto the piston.

2. Install the lower oil control piston ring onto the piston (1).



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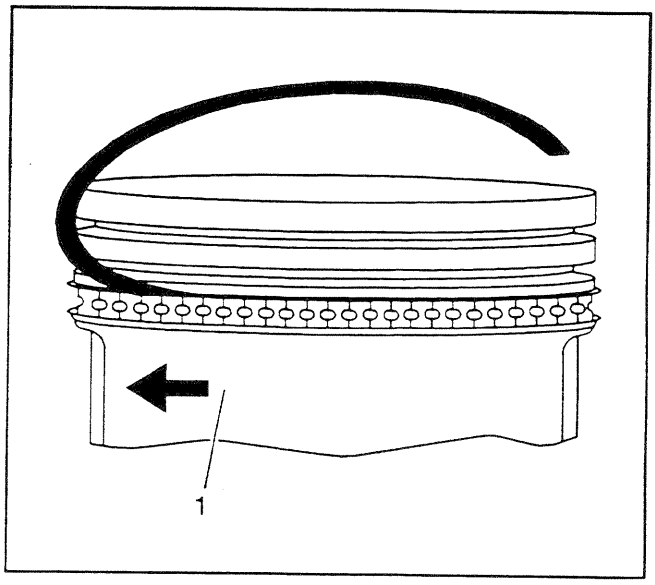
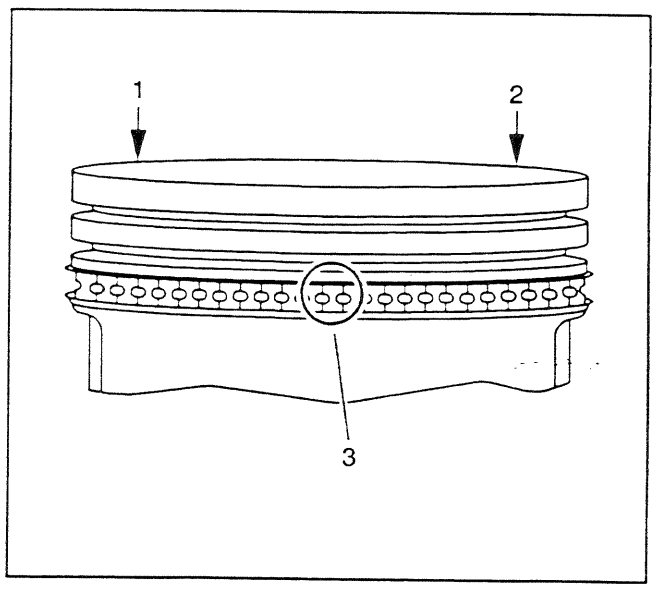
3. Install the upper oil control piston ring onto the piston (1).



562839

4. Space the oil control piston ring end gaps a minimum of 90 degrees apart.



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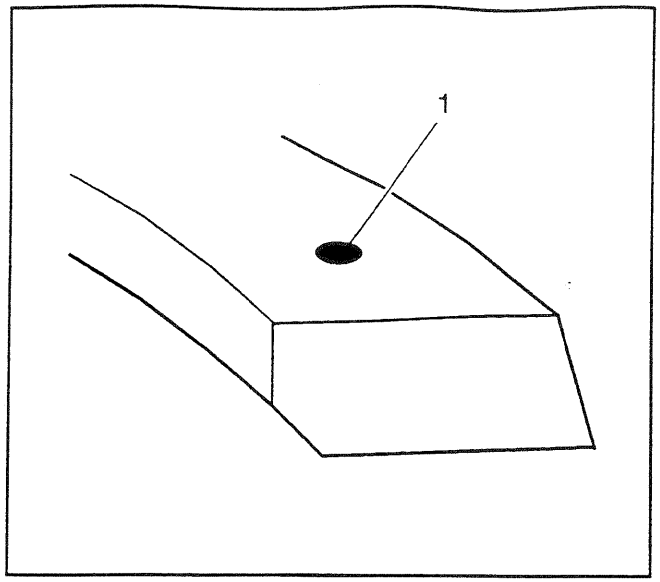

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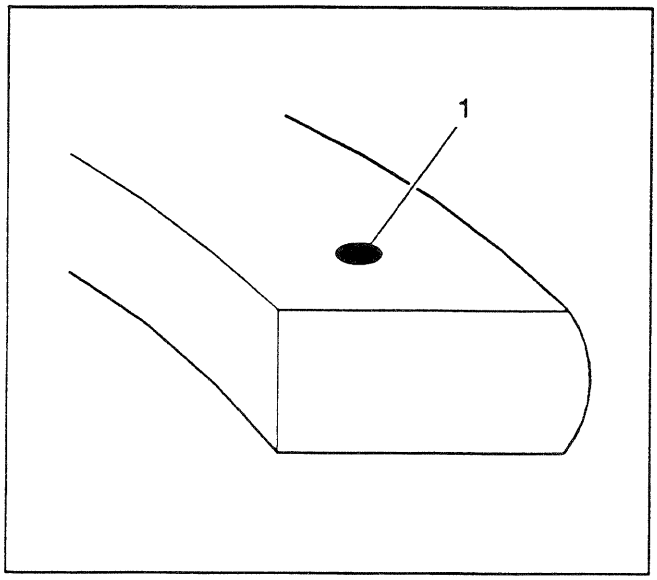
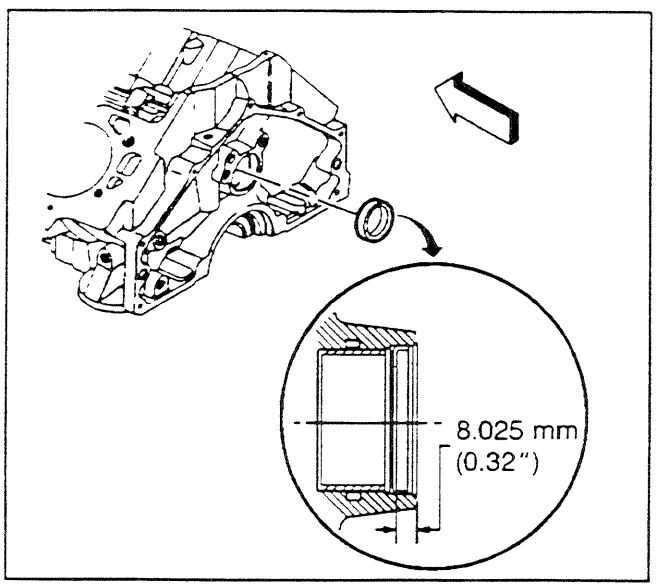
5. Install the lower compression piston ring onto the piston (1).
   The mark on the side of the piston ring should face the top of the piston.



562819

6. Install the upper compression piston ring onto the piston.
   The mark (1) on the side of the piston ring should face the top of the piston.
7. Space the compression piston ring end gaps 120 degrees apart.



180956

Camshaft Bearing Removal

SIE-ID = 198752

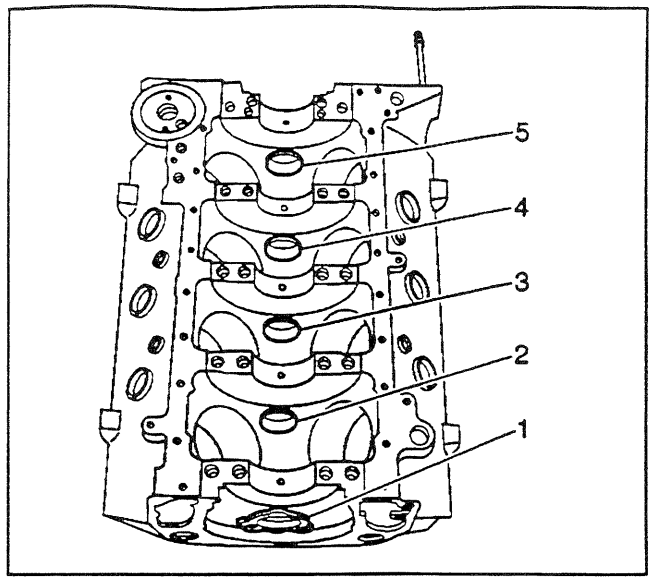
Tools Required

J 33049 Camshaft Bearing Remover/Installer

1. Remove the rear camshaft plug.
   Insert a long bar through the front of the engine and drive the plug out of the rear bore.

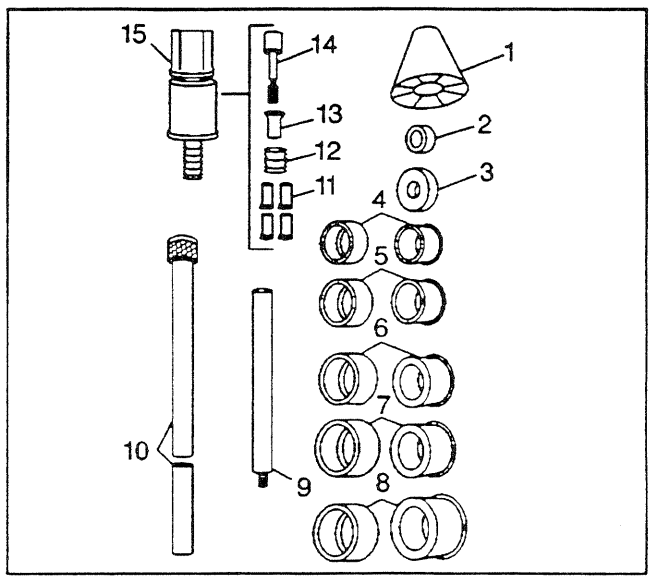
Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block bearing bore.

Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores (positions 1–5).



452376

2. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*.
3. Assemble the *J 33049*.

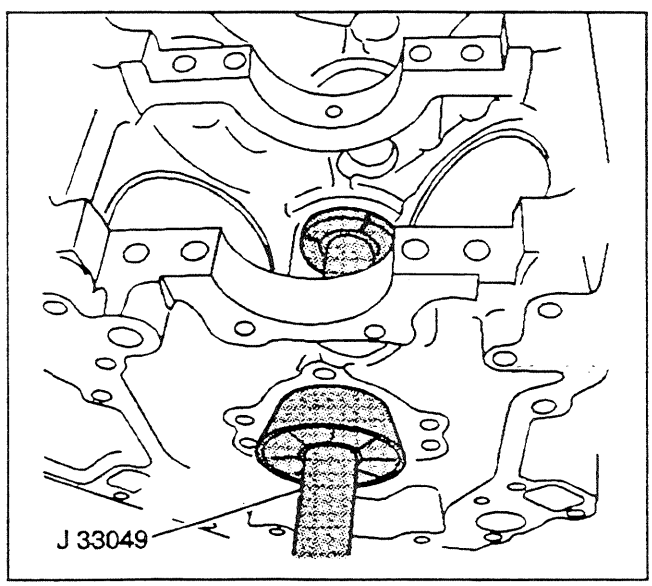


66100

Important: Remove the inner bearings (positions 2, 3, and 4) first. The outer bearings (positions 1 and 5) serve as a guide for the *J 33049*.

Insert the *J 33049* through the front of the engine block and into the bearing.

4. Tighten the expander assembly nut until snug.
5. Push the guide cone into the front camshaft bearing (position 1) to align the *J 33049*.
6. Drive the inner bearings (positions 2, 3, and 4) from their block bores.



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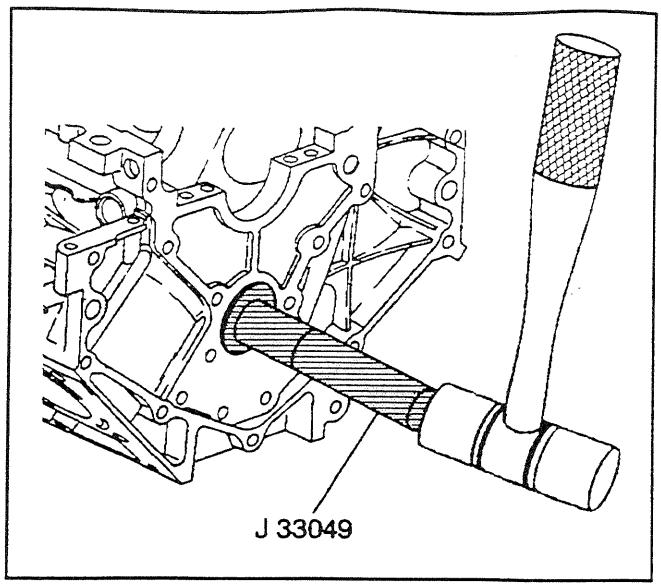
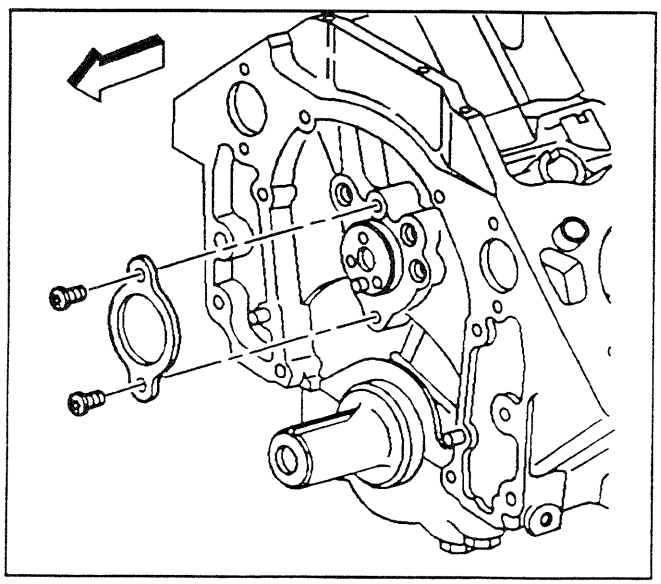


63219

7. Assemble the *J 33049* handle, expanding driver, and washer.
8. Insert the *J 33049* into the outer camshaft bearings (positions 1 or 5).
9. Drive the outer bearings (positions 1 or 5) from the bore.



193223

Camshaft and Bearings Clean and Inspect

SIE-ID = 198875

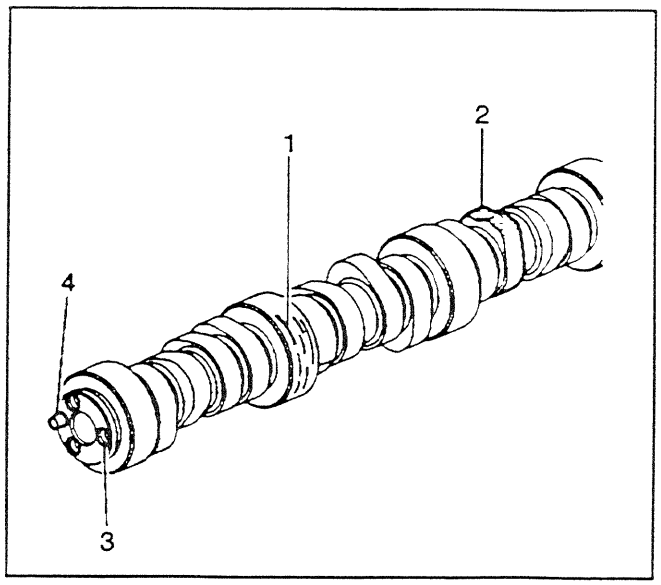
Tools Required

J 7872 Magnetic Base Dial Indicator Set

1. Clean the camshaft in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

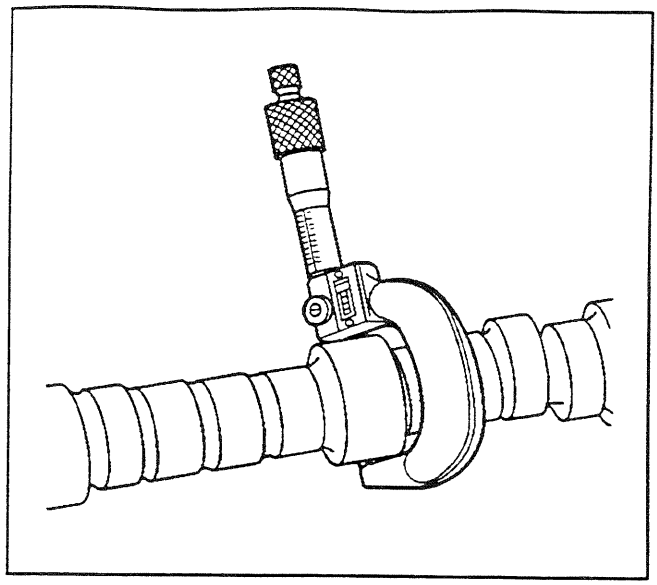
2. Dry the camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.



188095

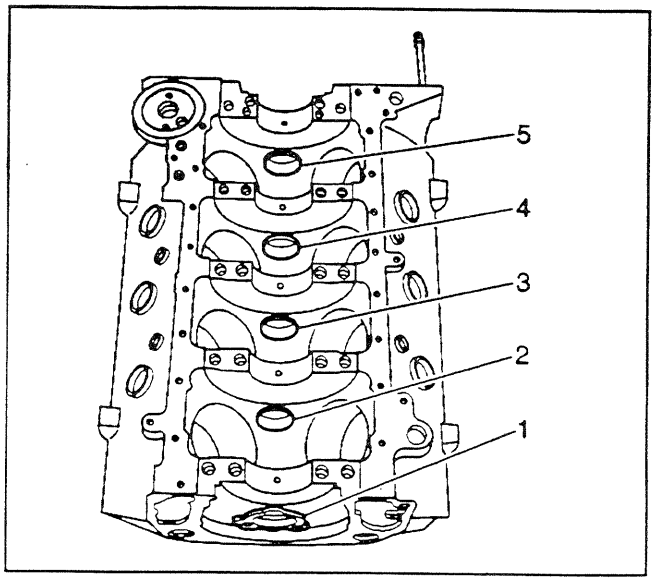
4. Inspect the camshaft for the following conditions:
   - Camshaft bearing journals (1) that are:
     - Worn
     - Scored
     - Damaged
   - Worn camshaft lobes (2)
   - Damaged sprocket bolt threads (3)
   - Damaged sprocket pin (4)

5. Measure the camshaft journals with a micrometer. Refer to *Engine Mechanical Specifications.*
6. Measure for a bent camshaft or excessive camshaft runout using *J 7872.*
   6.1. Mount the camshaft in a suitable fixture.
   6.2. Use the *J 7872* in order to measure for a bent camshaft. Refer to *Engine Mechanical Specifications.*
7. Replace the camshaft if runout exceeds specifications.



35212

8. Inspect the camshaft bearings (1–5) for serviceability.
9. Replace the camshaft bearings if necessary. Refer to *Camshaft Bearing Removal* and *Camshaft Bearing Installation.*



452376

Camshaft Bearing Installation

SIE-ID = 19997C

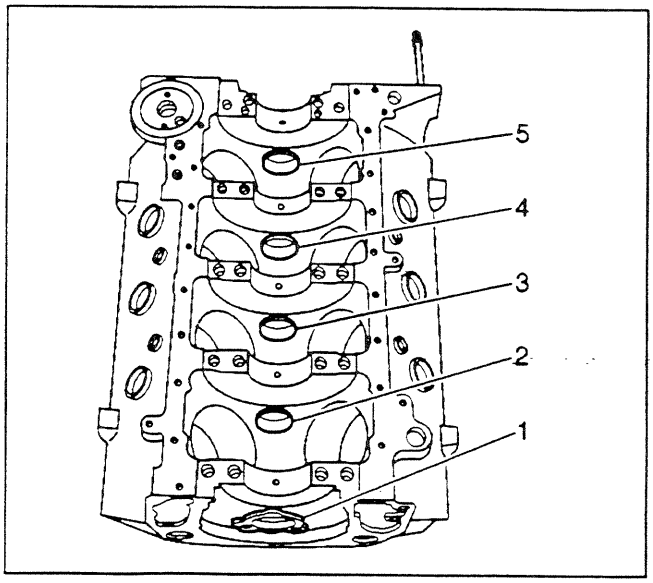
Tools Required

J 33049 Camshaft Bearing Remover/Installer

Important: The outer camshaft bearings (positions 1 and 5) must be installed first. These bearings serve as guides for the tool and help center the inner bearings during the installation process.

Ensure the correct camshaft bearing fits into the proper bore. The camshaft bearing bores may vary in size.

Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.



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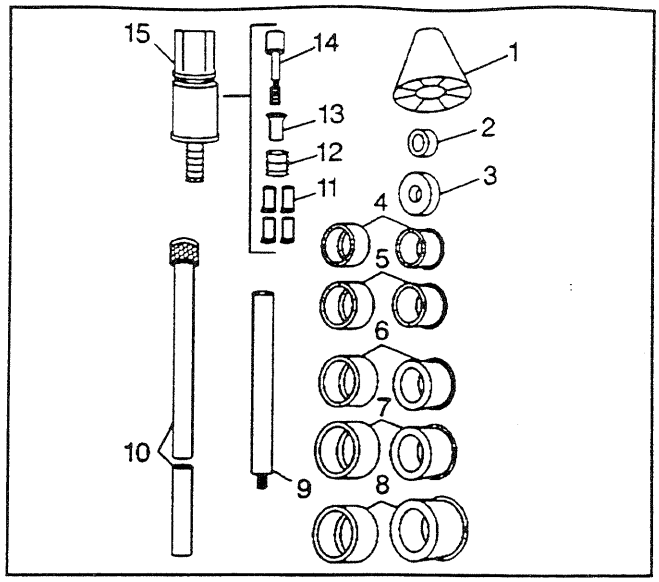
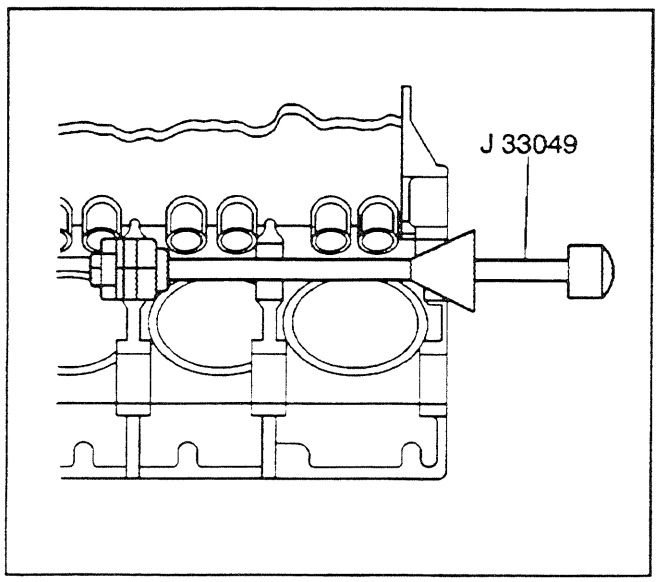


66100

1. Assemble the tool handle (10), expanding driver (4-8), and washer (2 or 3).



4985

2. Insert the *J 33049* into the engine block end camshaft bearings (positions 1 or 5).

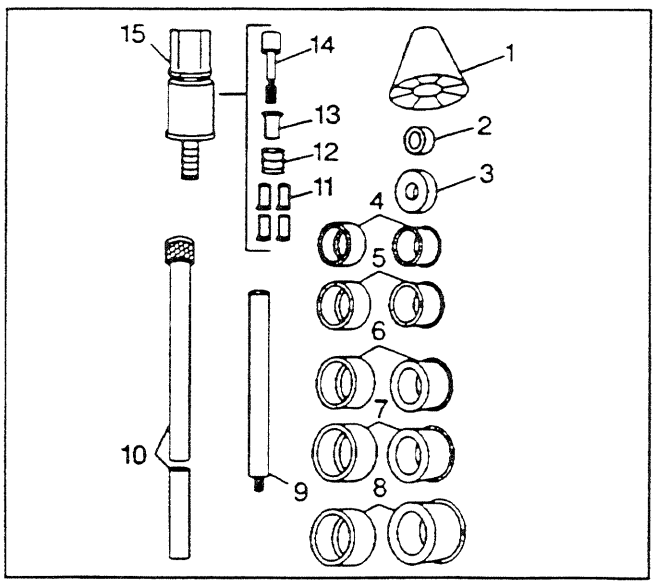
Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

Drive the end bearings (positions 1 and 5) into the bore.



66100

3. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*.
4. Assemble the tool.

5. Insert the *J 33049* through the front of the engine block and to the inner bearing bores (positions 2, 3, and 4).
6. Install the bearing onto the expanding driver.
7. Tighten the expander assembly nut until the tool is snug in the bearing.

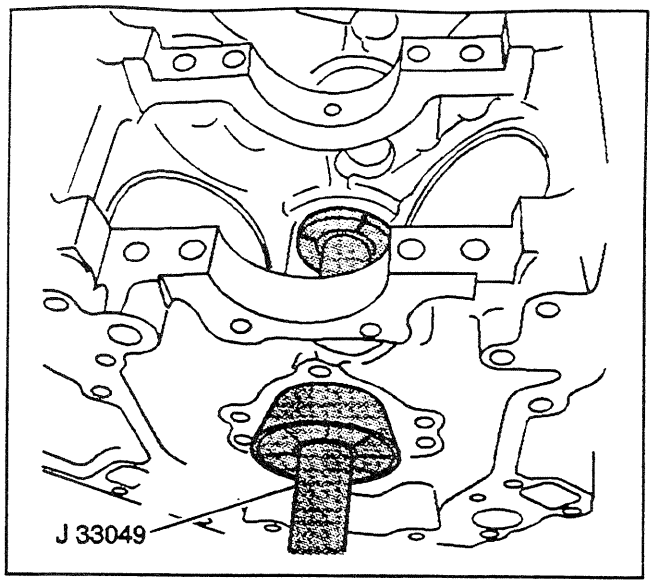
Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

Align the oil lubrication hole in the bearing with the oil galleries in the engine block.

8. Push the guide cone into the front camshaft bearing bore to align the tool.
9. Drive the bearing into the bore.



64183

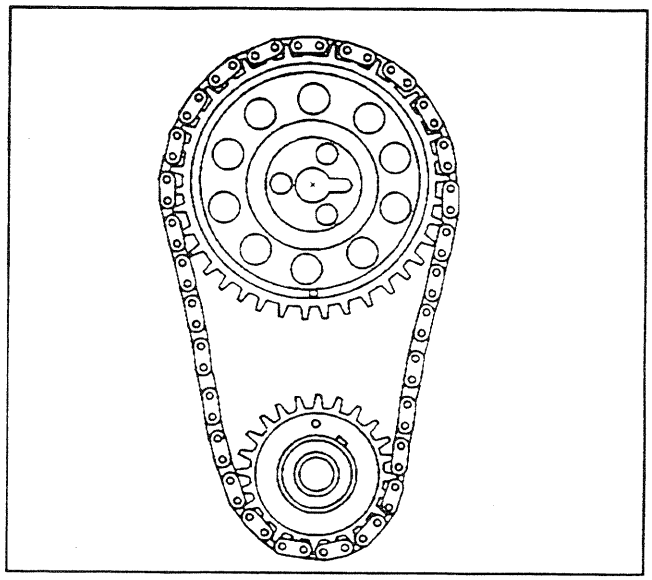
Timing Chain and Sprockets Clean and Inspect

SIE-ID = 199175

1. Clean the camshaft timing components in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

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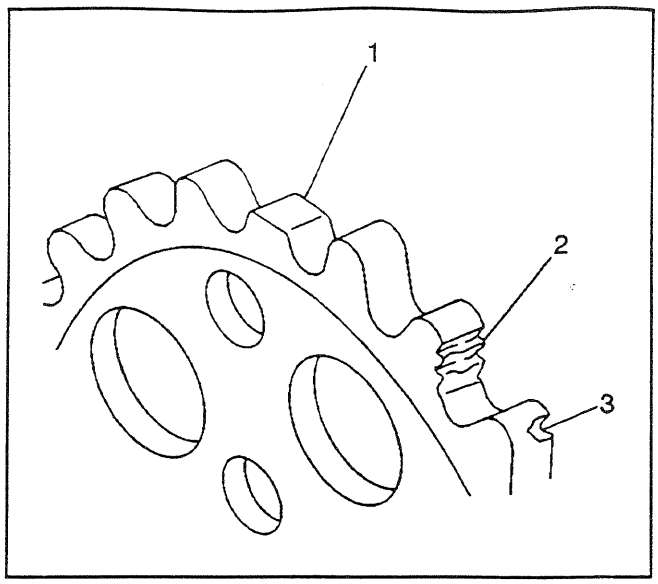


188097

Important: If the sprocket(s) must be replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

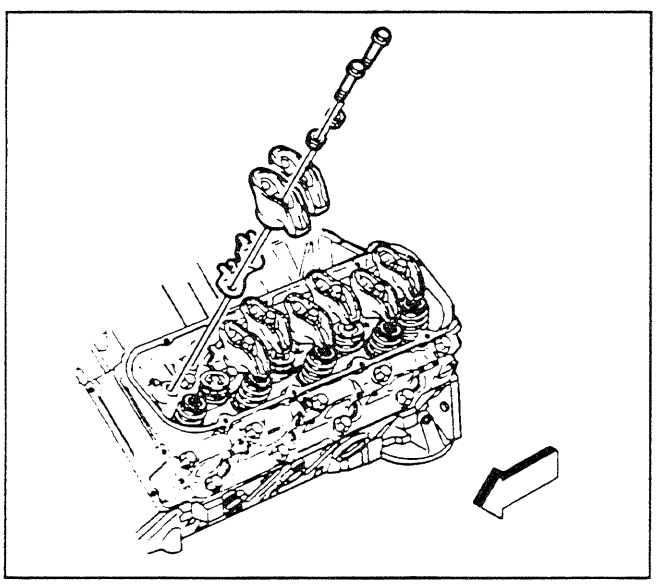
Inspect the camshaft and crankshaft sprockets for the following conditions

- Worn teeth (1)
- Damaged teeth (2)
- Chipped teeth (3)
- Uneven wear on one edge of the teeth
- Worn valleys between the sprocket teeth
- Crankshaft sprocket keyway for wear
- Crankshaft sprocket key for wear or damage

Important: If the crankshaft sensor reluctor ring is removed from the crankshaft, a new crankshaft sensor reluctor ring must be installed.

Inspect the crankshaft position reluctor ring the following conditions:

- Bend or distortion
- Missing teeth
- Damaged teeth
- Chipped teeth
- Bent teeth
- Keyway slot for wear or damage



354070

Valve Rocker Arm and Push Rods Clean and Inspect

SIE-ID = 199277

Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

Clean the components with cleaning solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

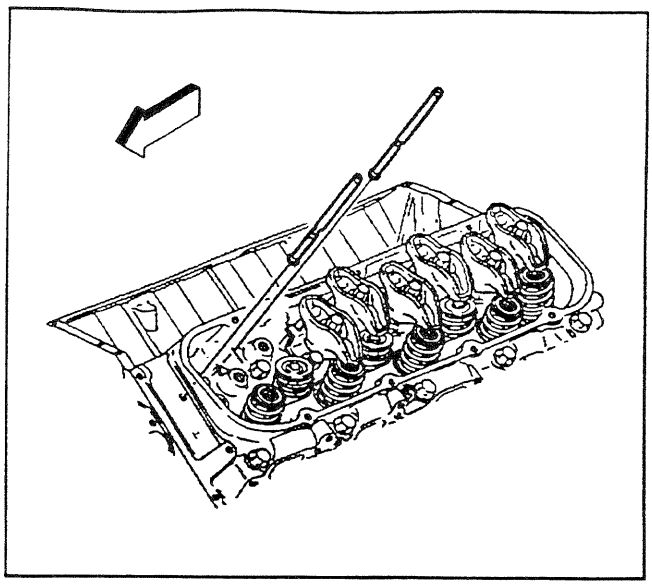
1. Dry the components with compressed air.
2. Inspect the valve rocker arms for wear or scoring in the ball area.
3. Inspect the valve rocker arm pushrod sockets and valve stem tip mating surfaces.
4. Inspect the valve rocker arm ball for wear or scoring.

   These surfaces should be smooth with no scoring or exceptional wear.

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

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

7. Inspect the pushrod oil passages for restrictions.
   - Clean out the pushrod tube with compressed air.
   - Visually look through the pushrod tube for obstructions, a clear pushrod will allow light through.
   - Replace pushrod(s) that cannot be cleaned out.



202196

Valve Lifters and Guides Clean and Inspect

SIE-ID = 199299

Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

Important: Store the valve lifters upright in order to prevent the oil from draining from the plunger cavity.

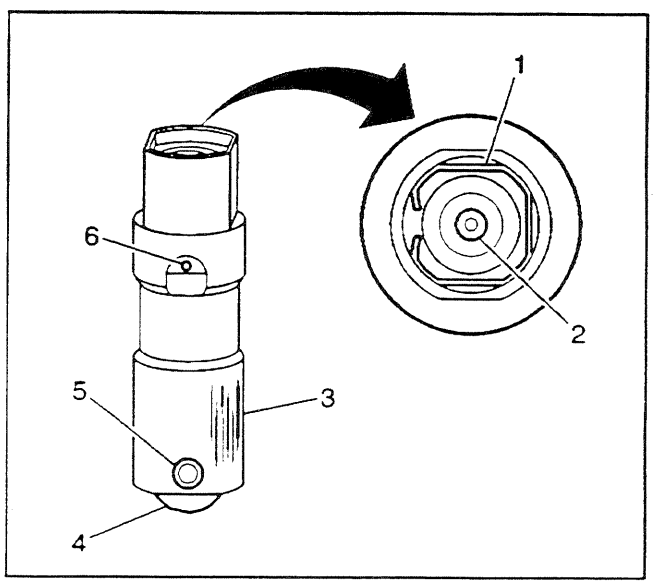
Important: Disassembly of the valve lifter(s) is not recommended.

Clean the components in cleaning solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

1. Dry the components with compressed air.
2. Inspect the valve lifters for the following:
   - A damaged, mispositioned or broken clip (1)
   - A scored or worn pushrod socket (2)
   - A severely scuffed or worn lifter body (3)

     If the valve lifter body shows scuffing or wear, inspect the engine block valve lifter bores for wear or damage.
   - Flat spots on the roller (4)
   - Roller wheel vertical play (4)
   - A loose pin (5)
   - A plugged oil hole (6)
3. If flat spots are found on the lifter(s), inspect the corresponding lobe on the camshaft for damage.



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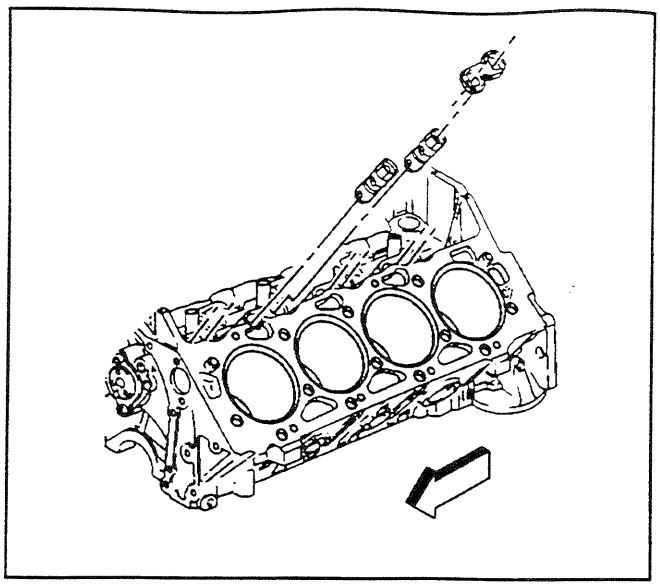
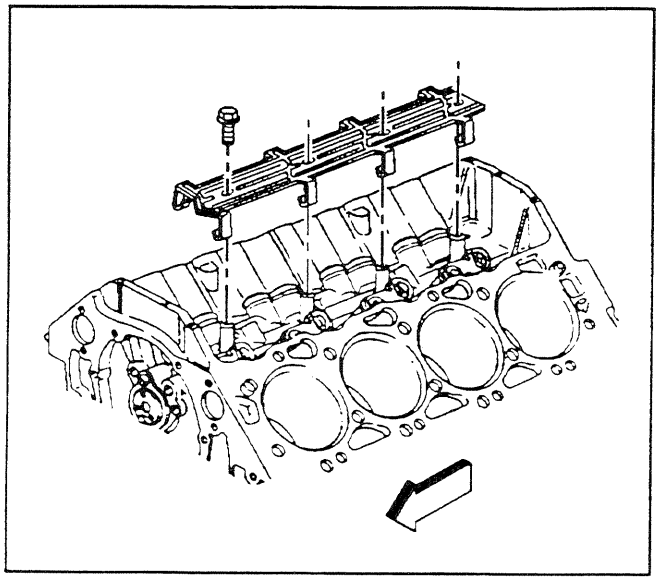


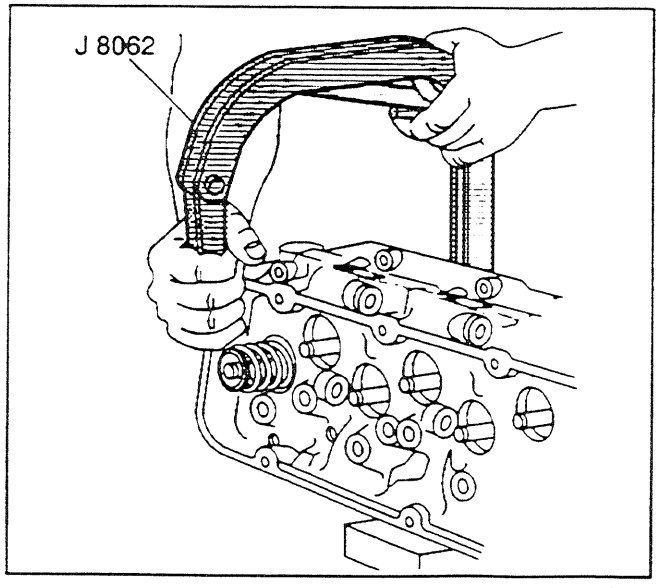
173176

4. Inspect the valve lifter guides for the following:
   - Excessive guide slot side wear
   - Cracks or damage



173193

5. Inspect the valve lifter guide retainer for the following:
   - Wear, damage, or stress cracking in the leg areas
   - Wear or damage around the retainer bolt holes



196664

Cylinder Head Disassemble

SIE-ID = 199439

Tools Required

J 8062 Valve Spring Compressor

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

Caution: *SIO-ID = 411464* ***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.***

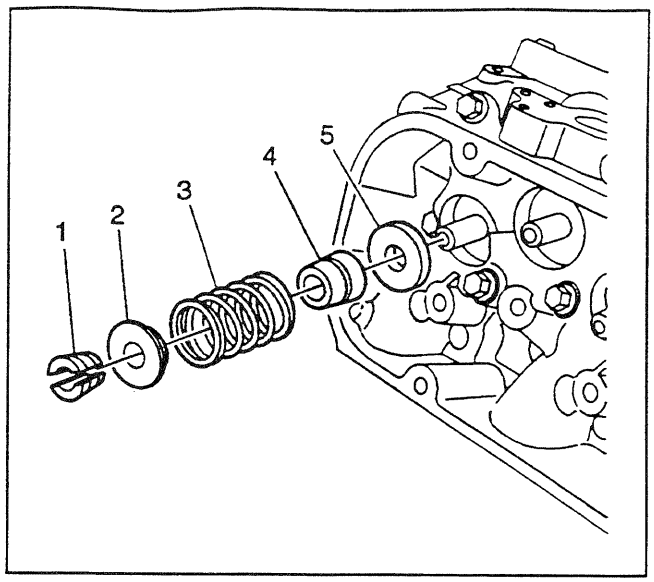
Important: Mark, sort, or organize components for return to their original locations.

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

1. Remove the valve stem keys (1).
2. Release and remove *J 8062*.
3. Remove the cap (2).
4. Remove the valve spring (4).
5. Remove the valve stem oil seal (3).
6. Remove the valve rotator (5).

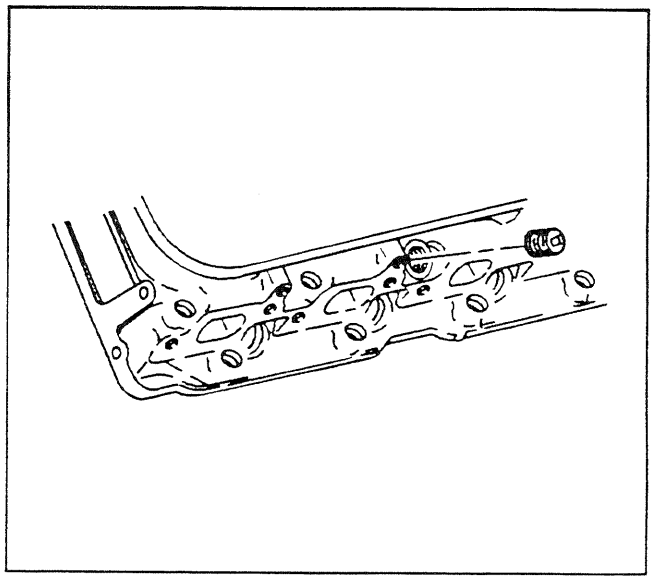
Notice: SIO-ID = 16285 Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

7. Remove the valve (6).



562791

8. Remove the ECT sensor hole plug, if required.



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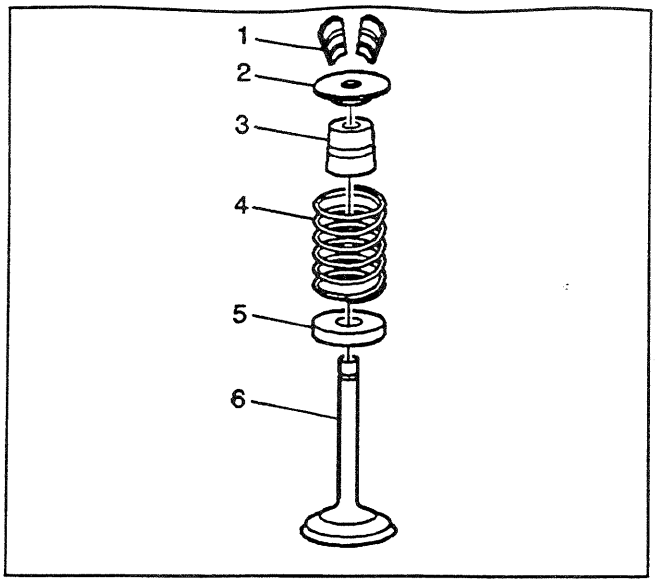

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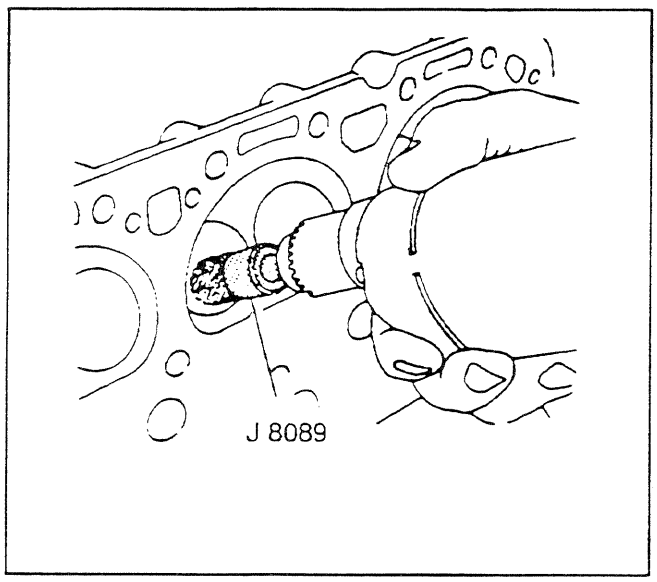


3520

Cylinder Head Clean and Inspect

SIE-ID = 199475

Cleaning Procedure

Tools Required

J 8089 Carbon Removing Brush

Caution: SIO-ID = 5011 ***Wear safety glasses in order to avoid eye damage.***

Important: Mark, sort, or organize components for return to their original locations.

Clean the valve heads on a buffing wheel.

1. Clean the following components in solvent
   - Valve stem keys (1)
   - Valve spring cap (2)
   - Valve spring (4)
   - Valve rotators (5)
   - Valve (6)
   - Cylinder head

Caution: SIO-ID = 5011 ***Wear safety glasses in order to avoid eye damage.***

2. Dry the components with compressed air.

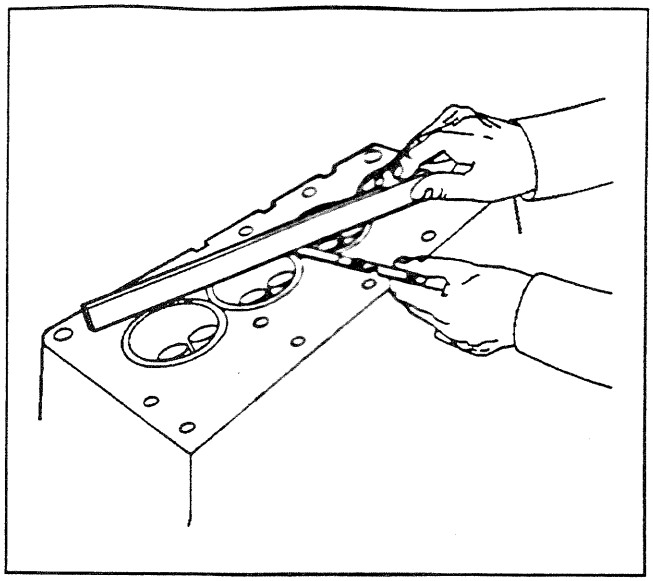
Important: Be careful not to scuff the chamber or damage the valve seat.

Use the *J 8089* in order to clean the carbon from the combustion chambers.

Visual Inspection Procedure

Inspect the cylinder head for the following conditions:

- Damaged gasket surfaces
- Damage to threaded bolt holes
- Burnt or eroded areas in the combustion chamber
- Cracks in the exhaust ports and combustion chambers
- External cracks in the water chamber
- Restrictions in the intake or exhaust passages
- Restrictions in the cooling system passages



64318

Flatness Measurement Procedure

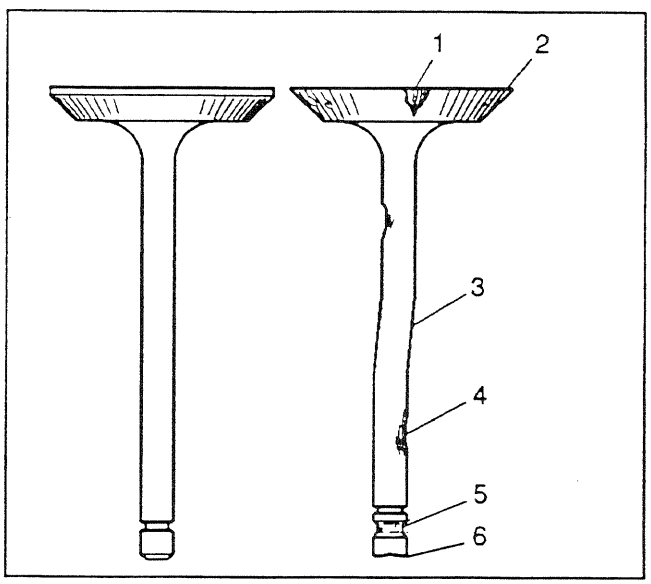
1. Measure the cylinder head for warpage with a straight edge and feeler gauge.
   - A cylinder head block deck with warpage in excess of 0.076 mm (0.003 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head exhaust manifold deck with an overall warpage in excess of 0.152 mm (0.006 in) must be repaired or replaced.
   - A cylinder head intake manifold deck with warpage in excess of 0.10 mm (0.004 in) must be repaired or replaced.
2. A cylinder head block deck can be resurfaced up to 0.305 mm (0.012 in) maximum removal.

Important: Excessive cylinder head resurfacing will affect compression ratio and emission control.

A cylinder head that requires excessive resurfacing must be replaced.

Valve Inspection Procedure

1. Inspect the valves for the following conditions:
   - Burnt or damaged areas (1)
   - Undersized valve margin (2)
   - Bent stem (3)
   - Wear, scoring or other damage to the stem (4)
   - Worn key groove (5)
   - Worn stem tip (6)



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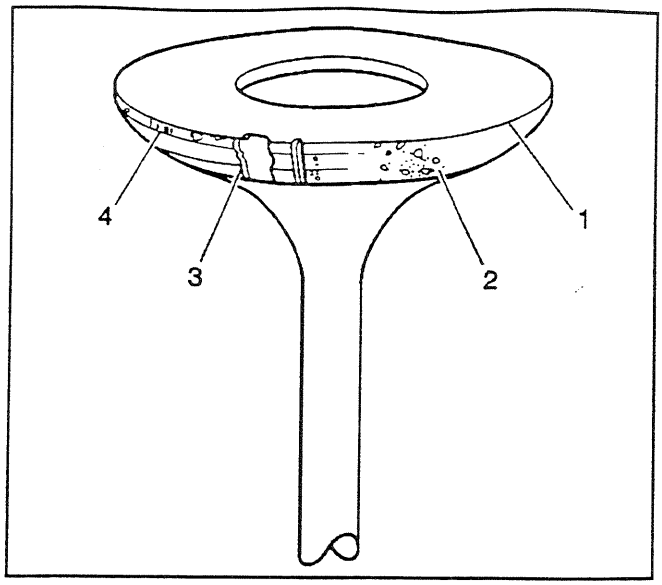
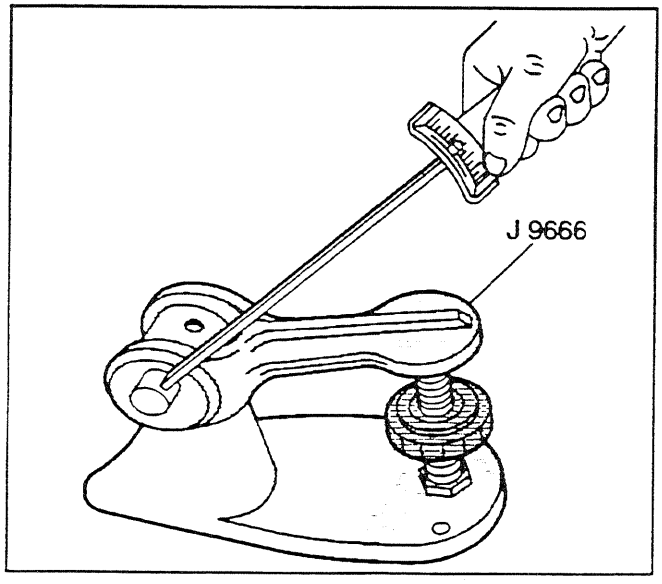


156173

2. Inspect the valve contact surface for the following conditions:
   - Undersized margin (1)
   - Pitted surface (2)
   - Burnt or eroded areas (3)
   - Acceptable edge (margin) (4)

Important: Minor imperfections of the valve may be corrected during reconditioning.

Valves with excessive damage must be replaced.



496C

Valve Spring Inspection and Measurement

Tools Required

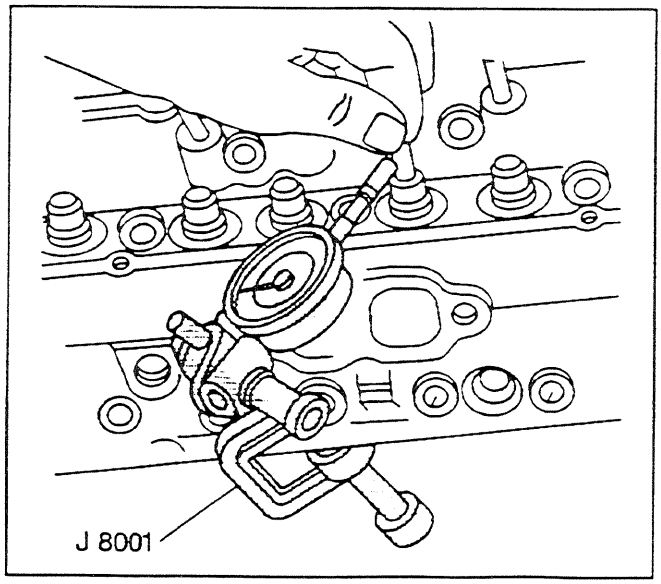
J 9666 Valve Spring Tester

1. Inspect the valve springs for broken coils or coil ends.
2. Use the *J 9666* in order to measure the valve spring tension. Refer to *Engine Mechanical Specifications*.

Important: Add a maximum of one shim up to 0.726 mm (0.030 in) thick to increase tension.

If low valve spring tension is found, use a shim to increase tension.

3. Recheck the valve spring tension, a valve spring that does not meet specification must be replaced.



35214

Valve Guide Measurement Procedure

Tools Required

J 8001 Dial Indicator Set

Important: 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.

Measure the valve stem-to-guide clearance.

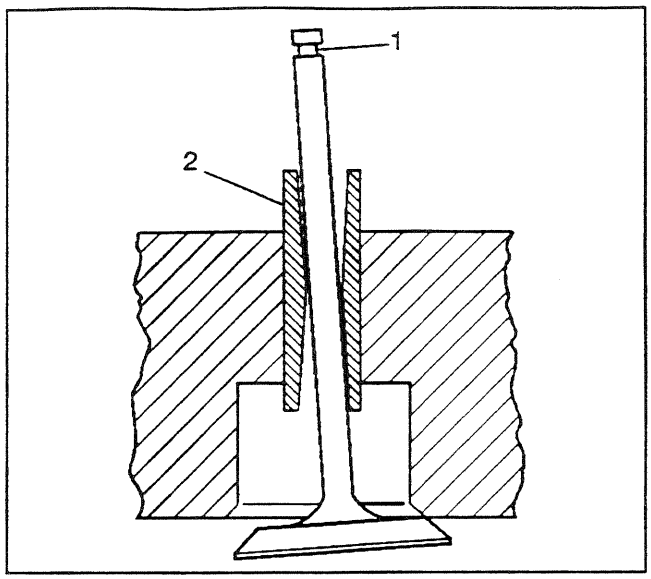
- Clamp the *J 8001* on the exhaust port side of the cylinder head.

Important: The indicator stem must contract the side of the valve stem just above the valve guide.

Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.

- Drop the valve head about 1.6 mm (0.064 in) off the valve seat.
- Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to *Engine Mechanical Specifications*.

1. A valve guide (2) with excessive clearance must be repaired. Refer to *Valve Guide Reaming/Valve and Seat Grinding*.
2. Replace the cylinder head if the valve guide cannot be repaired.



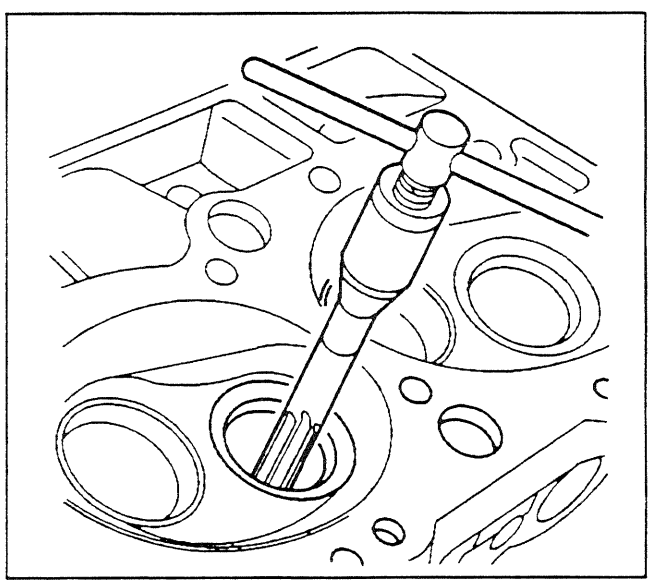
156172

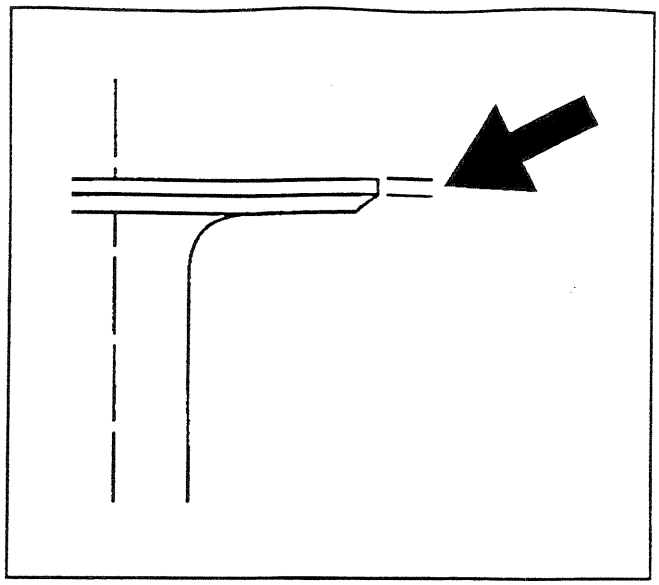
Valve Guide Reaming/Valve and Seat Grinding

SIE-ID = 199579

Valve Guide Reaming Procedure

1. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance.
   1.1. Ream the valve guide oversize to accept a valve guide sleeve.
   1.2. Insert the valve guide sleeve into the guide bore.
   1.3. Ream the sleeve to achieve proper valve stem-to-guide clearance.
2. Always recondition the valve seat after reaming the valve guide bores or installing new valves.
3. Replace the cylinder head if the valve guide cannot be repaired.


4956



57502

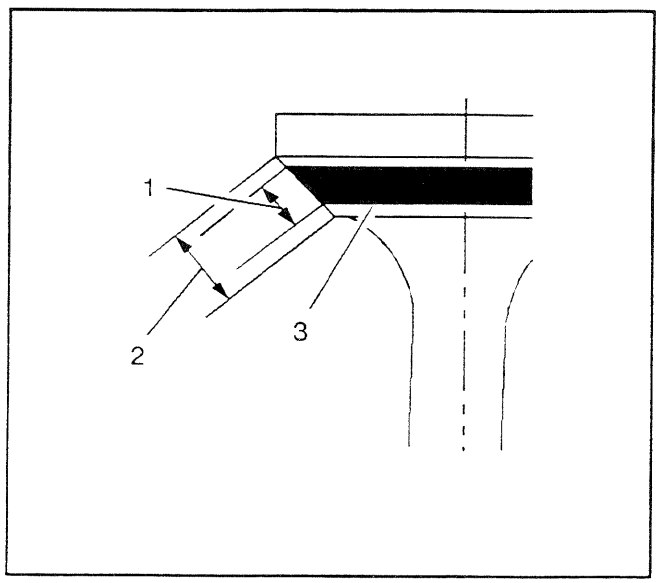
Valve Reconditioning Procedure

1. Replace the valve if the valve stem shows excessive wear or is warped.

Important: Several different types of equipment are available for reconditioning valves. Use the manufacturers recommendations of equipment to attain the proper results.

Reface pitted valves on a valve refacing machine in order to insure the correct relationship between the head and the stem.

2. Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.



53234

Valve Seat Reconditioning Procedure

Important: Several different types of equipment are available for reconditioning valves. Use the manufacturers recommendations of equipment to attain the proper results.

Important: Always recondition the valve seat after reaming the valve guide bores or installing new valves.

Reconditioning of the valve seats:

1. The valves must seat perfectly for the engine to deliver optimum power, performance and emission control.
2. Ensure that the valve seat and valve are not shrouded (1) after valve seat reconditioning. Adequate flow past the valve seat and valve is essential for cooling the valve head and valve seat area.
3. Correct contact (1) between each valve and its seat in the cylinder head is also essential to ensure that the heat in the valve head is properly carried away.

Important: Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.

The valve seats should be concentric to within 0.05 mm (0.002 in) total indicator runout.

Cylinder Head Assemble

SIE-ID = 199829

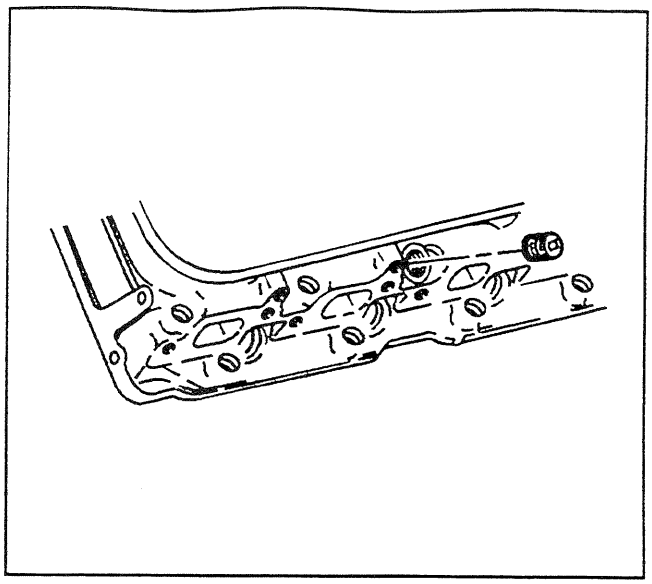
ECT Sensor Hole Plug Installation

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

Install the ECT sensor hole plug using sealant GM P/N 12346004 or equivalent, if removed.

Tighten

Tighten the ECT sensor hole plug to 23 N·m (17 lb ft).



492036

Valve Installation

Tools Required

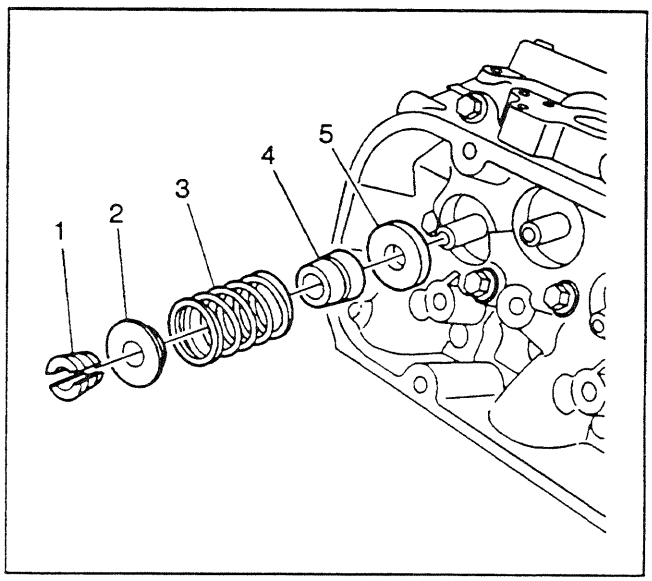
J 8062 Valve Spring Compressor

1. Lubricate the valve stems with clean engine oil.
2. Insert the valves into their proper locations.
3. Lubricate rotators with clean engine oil (5).
4. Install the rotators over the guide and onto the cylinder head.

Important: When installing valve stem oil seals onto the valve guides be careful not to tear the seal lip during installation.

Install the valve stem oil seal (4) onto the valve guide.

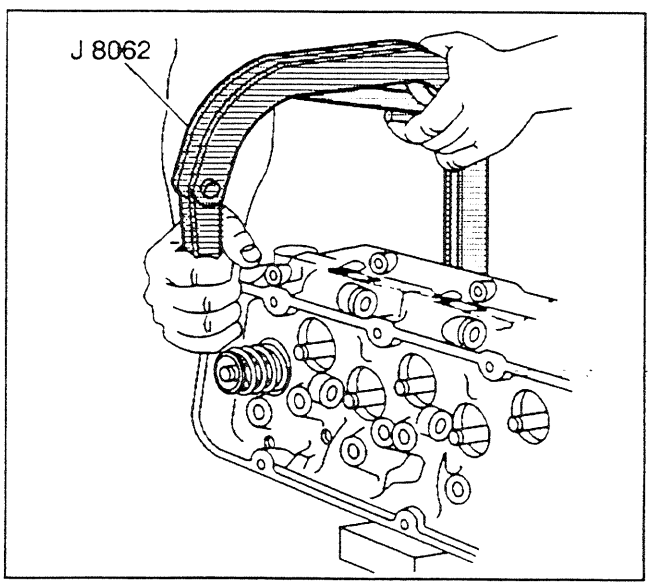
5. Install the valve spring (3).
6. Install the valve spring cap (2).



562791

Caution: SIO-ID = 411464 ***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.***

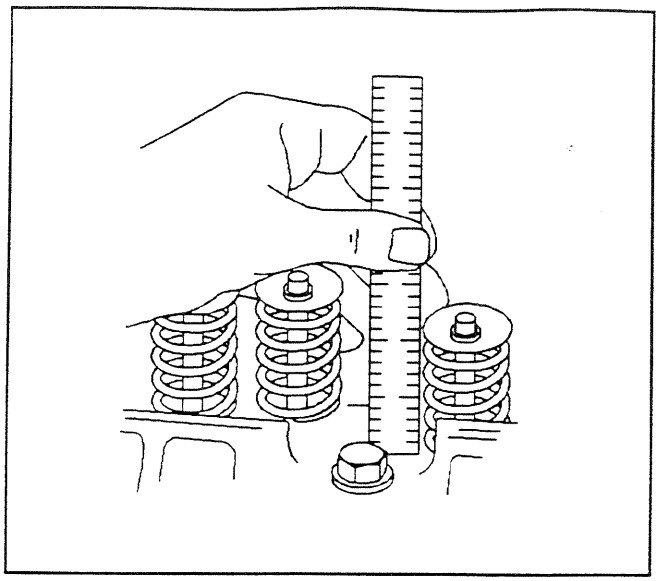
7. Compress the valve spring, using the *J 8062*, in order to clearly see the valve stem key grooves.
8. Install the valve stem keys (1).
   - 8.1. Use grease in order to hold the keys in place.
   - 8.2. Ensure that the valve stem keys seat properly in the upper groove of the valve stem.
   - 8.3. Release the *J 8062*.



196664

8.4. Remove the *J 8062*.

8.5. Tap the end of the valve stem with a plastic-faced hammer in order to seat the valve stem keys.



35203

Checking Valve Spring Installed Height

1. Measure the valve spring for the properly installed height.

   Use a thin scale and measure from the cylinder head spring seat to the top of the valve spring cap. Refer to *Engine Mechanical Specifications* for proper valve spring installed height specifications.

Important: Never shim the valve spring to obtain an valve spring installed height under the specified amount.

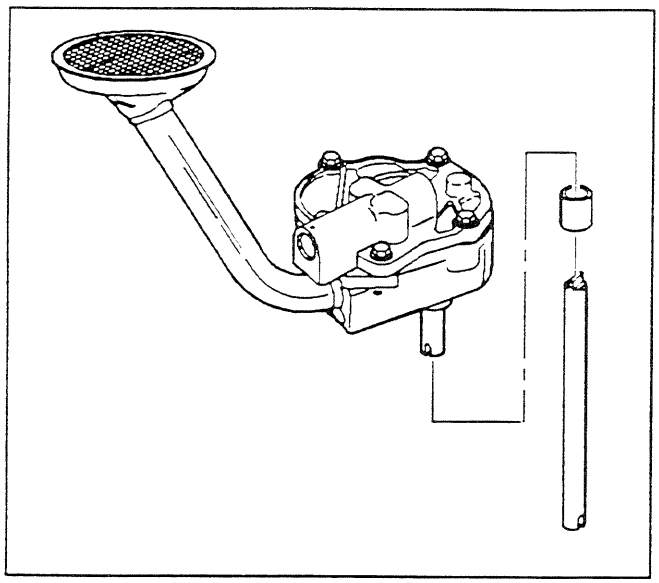
Important: Install the valve spring seat shims under the rotator (between the rotator and the cylinder head spring seat).

Important: Add a maximum of one shim, up to 0.726 mm (0.030 in) thick, to achieve the valve spring installed height specification.

Important: The combination of shims to correct valve spring installed height and valve spring tension should not exceed 1.524 mm (0.060 in) thick.

   Install a valve spring seat shim if the valve spring installed height measurement is above the specification.

2. Recheck the valve spring installed height, replace the cylinder head if the valve spring installed height cannot be obtained.



427935

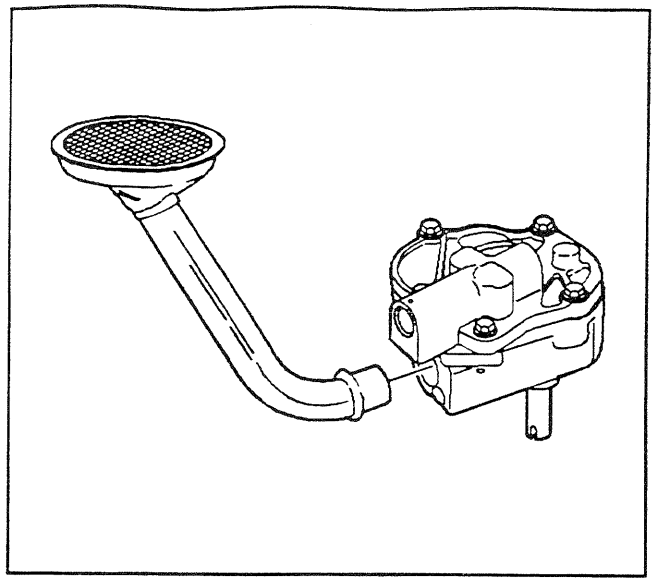
Oil Pump Disassemble

SIE-ID - 200009

1. Remove the oil pump driveshaft and retainer.

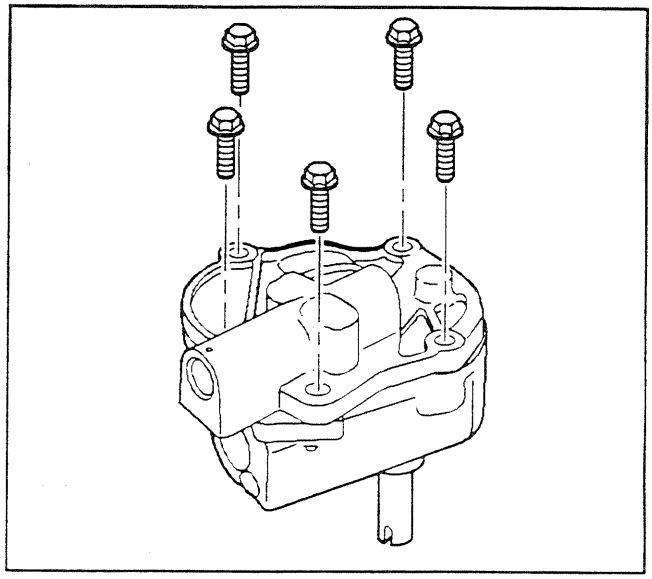
Important: The oil pump screen has a press fit in to the oil pump cover. DO NOT remove the screen from the pipe. The pipe and screen are serviced as a complete assembly.

Remove the oil pump screen.



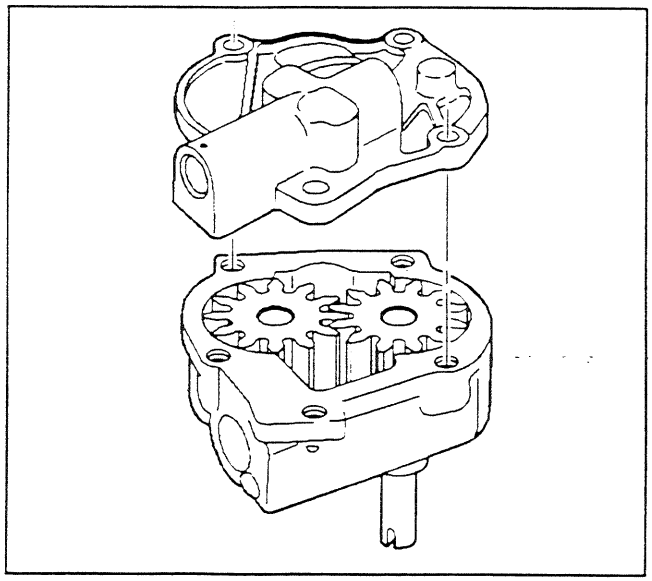
427937

2. Remove the oil pump cover bolts.



427941

3. Remove the pump cover and cover-to-body gasket.



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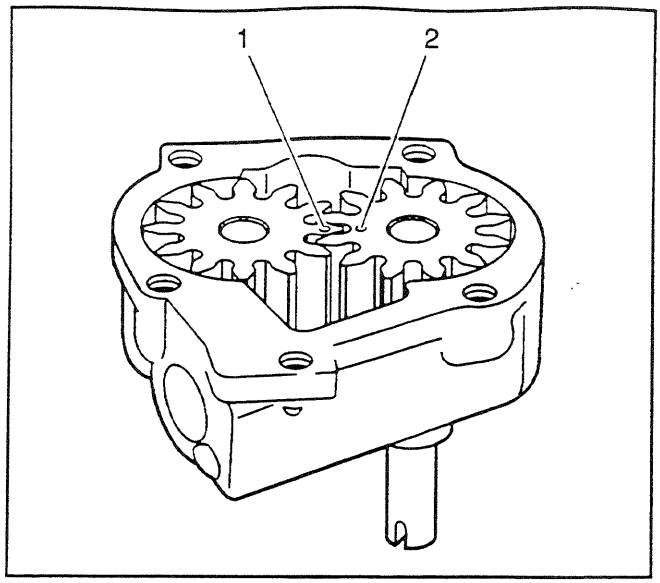
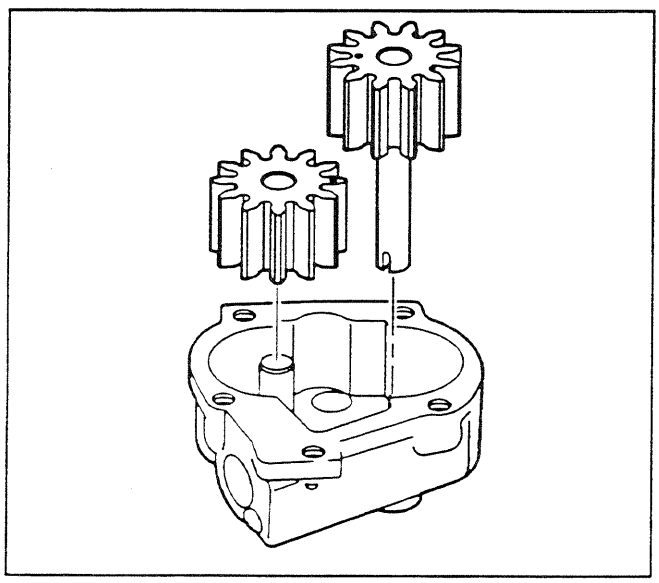
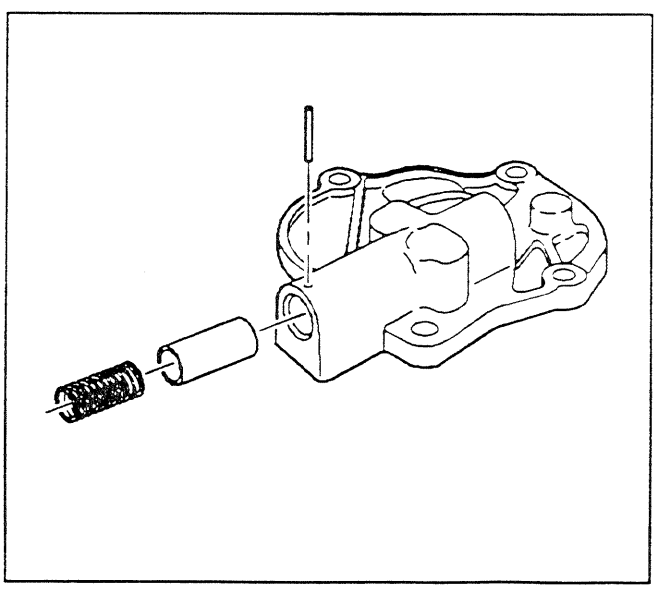


562796

4. Match mark the driven gear (1) and drive gear (2).


427946

5. Remove the drive gear and the driven gear. Matchmark the gear teeth for assembly.


427947

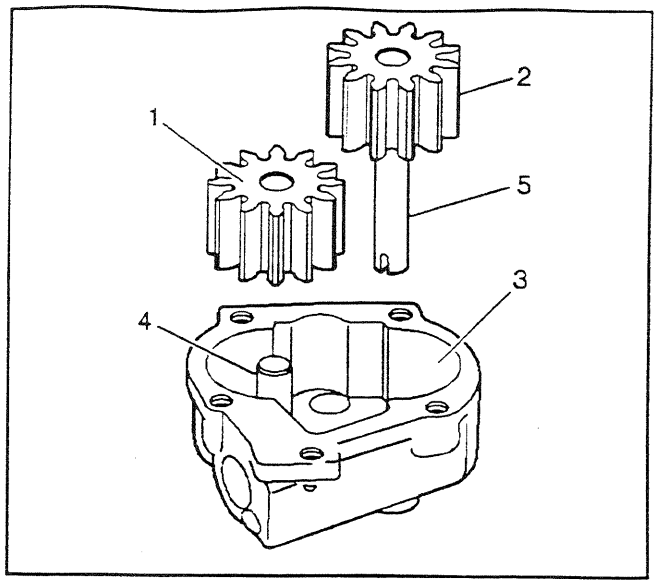
6. Remove the following items:
   6.1. The retaining pin
   6.2. The pressure relief spring
   6.3. The pressure relief valve

Oil Pump Clean and Inspect

SIE-ID = 430009

Caution: SIO-ID = 5011 ***Wear safety glasses in order to avoid eye damage.***

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
   - Scoring on the top of the gears (1)
   - Damaged gears (2) for the following:
     - Chipping
     - Galling
     - Wear
   - Scoring, damage or casting imperfections to the body (3)
   - Damaged or scored gear shaft (4)
   - Damaged or scored gear shaft (5)
   - Damaged bolt hole threads
   - Worn oil pump driveshaft bore
   - Damaged or sticking oil pump pressure relief valve (minor imperfections may be removed with a fine oil stone).
   - Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
5. During oil pump installation, install a NEW oil pump driveshaft retainer.



427950

Oil Pump Assemble

SIE-ID = 200235

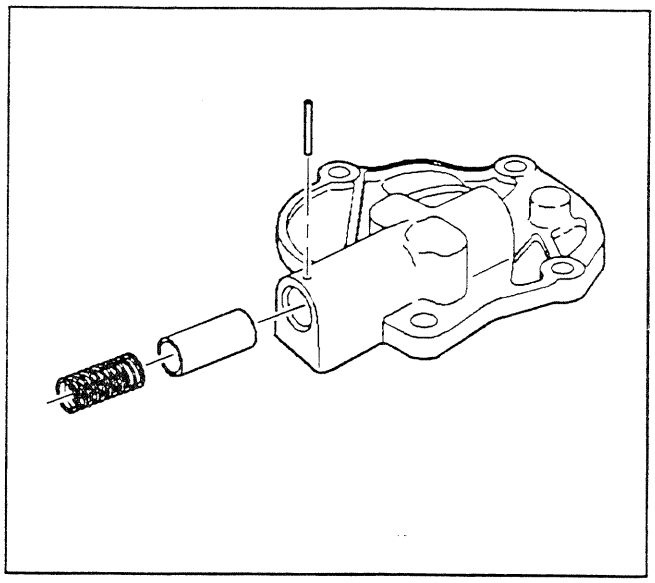
Tools Required

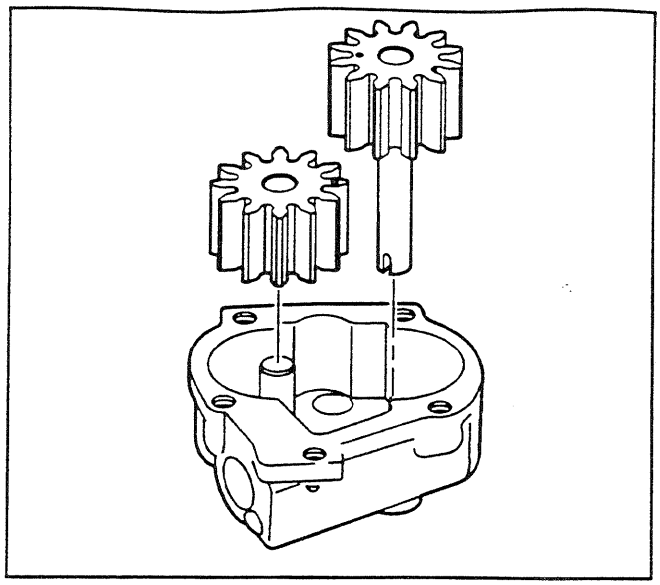
J 21882 Oil Suction Pipe Installer

Important: Replace the pressure relief valve spring when reusing the oil pump.

Install the following items:

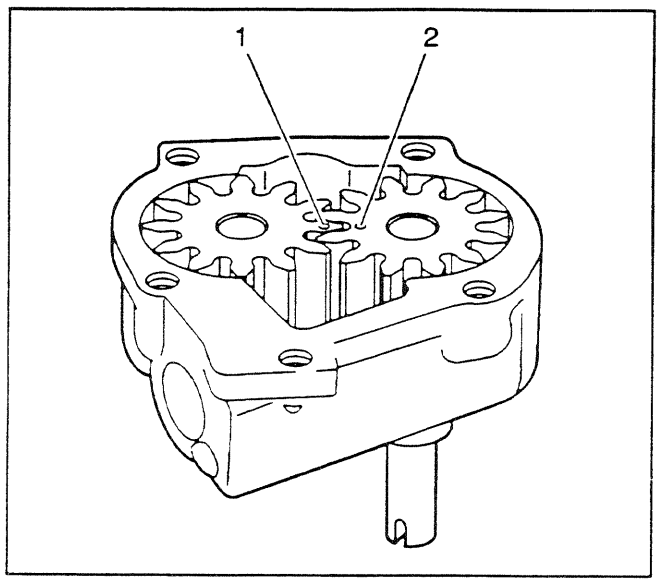
1. The pressure relief valve
2. The pressure relief spring
3. The retaining pin


427947



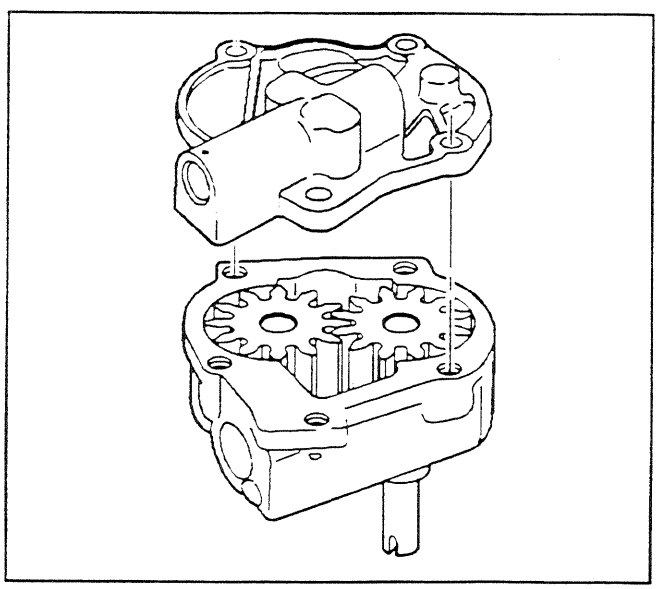
427946

1. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
2. Install the drive gear and the driven gear into the pump body. Align the matching marks on the gears. Install the smooth side of the gear toward the pump cover.



562796

3. Ensure the match marks line up (1, 2).



427945

4. Install the oil pump cover and NEW cover-to-body gasket.

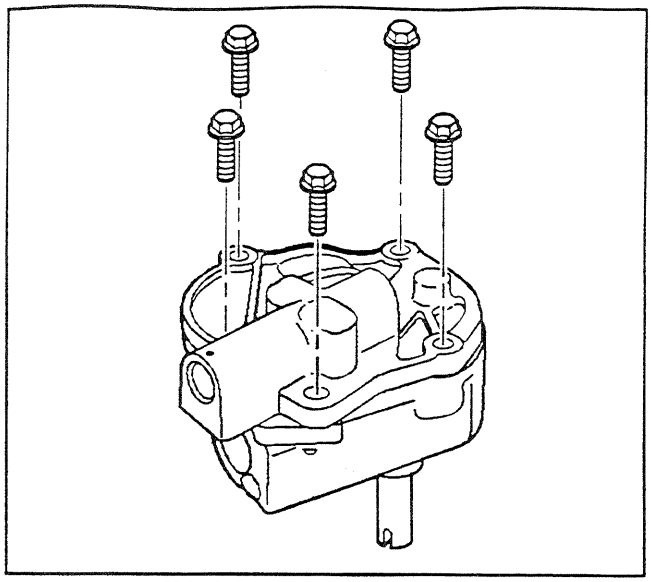
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the oil pump cover bolts.

   Tighten

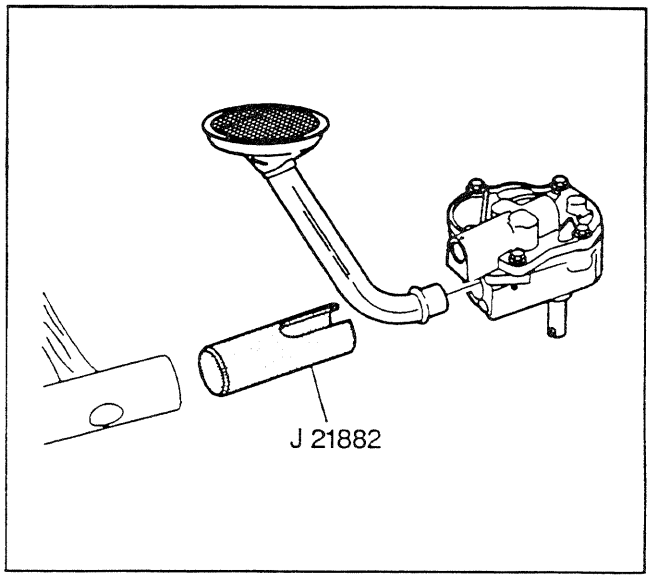
   Tighten the oil pump cover bolts to 12 N·m (106 lb in).

6. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.



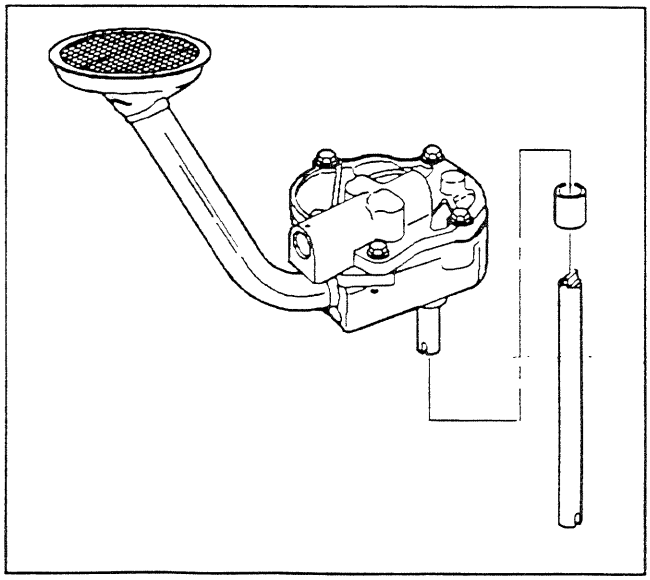
427941

7. Install the oil pump screen:
   - 7.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
   - 7.2. Mount the oil pump in a soft-jawed vise.
   - 7.3. Apply sealer to the end of the pipe.
   - 7.4. Use the *J 21882* and a soft-faced hammer in order to tap the oil pump screen into the pump body. The screen must align parallel with the bottom of the oil pan when it is installed.

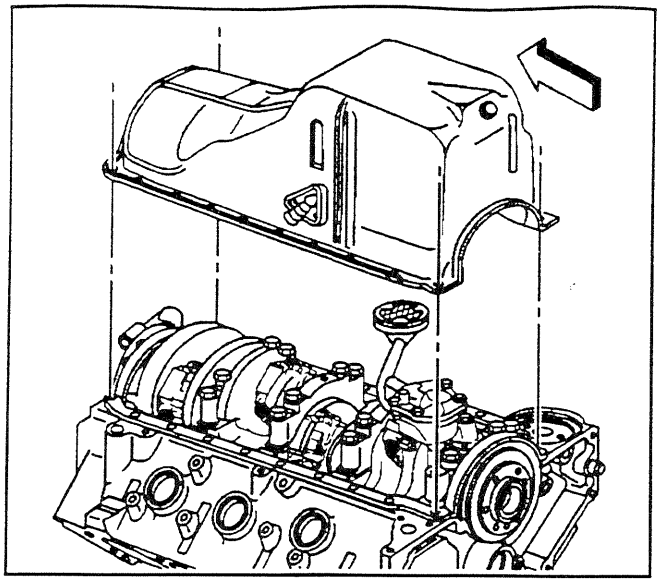


427953

8. Install the oil pump driveshaft and the new retainer.



427935



351803

Oil Pan Clean and Inspect

SIE-ID = 200373

1. Clean the oil pan in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

2. Dry with compressed air.
3. Inspect the oil pan for the following conditions:
   - The drain plug hole for damaged threads.
   - Gouges or damage to the oil pan sealing surfaces
   - Damage to the oil pan baffle
   - Dents or damage to the exterior of the oil pan

     An oil pan that is dented may interfere with the position of the oil pump screen or not distribute oil properly in the pan sump area.
   - Damage to the oil level indicator tube area
   - Damage to the oil pan gasket.

Engine Front Cover Clean and Inspect

SIE-ID = 558048

Cleaning Procedure

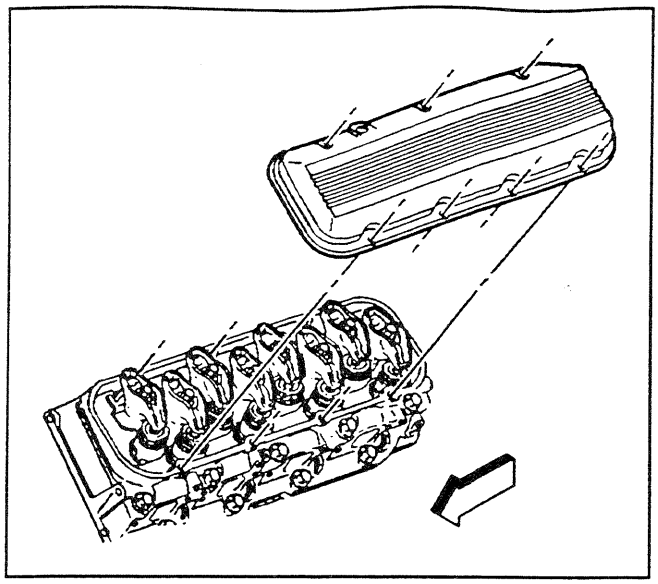
1. Remove the any sealant from the engine front cover.
2. Clean out debris from the bolt holes.
3. Clean the engine front cover in solvent.

Caution: SIO-ID = 5011 ***Wear safety glasses in order to avoid eye damage.***

4. Dry the engine front cover with compressed air.

Inspection Procedure

1. Inspect the engine front cover for the following:
   - Excessive scratches or gouging of the gasket sealing surfaces
   - Damaged threaded bolt holes
   - Damaged crankshaft oil seal mounting bore
   - Damaged crankshaft position sensor mounting hole
2. Repair or replace the engine front cover as necessary.



354006

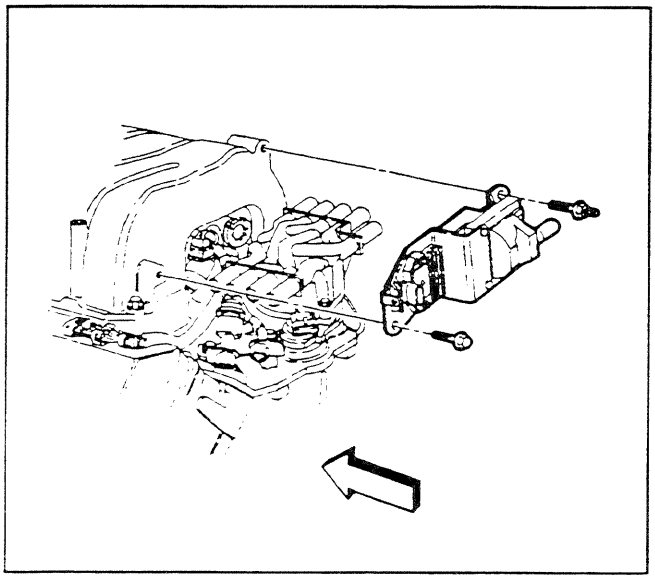
Valve Rocker Arm Cover Clean and Inspect

SIE-ID = 200301

1. Clean the valve rocker arm cover in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

2. Dry the covers with compressed air.
3. Inspect the covers for the following components:
   - Gouges or damage to the sealing surfaces
   - Dent or damage to the exterior of the cover
     A dented or damaged cover may interfere with the valve rocker arms.
   - Restrictions to the ventilation system passages
   - The PCV valve grommet for cracking or damage

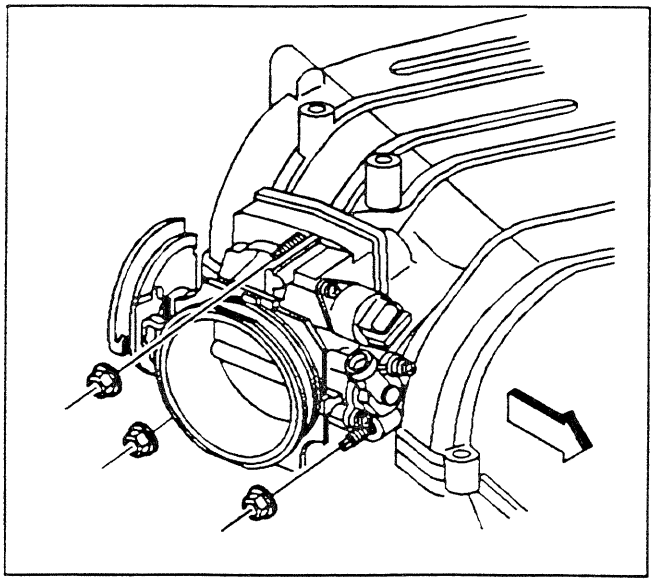


6850E

Intake Manifold Disassemble (Upper)

SIE-ID = 377021

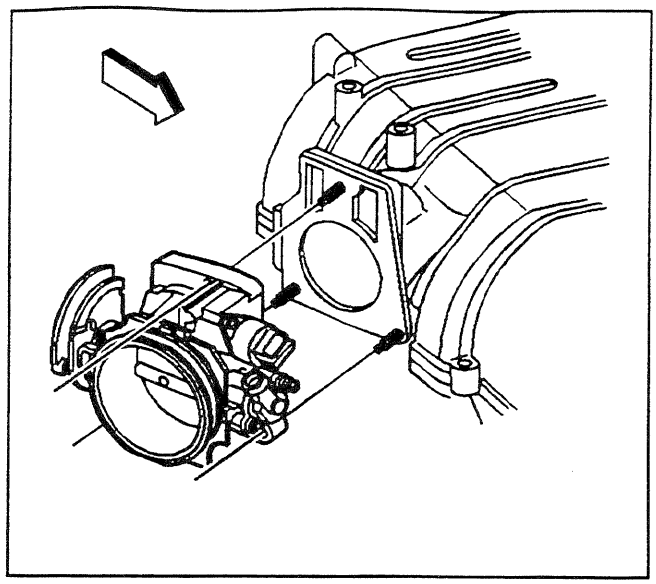
1. Remove the ignition coil bolt and stud.
2. Remove the ignition coil.



18299

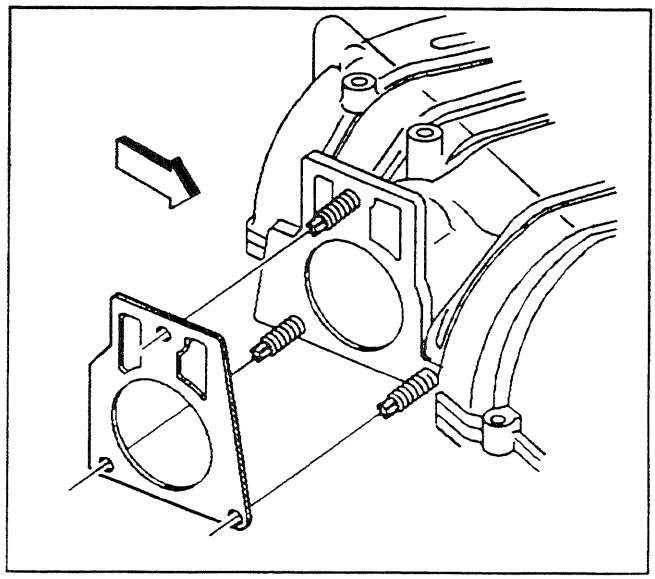
3. Remove the throttle body nuts.

4. Remove the throttle body.



18302

5. Remove the throttle body gasket.
6. Remove the throttle body studs, if required.



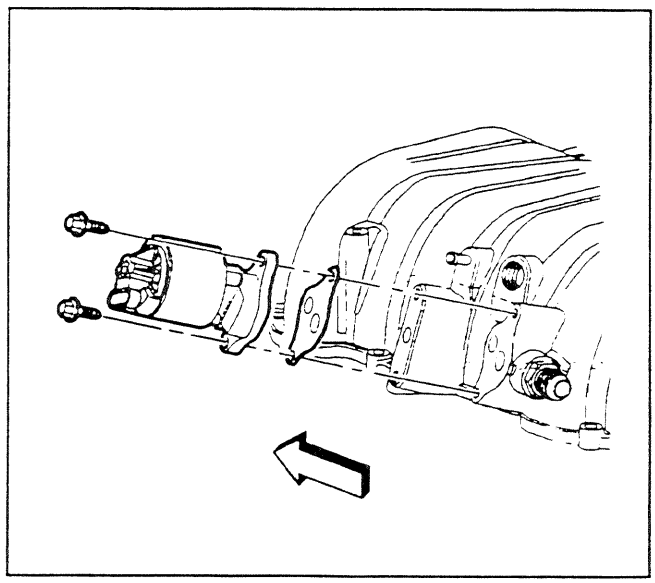
18303

Important: Note the position of the EGR valve before removal. It is possible to improperly install the EGR valve 180 degrees from the original position.

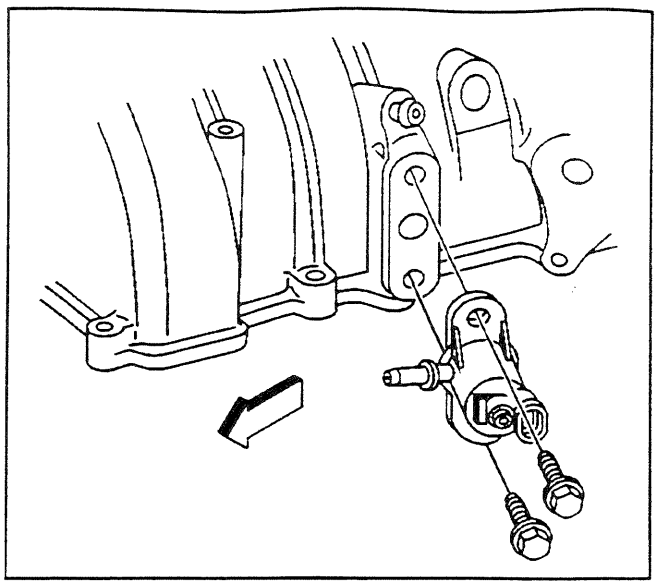
Remove the EGR valve bolts.

Notice: SIO-ID - 5005 The Linear EGR valve is an electrical component. DO NOT soak in any liquid cleaner or solvent because damage may result.

7. Remove the EGR valve.
8. Remove the EGR gasket.

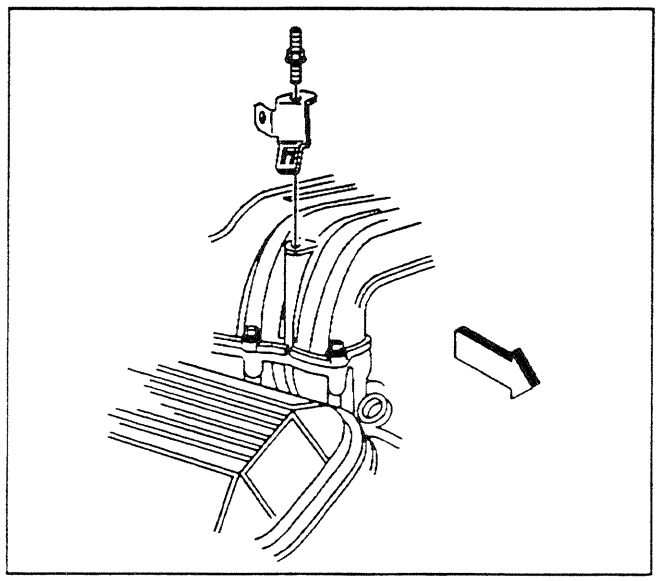


276413



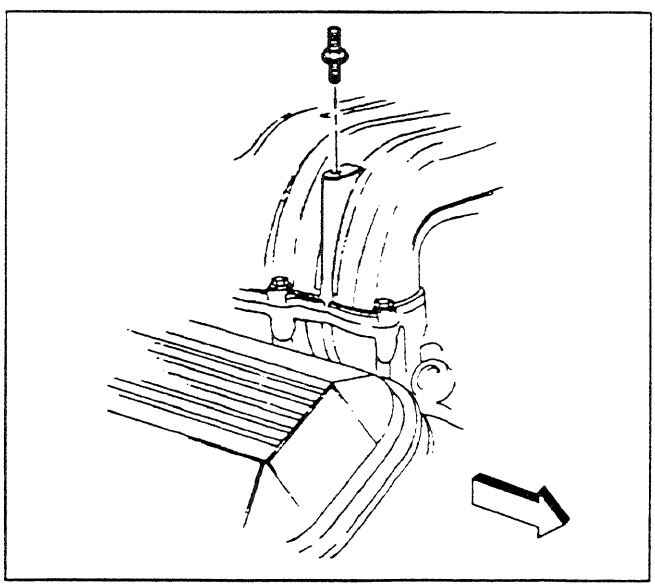
351775

9. Remove the EVAP purge valve bolts.
10. Remove the EVAP purge valve.



354044

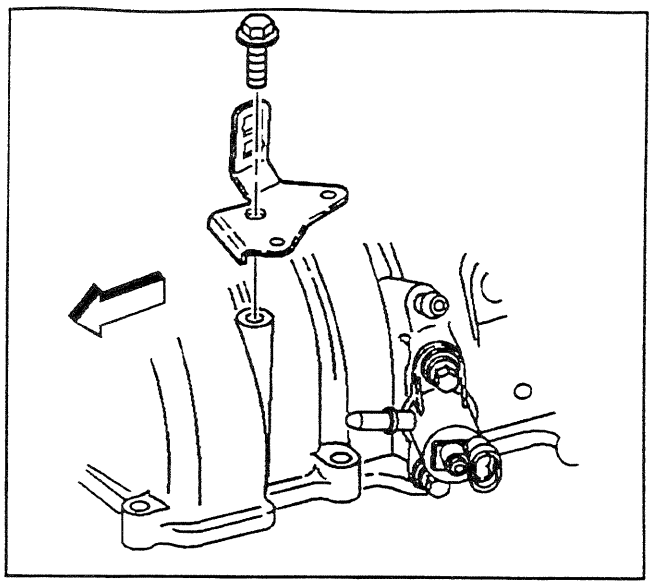
11. Remove the secondary air injection check valve bracket stud and secondary air injection check valve bracket (RPO K19 only), if required.



501418

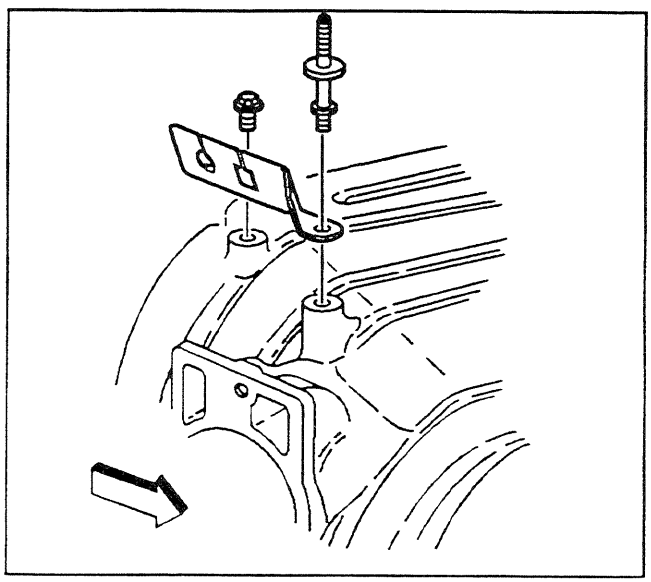
12. Remove the secondary air injection check valve bracket stud (without RPO K19), if required.

13. Remove the ECT wiring harness connector bracket bolt and ECT wiring harness connector bracket, if required.



492023

14. Remove the accelerator control cable bracket bolt and stud, and accelerator control cable bracket, if required.

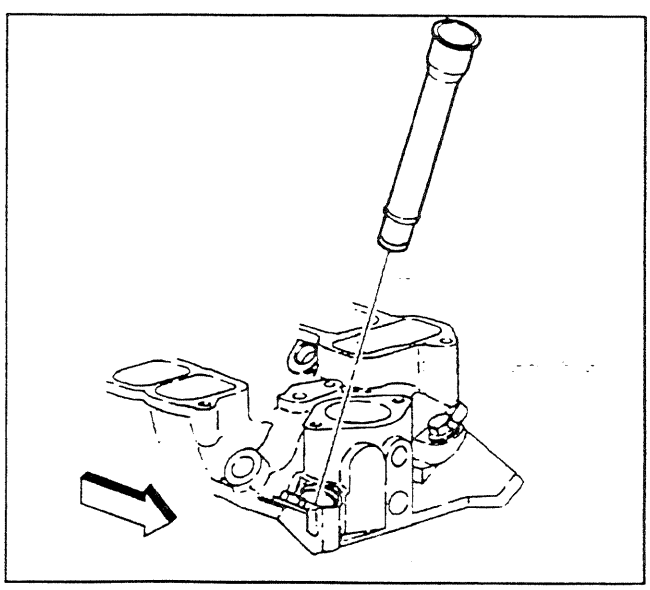


492027

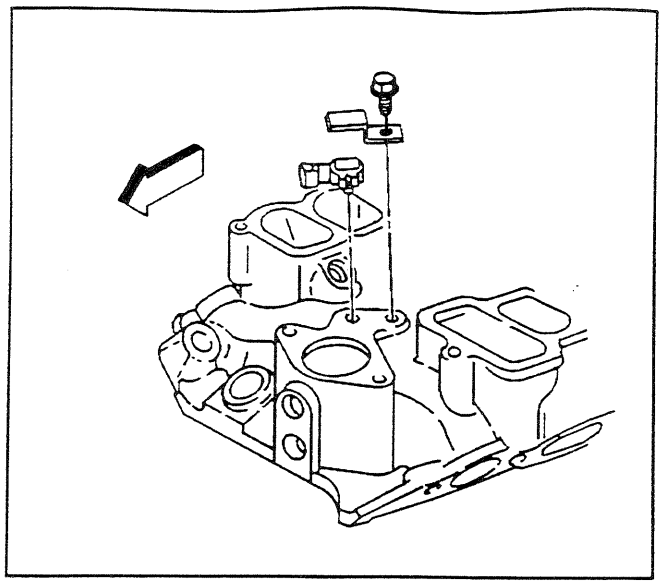
Intake Manifold Disassemble (Lower)

SIE-ID = 3??2?6

1. Remove the oil fill tube, if required.

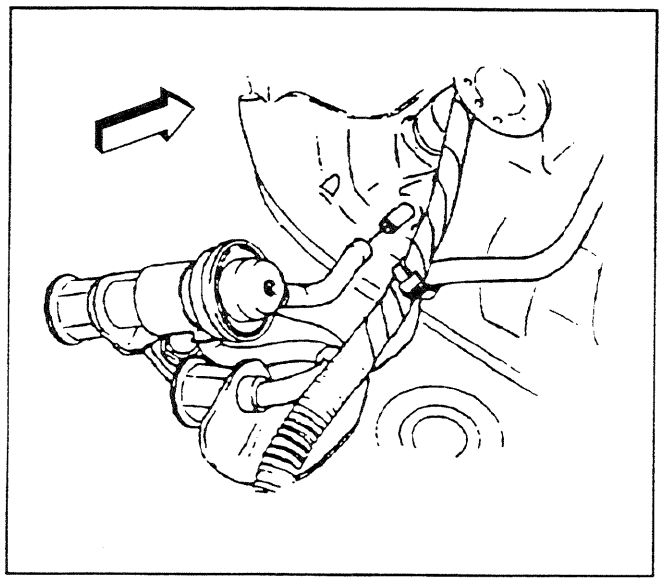


501419



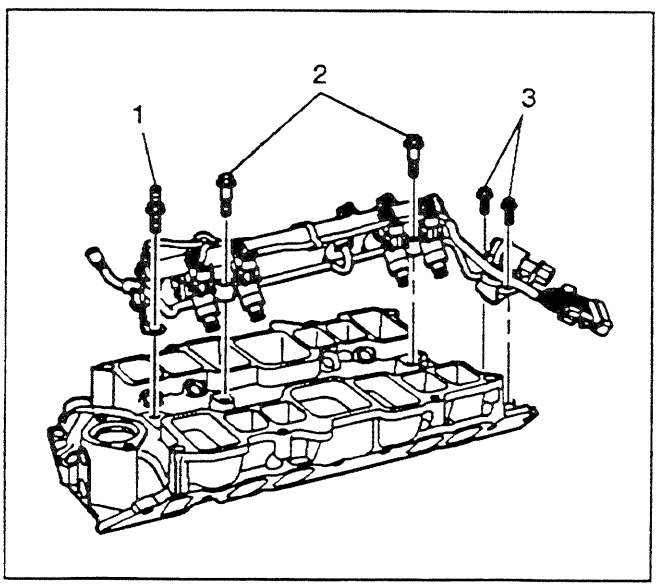
19673

2. Remove the MAP sensor retainer nut.
3. Remove the MAP sensor retainer.
4. Remove the MAP sensor.



501422

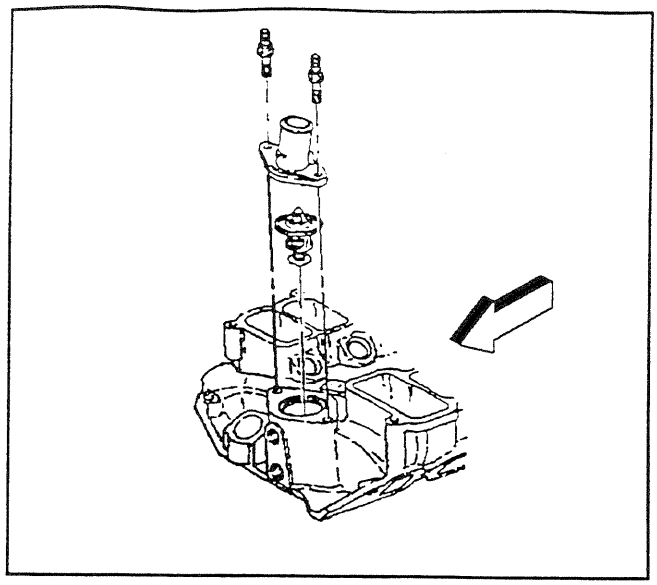
5. Disconnect the fuel injector regulator vacuum hose connection from the intake manifold fitting.



492021

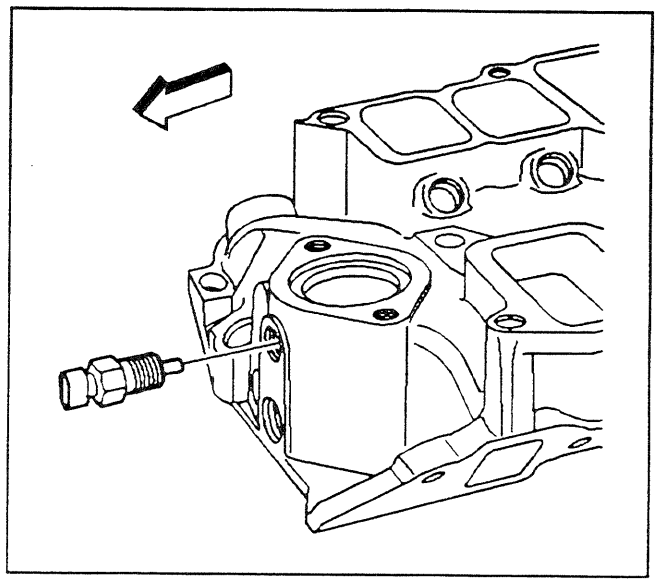
6. Remove the fuel rail stud (1) and bolts (2, 3).
7. Remove the fuel rail.

8. Remove the coolant outlet housing bolts.
9. Remove the coolant outlet housing.
10. Remove the thermostat.



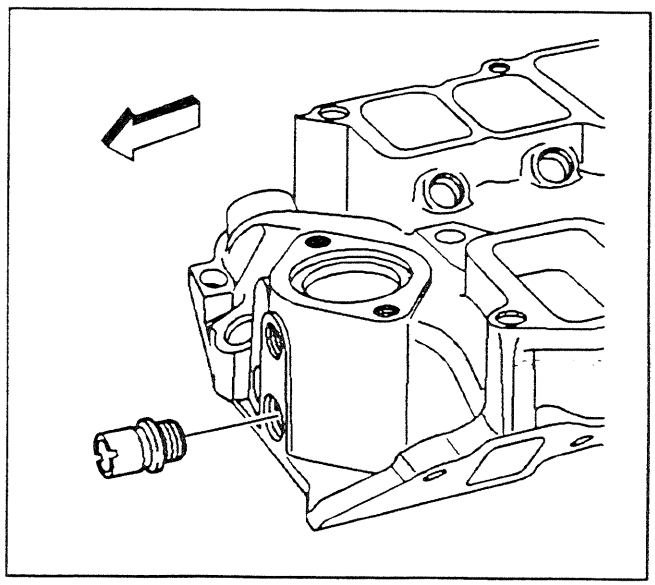
65322

11. Remove the ECT sensor, if required.

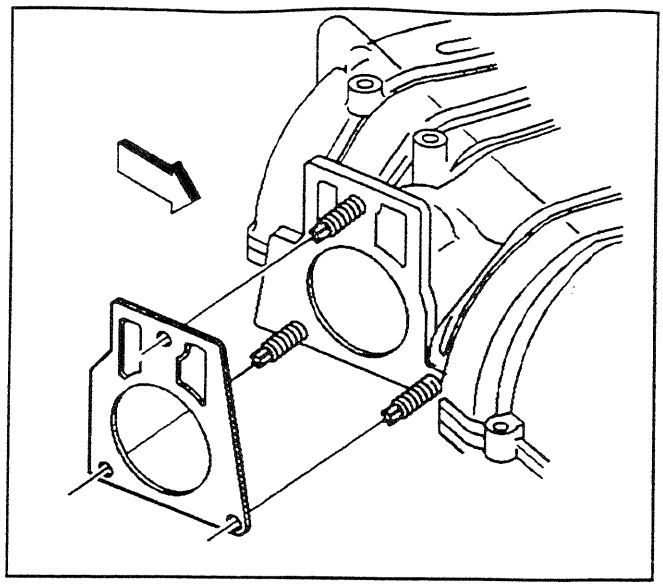


492032

12. Remove the thermostat bypass hose fitting, if required.



492031



18303

Intake Manifold Clean and Inspect (Upper)

SIE-ID = 377032

Important: Do not reuse the upper intake manifold-to-lower intake manifold sealing gaskets.

1. Remove and discard the upper intake manifold-to-lower intake manifold gaskets.
2. Remove and discard the throttle body gasket.
3. Clean the upper intake manifold in an approved solvent.
   - Clean the upper intake manifold gasket sealing surfaces.
   - Clean all engine coolant passages of scale build up.
   - Clean all carbon from the EGR passages.
   - Clean all upper intake manifold ports.
   - Inspect upper intake manifold sealing surfaces for nicks and cracks.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

- Dry the upper intake manifold with compressed air.

Intake Manifold Clean and Inspect (Lower)

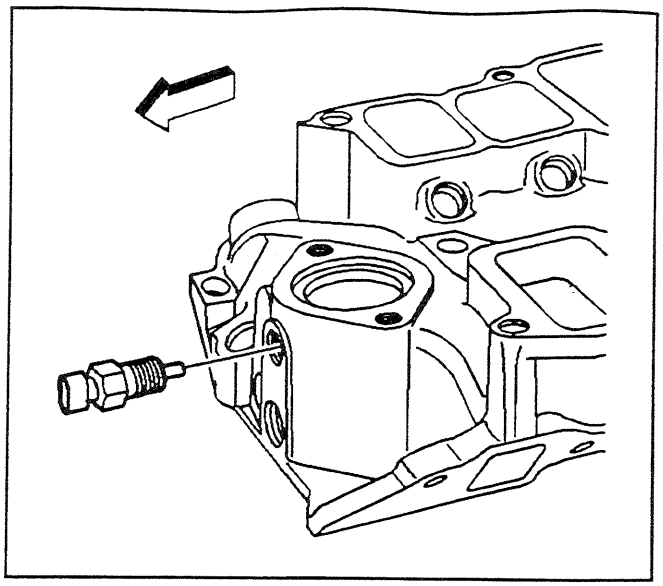
SIE-ID = 377034

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

1. Inspect the sealing grommet on the MAP sensor. The grommet should not be torn or damaged.
2. Remove and discard the lower intake manifold-to-cylinder head gaskets.
3. Clean the lower intake manifold in an approved solvent.
   - Clean the lower intake manifold gasket sealing surfaces.
   - Clean all engine coolant passages of scale build up.
   - Clean all carbon from the EGR passages.
   - Clean all lower intake manifold ports.
   - Inspect lower intake manifold sealing surfaces for nicks and cracks.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

   - Dry the lower intake manifold with compressed air.



492032

Intake Manifold Assemble (Lower)

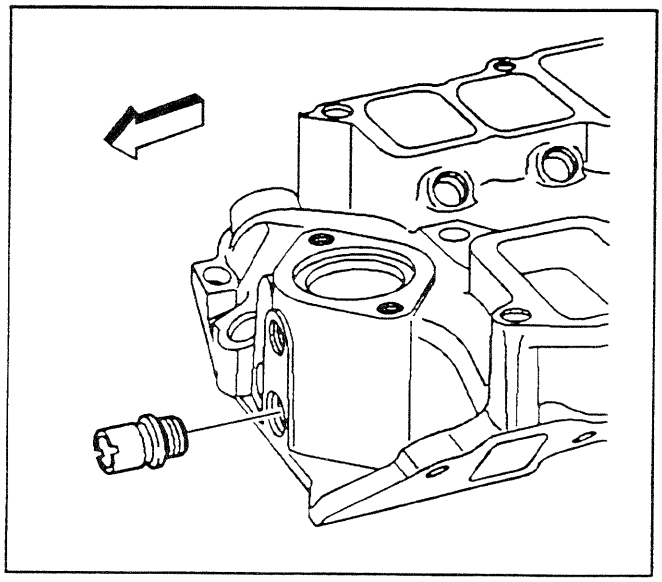
SIE-ID = 377036

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

1. Install the ECT sensor using sealant GM P/N 12346004 or equivalent, if removed.

   Tighten

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

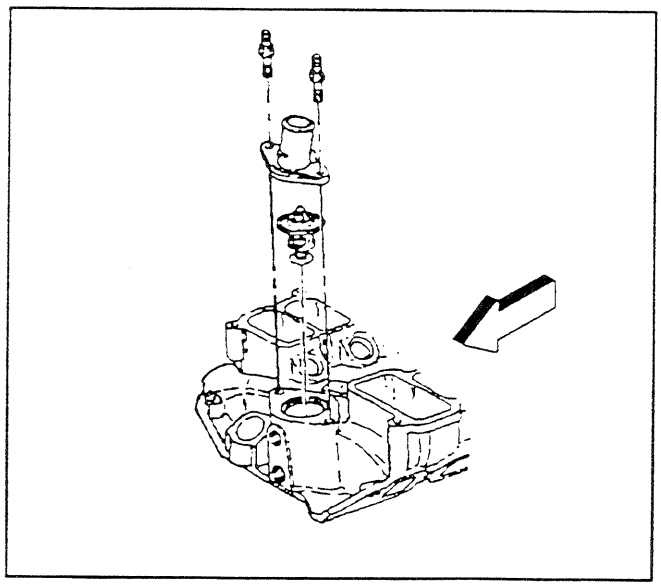


492031

2. Install the thermostat bypass hose fitting using sealant GM P/N 12346004 or equivalent, if removed.

   Tighten

   Tighten the thermostat bypass hose fitting to 15 N·m (11 lb ft).



65322

3. Install the thermostat and NEW thermostat seal.
4. Install the coolant outlet housing.
5. Install the coolant outlet housing bolts.

   Tighten

   Tighten the coolant outlet housing bolts to 40 N·m (30 lb ft).

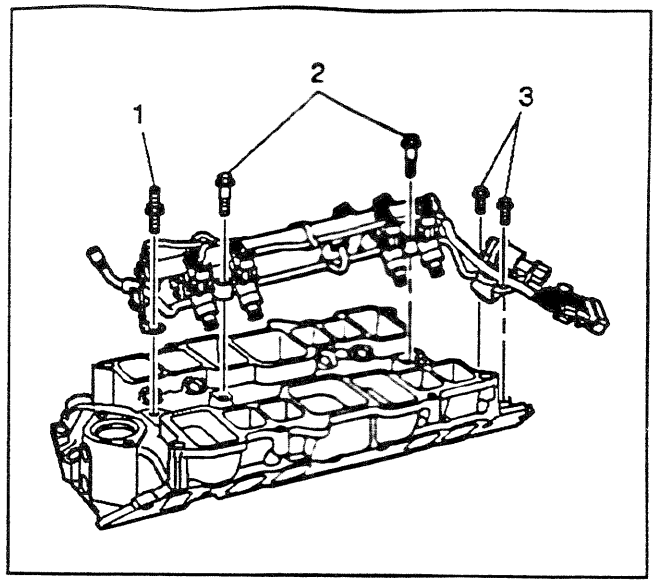
Important: Lubricate the injector O-ring seals with clean engine oil and install onto the spray tip end of each injector.

Install the fuel rail assembly in intake manifold. Tilt the rail assembly to install the injectors.

6. Install the fuel rail stud (1) and bolts (2, 3).

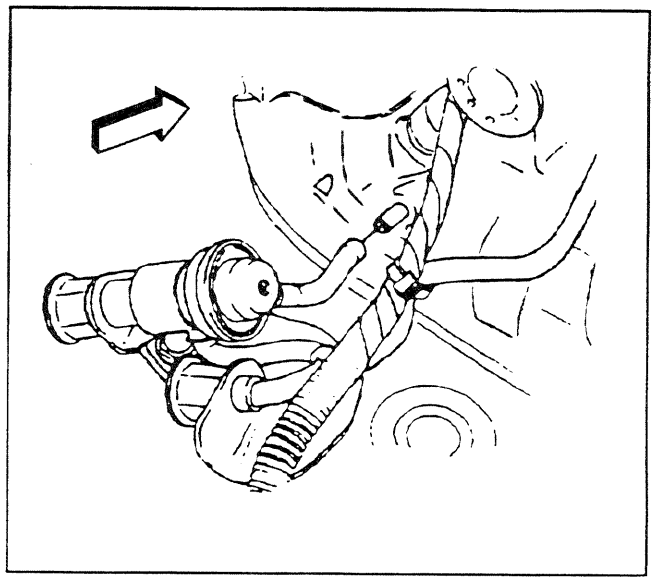
   Tighten

   - Tighten the fuel rail stud (1) to 25 N·m (18 lb ft).
   - Tighten the fuel rail bolts (2, 3) to 10 N·m (89 lb in).



492021

7. Connect the fuel injector regulator vacuum hose connection to the intake manifold fitting.


501422

8. Apply lubricant GM P/N 9985770 or equivalent to the MAP sensor seal.

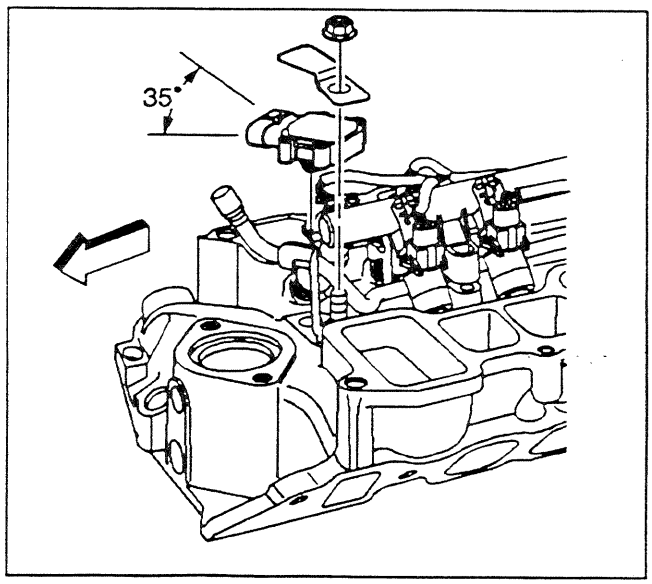
Important: Position the MAP sensor correctly in order to ensure proper clearance for the wiring harness connector.

Install the MAP sensor.

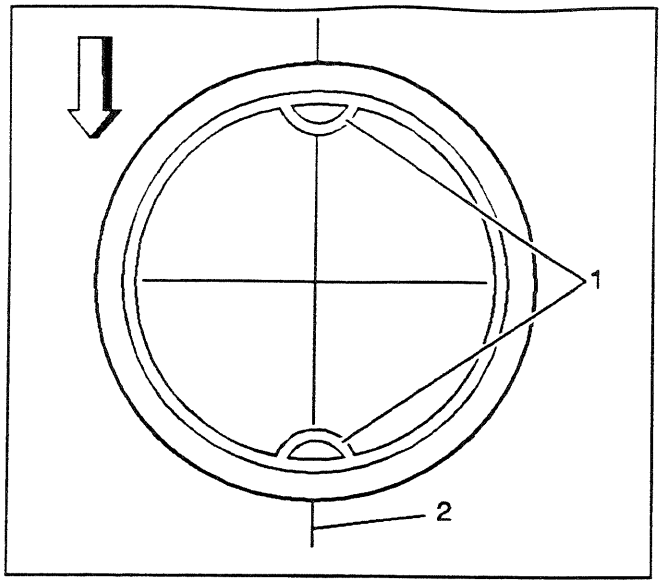
9. Install the MAP sensor retainer.
10. Install the MAP sensor retainer nut.

    Tighten

    Tighten the MAP sensor retainer nut to 25 N·m (18 lb ft).

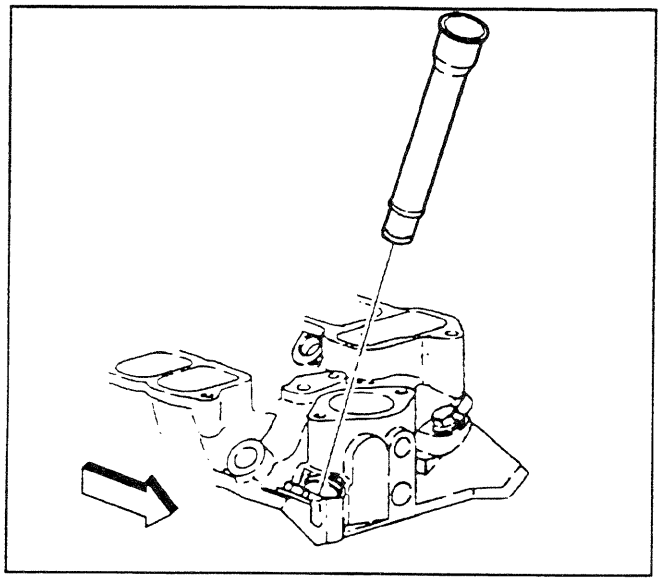


351773



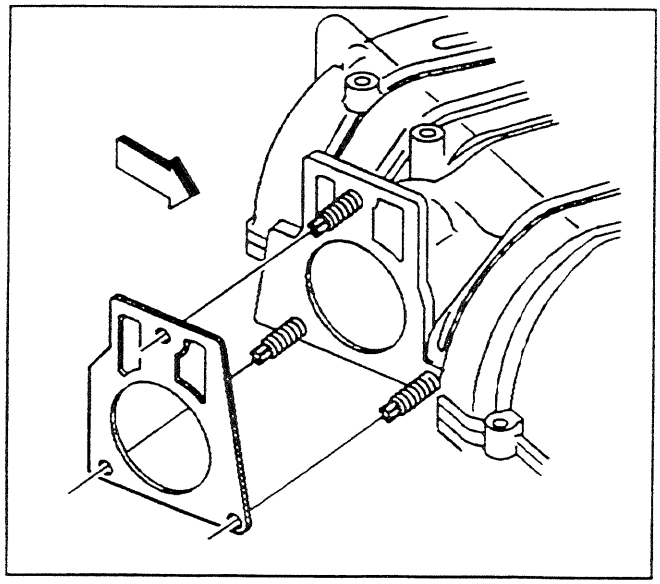
501420

11. Align the oil fill tube notches (1) parallel to the center line of the crankshaft (2).



501419

12. Apply a 6.0 mm (0.240 in) bead of sealant GM P/N 9985409 or equivalent to the intake manifold end of the oil fill tube.
13. Install the oil fill tube, if removed.



18303

Intake Manifold Assemble (Upper)

SIE ID - 377046

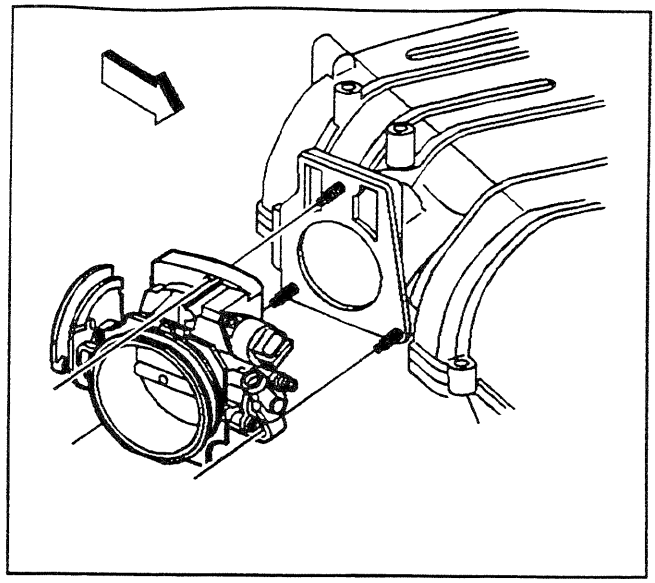
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the throttle body studs, if removed.

   Tighten

   Tighten the throttle body studs to 12 N·m (106 lb in).
2. Install the NEW throttle body gasket.

3. Install the throttle body.

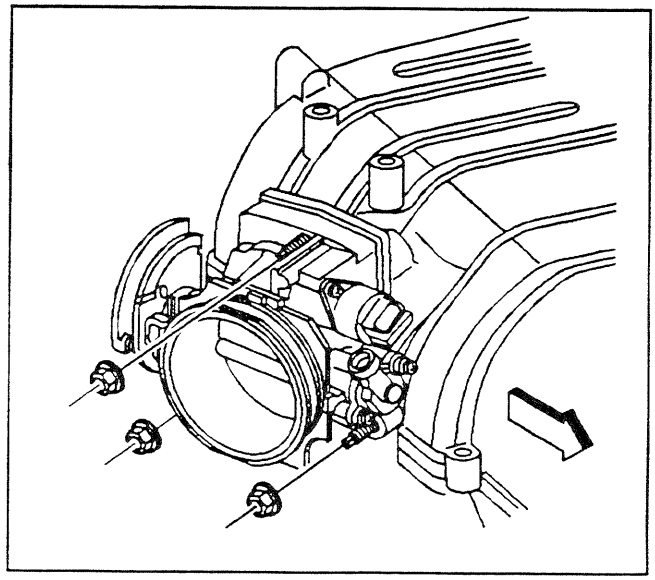


18302

4. Install the throttle body nuts.

   Tighten

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



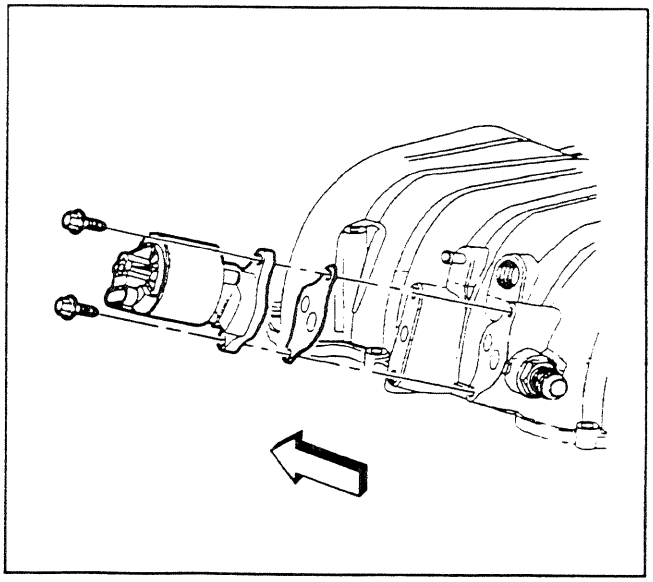
18299

5. Install the NEW EGR gasket
6. Install the EGR valve.
7. Install the EGR valve bolts.

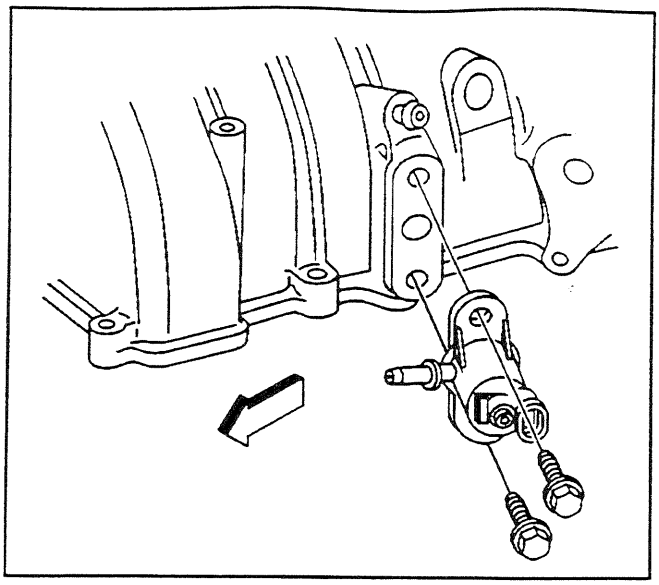
   Tighten

   7.1. Tighten the EGR valve bolts a first pass to 10 N·m (89 lb in).

   7.2. Tighten the EGR valve bolts a final pass to 22 N·m (16 lb ft).



276413

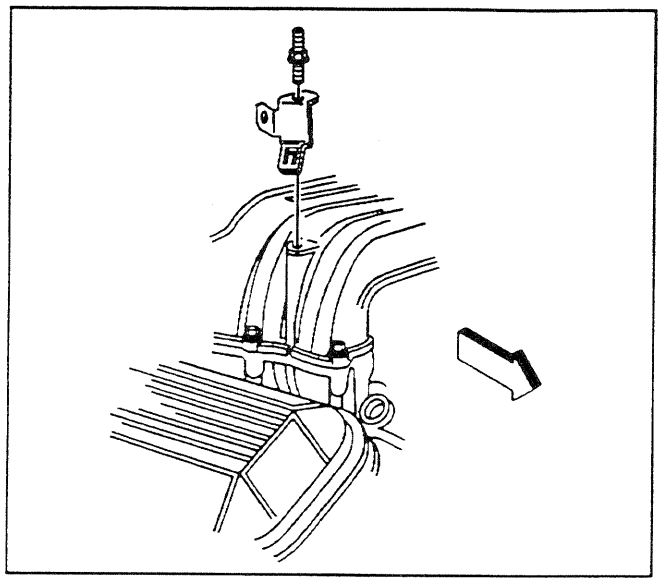


351775

8. Install the EVAP purge solenoid valve.
9. Install the EVAP purge solenoid valve bolts.

Tighten

Tighten the EVAP purge solenoid valve bolts to 12 N·m (106 lb in).

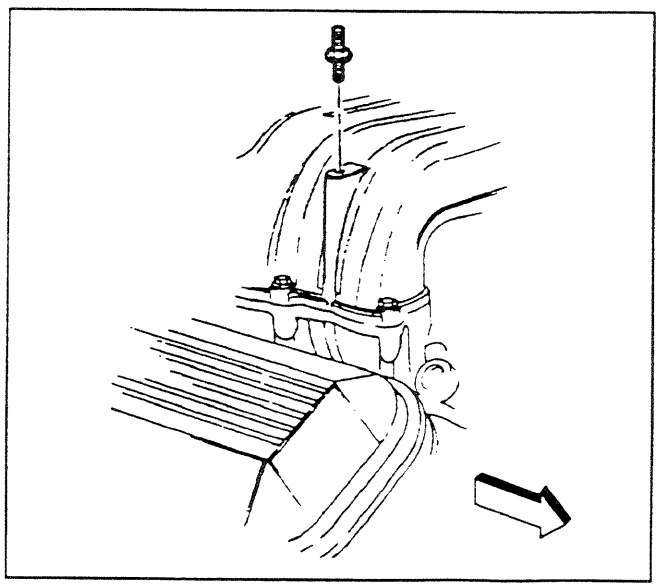


354044

10. Install the secondary air injection check valve bracket (RPO K19 only), if removed.
11. Install the secondary air injection check valve bracket stud.

Tighten

Tighten the secondary air injection check valve bracket stud to 25 N·m (18 lb ft).



501418

12. Install the secondary air injection check valve bracket stud (without RPO K19), if removed.

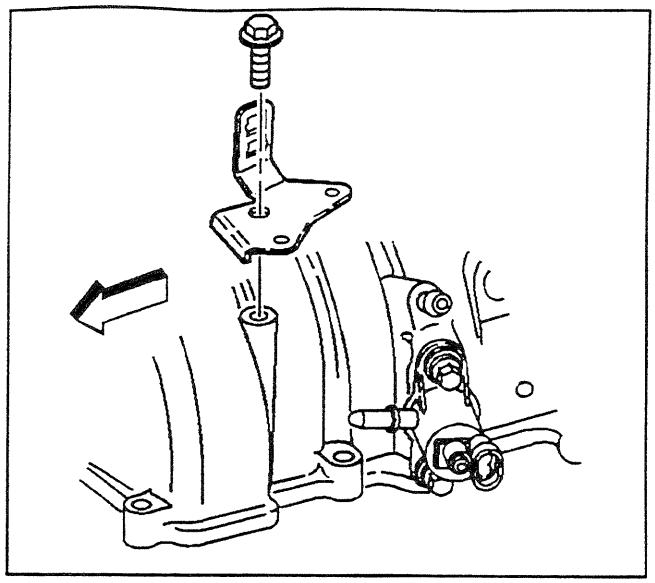
Tighten

Tighten the secondary air injection check valve bracket stud to 25 N·m (18 lb ft).

13. Install the ECT wiring harness connector bracket, if removed.
14. Install the ECT wiring harness connector bracket bolt.

    Tighten

    Tighten the ECT wiring harness connector bracket bolt to 25 N·m (18 lb ft).

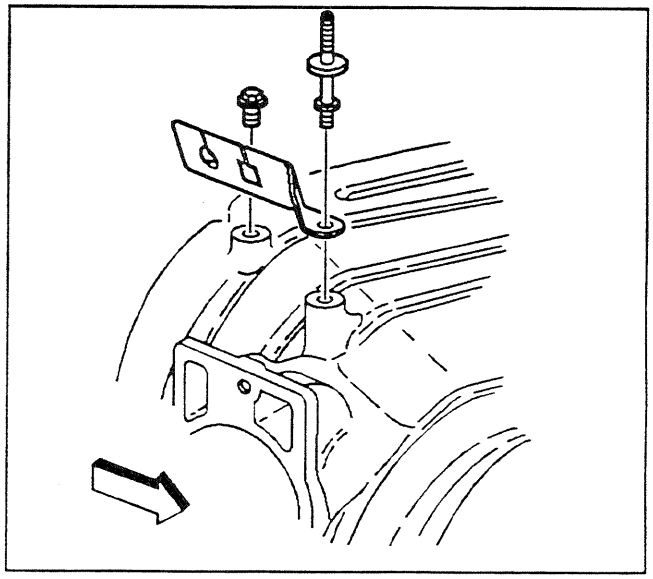


492023

15. Install the accelerator control cable bracket, if removed.
16. Install the accelerator control cable bracket bolt and stud.

    Tighten

    Tighten the accelerator control cable bracket bolt and stud to 25 N·m (18 lb ft).



492027

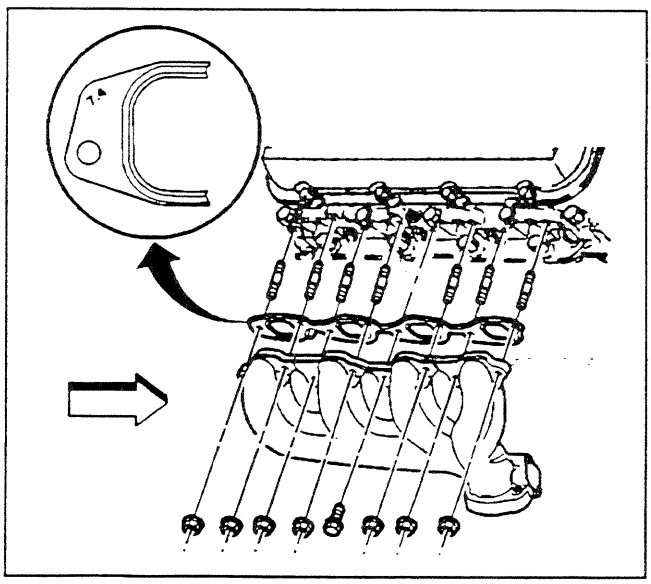
Exhaust Manifold Clean and Inspect (without RPO K19)

SIE-ID = 290773

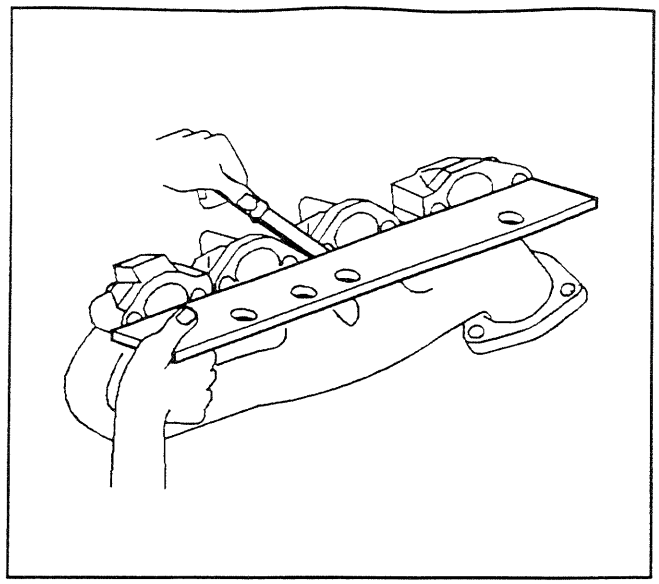
1. Clean the exhaust manifolds in solvent.

Caution: SIO-ID = 5011 ***Wear safety glasses in order to avoid eye damage.***

2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
   - Damage to the gasket sealing surfaces
   - Loose or damaged exhaust gas recirculation (EGR) pipe fitting (if applicable)
   - Damage to the take down studs
   - Restrictions within the exhaust passages
   - Broken or damaged heat shields (if applicable)

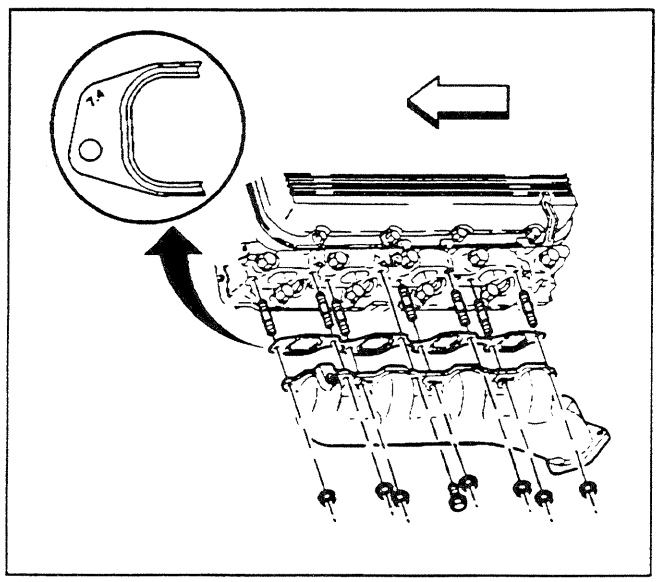


180921



66607

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gauge. Exhaust manifold surface flatness must not exceed 0.254 mm (0.01 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.



180888

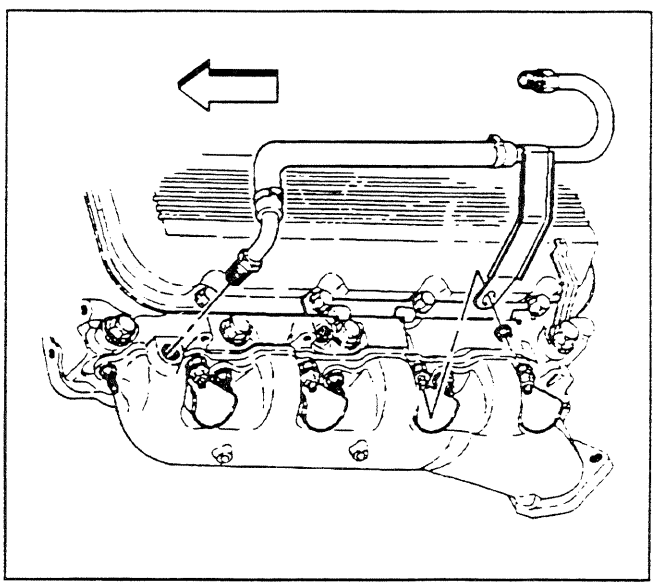
Exhaust Manifold Clean and Inspect (with RPO K19)

SIE-ID = 200426

1. Clean the exhaust manifolds in solvent.

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

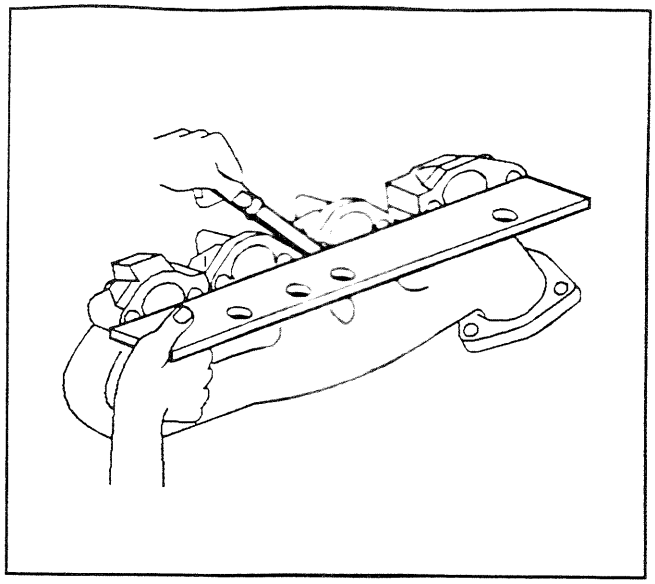
2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
   - Damage to the gasket sealing surfaces
   - Loose or damaged EGR pipe fitting (if applicable)
   - Damage to the take down studs
   - Restrictions within the exhaust passages
   - Broken or damaged heat shields (if applicable)



180942

4. Inspect for restrictions within the AIR system passages.
5. Inspect for damaged to the threads of AIR inlet pipe opening.

6. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gauge. Exhaust manifold surface flatness must not exceed 0.254 mm (0.01 in).
7. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.



66607

Water Pump Clean and Inspect

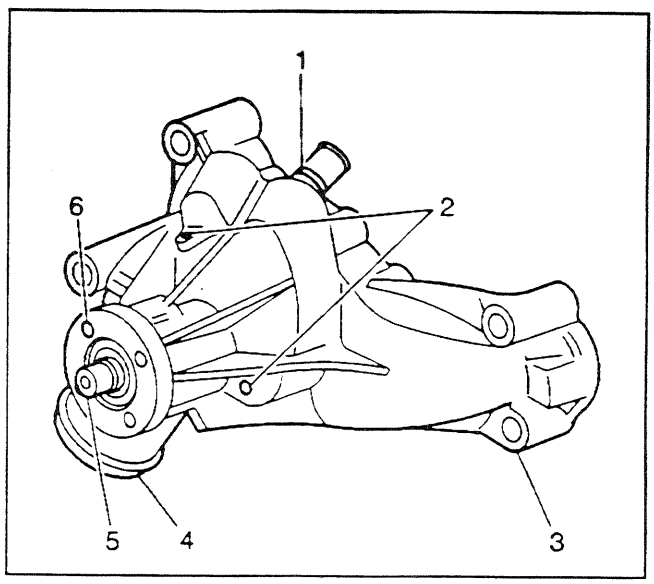
SIE-ID = 200432

Notice: SIO-ID = 16340 Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

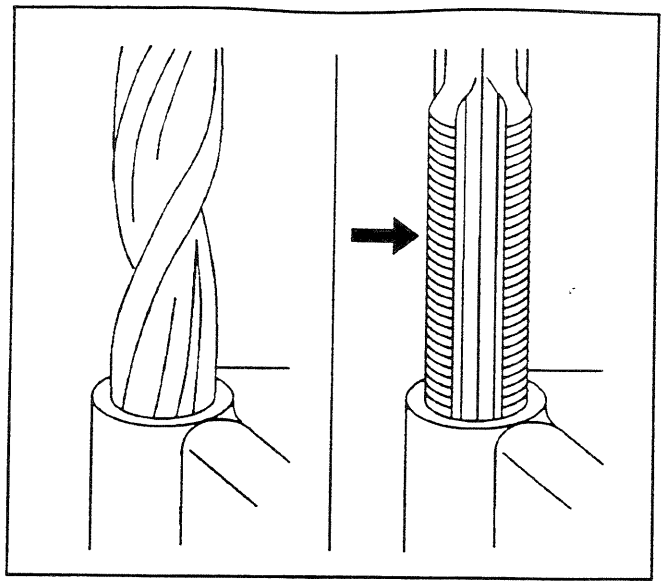
1. Remove the old gasket material from the water pump sealing surfaces. Refer to *Replacing Engine Gaskets*.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
   - Leakage at the hose fitting (1)
   - Leakage at the water pump weep hole (2)

     A stain around the weep hole is acceptable. If leakage occurs (dripping) with the engine running and the cooling system pressurized, replace the water pump.
   - Gasket sealing surfaces for excessive scratches or gouging (3)
   - Restrictions within the internal coolant passages (4)
   - Excessive side-to-side play in the pulley shaft (5)

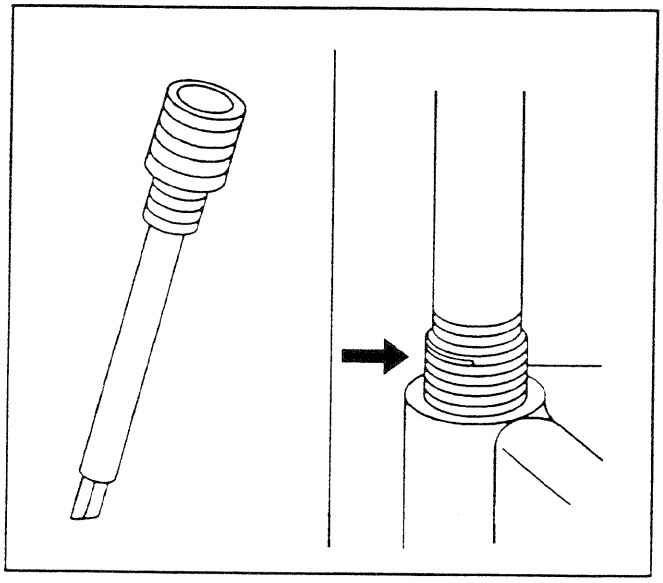
     If the shaft end play exceeds 0.381 mm (0.015 in), replace the water pump.
   - Rotate the pump shaft by hand and inspect for roughness of operation (5)
     - If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
     - The shaft and fan hub must turn straight and smoothly.
   - Damage to threaded bolt holes (6)



381961



4962



4963

Thread Repair

SIE-ID = 43119

General purpose thread repair kits are available commercially.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Important: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use.

Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

Determine the size, the pitch, and the depth of the damaged thread.

1. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
2. Drill out the damaged thread.
3. Remove the chips.
4. Apply clean engine oil to the top thread.
5. Use the tap in order to cut new thread.
6. Clean the thread.
7. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

Important: The thread insert should be flush to 1 turn below the surface.

Lubricate the thread insert with clean engine oil (except when installing in aluminum) and install the thread insert.

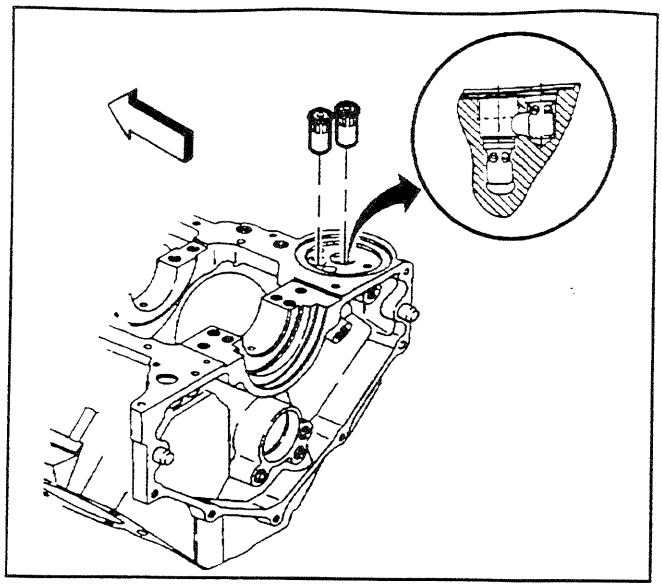
8. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

Service Prior to Assembly

SIE-ID = 195835

SIO-ID = 40497

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.



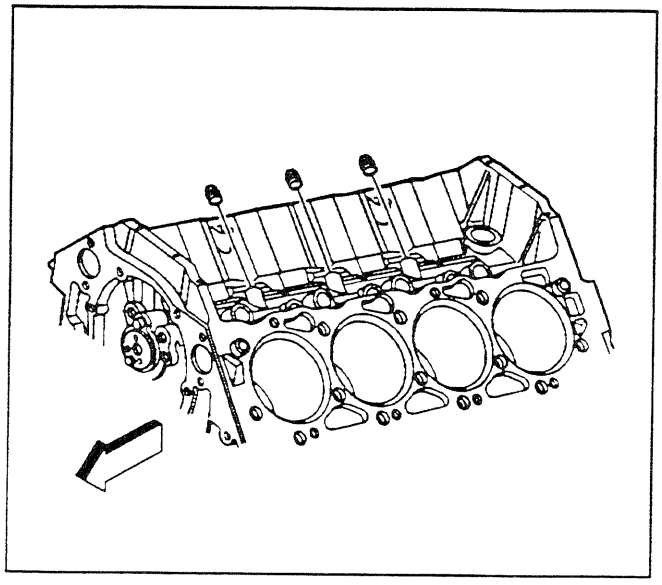
180862

Engine Block Plug Installation

SIE-ID = 200442

1. Install NEW oil filter bypass valves to the proper depth, if removed.

   Stake the area around the bypass valve.



180870

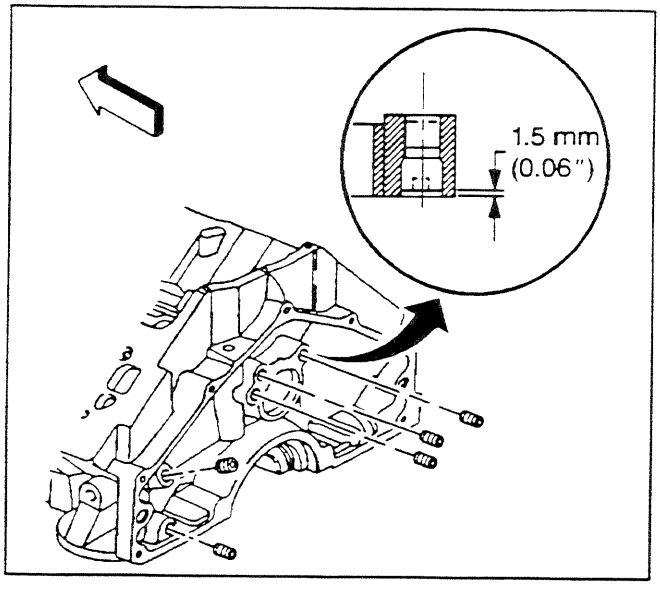
2. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.

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

3. Install the engine block top oil gallery plugs.

   Tighten

   Tighten the top oil gallery plugs to 20 N·m (15 lb ft).



180866

4. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.
5. Install the engine block rear oil gallery plugs.

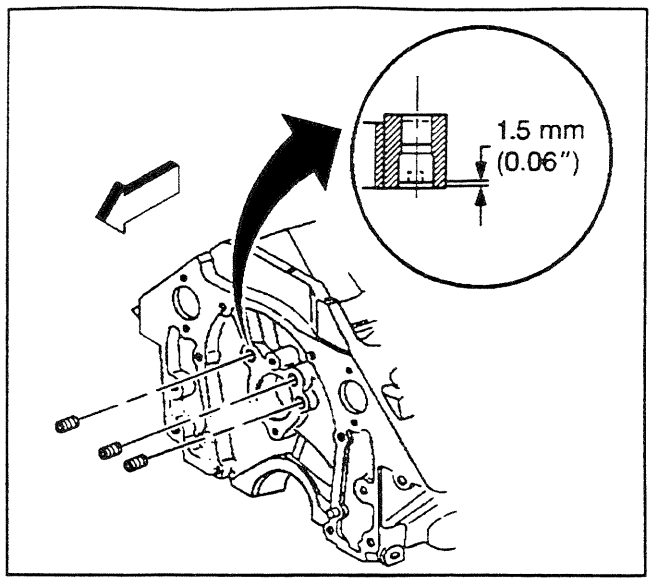
   Tighten

   Tighten the rear oil gallery plugs to 30 N·m (22 lb ft).

6. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.
7. Install the engine block front oil gallery plugs.

   Tighten

   Tighten the front oil gallery plugs to 30 N·m (22 lb ft).

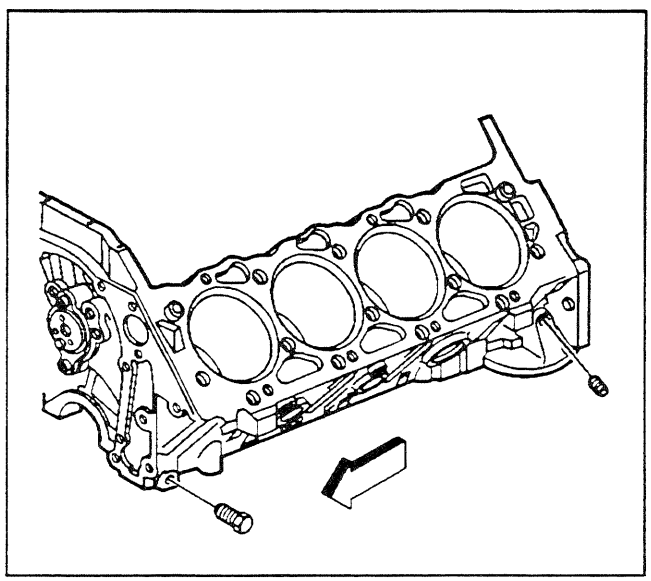


180871

8. Apply sealant GM P/N 12346004 or equivalent to the threads of the oil gallery plugs.
9. Install the engine block left side oil gallery plugs.

   Tighten

   Tighten the side oil gallery plugs to 30 N·m (22 lb ft).

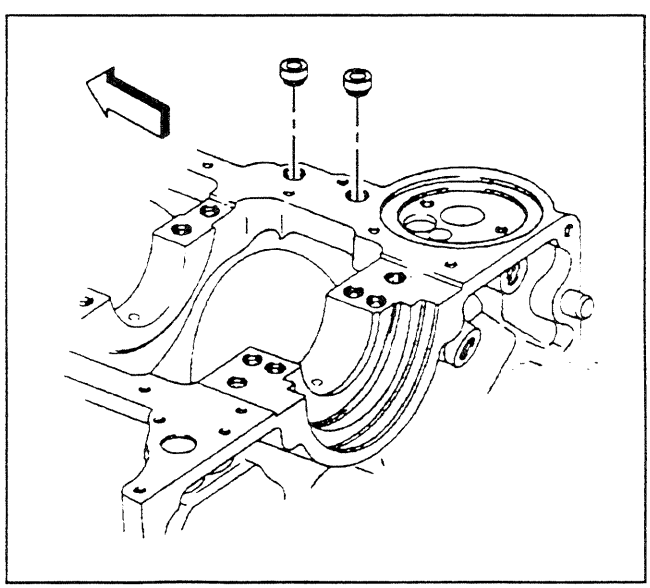


180869

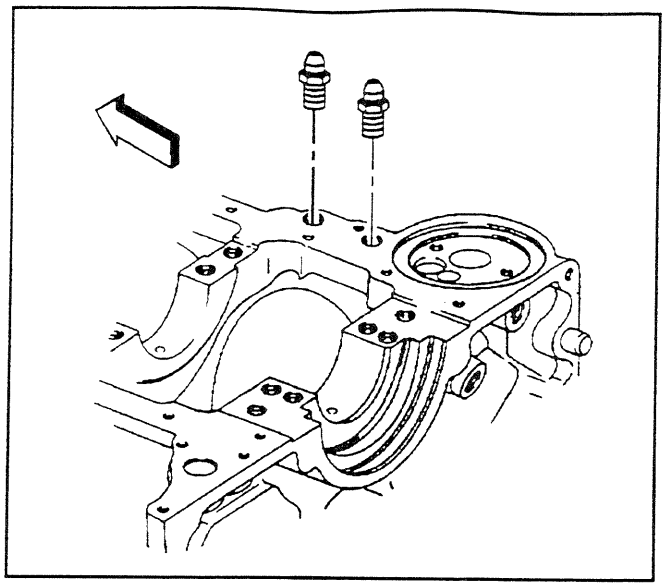
10. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block oil cooler plugs (without oil cooler).
11. Install the engine block oil cooler plugs (without oil cooler).

    Tighten

    Tighten the engine block oil cooler plugs to 30 N·m (22 lb ft).



354082

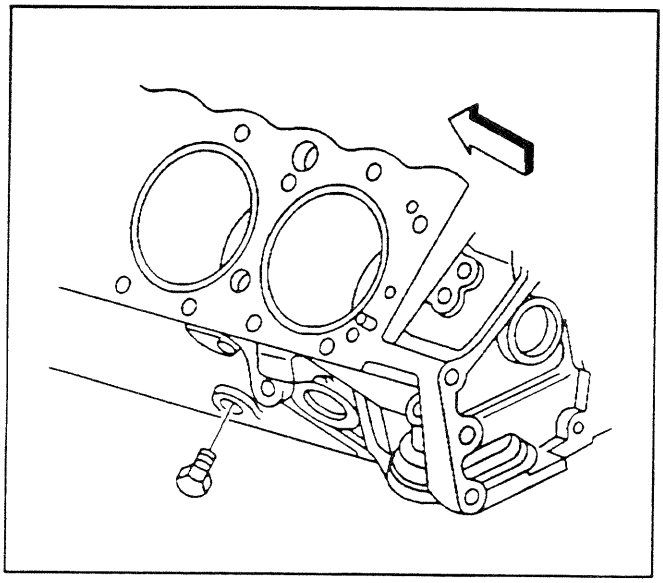


180864

12. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block oil cooler hose fittings (with oil cooler).
13. Install the engine block oil cooler hose fittings (with oil cooler).

    Tighten

    Tighten the engine block oil cooler hose fittings to 23 N·m (17 lb ft).

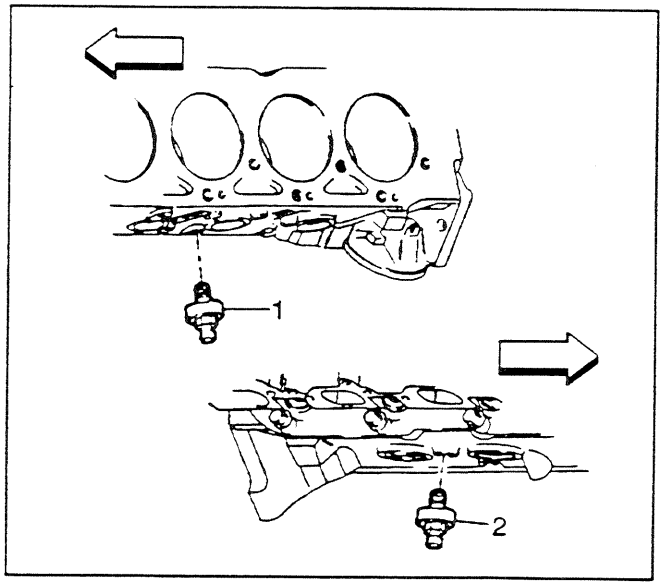


69033

14. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block coolant drain hole plug.
15. Install the engine block coolant drain hole plug.

    Tighten

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



181034

16. Apply sealant GM P/N 12346004 or equivalent to the threads of the knock sensors.
17. Install the left knock sensor (1) to the engine block.

    Tighten

    Tighten the knock sensor to 19 N·m (14 lb ft).
18. Install the right knock sensor (2) to the engine block.

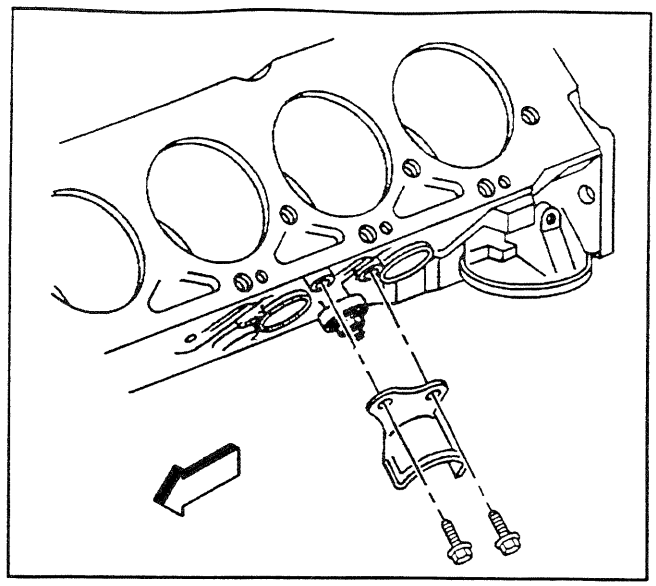
    Tighten

    Tighten the knock sensor to 19 N·m (14 lb ft).

19. Install the left side knock sensor shield.
20. Install the left side knock sensor shield bolts.

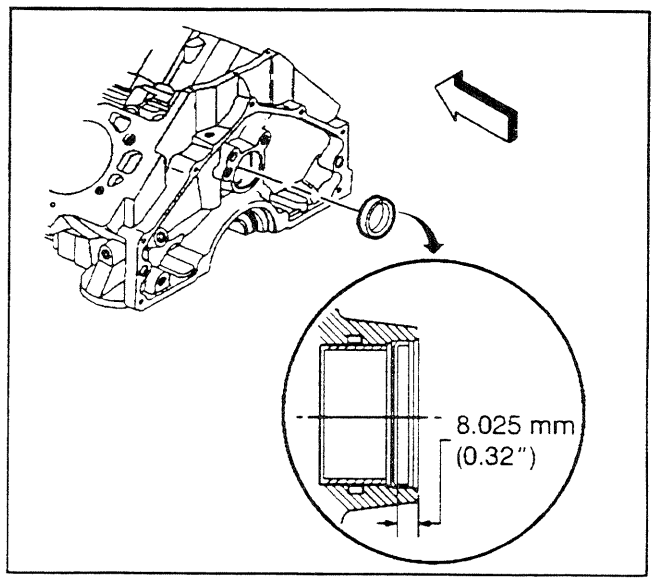
    Tighten

    Tighten the left side knock sensor shield bolts to 12 N·m (106 lb in).



354072

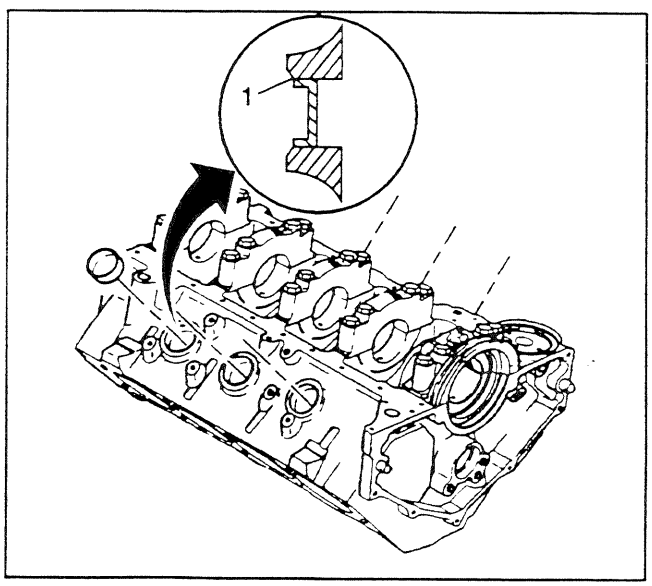
21. Apply sealant GM P/N 12345493 or equivalent to the engine block camshaft rear bearing hole.
22. Install a NEW camshaft rear bearing hole plug to the proper depth.



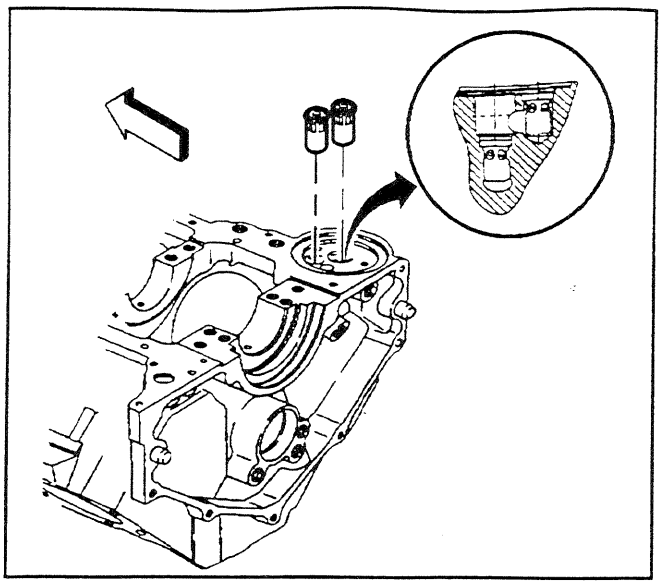
180956

23. Apply sealant GM P/N 12345493 or equivalent to the engine block expansion plug holes.
24. Install NEW engine block expansion plugs to the proper depth.

    A properly installed expansion plug will be installed until flush or slightly below flush (1) with the face of the block.



562804

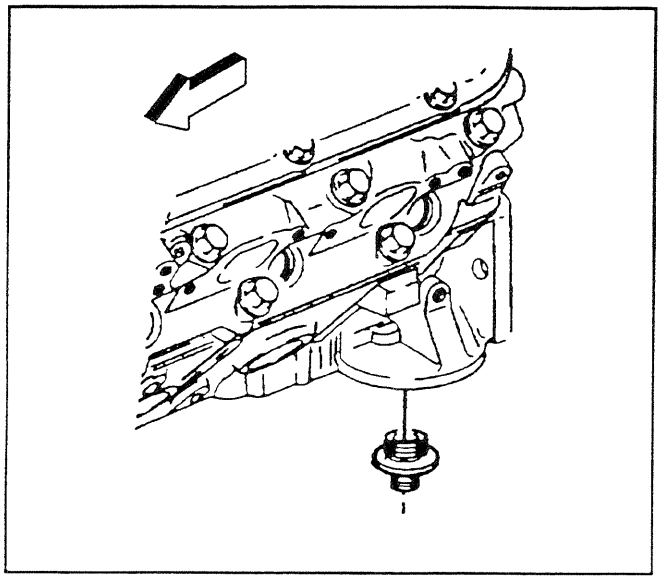


180862

Oil Filter Adapter Installation (2WD)

SIE-ID = 281111

1. Install the new oil bypass valves, if removed. Stake the tangs on the oil bypass valves.



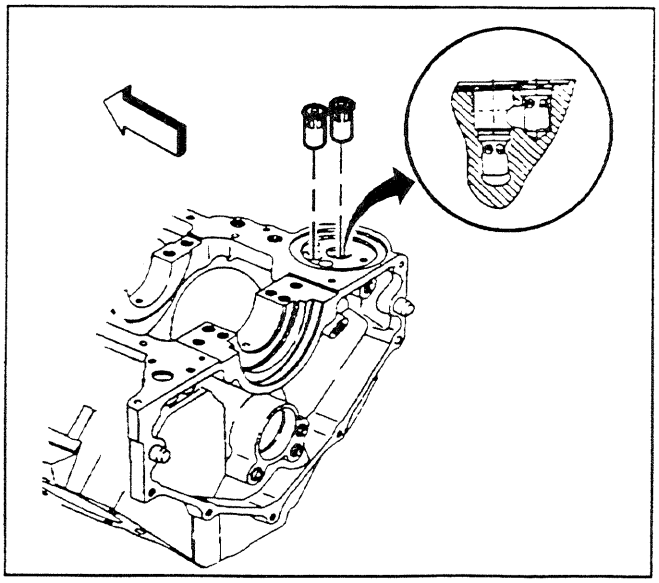
70416

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

2. Install the oil filter fitting.

   Tighten

   Tighten the oil filter fitting to 66 N·m (49 lb ft).



180862

Oil Filter Adapter Installation (4WD)

SIE-ID = 200484

1. If removed, install the new oil bypass valves. Stake the tangs on the oil bypass valves.

2. Lubricate the NEW oil filter adapter O-ring seal with clean engine oil.
3. Install the oil filter adapter, with NEW adapter O-ring seal.

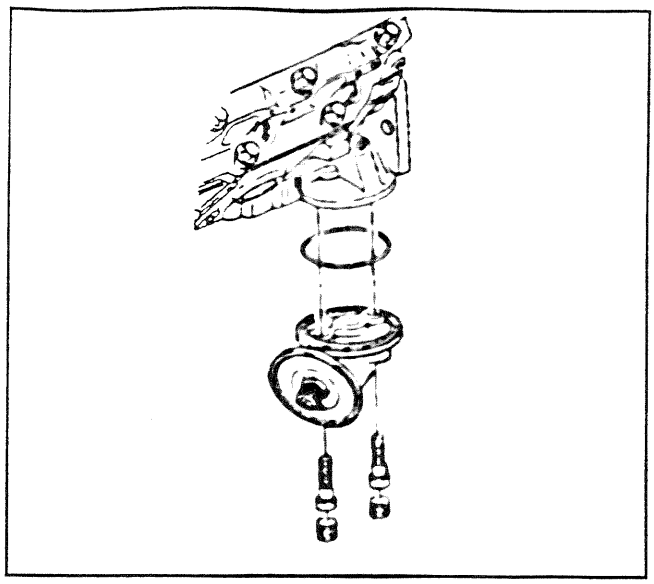
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the oil filter adapter bolts.

   Tighten

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

5. Install the plugs into the oil filter adapter.



70415

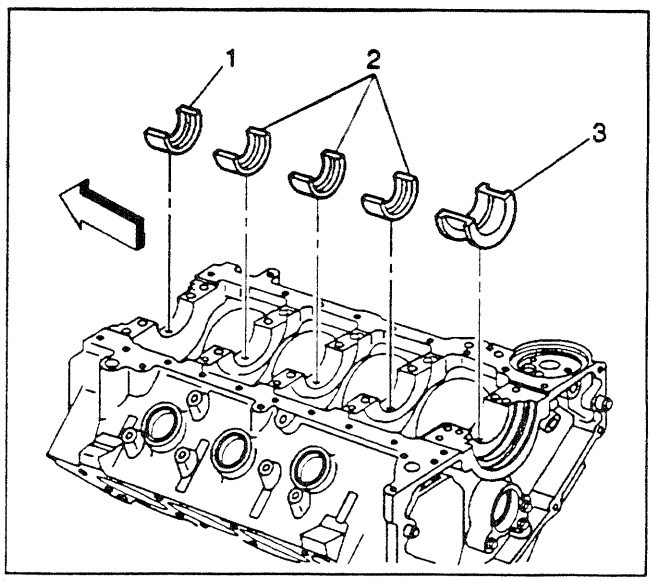
Crankshaft and Bearings Installation

SIE-ID = 200566

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

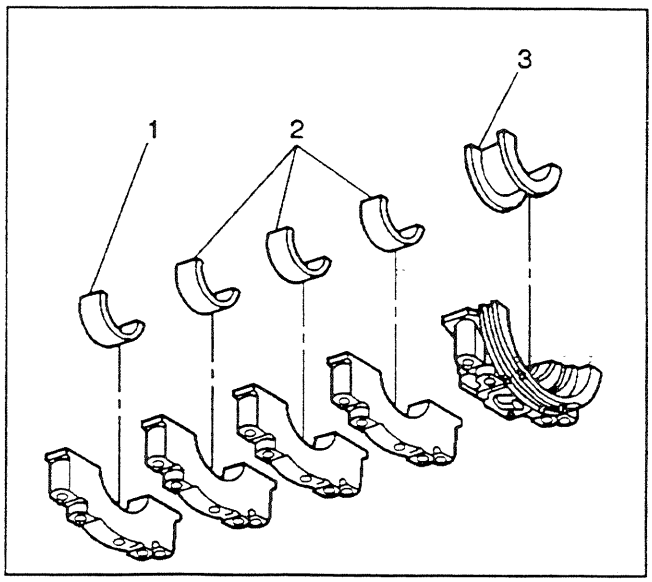
Important: If undersized bearings are used, ensure that the bearings are fitted to the proper journals. Lubricate the crankshaft bearings and crankshaft with clean engine oil.

Install the crankshaft upper bearings (1–3) into the block.

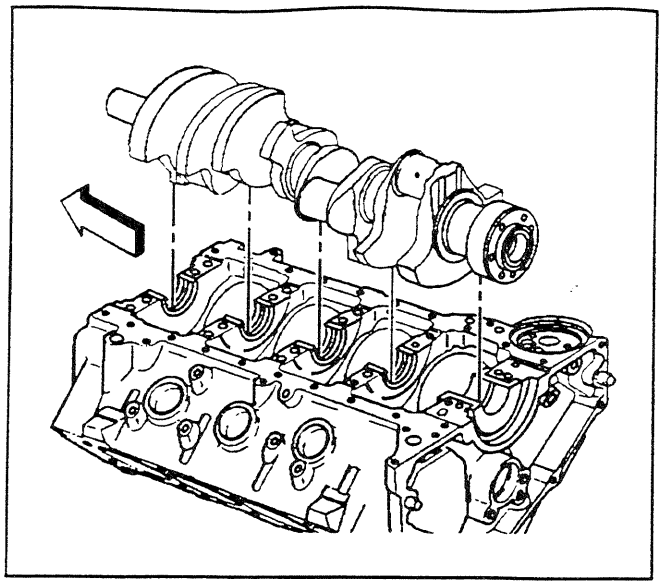


351777

1. Install the crankshaft lower bearings (1–3) into the crankshaft bearing caps.

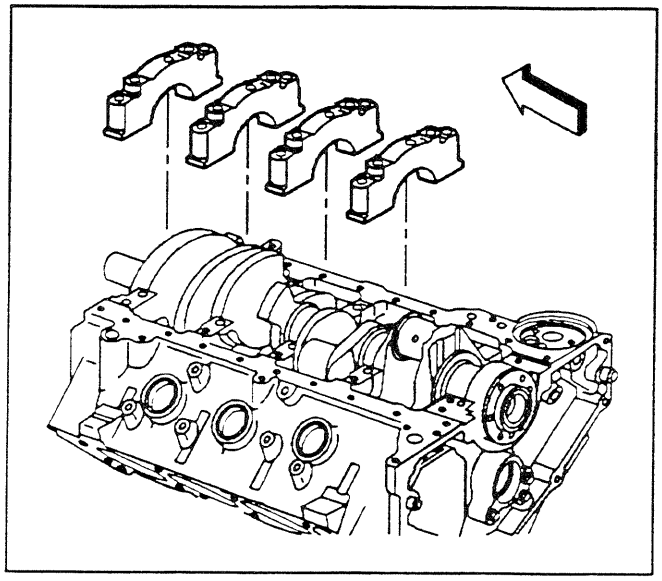


351781



351779

2. Install the crankshaft.

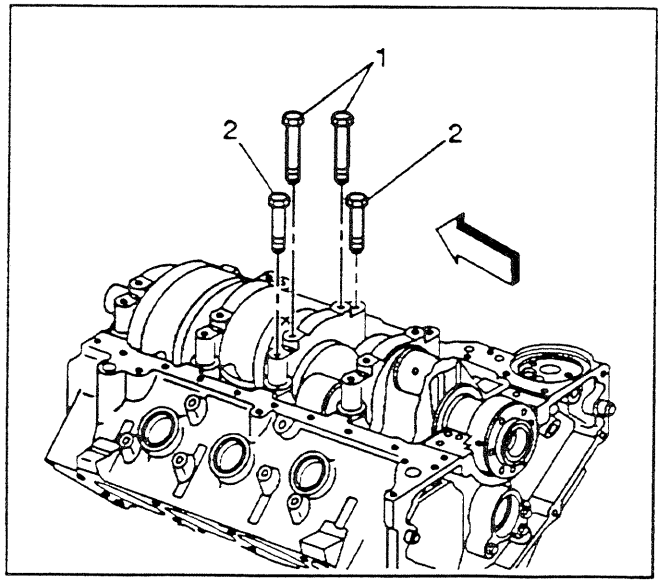


351786

Notice: SIO-ID = 16506 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.

Important: Ensure that the triangle symbol on the crankshaft bearings caps are facing the front of the engine. DO NOT install the crankshaft rear bearing cap at this time.

Install the crankshaft bearing caps.



351789

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

Important: Tighten the crankshaft bearing cap inner bolts (1) before tightening the crankshaft bearing cap outer bolts (2).

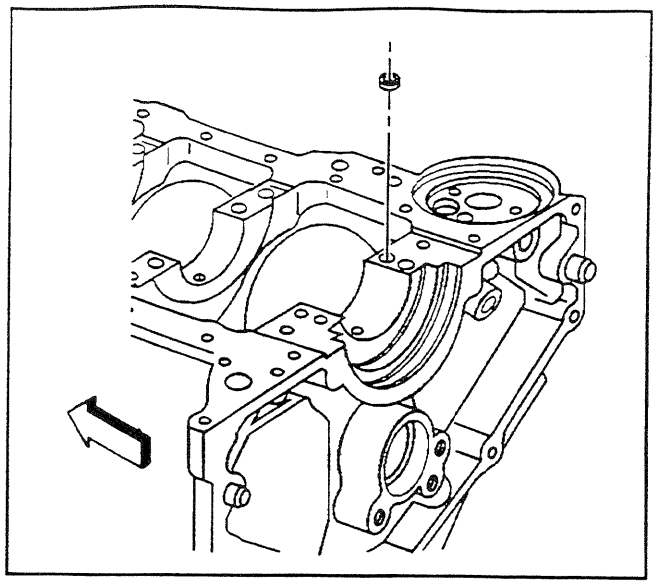
Install the crankshaft bearing cap bolts (1, 2).

Tighten

2.1. Tighten the crankshaft bearing cap inner bolts (1) to 138 N·m (102 lb ft).

2.2. Tighten the crankshaft bearing cap outer bolts (2) to 138 N·m (102 lb ft).

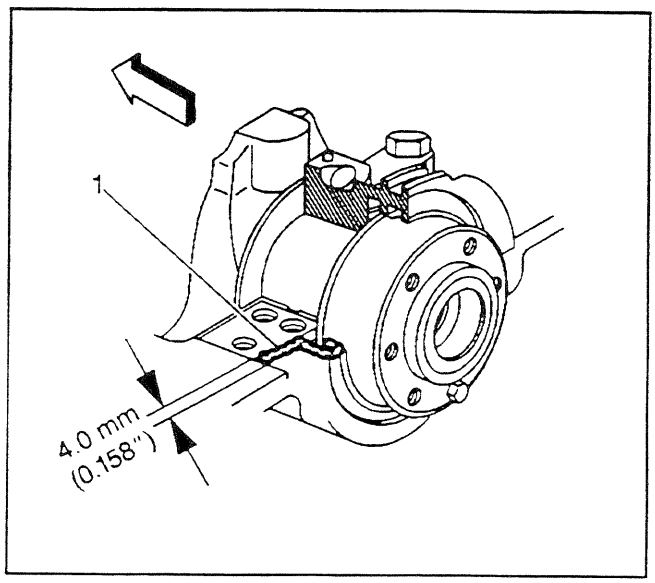
3. Install the crankshaft rear bearing cap oil seal.



351825

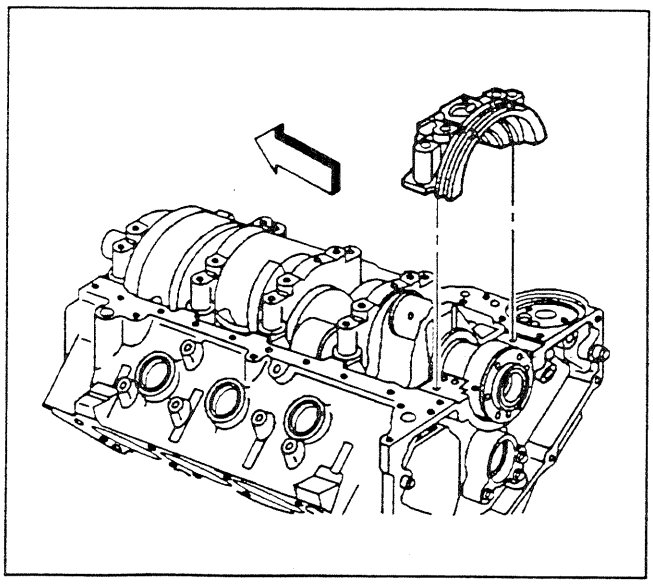
4. Apply a 4 mm (0.158 in) bead of sealant GM P/N 12345739 or equivalent to the rear bearing cap sealing face or to the rear bearing cap channel of the engine block (1).

   Apply the sealant from the corner of the rear thrust bearing pocket to the edge of the channel.

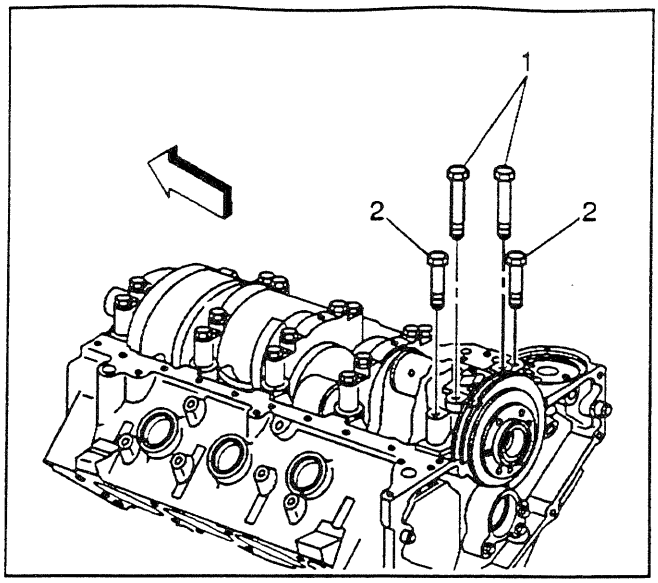


180890

5. Install the crankshaft rear bearing cap.



351792



351795

Important: Tighten the crankshaft bearing cap inner bolts (1) before tightening the crankshaft bearing cap outer bolts (2).

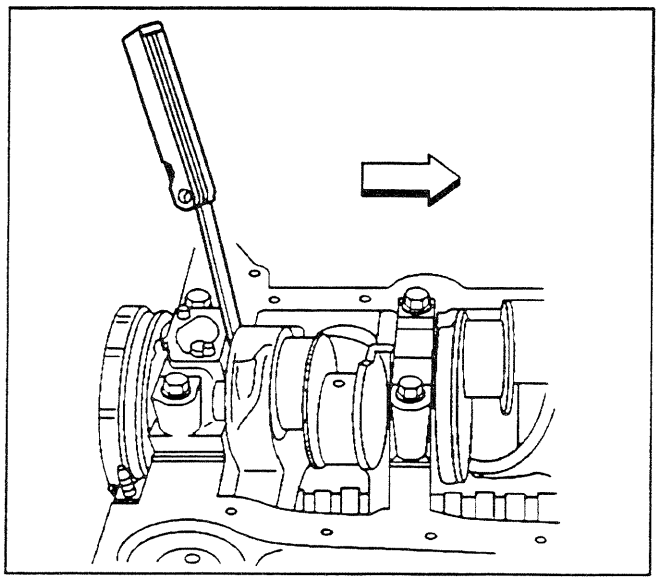
Install the crankshaft rear bearing cap bolts (1, 2) to the block.

Tighten

Tighten the crankshaft rear bearing cap bolts (1, 2) to 4 N·m (35 lb in).

6. Measure the crankshaft end play as follows:

   Firmly thrust the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.


35199

7. With the crankshaft wedged forward, insert a feeler gauge between the thrust bearing and crankshaft thrust surface.

   The proper clearance is 0.127–0.279 mm (0.005–0.011 in)

8. Rotate the crankshaft and check for binding.

   If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts on one cap at a time until the tight bearing is located.

   A bent crankshaft or lack of bearing clearance may cause binding.

9. A lack of bearing clearance may be caused by the following conditions:
   - Burrs on the bearing cap
   - Foreign material between the bearing and the block
   - Foreign material between the bearing and the bearing cap
   - Damaged bearing
   - Improper size bearing

Important: Tighten the crankshaft bearing cap inner bolts (1) before tightening the crankshaft bearing cap outer bolts (2).

Tighten the crankshaft rear bearing cap bolts (1, 2).

Tighten

9.1. Tighten the crankshaft rear bearing cap inner bolts (1) to 138 N·m (102 lb ft).

9.2. Tighten the crankshaft rear bearing cap outer bolts (2) to 138 N·m (102 lb ft).

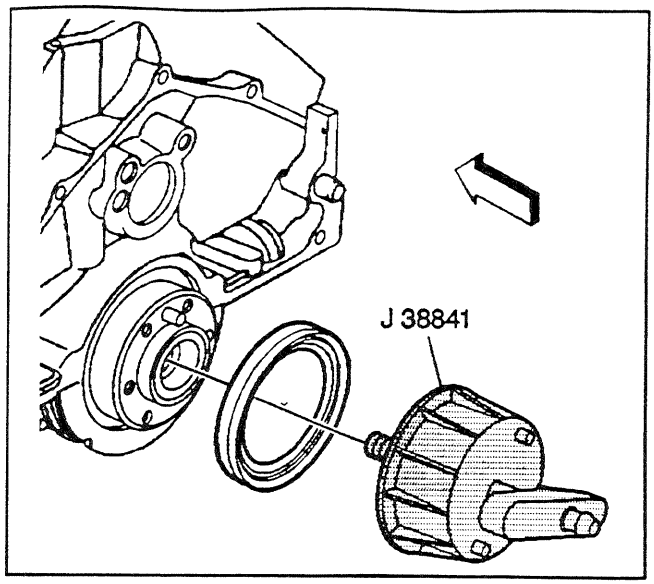
Crankshaft Rear Oil Seal Installation

SIE-ID = 67682

Tools Required

J 38841 Crankshaft Rear Oil Seal Installation

1. Make sure the crankshaft rear chamfer is free of grit, loose rust, and burrs. Correct as needed.
2. Lubricate the inner and the outer diameter of the seal with engine oil.
3. Install the seal on *J 38841*.
4. Position *J 38841* against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Turn the handle until it bottoms.
7. Remove *J 38841*.



290961

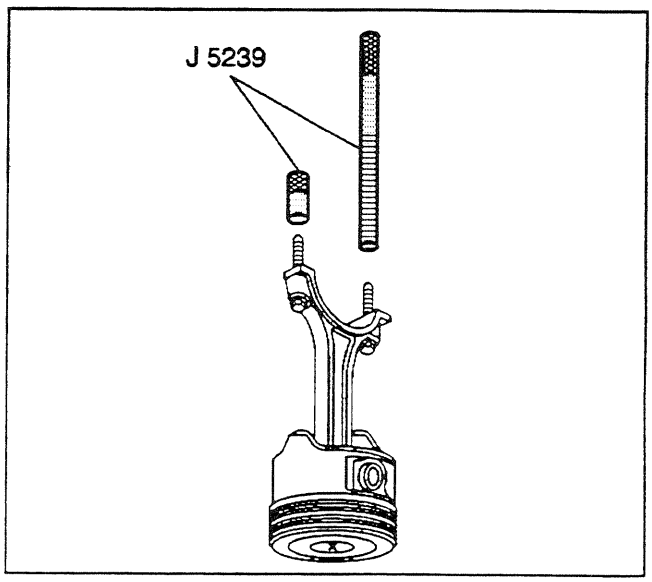
Piston, Connecting Rod, and Bearing Installation

SIE-ID = 200725

Tools Required

- *J 5239* Guide Set
- *J 8037* Piston Ring Compressor

1. Coat the following components with clean engine oil:
   - The piston
   - The piston rings
   - The cylinder bore
   - The bearing surfaces
2. Install the *J 5239* onto the connecting rod.

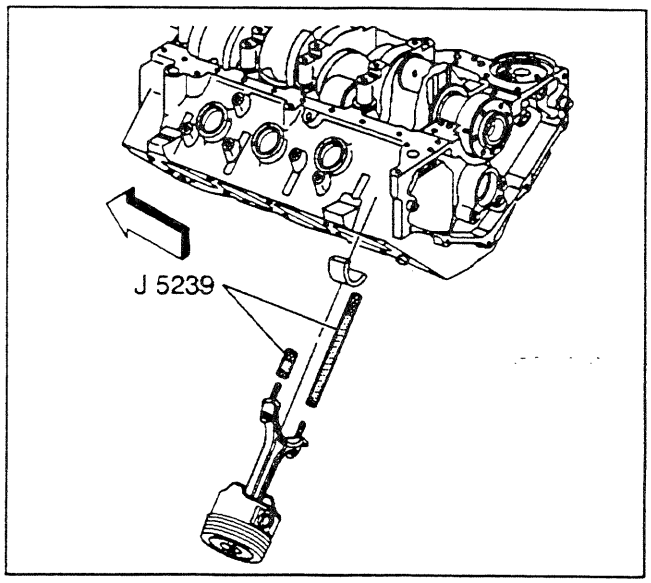


354027

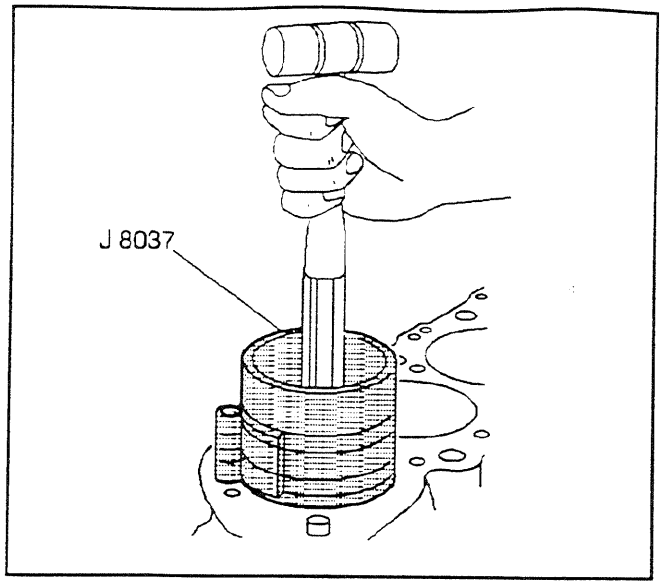
Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

Important: The mark on the top of the piston must face the front of the engine block. When assembled, the flanges on the connecting rod and cap should face to the front of block on the left bank and to the rear of block on the right bank.

Install the piston, connecting rod and upper connecting rod bearing through the top of the engine block using the *J 5239*.

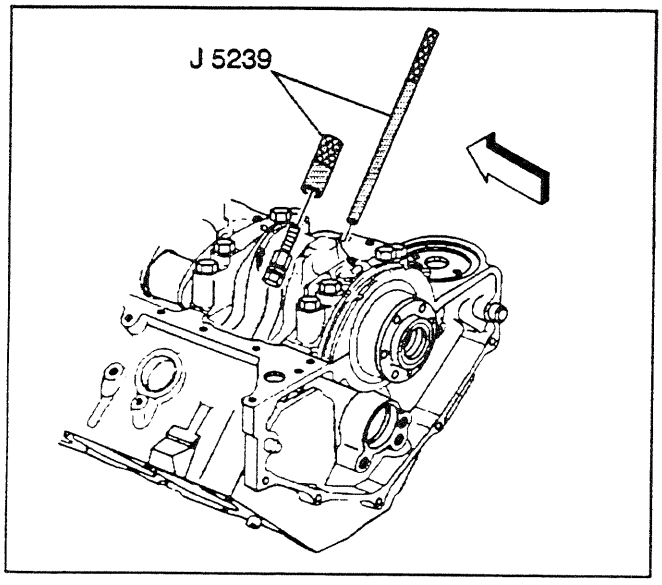


354028



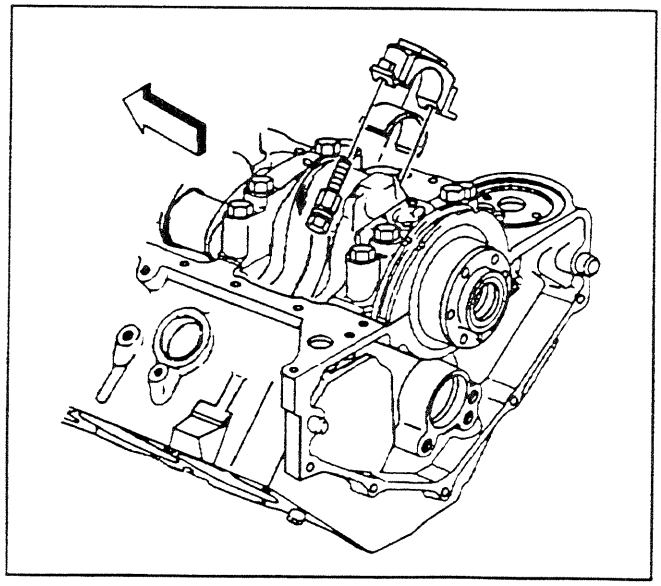
5159

3. Install the *J 8037* onto the piston and compress the piston rings.
4. Use the *J 8037* and the *J 5239* and lightly tap the top of the piston with a wooden hammer handle.
5. Hold the *J 8037* firmly against the engine block until all of the piston rings have entered the cylinder bore.



354029

6. Use the *J 5239* in order to guide the connecting rod onto the crankshaft journal.
7. Remove the *J 5239*.



354030

Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

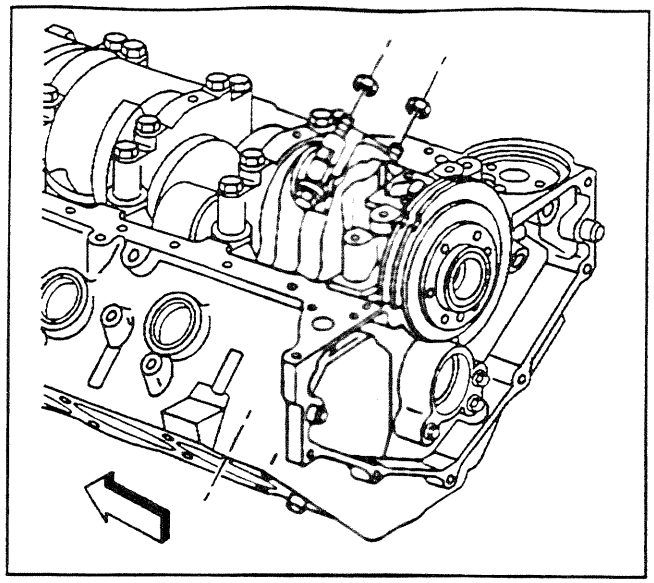
8. Install the connecting rod cap and lower connecting rod bearing.

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

9. Install the connecting rod nuts.

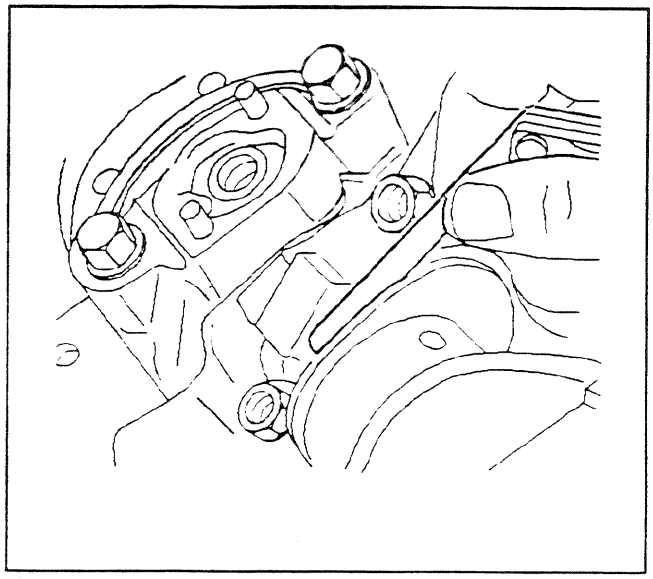
   Tighten

   Tighten the connecting rod nuts to 64 N·m (47 lb ft).



354031

10. Once the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly (parallel to the crankpin) in order to make sure that they have side clearance.
11. Use a feeler gauge or a dial indicator to measure the side clearance between the connecting rod caps. The rod side clearance should be 0.033–0.584 mm (0.0013–0.0230 in).



5163

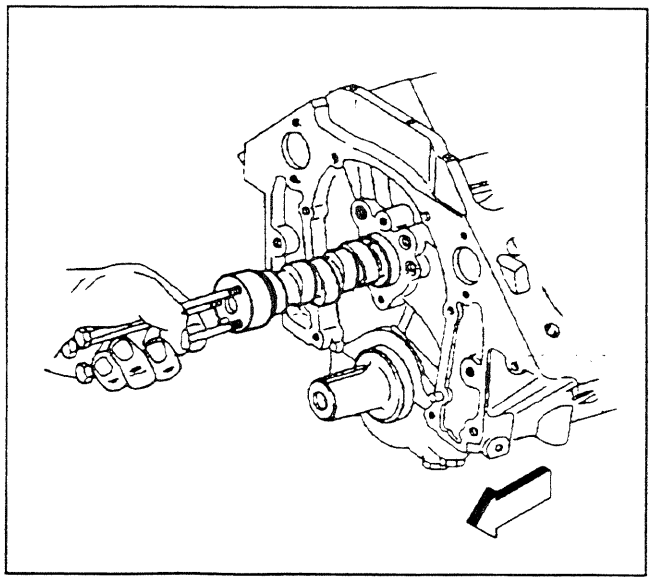
Camshaft Installation

SIE-ID = 200771

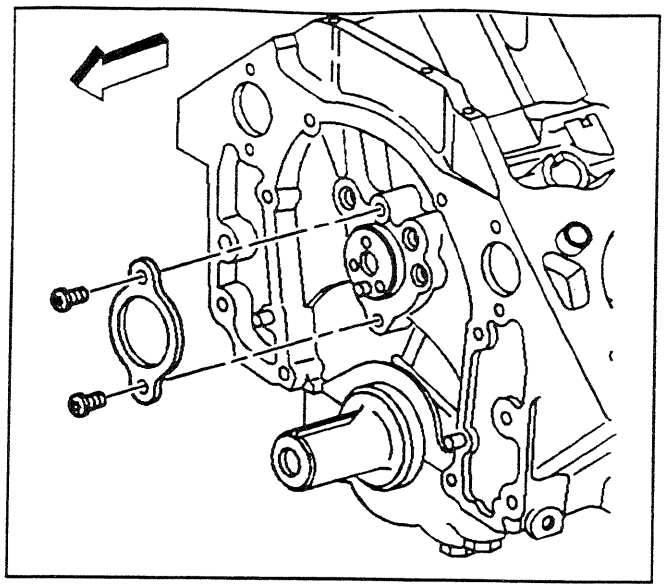
1. Lubricate the following components with clean engine oil, engine oil supplement GM P/N 1052367, or equivalent:
   - The camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

Notice: SIO-ID = 13833 All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

2. Install the three 5/16–18 x 4.0 inch bolts in the camshaft front bolt holes.
3. Using the bolts as a handle, install the camshaft.
4. Remove the three bolts from the front of the camshaft.



196588



193223

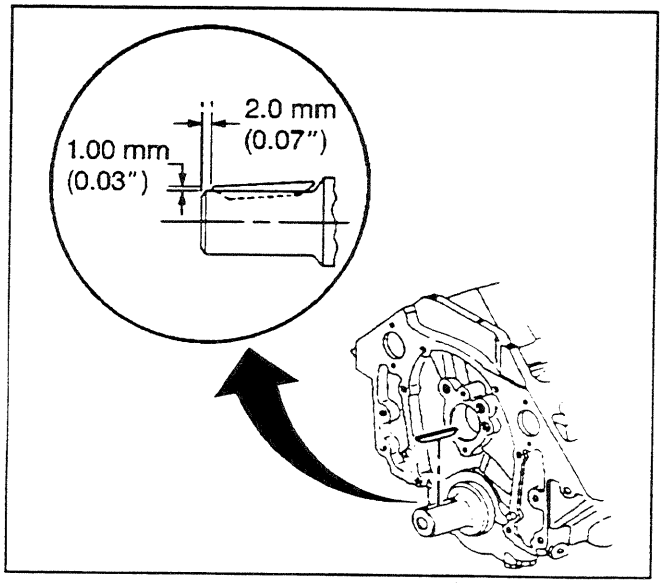
5. Install the camshaft retainer.

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

6. Install the camshaft retainer bolts.

Tighten

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



180902

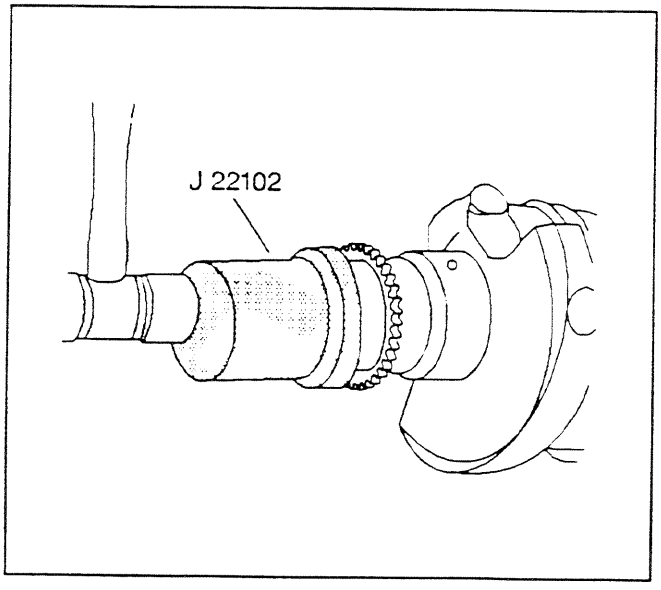
Timing Chain and Sprockets Installation

SIE-ID = 201100

Tools Required

J 22102 Crankshaft Sprocket Installer

1. Properly install the crankshaft key into the crankshaft keyway, if removed.



65850

Important: If the sprocket(s) are being replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

Install and align the keyway of the crankshaft sprocket with the crankshaft key.

2. Use the *J 22102* in order to install the crankshaft sprocket.
3. Rotate the crankshaft until the crankshaft sprocket alignment mark is at the 12 o'clock position.
4. Rotate the camshaft until the camshaft alignment pin is in the 3 o'clock position.

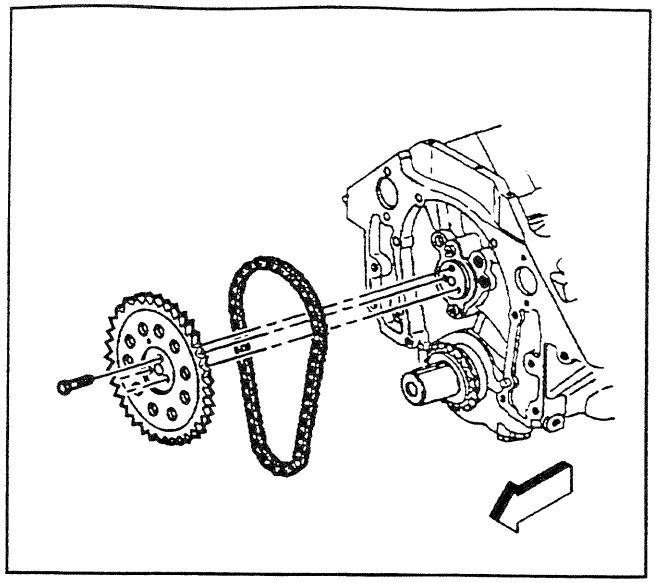
Notice: SIO-ID = 16333 Do not hammer the camshaft sprocket onto the camshaft. To do so may dislodge the rear camshaft plug and damage the camshaft.

Notice: SIO-ID = 609688 The sprocket teeth must mesh with the timing chain in order to prevent damage to the camshaft retainer.

Important: Ensure the camshaft alignment pin is engaged with the camshaft sprocket slot.

Place the timing chain on the camshaft sprocket with the camshaft sprocket alignment mark in the 6 o'clock position.

5. Install the camshaft sprocket and timing chain.



196671

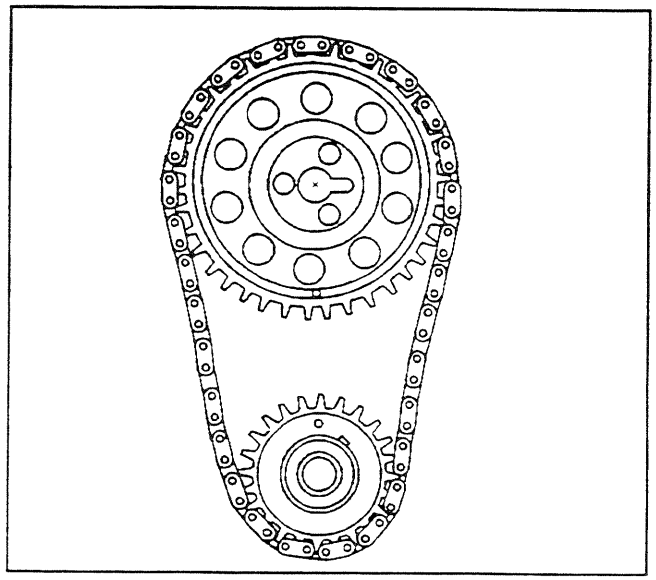
6. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

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

7. Install camshaft sprocket bolts.

Tighten

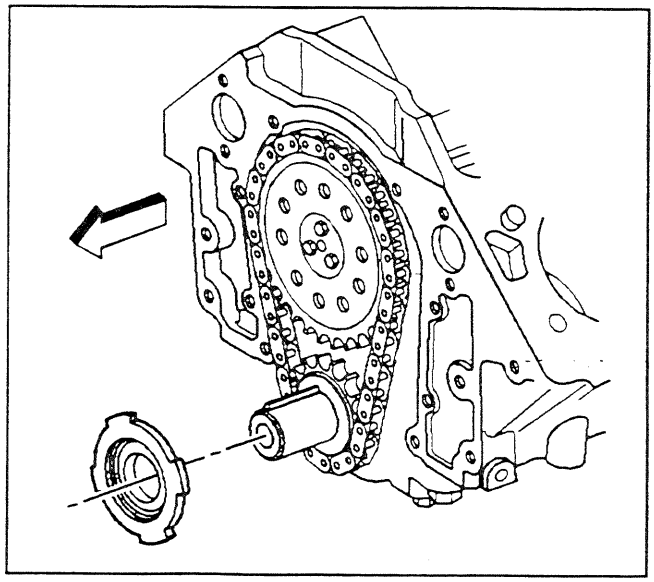
Tighten the camshaft sprocket bolts to 30 N·m (22 lb ft).



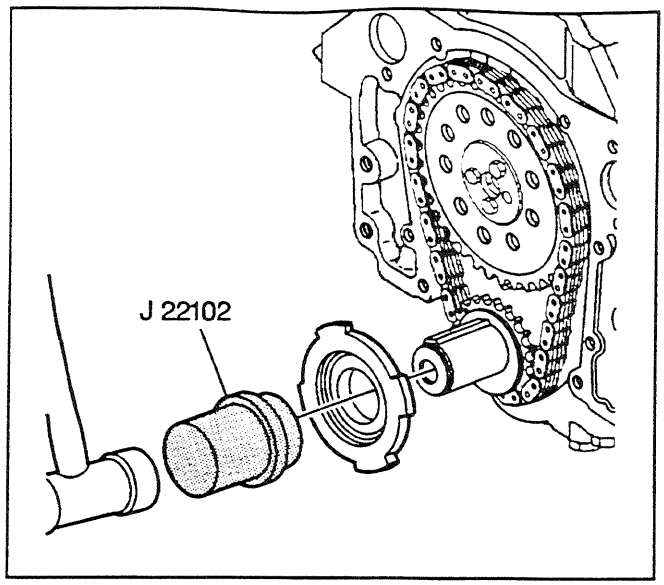
196651

Important: If the crankshaft sensor reluctor ring has been removed from the crankshaft, a new crankshaft sensor reluctor ring must be installed.

Install and align the keyway of the crankshaft position reluctor ring with the crankshaft key.



196642

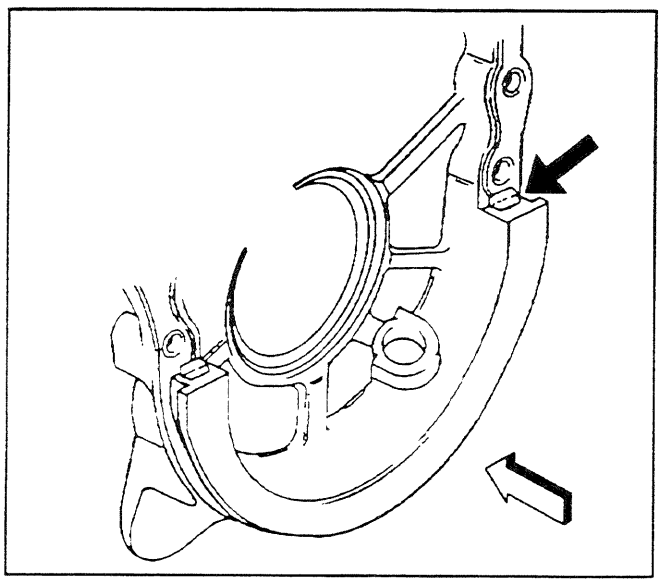


562808

Important: Ensure the *J 22102* contacts the crankshaft balancer contact area of the crankshaft position reluctor ring in order to prevent bending or damage to the crankshaft position reluctor ring teeth.

Important: It should be necessary to apply only light force in order to install the crankshaft position reluctor ring with the *J 22102*.

Use the *J 22102* in order to install the crankshaft position reluctor ring onto the crankshaft until the ring is completely seated against the crankshaft sprocket.



173190

Engine Front Cover Installation

SIE-ID = 201101

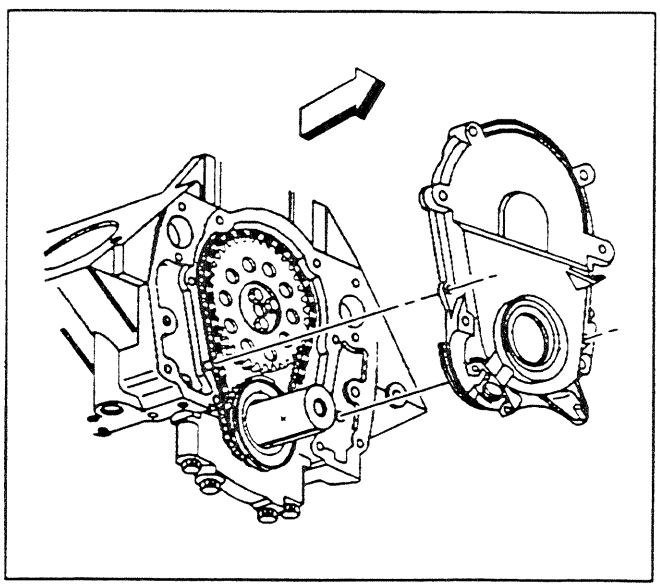
Tools Required

J 22102 Seal Installer

1. Install a NEW crankshaft front oil seal into the engine front cover using the *J 22102*.
2. Lubricate the sealing surface of the crankshaft front oil seal with clean engine oil.

Important: The engine front cover must be installed and the fasteners tightened while the sealant is still wet to the touch.

Apply the sealant GM P/N 12345739 or equivalent in two sealant points on the engine front cover where the engine front cover meets the oil pan.



64547

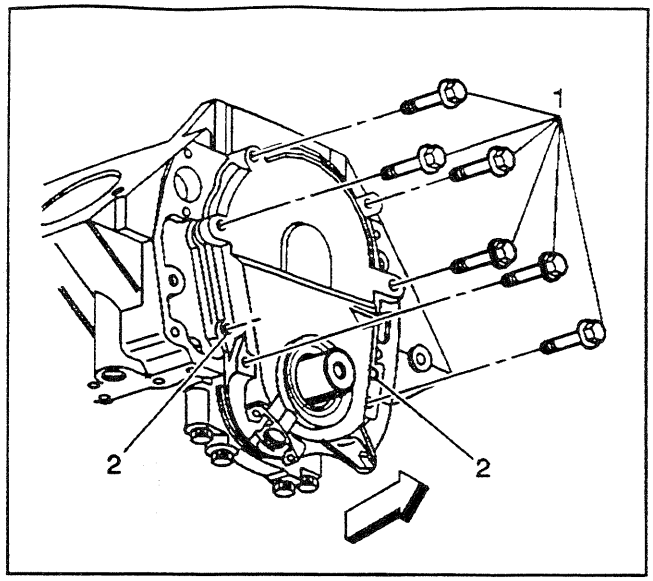
3. Install the engine front cover.

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

4. Install the engine front cover bolts (1).

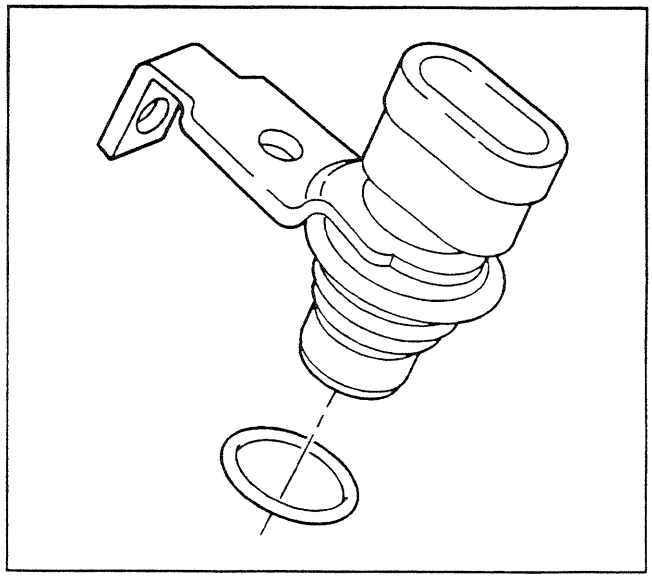
   Tighten

   Tighten the engine front cover bolts (1) to 12 N·m (106 lb in).



342207

5. Install the new O-ring seal onto the crankshaft position sensor. Apply clean engine oil to the O-ring.



562733

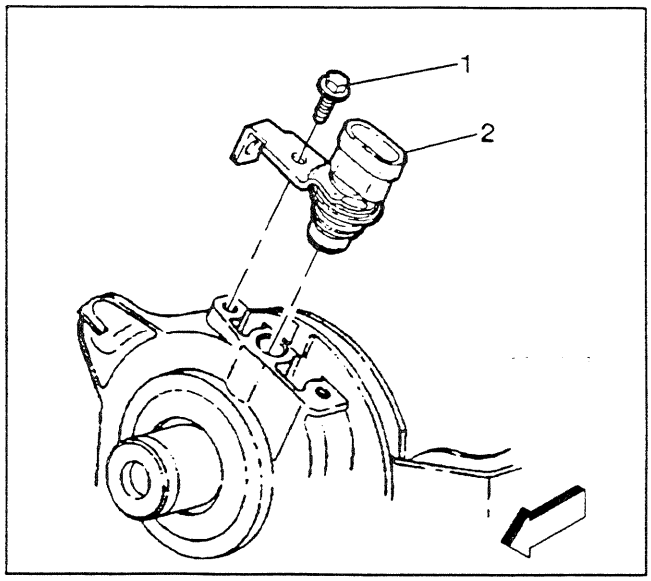
6. Install the crankshaft position sensor (2).

Notice: SIO-ID = 451379 This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

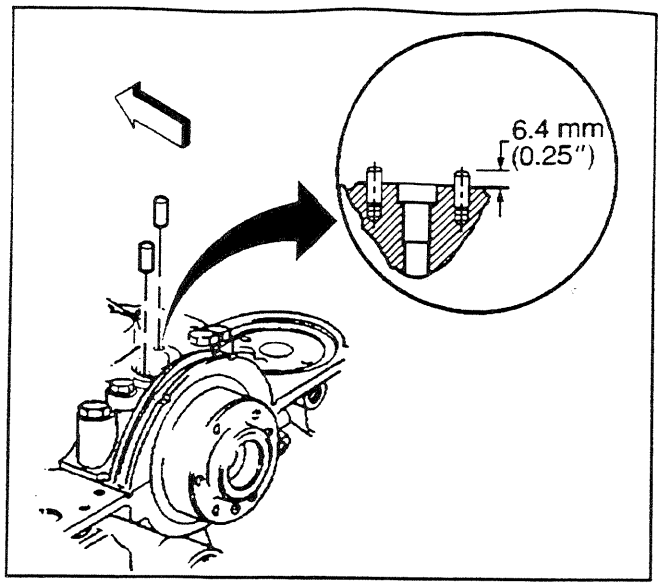
7. Install the crankshaft position sensor bolt (1).

   Tighten

   Tighten the crankshaft position sensor bolt (1) to 12 N·m (106 lb in).



18090

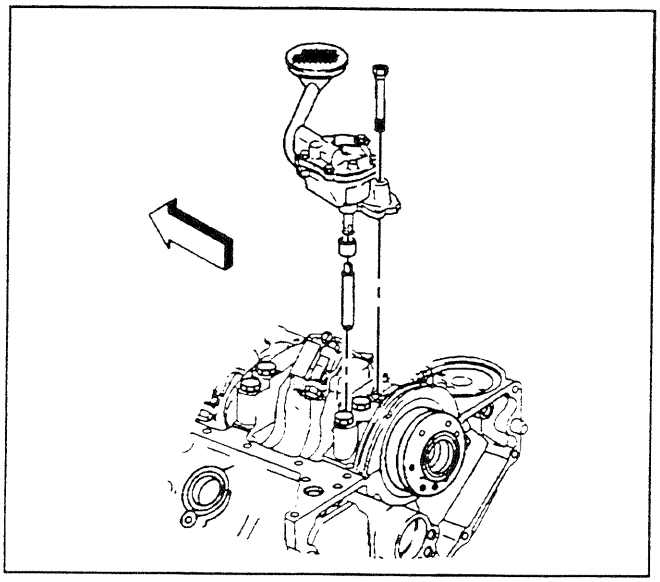


180863

Oil Pump, Pump Screen and Deflector Installation

SIE-ID = 201109

1. Inspect for properly installed oil pump locating pins.



173183

Important: During assembly, install a NEW oil pump driveshaft retainer. Slightly heat retainer above room temperature for ease of installation onto the oil pump driveshaft.

Assemble the oil pump, driveshaft, and a NEW retainer.

2. Install the oil pump assembly.

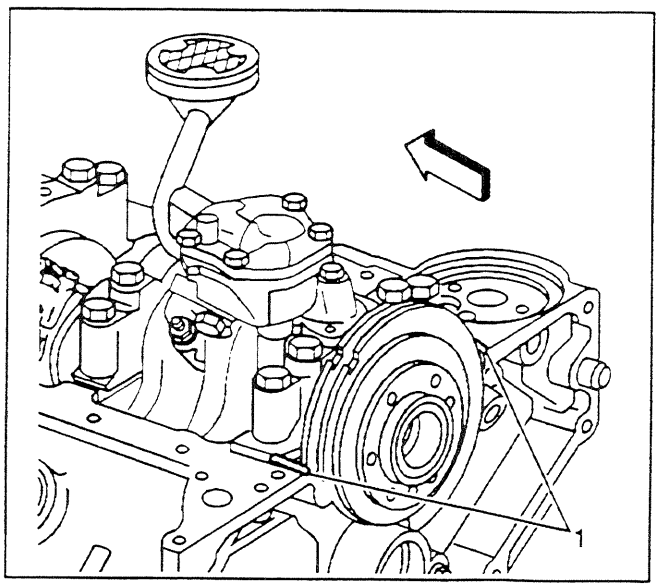
   Position the oil pump onto the locating pins.

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

3. Install the bolt attaching the oil pump to the rear crankshaft bearing cap.

   Tighten

   Tighten the oil pump bolt to 88 N·m (65 lb ft).



351798

Oil Pan Installation

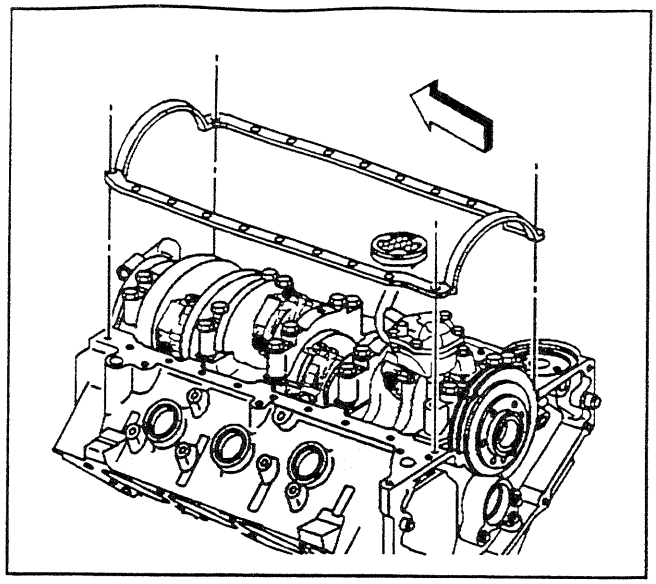
SIE-ID = 489062

Important: The oil pan must be installed and the fasteners tightened while the sealant is still wet to the touch.

Apply sealant GM P/N 12345739 or the equivalent in two sealant points where rear crankshaft bearing cap meets the engine block (1).

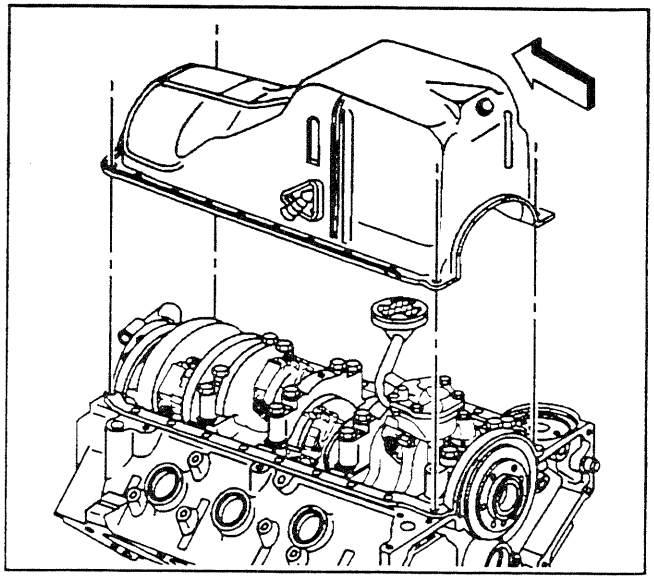
1. Apply sealant GM P/N 12345739 or the equivalent in two sealant points where engine front cover meets the block.

2. Install the oil pan gasket onto the engine block.



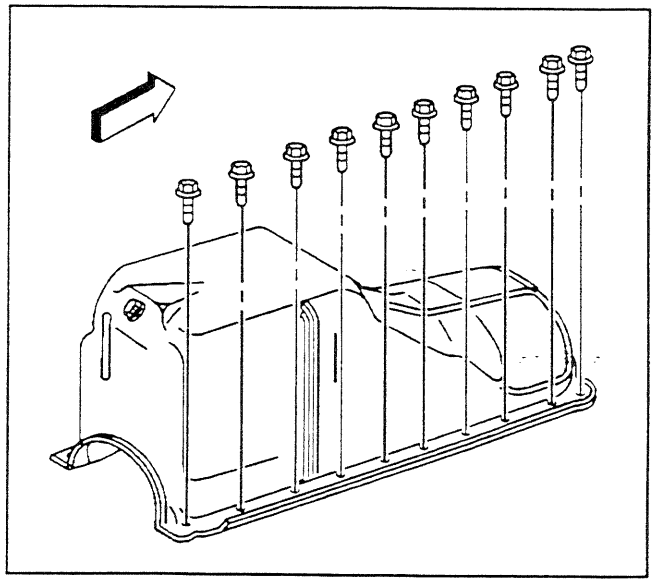
351800

3. Install the oil pan.

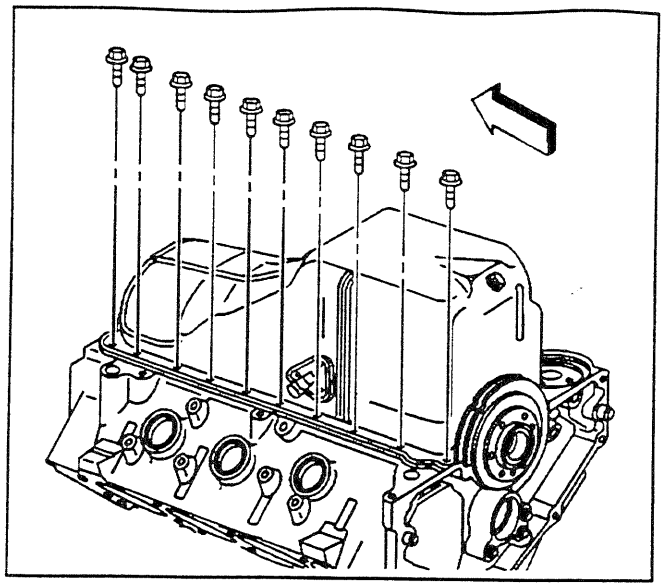


351803

4. Loosely install the left side oil pan bolts.



351809



351806

5. Loosely install the right side oil pan bolts.

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

6. Install the oil pan bolts.

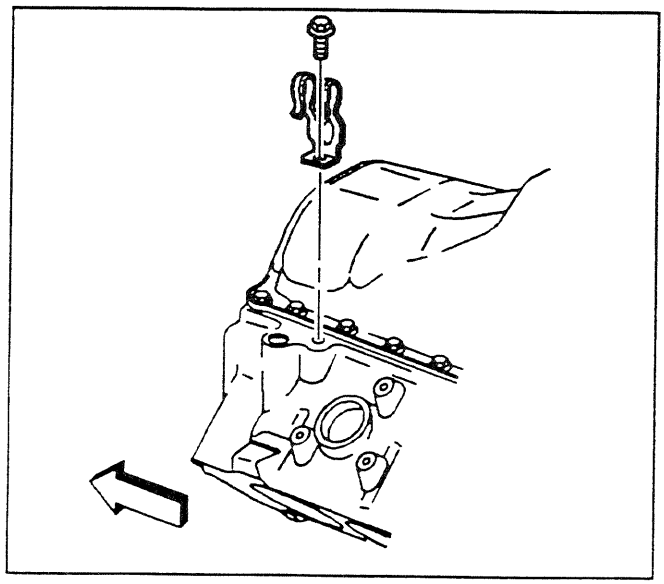
   Tighten

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

7. Install the oil pan drain plug.

   Tighten

   Tighten the oil pan drain plug to 28 N·m (21 lb ft).

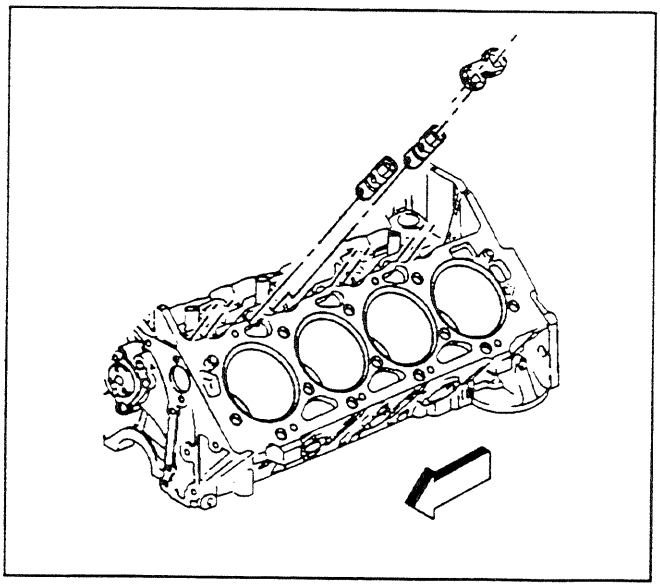


492038

8. Install the transmission oil cooler pipe clip (RPO MT1).
9. Install the transmission oil cooler pipe clip bolt (RPO MT1).

   Tighten

   Tighten the transmission oil cooler pipe clip bolt to 22 N·m (16 lb ft).



173176

Valve Lifter Installation

SIE-ID = 201124

SIO-ID = 201123

Important: If a new camshaft is installed, replace all the valve lifters.

Coat the valve lifter rollers with prelube, GM P/N 1052367 or equivalent.

Important: If reusing the valve lifters, install in their original location. The valve lifter guide retainer must contact all of the valve lifter guides. If the valve lifter guide retainer is bent, the valve lifter guide retainer must be replaced.

Install the valve lifters.

1. Install the valve lifter guides.

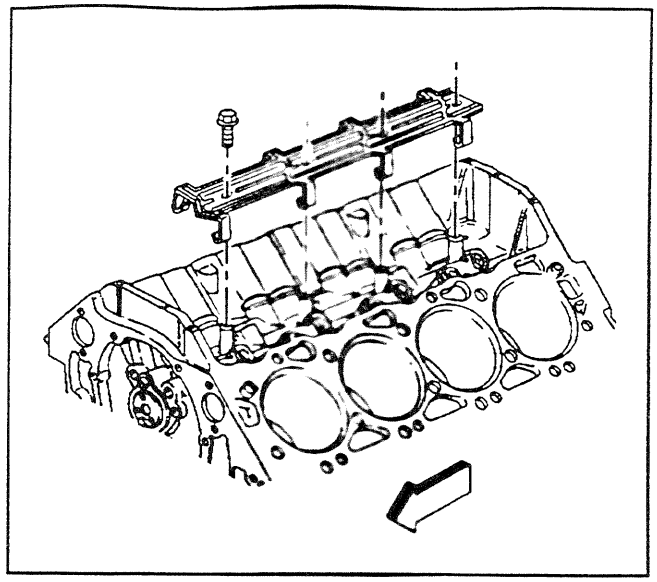
2. Install the valve lifter guide retainer.

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

3. Install the valve lifter guide retainer bolts.

   Tighten

   Tighten the valve lifter guide retainer bolts to 25 N·m (18 lb ft).

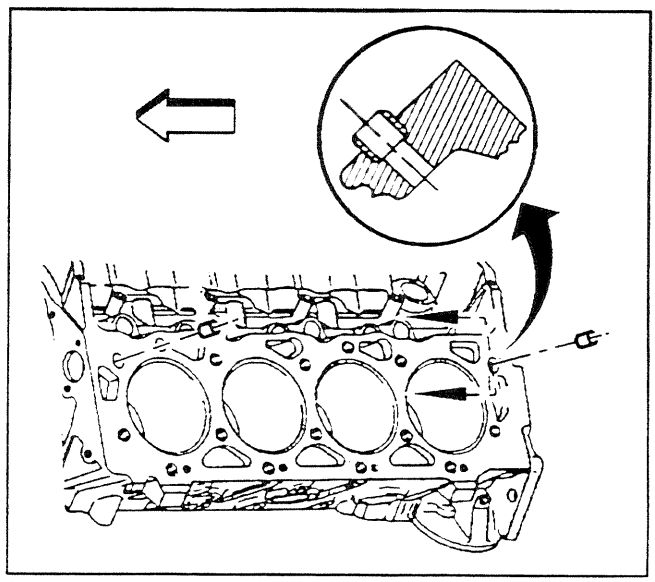


173193

Cylinder Head Installation (Left)

SIE-ID = 441909

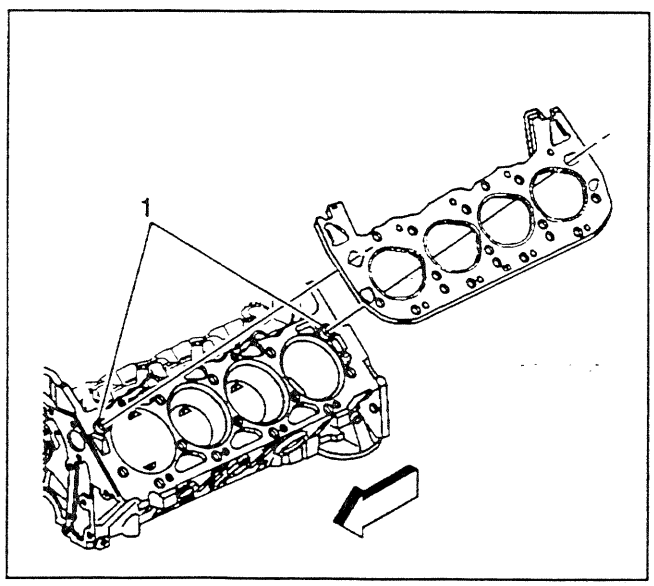
1. Clean the cylinder head gasket surfaces. Refer to *Replacing Engine Gaskets.*
2. Install the cylinder head locating pins, if removed.



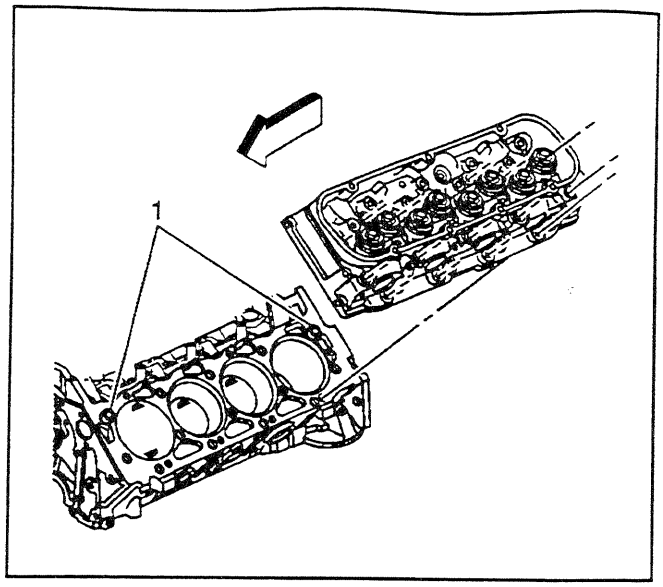
180904

Important: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket. Align the cylinder head gasket locating mark to face up.

Place the cylinder head gasket in position over the cylinder head locating pins (1).



354038



354040

Important: Guide the cylinder head carefully into place over the locating pins (1) and the cylinder head gasket.

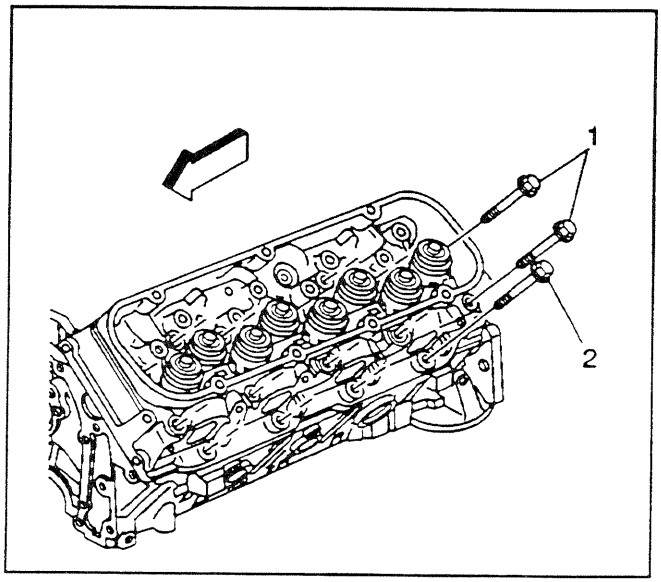
Install the cylinder head to the block.

Notice: SIO-ID = 311287 Always use NEW cylinder head bolts when servicing the cylinder head.

Do not reuse the cylinder head bolts, because the bolts may stretch or break causing engine damage.

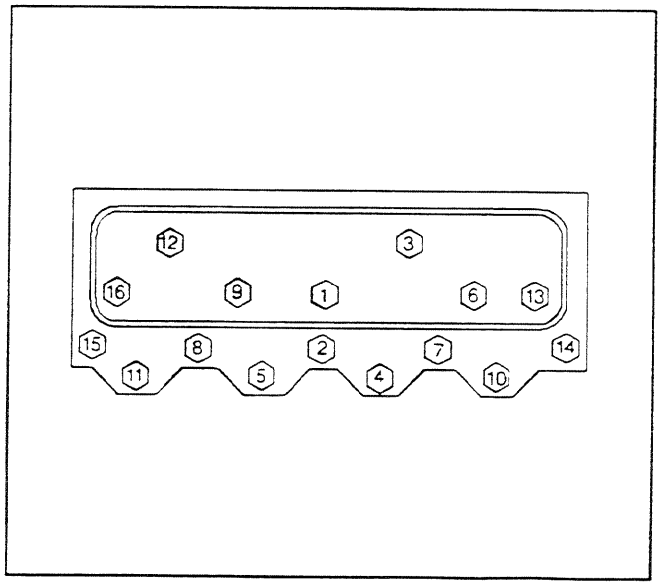
Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the cylinder head bolts. Refer to *Use of RTV and Anaerobic Sealer.*



354041

3. Loosely install the cylinder head bolts (1 and 2).



64549

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

4. Install the cylinder head bolts.
   - 4.1. First Pass

     Tighten

     Tighten the cylinder head bolts to 50 N·m (37 lb ft).
   - 4.2. Final Pass

     Tighten

     150 degrees bolt #1, 2, 3, 6, 7, 8, 9, 12, 14, 15

     150 degrees bolt #13, 16

     90 degrees bolt #4, 5, 10, 11
5. Install the spark plugs.

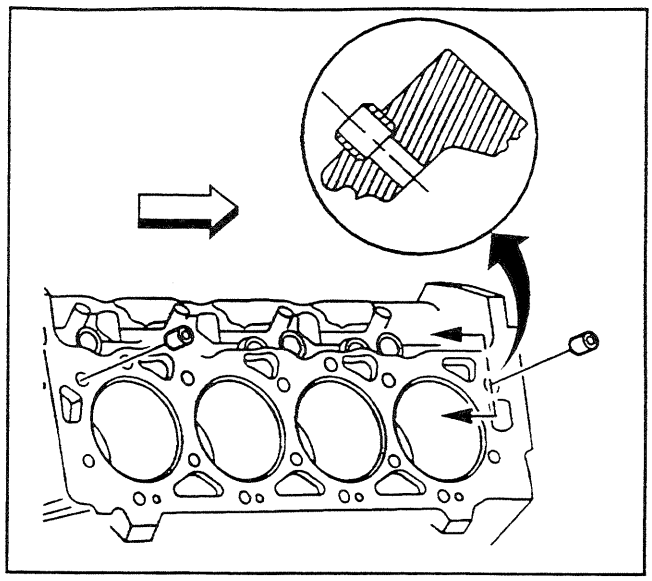
   Tighten

- Tighten the spark plugs in a new cylinder head to 30 N·m (22 lb ft).
- Tighten the spark plugs in serviced cylinder heads to 20 N·m(15 lb ft).

Cylinder Head Installation (Right)

SIE-ID = 441910

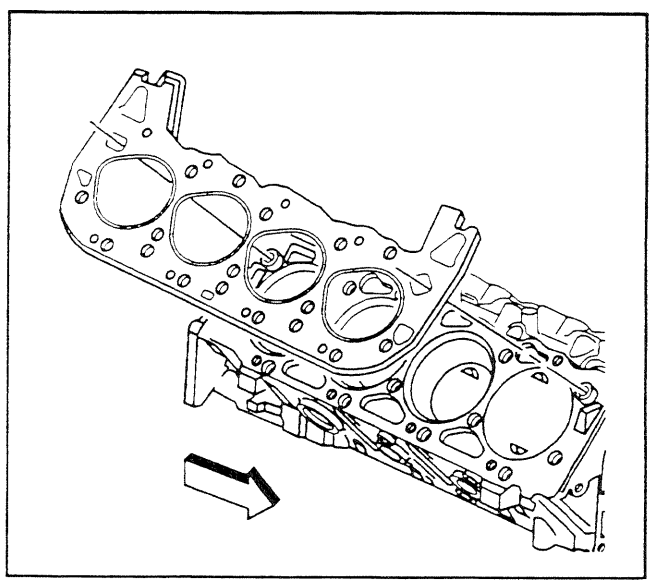
1. Clean the cylinder head gasket surfaces. Refer to *Replacing Engine Gaskets*.
2. Install the cylinder head locating pins, if removed.



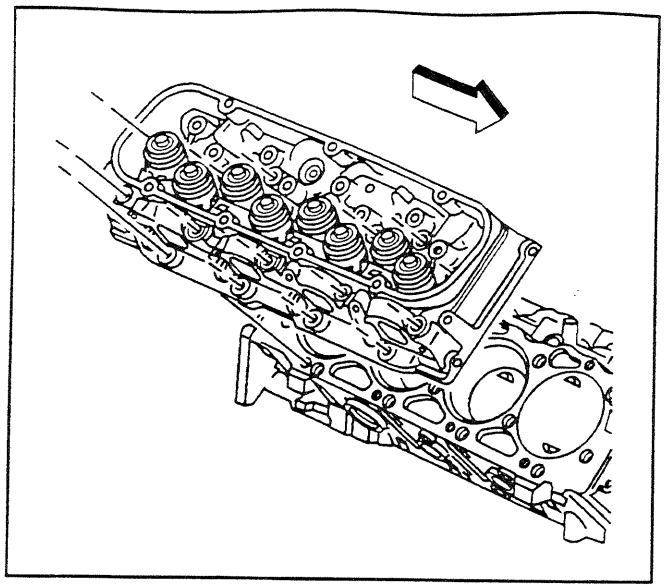
562727

Important: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket. Align the cylinder head gasket locating mark to face up.

Place the cylinder head gasket in position over the cylinder head locating pins.



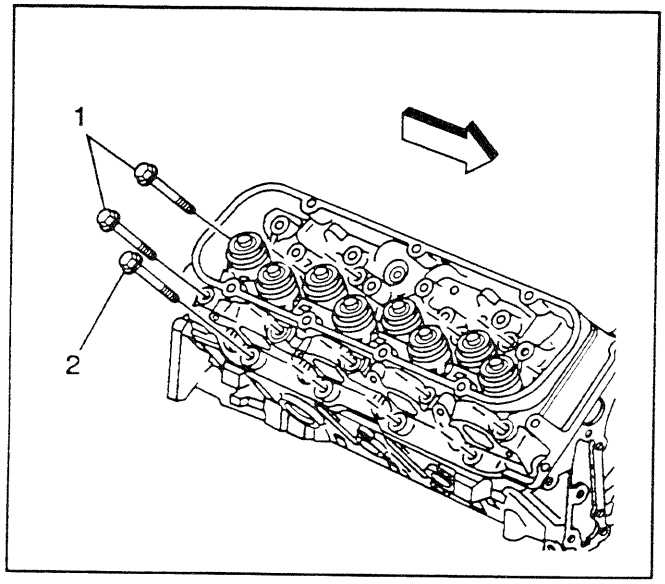
562717



562710

Important: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

Install the cylinder head to the block.



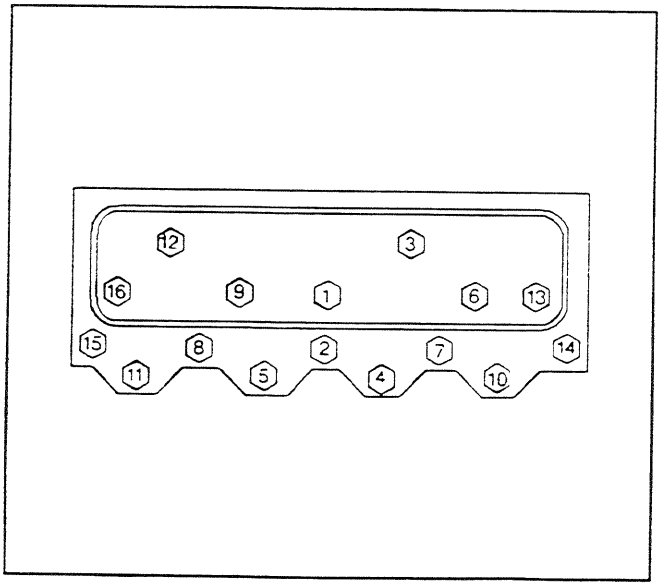
562687

Notice: SIO-ID = 311287 Always use NEW cylinder head bolts when servicing the cylinder head.

Do not reuse the cylinder head bolts, because the bolts may stretch or break causing engine damage.

Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004 or equivalent to the cylinder head bolts (1, 2). Refer to *Use of RTV and Anaerobic Sealer.*



64549

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

3. Install the cylinder head bolts.
   - 3.1. First Pass

     Tighten

     Tighten the cylinder head bolts to 50 N·m (37 lb ft).
   - 3.2. Final Pass

     Tighten

     150 degrees bolt #1, 2, 3, 6, 7, 8, 9, 12, 14, 15

     150 degrees bolt #13, 16

     90 degrees bolt #4, 5, 10, 11
4. Install the spark plugs.

   Tighten

- Tighten the spark plugs in a new cylinder head to 30 N·m (22 lb ft).
- Tighten the spark plugs in serviced cylinder heads to 20 N·m(15 lb ft).

Valve Rocker Arm and Push Rod Installation

SIE-ID = 201161

Important: Be sure to keep parts in order. Parts must be put back from where they were removed.

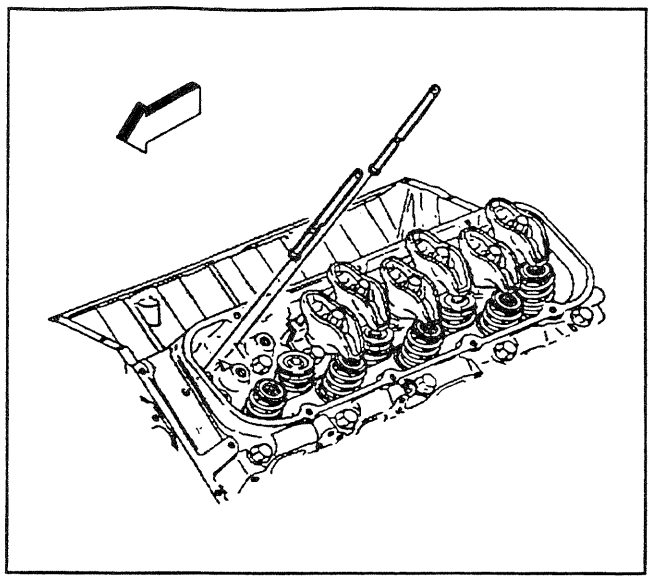
Coat the valve rocker arm and valve rocker arm ball bearing surfaces with prelube GM P/N 1052367 or equivalent.

Important: Be sure that the valve pushrods seat in the valve lifter sockets.

Important: The 7.4L engine uses different length intake and exhaust valve pushrods.

The exhaust valve pushrods are longer than the intake valve pushrods.

Install the valve pushrods.



202196

1. Set the number one cylinder to top dead center (TDC) on the compression stroke.
2. Loosely install the following parts:
   2.1. The valve pushrod guides
   2.2. The valve rocker arms
   2.3. The valve rocker arm balls
   2.4. The valve rocker arm bolts

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

Important: It is necessary to follow the following procedure for proper valve train alignment.

Tighten the intake rocker arm bolts on cylinders 1, 2, 5 and 7.

Tighten

Tighten the above intake rocker arm bolts to 54 N·m (40 lb ft).

3. Tighten the exhaust rocker arm bolts on cylinders 1, 3, 4 and 8.

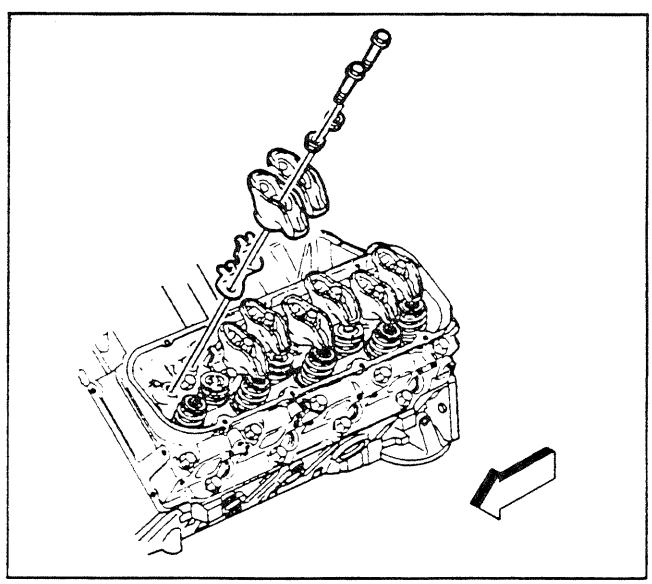
   Tighten

   Tighten the above intake rocker arm bolts to 54 N·m (40 lb ft).
4. Rotate the crankshaft one full turn (360 degrees).
5. Tighten the intake rocker arm bolts on cylinders 3, 4, 6 and 8.

   Tighten

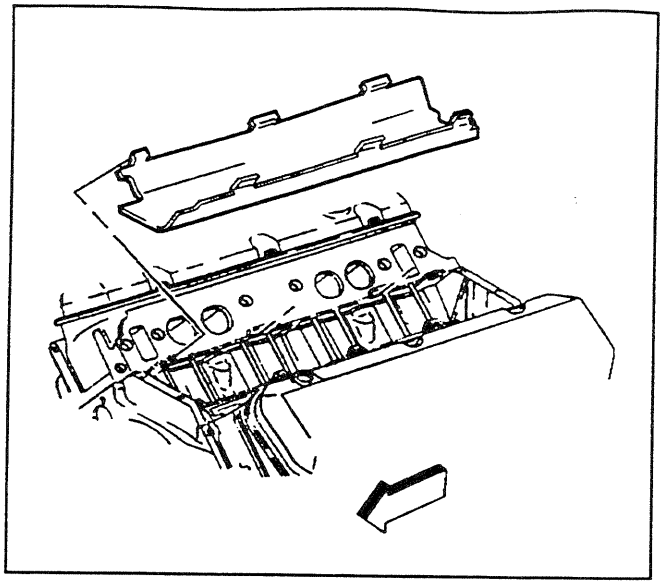
   Tighten the above intake rocker arm bolts to 54 N·m (40 lb ft).
6. Tighten the exhaust rocker arm bolts on cylinders 2, 5, 6 and 7.

   Tighten



354070

Tighten the above intake rocker arm bolts to 54 N·m (40 lb ft).

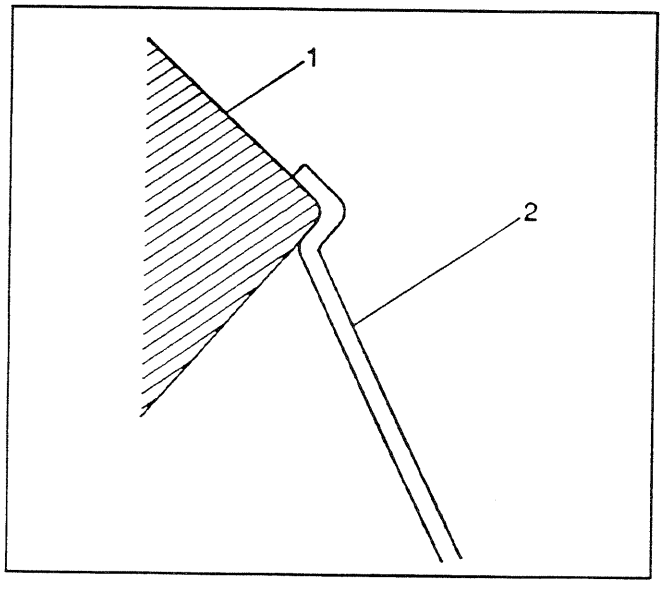


276364

Intake Manifold Installation

SIE-ID = 201174

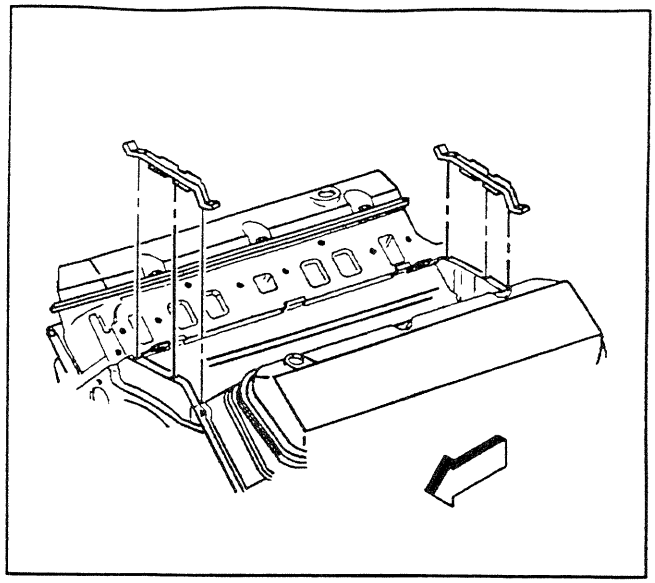
1. Install the splash shield.



413867

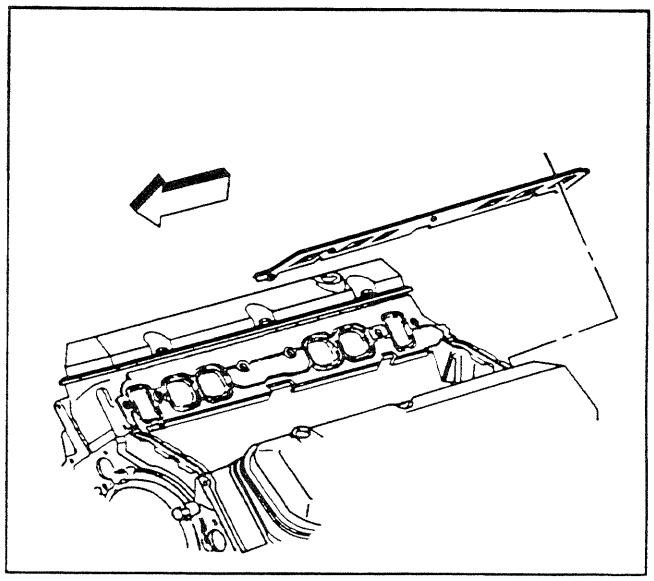
2. Ensure the splash shield (2) snap fits between the cylinder heads (1).

3. Install the new lower intake manifold seals.



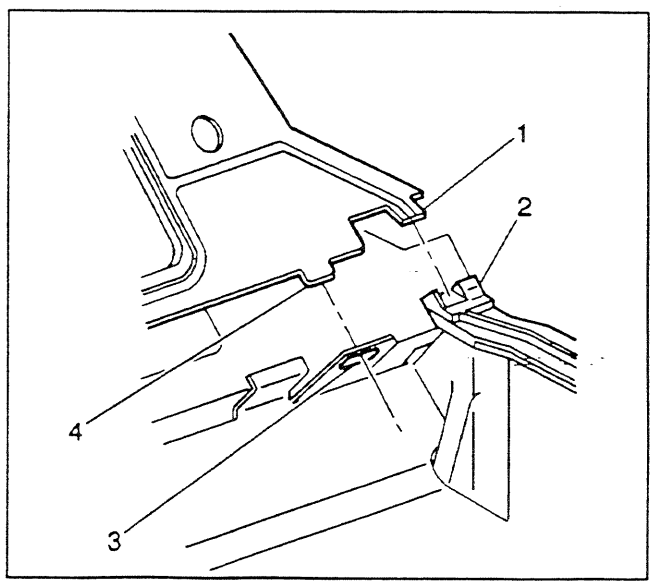
351757

4. Install the new lower intake manifold gaskets onto the cylinder heads.

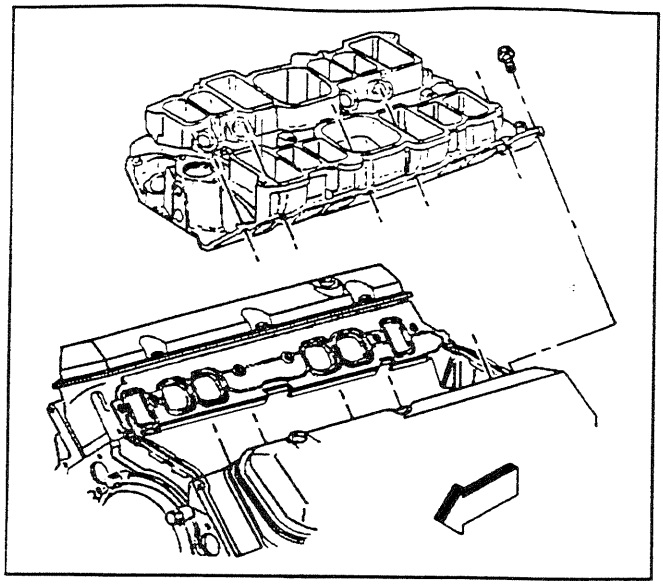


351760

5. Ensure the lower intake manifold gasket tabs (4) align with the hole in the head gasket (3).
6. Ensure the lower intake manifold gasket tabs (1) align with the slot in the lower intake manifold seals (2).

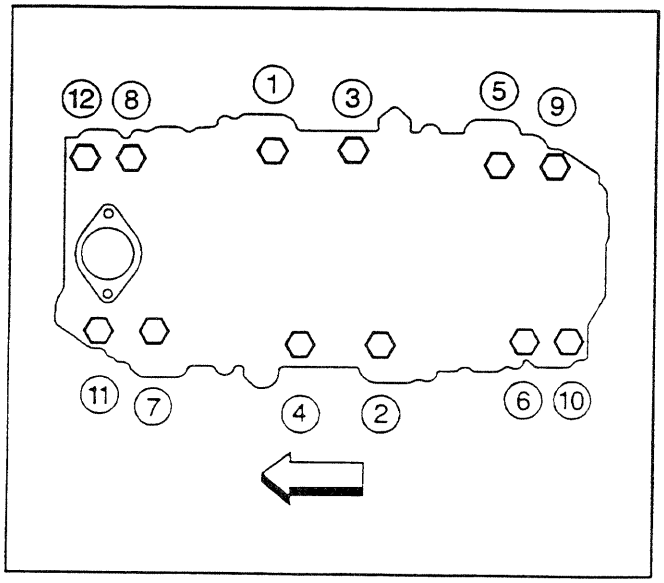


351762



351763

7. Install the lower intake manifold onto the engine block.
8. Apply sealer GM P/N 12345382 or equivalent to a minimum of eight threads of the lower intake manifold bolts.



677BC

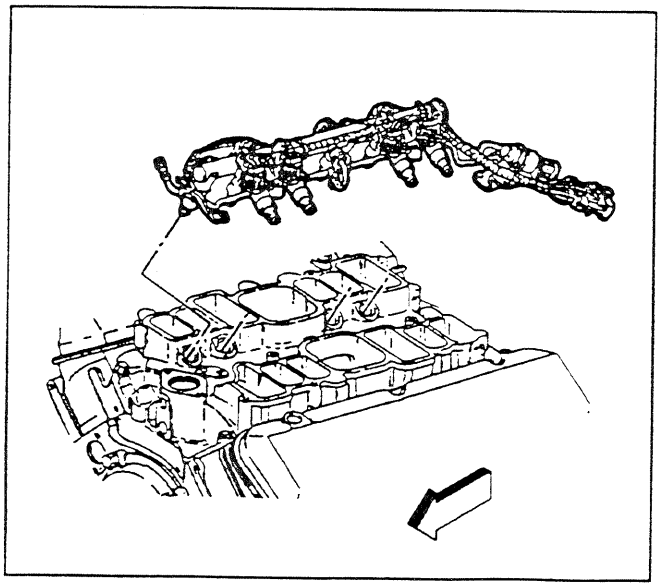
Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Install the lower intake manifold bolts.

   Tighten

   9.1. Tighten the lower intake manifold bolts (1-8) a first pass in sequence to 30 N·m (22 lb ft).

   9.2. Tighten the lower intake manifold bolts (1-8) a final pass in sequence to 40 N·m (30 lb ft).



276369

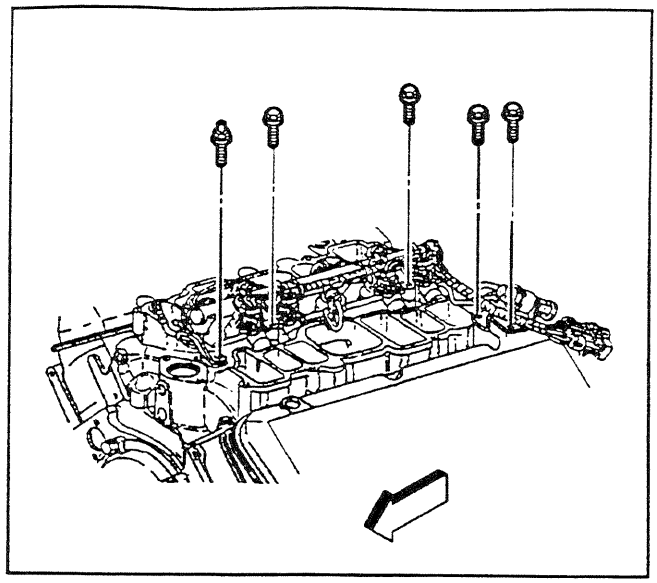
Important: Lubricate the injector O-ring seals with clean engine oil and install onto the spray tip end of each injector.

Install the fuel rail assembly into the intake manifold. Tilt the rail assembly to install the injectors.

10. Install the fuel rail bolts and stud.

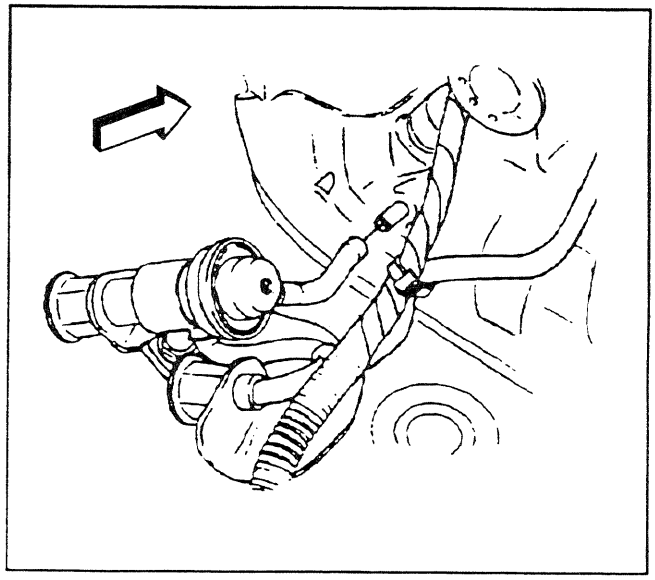
    Tighten

    - Tighten the fuel rail bolts to 10 N·m (89 lb in).
    - Tighten the fuel rail stud to 25 N·m (18 lb ft).



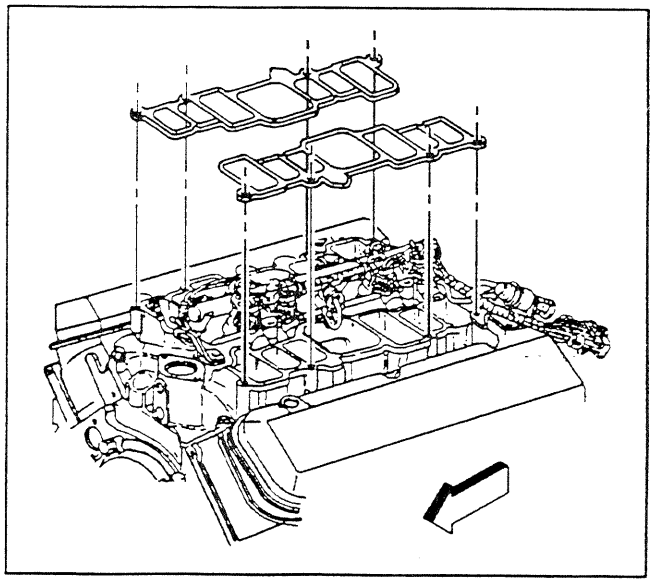
276370

11. Connect the fuel injector regulator vacuum hose connection to the intake manifold fitting.

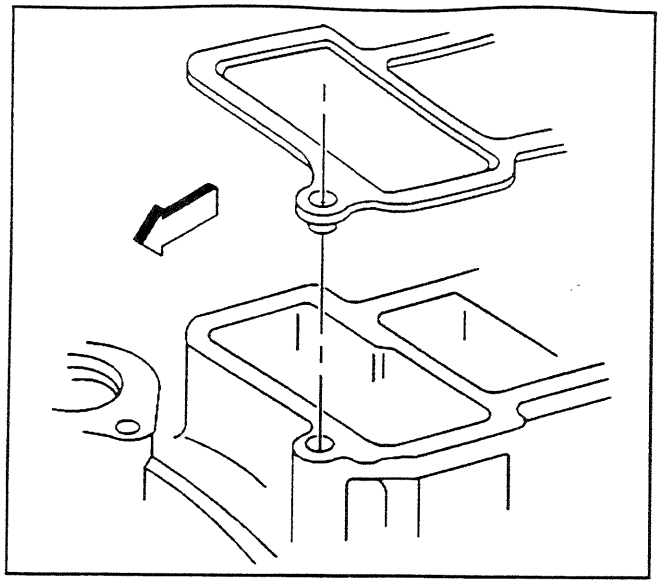


501422

12. Install the new upper intake manifold gaskets.

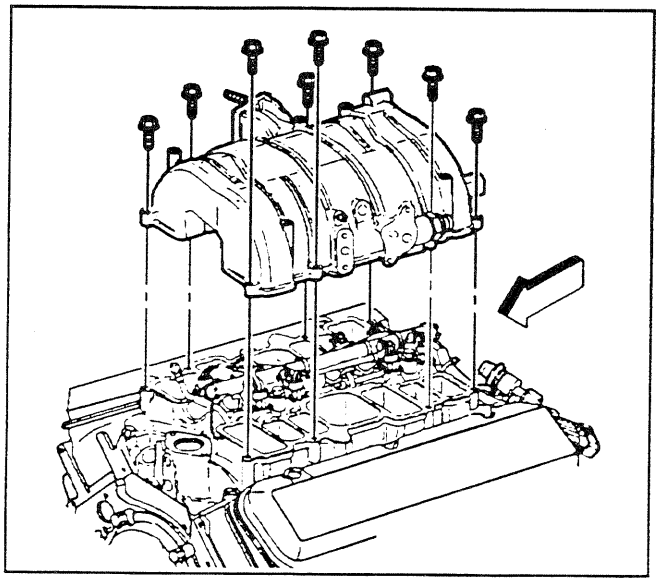


351764



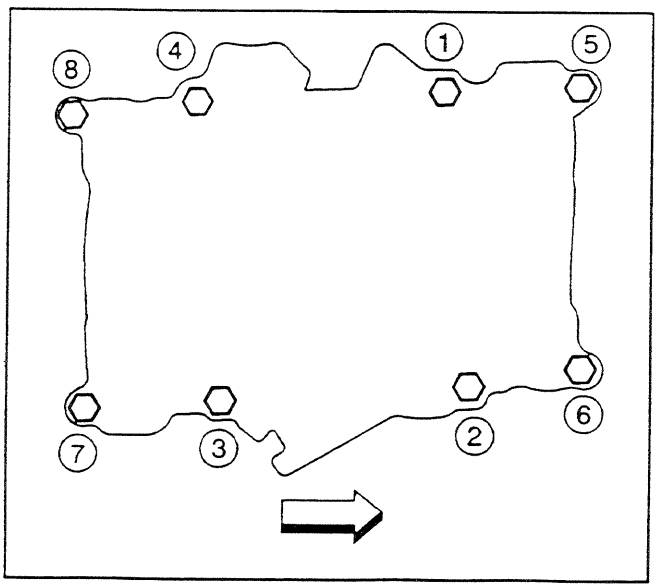
351766

13. Ensure the locating tabs on the gasket fit into the lower intake manifold counterbores.



351769

14. Install the upper intake manifold.
15. Apply sealer GM P/N 12345493 or equivalent to a minimum of eight threads of the upper intake manifold bolts.



67778

16. Install the upper intake manifold bolts.

Tighten

16.1. Tighten the upper intake manifold bolts (1–8) a first pass in sequence to 8 N·m (71 lb in).

16.2. Tighten the upper intake manifold bolts (1–8) a final pass in sequence to 18 N·m (13 lb ft).

Throttle Body Installation

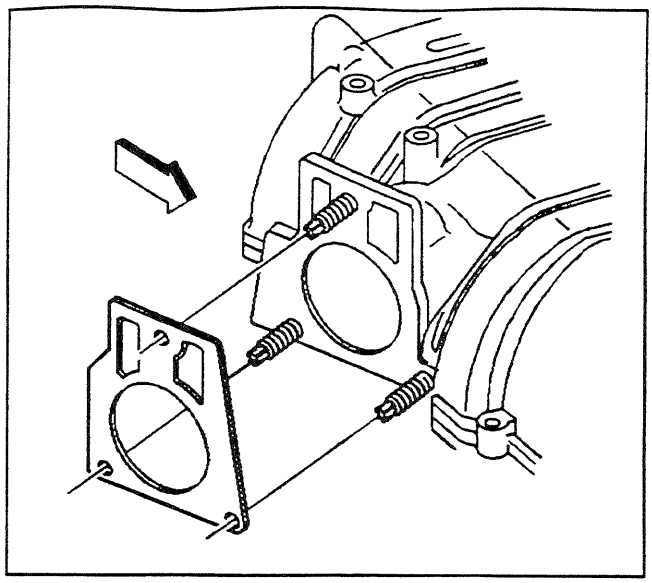
SIE-ID = 563867

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

1. Install the throttle body studs, if removed.

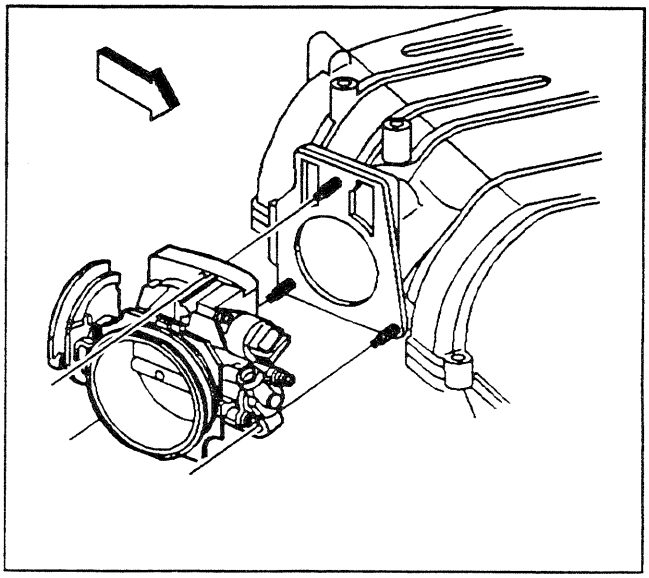
   Tighten

   Tighten the studs to 12 N·m (18 lb ft).
2. Install the throttle body gasket.



18303

3. Install the throttle body onto the manifold.

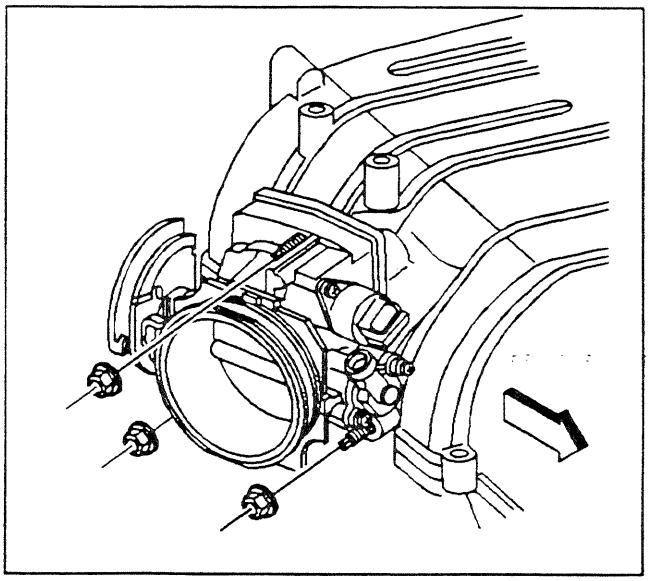


18302

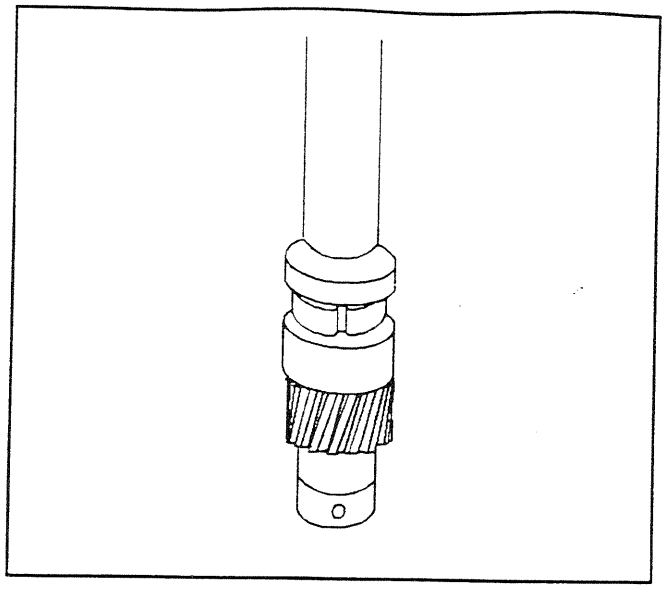
4. Install the throttle body nuts.

   Tighten

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



18299



43756

Distributor Installation

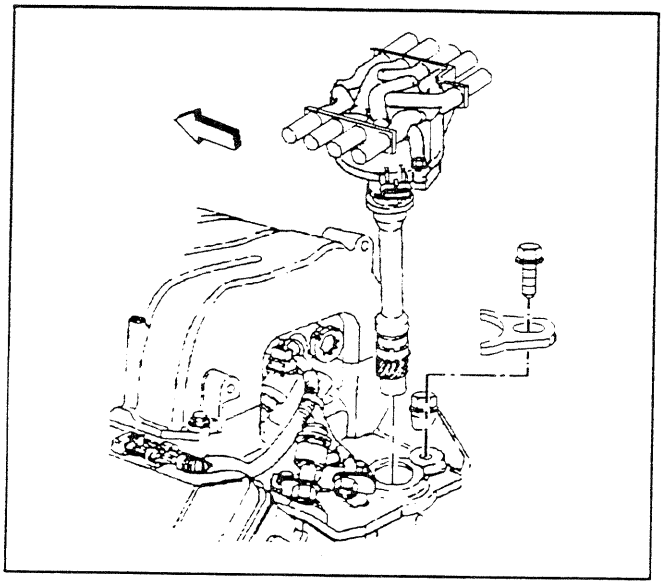
SIE-ID = 201189

1. Bring cylinder number one piston to TDC (Top Dead Center) of the compression stroke.

Important: Distributor cap screws are not captured in the distributor cap.

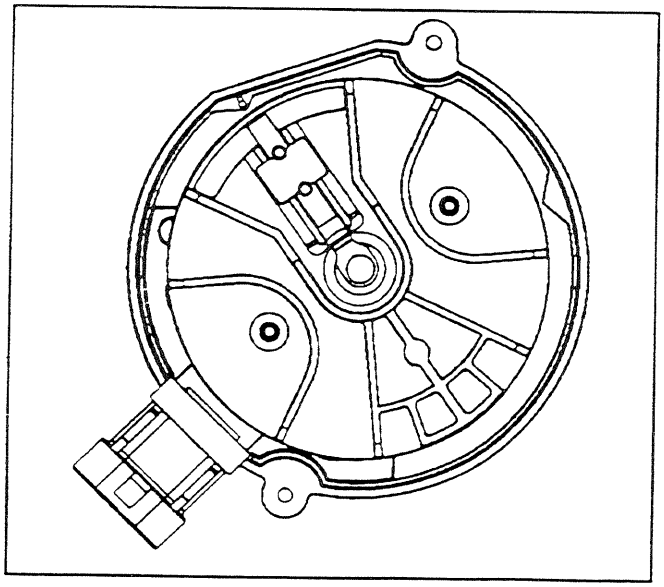
Remove the distributor cap screws to expose the rotor.

2. Align the pre-drilled indent hole in the distributor driven gear with the white painted alignment line on the lower portion of the shaft housing.
3. Using a long screw driver, align the oil pump drive shaft in the engine with the mating drive tab at the end of the distributor shaft.



68504

4. Guide the distributor into place.
5. Make sure the distributor is fully seated in the engine.
   5.1. If the distributor is not fully seated, the oil pump drive shaft may not be aligned with the mating drive tab at the end of the distributor shaft.
   5.2. Remove the distributor and align the oil pump drive shaft as stated above.



68505

6. Once the distributor is fully seated, the rotor segment should be aligned with the pointer cast into the distributor base.
   - The pointer has a (8) cast into it, indicating the distributor is for an eight cylinder engine.
   - If the rotor segment does not come out within a few degrees of the pointer (8), the gear mesh between the distributor and the camshaft may be OFF by a tooth or more.
   - If this is the case repeat this procedure to achieve the proper alignment.

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

7. Install the distributor hold down clamp bolt to the lower intake manifold.

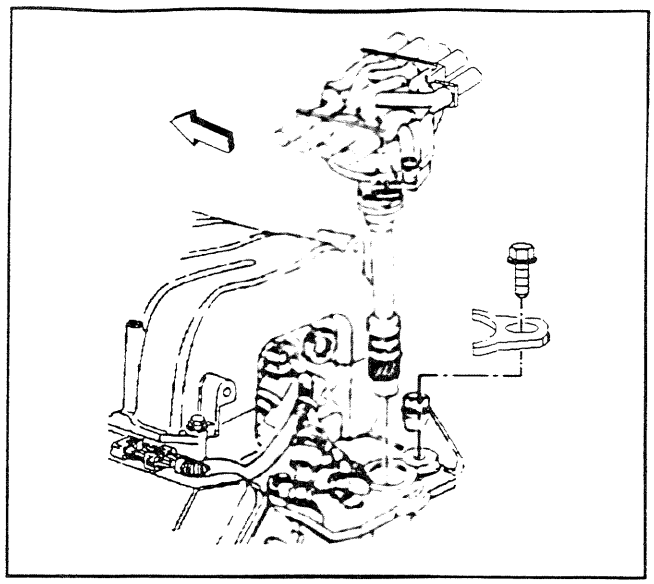
   Tighten

   Tighten the distributor clamp bolt to 33 N·m (24 lb ft).

8. Install the distributor cap.
9. Install the distributor cap screws. Do not overtighten.

   Tighten

   Tighten the cap holding screws to 5 N·m (40 lb in).

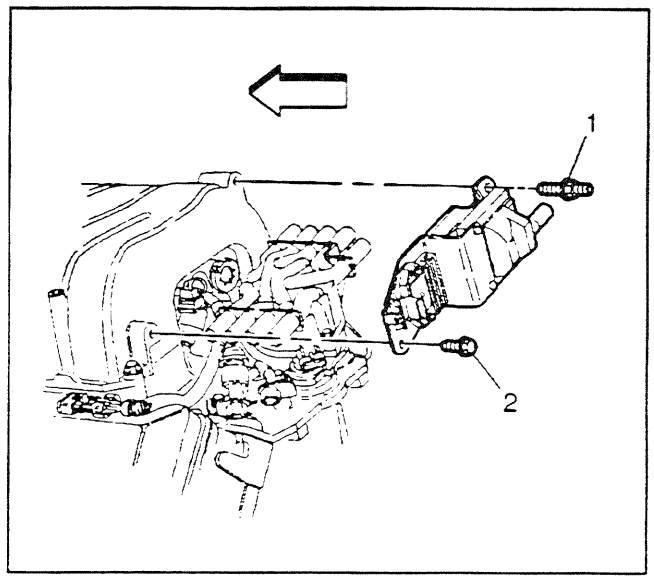


68504

10. Install the ignition coil to the upper intake manifold.
11. Install the ignition coil bracket bolt (2) and stud (1) to the upper intake manifold.

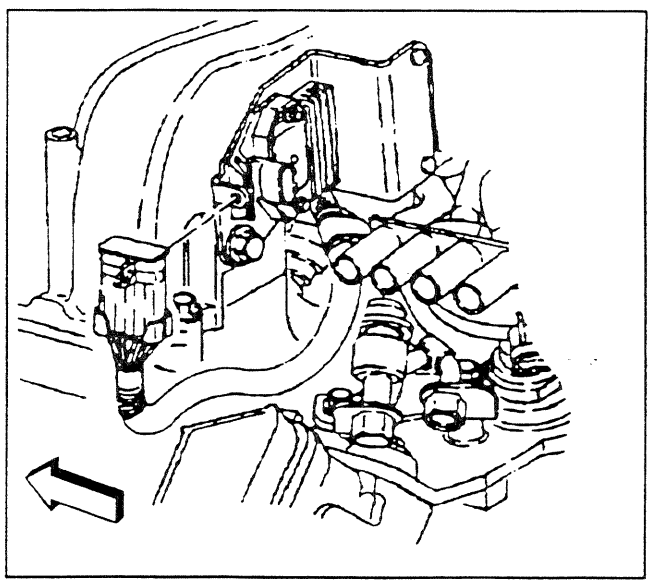
    Tighten

    Tighten ignition coil bracket bolt (2) and stud (1) to 25 N·m (18 lb ft).

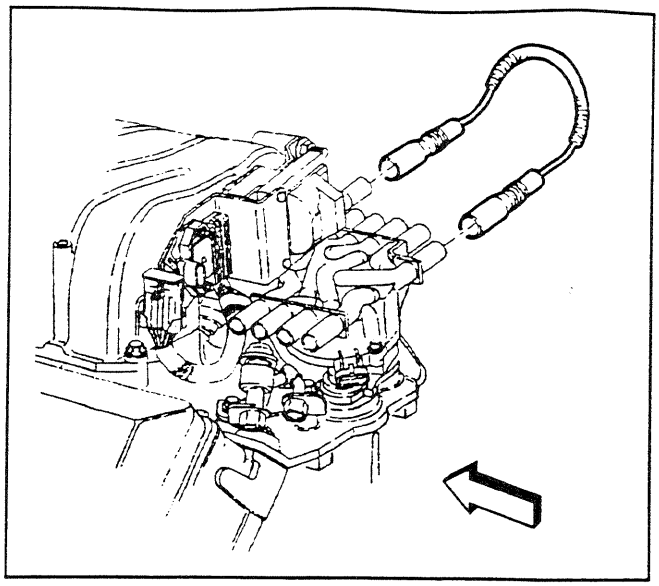


180900

12. Connect the fuel injector wiring harness connector to the ignition coil bracket.

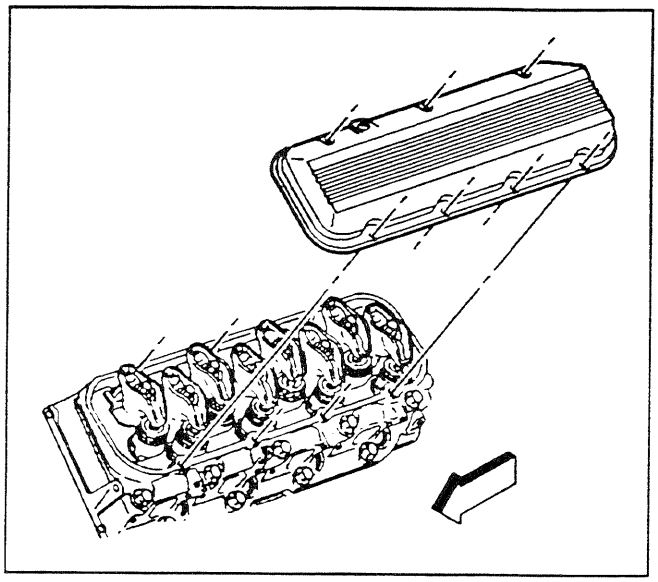


501421



492041

13. Connect the ignition coil wire to the distributor and ignition coil.

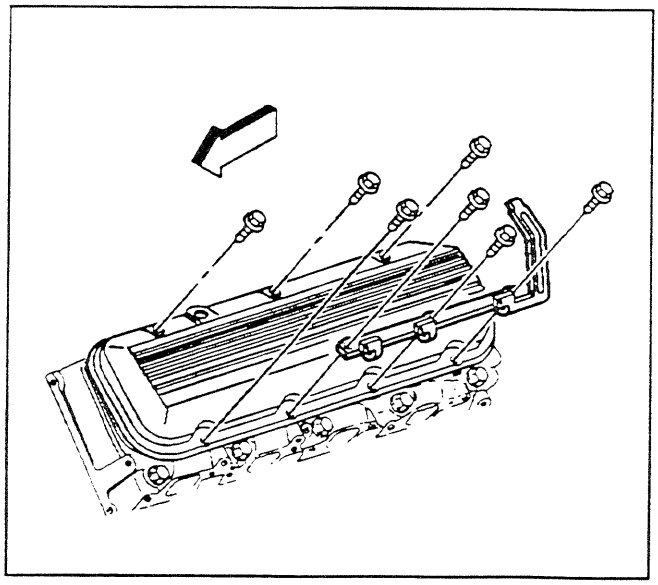


354006

Valve Rocker Arm Cover Installation (Left)

SIE-ID - 201220

1. If valve rocker arm cover gasket was removed from the valve rocker arm cover, install a NEW valve rocker arm cover gasket.
2. Install the valve rocker arm cover with gasket.



354009

3. Install the spark plug wiring harness bracket(s) onto the valve rocker arm cover.

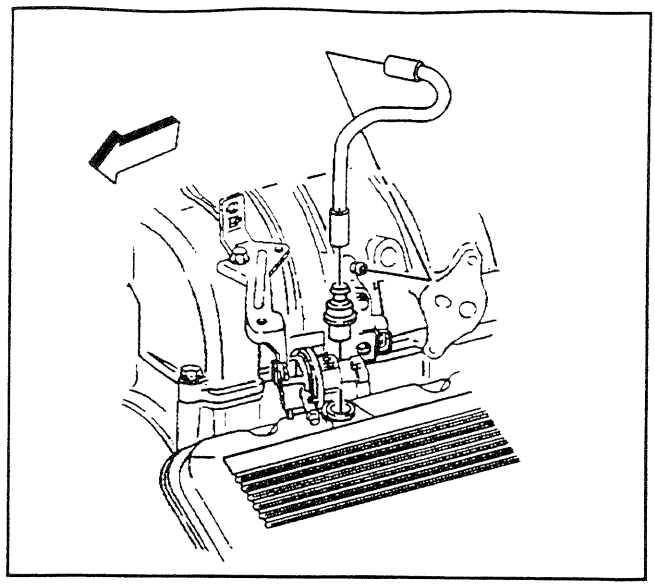
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

   Tighten

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

5. Remove the Positive Crankcase Ventilation Valve (PCV) and crankcase ventilation tube.

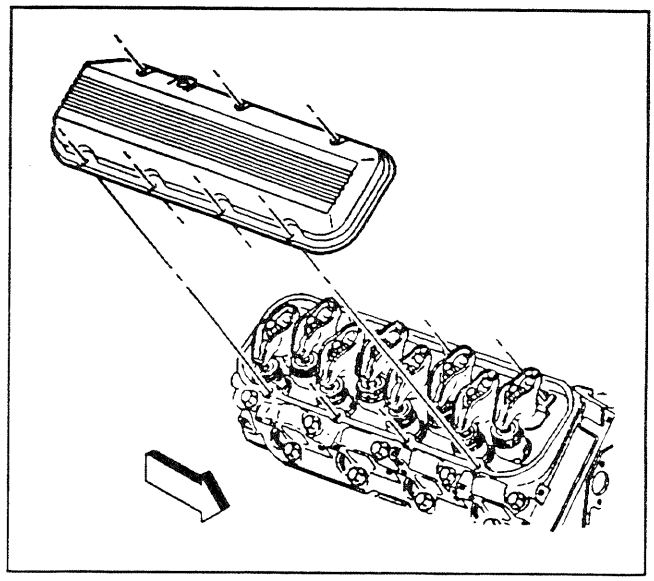


173187

Valve Rocker Arm Cover Installation (Right)

SIE-ID = 201223

1. If valve rocker arm cover gasket was removed from the valve rocker arm cover, install a NEW valve rocker arm cover gasket.
2. Install the valve rocker arm cover with gasket.



354010

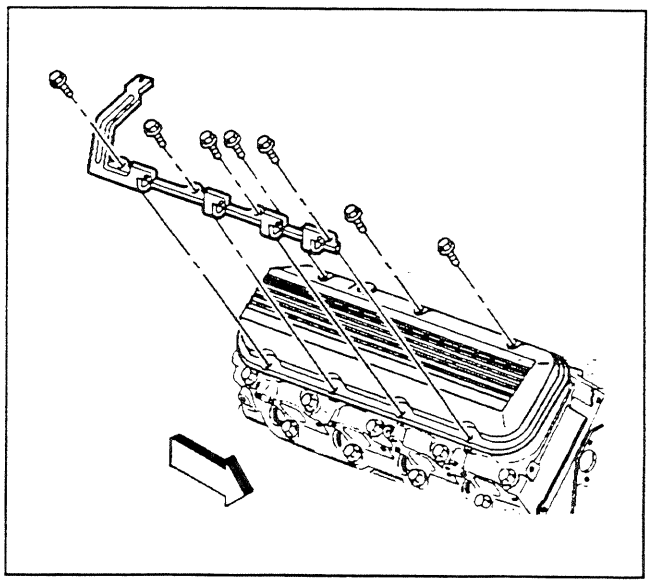
3. Place spark plug wiring harness bracket(s) onto valve rocker arm cover.

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

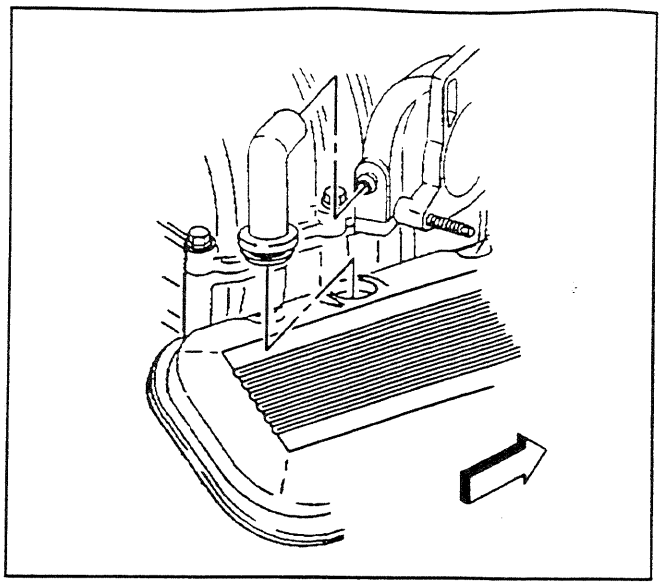
4. Install the valve rocker arm cover bolts.

   Tighten

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

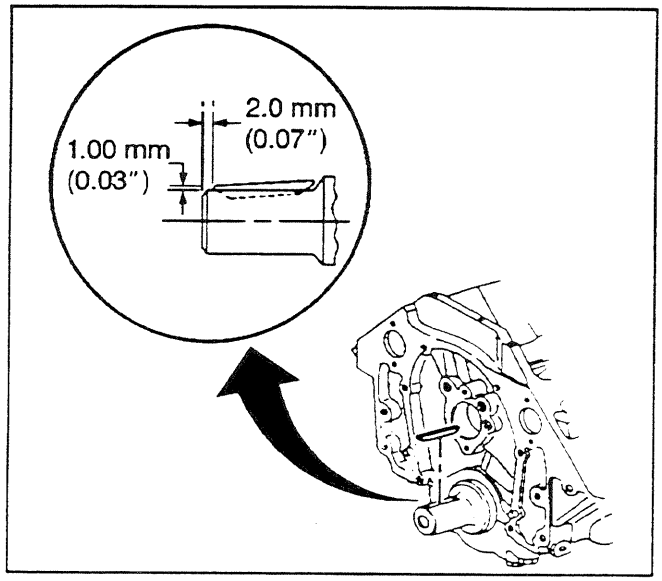


354012



173189

5. Install the crankcase ventilation tube.



180902

Crankshaft Balancer Installation

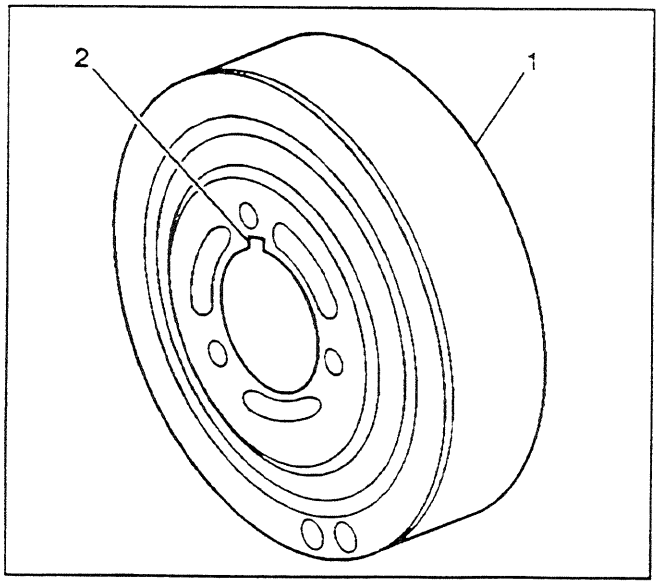
SIE-ID = 201268

Tools Required

J 23523-F Crankshaft Balancer Remover and Installer

Notice: SIO-ID = 16580 The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

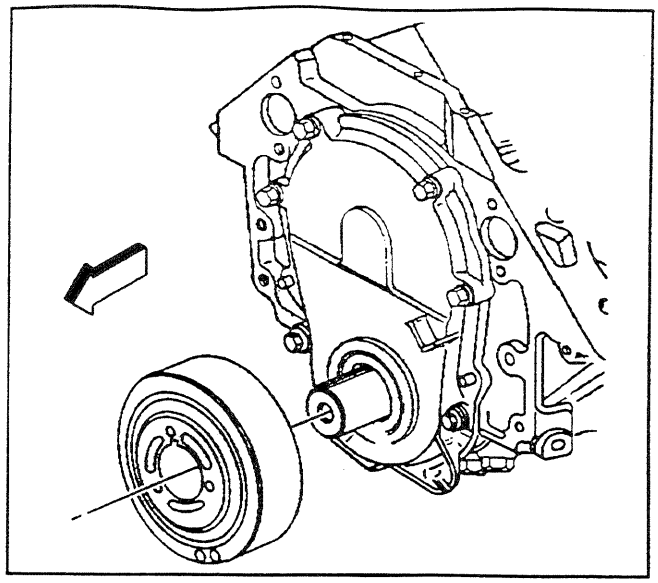
1. Apply a small amount of GM P/N 12346141 or equivalent onto the crankshaft key and keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
2. Install the key into the crankshaft keyway.



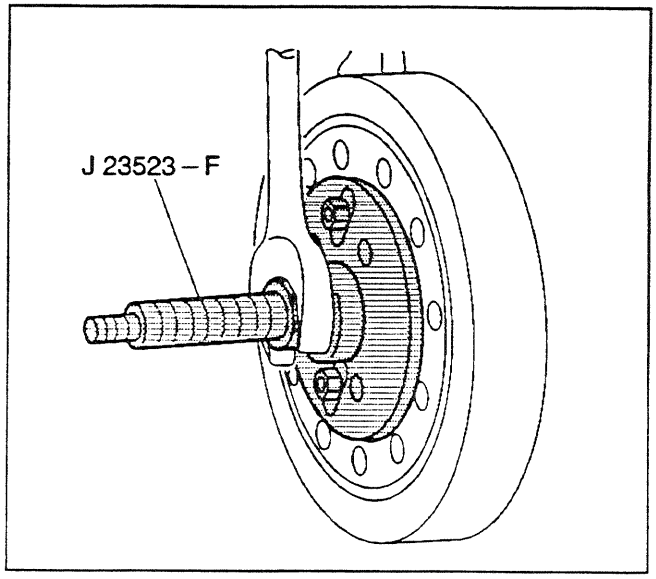
354018

3. Apply a small amount of GM P/N 12346141 or equivalent onto the crankshaft balancer keyway (2) in order to seal the crankshaft balancer keyway and crankshaft joint.

4. Install the crankshaft balancer onto the end of the crankshaft.
5. Align the keyway of the crankshaft balancer with the crankshaft key.


354021

6. Use the *J 23523-F* in order to press the crankshaft balancer onto the crankshaft.
   6.1. Install the *J 23523-F* into the front of the crankshaft.
   6.2. Rotate the *J 23523-F* nut until the nut, washer, and bearing are firmly against the crankshaft balancer.
   6.3. Use one wrench to hold the *J 23523-F* forcing screw.
   6.4. Use a second wrench and rotate the *J 23523-F* nut clockwise until the hub is completely seated against the crankshaft position sensor reluctor ring.
   6.5. Remove the *J 23523-F* from the crankshaft.



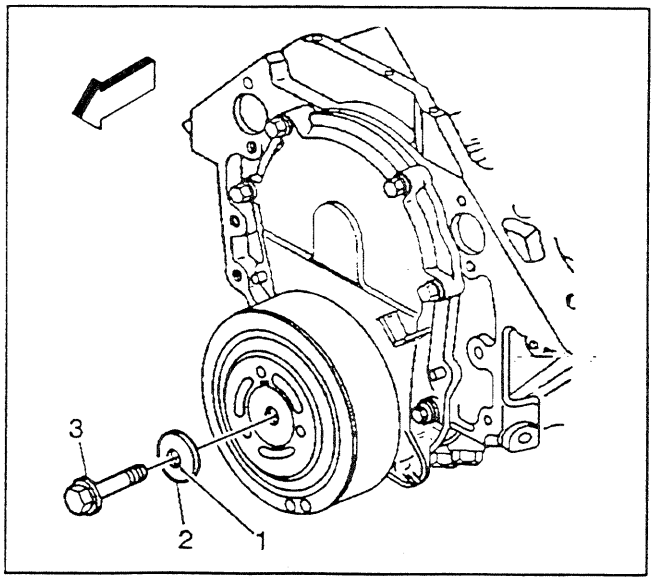
4065

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

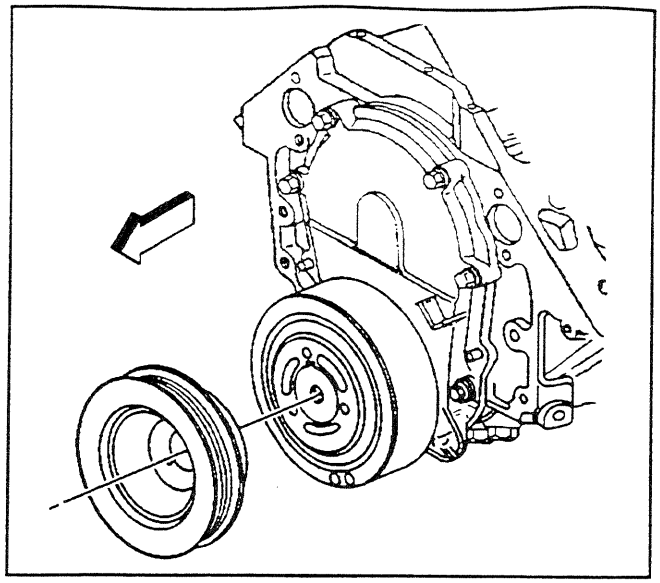
7. Install the crankshaft balancer washer (2) and bolt (3).

   Tighten

   Tighten the crankshaft balancer bolt to 149 N·m (110 lb ft).

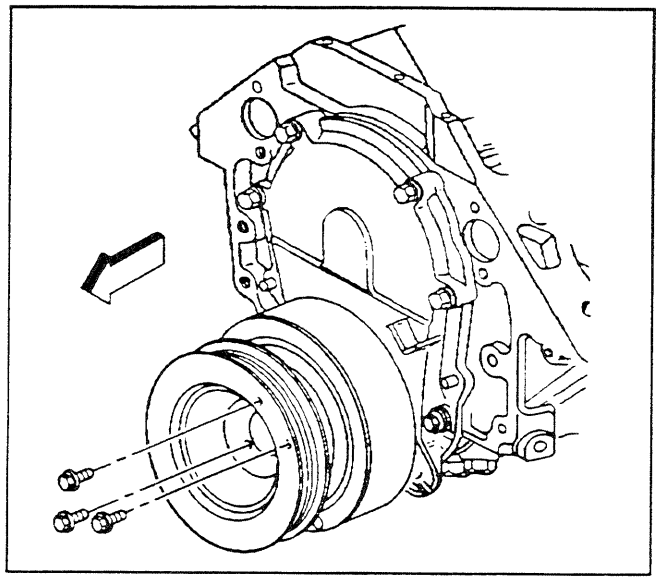


354016



354015

8. Install the crankshaft pulley.

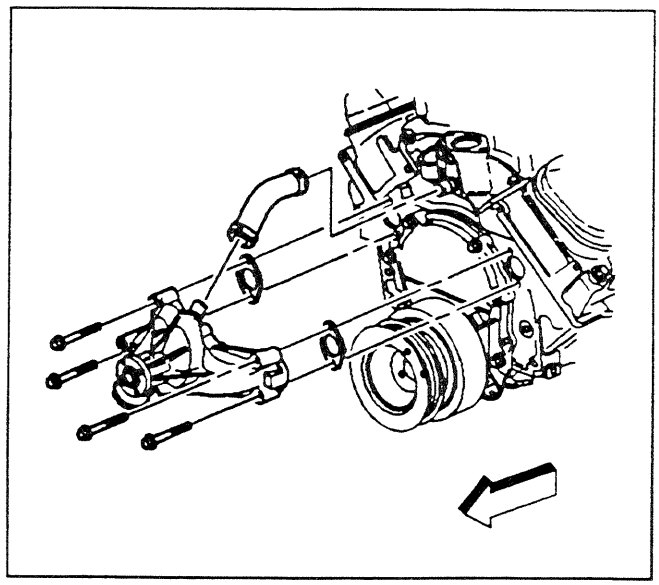


354014

9. Install the crankshaft pulley bolts.

   Tighten

   Tighten the crankshaft pulley bolts to 58 N·m (43 lb ft).



66263

Water Pump Installation

SIE-ID = 66628

1. Install the water pump gaskets.
2. Install the water pump bypass hose to the pump.
3. Loosely install the water pump bypass hose clamps.
4. Install the water pump.

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

5. Install the water pump bolts.

   Tighten

   Tighten the water pump bolts to 40 N·m (30 lb ft).

6. Position the water pump bypass hose clamps.

   Tighten

   Tighten the water pump bypass clamps to 4 N·m (35 lb in).

Exhaust Manifold Installation (Left)

SIE-ID = 367923

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

1. Install the exhaust manifold studs, if removed.

   Tighten

   Tighten the exhaust manifold studs to 30 N·m (22 lb ft).

Important: Make sure the 7.4 marking on the gasket is facing away from the cylinder head.

Install the new exhaust manifold gasket.

2. Install the exhaust manifold.
3. Install the exhaust manifold nuts and center bolt.

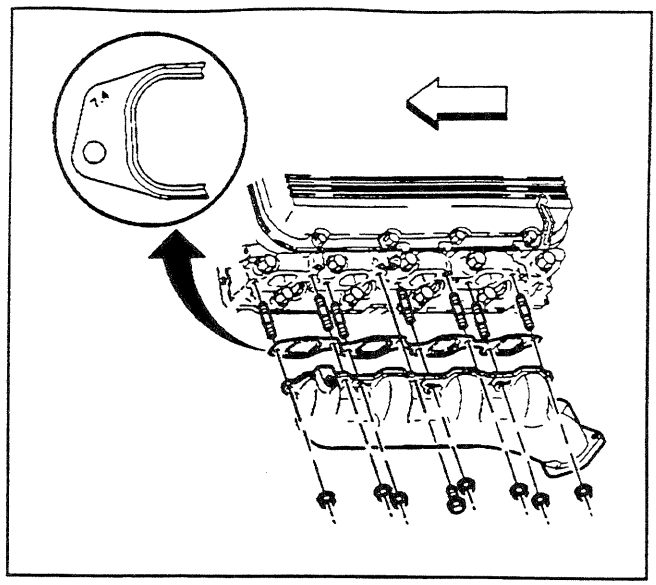
   Tighten

   3.1. Tighten the exhaust manifold nuts to 30 N·m (22 lb ft).

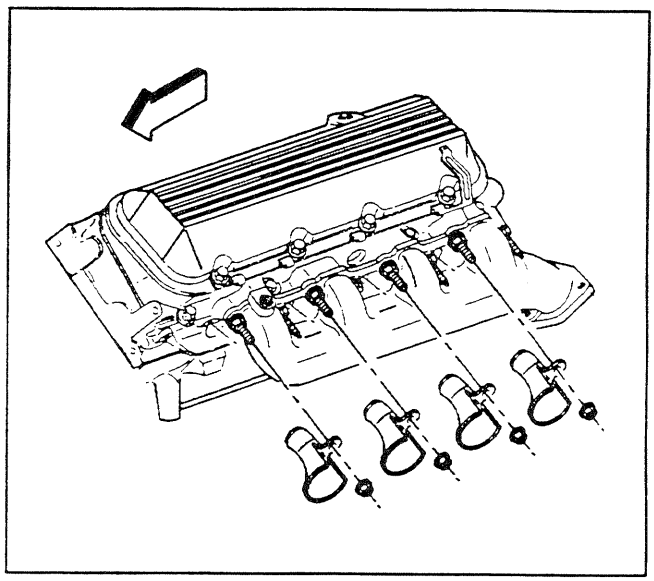
   3.2. Tighten the exhaust manifold center bolt to 54 N·m (40 lb ft).
4. Install the spark plug heat shields.
5. Install the spark plug heat shield nuts.

   Tighten

   Tighten the spark plug heat shield nuts to 20 N·m (15 lb ft).



180888

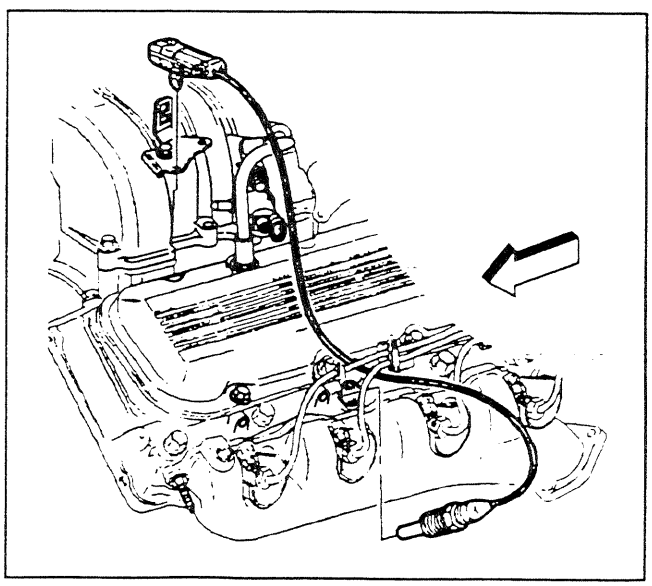


354056

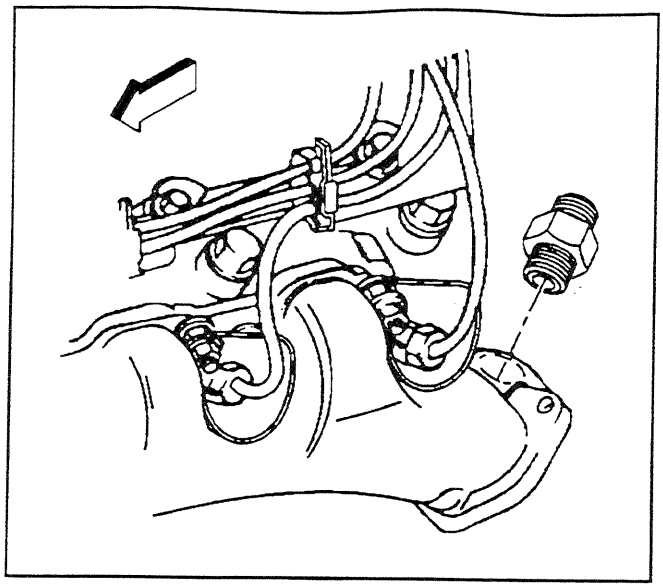
6. Install the ECT sensor into the left cylinder head.

   Tighten

   Tighten the ECT sensor to 20 N·m (15 lb ft).
7. Connect the ECT sensor wiring harness connector to the bracket on the upper intake manifold.



492025

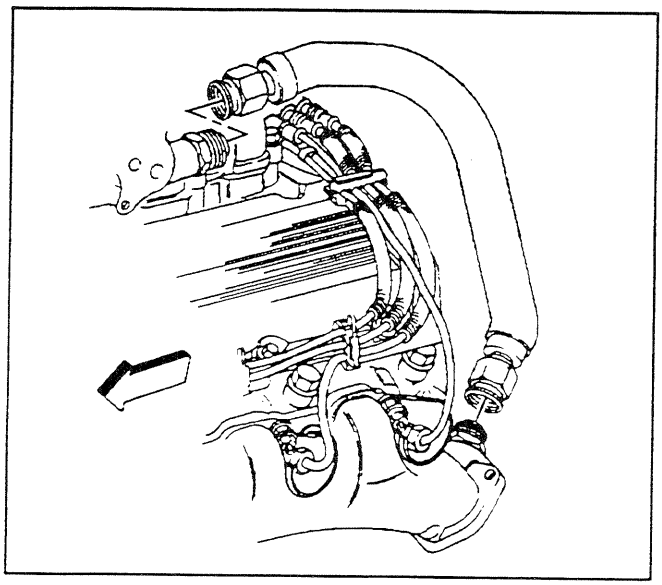


354034

8. Install the exhaust adapter, if removed.

   Tighten

   Tighten the exhaust adapter to 160 N·m (117 lb ft).



173284

9. Install the exhaust gas recirculation (EGR) inlet pipe to the exhaust manifold.

   Tighten

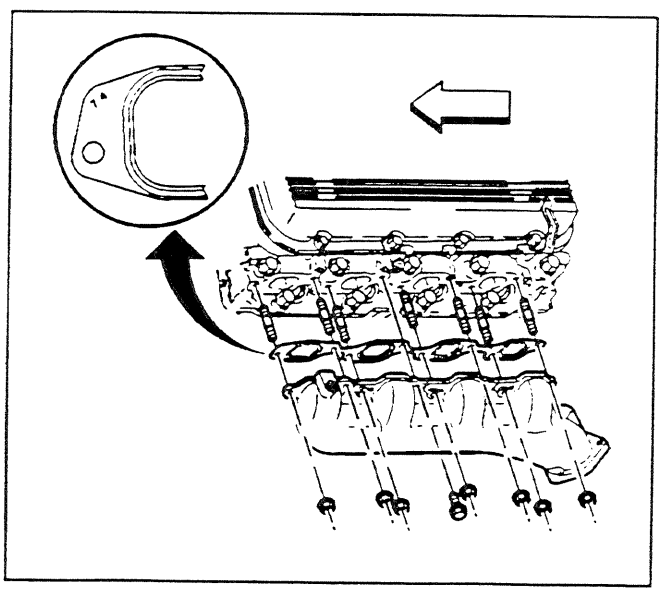
   Tighten the EGR inlet pipe at the exhaust manifold to 60 N·m (44 lb ft).

10. Install the EGR inlet pipe to the intake manifolds.

    Tighten

    Tighten the EGR inlet pipe at the intake manifold to 60 N·m (44 lb ft).

11. Install the spark plug wires onto the spark plugs.



180888

Exhaust Manifold Installation (Left Side with RPO K19)

SIE-ID = 201744

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

1. Install the exhaust manifold studs, if removed.

   Tighten

   Tighten the exhaust manifold studs to 30 N·m (22 lb ft).

Important: Make sure the 7.4 marking on the gasket is facing away from the cylinder head.

Install the new exhaust manifold gasket.

2. Install the exhaust manifold.
3. Install the exhaust manifold nuts and center bolt.

   Tighten

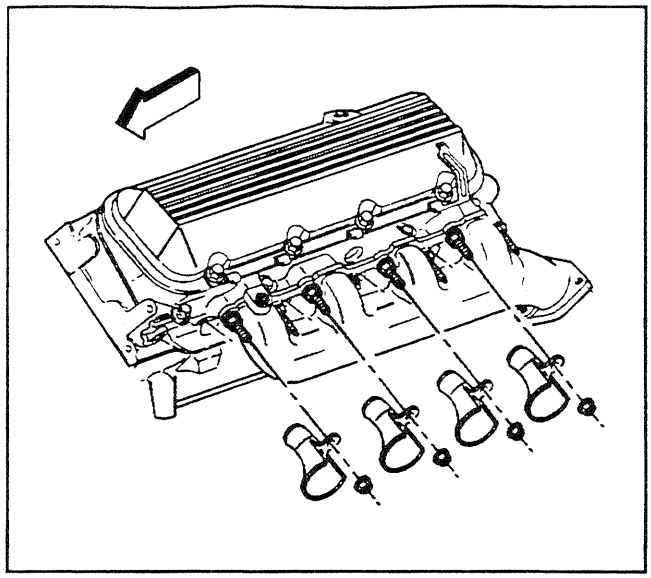
3.1. Tighten the exhaust manifold nuts to 30 N·m (22 lb ft).

3.2. Tighten the exhaust manifold center bolt to 54 N·m (40 lb ft).

4. Install the spark plug heat shields.
5. Install the spark plug heat shield nuts.

Tighten

Tighten the spark plug heat shield nuts to 20 N·m (15 lb ft).



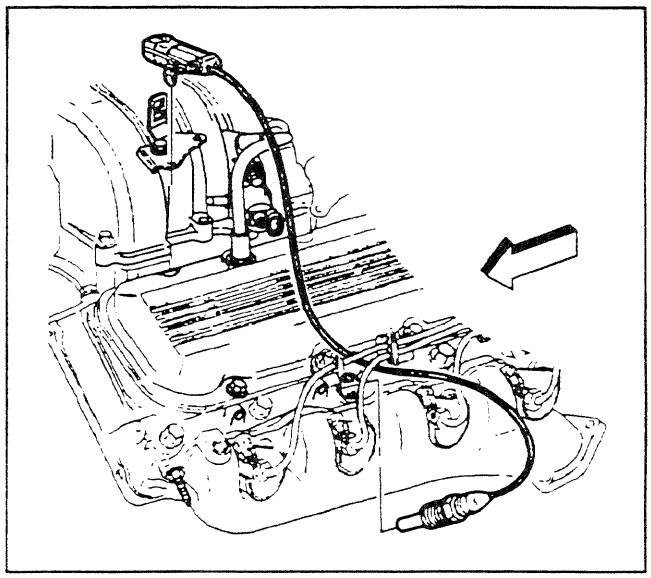
354056

6. Install the ECT sensor into the left cylinder head.

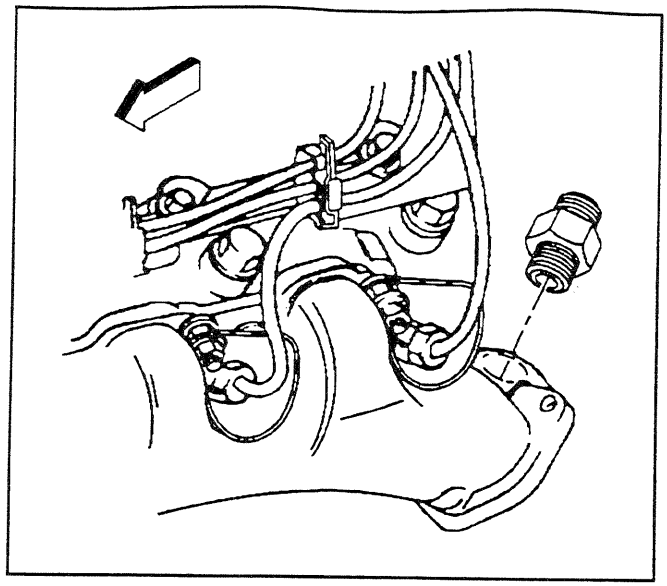
Tighten

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

7. Connect the ECT sensor wiring harness connector to the bracket on the upper intake manifold.



492025

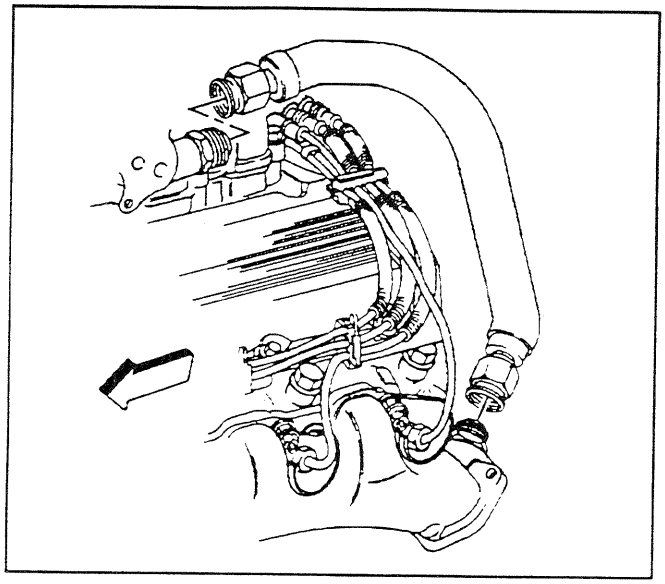


354034

8. Install the exhaust manifold adapter to the exhaust manifold, if removed.

   Tighten

   Tighten the exhaust manifold adapter to 160 N·m (118 lb ft).



173284

9. Install the exhaust gas recirculation (EGR) inlet pipe to the exhaust manifold.

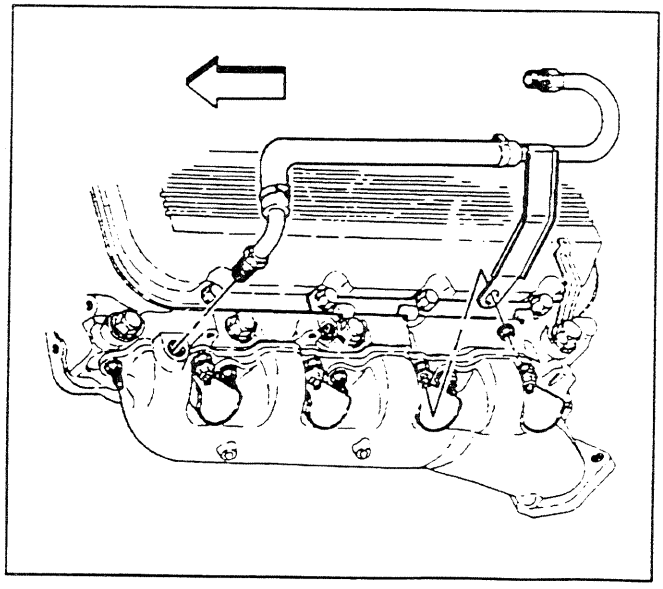
   Tighten

   Tighten the EGR inlet pipe nut at the exhaust manifold to 60 N·m (44 lb ft).

10. Install the EGR inlet pipe to the intake manifold.

    Tighten

    Tighten the EGR inlet pipe nut at the intake manifold to 60 N·m (44 lb ft).



180942

11. Install the AIR tube assembly pipe to the exhaust manifold, if removed.

    Install the AIR tube assembly pipe bracket nut onto the exhaust manifold stud.

    Tighten

    - Tighten the AIR tube assembly pipe nut to 60 N·m (44 lb ft).
    - Tighten the AIR tube assembly pipe bracket nut to 30 N·m (22 lb ft).

12. Install the spark plug wires onto the spark plugs.

Exhaust Manifold Installation (Right)

SIE-ID = 367927

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

1. Install the exhaust manifold studs, if removed.

   Tighten

   Tighten the exhaust manifold studs to 30 N·m (22 lb ft).

Important: Make sure the 7.4 marking on gasket is facing away from the cylinder head.

Install the new exhaust manifold gasket.

2. Install the exhaust manifold.
3. Install the exhaust manifold nuts and center bolt.

   Tighten

   3.1. Tighten the exhaust manifold nuts (2) to 30 N·m (22 lb ft).

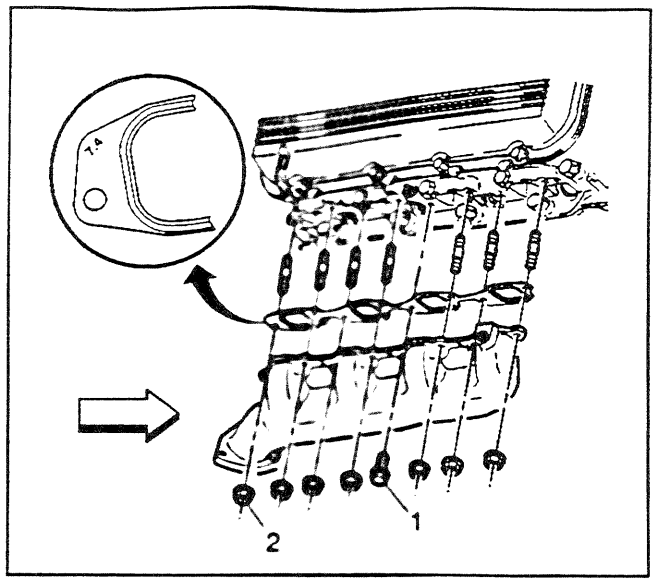
   3.2. Tighten the exhaust manifold center bolt (1) to 54 N·m (40 lb ft).

4. Install the spark plug heat shields.
5. Install the spark plug heat shield nuts.

   Tighten

   Tighten the spark plug heat shield nuts to 20 N·m (15 lb ft).

6. Install the spark plug wires.



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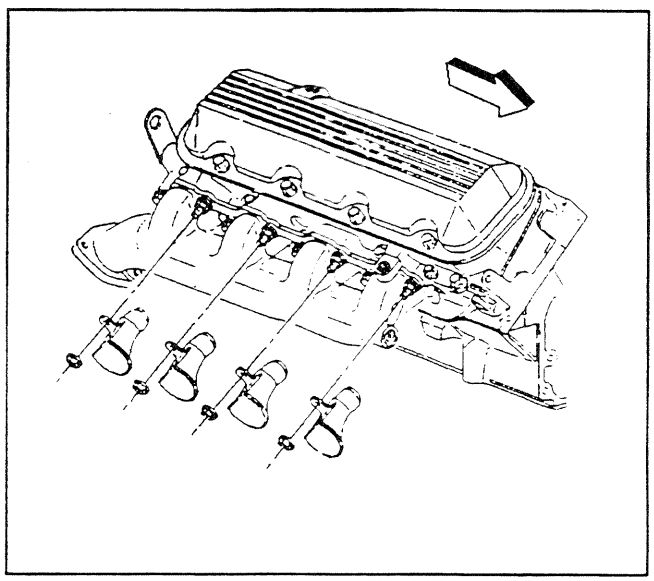


65852

Exhaust Manifold Installation (Right Side with RPO K19)

SIE-ID = 20179

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

1. Install the exhaust manifold studs, if removed.

   Tighten

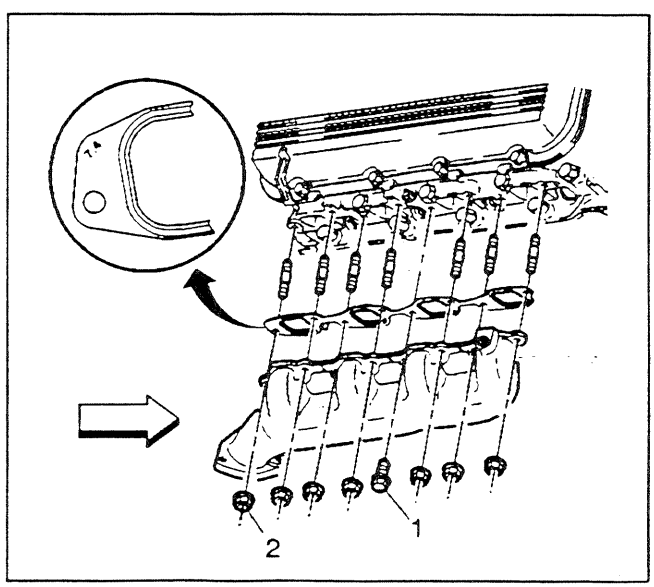
   Tighten the exhaust manifold studs to 30 N·m (22 lb ft).

Important: Make sure the 7.4 marking on gasket is facing away from the cylinder head.

Install the new exhaust manifold gasket.

2. Install the exhaust manifold.
3. Install the exhaust manifold nuts (2) and center bolt (1).

   Tighten



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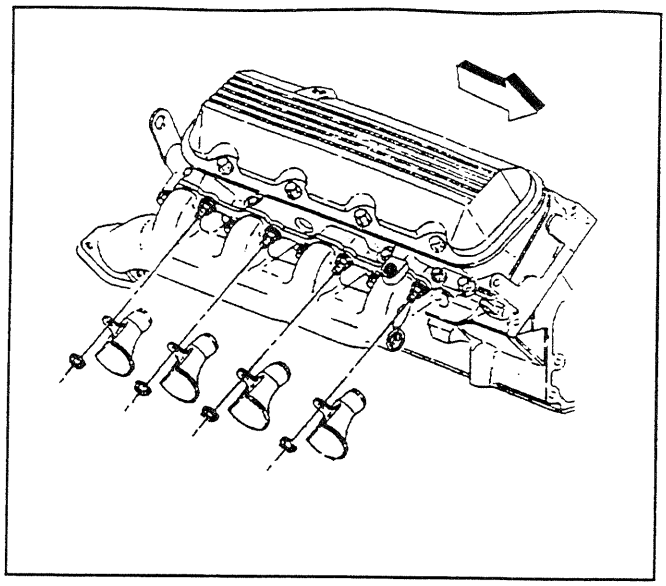


65852

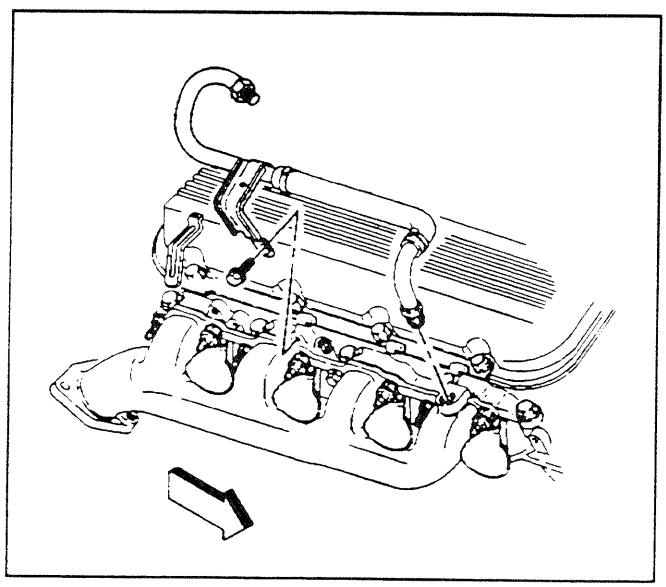
3.1. Tighten the nuts to 30 N·m (22 lb ft).

3.2. Tighten the center bolt to 54 N·m (40 lb ft).

4. Install the spark plug heat shields.
5. Install the spark plug heat shield nuts.

Tighten

Tighten the spark plug heat shield nuts to 20 N·m (15 lb ft).



354054

6. Install AIR tube assembly pipe into the exhaust manifold, if removed.
7. Install the AIR tube assembly pipe bracket bolt to the cylinder head.

Tighten

- Tighten the AIR tube assembly pipe nut to 60 N·m (44 lb ft).
- Tighten the AIR tube assembly pipe bracket bolt to 40 N·m (30 lb ft).

8. Install the spark plug wires.

Oil Level Indicator and Tube Installation

SIE-ID = 201108

1. Install the oil level indicator tube (3) and NEW O-ring (4) into the oil pan (5).

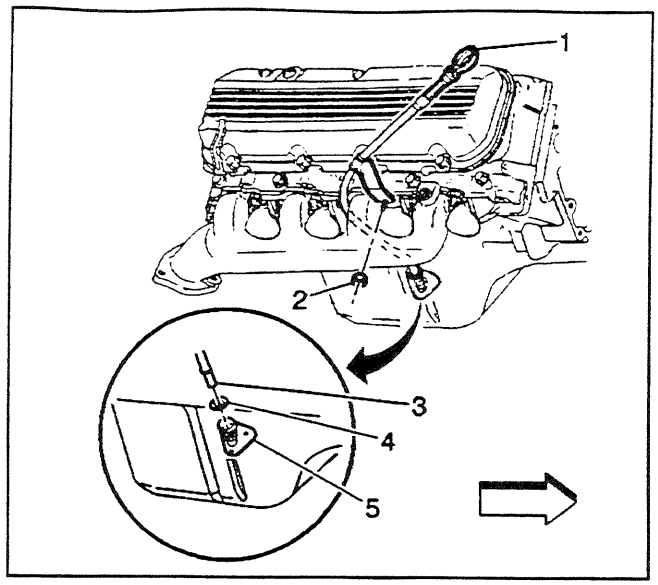
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Properly position the oil level indicator tube (1) and install the oil level indicator tube bracket nut (2) to the right exhaust manifold stud.

   Tighten

   Tighten the oil level indicator tube bracket nut to 54 N·m (40 lb ft).

3. Install the oil level indicator into the oil level indicator tube.
4. In order to prevent rub condtions from occuring ensure the correct orientation of the following:
   - Spark plug wires
   - Ignition coil harness
   - Fuel injector harness
   - ECT sensor wire harness
   - Vacuum hoses
   - Coolant hoses



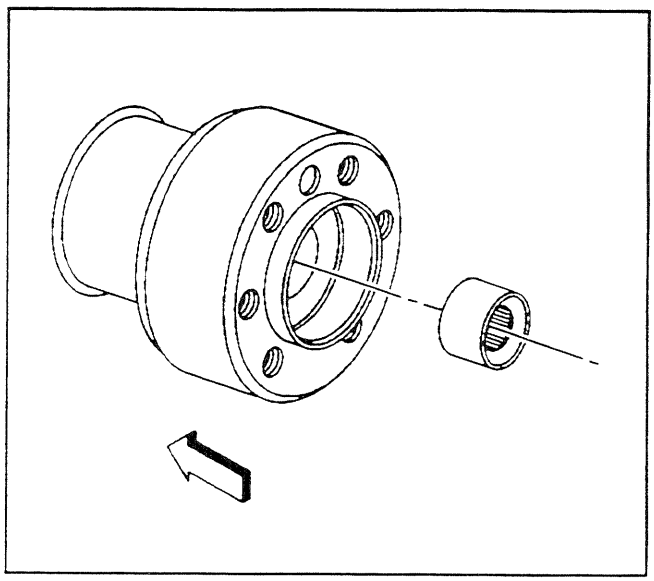
180884

Clutch Pilot Bearing Installation

SIE-ID = 378501

Caution: *SIO-ID = 5011* ***Wear safety glasses in order to avoid eye damage.***

1. Install the NEW clutch pilot bearing using a suitable clutch pilot bearing installation tool.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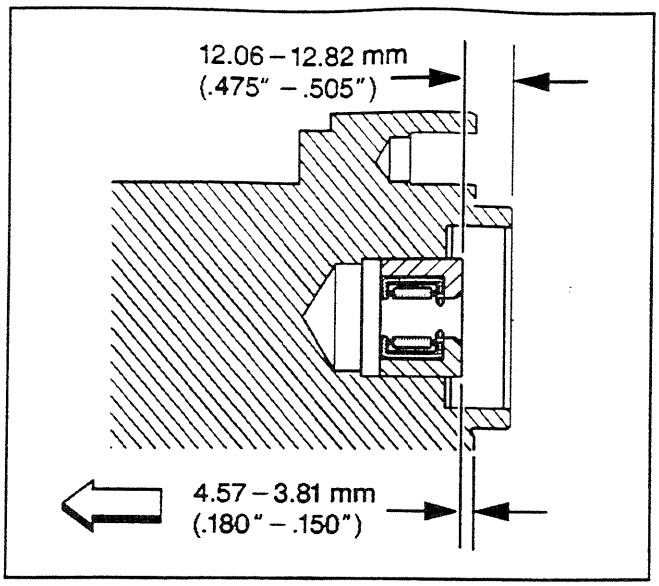
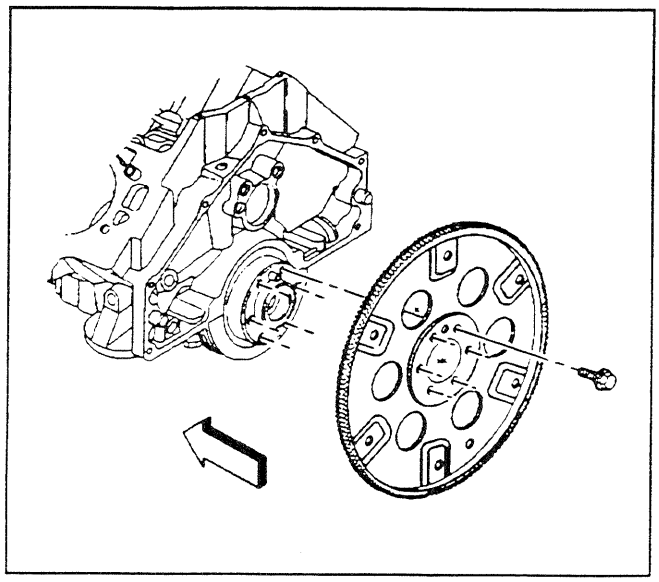


354088

2. Measure to ensure the proper installation depth is obtained.



363414

Engine Flywheel Installation (MT1 Automatic Transmission)

SIE-ID = 367909

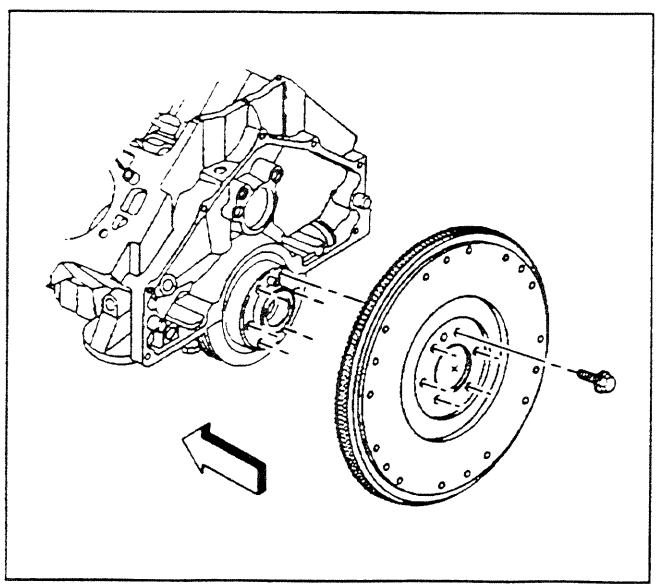
1. Install the engine flywheel.

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

2. Install the engine flywheel bolts.

   Tighten

   Tighten the engine flywheel bolts to 90 N·m (66 lb ft).



363409

Engine Flywheel Installation (MW3 Manual Transmission)

SIE-ID = 367912

1. Install the engine flywheel.

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

2. Install the engine flywheel bolts.

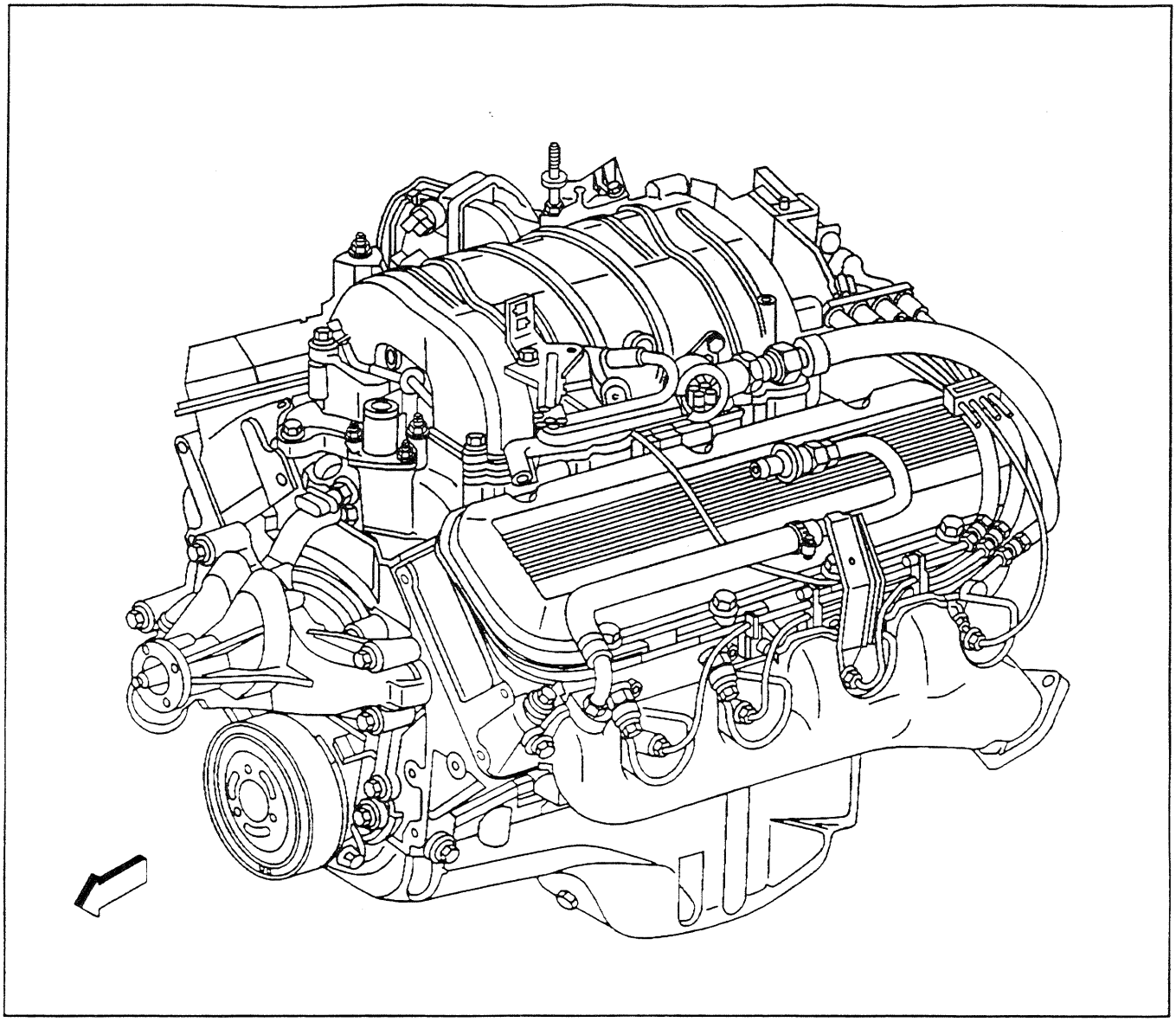
   Tighten

   Tighten the engine flywheel bolts to 90 N·m (66 lb ft).

Description and Operation

Engine Component Description

SIE-ID = 66632



180831

Cylinder Block

The engine block is made of cast iron and it has eight cylinders arranged in a V shape with four cylinders in each bank. The cylinder block is a one piece casting with the cylinders encircled by coolant jackets.

Cylinder Head

The cylinder heads are cast iron and have parent metal inlet valve guides and inlet valve seats. Cast iron exhaust valve guides and powdered metal valve seats are pressed into the exhaust ports. A spark plug is located between the valves in the side of the cylinder head.

Camshaft

A steel camshaft is supported by five bearings pressed into the engine block. The camshaft sprocket, mounted to the front of the camshaft, is driven by the crankshaft sprocket through a camshaft timing chain.

Motion from the camshaft is transmitted to the valves by hydraulic roller valve lifters, valve pushrods, and ball-pivot type rocker arms. A spiral gear machined into the camshaft near the rear journal drives a shaft assembly which operates the oil pump driveshaft assembly.

Crankshaft

The crankshaft is made of cast nodular iron. The crankshaft is supported by five crankshaft bearings. The crankshaft bearings are retained by the crankshaft bearing caps, which are machined with the block for proper alignment and clearance. The engine crankshaft bearing caps are retained by four bolts each. The number five crankshaft bearing at the rear of the engine is the end thrust bearing. The four connecting rod journals (two rods per journal) are spaced 90 degrees apart. The crankshaft position sensor reluctor ring is pushed onto the front of the crankshaft. The crankshaft position sensor reluctor ring has four lugs used for crankshaft timing and it is constructed of powdered metal. The reluctor ring has an interference fit onto the crankshaft and an internal keyway for correct positioning.

Pistons and Connecting Rods

The pistons are cast aluminum alloy that use two compression rings and one oil control ring assembly. The piston pins are a floating fit in the pistons and they are retained by a press fit in the connecting rod assembly. Connecting rods are forged steel, with precision insert type crankpin bearings.

Valve Train

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular valve pushrods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic roller valve lifters keep all parts of the valve train in constant contact. Each lifter act as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment. The valve rocker arm bolt retains the valve rocker arm and ball seat. The valve rocker arm bolt is threaded into the cylinder head.

Intake Manifold

The intake manifold is a two-piece design. Both upper and lower portions are made of cast aluminum. The throttle body is attached to the upper manifold. A linear EGR port is cast into the upper intake manifold for exhaust gas recirculation mixture. The (EGR) valve bolts into the upper intake manifold. The fuel rail assembly with eight separate fuel injectors is retained to the intake manifold by six bolts. The injectors are seated in their individual manifold bores with O-ring seals to provide sealing. A Manifold Absolute Pressure (MAP) sensor is mounted at the front of the upper intake manifold and sealed by an O-ring seal. The MAP sensor is retained by a retainer.

Exhaust Manifold

The two exhaust manifolds are constructed of cast iron. The manifolds direct exhaust gases from the combustion chambers to the exhaust system. The manifolds have a threaded port for EGR inlet system pipe fittings. Some manifolds have a threaded port for AIR pipe connections.

Drive Belt System Description

SIE-ID = 592000

The drive belt system consists of the following components:

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

The drive belt system may use one belt or two belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

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

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

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

New Product Information

SIE-ID = 528681

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

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required

- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

- Cylinder head bolts are tightened in four passes.
- Upper intake manifold bolts are tightened in two passes.

Refer to *Fastener Tightening Specifications*

Changed Engine Specifications

- Crankshaft connecting rod diameter has changed slightly.
- Piston pin diameter specification was changed slightly.

Refer to *Engine Mechanical Specifications*

Disassembly and Assembly Procedure Revisions

- Engine front cover removal procedure has been revised.
- Reluctor ring removal procedure has been revised.

Refer to *Timing Chain and Sprockets Removal*

- Install a NEW oil pump driveshaft retainer whenever removing or installing an oil pump assembly.
- Oil bypass valve removal and installation procedure has been revised.
- Upper intake manifold bolt tightening sequence revised.

Engine Mechanical Diagnostic Procedure Revisions

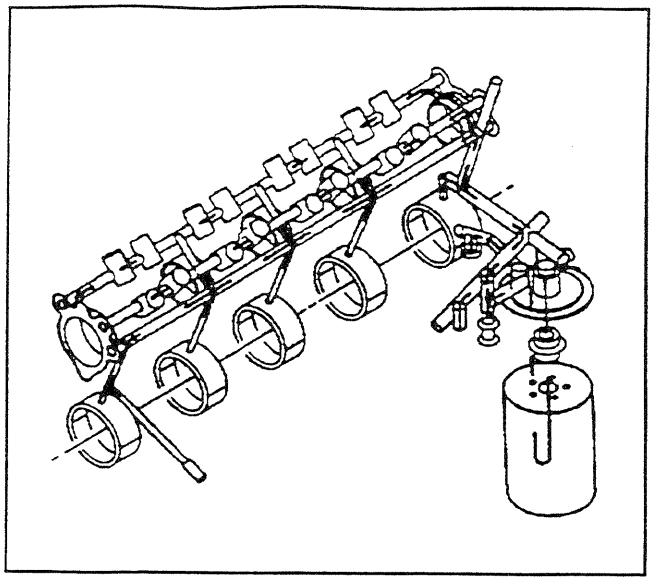
A new engine mechanical Base Engine Misfire chart has been added. Refer to *Base Engine Misfire Diagnosis*

New Special Tools Required

- The valve lifter remover pliers *J 3049-A* replaces *J 9290-01*.
- Spark plug port adapter *J 23590* has been replaced by *J 22794*.
- The crankshaft balancer remover/installer *J 39046* has been replaced by *J 23523-F*.
- Refer to *Special Tools*.

Lubrication

SIE-ID = 66633



66606

The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the distributor which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube. Pressurized oil is delivered through internal passages in order to lubricate camshaft and crankshaft bearings and to provide lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve pushrods in order to lubricate the valve rocker arms and ball pivots. Oil returning to the oil pan from the cylinder heads and the front camshaft bearing, lubricates the camshaft timing chain and the crankshaft and the camshaft sprockets.

Separating Parts

SIE-ID = 189993

SIO-ID = 189980

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When disassembling the engine, internal components MUST be separated, marked or organized in a way to ensure reinstallation to 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
- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, guides, pushrods, pivot supports and rocker arms
- Valve to the valve guide
- Valve spring and shim to the cylinder head location

- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

Cleanliness and Care

SIE-ID = 189826

SIO-ID = 189770

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Replacing Engine Gaskets

SIE-ID = 66654

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

  Do not use any other method or technique to remove the sealant or the gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.

  This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

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

Use of RTV and Anaerobic Sealer

SIE-ID = 411537

Sealant Types

Important: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant (or equivalent) as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket

  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

Important: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

The surfaces to be sealed must be clean and dry.

- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch (within 3 minutes). Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.

The surfaces to be sealed must be clean and dry.

Important: Do not allow the gasket eliminator sealant to enter any blind threaded holes, as the gasket eliminator sealant may prevent the fasteners from clamping properly, seating properly, or cause damage when the fastener tightened.

Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.

Important: Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than five minutes, may result in incorrect shimming and sealing of the joint.

Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

Important: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than five minutes, may result in incorrect clamp load of assembled components.

Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

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

Use the following information when using pipe sealant:

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

Important: Do not allow the pipe sealant to enter any of the blind threaded holes, as the pipe sealant may prevent the fastener from clamping properly, or cause component damage when the fastener is tightened.

Apply the pipe sealant bead to the inside of any bolt hole areas.

- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Tools and Equipment

SIE-ID = 190154

SIO-ID = 190145

- 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

SIE-ID = 311462

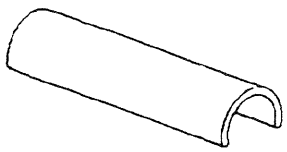
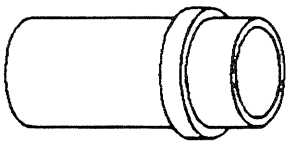
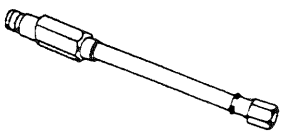
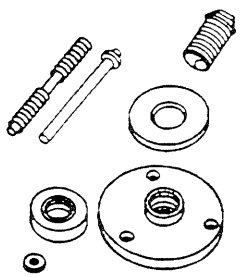
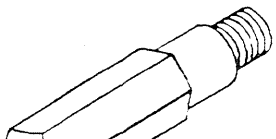
Illustration	Tool Number/ Description
 3416	J 21882 Oil Suction Pipe Installer
 65325	J 22102 Crankshaft Oil Seal and Sprocket Installer
 26998	J 22794 Spark Plug Port Adapter
 3398	J 23523-F Crankshaft Balancer Remover and Installer
 3400	J 23590 Spark Plug Port Adapter

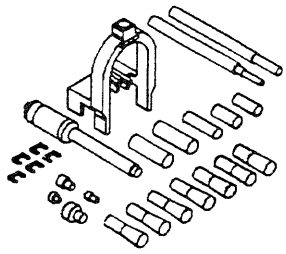
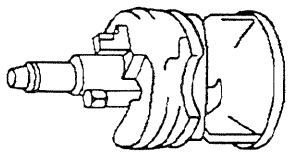
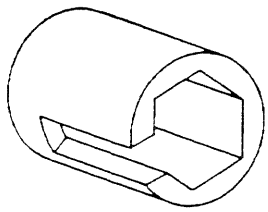
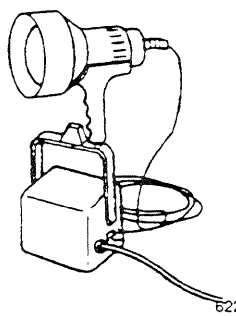
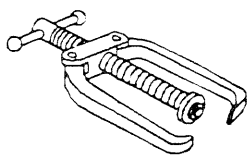
Illustration	Tool Number/ Description
 14495	J 24086-C Piston Pin Remove and Install
 3412	J 24270 Cylinder Bore Ridge Reamer
 9192	J 25254-10A Oil Pressure Sending Unit Socket
 62292	J 28428-E High Intensity Black Light
 66880	J 28509-A Counter Gear Bearing Remover

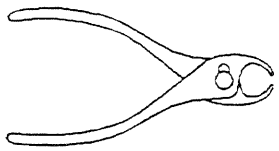
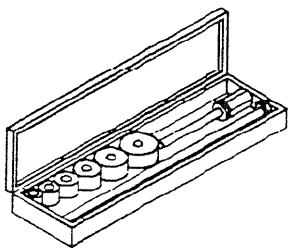
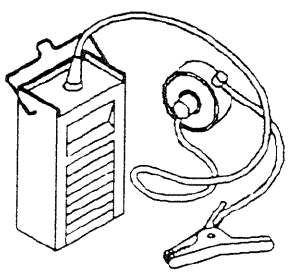
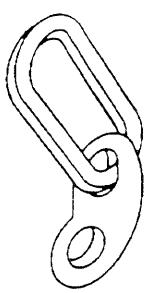
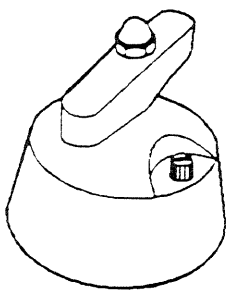
Illustration	Tool Number/ Description
 14487	J 3049-A Hydraulic Lifter Remover
 5118	J 33049 Camshaft Bearing Service Set
 3413	J 36660 Torque Angle Meter
 68653	J 36857 Engine Lift Bracket
 65999	J 38841 Crankshaft Rear Main Seal Installer

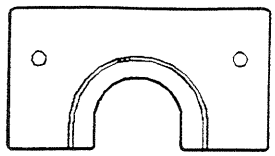
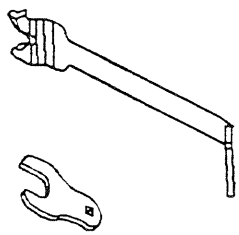
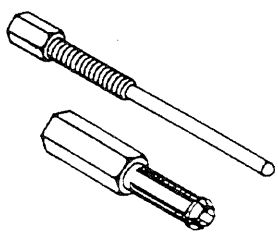
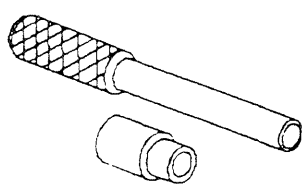
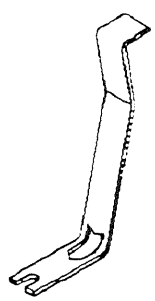
Illustration	Tool Number/ Description
 68391	J 41371 Reluctor Wheel Remover
 48304	J 41240 Fan Clutch Wrench
 355040	J 43276 Clutch Pilot Bearing Remover
 3404	J 5239 Connecting Rod Bolt Guide Tool
 3399	J 5892-C Valve Spring Compressor

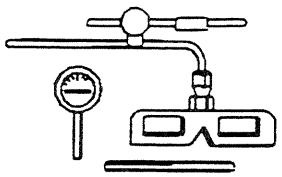
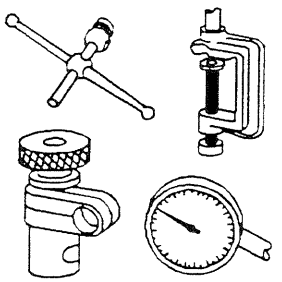
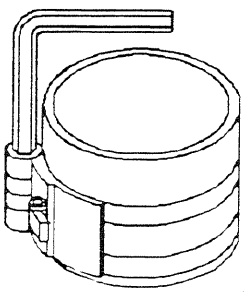
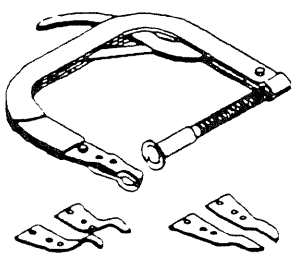
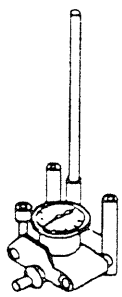
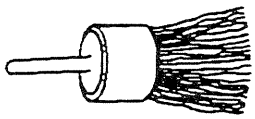
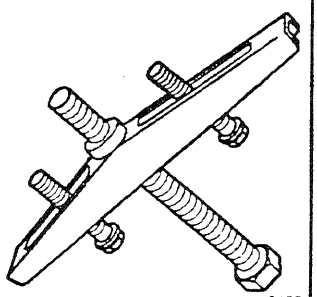
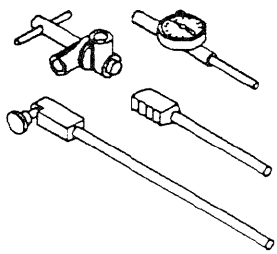
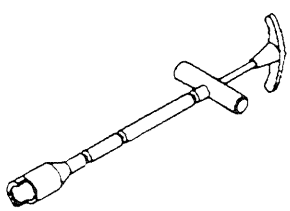
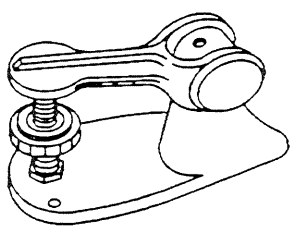
Illustration	Tool Number/ Description
 35463	J 7872 Magnetic Base Dial Indicator Set
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Piston Ring Compressor
 3414	J 8062 Valve Spring Compressor (Cylinder Head Off)
 5110	J 8087 Cylinder Bore Checking Gauge

Illustration	Tool Number/ Description
 4994	J 8089 Wire Brush
 6185	J 8433 Puller
 3408	J 8520 Camshaft Lobe Lift Indicator
 14489	J 9290-01 Valve Lifter Remover
 4997	J 9666 Valve Spring Tester

Notes

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