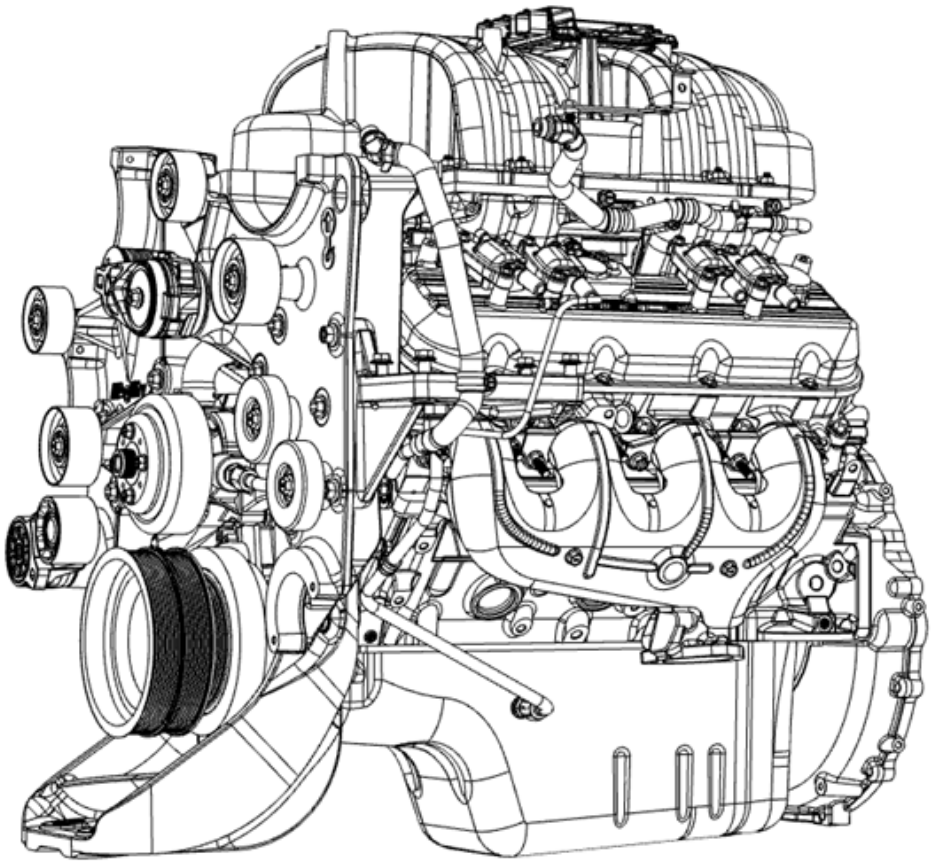
HEXAGON AGILITY

488LPI Propane Autogas Engine Mechanical and Fuel Components Service Manual



PROPANE

DSM.0052 Ver. 1.0
May 27, 2022

Preface

This manual is designed as a support document for trained technicians in the maintenance and repair procedures of the 488LPI™ propane autogas engine and fuel system provided by Hexagon Agility®.

No attempt shall be made to install, maintain, or repair this product until this manual and all referenced supporting documentation have been read and fully understood.

Original Equipment Manufacturer (OEM) parts not serviced by Hexagon Agility® may be obtained by contacting Freightliner Custom Chassis Corporation or Thomas Built Buses.

Fuel system warranty or non-warranty product support may be obtained by calling or emailing Hexagon Agility® Customer Care and Technical Services (CCTS).

Please provide **your name, phone number, email address, and complete vehicle information: VIN, year, make, model, mileage, unit number, vehicle owner,** and **current vehicle location.** A service advisor will contact you to arrange vehicle repair or ship a part.

⚠WARNING

All parts must adhere to the accepted standards and ratings as specified by Hexagon Agility®. Use of any part that is not approved by Hexagon Agility® is not recommended and may compromise the integrity and safety of the system.

NOTICE

Do not remove components from original packaging until necessary. Any components that are to be reinstalled must be thoroughly cleaned, inspected, and stored in a satisfactory manner until reinstallation.

Table of Contents

Acronyms and Application Codes

A	air brakes
A/C	air conditioning
CKP	crankshaft position sensor
CMP	camshaft position sensor
D	Dual air conditioning
ECM	engine control module
ETC	electronic throttle control sensor
ECT	engine coolant temperature sensor
EVAP	evaporative emissions
FEAD	front end accessory drive
FPT	fuel pressure/temperature sensor
LPG	liquid propane gas
LPI	Liquid Propane Injection
MAP	manifold absolute pressure sensor
MAF	mass air flow sensor
N	No air conditioning
NFPA	National Fire Protection Association
S	single air conditioning

Safety

Hexagon Agility® provides safety guidelines to ensure the safety of personnel servicing and / or operating liquid propane gas[1] (LPG) equipment. All personnel involved must adhere to industry standards including NFPA 58, specialized training, and all federal, state, and municipal laws and regulations.

Hexagon Agility® minimizes potential hazards through state-of-the art design and testing practices. Always observe the procedures and recommendations of this manual.

Due to the presence of high-pressure and flammable fuel, LPG fuel systems are a form of hazardous energy storage.

Warning and Signal Words Used in this Manual

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

***NOTICE* is used to address practices not related to physical injury, such as best practices or tips to help an operation or procedure go smoothly and prevent equipment damage.**

Critical Characteristic

Product feature directly affects:

- **Safety of vehicle users, people nearby and maintenance personnel, or**
- **Regulatory compliance.**

Qualified Personnel

LPG systems must be maintained and inspected exclusively by trained personnel with qualifications in accordance with the applicable codes.

WARNING

Individuals involved in any aspect of LPG fuel system maintenance, emergency response, servicing or testing must be properly trained. Individuals who are not trained are not permitted to service, maintain, test, or inspect a system.

[1] LPG used for automotive applications is often referred to as “propane autogas.”

Air Compressor Belt Replacement

REMOVAL PROCEDURE

1. Secure vehicle and verify engine is off and cool.
2. Insert a 1/2-in drive breaker bar into square socket (1) on Belt Tensioner (2) to relieve tension on Main Accessory Drive Belt. *Figure 1*
3. Remove Main Accessory Drive Belt *(not shown).*
4. Use Stretch Belt Installation Tool (*Figure 3*) to carefully slip Air Compressor Belt (6) off Air Compressor Pulley (4). *Figure 2*

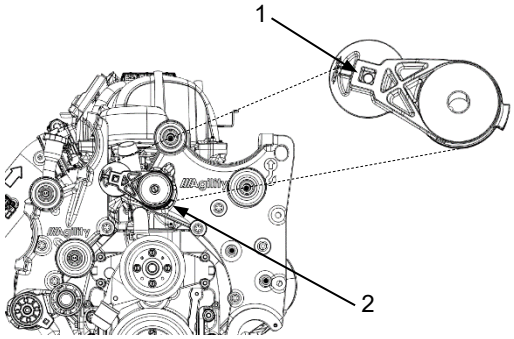


Figure 1:
Belt Tensioner (2) and Drive Socket (1)

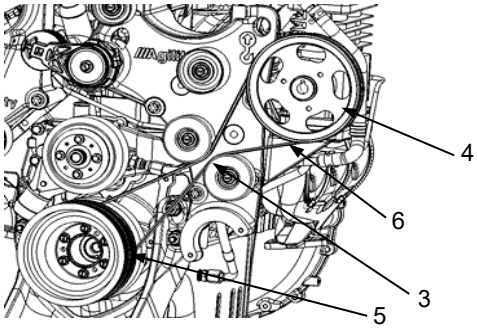


Figure 2:
Air Compressor Belt (6) routing: Harmonic Damper Pulley (5); between Idler Pulleys at location (3); Air Compressor Pulley (4)

INSTALLATION PROCEDURE

1. Route Air Compressor Belt (6) around crankshaft Harmonic Damper Pulley (5).

   NOTICE

   Harmonic Damper Pulley is the four-groove, smaller diameter pulley, closest to engine block. *Figure 2*
2. Route Air Compressor Belt (6) between Idler Pulleys at location (3). *Figure 2*
3. Use Stretch Belt Installation Tool (*Figure 3*) to install Air Compressor Belt (6) on Air Compressor Pulley (4). *Figure 2*
4. Install Main Accessory Drive Belt. *Refer to OEM service manual for procedure and proper routing.*
5. Verify proper operation.

Figure 3:
Stretch Belt Installation Tool

Air Compressor Bracket Replacement

REMOVAL PROCEDURE

1. Secure vehicle; verify engine is off and cool.
2. Remove Air Compressor *(not shown). Refer to Air Compressor Replacement.*
3. Disconnect Oil Drain Line (3). *Figure 1*

   NOTICE

   Collect any excess oil for reuse or proper disposal.
4. Remove Air Compressor Coolant Line Retaining Clip Bolt (4). *Figure 1*
5. Remove lower Idler Pulley Bolt (5) and set lower Idler Pulley (6) aside. *Figures 1 & 2*
6. Remove two (2) Air Compressor Bracket Retaining Bolts (2) from face of Main Accessory Drive Bracket and one (1) Bolt (2) from below Air Compressor Bracket. *Figures 1 & 2*
7. Remove Air Compressor Bracket (1) from Main Accessory Drive Bracket (7). *Figure 2*

   NOTICE

   Store Air Compressor to Bracket Alignment Pins *(not shown)* for reuse.

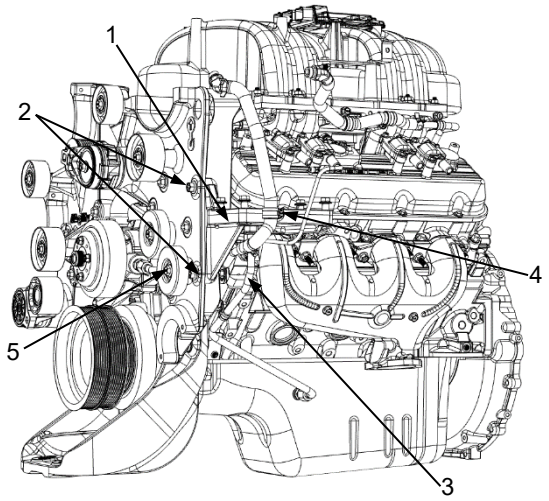


Figure 1:
Air Compressor Bracket (1), Retaining Bolts (2), Oil Drain Line (3), Idler Pulley Bolt (5), Coolant Line Retaining Clip Bolt (4)

INSTALLATION PROCEDURE

1. Install Air Compressor Bracket (1) on Main Accessory Drive Bracket (7) using Air Compressor Bracket Retaining Bolts (2). *Figure 2*
2. Torque Air Compressor Bracket Retaining Bolts (2). *Refer to Front End Accessory Drive (FEAD) Torque Specifications. Figure 2*
3. Install Idler Pulley (6) with Bolt (5). *Figure 2*
4. Torque Idler Pulley Bolt (5). *Refer to Front End Accessory Drive (FEAD) Torque Specifications. Figure 2*
5. Connect Oil Drain Line (3). *Figure 1*
6. Install Coolant Line Retaining Clip Bolt (4). *Figure 1*
7. Install Air Compressor. *Refer to Air Compressor Replacement*.
8. **Check engine oil level; refer to *488LPI™ Owner Manual* for specification and procedure.**
9. Verify proper operation.

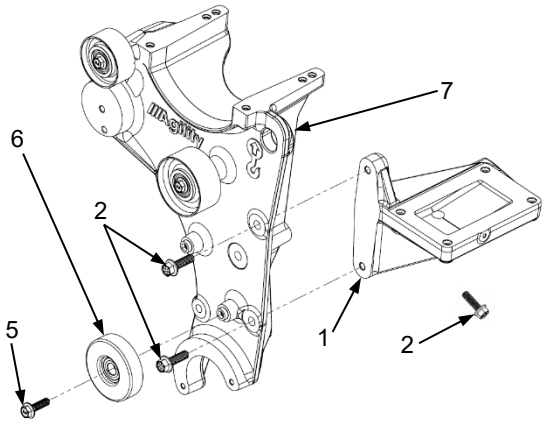


Figure 2:
Main Accessory Drive Bracket (7),
Air Compressor Bracket (1),
Air Compressor Bracket Retaining Bolts (2),
Idler Pulley (6), Idler Pulley Bolt (5)

Air Compressor Replacement

REMOVAL PROCEDURE

NOTICE

Clean all hose and pipe connections prior to servicing to prevent debris from entering the coolant or oiling passages.

1. Secure vehicle and verify engine is off and has had time to cool.
2. **CAUTION**

   Carefully relieve engine cooling system pressure by slowly loosening Coolant Reservoir Pressure Cap.
3. Partially drain coolant from radiator. *Follow OEM procedure*.
4. Drain all air tanks. *Refer to OEM Air Brake Reservoir Service.*
5. Insert a 1/2-in drive breaker bar into square socket (1) on Tensioner (2) to relieve tension on Main Accessory Drive Belt. *Figure 1*
6. Remove Main Accessory Drive Belt.
7. Remove Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
8. Disconnect Air Inlet and Air Discharge Hoses from Air Compressor (7) ports (3, 4). *Figure 3*

   NOTICE

   Collect any coolant from Air Compressor cylinder head for reuse or proper disposal.
9. Disconnect Water Inlet and Outlet Hoses from Air Compressor (7) ports (5, 6). *Figure 3*

   NOTICE

   Collect any coolant from Air Compressor cylinder head for reuse or proper disposal.

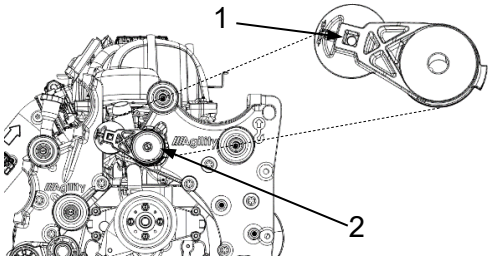


Figure 1:
Belt Tensioner (2) and Drive Socket (1)

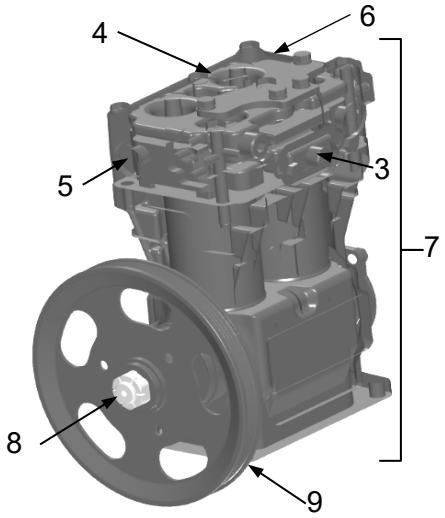


Figure 2:
Air Compressor (7) port locations:
Air Inlet (3), Air Discharge (4),
Water Inlet (5), Water Outlet (6);
Pulley (9), Pulley Castle Nut (8)

10. Disconnect Oil Supply Line *(not shown)* at rear of Air Compressor.
11. Remove Air Compressor Pulley Castle Nut (8). *Figure 3*
12. Use a special tool to remove Air Compressor Pulley (9) *Figure 3*

NOTICE

If pulley is bent during this process, replace the pulley with a new part.

13. Remove four (4) Air Compressor Retaining Bolts (10) from Air Compressor Bracket *(not shown). Figure 3*.
14. Remove Air Compressor from vehicle taking care not to misplace Air Compressor Bracket Alignment Pins (11). *Figure 3*
15. Discard used Air Compressor Base Gasket (12). *Figure 3*

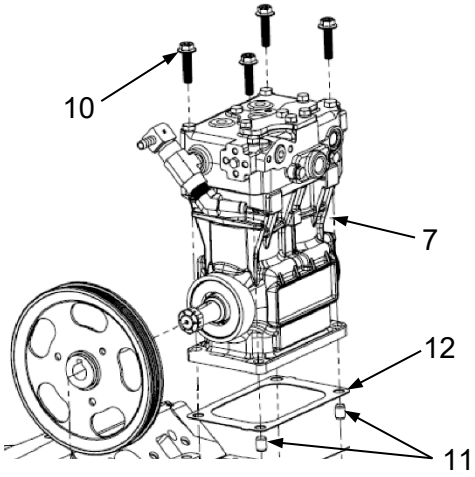


Figure 3:
Air Compressor (7), Retaining Bolts (10), Bracket Alignment Pins (11), Air Compressor Gasket (12)

INSTALLATION PROCEDURE

1. Verify Air Compressor Bracket alignment pins (11) are in place. *Figure 3*
2. Install new Air Compressor base gasket (12) on Air Compressor bracket *(not shown). Figure 3*
3. Install Air Compressor on Base Gasket (12) and tighten four (4) Air Compressor Retaining Bolts (10) in a cross pattern. *Figure 4*. *Refer to* *Front End Accessory Drive Torque Specifications.*
4. Press Air Compressor Pulley (9) on Air Compressor (7). *Figure 2*

Verify Pulley Keyway is properly aligned.

5. Torque Air Compressor Pulley Retaining Nut (8). *Figure 2. Refer to* *Front End Accessory Drive Torque Specifications.*

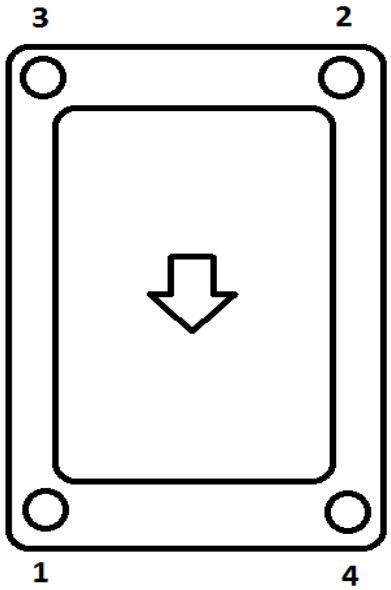


Figure 4:
Air Compressor Retaining Bolt Tightening Sequence

6. Install Water Inlet and Outlet Hoses on Air Compressor (7) at locations (5) and (6) and tighten clamps. *Figure 2*
7. Install Air Inlet and Discharge Hoses on Air Compressor (7) at locations (3) and (4) and tighten clamps. *Figure 2*
8. Connect Oil Supply Line *(not shown)* to Air Compressor. *Refer to Front End Accessory Drive (FEAD) Torque Specifications.*
9. Install Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
10. Install Main Accessory Drive Belt. *Refer to OEM service manual for procedure and routing*.
11. Fill cooling system. *Follow OEM specifications.*
12. Verify proper operation.
13. Run engine to operating temperature and inspect for leaks.
14. Clean any excess oil or coolant from engine.

Air Conditioning (A/C) Compressor Removal

(in conjunction with Upper and Lower Intake Manifold Removal)

REMOVAL PROCEDURE

NOTICE

If vehicle is equipped with single or dual A/C compressors the A/C system does not need to be discharged when removing the Upper and/or Lower Intake manifold.
Refer to Upper Intake Manifold and Lower Intake Manifold Replacement Procedure.

1. Secure vehicle.
2. Disconnect battery ground cable.
3. Remove Drive Belt (3) from A/C compressor(s). *Figure 1*
   Refer to OEM Drive Belt Replacement Procedure.
4. Disconnect electrical wire connectors at back of A/C compressor.
5. Remove QTY: 4 A/C compressor mounting bolts (1) per compressor (2). *Figure 1*.
6. Remove A/C compressor(s) (2). *Figure 1*
7. Lift A/C compressors (2) and hoses over to top of intake manifold and place on driver side inner fender well. *Figure 2*

   NOTICE

   Use wire to temporarily secure A/C compressors out of work area.

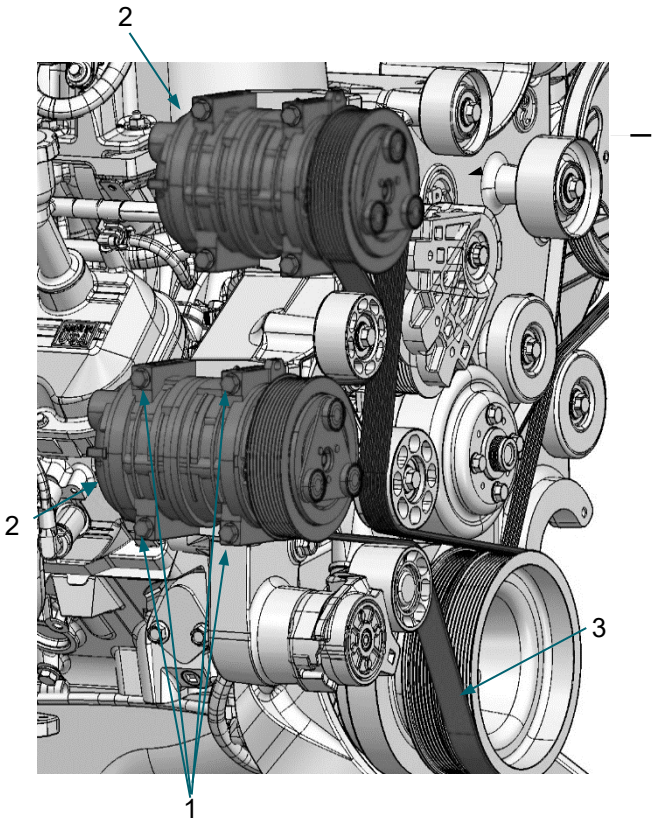


Figure 1
A/C compressor mounting bolts (1), Compressor (2), Drive Belt (3). *NOTE: Dual A/C configuration shown; single A/C configuration similar*

INSTALLATION PROCEDURE

1. Lift A/C compressor(s) and hose assemblies over top of Upper Intake Manifold. *Figure 2*
2. Position A/C compressor(s) into mount(s).
3. Install QTY:4 mounting bolts for each A/C compressor and tighten to spec. *Figure 1*
4. Connect electrical wire connectors.

   C **Apply dielectric grease to connectors.**
5. Reinstall drive belt. *Figure 1. Refer to OEM Drive Belt Replacement Procedure.*
6. Verify proper operation.

Figure 2
A/C lines (4) in place prior to A/C compressor (2) removal. Once A/C compressor(s) is/are removed from engine, compressor and hose assembly may be flipped over top of engine and placed on driver side of engine compartment.

Air Intake Tube Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Disconnect Mass Air Flow (MAF) Sensor Electrical Connector (1). *Figure 1*
3. Remove (2) Nylon Push Pins—aka "Christmas Tree Pins"—*(not shown)* securing Engine Harness to Air Intake Tube Bosses (9). *Figure 2*
4. Loosen Worm Clamp Collar (4) at Air Filter Housing Elbow.

   NOTICE

   Air Cleaner *(not shown)* varies with OEM.
5. Loosen Worm Clamp Collar (2) at Throttle Body (6). *Figure 1*
6. Disconnect Makeup Air Tube at location (7) from Air Intake Tube (3). *Figure 2*
7. Using a twisting motion, walk Air Intake Tube (3) off Throttle Body (6)
   Figure 1.

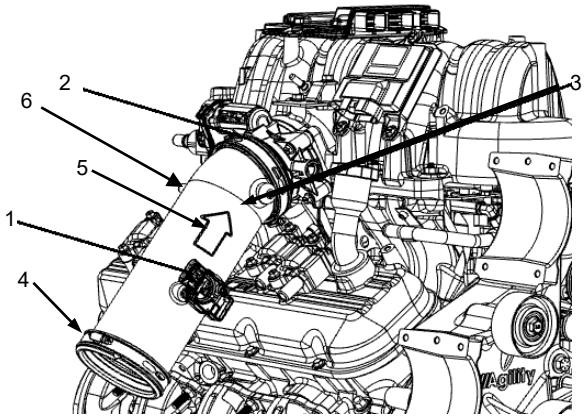


Figure 1:
Partial Air Intake Assembly: MAF Sensor (1), Worm Clamp Collars (2 and 4), Air Intake Tube (3), Throttle Body (6), Flow Direction Arrow (5)

INSTALLATION PROCEDURE

1. *If removed*: Inspect Mass Air Flow (MAF) Sensor (8) O-Ring for wear. *Figure 1*

   NOTICE

   Replace MAF Sensor O-Ring if damaged.
2. If removed: Install MAF Sensor (8) *Figure 2. Refer to Mass Air Flow Sensor Replacement.*
3. Install Air Intake Tube (3) on Air Filter Housing Elbow (not shown).

   NOTICE

   To ease installation, apply a light coat of soapy water to rubber grommets on Air Intake Tube ends.
4. Install other end of Air Intake Tube (3) on Throttle Body (6).

   C **Verify Flow Arrow (5) points at Throttle Body (6).** *Figure 1*
5. Verify Air Intake Tube (3) is centered on both ends and MAF Sensor (8) is perpendicular to Air Intake Tube. *Figure 2*
6. Make sure the Worm Clamp Collars are pushed all the way on to the throttle body, tighten Worm Clamp Collar (2) and (4). *Figures 1 & 2*
7. Connect MAF Sensor Electrical Connector (1). *Figure 1*
8. Secure Engine Harness by installing (2) Nylon Push Pins—aka “Christmas Tree Pins”—(not shown) into Air Intake Tube Bosses (9). *Figure 2*
9. Install Makeup Air Tube at location (7) on Air Intake Tube. *Figure 2*
10. Verify operation and check for air leaks.

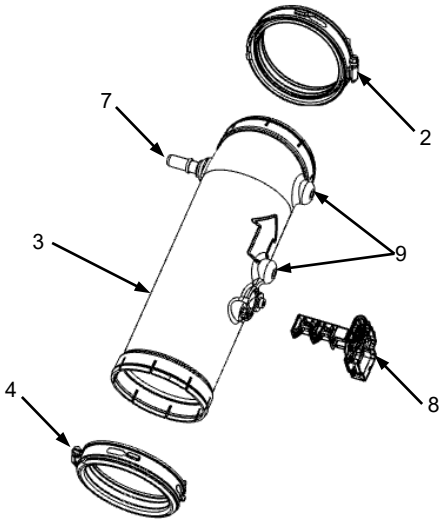


Figure 2.
Air Intake Tube (3), Air Make Up Tube location (7), MAF Sensor (8), Worm Clamp Collars (2 & 4), Engine Harness Pin Bosses (9)

Alternator Removal

Hexagon Agility does not supply the alternator for the 488LPI™ propane autogas engine but provides this instruction as a courtesy because alternator removal may be required for certain service procedures. Obtain alternator diagnostics and parts from vehicle OEM.

REMOVAL PROCEDURE

1. Secure vehicle.
2. Disconnect battery (–) ground cable.
3. Remove drive belt. *Refer to OEM Drive Belt Replacement Procedure.*
4. Disconnect electrical wire connectors *(not visible)* at back of Alternator.
5. Remove four (4) Bolts (2) securing Alternator (1). *Figure 1*
6. Remove Alternator (1). *Figure 1*

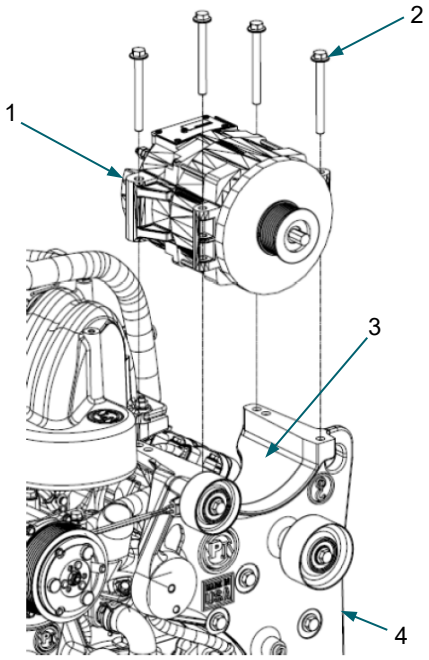


Figure1:
Alternator (1), Bolts (2), Saddle (3), Front End Accessory Drive bracket (4)

INSTALLATION PROCEDURE

1. Position Alternator (1) in mounting saddle (3) on Front End Accessory Drive bracket (4). *Figure 1*
2. Secure Alternator (1) to Front End Accessory Drive bracket (4) using four Bolts (2). *Figure 1*

   C **Tighten bolts to 55 Nm (41 ft-lbs).**
3. Connect electrical wire connectors.

   C **Apply dielectric grease to connectors.**
4. Reinstall drive belt. *Refer to OEM Drive Belt Replacement Procedure.*
5. Reconnect battery (–) ground cable.
6. Verify proper operation.

Belt Tensioner Replacement

REMOVAL PROCEDURE

1. Verify vehicle is secured properly. Ensure engine is off and cool.
2. Insert a 1/2-in drive breaker bar into square socket (1) on the appropriate Belt Tensioner (3) or (6) to relieve tension on the Main Accessory Drive Belt *(not shown). Figure 1, 2, or 3*
3. Remove Main Accessory Drive Belt.
4. Remove Belt Tensioner Retaining Bolt *(not shown).*
5. Remove Belt Tensioner (3) or (6). *Figure 1, 2, or 3*

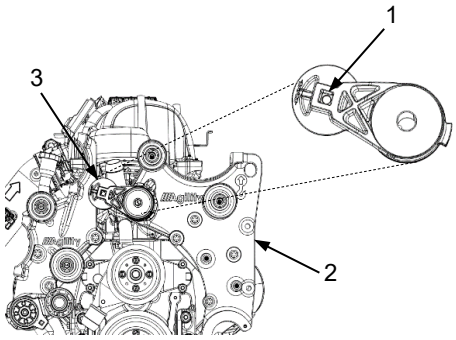


Figure 1:
Belt Tensioner (3) location on Front End Accessory Drive (FEAD) Bracket (2) and Drive Socket (1).
NOTE: *Non-AC and Dual A/C equipped engines*

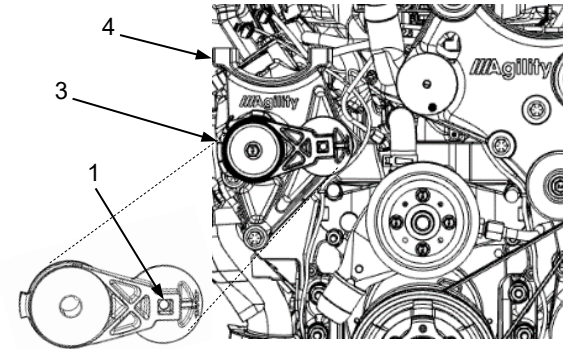


Figure 2:
Belt Tensioner (3) location on Single A/C Bracket (4) and Drive Socket (1).
NOTE: *Single A/C equipped engines only.*

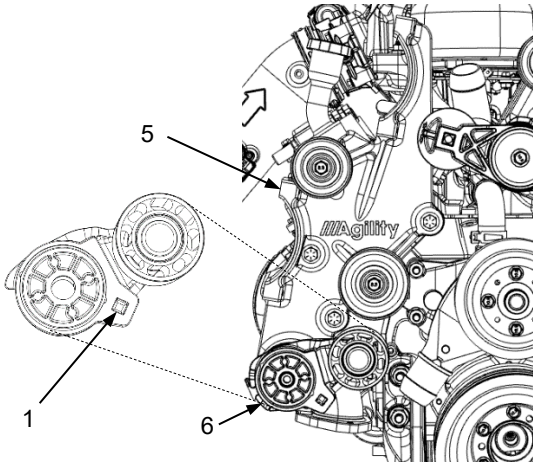


Figure 3:
Dual A/C Belt Tensioner (6) on Dual A/C Bracket (5) and Drive Socket location (1).
NOTE: *Dual A/C equipped engines only.*

INSTALLATION PROCEDURE

1. Position Belt Tensioner (3) or (6) on appropriate Drive Bracket. *Figure 1, 2, or 3*
2. Install Belt Tensioner Retaining Bolt *(not shown).*

   C **Tighten Belt Tensioner Retaining Bolt** *(not shown). Refer to Engine Front End Accessory Drive (FEAD) Torque Specifications.*
3. Route and install Main Accessory Drive Belt. *Refer to OEM service manual for procedure and routing.*
4. Verify proper operation.

Block Heater Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is off and has had ample time to cool before attempting procedure.
3. Drain coolant from Radiator. *Follow OEM procedure.*

   NOTICE

   Reuse or properly dispose of coolant.
4. Loosen Block Heater Expansion Bolt.

   NOTICE

   Do not remove Bolt.
5. Remove Block Heater (2) from location (1) on engine. *Figure 2*

   NOTICE

   Prepare to collect coolant. Reuse or properly dispose of coolant.

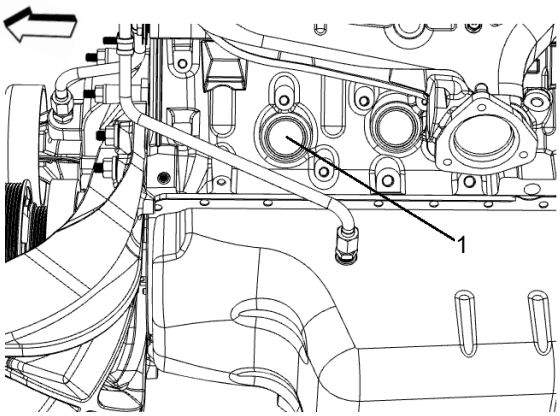


Figure 1:
Factory installed Block Heater location (1)

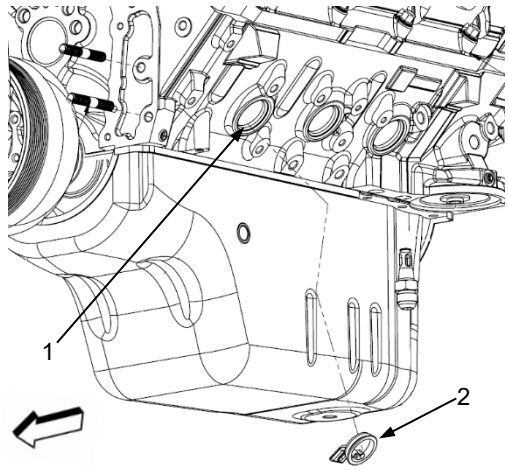


Figure 2:
Block Heater (2) and Block Heater location (1)

INSTALLATION PROCEDURE

1. Clean gasket surface in engine block at Block Heater location (1). *Figures 1 and 2*
2. Install new Block Heater (2) in engine at location (1). *Figure 2*
3. Tighten Block Heater Expansion Bolt. *Refer to Engine Mechanical Torque and Clearance Specifications.*
4. Fill engine coolant. *Follow OEM procedure.*
5. Clean any spilled fluids.
6. Verify proper operation.

Camshaft Inspection and Replacement Procedure

Camshaft Lobe wear may be identified by measuring valve lift. A spun Camshaft Bearing may restrict oil flow to the valvetrain and other critical engine components. Premature Camshaft Bearing or Lobe wear may cause low or sporadic engine vacuum readings resulting in stored ECM fault codes. Use the procedures outlined below for Camshaft inspection and verification of Camshaft failure. If the Camshaft Lobes or Camshaft Bearings are deemed defective or worn, the engine must be taken out of service.

CAMSHAFT LOBE INSPECTION PROCEDURE (Indirect - via valve lifter wear)

1. Secure vehicle and verify engine is cool.
2. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement*.
3. Remove Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement*.
4. Remove Valley Pan. *Refer to Valley Pan Replacement*.
5. Remove Valve Covers. *Refer to Valve Cover Replacement*.
6. Loosen Valve Rocker Arms. *Refer to Valve Rocker Arm Replacement*.
7. Remove and Inspect Pushrods. *Refer to Pushrod Inspection and Replacement*.

   C **Clean lifters in parts washer solvent.**

   NOTICE

   Intake and Exhaust Pushrods are different lengths. Pushrods must be kept in order of removal. If abnormal Pushrod wear is evident or Pushrod oil passages are clogged, inspect for Camshaft and other valvetrain damage.
8. Remove Valve Lifters from block. *Refer to Valve Lifter Replacement*.

   NOTICE

   Clean Valve Lifters in parts washer solvent and organize Valve Lifters in order of removal.
9. Visually inspect each Valve Lifter for signs of wear, scoring, or metal shavings.

   NOTICE

   If abnormal Valve Lifter wear is evident, Camshaft Lobe wear is likely.

   C **Document all findings in detail to support Engine Warranty Repair/ Replacement requirements and authorization.**
10. *Proceed to Camshaft Removal / Camshaft Lobe, Journal and Bearing Inspection Procedure (below)*.

CAMSHAFT REMOVAL / CAMSHAFT LOBE, JOURNAL AND BEARING INSPECTION PROCEDURE (Direct - visual & quantitative)

1. Follow Steps 1-9 of *Camshaft Lobe Inspection Procedure (above)*.
2. Remove Cooling Pack. *Follow OEM procedure.*
3. Remove Main Accessory Drive Belt. *Follow OEM procedure.*
4. *If equipped:* Remove Air Compressor Belt. *Refer to Air Compressor Belt Replacement*.
5. Remove Water Pump. *Refer to Water Pump Replacement.*
6. Remove Harmonic Damper. *Refer to Harmonic Damper Replacement.*
7. Remove Engine Front Cover. *Refer to Engine Front Cover Replacement.*
8. Remove Timing Chain and Sprockets. *Refer to Timing Chain and Sprocket Replacement*.
9. Remove two (2) Camshaft Retaining Bolts (1) and Camshaft Retainer (2). *Figure 1*
10. Install three (3) 8-1.25 x 100mm Bolts (3) in Camshaft front snout (4). *Figure 2*
11. Using three (3) 8-1.25 x 100mm Bolts as a handle, carefully remove Camshaft while slowly rotating it back and forth and remove Bolts. *Figure 2*

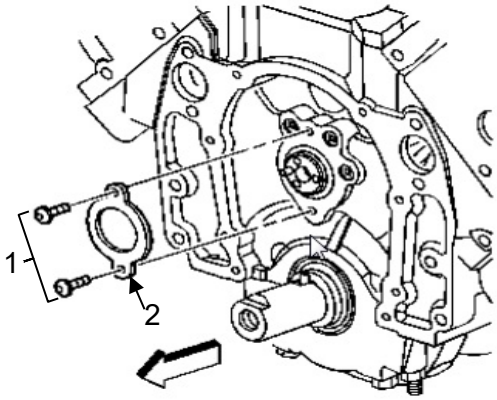


Figure 1:
Camshaft Retainer (2) and
Camshaft Retainer Bolts (1)

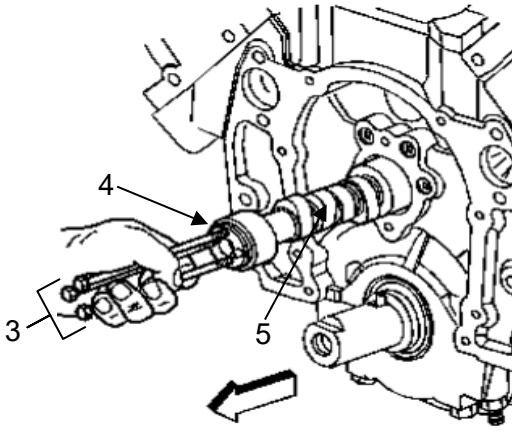


Figure 2:
Install three (3) 8-1.25 x 100mm Bolts (3)
in Camshaft front snout (4);
use as handle to remove Camshaft (5)

12. Inspect Camshaft Lobes (6) for signs of damage. *Figures 3 & 4*

NOTICE

Normal Camshaft Lobes show an even wear pattern: wide at the Lobe Nose and narrowing back to the Lobe Heel. Abnormal Cam Lobes exhibiting wide wear across entire lobe surface require Camshaft replacement; *follow Warranty Authorization procedure before proceeding.*

13. Inspect Cam Bearing Journals (9) for signs of damage. *Figures 3 & 5*

NOTICE

Before reusing Camshaft, verify all Camshaft Journals are same diameter with a Micrometer (10) as shown in *Figure 5.* If not, Camshaft Bearing damage may occur.

14. Use inspection mirror and flashlight to inspect Camshaft Bearings (11) for visual evidence of excessive wear*, galling, pitting, scoring, or embedded debris.

C ***Measure Camshaft Bearing inside diameter (ID) using a Micrometer to verify an oversize condition**. *Figure 6*

NOTICE

Bearing material with different shades of gray is normal, and NOT evidence for bearing replacement.

C **Verify no Camshaft Bearings have spun out of position. This could cause oil flow blockage.**

15. If Camshaft Bearing damage or misalignment is found, *refer to Engine Replacement procedure.*

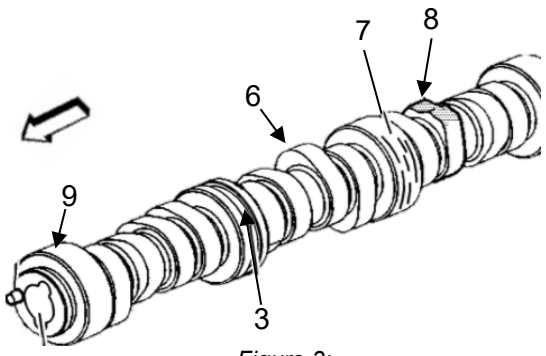


Figure 3:
Camshaft (3) with abnormal Camshaft Journal showing scoring / excessive wear (7), abnormal Camshaft Lobe exhibiting scoring / excessive wear (8), normal Camshaft Lobe (6), normal Camshaft Journal (9)

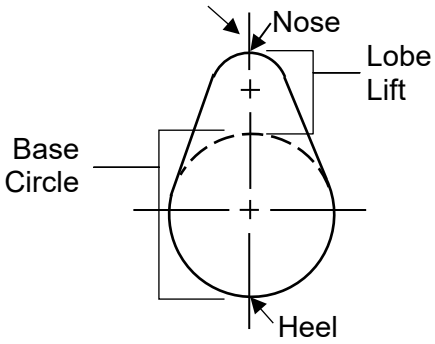


Figure 4:
Camshaft Lobe (6) Features

CAMSHAFT INSTALLATION

1. **Lubricate Camshaft Lobes (6) and Journals (9) with clean engine oil.** *Figures 1 and 3*
2. Install three (3) 8-1.25 x 100mm Bolts (3) in Camshaft front snout (4). *Figure 7*
3. **NOTICE**
   Use Bolts as a handle to carefully install Camshaft (5). *Figure 7*
4. Remove Bolts from Camshaft.
5. Install Camshaft Retainer (2) with two (2) Camshaft Retainer Bolts (1) as shown in *Figure 8. Refer to Engine Mechanical Torque and Clearance Specifications.*
6. Install Timing Chain and Sprockets. *Refer to Timing Chain and Sprocket Replacement.*
7. Install Engine Front Cover. *Refer to Engine Front Cover Replacement.*
8. Install Valve Lifters. *Refer to Valve Lifter Replacement.*
9. Install Pushrods. *Refer to Pushrod Inspection and Replacement.*
10. Install Valve Rocker Arms. *Refer to Valve Rocker Arm Replacement.*
11. Install Valve Covers. *Refer to Valve Cover Replacement.*
12. Install Valley Pan. *Refer to Valley Pan Replacement.*
13. Install Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
14. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
15. Install Water Pump. *Refer to Water Pump Replacement.*
16. Install Harmonic Damper. *Refer to Harmonic Damper Replacement.*
17. *If equipped*: Install Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
18. Install Main Accessory Drive Belt. *Follow OEM procedure.*

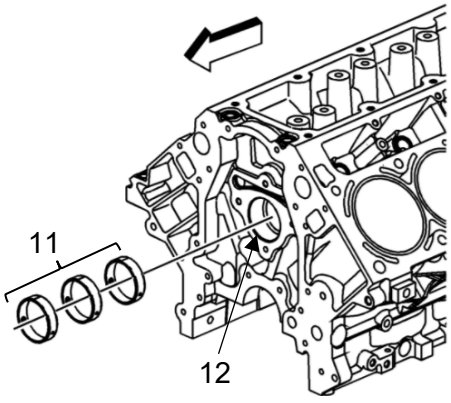


Figure 6:
Camshaft Bearings (11).
NOTE: Exploded view shown for illustrative purposes; bearings will still be installed in Engine Block at position (12).

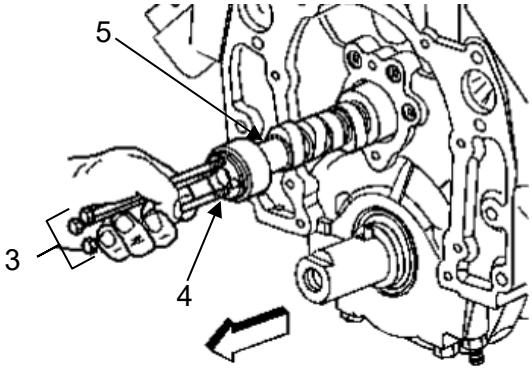


Figure 7:
Install Camshaft (5) using three (3) 8-1.25 x 100mm Bolts (3) as a handle.

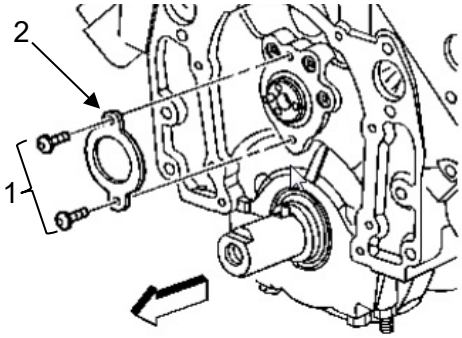


Figure 8:
Install Camshaft Retainer (2) and two (2) Camshaft Retainer Bolts (1)

19. Install Cooling Pack. *Follow OEM procedure.*
20. Fill engine fluids. *Follow OEM procedure and specifications in* 488LPI™ Operators Manual.
21. Verify proper operation.

Crankshaft Front Oil Seal Replacement

DESCRIPTION AND OPERATION

The Crankshaft Front Oil Seal retains engine oil in the oil pan while allowing the Crankshaft to rotate. The seal is a standalone press fit design with no bolts holding it in the engine block.

REMOVAL PROCEDURE

1. Secure vehicle.
2. Disconnect battery ground cable.
3. Verify engine has had ample cooling time.
4. Drain engine oil.
5. Remove Main Accessory Drive Belt. *Refer to Main Accessory Drive Belt Replacement.*
6. *If equipped*: Remove Air Compressor Drive Belt. *Refer to Air Compressor Drive Belt Replacement.*
7. Remove Harmonic Damper (1). *Figure 1. Refer to Harmonic Damper Replacement.*
8. Remove Crankshaft Front Oil Seal (2) from Engine Front Cover (3). *Figure 2*

NOTICE

Use care not to damage Engine Front Cover or Crankshaft sealing area when removing Crankshaft Front Oil Seal.

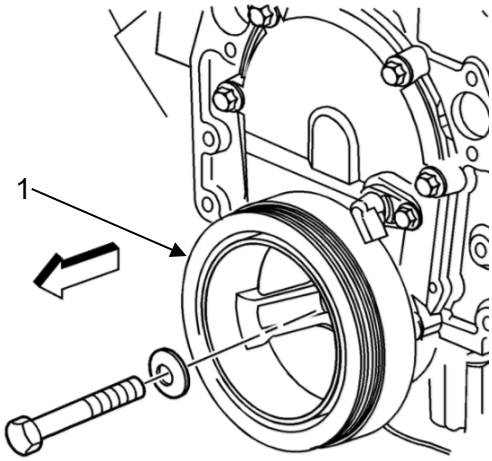


Figure 1:
Remove Harmonic Damper (1)

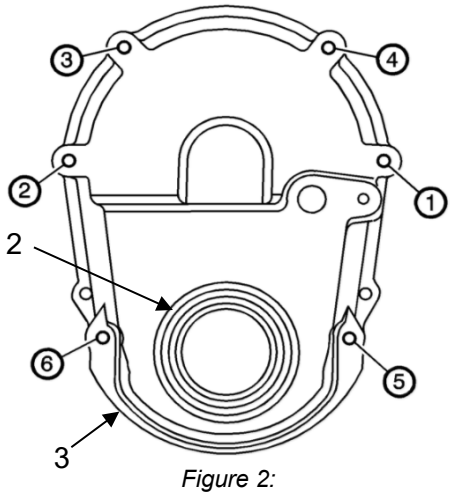


Figure 2:
Crankshaft Front Oil Seal (2) in Engine Front Cover (3)

INSTALLATION PROCEDURE

1. Apply a very light film of oil to Crankshaft Front Oil Seal sealing surface.
2. Use Special Tool J 42581 to install new Crankshaft Front Oil (2) Seal in Engine Front Cover (3). *Figure 2*
3. Install Harmonic Damper (1). *Figure 1* *Refer to Harmonic Damper Replacement.*
4. Install Air Compressor Drive Belt. *Refer to Air Compressor Drive Belt Replacement.*
5. Install Main Accessory Drive Belt. *Refer to Main Accessory Drive Belt Replacement. Follow OEM routing instructions.*
6. Fill engine oil. *Refer to OEM specifications.*
7. Verify proper operation.

Crankshaft Bearing Inspection

INSPECTION PROCEDURE

1. Drain engine oil.

   NOTICE

   Collect oil for inspection or analysis and dispose of properly.
2. Remove Oil Pan. *Refer to Oil Pan Replacement*.
3. Remove Oil Pickup Tube.
4. Remove Connecting Rod Cap Nuts.

   Keep Rod Cap Nuts in order with their respective Connecting Rods.
5. Remove Main Bearing Cap Bolts.

   Keep Cap Bolts in order with their respective Main Bearing Caps.
6. Inspect Connecting Rod Bearings and Main Bearings visually for signs of irregular wear (metal shavings, grit, etc.).
7. *If wear / shavings are discovered*, remove suspect Main Bearing Cap for in-depth inspection.

   Figure 1 shows types of irregular wear.
8. Document any damage found.

   NOTICE

   Obtain necessary warranty approval authorization before beginning *Engine Replacement* **procedure.**
9. *If no trouble is found*, replace Connecting Rod Cap Nuts. *Refer to Engine Mechanical Torque and Clearance Specifications.*
10. *If no trouble is found*, replace Main Bearing Cap Bolts. *Refer to Engine Mechanical Torque and Clearance Specifications.*
11. Install Oil Pickup Tube.
12. Install Oil Pan. *Refer to Oil Pan Replacement.*

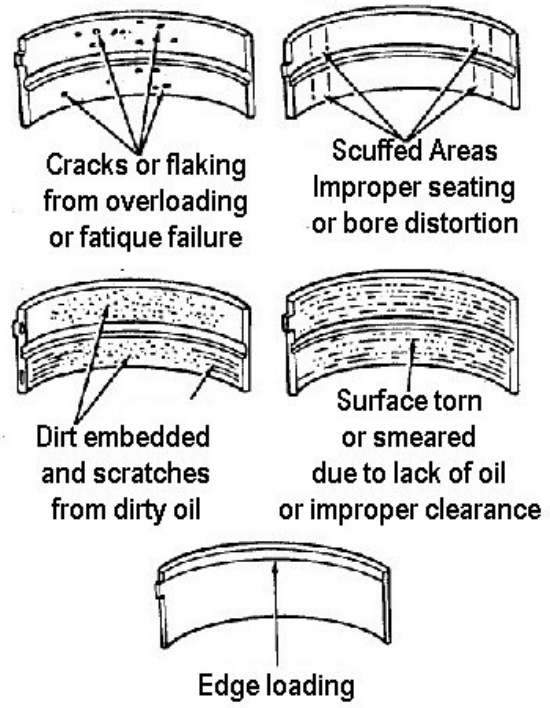


Figure 1:
Irregular bearing wear indicators

13. Replace Oil Filter.
    RECOMMENDED: *Install new Oil Filter.*
14. Fill engine oil. *Refer to OEM procedure and 488LPI™ Operator Manual.*
15. Verify proper operation.

Crankshaft Rear Oil Seal Replacement

REMOVAL PROCEDURE

1. Remove Transmission. *Follow OEM procedure.*
2. Remove Flywheel. *Refer to Flywheel and Transmission Adaptor Replacement.*
3. Remove Starter. *Follow OEM procedure.*
4. Install Special Tool Kit J 43320 Guide Pins (1) in two (2) opposing Crankshaft flange (2) holes as shown in *Figure 1*
5. Install J 43320 (3) over Guide Pins (1). *Figures 1 and 2*
6. Use a power drill with adequate torque to insert eight (8) Self-Tapping Sheet Metal Screws from Special Tool J 43320 into Rear Crankshaft Oil Seal in a crisscross pattern as shown in *Figure 2.*
7. Thread J 43320 Center Bolt (4) into Crankshaft to remove old Crankshaft Rear Oil Seal and discard seal. *Figure 3*
8. Remove Guide Pins (1) from Crankshaft flange (2) holes. *Figure 1*

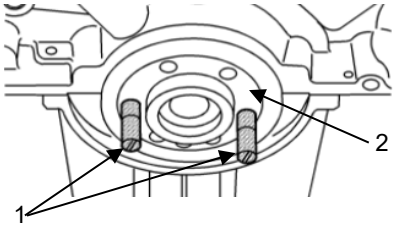


Figure 1:
J 43320 Guide Pins (1) inserted in

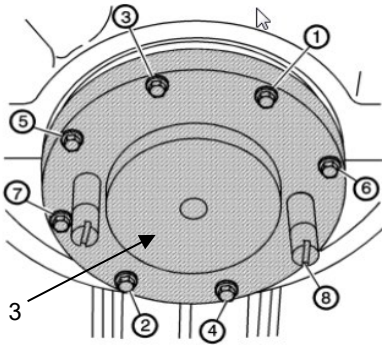


Figure 2:
J 43320 (3) with Self-Tapping Screws

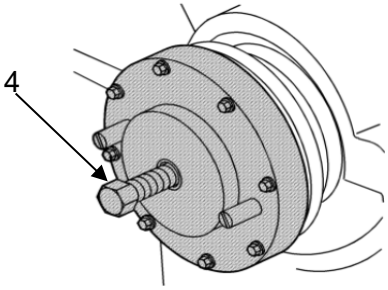


Figure 3:
J 43320 Center Bolt (4)

INSTALLATION PROCEDURE

1. Inspect Crankshaft rear chamfer (5) for grit, loose rust, and burrs. *Correct as needed. Figure 4*
2. Apply a very light film of clean engine oil to Crankshaft sealing surface.

   C DO NOT apply oil to sealing surface of engine block.
3. Install new Crankshaft Rear Oil Seal in Special Tool J 42849 (6).
4. Position J 42849 against Crankshaft.
5. Thread J 42849 guide pins into tapped holes in Crankshaft. *Figure 4*
6. Tighten J 42849 guide pins *(not shown)* securely with a screwdriver to insure Crankshaft Rear Oil Seal is installed squarely over Crankshaft.
7. Tighten J 42849 Center Nut (7) until J 42849 bottoms. *Figure 5*
8. Remove Special Tool J 42849.
9. Install Starter. *Follow OEM procedure.*
10. Install Flywheel. *Refer to Flywheel and Transmission Adaptor Replacement.*
11. Install Transmission. *Follow OEM procedure*.
12. Fill engine fluids. *Follow OEM procedure and specifications in* 488LPI™ Operators Manual.
13. Verify proper operation.

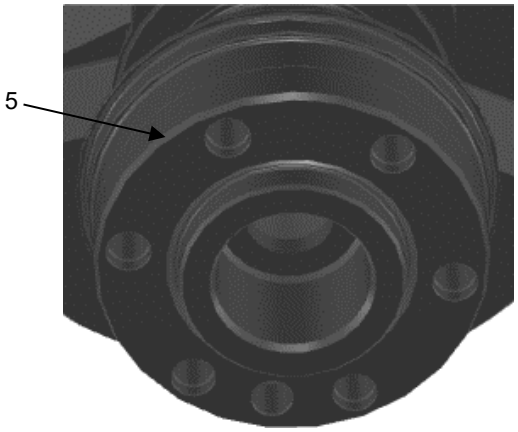


Figure 4:
Crankshaft rear chamfer (5)

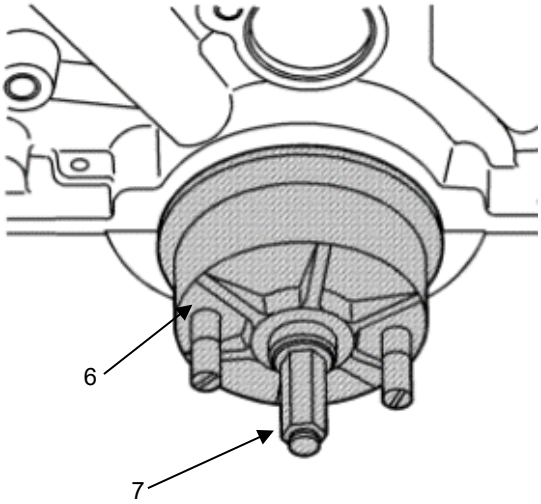


Figure 5:
Special Tool J 42849 (6) and Center Nut (7)

Cylinder Head Inspection and Replacement

REMOVAL PROCEDURE

1. Drain engine coolant. *Follow OEM procedure.*
2. Remove Fan. *Follow OEM procedure.*
3. Remove Main Accessory Drive Belt. *Follow OEM procedure.*
4. Driver side Cylinder Head ONLY. *If equipped:* Remove Air Compressor. *Refer to Air Compressor Replacement.*
5. Remove Front End Accessory Drive Brackets. *Refer to appropriate bracket replacement procedure.*
6. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
7. Remove Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
8. Remove Valve Covers. *Refer to Valve Cover Replacement.*
9. Remove Valve Roller Rockers. *Refer to Valve Roller Rocker Replacement.*
10. Disconnect remaining electrical connections including Ground Ring(s) at rear of Cylinder Head(s). Move wiring aside and secure.
11. Remove Push Rods.

    NOTICE

    Intake and Exhaust Valve Push Rods are different lengths. Use a divided tray to organize parts in the order removed. *Figure 2*
12. Disconnect Exhaust Y-Pipe from Exhaust Manifold of Cylinder Head to be removed. *Follow OEM procedure.*

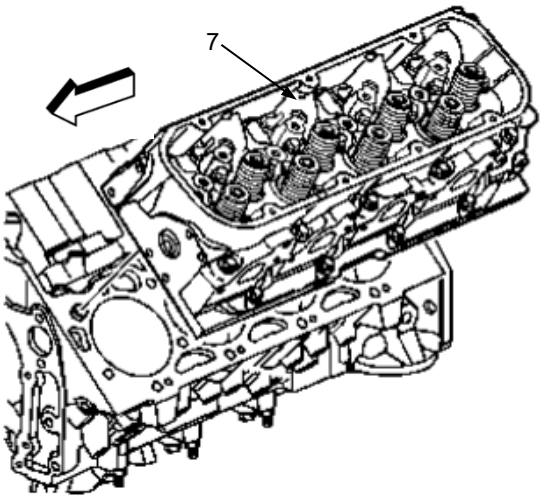


Figure 1:
Driver side Cylinder Head (7) with Valve Rocker Cover and Valve Rockers removed.

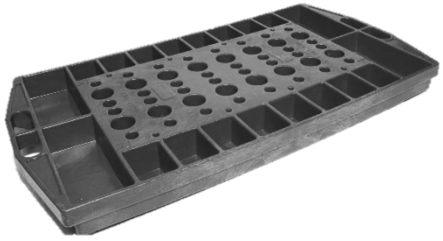


Figure 2:
Use an engine tear down tray to organize valvetrain components.

13. Remove Exhaust Manifold. *Refer to Exhaust Manifold Replacement.*
14. Remove Cylinder Head Bolts (1, 2, 3) and discard. *Figure 3*

NOTICE

Three (3) different bolt sizes are used.

15. Remove Cylinder Head (7). *Figure 1*
16. Remove Cylinder Head Gasket (4) and discard. *Figure 4*

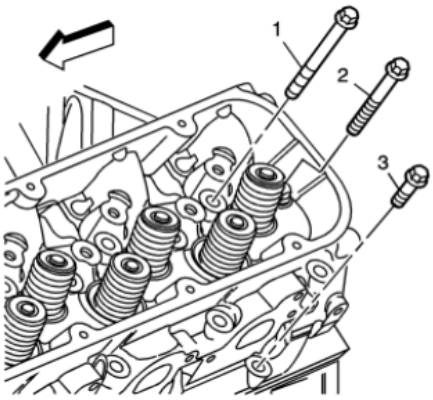


Figure 3:
Cylinder Head Bolts (1, 2, 3) are three (3) different lengths and non-reusable; discard after removal

INSPECTION PROCEDURES

Visual Inspection Procedure

Inspect Cylinder Head for the following conditions:

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

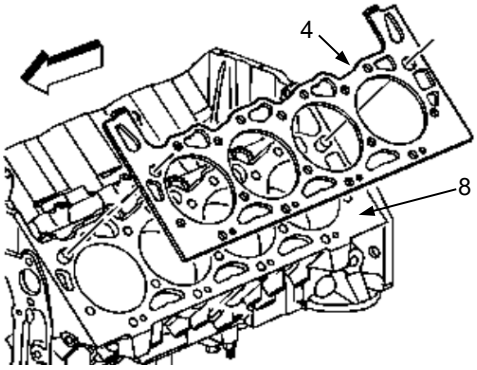


Figure 4:
Cylinder Head Gasket (4) and Engine Block Cylinder Bank Deck (8)

Flatness Measurement Procedure

1. Measure Cylinder Head (7) for warpage with a Straight Edge (4) and Feeler Gauge (5). *Figure 5*
   - Cylinder Head Block Deck with warpage > 0.050 mm (0.002 in) within a 150.0 mm (6.0 in) area must be repaired or replaced.
   - Cylinder Head Exhaust Manifold Deck with overall warpage > 0.102 mm (0.004 in) must be repaired or replaced.
   - Cylinder Head Intake Manifold Deck with warpage > 0.080 mm (0.003 in) must be repaired or replaced.
2. Engine Block Cylinder Head Deck can be resurfaced up to 0.305 mm (0.012 in) maximum removal.

   C **Excessive Cylinder Head resurfacing will affect compression ratio and emissions.**
3. Cylinder Heads requiring excessive resurfacing must be replaced.

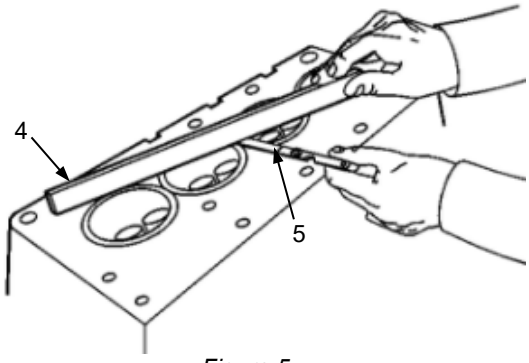


Figure 5:
Use Straightedge (4) and Feeler Gauge (5) to check Cylinder Head for warpage.
NOTE: *Engine Block Deck mating surface shown.*

INSTALLATION PROCEDURE

C **Verify threaded Cylinder Head holes in Engine Block are clean and not damaged.**

C **Clean block head and head surface with acetone or brake cleaner and blow surfaces dry prior to installing head gasket.**

1. Place new Cylinder Head Gasket (6) on Engine Block Cylinder Bank Deck (8). *Figure 6*

C **Do not use gasket sealer on engines using composition type gaskets.**

C **Align Cylinder Head Gasket locating marks to face up. Ensure Cylinder Head Gasket Tabs are located over Number 1 (LH) and 2 (RH) Cylinders for correct installation.**

2. Install Cylinder Head (7). *Figure 7*

C **Do not reuse cylinder head bolts. NEW cylinder head bolts must be used.** *Cylinder head bolts are torque-to-yield bolts and cannot be reused. During initial torque of the cylinder head bolt the fastener is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used bolt is torqued again. A stretched cylinder head bolt can also break when torqued.*

C **Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.**

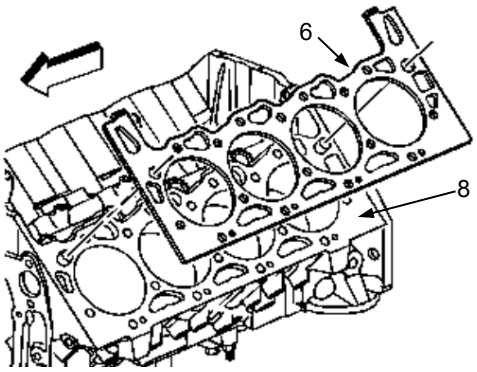


Figure 6:
Cylinder Head Gasket (6) and
Engine Block Cylinder Bank Deck (8)

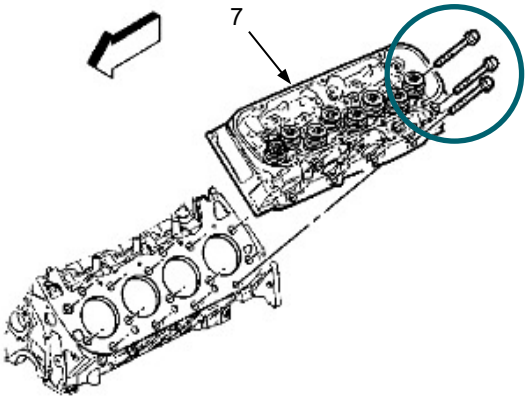


Figure 7:
Driver Side Cylinder Head (7), Cylinder Head Bolts *(circled)*

3. If not pre-applied to the new Cylinder Head Bolts (1, 2, 3), apply sealer. *Use GM 12346004 Liquid Teflon Sealant or equivalent.*

   Sealer must be applied to a minimum of eight (8)) threads starting at the point of the Cylinder Head Bolt.

4. Install cylinder head bolts. *Figure 8*
   a. Tighten cylinder head bolts first pass in sequence to 50nm (37 lb ft).
   b. Final pass: Tighten the cylinder head bolts #1, 2, 3, 6, 7, 8, 9, 12, 14 and 15 an additional 75 degrees using a torque/angle meter.
   c. Tighten cylinder head bolts #13 and 16 an additional 70 degrees using a torque/angle meter.
   d. Tighten cylinder head bolts #4, 5, 10 and 11 an additional 50 degrees using a torque/angle meter.
5. Install Exhaust Manifold. *Refer to Exhaust Manifold Replacement.*
6. Connect Exhaust "Y" Pipe to Exhaust Manifold. *Follow OEM procedure.*
7. Install Push Rods. *Refer to Push Rod Inspection and Replacement.*

   NOTICE

   Intake and Exhaust Valve Push Rods are different lengths.

   Ensure push rod installation order matches order removed.

8. Route Engine Harness and connect electrical connections including Ground Ring(s) at rear of Cylinder Head(s).
9. Install Valve Roller Rockers and set lash. *Refer to Valve Roller Rocker Replacement and Valve Lash Adjustment.*
10. Install Fan. *Refer to OEM procedure.*

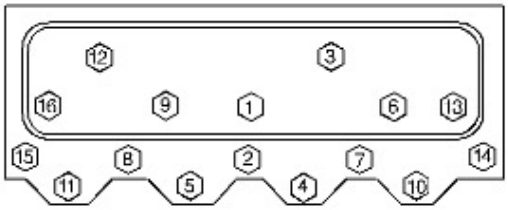


Figure 8:
Cylinder Head Bolt Tightening Sequence

11. Install Main Accessory Drive Belt. *Follow OEM procedure.*
12. Install Valve Covers. *Refer to Valve Cover Replacement.*
13. Install Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
14. Install the Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
15. Install Front End Accessory Drive Bracket. *Refer to Front End Accessory Drive Bracket Replacement*.
16. Driver Side Cylinder Head ONLY. *If removed:* Install Air Compressor. *Refer to Air Compressor Replacement.*
17. Fill engine fluids. *Follow OEM procedure and specifications in* 488LPI™ Operators Manual.
18. Clean engine with engine degreaser.
19. Start Engine and bring up to operating temperature.
20. Verify proper operation.
21. Check for leaks.

Dual A/C Drive Bracket Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is off and cool.
3. Using a 3/8” drive breaker bar, relieve tension on Dual A/C Drive Belt using Socket (5) on Dual A/C Tensioner (4). *Figure 1*
4. Remove Dual A/C Drive Belt. *Follow OEM Procedure.*
5. Remove two (2) A/C Compressors (not shown from locations (2). *Follow OEM procedure. Figure 1*
6. Remove three (3) Dual A/C Bracket Retaining Bolts (1) and Washers (6). *Figure 1*
7. Remove Dual A/C Bracket (3) from passenger side Cylinder Head (7).

⚠CAUTION

Bracket is heavy and has accessory drive Pulleys attached. Please take precautions when removing to avoid personal injury or damage to components.

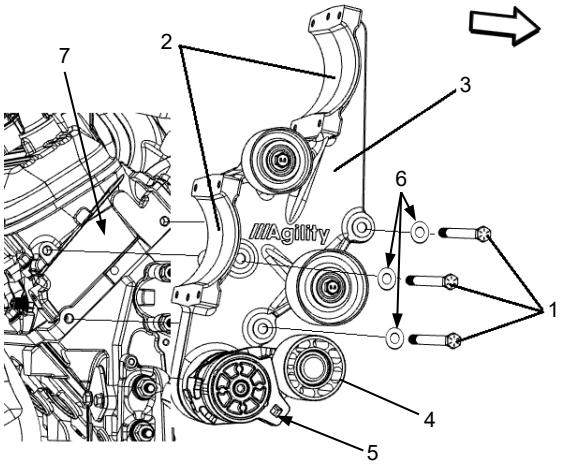


Figure 1:
Dual A/C Bracket (3), A/C Compressor locations (2), Dual A/C Tensioner (4), ½” Drive Socket location (5), Dual A/C Bracket Retaining Bolts (1) and Washers (6), passenger side Cylinder Head

INSTALLATION PROCEDURE

⚠CAUTION

A/C Bracket is heavy and has accessory drive Pulleys attached. Please take precautions when removing to avoid personal injury or damage to components.

1. Thread one (1) Dual A/C Bracket Retaining Bolt (1) and Washer (6) through Dual A/C Bracket into passenger side Cylinder Head (7). *Figure 2.* **NOTE:** *This helps distribute bracket weight and eases alignment.*
2. Align Dual A/C Bracket (2) mounting holes with Cylinder Head (7) holes. *Figure 2*
3. Install two (2) remaining Retaining Bolts (1) and Washers (6) and torque all (3) Bolts (1). *Refer to Front End Accessory Drive Torque Specifications*. *Figure 2*
4. Install two (2) A/C Compressors (not shown) at locations (2) on Dual A/C Bracket (3). *Figure 2. Follow OEM procedure.*
5. Install Dual A/C Drive Belt. *Follow OEM procedure.*
6. Verify proper operation.

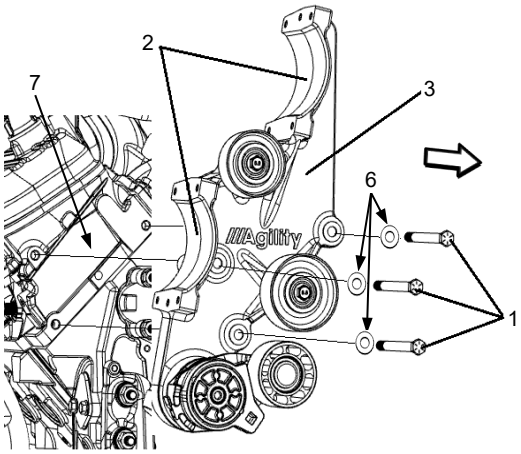


Figure 2:
Install and thread one (1) Bolt (1) and Washer (6) to hold and align Dual A/C Bracket (3) to Cylinder Head (7) before installing and tightening remaining two (2) Bolts (1) and Washers (6)

Engine Front Cover and Front Crankshaft Oil Seal Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Confirm engine is has cooled.
3. Remove Cooling Pack. *Follow OEM procedure.*
4. Remove Accessory Belt. *Follow OEM procedure.*
5. *If equipped:* Remove Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
6. Remove Water Pump. *Refer to Water Pump Replacement.*
7. Remove Harmonic Damper. *Refer to Harmonic Damper Replacement.*
8. Remove Camshaft Position Sensor Retaining Bolt (3) and Camshaft Position Sensor (4). *Figure 1*
9. Inspect Camshaft Position Sensor O-ring (5) for cuts, cracks, tears and damage. *Figure 1*

   C **Replace O-ring as needed.**
10. Drain engine oil.
11. Loosen Oil Pan Bolts.

    NOTICE

    Only loosen bolts enough to relieve tension on the bottom edge of Engine Front Cover as its base is sealed by the Oil Pan Gasket. *Refer to Oil Pan Replacement.*
12. Remove six (6) Engine Front Cover Retaining Bolts (2). *Figure 2*
13. Remove Engine Front Cover (1) and inspect. *Figure 2*

    NOTICE

    Engine Front Cover Gasket is reusable.
14. Remove Front Crankshaft Oil Seal *(not shown)* from Engine Front Cover.

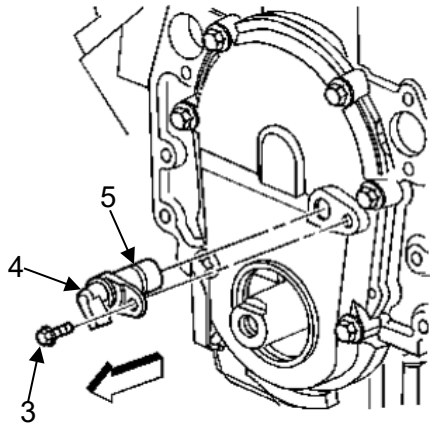


Figure 1:
Camshaft Position Sensor (4), Sensor Retaining Bolt (3), and Sensor O-ring (5)

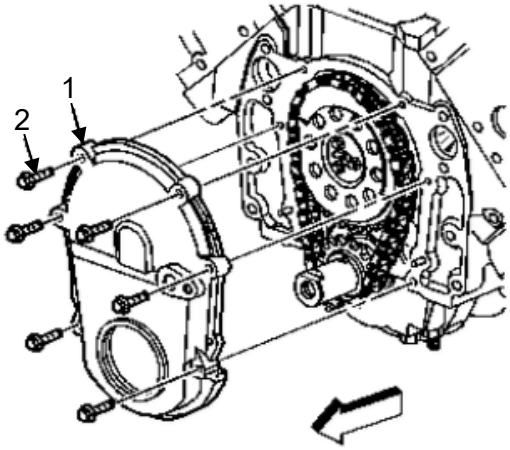


Figure 2:
Engine Front Cover (1) and Retaining Bolts (2)

INSTALLATION PROCEDURE

1. Install new Front Crankshaft Oil Seal using special tool J 42851 (Front Cover Oil Seal Installer).
2. Lubricate sealing surface of Front Crankshaft Seal with clean engine oil.
3. Apply 2.0 mm (0.08 in) of sealant to two (2) locations (3) on the Engine Block where the Engine Front Cover meets the Oil Pan. *Figures 3 and 4.*

   c **Engine Front Cover must be installed and fasteners tightened while sealant is still wet.**
4. Install Front Engine Cover Gasket (not shown) into the Front Engine Cover.

   c **Use care not to push sealant out.**
5. Install the Engine Front Cover as shown in *Figure 4* as follows:
   a. Hold Engine Front Cover (1) up to Crankshaft nose (2).
   b. Lift Engine Front Cover (1) while sliding cover over Crankshaft (2).
   c. Slide Engine Front Cover towards the Engine Block surface (5) while keeping cover raised.
   d. Lower Engine Front Cover down over the Dowel Pin (4), allowing the cover to rest on the sealant (3).
6. Install and tighten six (6) Engine Front Cover Bolts using *Figure 5* sequence. *Refer to Engine Mechanical Torque and Clearance Specifications for torque values.*

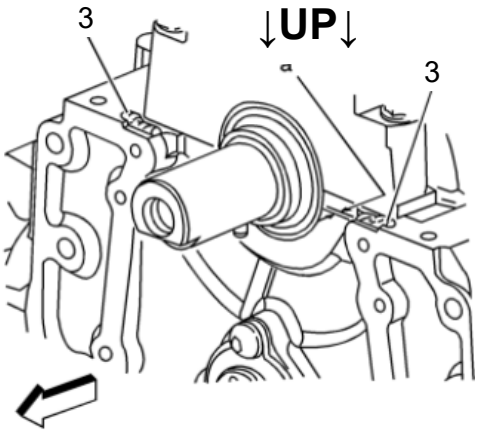


Figure 3:
Apply sealant to Engine Block (5) at locations (3)

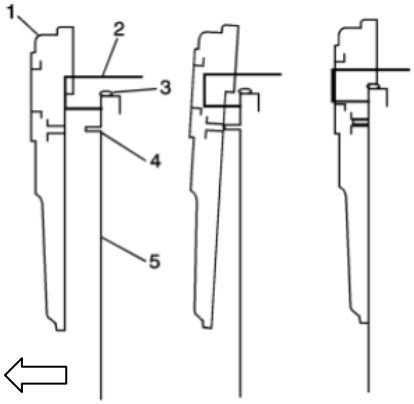


Figure 4:
Proper Engine Front Cover Alignment and Installation Sequence (side view)

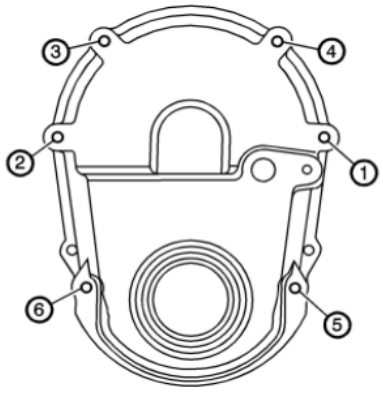


Figure 5:
Engine Front Cover Bolt Tightening Sequence

7. Install Camshaft Position Sensor (4) using Camshaft Position Sensor Retaining Bolt (3). *Figure 1*

   C **Inspect Camshaft Position Sensor O-ring; replace if damaged.**

8. Install Harmonic Damper. *Refer to Harmonic Damper Replacement.*
9. Install Water Pump. *Refer to Water Pump Replacement*.
10. *If equipped:* Install Air Compressor Belt. *Refer to Air Compressor Belt Replacement*.
11. Install Main Accessory Belt. *Follow OEM procedure.*
12. Install Cooling Pack. *Follow OEM procedure.*
13. Fill engine fluids. *Follow OEM procedure and specifications in* 488LPI™ Operators Manual.
14. Verify engine operation: bring up to operating temperature and check for leaks.

Engine Removal and Replacement

NOTICE

Always obtain warranty service approval before beginning engine repair.

⚠WARNING

- **Prior to starting work on removing the engine the fuel lines must be drained.** *Follow Fuel Line Drain Procedure.*
- **Purge fuel lines only in a properly ventilated area.**
- **Never purge propane near a drain or in a low area such as a service pit.**

REMOVAL PROCEDURE

1. Secure vehicle outdoors in a safe location away from any source of ignition.
2. Close LPI® fuel supply and fuel return Manual Shutoff Valves on Fuel Tank(s).
3. Disconnect Battery. *Follow OEM procedure.*
4. Remove vehicle Hood. *Follow OEM procedure.*
5. Remove vehicle Cooling Pack. *Follow OEM procedure.*
6. Remove Oil Dipstick Tube. *Follow OEM procedure*.
7. Remove Air Cleaner Assembly. *Follow OEM procedure.*
8. Remove Air Intake Tube. *Refer to Air Intake Tube Replacement.*
9. Remove Main Accessory Drive Belt. *Refer to OEM procedure.*
10. Remove Alternator. *Follow OEM procedure.*
11. *If equipped:* Remove Air Compressor. *Refer to Air Compressor Replacement*.
12. *If equipped:* Remove Air Conditioning Compressor(s). *Follow OEM procedure.*

13. Remove Air Conditioning Compressor Bracket. *Refer to Single- or Dual-A/C Drive Bracket Replacement.*
14. Remove Spark Plug Wires with their respective Ignition Coils attached; set aside in order removed. *Refer to Spark Plug Wire Replacement* and *Ignition Coil Replacement.*
15. Disconnect Engine Harness from Engine and engine accessory attachment points. *Refer to Engine Harness Replacement.*
16. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
17. Remove Fuel Rails. *Refer to Fuel Rail Replacement.*

NOTICE

Secure Fuel Supply and Fuel Return Lines out of way in engine compartment.

18. Secure vehicle on approved hoist and raise vehicle.
19. Remove three (3) Nuts (2) securing each of the Y-Pipe Assemblies (3) to Exhaust Manifolds (1). *Figure 1*
20. Remove Y-Pipe Gaskets (4) and discard. *Figure 1*
21. Loosen Y-Pipe Hanger (not shown) at Transmission. *Follow OEM procedure.*
22. Remove Starter. *Follow OEM procedure*.
23. Remove Transmission. *Follow OEM procedure.*
24. Disconnect Post-catalyst Heated Exhaust Gas Oxygen (HEGO) sensors from Engine Harness. *Refer to OEM procedure.*

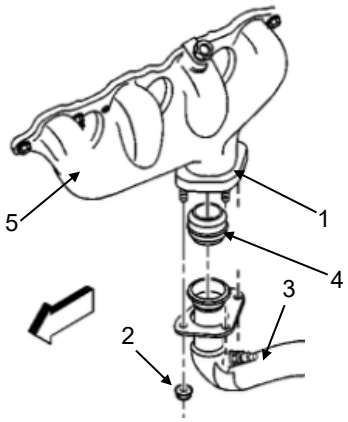


Figure 1:
Y-Pipe Assembly (3), Y-Pipe Gasket (4), Exhaust Manifold Heat Shield (5), Exhaust Manifold (1), and Nut (2)

25. **NOTICE**

    Confirm Engine Harness Ground Rings at rear of each Cylinder Head have been disconnected. *Refer to Step 14* and *Engine Harness Replacement.*
26. Lower vehicle.
27. Unbolt Front Engine Mount from vehicle frame. *Refer to Front Engine Mount Replacement.*
28. Use approved hoist and proper lifting hardware to remove Engine using Main Accessory Drive Bracket (7) Lift Point (6). *Figure 2*

    NOTICE

    - **Avoid damage to engine components and peripheral items.**
    - **Place Engine on approved engine stand before removing dress components for reuse.**
29. Remove Main Accessory Drive Bracket. *Refer to Main Accessory Drive Bracket Replacement.*
30. Remove Water Pump. *Refer to Water Pump Replacement.*
31. Remove Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
32. Remove Flexplate and Transmission Adapter. *Refer to Flexplate and Transmission Adapter Replacement.*
33. Remove Exhaust Manifolds. *Refer to Exhaust Manifold Replacement.*
34. *If equipped:* Remove Engine Block Heater. *Refer to Engine Block Heater Replacement.*
35. Remove Front Engine Mount from Engine. *Refer to Front Engine Mount Replacement.*

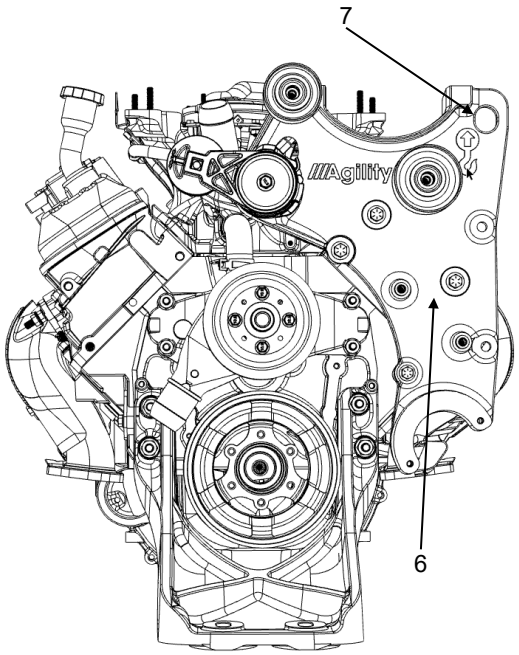


Figure 2:
Engine Lift Point (7) on
Main Accessory Drive Bracket (6)

INSPECTION PROCEDURE

Before installing previously used engine components check for the following conditions:

- Broken electrical connectors or frayed wires
- Damaged seals and gasket surfaces
- External cracks on metal and composite parts
- Damage to threaded bolt holes
- Cracks inside intake and exhaust manifold ports
- Warped or worn flywheel or damaged flywheel teeth

NOTICE

Replace any suspect components or wear items including non-reusable gaskets, seals, belts, spark plugs, spark plug wires, thermostats, etc.

INSTALLATION PROCEDURE

1. Remove Valve Covers from replacement Engine; recycle or dispose of Valve Covers.
2. Install Valve Rocker Covers from vehicle engine on replacement Engine. *Follow Valve Cover Replacement Procedure.*
3. *If equipped:* Install Engine Block Heater. *Refer to Engine Block Heater Replacement.*
4. Install Water Pump. *Refer to Water Pump Replacement.*
5. Install Front Engine Mount on Engine. *Refer to Front Engine Mount Replacement.*
6. Install Exhaust Manifolds. *Refer to Exhaust Manifold Replacement.*
7. Install Spark Plug Wires and Ignition Coils. *Refer to Spark Plug Wire Replacement and Ignition Coil Replacement.*
8. Install Fuel Rails. *Refer to Fuel Rail Replacement*.
9. Install Main Accessory Drive Bracket. *Refer to Main Accessory Drive Bracket Replacement.*
10. Install Transmission Adapter and Flexplate. *Refer to Flexplate and Transmission Adapter Replacement.*
11. Using an approved hoist and proper lifting hardware, install Engine in vehicle using Main Accessory Drive Bracket (7) Lift Point (6). *Figure 3*
12. Install Front Engine Mount to vehicle frame. *Refer to Front Engine Mount Replacement.*
13. Connect LPI® Fuel Supply and Return Lines. *Refer to Fuel System Torque and Tightening Specifications.*

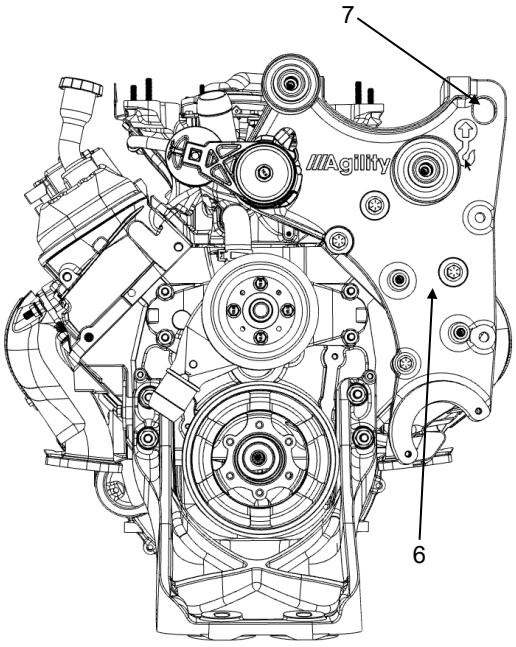


Figure 3:
Engine Lift Point (7) on
Main Accessory Drive Bracket (6)

⚠WARNING

14. **Prior to installing the upper intake manifold the fuel system will need to be checked for leaks**. To check the for leaks the supply solenoid must be energized to allow fuel to flow and pressurize the fuel system.
    - Open the supply and return valves.
    - Disconnect supply valve solenoid harness from tank harness *Figure 4*
    - Energize solenoid using a power probe or similar tool. An audible click should be heard indicating the solenoid has opened.
    - Once the system is pressurized spray each hose connection with an approved leak check solution and look for bubbles around each hose connection.
    - If any leaks are found, retighten hoses and leak check again.
15. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
16. Install Alternator. *Refer to Alternator Replacement procedure.*
17. Install Engine Harness on Engine. *Refer to Engine Harness Replacement.*
18. *If equipped:* Install Air Conditioning Compressor Bracket. *Refer to Single- or Dual-A/C Drive Bracket Replacement.*
19. *If equipped:* Install Air Conditioning Compressor(s). *Follow OEM procedure.*
20. *If equipped:* Install Air Compressor. *Refer to Air Compressor Replacement.*
21. Install Main Accessory Drive Belt. *Follow OEM procedure*.

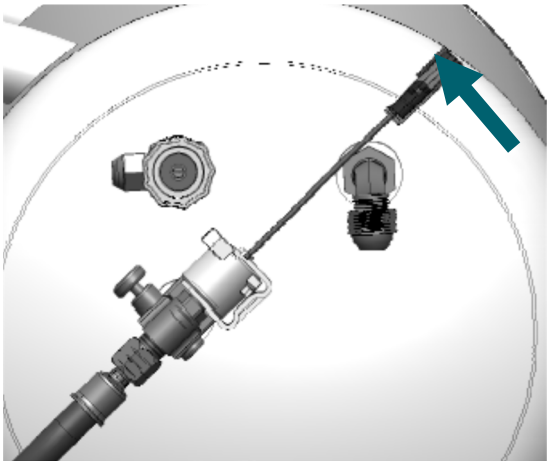


Figure 4:
Disconnect supply solenoid harness *(arrow)* from tank harness and energize solenoid with 12 volts.

22. Install Oil Dipstick Tube. *Follow OEM procedure.*
23. Install Air intake Tube. *Refer to Air Intake Tube Replacement.*
24. Install Air Cleaner. *Follow OEM procedure.*
25. Install vehicle Cooling Pack. *Follow OEM procedure.*
26. Secure vehicle on approved hoist and raise vehicle.
27. Connect Post-catalyst Heated Exhaust Gas Oxygen (HEGO) sensors to Engine Harness. *Refer to OEM procedure.*
28. Install Transmission. *Follow OEM procedure.*
29. Install Starter. *Follow OEM procedure.*
30. Install new Y-Pipe Gasket (4). *Figure 5*
31. Connect Y-pipes to Exhaust Manifolds (5). *Figure 5. Refer to Exhaust Manifold Replacement.*
32. Tighten Y-Pipe Hangers (not shown). *Follow OEM procedure.*
33. Install Y-Pipe Assemblies (3). *Follow OEM procedure. Figure 5*
34. Lower vehicle.
35. Fill Engine Coolant. *Follow OEM manual for capacity and procedure. Refer to* 488LPI™ Owners Manual *for coolant specifications.*
36. Check Engine Oil Level and top off if necessary. *Refer to* 488LPI™ Owners Manual *for procedure and specifications.*
37. Check Transmission Fluid Level and Quality. *Follow OEM procedure.*
38. Clean any spilled fluids.
39. Install vehicle Hood. *Follow OEM procedure.*

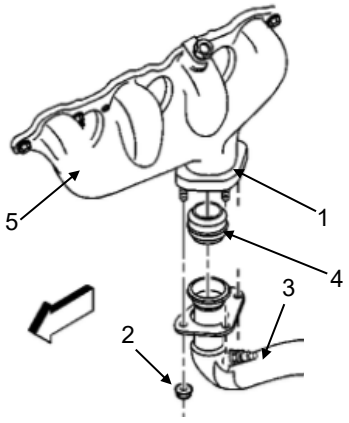


Figure 5:
Y-Pipe Assembly (3), Y-Pipe Gasket (4), Exhaust Manifold Heat Shield (5), Exhaust Manifold (1), and Nut (2)

40. Turn LPI® fuel supply and fuel return Manual Shutoff Valves to OPEN position.

    NOTICE

    Manual Shutoff Valves must always be fully open for engine operation or warranty will be void.

41. Verify proper operation.
42. Follow Engine Break In Procedure as required by 488LPI™ Owners Manual.

Exhaust Back Pressure Test

DESCRIPTION AND OPERATION

Perform an Exhaust Back Pressure Test if a vehicle powered by the 488LPI™ engine exhibits the following symptoms:

- Misfire Diagnostic Trouble Codes (DTCs) SPNs 1323-1330 FMI 31 **OR**
- Mass Air Flow (MAF) Sensor DTCs SPN 132 FMIs 2, 3, 4 or 7 **AND/OR**
- **Low power on acceleration**

NOTICE

In some cases, an over-fueling condition resulted in high exhaust back pressure causing the Catalytic Converter(s) to clog and fail. Therefore, this possibility, (if applicable) can and should be assessed to prevent repeat Catalytic Converter failures. Check both fuel system and ignition system components, wiring, and controls.

TEST PROCEDURE

1. Secure vehicle on an approved hoist and allow engine to cool.
2. Raise vehicle.
3. Remove driver side Pre-Catalyst Heated Exhaust Gas Oxygen (HEGO) Sensor. *Refer to HEGO Replacement.*
4. Install Adapter Fitting in head pipe HEGO Sensor Bung.
5. Connect Exhaust Back Pressure Gauge to Adapter Fitting.
6. Lower vehicle
7. Start engine. Have an assistant record exhaust back pressure readings at all engine speeds specified in *Table 1*.
8. Remove Exhaust Back Pressure Gauge and Adapter Fitting.

   CAUTION

   Adapter and Gauge Connection may be hot.
9. Install Pre-Catalyst Heated Exhaust Gas Oxygen (HEGO) Sensor. *Refer to HEGO Replacement.*
10. ***If exhaust back pressure readings exceed normal levels listed in Table 1 AND vehicle exhibited low power on acceleration,*** go to Step 11.
11. Repeat Steps 2 through 9 for passenger side Pre-Catalyst Heated Exhaust Gas Oxygen (HEGO) Sensor.

Normal Exhaust Back Pressure Ranges		
Engine RPM	**PSI**	**kPa**
Idle	1.25	8.6
Throttle Snap	3.0 - 4.0	20.7 - 27.5
2,000	0.5	3.4
2,500 (sustained)	0 - 2.0	0 - 13.7

Table 1:
Normal Exhaust Back Pressure Values

Exhaust Manifold Replacement

REMOVAL PROCEDURE

1. Secure vehicle on a approved hoist and raise vehicle.
2. *Driver side:* remove three (3) Nuts (2) securing Y-Pipe Assembly (3) to Exhaust Manifold(s) (1). *Figure 1*
3. *Passenger side:* remove three (3) Nuts (2) securing Y-Pipe Assembly (3) to Exhaust Manifold(s)
4. Remove Y-Pipe Gaskets (4) and discard. *Figure 1*
5. Loosen Y-Pipe Hanger (not shown) at Transmission. *Follow OEM procedure.*
6. Lower vehicle and open hood.
7. **NOTE**: *Passenger side manifold only.* Remove Oil Dipstick Tube. *Follow OEM procedure.*
8. **NOTE**: *Passenger side manifold only.* Remove Air Cleaner Assembly. *Follow OEM procedure.*
9. **NOTE**: *Driver side manifold only, and if equipped:* Remove Air Compressor. *Refer to Air Compressor Replacement*.
10. Remove Spark Plug Wires.

    NOTICE

    Twist Spark Plug Boot 1/2-turn to release boot. Pull on Spark Plug Boot only; do not pull on Spark Plug Wire or risk damage.
11. Remove Spark Plugs *(not shown).*
12. Remove Exhaust Heat Shield Bolts *(not shown).*
13. Remove Exhaust Heat Shield (5). *Figure 1*.
14. Remove Exhaust Manifold Bolt (6) and seven (7) Nuts (7). *Figure 2*
15. Remove Exhaust Manifold (1) and Exhaust Manifold Gasket (8). Discard gasket.

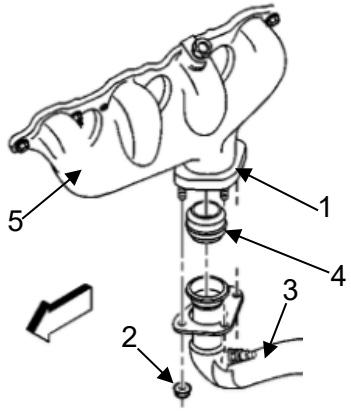


Figure 1:
Y-Pipe Assembly (3), Y-Pipe Gasket (4), Exhaust Manifold Heat Shield (5), Exhaust Manifold (1), and Nut (2)

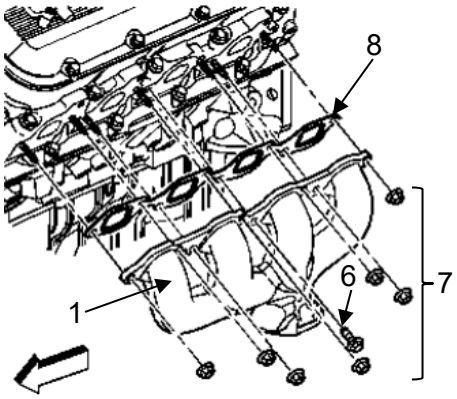


Figure 2:
Exhaust Manifold (1), Exhaust Manifold Gasket (8), Exhaust Manifold Nuts (7) and Bolt (6)

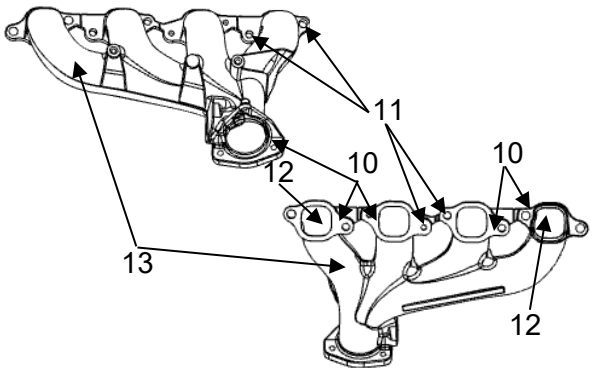


Figure 3:
Exhaust Manifold Visual Inspection Locations

INSPECTION PROCEDURE

Visual Inspection Procedure

Inspect Exhaust Manifold for the following conditions at locations indicated on *Figure 3*:

- Damaged gasket surfaces (10)
- Damage to threaded bolt holes (11)
- Cracks inside exhaust ports (12)
- External cracks (13)

INSTALLATION PROCEDURE

1. Install new Exhaust Manifold Gasket (8). *Figure 4*
2. Install Exhaust Manifold (1). *Figure 1*
3. Install Exhaust Manifold Bolt (6) and Nuts (7). *Figure 2. Refer to Engine Mechanical Torque and Clearance Specifications.*
4. Install Exhaust Manifold Head Shield (5) using two (2) Bolts (9). *Figure 4. Refer to Engine Mechanical Torque and Clearance Specifications.*
5. Install Spark Plugs. *Refer to Engine Electrical Sensors and Components Torque Specifications.*
6. Install Spark Plug Wires.
7. Raise vehicle on hoist.
8. Install new Y-Pipe Gaskets. *Figure 1*
9. Tighten Y-Pipe Hanger *(not shown). Follow OEM procedure.*
10. Install Y-Pipe Assembly (3). *Figure 1*
11. Lower vehicle.
12. Start vehicle, warm up to operating temperature and check exhaust manifold flange gaskets for exhaust leaks.

NOTICE

If exhaust leaks are found, these must be repaired as exhaust leaks affect O2 operation.

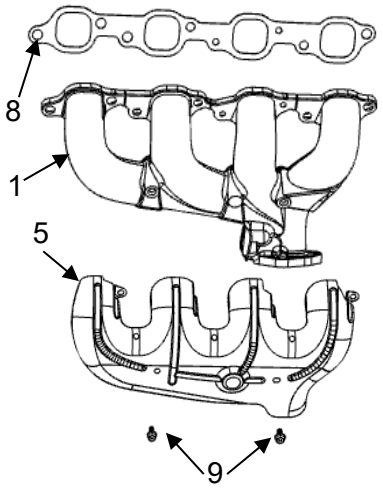


Figure 4:
Exhaust Manifold (1), Exhaust Manifold Gasket (8), Heat Shield (5), and Heat Shield Bolts (9)

Flexplate and Transmission Adaptor Replacement

REMOVAL PROCEDURE

1. Secure vehicle on approved hoist.
2. Raise vehicle.
3. Remove Transmission. *Follow OEM procedure.*
4. Remove Flexplate Pilot Bolt from location (1) and six (6) Flexplate Retaining Bolts (2). *Figures 1 and 3*
5. Remove Flexplate (3).
6. *If replacing Transmission Adaptor (4)*:
   a. Remove six (6) Transmission Adaptor Retaining Bolts (5). *Figure 2*
   b. Remove Transmission Adaptor (4).

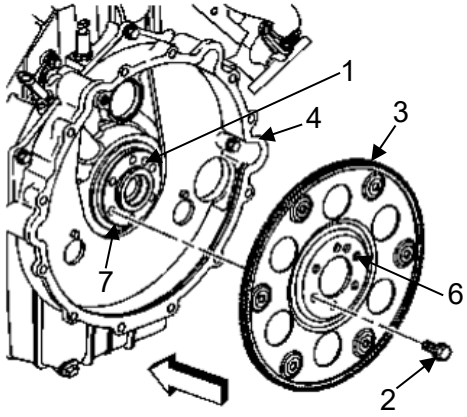


Figure 1:
Flexplate (2) to Crankshaft flange (5) Installation.

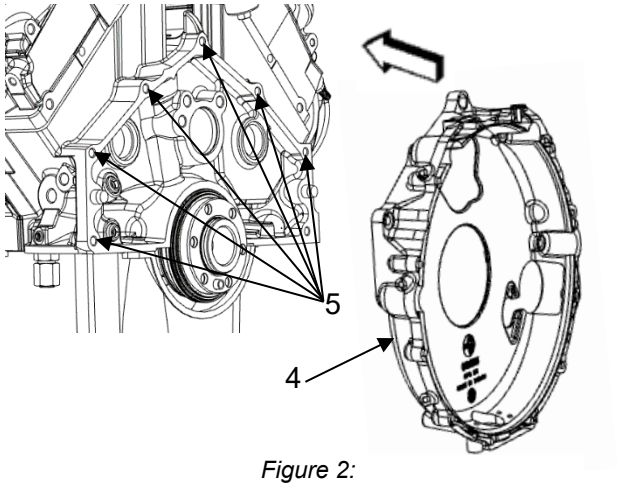


Figure 2:
Transmission Adaptor (4) and Transmission Adaptor Retaining Bolt Locations (5)

INSTALLATION PROCEDURE

1. *If removed:* Install Transmission Adaptor (4). *Figure 2*
2. Install six (6) Transmission Adaptor Retaining Bolts at locations (5). *Figure 2. Refer to Engine Mechanical Torque and Clearance Specifications.*
3. Install Flexplate.

   C **Verify Flexplate mounting holes (6) line up with corresponding Crankshaft flange (7) holes and Flexplate is keyed to Crankshaft.**
4. Finger tighten Pilot Flexplate Bolt (1). *Figure 3*

   NOTICE

   If not pre-applied: **Apply Loctite® Blue to Flexplate Retaining Bolt threads.**
5. Install remaining six (6) Flexplate Retaining Bolts and tighten in star pattern shown in *Figure 3. Refer to Engine Mechanical Torque and Clearance Specifications.*
6. Tighten Flexplate Pilot Bolt (1). *Figure 3. Refer to Engine Mechanical Torque and Clearance Specifications.*
7. Install Transmission. *Follow OEM procedure*.
8. Lower vehicle
9. Verify proper operation.

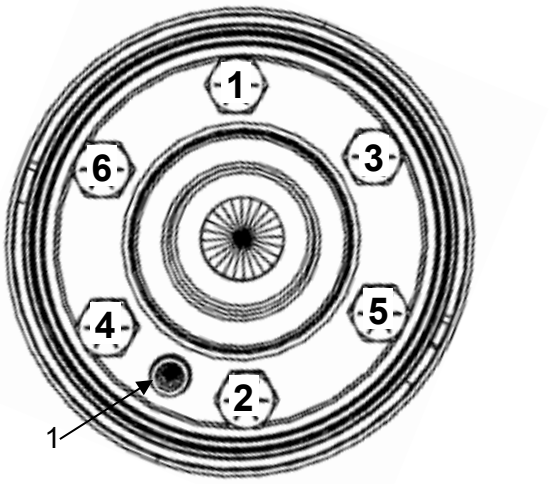


Figure 3:
Finger tighten Flexplate Pilot Bolt (1) before inserting remaining Flexplate Retaining Bolts. Tighten Flexplate Bolts in a star pattern as numbered 1-6.
Torque Flexplate Retaining Nuts and Flexplate Pilot Bolt.

Front End Accessory Drive (FEAD) Component Replacement

REMOVAL PROCEDURE

NOTE 1: *Depending on configuration, Pulley and Tensioner locations and sizes may be different.*
NOTE 2: *A bolt-on Pulley used on for the Dual A/C option is tightened using a crosshatch pattern.*
NOTE 3: *Belt routing diagrams may be found in the OEM service manual*.

1. Secure vehicle.
2. Verify engine is off and has had ample cooling time before attempting procedure.
3. *If necessary; varies by application:* Remove Fan Shroud and/or Fan. *Follow OEM procedure*.
4. Using a ½-in drive breaker bar at position (1) on Tensioner (2), relieve tension on Main Accessory Drive Belt. *Figures 1 through 6*
5. Remove Main Accessory Drive Belt.
6. Remove Retaining Bolt(s) for component being serviced. **NOTE**: *Refer to Figure 6 for general pulley identification.*

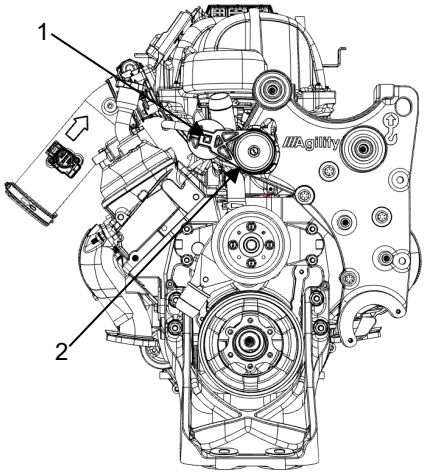


Figure 1:
No A/C or Air Brake Compressor

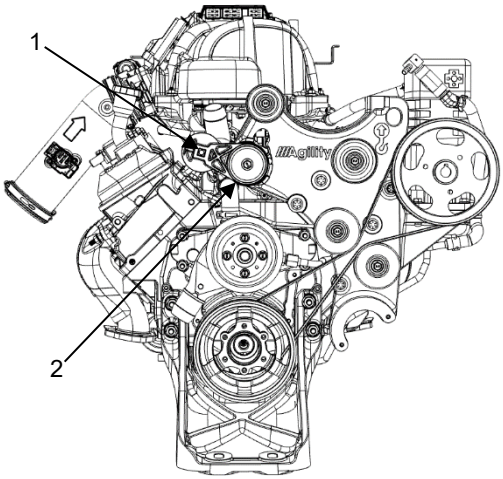


Figure 2:
No A/C with Air Brake Compressor

INSTALLATION PROCEDURE

1. Install Retaining Bolt(s) for component being serviced.
2. Tighten Retaining Bolt(s). *Refer to Front End Accessory Drive Torque Specifications.*
3. Route and install Main Accessory Drive Belt. *Follow OEM procedure*.
4. *If removed:* Install Fan and/or Fan Shroud.

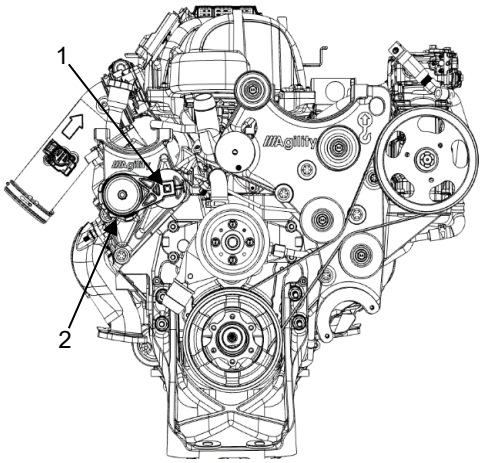


Figure 4:
Single A/C with Air Brake Compressor

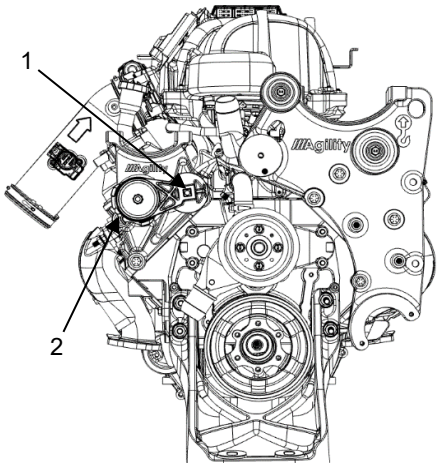


Figure 3:
Single A/C without Air Brake Compressor

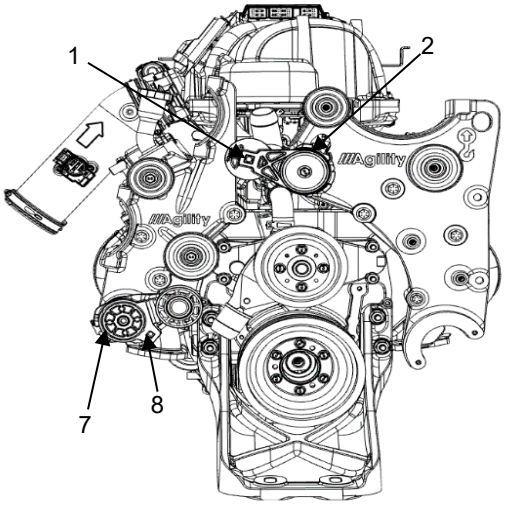


Figure 5:
Dual A/C without Air Brake Compressor
NOTE: Dual A/C Belt Tensioner (7)
with ½" Drive Socket (8)

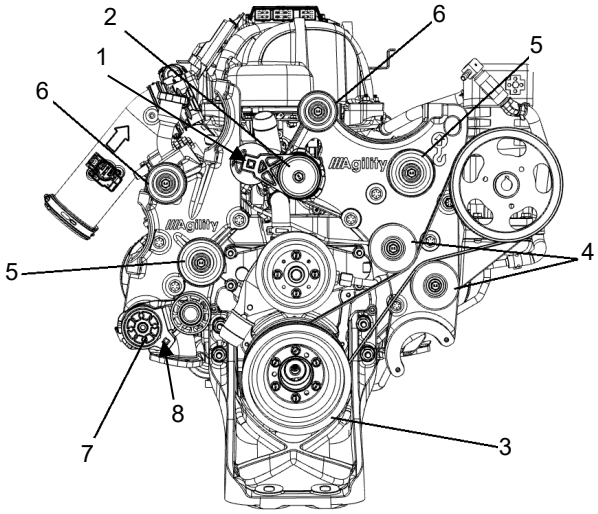


Figure 6:
Dual A/C with Air Brake Compressor.
Harmonic Damper (3), Air Brake Compressor Idler
Pulleys (4), Large Idler Pulleys (5),
and Small Idler Pulleys (6)
NOTE: Dual A/C Belt Tensioner (7)
with ½" Drive Socket (8)

Front Engine Mount Replacement

REMOVAL PROCEDURE

1. Verify vehicle is secured properly. Ensure engine is off and cool.
2. Support engine using jack stands placed as indicated on Lower Engine Rail Pads (1). *Figure 1*

   NOTICE

   DO NOT lift or support engine on Oil Pan (2).
3. Using jack stands, relieve load on Front Engine Mount (4). *Figures 1 and 2*
4. Remove two (2) Front Engine Mount to Frame Bolts (not shown) at position (3). *Figures 1 and 2*
5. Remove four (4) Front Engine Mount to Engine Nuts (5). *Figure 2*
6. Remove Front Engine Mount from vehicle.

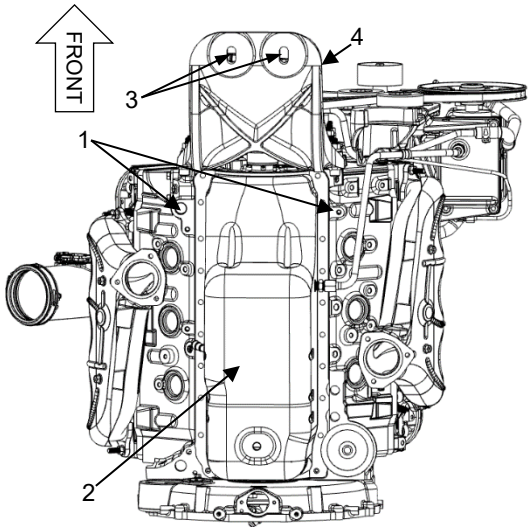


Figure 1:
Lower Engine Rail Pad jacking points (1),
Front Engine Mount (4), Oil Pan (2),
Front Engine Mount to Frame Bolt locations (3)

INSTALLATION PROCEDURE

1. Install Front Engine Mount (4) using four (4) Front Engine Mount to Engine Nuts (5). *Figure 2*
2. Tighten Front Engine Mount to Engine Nuts (5). *Refer to Engine Mechanical Torque and Clearance Specifications.*
3. Remove jack stands.

   C **When lowering engine, align two (2) Front Engine Mount bolt holes (3) with vehicle frame holes.** *Figure 2*
4. Tighten two (2) Front Engine Mount to Frame Bolts (not shown). *Refer to OEM specifications.*
5. Verify proper operation.

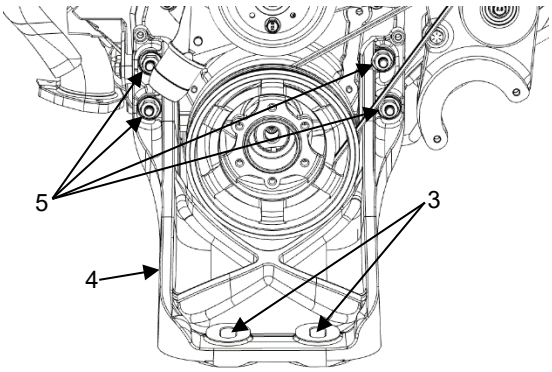


Figure 2:
Front Engine Mount (4),
Front Engine Mount Bolt Holes (3),
Front Engine Mount to Engine Nuts (2)

Fuel Distribution Block Replacement

REMOVAL PROCEDURE

1. Secure vehicle outside in a safe area.
2. Bleed Fuel Lines. *Refer to NFPA 58 for Fuel Line Bleed Procedure.*
3. Bring vehicle into service bay and secure.
4. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
5. *Passenger side only:* Remove Fuel Return Line from Fuel Distribution Block (2) at Nipple (4). *Refer to Fuel Supply and Fuel Return Line Replacement. Figure 1*
6. *Passenger side only:* Remove Engine Fuel Return Lines (6) at Distribution Block (2).
7. *Passenger side only:* Remove Fuel By-Pass Solenoid (7). *Refer to Fuel By-Pass Solenoid Replacement. Figures 1 & 2*
8. *Driver side only:* Remove Fuel Supply Line at Fuel Distribution Block (1) Nipple (3). *Refer to Fuel Supply and Fuel Return Line Replacement. Figure 1*
9. *Driver side only:* Remove Engine Fuel Supply Lines (5) at Distribution Block (1).
10. Remove four (4) Fuel Distribution Block Retaining Bolts (11) securing Distribution Block (1 or 2) to Bracket (9). *Figure 2*
11. Remove respective Fuel Distribution Block (1 or 2). *Figures 1 and 2*

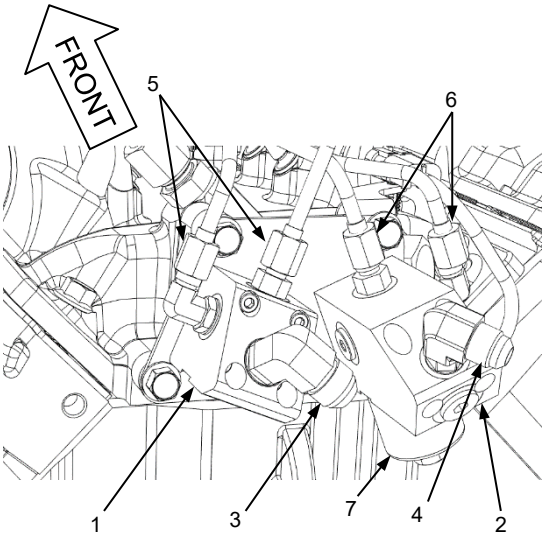


Figure 1:
Driver side Fuel Distribution Block (1), Passenger side Fuel Distribution Block (2), Fuel Supply Line Nipple (3), Fuel Return Line Nipple (4), Engine Fuel Supply Line Fittings (5), Engine Fuel Return Line Fittings (6), Fuel By-Pass Solenoid (7)

INSTALLATION PROCEDURE

1. *Passenger side only:* Install Fuel By-Pass Solenoid (7) *Refer to Fuel By-Pass Solenoid Replacement. Figures 1 & 2*
2. Install respective Fuel Distribution Block (1 or 2) with four (4) Retaining Bolts (11). *Refer to Fuel System Torque and Tightening Specifications. Figure 2*
3. *Passenger side only:* Connect Engine Fuel Return Line (6) Fittings (10) to Fuel Distribution Block (2). *Refer to Fuel System Torque and Tightening Specifications. Figures 1 & 2*
4. *Passenger side only:* Connect Fuel Return Lines to Fuel Distribution Block (2) Nipple (4). *Refer to Fuel System Torque and Tightening Specifications.*
5. *Driver Side only:* Connect Engine Fuel Supply Lines (5) to Fuel Distribution Block (1). *Refer to Fuel System Torque and Tightening Specifications.*
6. *Driver Side only:* Connect Fuel Supply Line to Fuel Distribution Block (1) Nipple (3). *Refer to Fuel Supply and Fuel Return Line Replacement and Fuel System Torque and Tightening Specifications. Figure 1*
7. Pressurize fuel system to prepare for leak check as follows:
   a. Open Fuel Tank Supply and Return Valves.
   b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (7) Electrical Connector (a) to pressurize fuel system. *Figure 3*
8. Perform leak check. Refer to *Fuel System Leak Detection Procedure.*
9. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
10. Verify proper operation.

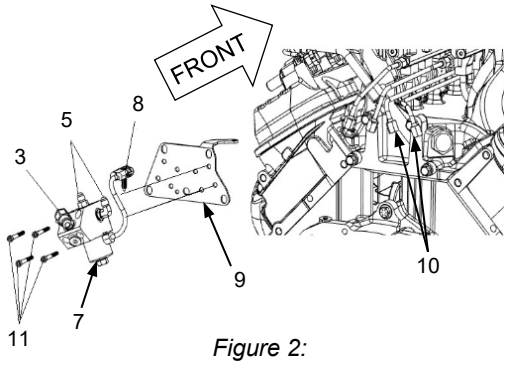


Figure 2:
Passenger side Fuel Distribution Block detail: Fuel Return Line Nipple (3), Engine Fuel Return Line Nipples (5), Engine Fuel Return Line Fittings (10), Fuel Distribution Block Retaining Bolts (11), Fuel By-Pass Solenoid (7) Electrical Connector (8).
NOTE: *It is not necessary to remove Fuel Distribution Block Bracket (9).*

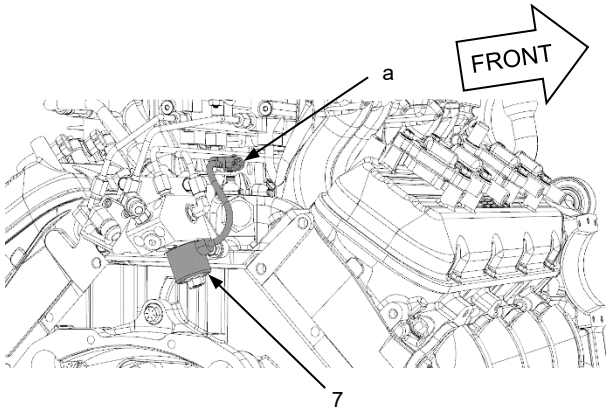


Figure 3:
Fuel By-Pass Solenoid (7), Electrical Connector (a)

Fuel Injector Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Bleed Fuel Lines outside. *Refer to NFPA 58 Fuel Line Bleed Procedure.*
3. Bring vehicle into service bay and secure.
4. Remove Battery Negative (–) Cable.
5. Remove Fuel Supply and Return Lines. *Refer to Fuel Supply and Fuel Return Line Replacement.*
6. Remove Alternator. *Refer to Alternator Removal.*
7. Remove Upper Intake Manifold. *Refer to Upper Intake Replacement.*
8. Disconnect Fuel Injector Harness Connectors (9) from Fuel Injector Electrical Connectors. *Figure 1*

   NOTICE

   Injectors 2-4-6-8 are on passenger side Fuel Rail; Injectors 1-3-5-7 are on driver side Fuel Rail.
9. Rotate Fuel Injector (1) to access Snap Ring (2). *Figures 2 & 4*
10. Remove Fuel Injector Snap Ring (2) using snap ring pliers. *Figures 2 & 4*
11. Remove Fuel Injector (1) from Fuel Rail (4). *Figures 2 & 4*
12. Inspect Injector Bore (3) in Fuel Rail for signs of debris. *Figures 2 & 4*
13. **NOTICE**

    Inspect Fuel Injector O-Rings (7) & (8) and replace if damaged. *Figure 3*

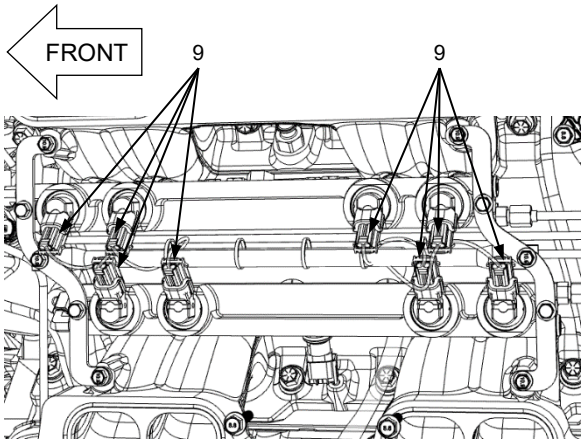


Figure 1:
Fuel Injector Harness Connectors (9)

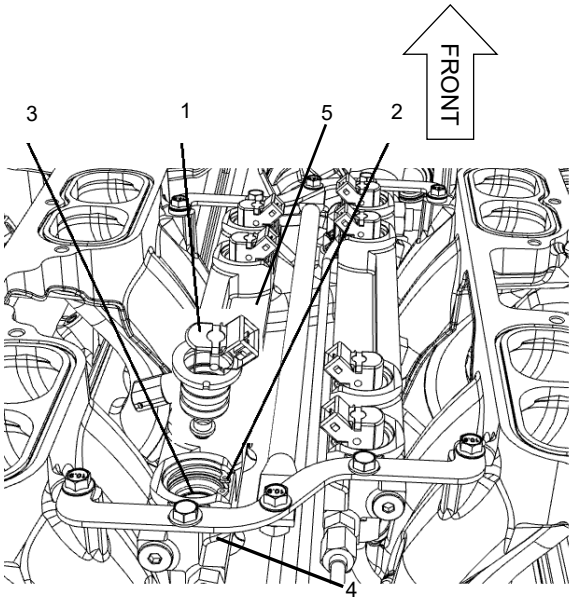


Figure 2:
Fuel Injector (1), Fuel Injector Snap Ring (2),
Fuel Injector Electrical Connector (5)
Fuel Injector Bore (3), Fuel Rail (4)

INSTALLATION PROCEDURE

1. Lubricate Fuel Injector O-Rings (7) and (8) with clean engine oil. *Figure 3*
2. Install Fuel Injector (1) into Fuel Injector Bore (3) on Fuel Rail (4). *Figures 2 & 4*
3. Install Fuel Injector Snap Ring Retainer (2). *Figures 2 & 4*

   Verify Snap Ring is fully seated; Snap Ring Gap (6) must be 3 mm minimum.
4. Verify Fuel Injector Adapter *(not shown)* seals properly to Fuel Injector Delivery Tube Upper O-Ring *(not shown). Refer to Fuel Injector Delivery Tube Replacement.*
5. Connect Fuel Injector Harness Connectors (9) to Fuel Injector Electrical Connectors (5). *Figures 1, 2, 3, & 4*

   Apply dielectric grease to connectors.
6. Install Fuel Supply and Fuel Return Lines. *Refer to Fuel Supply and Fuel Return Line Replacement.*
7. Pressurize fuel system to prepare for leak check as follows:
   a. Open Fuel Tank Supply and Return Valves. *Refer to OEM procedure.*
   b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (10) Electrical Connector (11) to pressurize fuel system. *Figure 5*
8. Perform leak check. *Refer to Fuel System Leak Verification Procedure.*
9. Install Upper Intake Manifold. *Refer to Upper Intake Replacement.*
10. Connect negative (–) Battery Cable.
11. Verify proper operation.

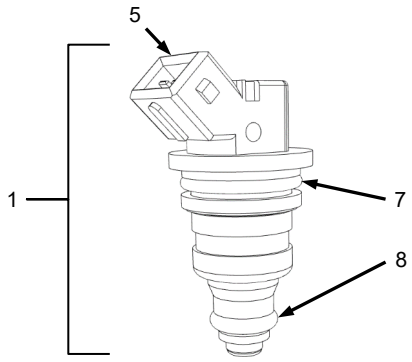


Figure 3:
Upper Fuel Injector O-Ring (7), Fuel Injector (1), Fuel Injector Electrical Connector (5), Lower Fuel Injector O-Ring (8)

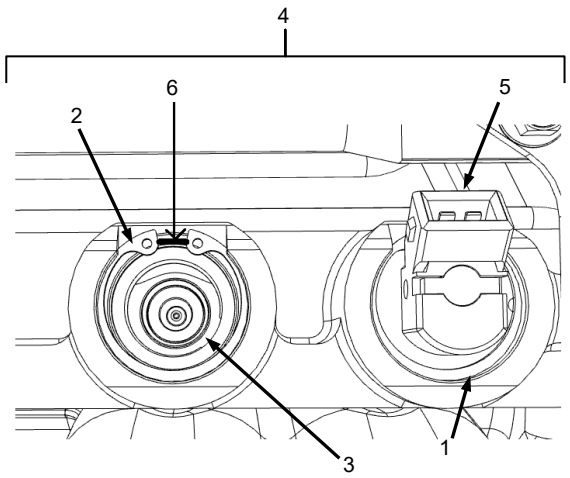


Figure 4:
Fuel Rail (4), Fuel Injector Bore (3) Installed Fuel Injector (1), Electrical Connector (5), 3 mm Minimum Gap (6) for Fuel Injector Snap Ring (2)

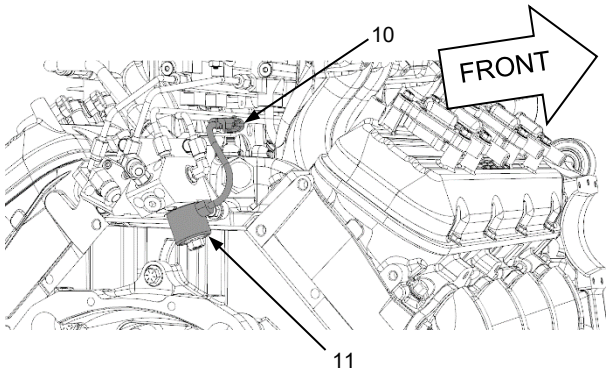


Figure 5:
Fuel By-Pass Solenoid (10), Electrical Connector (11)

Fuel Injector Tube Replacement

⚠WARNING

Fuel Line pressure can exceed 250 psi (17 bar). Exercise caution when removing Fuel Lines and Fuel Rails.

REMOVAL PROCEDURE

1. Secure vehicle outdoors in a safe location.
2. Bleed Fuel Lines. *Refer to NFPA 58 Fuel Line Bleed Procedure.*
3. Bring vehicle into service bay and secure.
4. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
5. Remove the respective Fuel Rail for Fuel Injector Tube (3) being replaced. *Refer to Fuel Rail Replacement. Figures 1 & 2*
6. Remove Injector Tube Retaining Snap Ring (2). *Figure 3*
7. Remove Fuel Injector Tube (3). *Figures 1, 2, 3, & 4*
8. Inspect Fuel Injector Tube (3) for damage.
9. Inspect Fuel Injector Tube O-Rings (3) and (7) for damage; replace as necessary. *Figures 3 & 4*
10. C **Inspect Fuel Rail Injector Tube Opening for debris; clean as necessary**.

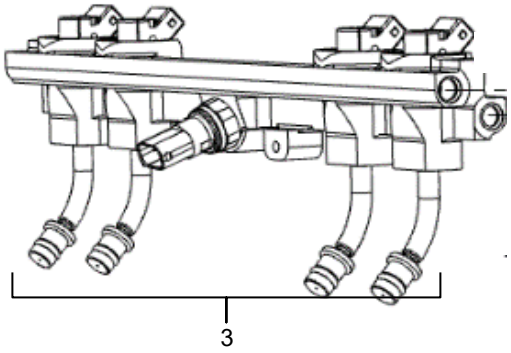


Figure 1:
Driver side Fuel Rail
with Fuel Injector Tubes (3)

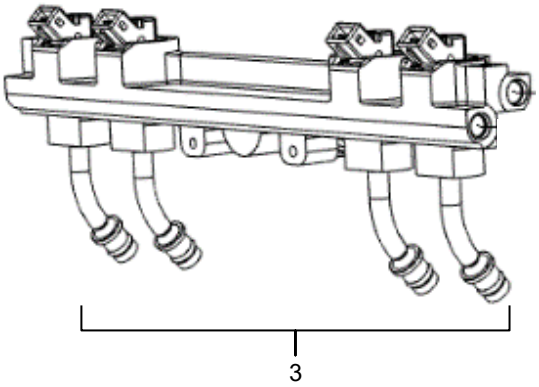


Figure 2:
Passenger side Fuel Rail with
Fuel Injector Tubes (3)

INSTALLATION PROCEDURE

1. Apply a light film of Parker O-Lube or equivalent to Fuel Injector Tube O-Rings (4) and (7). *Figure 4*
2. Install Fuel Injector Tube O-Ring (7) into Fuel Rail. *Figures 3 & 4*
3. Install Fuel Injector Tube (3) in position in Fuel Rail. *Figure 3*
4. Install Fuel Injector Tube Retaining Snap Ring (2).

   C **Verify Snap Ring (2) is fully seated.** *Figure 3*
5. Install respective Fuel Rail. *Refer to Fuel Rail Replacement. Figures 1 & 2*
6. Pressurize fuel system to prepare for leak check as follows:
   a. Open Fuel Tank Supply and Return Valves. *Refer to OEM procedure.*
   b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (8) Electrical Connector (9) to pressurize fuel system. *Figure 5*
7. Perform leak check. Refer to *Fuel System Leak Detection Procedure.*
8. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
9. Verify proper operation.

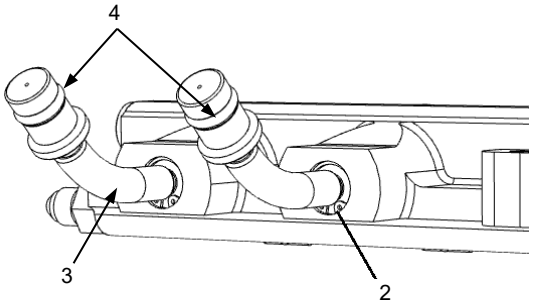


Figure 3:
Fuel Injector Tube (3), Injector Tube O-Rings (4) and Injector Tube Snap Ring (2)

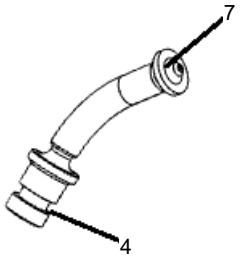


Figure 4:
Fuel Injector Tube O-Ring locations (7) & (4)

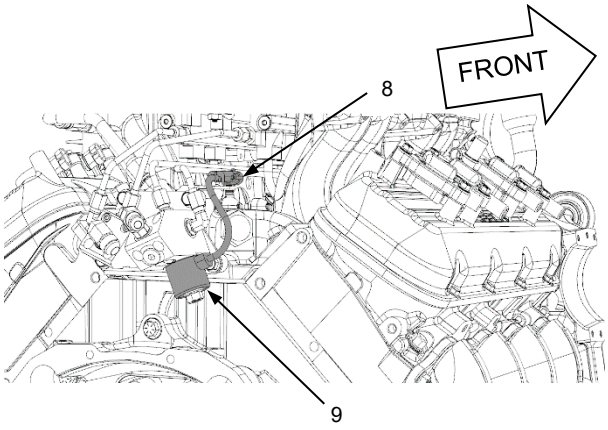


Figure 5:
Fuel By-Pass Solenoid (8), Electrical Connector (9)

Fuel Rail Fitting Replacement

⚠WARNING

Fuel Line pressure can exceed 250 psi (17 bar). Exercise caution when removing Fuel Lines.

REMOVAL PROCEDURE

1. Secure vehicle outdoors in a safe location.
2. Bleed Fuel Lines. *Refer to NFPA 58 for Fuel Line Bleed Procedure.*
3. Bring vehicle into service area and secure.
4. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
5. Disconnect Engine Fuel Supply Lines (1) and Engine Fuel Return Lines (2) to Fuel Rail Fitting to be replaced. *Refer to Fuel Supply and Fuel Return Line Replacement. Figure 1*
6. *Driver side Fuel Rail only:* Remove Fuel Rail Nipple(s) (2) or (3) or Plug(s) (1) from Fuel Rail (4). *Figure 2*
7. *Passenger side Fuel Rail only:* Remove Fuel Rail Nipple(s) (2) or (3) or Plug(s) (1) from Fuel Rail (5). *Figure 3*

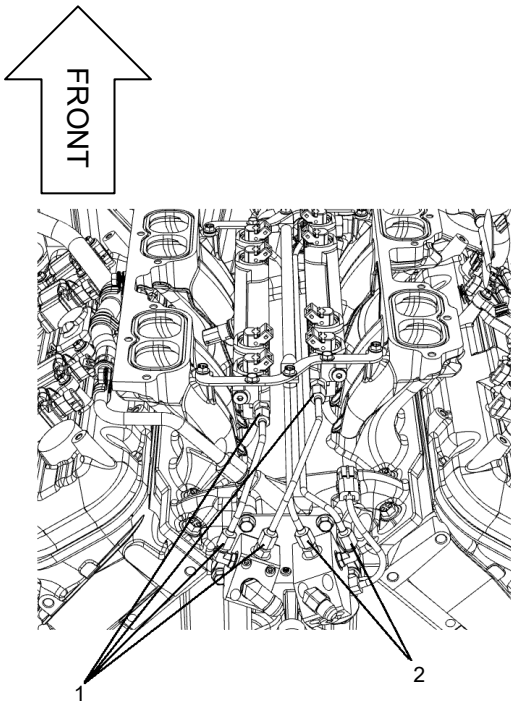


Figure 1:
Rear Engine Fuel Supply (1) and Engine Fuel Return Lines (2)

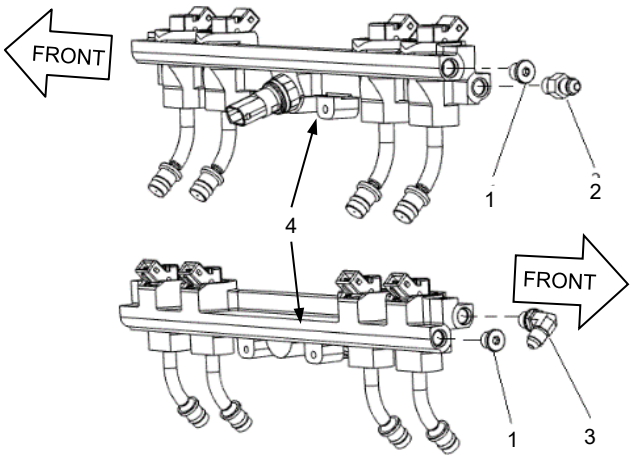


Figure 2:
Driver side Fuel Rail (4), Straight Fuel Supply Line Nipple (2), 45° Fuel Return Line Nipple (3), Plugs (1)

INSTALLATION PROCEDURE

1. Install Fuel Rail Fitting(s). *Refer to Fuel System Torque and Tightening Specifications. Figures 1, 2, & 3*

   C **Do not overtighten Fittings as damage or leaks may occur.**

2. Connect Fuel Supply and Fuel Return Lines to Fuel Rail Fitting being replaced. *Refer to Fuel Supply and Fuel Return Line Replacement. Figures 1, 2, & 3*
3. Check the fuel for fuel leaks:
   a. Open fuel supply and return valves.
   b. Energized supply solenoid will need to be to allow fuel to flow and pressurize the system. Use a Power Probe or similar tool to apply power to the two wires of the supply solenoid connector, this will energize the supply solenoid and pressurize the system.
4. Once the system is pressurized, perform leak check. *Refer to Fuel System Leak Verification Procedure.*
5. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
6. Verify proper operation.

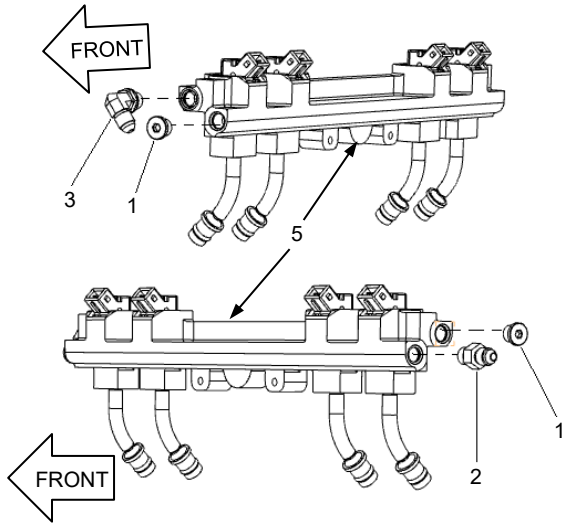


Figure 3:
Passenger side Fuel Rail (5),
Straight Fuel Supply Line Nipple (2),
45° Fuel Return Line Nipple (3), Plugs (1)

Fuel Rail Replacement

DESCRIPTION AND OPERATION

Two (2) Fuel Rails supply liquid propane to 488LPI™ Engine and return fuel back to the Fuel Tank(s) via Fuel Supply and Return Lines and Hoses. The Fuel Rails are designed to dissipate heat and regulate liquid propane to the Fuel Injectors. Pressure in the Fuel Rails varies directly with temperature: fuel pressure increases with temperature and vice versa.

⚠WARNING

Fuel Rail and Fuel Line pressure can exceed 250 psi (17 bar); exercise caution.

REMOVAL PROCEDURE

1. Secure vehicle outdoors in a safe location.
2. Bleed Fuel Lines. *Refer to NFPA 58 for procedure.*
3. Bring vehicle into service bay and secure.
4. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
5. Disconnect Fuel Supply Lines (1) and Fuel Return Lines (2) to Fuel Rail(s) (3) to be removed. *Figure 1. Refer to Fuel Supply & Return Line Replacement.*
6. Disconnect Fuel Injector Harness from Engine Harness. *Refer to Fuel Pressure/ Temperature (FPT) Sensor Replacement.*
7. Disconnect Fuel Injectors from Fuel Injector Harness Electrical Connectors (not shown). *Refer to Fuel Injector Replacement.*
8. *If replacing driver side Fuel Rail only:* Remove Fuel Pressure/Temperature (FPT) Sensor (6) from driver side Fuel Rail. *Refer to Fuel Pressure/Temperature Sensor Replacement. Figures 2 & 5*
9. *If replacing passenger side Fuel Rail only:* Remove Fuel Rail Plug (9) from passenger side Fuel Rail.

   NOTICE

   Inspect Fuel Rail Side Plug O-Ring for damage; replace as necessary. *Figure 3*

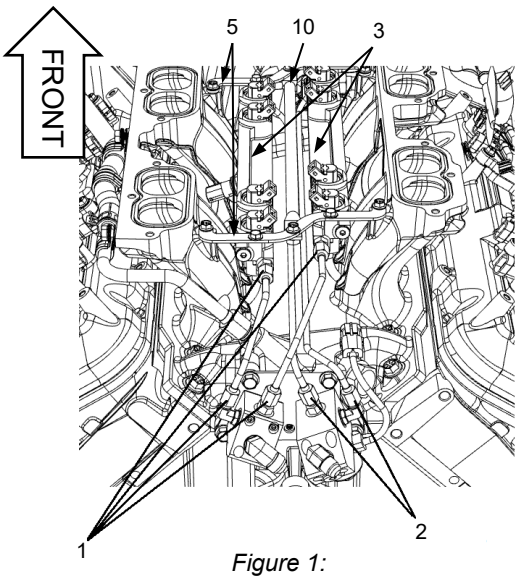


Figure 1:
Fuel Rails (3), Fuel Rail Top Brackets (5), Fuel Injector Harness Brace (10),
Fuel Supply Lines (1), Fuel Return Lines (2)

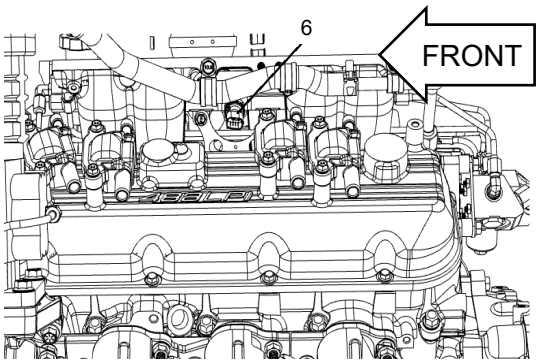


Figure 2:
Fuel Pressure/Temperature (FPT) Sensor (6) location (driver side Fuel Rail only)

10. Remove eight (8) Fuel Rail Top Bracket Retaining Bolts (4) and remove (2) Fuel Rail Top Brackets (5) together with Brace (10), and Fuel Injector Harness (not shown). *Figure 4*
11. Remove four (4) Fuel Rail Side Bracket Retaining Bolts (9) and remove Fuel Rail Side Bracket (7) securing Rail to be removed. Repeat for other side if removing both Fuel Rails. *Figures 5 & 6*
12. Clean debris from around Fuel Injector Delivery Tubes *(not shown)* using compressed air.
13. Gently wiggle Fuel Rail (3) and lift rail from Lower Intake Manifold. *Figures 1, 5, & 6*
14. **NOTICE**

    Inspect Injector Ports in Fuel Rail(s) for damage.
15. Cover Fuel Injector Ports in Fuel Rails and Lower Intake Manifold.

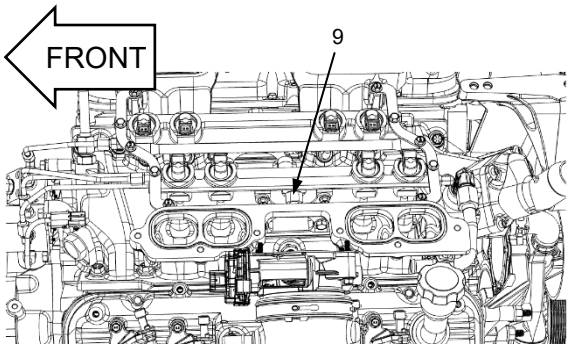


Figure 3:
Fuel Rail Side Plug (9) location
(passenger side Fuel Rail only)

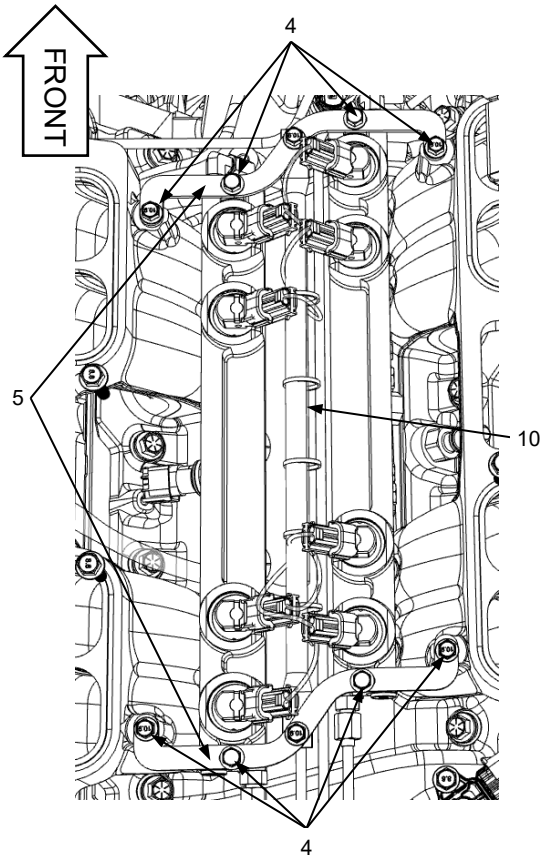


Figure 4:
Fuel Rail Top Bracket Retaining Bolts (4),
Fuel Rail Top Brackets (5),
Fuel Injector Harness Brace (10)

INSTALLATION PROCEDURE

1. Apply a light film of clean engine oil to Fuel Injector Delivery Tube O-Rings. *Refer to Fuel Injector Delivery Tube Replacement.*
2. Install Fuel Rail(s) (3) in position.

   NOTICE

   Verify Fuel Injector Delivery Tubes are orientated facing Intake Ports and O-Rings seat properly. *Do not force Fuel Rail into place as damage to Fuel Injector Delivery Tubes may occur.*
3. Install Fuel Rail Side Bracket (7) using four (4) Bolts (8). Repeat for other side if replacing both Fuel Rails. *Figures 5 & 6. Refer to Fuel System Torque and Tightening Specifications.*
4. Install two (2) Fuel Rail Top Brackets (5), Brace (10), and Fuel Injector Harness (not shown) as an assembly using eight (8) Bolts (4) *Figures 4 & 6. Refer to Fuel System Torque and Tightening Specifications.*

   C **Do not overtighten Bolts as damage may occur.**
5. *If replacing driver side Fuel Rail only:* Install FPT Sensor (6) in driver side Fuel Rail. *Refer to Fuel Pressure/Temperature (FPT) Sensor Replacement. Figures 2 & 5*
6. *If replacing passenger side Fuel Rail only:* Install Fuel Rail Side Plug (9) in driver side Fuel Rail. *Figure 3*

   C **Apply a light film of clean engine oil to Fuel Rail Side Plug O-Ring** *(not shown).*
7. Install Fuel Supply Lines (1) and Fuel Return Lines (2). *Figure 1*

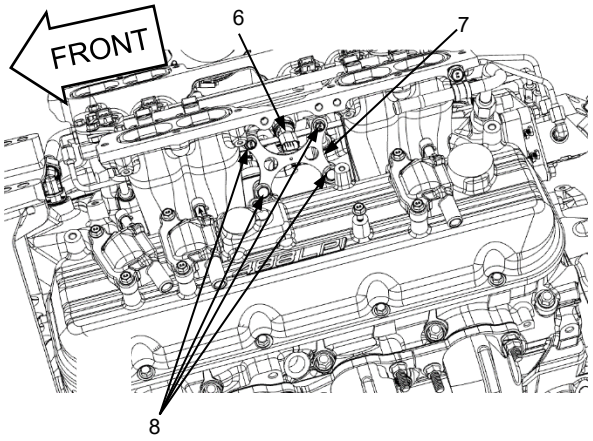


Figure 5:
FPT Sensor (6), Fuel Rail Side Bracket (7), Fuel Rail Side Bracket Retaining Bolts (8).
NOTE: *Driver side shown; passenger side similar. Ignition Coil omitted for clarity; no need to remove.*

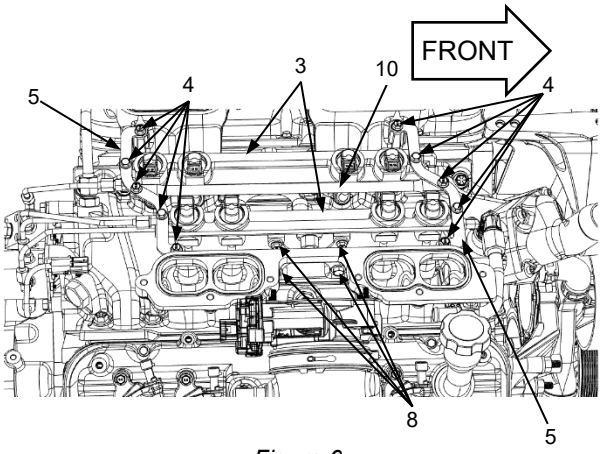


Figure 6:
Fuel Rails (3), Fuel Rail Top Brackets (5), Brace (10), Fuel Rail Top Bracket Retaining Bolts (4), Side Fuel Rail Bracket Bolts (8).
NOTE: *Passenger side shown; driver side similar.*

8. Pressurize fuel system to prepare for leak check as follows:
   a. Open Fuel Tank Supply and Return Valves. *Refer to OEM procedure.*
   b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (11) Electrical Connector (12) to pressurize fuel system. *Figure 7*
9. Perform leak check. *Refer to Fuel System Leak Verification Procedure.*
10. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
11. Verify proper operation.

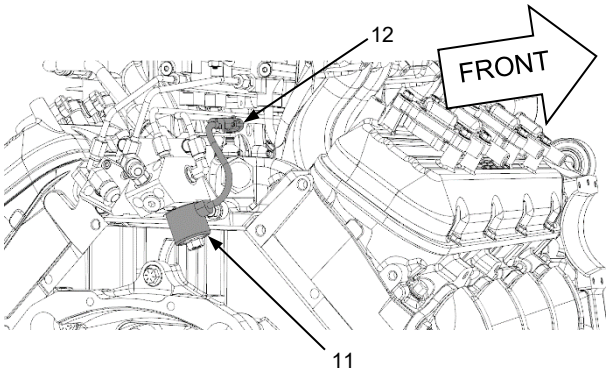


Figure 7:
Fuel By-Pass Solenoid (11), Electrical Connector (12)

Fuel Rail Supply/Return Lines Replacement

DESCRIPTION AND OPERATION

Fuel Rail Supply and Return Lines on the 488LPI engine carry liquid propane from the Fuel Distribution Blocks via two Fuel Supply Lines to the Fuel Rails. Fuel Return Line Fittings circulate fuel from the Fuel Rails to the Fuel Distribution Blocks. The passenger side Fuel Distribution Blocks houses the Fuel By-Pass Solenoid which allows liquid fuel and vapor to be returned to the fuel storage system.

REMOVAL PROCEDURE

1. Perform fuel line bleed procedure. *Refer to NFPA 58 Fuel Line Bleed Procedure.*
2. Tow or push vehicle into service bay.
3. Remove Upper Intake Manifold. *Follow Upper Intake Manifold Replacement procedure.*
4. Disconnect stainless steel Fuel Supply Fittings and/or Return Line Fittings (2) for the respective side being serviced. *Figure 1*
5. Remove line(s) being serviced from the vehicle.

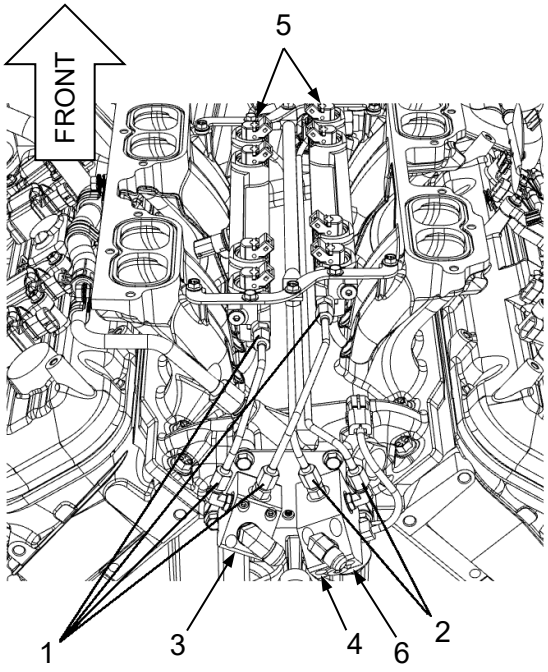


Figure 1:
Rear of engine with Upper Intake Manifold removed. Fuel Supply Line Fittings (1), Fuel Distribution Block (3), Fuel Rails (5), Fuel Return Line Fittings (2), Fuel Return Block (4), Fuel By-Pass Solenoid (6).

INSTALLATION PROCEDURE

1. Install stainless steel Supply/Return Line being serviced. *Figure 1. Refer to Fuel System Torque and Tightening Specifications.*
2. *If removed:* connect Fuel Storage System Fuel Supply Hose and/or Fuel Return Hose *(both not shown)* to the driver side Fuel Distribution Block (3) and/or passenger Fuel Distribution Block (4) 90-degree elbow fittings. *Figure 1*
3. Pressurize fuel system to prepare for leak check as follows:
   a. Open Fuel Tank Supply and Return Valves. *Refer to OEM procedure.*
   b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (6) Electrical Connector (7) to pressurize fuel system. *Figure 2*
4. Perform leak check. *Refer to Fuel System Leak Verification Procedure.*
5. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
6. Verify proper operation.

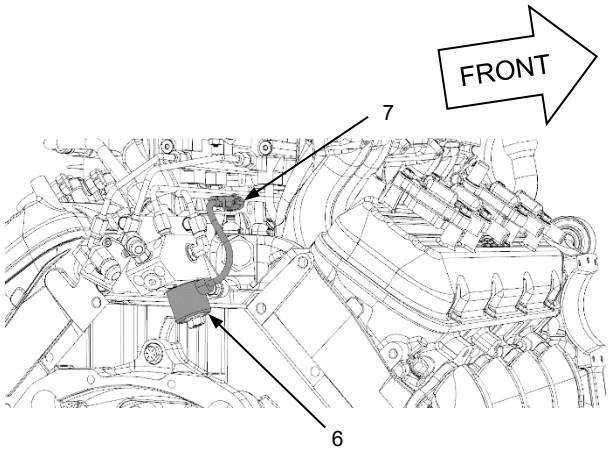


Figure 2:
Fuel By-Pass Solenoid (6), Electrical Connector (7)

Harmonic Damper Replacement

REMOVAL PROCEDURE

1. Secure vehicle on an approved hoist.
2. Verify engine is off and cool.
3. Raise vehicle.
4. Remove Transmission Adapter. *Refer to Flexplate & Transmission Adapter Replacement.*
5. Attach Flywheel Holding Tool to Starter bolt holes. *Figure 1*

   C Verify holding tool teeth fully engage Flywheel.
6. Lower vehicle.
7. Remove Cooling Pack. *Follow OEM procedure.*
8. Remove Main Accessory Belt. *Follow OEM procedure.*
9. *If equipped:* Remove Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*

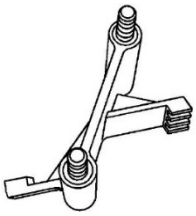


Figure 1:
Flywheel Holding Tool

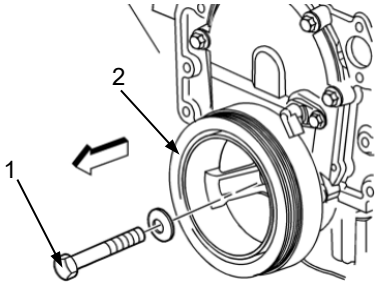


Figure 2:
Harmonic Damper Flanged Bolt (1)

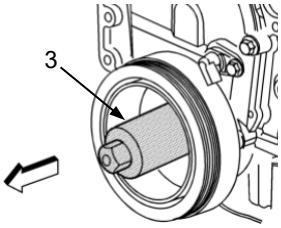


Figure 3:
Fit special tool (3) over Crankshaft snout

10. *If equipped:* Remove Dual A/C Drive Pulley. *Refer to Front End Accessory Drive Components Replacement.*
11. Remove Harmonic Damper Flanged Bolt (1) from Harmonic Damper (2). Figure 2
12. Install removal tool (3) over Crankshaft snout (6). *Figures 3 & 5.*
13. Install special tool (4) on Harmonic Damper (5). *Figure 4*
14. Tighten special tool center screw to pull Harmonic Damper off Crankshaft.
15. Remove Harmonic Damper (5), taking care not to lose the Alignment Key *(not shown).*
16. Remove special tool from Harmonic Damper (5). *Figure 4*
17. Clean and inspect Harmonic Damper.

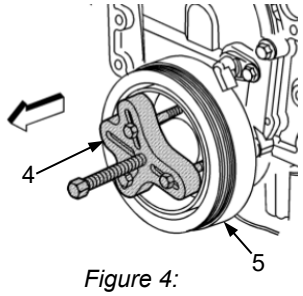


Figure 4:
Install removal tool (4) on Harmonic Damper (2)

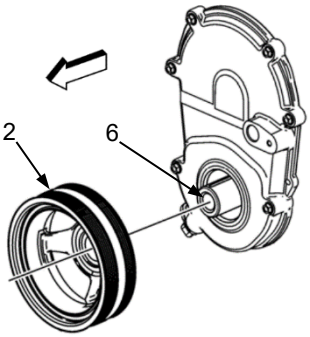


Figure 5:
Harmonic Damper (2) and Crankshaft snout (6)

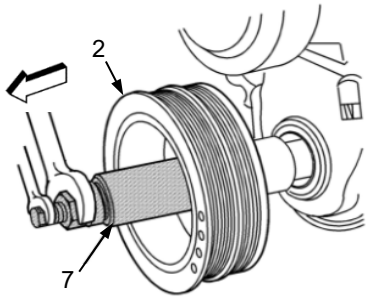


Figure 6:
Tighten nut on special tool (7) to seat Harmonic Damper (2) on Crankshaft snout (6)

INSTALLATION PROCEDURE

RECOMMENDED: Replace Front Crankshaft Seal prior to reassembly. *Refer to Front Crankshaft Seal Replacement.*

1. Install Alignment Key (not shown) and Harmonic Damper (5) on Crankshaft snout (6). *Figure 5*

   NOTICE

   Position Harmonic Damper as straight as possible on Crankshaft. Apply a coat of clean engine oil to Crankshaft snout and inside Harmonic Damper to prevent galling during assembly.
2. Install special tool (7) on Harmonic Damper (5). *Figure 6*

   C **Lubricate tool threads with anti-seize grease before each use.**
3. Using special tool (7), press Harmonic Damper on Crankshaft nose.
4. Tighten special tool nut until Harmonic Damper is completely seated against Crankshaft Timing Sprocket and remove.
5. Install new Harmonic Damper Flanged Bolt (1). *Figure 2. Refer to Engine Mechanical Torque and Clearance specifications.*
6. *If equipped:* Install Dual A/C Drive Pulley. *Refer to Front End Accessory Drive Components Replacement.*
7. *If equipped:* Install Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
8. Install Main Accessory Belt. *Follow OEM procedure.*
9. Install Cooling Pack. *Follow OEM procedure*.
10. Raise vehicle.
11. Remove Flywheel Holding Tool. *Figure 1*
12. Install Transmission Adapter. *Refer to Flexplate & Transmission Adapter Replacement.*
13. Fill engine fluids. *Follow OEM specifications*.
14. Verify proper operation.

Lower Intake Manifold Replacement

REMOVAL PROCEDURE

⚠WARNING

Drain fuel lines prior to towing or pushing vehicle into shop. *Refer to NPFA 58 Fuel Line Bleed Procedure.*

NOTICE

Remove air filter housing bracket (along with filter housing and hose) from the firewall by removing the four T40 Torx bolts.

NOTICE

If the vehicle is equipped with single or dual A/C compressors *Refer to A/C Compressor Removal Procedure.*

1. Loosen Air Intake Tube hose clamps, remove the air filter housing bracket (along with the filter housing and hose) by removing four T40 Torx bolts.
2. Drain engine coolant. *Follow OEM procedure.*
3. *If equipped with Air Conditioning:*
   a. Remove upper Dual A/C Compressor *(not shown),* OR
   b. Remove Single A/C Compressor *(not shown). Follow OEM procedure.*
4. Remove Upper Intake Manifold and Air Intake Tube *(both not shown)* as an assembly. *Refer to Upper Intake Manifold Replacement.*
5. Disconnect Fuel Supply and Fuel Return Hoses *(not shown)* at respective Fuel Distribution Blocks (16) and (17). *Figure 4. Refer to Fuel Supply and Return Line Replacement.*
6. *If equipped:* Remove Air Compressor Coolant Feed Line Flare Nut (8) from rear of Lower Intake Manifold (1). *Figure 1. Refer to Air Compressor Replacement.*

   NOTICE

   Collect coolant for reuse or proper disposal.

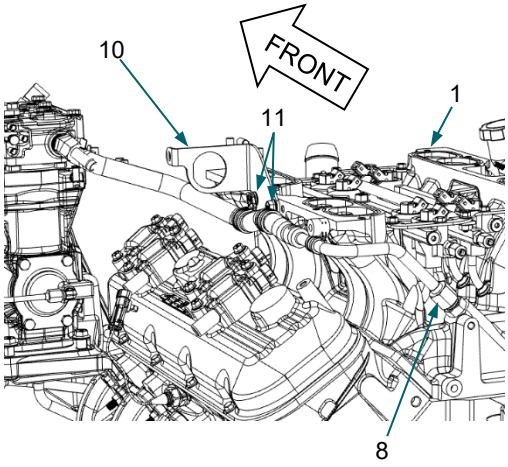


Figure 1:
Air Compressor Coolant Feed Line Flare Nut (8) at Lower Intake Manifold (1) rear; Electrical Bulkhead Connector Bracket (10), Retaining Bolts (11)

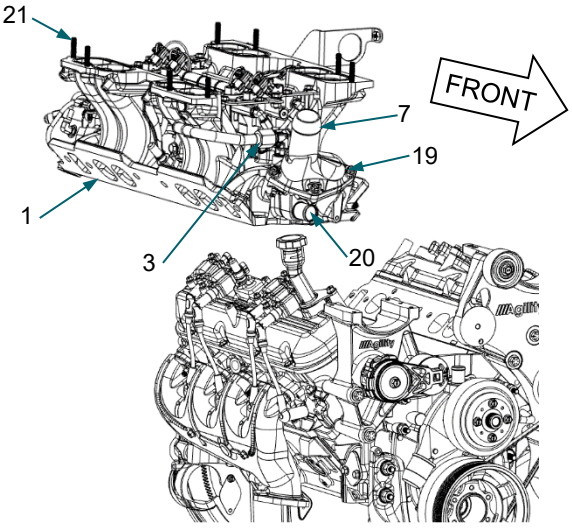


Figure 2:
Lower Intake Manifold (1), Coolant By-Pass Adapter (20), Heater Coolant Feed Line Flare Nut (3), Upper Radiator Hose location (7), Thermostat Housing (19), Upper Intake Manifold Mounting Studs (21)

7. Disconnect Upper Radiator Hose *(not shown)* from Thermostat Housing (7). *Figure 2. Refer to Thermostat Replacement.*
8. Disconnect Coolant By-pass Hose *(not shown)* at Lower Intake Tube Adapter (20). *Figures 2 & 3*
9. Disconnect Heater Coolant Feed Line Flare Nut (3) at Lower Intake Manifold 90° Nipple Adapter *(not shown). Figure 2*
10. Remove twelve (12) Lower Intake Manifold Retaining Bolts (12) and Washers (13). *Figure 3*
11. Remove Lower Intake Manifold Assembly (1) from Engine. *Figure 2*
12. Remove Lower Intake Manifold Gaskets (4) and discard. *Figure 3*

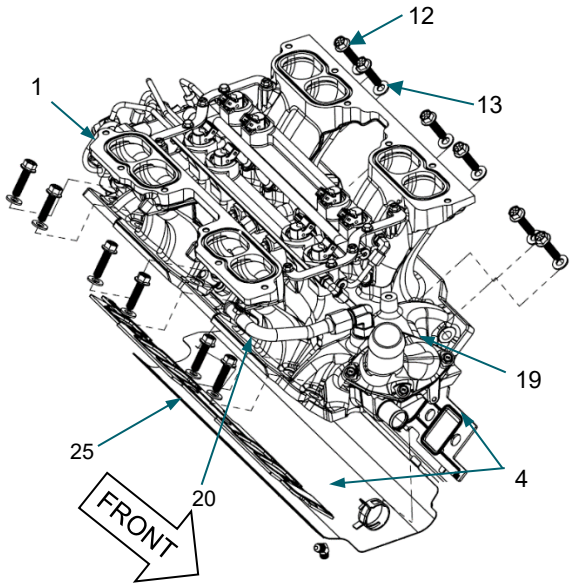


Figure 3:
Lower Intake Manifold (1), Lower Intake Gaskets (4), Bolts (5), Washers (6); Coolant By-pass Hose Adapter (20), Thermostat Housing (19), Valley Pan (25)

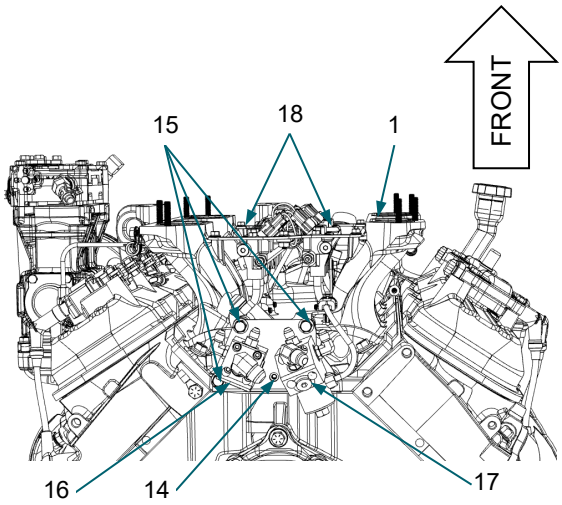


Figure 4:
Lower Intake Manifold (1), Fuel Rails (18), Fuel Distribution Block Bracket (14), Bolts (15), Fuel Supply Distribution Block (16), Fuel Return Distribution Block (17).
NOTE: Fuel Supply and Return Lines not shown.

INSTALLATION PROCEDURE

1. Remove any RTV Silicone residue from Lower Intake Manifold, Cylinder Head and Engine China Wall sealing surfaces. *Figure 5*

   Use care around ports to avoid contamination.

   Lower Intake Manifold is aluminum; use care in removing gasket/RTV material.

2. Clean all Lower Intake Manifold mating surfaces with isopropyl alcohol. *Figure 5*
3. Verify Valley Pan (25) is in place. *Figure 3*
4. Apply a 0.25-in (6mm) to 0.50-in (12.5mm) bead of engine RTV Silicone around Lower Cylinder Head Coolant Ports (22). *Figure 5*
5. Install new Lower Intake Manifold Gaskets (4) on Cylinder Heads (24).

   Verify Gasket Alignment Tabs (6) are fully seated. *Figure 5*

6. Apply 3 beads 0.25-in (6mm) to 0.50-in (12.5mm) of High Temp RTV Silicone to the Engine China Walls, 2 beads along the China wall and the 3rd bead on top of the 2 beads on the China Walls (5). *Figure 5*
7. Apply a 0.25-in (6mm) to 0.50-in (12.5mm) bead of High Temp RTV Silicone to Lower Intake Manifold Gaskets (4) around Gasket Coolant Ports (23). *Figure 5*
8. **NOTICE**

   It is recommended that two people carefully center Lower Intake Manifold (1) when placing on engine; this will prevent High Temp RTV from being dislocated from China Wall and allow for a proper seal. *Figure 2*

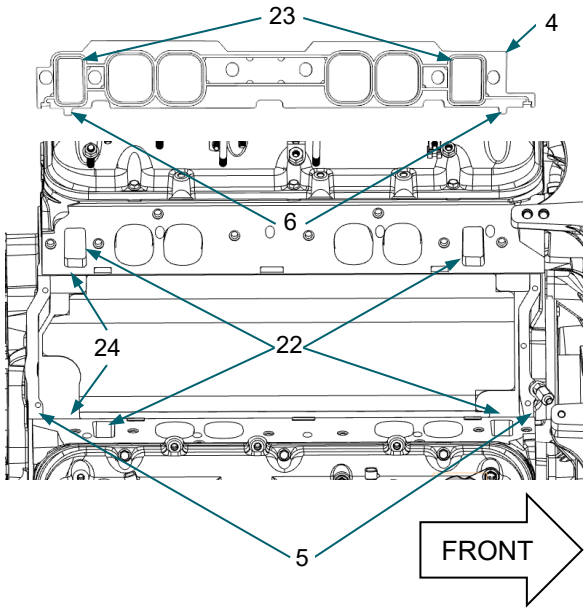


Figure 5:
Lower Intake Manifold Gasket (4), Gasket Alignment Tabs (6), Gasket Coolant Ports (23) Cylinder Head Coolant Ports (22); China Walls (5)

9. *If not pre-applied:* **Apply Loctite® 565 PST® Pipe Sealant to Lower Intake Manifold Bolts (12).** *Figure 3*
10. Install Lower Intake Manifold Bolts (12) and Washers (13). *Figure 3*

    Start all bolts by hand and run down until hand tight.

11. Tighten Intake Bolts (12) following torque sequence in *Figure 6*. *Refer to Engine Mechanical Torque and Clearance Specifications.*
12. Connect Upper Radiator Hose to Thermostat Housing (19) at location (7). *Figure 2. Refer to Thermostat Replacement.*
13. Connect Heater Core Coolant Feed Line Flare Nut (3) at Lower Intake 90° Nipple Adapter *(not shown). Figure 2*
14. Connect By-pass Hose *(not shown)* at Lower Intake Manifold Tube Adapter (9). *Figure 2*
15. *If equipped:* Install Air Compressor Coolant Feed Line (8) to Lower Intake Manifold (1) rear. *Figure 1*
16. Connect Fuel Supply and Fuel Return Hoses at respective Distribution Blocks (16) and (17). *Figure 4. Refer to Fuel Supply and Return Line Replacement*.
17. Pressurize fuel system to prepare for leak check as follows:
    a. Open Fuel Tank Supply and Return Valves. *Refer to OEM procedure.*
    b. Use a Power Probe or similar tool to apply power to two wires of the Fuel By-Pass Solenoid (11) Electrical Connector (12) to pressurize fuel system. *Figure 7*
17. Perform leak check. *Refer to Fuel System Leak Check Procedure.*
18. Install Upper Intake Manifold *(not shown). Refer to Upper Intake Manifold Replacement.*

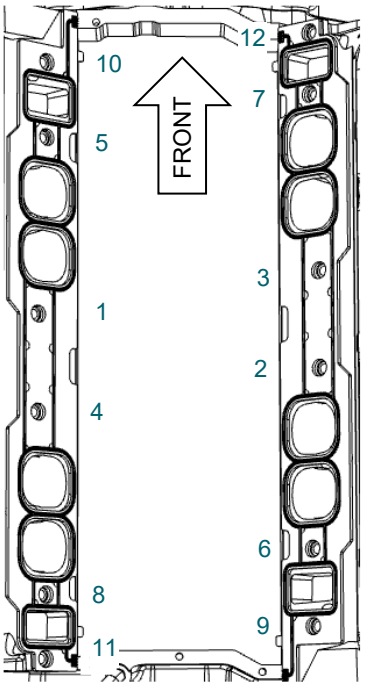


Figure 6:
Lower Intake Manifold Retaining Bolt Torque Sequence (numbered locations)

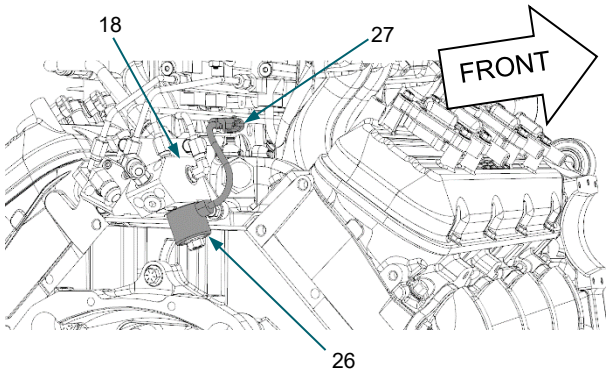


Figure 7:
Fuel By-Pass Solenoid (26), Electrical Connector (27), Fuel Return Distribution Block (18)

19. *If equipped:*
    a. Install Single A/C Compressor, OR
    b. Install Dual A/C Compressor.
    Follow OEM procedure.
20. Fill cooling system. *Follow OEM procedure; refer to* 488LPI™ Owners Manual *for coolant specifications*.
21. Clean any spilled fluids from engine.
22. Bring engine up to operating temperature and verify proper operation.

Main Front End Accessory Drive (FEAD) Bracket Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Ensure engine is off and cool.

   NOTE: *For Steps 4 & 5, refer to OEM Main Accessory Drive Belt Replacement to remove tension on respective belts*.
3. *If equipped:* Remove A/C Drive Belt.
4. Remove Main Accessory Drive Belt.
5. Remove Air Compressor. *(not shown) Refer to Air Compressor Replacement.*
6. *If equipped:* Remove Air Compressor Bracket (3). *Figure 1. Refer to Air Compressor Bracket Replacement.*
7. Remove Power Steering Pump *(not shown)* from Main Front Engine Accessory Drive (FEAD) Bracket position (5). *Figure 1. Follow OEM procedure.*
8. Remove Alternator (not shown) from Main FEAD Bracket position (4). *Figure 1. Refer to Alternator Removal.*
9. Remove three (3) Upper Bolts (2) and Washers (6) and Lower Bolt (7) and Washer (8). *Figure 1.*

   NOTICE

   Bolt (7) and Washer (8) are different from (2) and (6).
10. Remove Main FEAD Bracket (1) from engine. *Figure 1*

    ⚠CAUTION

    Bracket is heavy, and accessory drive pulleys will remain attached. Please take necessary precautions when handling to prevent personal injury or component damage.

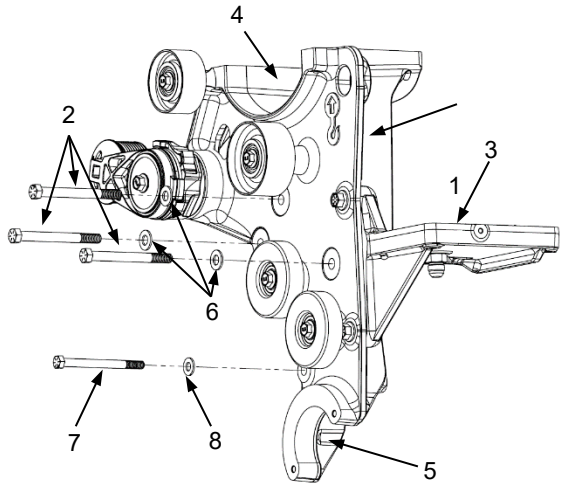


Figure 1:
Main Front End Accessory Drive (FEAD) Bracket (1), Air Compressor Bracket (3); Upper Bolts (2) and Washers (6), Lower Bolt (7) and Washer (8), Power Steering Pump location (5), Alternator location (4),

INSTALLATION PROCEDURE

⚠CAUTION

Bracket is heavy, and accessory drive pulleys will remain attached. Please take necessary precautions when handling to prevent personal injury or component damage.

1. Thread one (1) Upper Bolt (2) and Washer (6) through Main FEAD Bracket (1) and into engine block. *Figure 2*.

NOTICE

Bolt holds Bracket temporarily and eases alignment.

2. Align Main FEAD Bracket (1) to engine *(not shown). Figure 1*
3. Install remaining two (2) Upper Bolts (2) and Washers (6) and Lower Bolt (7) and Washer (8) *(not shown). Figure 1.*
4. Torque all four (4) Main Accessory Drive Retaining Bolts (2 & 7). *Figure 1. Refer to Front End Accessory Drive Torque Specifications.*
5. Install Power Steering Pump. *Follow OEM procedure.*
6. Install Alternator. *Refer to Alternator Removal Procedure.*
7. *If equipped:* Install Air Compressor Bracket. *Refer to Air Compressor Bracket Replacement.*
8. *If equipped:* Install Air Compressor. *Refer to Air Compressor Replacement.*
9. Install Main Accessory Drive Belt. *Follow OEM procedure and route belt according to OEM diagram.*
10. *If equipped:* Install A/C Drive Belt. *Follow OEM procedure and route belt according to OEM diagram*.
11. Verify proper operation.

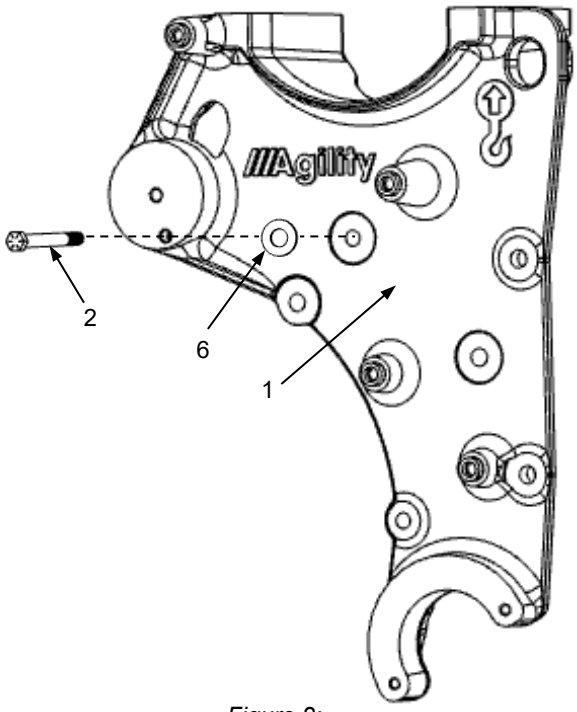


Figure 2:
Thread one (1) Upper Bolt (2) and Washer (6) to locate Main Accessory Drive (1) on engine.

NOTE: *Accessory Pulleys and optional Air Compressor Bracket not shown.*

Manifold Absolute Pressure (MAP) Sensor Replacement

DESCRIPTION AND OPERATION

The Manifold Absolute Pressure (MAP) Sensor is a three (3) wire sensor that provides a signal to the Engine Control Module (ECM) based on pressure changes in the Intake Manifold. Pressure changes occur dependent on a combination of engine speeds, throttle openings, air temperature, and barometric pressure. The ECM supplies five (5) volts to the MAP Sensor on the 5 V Reference Circuit and Ground on the Low Reference Circuit.

The MAP Sensor provides a signal to the ECM on the Signal Circuit relative to intake pressure changes. The MAP Sensor Signal is low during idle or deceleration. The MAP Sensor Signal is high during Ignition ON, Engine OFF, or at Wide Open Throttle (WOT). The MAP Sensor also measures barometric pressure (BARO). This occurs with Ignition ON, Engine OFF. The BARO reading may also be updated whenever the Throttle Position Sensor (TPS) is at Wide Open Throttle.

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is off.
3. Disconnect Manifold Absolute Pressure (MAP) Sensor (1) Electrical Connector (6) from Engine Harness Connector *(not shown). Figures 1 & 2*
4. Remove MAP Sensor Mounting Bolt (3). *Figure 1.*
5. Remove MAP Sensor (1) from Upper Intake Manifold (4). *Figure 1*
6. Inspect MAP Sensor O-Ring Seal (5) for tears, dryness, or cracks. *Figure 2*

NOTICE

If O-ring is damaged, the MAP Sensor must be replaced.

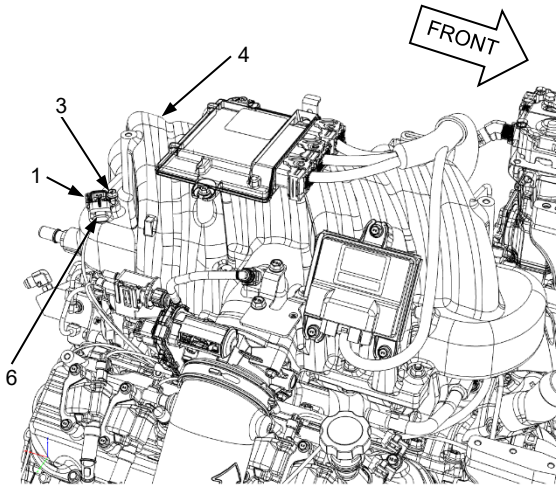


Figure 1:
Manifold Absolute Pressure (MAP) Sensor (1),
MAP Sensor Electrical Connector (6),
MAP Sensor Mounting Bolt (3),
Upper Intake Manifold (4)

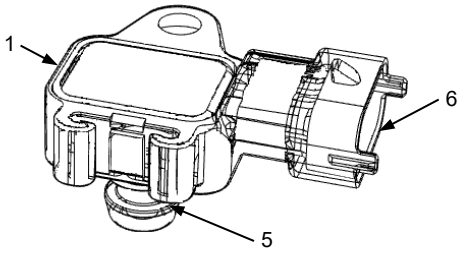


Figure 2:
Manifold Absolute Pressure (MAP) Sensor (1),
MAP Sensor O-Ring Seal (5),
MAP Sensor Electrical Connector (6)

INSTALLATION PROCEDURE

1. Lightly coat MAP Sensor O-Ring Seal (5) with clean engine oil before installing sensor. *Figure 2*

   NOTICE

   Apply clean engine oil with a sponge or a brush. To prevent sensor blockage, avoid dipping MAP Sensor port directly into liquid.
2. Install MAP Sensor (1) on Upper Intake Manifold (4). *Figure 1*
3. Install MAP Sensor Mounting Bolt (3) and tighten. *Figure 1. Refer to Electrical Component & Sensor Torque Specifications.*
4. Connect MAP Sensor Electrical Connector (6) to Engine Harness Connector (2). *Figures 1 & 2*
5. Verify proper operation.

Oil Pan Replacement

REMOVAL PROCEDURE

1. Secure vehicle on approved hoist and raise vehicle.
2. Remove Oil Dipstick Tube Bolt and release Tube from bottom Clip. *Follow OEM procedure.*
3. Remove Oil Dipstick Tube from Oil Pan and secure out of the way.
4. Drain engine oil.
5. Disconnect Engine Oil Cooler Lines. *Follow OEM procedure.*
6. *Air Compressor equipped engines only:* Disconnect Oil Return Line (3) at Adapter (2). *Figure 1*
7. Temporarily plug Air Compressor Oil Return Line and secure out of the way.
8. *If replacing a damaged Oil Pan on an Air Compressor equipped engine only:* Remove Oil Return Line Adapter (2) from Oil Pan (4). *Figure 1*
9. Remove twenty (20) Oil Pan Retaining Bolts (1). *Figure 1*
10. Remove Oil Pan (4) from vehicle.
11. Remove Oil Pan Gasket and discard.

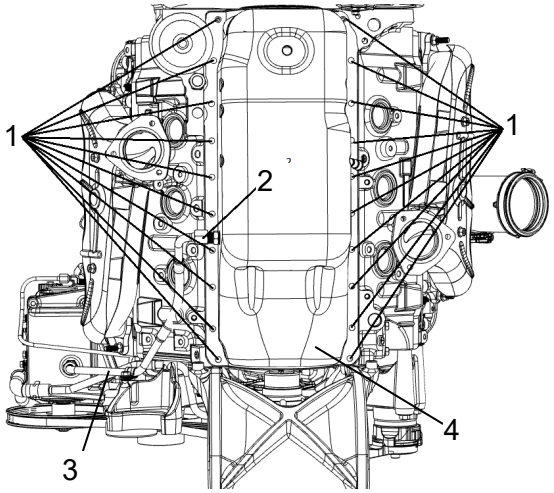


Figure 1:
Oil Pan (4), Oil Pan Retaining Bolts (1),
Air Compressor Oil Return Line (3) and Adapter (2)

INSTALLATION PROCEDURE

1. Inspect Oil Pan to Engine mounting surfaces.
2. Install new Oil Pan Gasket on Oil Pan.
3. Install Oil Pan (4) on engine. *Figure 2*
4. Torque Oil Pan Retaining Bolts following *Figure 2* torque sequence. *Refer to Engine Mechanical Torque and Clearance Specifications.*
5. *If installing a new Oil Pan on an Air Compressor equipped engine only:* Apply Teflon tape to the Return Line Adapter fitting. Install Oil Return Line Adapter (2) on Oil Pan (4). *Figure 2. Refer to Engine Mechanical Torque and Clearance Specifications.*
6. *Air Compressor equipped engines only:* Connect Air Compressor Oil Return Line (3) to Adapter (2). *Figure 1. Refer to Engine Mechanical Torque and Clearance Specifications.*
7. Connect Engine Oil Cooler Lines. *Follow OEM procedure.*
8. Install Oil Drain Plug *(if not installed). Refer to Engine Mechanical Torque and Clearance Specifications.*
9. Install Oil Dipstick Tube using lower Clip and Bolt. *Follow OEM procedure.*
10. Lower vehicle.
11. Fill engine oil. *Refer to* 488LPI™ Owner's Manual *for Capacities and Requirements.*
12. Clean any excess oil from engine.
13. Inspect for leaks.
14. Run engine to operating temperature for twenty (20) minutes.
15. Inspect again for leaks.

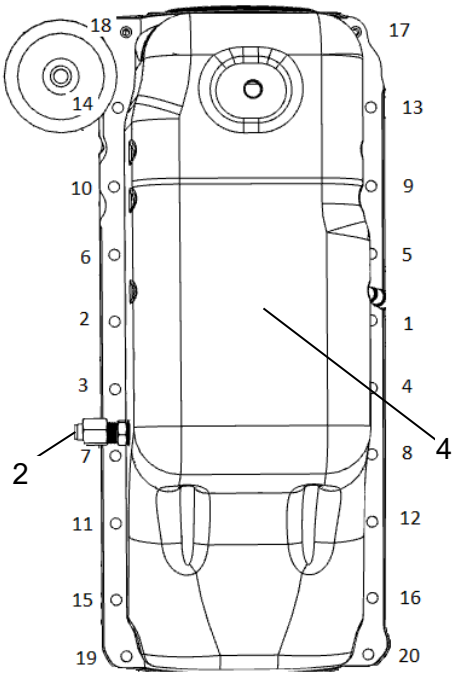


Figure 2:
Oil Pan Retaining Bolt Torque Sequence

Oil Pump Drive Replacement

REMOVAL PROCEDURE

1. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
2. Remove Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
3. Remove Valley Pan (1). *Figure 1*
4. Remove Oil Pump Drive Retaining Bolt (2). *Figure 2*
5. Slide Oil Pump Drive (3) from Oil Pump Bore (5) and remove from engine. *Figure 2*
6. Clean and inspect Oil Pump Drive (3). *Figure 2*

INSTALLATION PROCEDURE

1. Apply film of oil to Oil Pump Drive Gear (6) to ease assembly. *Figure 2*
2. Align Oil Pump Drive Gear (4) with Oil Pump Drive Shaft *(not shown). Figure 2*

   IMPORTANT: *Oil Pump Drive Gear must be aligned with the Oil Pump Drive Shaft turned by the Camshaft Gear. Align gears by rotating Oil Pump Drive back and forth until it seats itself. Do not force drive into position as gear damage may occur.*
3. Install Oil Pump Drive (3) into Oil Pump Bore (5). Verify Oil Pump Drive (3) is fully seated in bore. *Figure 2*
4. Install Oil Pump Drive Retaining Bolt (2). *Refer to Engine Mechanical Torque and Clearance Specifications. Figure 2*
5. Install Valley Pan (1). *Figure 1*
6. Install Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
7. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
8. Fill engine fluids. *Follow OEM procedure and* 488LPI™ Owners Manual *Maintenance Specifications.*
9. Verify proper operation.

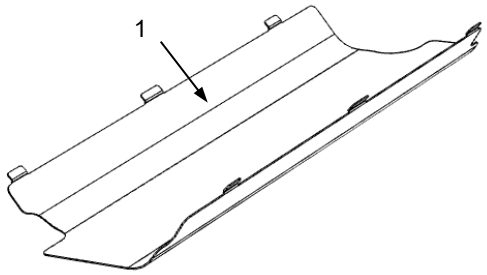


Figure 1:
Valley Pan (1)

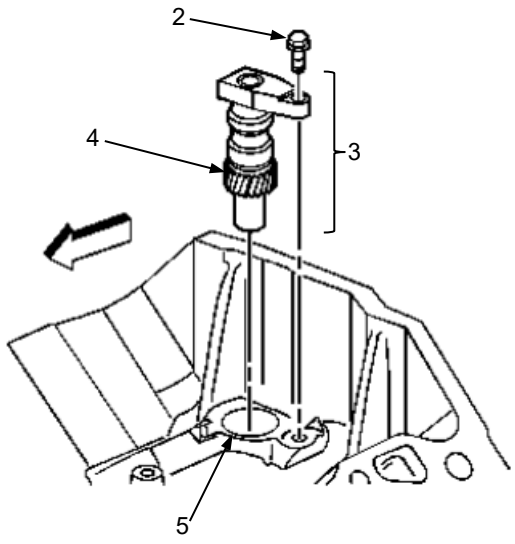


Figure 2:
Oil Pump Drive (3), Oil Pump Drive Retaining Bolt (2), Oil Pump Drive Gear (4), Oil Pump Bore (5)

Oil Pump Replacement

REMOVAL PROCEDURE

1. Secure vehicle. Verify engine is off and has had ample cooling time.
2. Drain engine oil.

   NOTICE

   Collect oil and dispose of properly.
3. Remove Oil Pan. *Refer to Oil Pan Replacement.*
4. Remove Oil Pump Retaining Bolt (1). *Figure 1.*
5. Remove Oil Pump (2), Oil Pump Shaft Retainer (3), and Oil Pump Driveshaft (4). *Figure 1*
6. Separate Oil Pump, Oil Pump Shaft Retainer, and Oil Pump Driveshaft.
7. Discard Oil Pump Retainer (3).

INSTALLATION PROCEDURE

1. Assemble new Oil Pump Shaft Retainer (3) and Oil Pump Driveshaft (4). *Figure 1*
2. **NOTICE**

   Oil Pump Gear must be aligned with the Oil Pump Drive Shaft turned by the Camshaft Gear. Align gears by rotating Oil Pump Driveshaft back and forth until it seats itself. Do not force Driveshaft into position as gear damage may occur.
3. Install Oil Pump Assembly. Position Oil Pump (2) on Locating Pins. *Figure 1*
4. Install Oil Pump Retaining Bolt (1). *Refer to Engine Mechanical Torque and Clearance Specifications.*
5. Install Oil Pan. *Refer to Oil Pan Replacement. Figure 1*
6. Fill engine oil. *Follow OEM procedure and* 488LPI™ Owners Manual.
7. Verify proper operation.

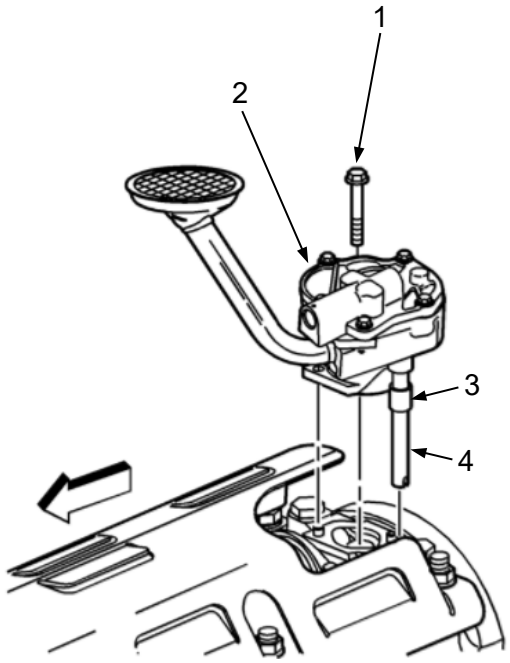


Figure 1:
Oil Pump (2), Oil Pump Retaining Bolt (1), Oil Pump Shaft Retainer (3), Oil Pump Driveshaft (4).

Power Steering Pump Pulley Replacement

DESCRIPTION AND OPERATION

The 488LPI™ engine is equipped with a provision for OEM power steering. The Crankshaft Pulley turns the Power Steering Pump Pulley driven via the Main Accessory Drive Belt.

NOTICE

When replacing the OEM-supplied Power Steering Pump, the Power Steering Pump Pulley must be transferred from the old Power Steering Pump to the new unit.

NOTICE

In the unlikely event of Power Steering Pump Pulley damage, replace the Pulley to avoid damage to the Power Steering Pump or Main Accessory Drive Belt.

REMOVAL PROCEDURE

1. Secure vehicle and verify engine is off and cool.
2. *If equipped:* Remove Dual Air Conditioning Compressor Drive Belt. *Refer to Dual Air Conditioning Compressor Belt Replacement.*
3. Remove Main Accessory Drive Belt. *Refer to OEM Main Accessory Drive Belt Replacement.*
4. Remove Power Steering Pump Pulley Bolt (5) and Washer *(not shown). Figure 1*
5. Use Special Tool to remove Power Steering Pump Pulley from Power Steering Pump *(not shown). Figure 2*

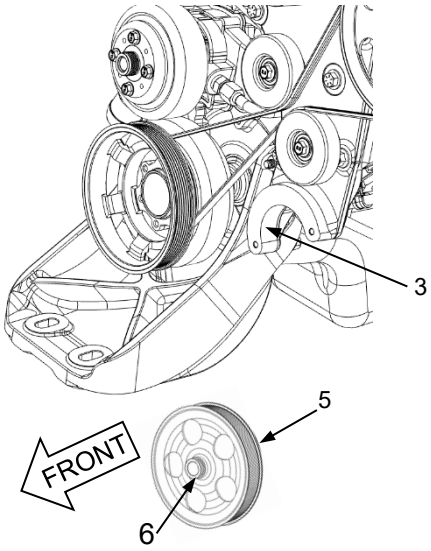


Figure 1:
Power Steering Pump location (3), Power Steering Pump Pulley (5), Bolt (6)

INSTALLATION PROCEDURE

1. *If installing a new Power Steering Pump:* Install Power Steering Pump *(not shown)* on Main Front End Accessory Drive (FEAD) Bracket at location (3). *Figure 1. Follow OEM procedure.*
2. Press Power Steering Pump Pulley (5) on Power Steering Pump *(not shown)* using Special Tool. *Figures 1 and 2*

   C **Verify Pulley Keyway is properly aligned.**
3. Install Power Steering Pump Pulley Bolt (6). *Figure 1*
4. Torque Power Steering Pump Pulley Bolt (6). *Figure 1. Refer to Front End Accessory Drive Specifications.*
5. Install Main Accessory Drive Belt. *Refer to OEM service manual for procedure and routing*.
6. *If equipped:* Install Dual Air Conditioning Compressor Drive Belt. *Refer to Dual Air Conditioning Air Compressor Belt Replacement.*
7. Verify proper operation.
8. Clean any spilled fluids from engine.
9. Run engine to operating temperature and inspect for leaks.

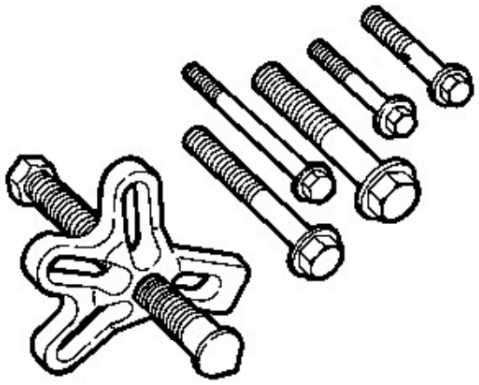


Figure 2:
Special Tool example

Pushrod Inspection and Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is cool.
3. Remove Valve Cover(s). *Refer to Valve Cover Replacement.*
4. Remove Roller Rocker Arm(s) for the Pushrod(s) being serviced. *Refer to Roller Rocker Arm Replacement.*
5. Remove Pushrod(s) (1), (2) being serviced.

   C **If Pushrod(s) being serviced will be re-used, organize Pushrods so they can be reinstalled in same location.**

   NOTICE

   Exhaust Pushrods (2) are longer than Intake Pushrods (1). Organize Pushrods in order of removal for proper reassembly.

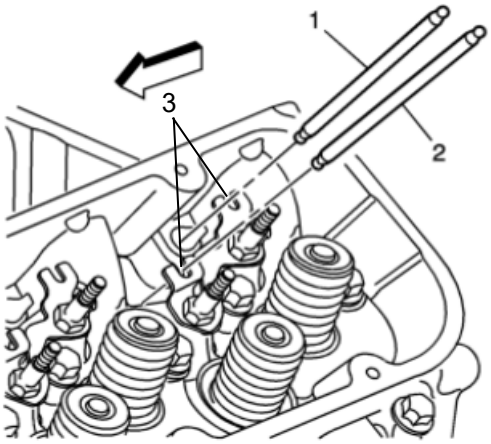


Figure 1:
Remove Pushrods (1) and (2) from Pushrod Guides (3)

INSPECTION PROCEDURE

1. Roll Pushrod on flat surface such as glass to verify Pushrod is straight.
2. Clean Pushrods using brake cleaner and an appropriately sized brush.
3. Check Oil Galleys in pushrod passages for restriction.

   NOTICE

   Replace any bent, internally-obstructed, or otherwise damaged pushrods.

INSTALLATION PROCEDURE

1. Install Pushrod(s)—Intake (1) and/or Exhaust (2)—being serviced. *Figure 2*
2. Install Valve Rockers. *Refer to Valve Rocker Replacement.*
3. Adjust valve lash. *Refer to Roller Rocker Valve Lash Adjustment Procedure.*
4. Install Valve Covers. *Refer to Valve Cover Replacement.*
5. Start engine.

   NOTICE

   Do not rev engine!
6. Bring engine up to temperature and verify proper operation.

   NOTICE

   Valvetrain noise be heard upon start up. This noise will stop when the system primes itself. If valvetrain noise persists additional diagnosis/repair is required.

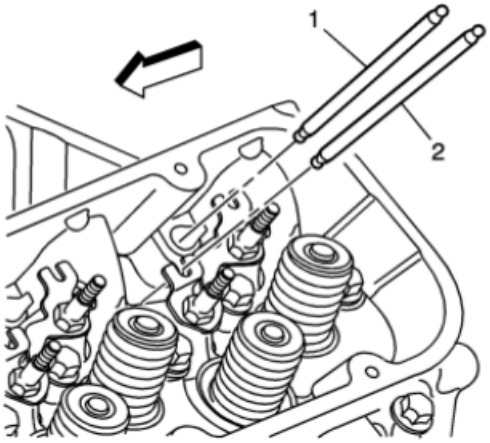


Figure 2:
Install shorter Intake Pushrod (1) and/or longer Exhaust Pushrod (2)

Roller Rocker Valve Lash Adjustment Procedure

Valve lash adjustment is required whenever the following cylinder head components are replaced.

- roller rocker arms
- cylinder valves
- push rods
- camshaft
- camshaft lifters

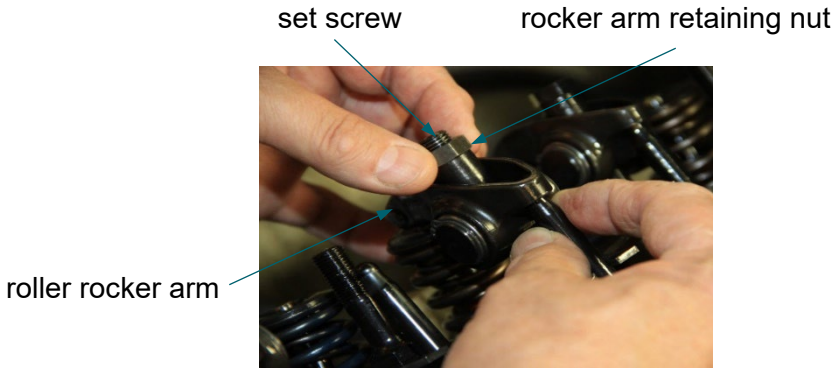
PROCEDURE

1. Remove both valve covers. *Refer* to *Valve Cover Replacement* procedure.
2. Remove all eight spark plugs to ease crankshaft rotation. *Refer* to *Spark Plug Replacement* procedure.

NOTICE

Store spark plugs by cylinder number for reinstallation.

3. Using an allen wrench, loosen all rocker arm retaining nut set screws so that at least one thread shows above nut surface.



4. Use a breaker bar to rotate crankshaft clockwise until compression stroke for cylinder #1 is on top-dead-center (TDC).
   - ➤ At TDC, the piston is on the base lobe/no lift on lifters.
5. Tighten cylinder #1 retaining nut on both intake and exhaust rocker arms until there is zero-lash between pushrods and rocker arms. Using your fingers, rotate pushrod while tightening retaining nut. Stop rotation when slight resistance is felt.

   - ➤ Cylinder #1 rocker arm is now at **zero-lash**.

6. Tighten rocker arm retaining nut an additional 3/4-turn to set lifter preload.
7. While holding rocker arm retaining nut using a closed-end wrench, use a torque wrench to tighten each set screw as follows:

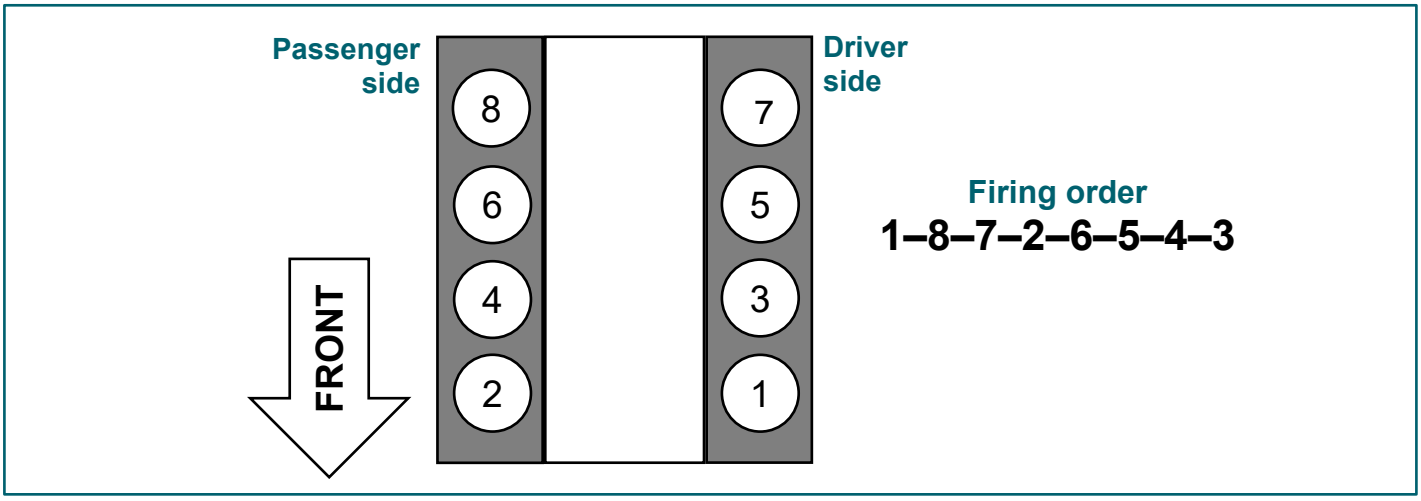
Intake: C **Torque set screws to 20 ft-lbs (27.1 Nm).**

Exhaust: C **Torque set screws to 15 ft-lbs (27.1 Nm).**

NOTICE **Use a paint or wax marker to mark the top of each set screw.**

➤ Cylinder #1 complete.

8. Working through the remaining firing-order (**8-7-2-6-5-4-3**), place each cylinder on TDC of its compression stroke.



C **Repeat Steps 4 through 7 above.**

9. C **Before reinstalling valve covers, pour clean engine oil on the rocker arms, making sure to coat rollers and pushrod tips to assure adequate lubrication until oil pump pressurizes lifters to feed oil up though the pushrods.**
10. Reinstall both valve covers. *Refer* to *Valve Cover Replacement* procedure.
11. Reinstall all eight spark plugs. *Refer* to *Spark Plug Replacement* procedure.
12. Verify proper operation.
13. Clean any excess fluids from engine.

Single Air Conditioning (A/C) Drive Bracket Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is off and is cool.
3. Remove main accessory drive Belt Tensioner (3) from Single A/C Bracket (2). *Figure 1*. *Refer to Belt Tensioner Replacement.*
4. Remove A/C Compressor (not shown) from location (4) on Single A/C Bracket (2). *Figure 2. Follow OEM procedure*.
5. Remove three (3) Single A/C Bracket Retaining Bolts (5) and Washers (6). *Figure 2*
6. Remove Single A/C Bracket (2) from passenger side Cylinder Head (7). *Figure 2*

⚠CAUTION

Bracket is heavy; please take necessary precautions when removing.

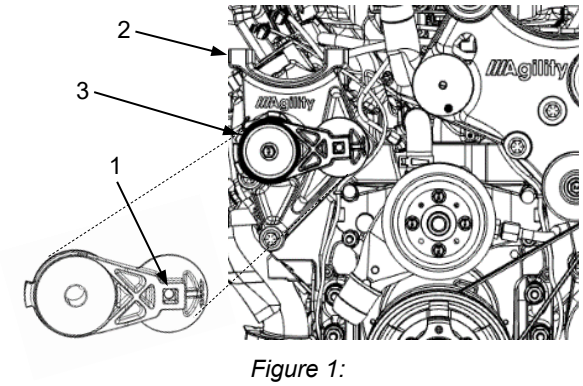


Figure 1:
Belt Tensioner (3) location on Single A/C Bracket (2) and ½" Drive Socket (1).

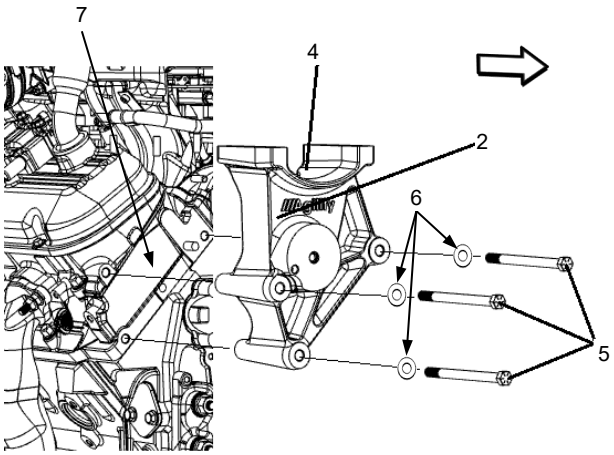


Figure 2:
Single A/C Bracket (2), A/C Compressor location (4), Bracket Retaining Bolts (5) and Washers (6), passenger side Cylinder Head (7)

INSTALLATION PROCEDURE

⚠CAUTION

A/C Bracket is heavy; please take necessary precautions when installing.

1. Thread one (1) Single A/C Bracket Retaining Bolt (5) and Washer (6) through Single A/C Bracket into passenger side Cylinder Head (7). *Figure 3.*

   NOTICE

   This helps distribute Bracket weight and eases alignment.

2. Align Single A/C Bracket (2) mounting holes with Cylinder Head (7) holes. *Figure 3*
3. Install two (2) remaining Bolts (5) and Washers (6) and torque all (3) Bolts (5). *Refer to Front End Accessory Drive Torque Specifications. Figure 2*
4. Install A/C Compressor (not shown) on Single A/C Bracket (2) at location (4). *Follow OEM procedure. Figure 2*
5. Install main accessory drive Belt Tensioner. *Refer to Belt Tensioner Replacement*.
6. Verify proper operation.

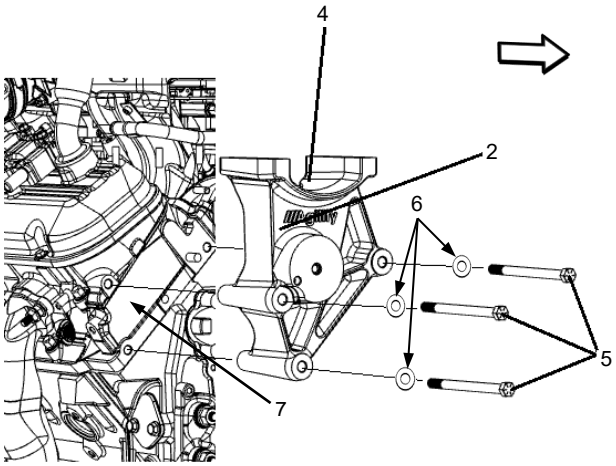


Figure 3:
Install and thread one (1) Single A/C Bracket Bolt (5) and Washer (6) to hold and align Single A/C Bracket (2) to Cylinder Head (7) before installing and tightening remaining two (2) Bolts (5) and Washers (6).

Thermostat Replacement

⚠CAUTION

Do not attempt to replace thermostat while the engine is hot, let engine cool down before changing thermostat to prevent being burned from hot coolant.

REMOVAL PROCEDURE

1. Drain Radiator coolant sufficiently below the Thermostat Housing. *Follow OEM procedure.*
2. Remove Upper Radiator Hose from its attachment point (2) on Thermostat Housing (4). *Figure 1*
3. Remove four (4) Thermostat Housing Bolts (1). *Figure 1*
4. Remove Thermostat Housing (4). *Figures 1 & 2*
5. Remove Thermostat(s) (3) from Lower Intake Manifold (5). *Figure 2*

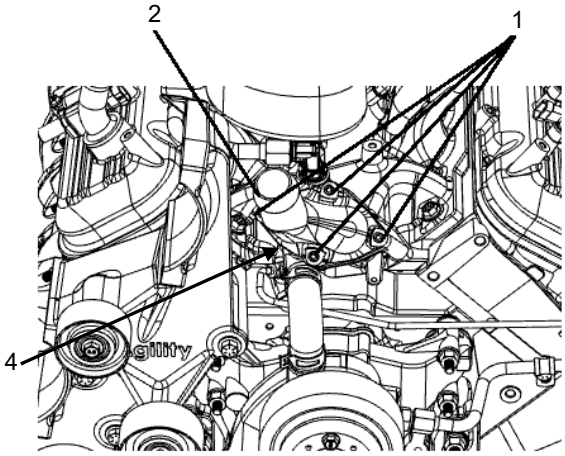


Figure 1:
Thermostat Housing (4),
Upper Radiator Hose attachment location (2),
Thermostat Housing Bolts (1)

CLEANING AND INSPECTION

NOTICE

While the thermostat housing is off the engine, check all the following:

- Check for cracks or corrosion in housing, replace if necessary.
- Clean old gasket material from housing.
- Clean old gasket material from Intake Manifold mating surfaces.
- Check Radiator hose and clamp and replace if necessary.

INSTALLATION PROCEDURE

1. Clean sealing surfaces on Thermostat Housing and Lower Intake Manifold.
2. Lubricate new Thermostat O-rings with a light coat of clean engine oil.
3. Install Thermostat(s) (3) in Lower Intake Manifold (5). *Figure 2*
4. Install Thermostat Housing (4). *Figure 2*
5. Install Thermostat Housing Bolts (1). *Figure 1. Refer to Engine Mechanical Torque and Clearance Specifications.*
6. Fill engine coolant. *Follow OEM instructions*. *Refer to* 488LPI™ Operators Manual *for coolant specifications*.
7. Clean any spilled fluids from engine.
8. Bring engine up to operating temperature and check for any coolant leaks.

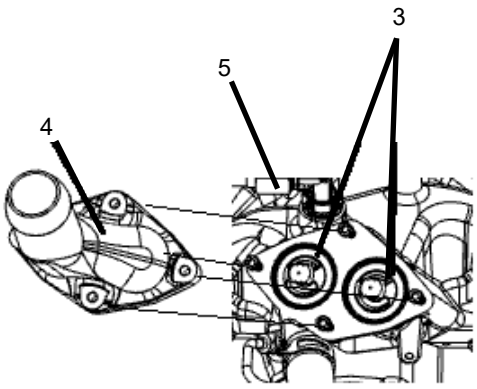


Figure 2:
Thermostat Housing (4),
Dual Thermostats (3),
Lower Intake Manifold (5)

Throttle Body Replacement

REMOVAL PROCEDURE

NOTICE

Handle Throttle Body components with care. Do not immerse Electronic Throttle Body in cleaning solvent of any kind.

NOTICE

Throttle Body Gasket should be replaced when removing the Throttle Body.

1. Remove Air Intake Tube *(not shown). Refer to Air Intake Tube Replacement.*
2. Disconnect Throttle Body Electrical Connector (4). *Figure 1*
3. Remove four (4) Throttle Body Retaining Bolts (3). *Figure 1*
4. Remove Throttle Body (2). *Figure 1*
5. Remove Throttle Body Gasket (1) and discard. *Figure 1*

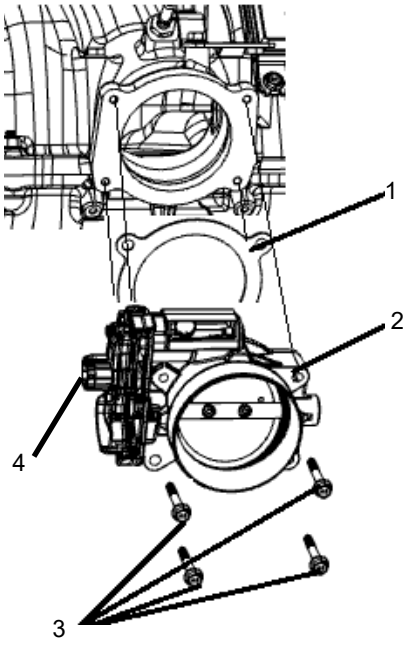


Figure 1:
Throttle Body (2), Gasket (1), Retaining Bolts (3), Electrical Connector (4)

INSTALLATION PROCEDURE

1. Clean Upper Intake Manifold and Throttle Body to Upper Intake mating surfaces with Throttle Body Cleaner.
2. Install two (2) Throttle Body Retaining Bolts (3) into Throttle Body (1). *Figure 1*
3. Install new Throttle Body Gasket (2) over the Throttle Body Retaining Bolts (3). *Figure 1*
4. While holding the (2) Throttle Body Bolts in place install Throttle Body and Gasket on Upper Intake Manifold and start the two (2) pre-installed bolts. *Figure 1*
5. Install remaining two (2) Throttle Body Bolts (3) and tighten all bolts in a crosshatch pattern. Hand tighten the (4) Throttle Body Bolts, then use a torque wrench to obtain proper torque. *Refer to Engine Sensors and Electrical Components Torque Specifications*. *Figure 1.*

   C **Verify electric connector to Throttle Body connector seals are properly installed and not damaged.**

   C **Apply dielectric grease to connectors.**
6. Connect Throttle Body Electrical Connector (4). *Figure 1*
7. Install Air Intake Tube. *Refer to Air Intake Tube Replacement*.
8. Verify proper operation.

Timing Chain and Sprocket Replacement

REMOVAL PROCEDURE

1. Remove Cooling Pack. *Follow OEM procedure.*
2. Remove Accessory Belt. *Follow OEM procedure.*
3. *If equipped:* Remove Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
4. Remove Water Pump. *Refer to Water Pump Replacement.*
5. Remove Harmonic Damper. *Refer to Harmonic Damper Replacement.*
6. Remove Timing Chain Cover. Refer to *Timing Chain Cover Replacement*.
7. Remove Valve Covers and loosen Roller Rockers. *Refer to Valve Cover Replacement and Roller Rocker Arm Replacement procedures.*
8. Align Camshaft Sprocket timing mark (1) and Crankshaft Sprocket timing mark (2) by rotating Crankshaft. *Figure 1*

NOTICE

- **Temporarily reinstall Harmonic Damper Flanged Bolt (3) to rotate engine using a breaker bar. Figure 2**
- **Removing Spark Plugs may ease this process.**
- **It may require up to two engine rotations to align the marks**

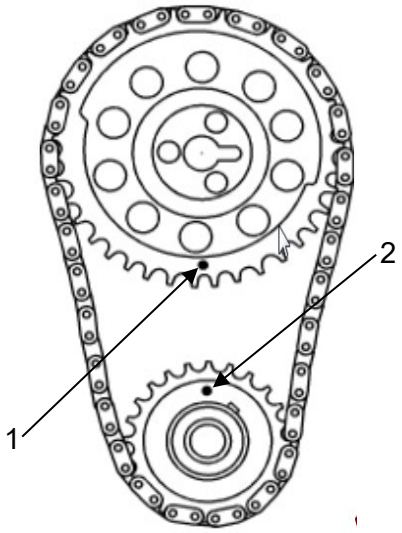


Figure 1:
Camshaft Sprocket timing mark (1) and Crankshaft Sprocket timing mark (2)

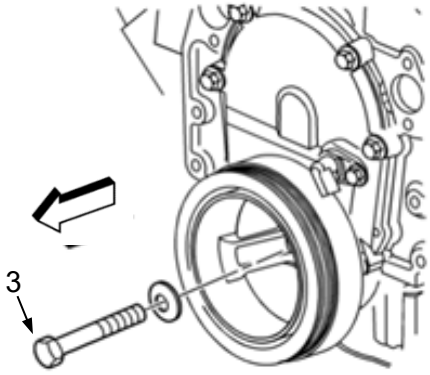


Figure 2:
Harmonic Damper Flanged Bolt (3)

9. Remove three (3) Camshaft Sprocket Retaining Bolts (4). *Figure 3*
10. Remove Camshaft Sprocket (5) and Timing Chain (6). *Figure 3*
11. *If necessary:* Remove Crankshaft Sprocket (9) using special tool J 42846 (7) and a Three Jaw Puller (8). *Figure 4*

INSTALLATION PROCEDURE

1. Use special tool J 22102 to drive Crankshaft Sprocket (9) on Crankshaft.

   NOTICE

   Verify Crankshaft Keyway is aligned with Crankshaft Sprocket.
2. Remove special tool J 22102.
3. Rotate Crankshaft Sprocket alignment mark (2) to 12 o'clock position. *Figure 1*
4. Install Camshaft Sprocket and Timing Chain. *Figures 1 and 3*

   NOTICE

   - **Verify Camshaft Sprocket timing mark (2) is at 6 o'clock position.**
   - **Verify Timing Chain meshes with Camshaft Sprocket teeth.**
   - **Do not use a hammer to install Camshaft Sprocket on Camshaft.**
5. Once installed, verify timing marks are aligned as follows:
   - **Crankshaft Sprocket mark (2) at 12 o'clock**
   - **Camshaft Sprocket (1) at 6 o'clock**

   Figure 1
6. Install (3) Camshaft Sprocket Bolts. *Figure 3. Refer to Engine Mechanical Torque and Clearance Specifications.*
7. Install, tighten and adjust Roller Rocker Arms. *Refer to Roller Rocker Arm Replacement.*
8. Install Valve Covers. *Refer to Valve Cover Replacement.*
9. Install Engine Front Cover. *Refer to Engine Front Cover Replacement.*

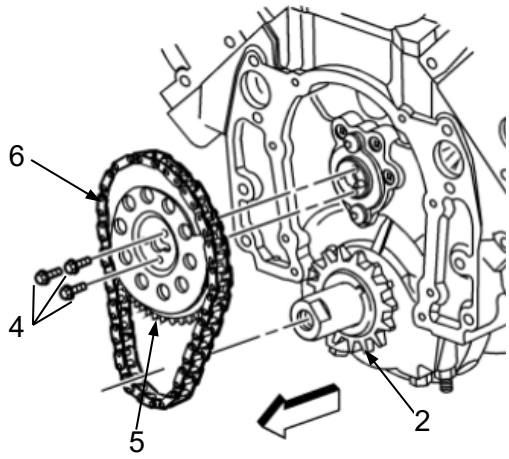


Figure 3:
Camshaft Sprocket (5), Sprocket Retaining Bolts (4), Timing Chain (6)

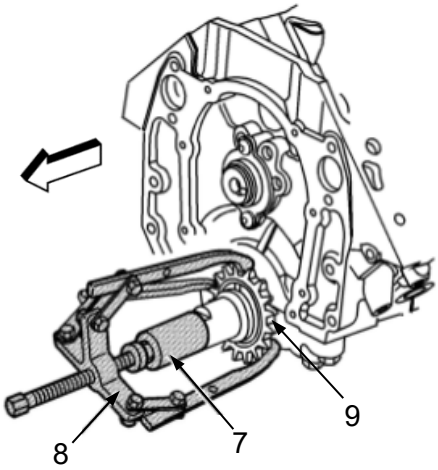


Figure 4:
Remove Crankshaft Sprocket (9) using special tool J 42846 (7) and Three Jaw Puller (8)

10. Install Harmonic Damper. *Refer to Harmonic Damper Replacement.*
11. Install Water Pump. *Refer to Water Pump Replacement.*
12. *If equipped:* Install Air Compressor Belt. *Refer to Air Compressor Belt Replacement.*
13. Install Main Accessory Belt. *Follow OEM procedure.*
14. Install Cooling Pack. *Follow OEM procedure.*
15. Fill engine fluids.
16. Start vehicle and bring up to temperature and check for leaks.

Upper Intake Manifold Replacement

REMOVAL PROCEDURE

NOTICE

If removing, Lower Intake Manifold, fuel must be drained from the fuel lines prior to bringing vehicle into shop. *Refer to LPG Fuel Line Drain Procedure.*

NOTICE

If removing Lower Intake, remove air filter housing bracket (along with filter housing and hose) from firewall by removing four T40 Torx bolts.

NOTICE

If the vehicle is equipped with single or dual A/C compressors *Refer to A/C Compressor Removal Procedure.*

1. Secure vehicle.
2. Disconnect vehicle battery.
3. Remove alternator. *Refer to Alternator Removal Procedure.*
4. Remove Air Cleaner Assembly (not shown). *Follow OEM procedure.*
5. Remove Air Intake Tube (2). *Figure 1. Refer to Air Intake Tube Replacement.*
6. Disconnect Engine Control Module (ECM) (3) Electrical Connectors.
7. Remove ECM Retaining Bolts and ECM (3).
8. Remove three bolts securing cab heater shut off valve and move valve down below throttle body, (this allows room to remove TSM bolts.)
9. Disconnect TSM (4) Electrical Connector.
10. Remove TSM (4) Retaining Bolts.
11. Remove TSM (4) and TSM Mounting Bracket.

NOTICE

Handle ECM and TCM carefully. Store in a safe location and do not expose to solvents or cleaners.

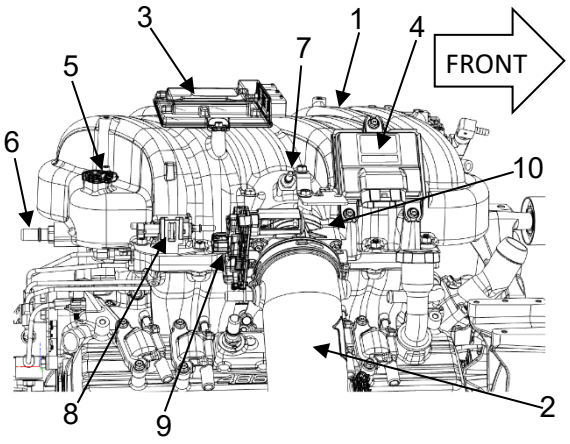


Figure 2:
Upper Intake Manifold (1) Mounted Components: Air Intake Tube (2), ECM (3), TSM (4), MAP/TIAP Sensor (5), Makeup Air Tube (6), Purge Solenoid Hose (7), Purge Solenoid (8), Throttle Body Connector (9), Throttle Body (10)

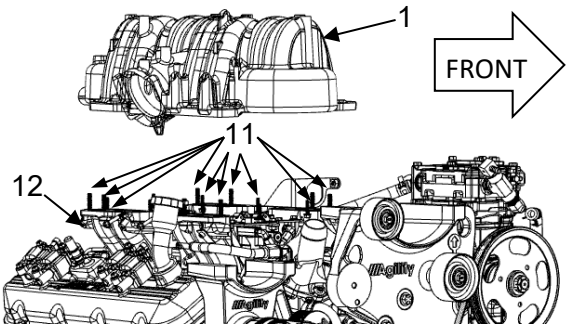


Figure 1: Upper Intake Manifold (1) with Upper Manifold Retaining Bolts (11) and Lower Intake Manifold (12).
NOTE: *Nuts not shown.*

12. Disconnect MAP/TIAP Sensor (5) Connector.
13. Remove MAP/TIAP Sensor (5). *Refer to MAP/TIAP Sensor Replacement.*
14. Disconnect Makeup Air Tube from rear of Upper Intake Manifold (6).
15. Disconnect Purge Solenoid (7) Electrical Connector.
16. Disconnect Purge Solenoid Hose from Upper Intake Manifold at location (7).
17. Remove Purge Solenoid (8).
18. Disconnect Throttle Body Electrical Connector at location (9).
19. Remove Throttle Body (10). *Refer to Throttle Body Replacement.*
20. Remove thirteen (13) Upper Intake Manifold Retaining Bolts (11) and Nuts. *Figure 2*
21. Remove Upper Intake Manifold (1) from engine and discard Upper Intake Manifold Gaskets *(not shown). Figure 2*
22. **NOTICE**
23. **Install four (4) Lower Intake Port Covers, on Lower Intake Manifold (12) to prevent debris falling into Lower Intake.** *Figure 2*
24. Inspect Upper and Lower Intake Manifold sealing surfaces for damage.

INSTALLATION PROCEDURE

1. Remove four (4) Lower Intake Port Covers from Lower Intake Manifold.
2. Install new Upper Intake Manifold Gaskets into grooves *(not shown)* on Lower Intake Manifold.
3. Place Upper Intake Manifold (1) on Lower Intake Manifold (12) and start thirteen (13) Upper Intake Retaining Bolts (11). *Figures 2 and 3*
4. Tighten Upper Intake Manifold Retaining Bolts and Nuts. *Refer to Engine Mechanical Torque and Clearance Specifications.*

   C **Follow tightening sequence in** *Figure 3.*
5. Install Purge Solenoid (8). *Figure 4*
6. Connect Purge Solenoid Hose and Purge Solenoid Electrical Connector.
7. Install MAP/TIAP Sensor (5).
8. Connect MAP/TIAP Sensor Connector.
9. Connect Make Up Air Hose (6).
10. Install Throttle Body (10).
11. Connect Throttle Body Electrical Connector at position (9).
12. Install TSM Mounting Bracket and TSM (4).
13. Connect TSM (4) Connector.
14. Install the three bolts that secure cab heater shut off valve to the upper intake.
15. Install ECM (3) and ECM Retaining Bolts.
16. Connect ECM (3) Connectors.
17. Install Air Intake Tube (2). *Refer to Air Intake Tube Replacement.*
18. Install Air Cleaner. *Follow OEM procedure*.
19. Verify proper operation.

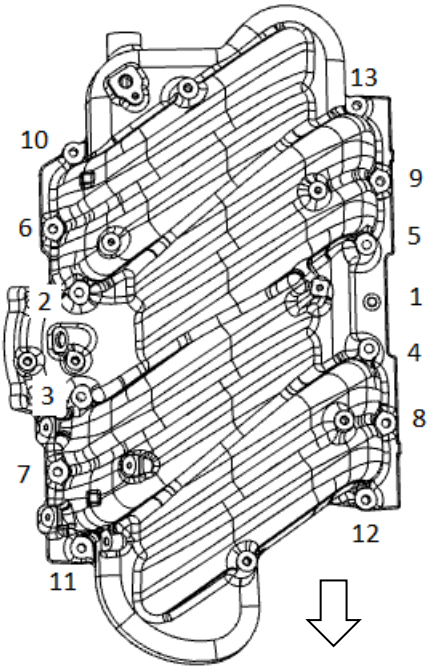


Figure 3:
Upper Intake Manifold Bolt Tightening Sequence

Valve Cover and Gasket Replacement

REMOVAL PROCEDURE

1. Secure vehicle. Verify engine is cool.
2. *Passenger side only: If required; varies by application.* Remove Air Cleaner. *Follow OEM procedure.*
3. *Passenger side only:* Remove Air Intake Tube. *Refer to Air Intake Tube Replacement.*
4. *Driver side only and if equipped:* Remove Air Compressor. *Refer to Air Compressor Replacement.*
5. Remove Spark Plug Wires (2). Gently twist Spark Plug Boots (3) 1/2-turn then pull boots off Spark Plug (4) and Ignition Coil (1). *Figure 1*

   NOTICE

   Do not pull on wire as wire damage may occur.
6. Remove four (4) Ignition Coils (1). *Figures 1 and 2*
7. Remove seven (7) Valve Cover Retaining Bolts (6). *Figure 2.* **NOTE:** *Valve Cover may be stuck to the Cylinder Head. Gently tap Valve Cover with rubber mallet to loosen cover.*
8. Remove Valve Cover (5-LH or 12-RH) from Cylinder Head (9). *Figures 2 and 3*
9. Inspect Valve Cover Gasket (8) and Grommets (7) for cracks or damage. *Figure 2.*

   C **If damage is found, replace Gasket or Grommet(s).**

NOTICE

Gasket is reusable if no damage is found. Gasket should be replaced if cover is being removed due to an oil leak. Grommets are serviced with Valve Cover Retaining Bolts.

10. *Passenger side only:* Inspect Oil Fill Tube (11), Oil Fill Cap (10), and Oil Fill Tube Gasket *(not shown)* for leaks. *Replace as needed. Figure 3*

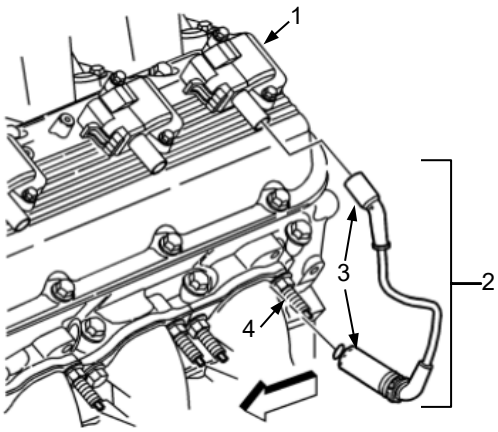


Figure 1:
Ignition Coil (1), Spark Plug Wire (2), Spark Plug Wire Boots (3), Spark Plug (4)

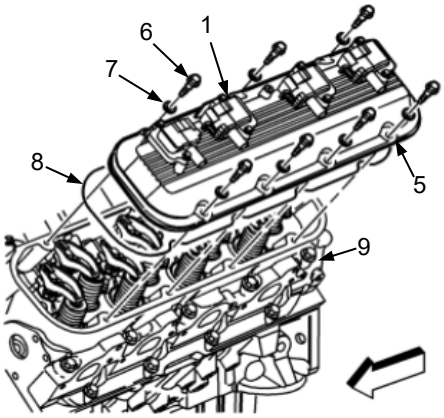


Figure 2:
Driver Side Valve Cover (5), Ignition Coil (1), Valve Cover Retaining Bolt (6) and Grommet (7), Valve Cover Gasket (8), Cylinder Head (9).
NOTE: Driver side shown; passenger side similar.

INSTALLATION PROCEDURE

1. Clean Valve Cover using either mineral spirits or brake cleaner.
2. Install Valve Cover Gasket (13) in groove in Valve Cover (14). *Figure 4*
3. Install Valve Cover (5-LH) or (12-RH) on Cylinder Head (9). *Figures 2 or 3*
4. Install Valve Cover Retaining Bolts (6) and Grommets (7). *Figure 2*
5. C **Tighten Valve Cover Retaining Bolts (6) in sequence shown.** *Figure 5. Refer to Engine Mechanical Torque and Clearance Specifications.*
6. Install four (4) Ignition Coils (1). *Figures 1 and 2. Refer to Engine Sensors and Electrical Components Torque Specifications.*
7. Install four (4) Spark Plug Wires (3).
8. *Driver Side Only, if equipped:* Install Air Compressor. *Refer to Air Compressor Replacement*.
9. *Passenger Side Only:* Install Air Intake Tube. *Refer to Air Intake Tube Replacement*.
10. *Passenger Side Only:* Install Air Cleaner. *Follow OEM procedure.*
11. Clean excess oil from engine.
12. Verify fluids are topped off.
13. Bring engine up to operating temperature and check for oil leaks.

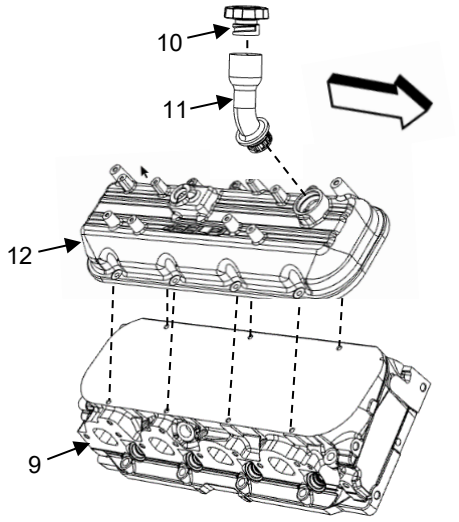


Figure 3:
Passenger Side Valve Cover (12), Oil Fill Tube (11), Oil Fill Cap (10), Cylinder Head (9).

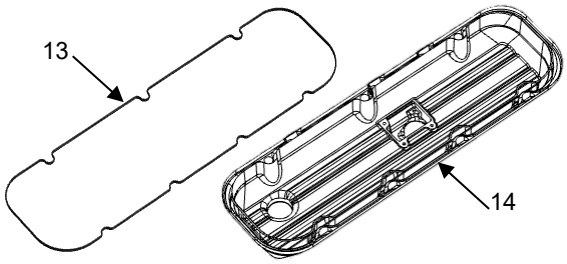


Figure 4:
Install Valve Cover Gasket (13) in Valve Cover (14) groove.

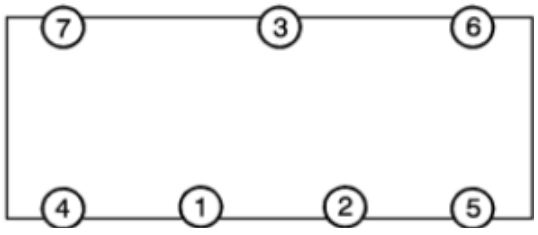


Figure 5:
Valve Cover Retaining Bolt Tightening Sequence.

Valve Lifter Replacement

REMOVAL PROCEDURE

1. Secure vehicle.
2. Verify engine is cool.
3. Remove Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
4. Remove Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
5. Remove Valley Pan (1). *Figure 1*
6. Remove Valve Cover(s). *Refer to Valve Cover Replacement.*
7. Remove Valve Rocker Arms. *Refer to Roller Rocker Arm Replacement.*
8. Remove Pushrods. *Refer to Pushrod Replacement.*
9. Remove four (4) Valve Lifter Guide Retaining Bolts (2) and Retainer (3). *Figure 2*
10. Remove Valve Lifter Guide (5). *Figure 3*
11. Remove Valve Lifter(s) (4) being serviced. *Figure 3*

    C **If servicing/ removing compete set of sixteen (16) Lifters with the intention to re-use, organize Lifters in order of removal.**

12. Clean and inspect Valve Lifter(s).

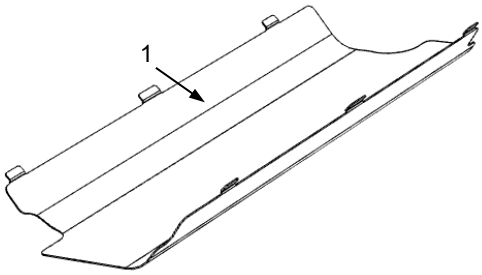


Figure 1:
Valley Pan (1)

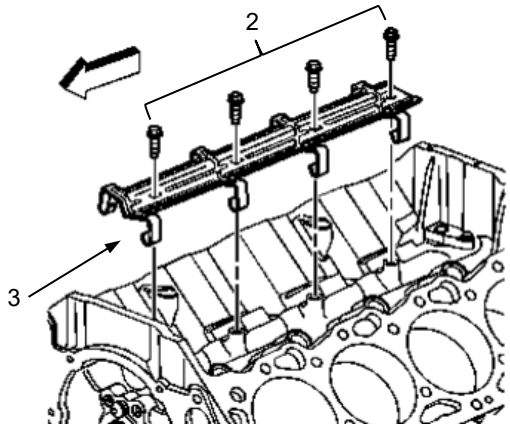


Figure 2:
Remove Valve Lifter Guide Retaining Bolts (2) and Retainer (3)

INSTALLATION PROCEDURE

1. **NOTICE**

   Soak Valve Lifters in clean engine oil prior to installation.
2. Install Valve Lifter(s) (4) being serviced in their respective Lifter Bores. *Figure 3*

   If re-using Lifter(s), verify Lifters are returned to original bore location(s).
3. Install Valve Lifter Guides (5). *Figure 3*
4. Install Lifter Guide Retainer (3) and Bolts (2). *Figure 2. Refer to Engine Mechanical Torque and Clearance Specifications*.
5. Install Pushrods. *Refer to Pushrod Replacement.*
6. Install Valve Rockers. *Refer to Roller Rocker Replacement.*
7. Adjust valve lash. *Refer to Valve Lash Adjustment Procedure.*
8. Install Valve Cover(s). *Refer to Valve Cover Replacement*.
9. Install Valley Pan (1). *Figure 1*
10. Install Lower Intake Manifold. *Refer to Lower Intake Manifold Replacement.*
11. Install Upper Intake Manifold. *Refer to Upper Intake Manifold Replacement.*
12. Fill engine oil.

    Only use oil specified in *488LPI™ Owner's Guide.*
13. Fill Cooling Pack. *Follow OEM procedure.*

    Only use coolant specified in *488LPI™ Owner's Guide.*
14. Bring engine to operating temperature and verify proper operation.

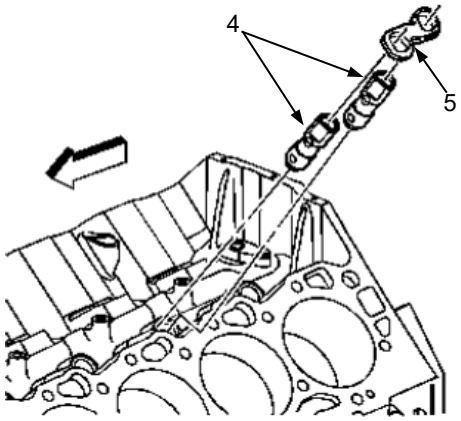


Figure 3:
Valve Lifters (4) and Valve Lifter Guide (5)

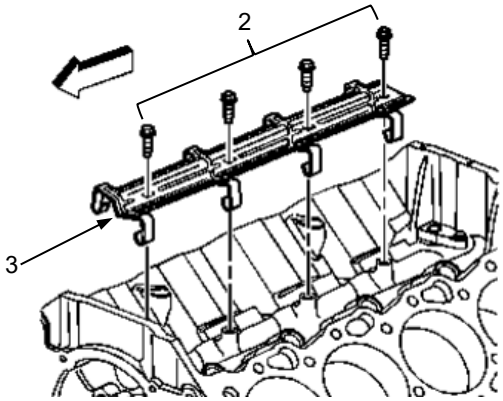


Figure 4:
Use Valve Lifter Guide Retaining Bolts (2) to install Retainer (3)

Water Pump Replacement

REMOVAL PROCEDURE

1. Secure vehicle. Verify engine is cool.
2. Drain coolant from Radiator. *Follow OEM procedure.*
3. *If necessary (varies by application):* Remove Fan Shroud and Fan. *Follow OEM procedure.*
4. Using a 1/2-in drive breaker bar at position (1), relieve tension on Main Accessory Drive Belt (not shown). *Refer to Main Accessory Drive Bracket Replacement.*
5. Remove Main Accessory Drive Belt. *Follow OEM procedure.*
6. Disconnect Lower Radiator Hose from Water Pump location (2).
7. Disconnect Air Compressor Coolant Feed Tube (3).
8. Remove Bypass Hose Clamp (4) and Bypass Hose (5) from Water Pump.
9. Remove four (4) Water Pump Retaining Bolts (6).
10. Slide Water Pump (7) off engine studs and remove.

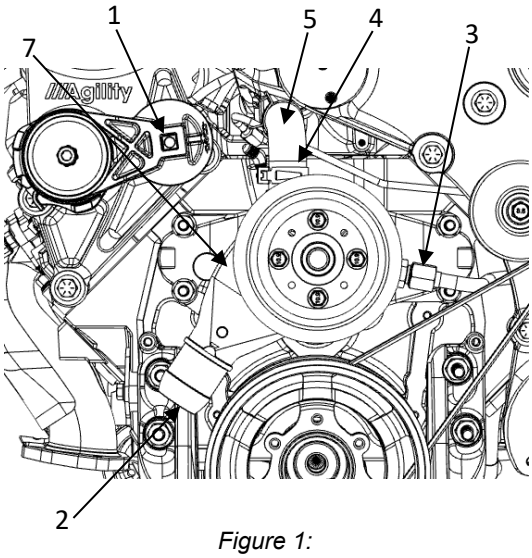


Figure 1:
Water Pump (7), Lower Radiator Hose Outlet (2), Air Compressor Coolant Feed Tube (3), Bypass Hose (5)

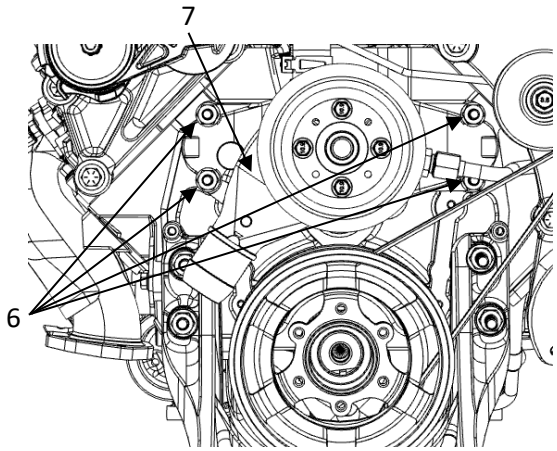


Figure 2:
Remove four (4) Bolts (6) to remove Water Pump (7)

INSTALLATION PROCEDURE

1. Clean Engine Block to Water Pump gasket surface.
2. Install new Water Pump Gaskets (not shown) on engine studs.
3. Install four (4) Water Pump Retaining Bolts (6). *Figure 2*
4. Tighten Water Pump Retaining Bolts using crisscross pattern shown in *Figure 3*. *Refer to Engine Mechanical Torque and Clearance Specifications*.
5. Install Bypass Hose (5) and Bypass Hose Clamp (4) on Water Pump. *Figure 1*
6. Install Air Compressor Coolant Feed Tube (3). *Figure 1*
7. Install Lower Radiator Hose and Clamp at location (2). *Figure 1*
8. Route Main Accessory Drive Belt. *Follow OEM procedure.*
9. *If removed:* Install Fan and Fan shroud. *Follow OEM procedure.*
10. Fill cooling system. *Follow OEM procedure.*
11. Clean spilled fluids from engine.
12. Bring vehicle up to operating temperature and check for coolant leaks.

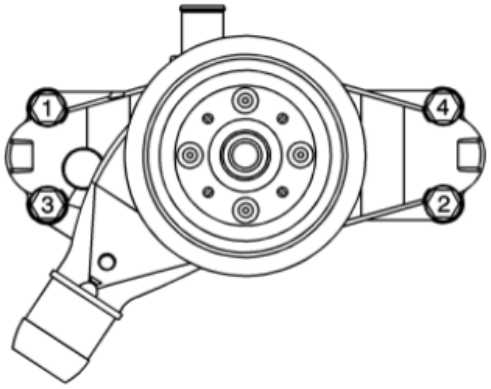


Figure 3:
Water Pump Retaining Bolt Torque Sequence

Engine Mechanical Torque and Clearance Specifications

Component	SPECIFICATION*	
	Metric	SAE
Air Compressor Coolant Return Line Bracket P-clamp Bolt, Large	36 Nm	27 ft-lbs
Air Compressor Coolant Return Line Bracket P-clamp Bolt, Small	15 Nm	11 ft-lbs
Air Compressor Coolant Supply Line Lower P-Clamp Bolt	50 Nm	37 ft-lbs
Air Compressor Coolant Supply Line Upper P-Clamp Bolt	15 Nm	11 ft-lbs
Air Compressor Coolant Supply Line Flare Nut	1.5 F.F.W.R.	
Air Compressor Oil Return Line to Air Compressor Bracket Adapter	1.5 F.F.W.R.	
Air Compressor Oil Return Line to Oil Pan Adapter	2-3 T.F.F.T	
Air Compressor Oil Supply Line to Air Compressor Flare Nut	2 F.F.W.R.	
Air Compressor Oil Supply Line Bracket Bolt	15 Nm	11 ft-lbs
Air Compressor Retaining Bolts	60 Nm	45 ft-lbs
Camshaft Retainer Bolts	12 Nm	106 in-lbs
Camshaft Sprocket Bolts	30 Nm	23 ft-lbs
Connecting Rod Nuts		
First Pass	30 Nm	23 ft-lbs
Final Pass	+ 90°	
Coolant Heater Hose Bracket Bolts	30 Nm	23 ft-lbs
Crankshaft Bearing Cap Bolts		
First Pass	30 Nm	23 ft-lbs
Final Pass	+ 90°	
Crankshaft Bearing Cap Studs		
First Pass	30 Nm	23 ft-lbs
Final Pass	+ 80°	
Crankshaft Windage Tray Mounting Nuts	50 Nm	37 ft-lbs

Component	SPECIFICATION*	
	Metric	SAE
Cylinder Head Bolts - In Sequence		
First Pass	30 Nm	23 ft-lbs
Second Pass	30 Nm + 120°	23 ft-lbs + 120°
Final Pass - Long Bolts #1, 2, 3, 6, 7, 8, 9, 12, 13, 14, 15, 16	60°	
Final Pass - Short Bolts #4, 5, 10, 11	30°	
Cylinder Head Coolant Hole Plug	50 Nm	37 ft-lbs
Engine Block Coolant Drain Hole M28 Plug - Left Front	60 Nm	44 ft-lbs
Engine Block Coolant Drain Hole Plug - Side	30 Nm	23 ft-lbs
Engine Block Coolant Heater	50 Nm	37 ft-lbs
Engine Block 45° Nipple to Air Compressor Oil Supply Line	2-3 T.F.F.T + align to 26° relative to engine front	
Engine Coolant Crossover Bracket Bolt	50 Nm	37 ft-lbs
Engine Coolant Temperature (ECT) Sensor	50 Nm	37 ft-lbs
Engine Harness Bracket Bolt	15 Nm	11 ft-lbs
Exhaust Manifold Mounting Nuts – In Sequence	16 Nm	12 ft-lbs
Exhaust Manifold Mounting Bolts	36 Nm	27 ft-lbs
Exhaust Manifold Mounting Studs	20 Nm	15 ft-lbs
Exhaust Manifold Heat Shield Mounting Bolts	25 Nm	18 ft-lbs
Exhaust Manifold Heat Shield Mounting Nuts	25 Nm	18 ft-lbs
Exhaust Manifold to Y-Pipe Mounting Nuts	OEM	OEM
Exhaust Manifold to Y-Pipe Mounting Studs	OEM	OEM
Flexplate Mounting Bolts – In Sequence		
First Pass	40 Nm	30 ft-lbs
Second Pass	80 Nm	59 ft-lbs
Final Pass	100 Nm	74 ft-lbs
Front Cover Bolts		
First Pass	6 Nm	53 in-lbs
Final Pass	12 Nm	106 in-lbs
Front Engine Mount Bracket-to-Engine Block Nut	95 Nm	70 ft-lbs
Front Engine Mount Bracket-to-Vehicle Frame Bolts	OEM	OEM
Ground Strap Bolt	50 Nm	37 ft-lbs
Harmonic Damper Bolt	255 Nm	189 ft-lbs

Component	SPECIFICATION*	
	Metric	SAE
Ignition Coil Bolts	12 Nm	106 ft-lbs
Ignition Coil Wiring Harness Bolts	12 Nm	106 ft-lbs
Lower Intake Retaining Manifold Bolts – In Sequence		
First Pass	10 Nm	7 ft-lbs
Second Pass	15 Nm	11 ft-lbs
Third Pass	20 Nm	15 ft-lbs
Fourth Pass	33 Nm	20 ft-lbs
Fifth Pass	47 Nm	35 ft-lbs
Oil Cooler Adapter	2-3 T.F.F.T.	
Oil Cooler Adapter Cap	1.5 F.F.W.R.	
Oil Filter Hand Tighten + 1-1.25 Turns	38 Nm	28 ft-lbs
Oil Filter Fitting	66 Nm	49 ft-lbs
Oil Level Sensor	20 Nm	15 ft-lbs
Oil Pan Bolts – In Sequence		
First Pass	10 Nm	89 in-lbs
Final Pass	25 Nm	18 ft-lbs
Oil Pan Drain Plug	28 Nm	21 ft-lbs
Oil Pressure Sensor	30 Nm	23 ft-lbs
Oil Pump Bolt	75 Nm	56 ft-lbs
Oil Pump Cover Bolt	12 Nm	106 in-lbs
Oil Pump Drive Bolt	25 Nm	18 ft-lbs
Rocker Arm Retainer Nut Set Screw – Intake Valve	21.7 Nm	20 ft-lbs
Rocker Arm Retainer Nut Set Screw – Exhaust Valve	20.3 Nm	15 ft-lbs
Spark Plug	30 Nm	23 ft-lbs
Thermostat Housing Bolts	30 Nm	23 ft-lbs
Throttle Body Nuts	10 Nm	89 in-lbs
Throttle Body Studs	12 Nm	106 in-lbs
Throttle Body Bolts	15 Nm	11 ft-lbs
Transmission Adapter Access Cover Bolt	15 Nm	11 ft-lbs
Transmission Adapter Retaining Bolts	67 Nm	50 ft-lbs
Transmission Dipstick Support Bracket Bolts	F.S.N.S.	
Upper Intake Manifold Retaining Bolts	30 Nm	23 ft-lbs
Upper Intake Manifold Retaining Nuts	30 Nm	23 ft-lbs

Component	SPECIFICATION*	
	Metric	SAE
Valve Lifter Guide Retainer Bolts	25 Nm	18 ft-lbs
Valve Cover Bolts – In Sequence		
First Pass	6 Nm	53 in-lbs
Final Pass	12 Nm	106 in-lbs
Water Pump to Air Compressor Coolant Adapter	2-3 T.F.F.T.	
Water Pump Mounting Studs	F.S.N.S.	

***SPECIFICATION KEY:**

F.F.W.R. = Flats From Wrench Resistance

F.S.N.S. = Fully Seated, Not Stripped

T.F.F.T. = Turns From Finger Tight

Front End Accessory Drive (FEAD) Torque Specifications

COMPONENT	SPECIFICATION		APPLICATION**
	Metric	SAE	
Air Compressor Bracket Bolts	70 Nm	52 ft-lbs	A
Air Compressor Retaining Bolts	60 Nm	44 ft-lbs	A
Air Compressor Oil Feed Line Flare Nut	2 F.F.W.R.*		A
Air Compressor Oil Return Line Flare Nut	1.5 F.F.W.R.*		A
Air Compressor Drive Pulley Retaining Nut	130 Nm	100 ft-lbs	A
Air Compressor Drive Belt Idler Pulley Bolts	50 Nm	37 ft-lbs	A
Drive Belt Idler Pulley Large Bolt	50 Nm	37 ft-lbs	A, D, N, S
Drive Belt Idler Pulley Small Bolt	50 Nm	37 ft-lbs	A, D, N, S
Dual A/C Drive Belt Tensioner Bolt	50 Nm	37 ft-lbs	D
Dual A/C Drive Bracket Bolts	70 Nm	52 ft-lbs	D
Dual A/C Drive Pulley Bolts	30 Nm	23 ft-lbs	D
Harmonic Damper Bolt	255 Nm	189 ft-lbs	A, D, N, S
Main FEAD Belt Tensioner Bolt	50 Nm	37 ft-lbs	A, D, N
Main FEAD Bracket Bolts	70 Nm	52 ft-lbs	A, D, N, S
Single A/C Drive Belt Tensioner Bolt	50 Nm	37 ft-lbs	S
Single A/C Drive Bracket Bolts	70 Nm	52 ft-lbs	S
Water Pump Bolts - First Pass	25 Nm	19 ft-lbs	A, D, N, S
Water Pump Bolts - Final Pass	50 Nm	37 ft-lbs	A, D, N, S
Water Pump Pulley Bolts	35 Nm	26 ft-lbs	A, D, N, S

***F.F.W.R.** = Flats From Wrench Resistance

****APPLICATION KEY**: A = Air Brakes, D = Dual Air Conditioning, S = Single Air Conditioning, N = No Air Conditioning