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Description

The low-pressure fuel system consists of components carrying fuel from the fuel tank to the fuel inlet ports of the injectors. The following figure illustrates low-pressure fuel flow (Figure 484) from the fuel filter (from tank) to each of the injectors.

Figure 484 Low-pressure fuel system

1. Cylinder head
2. Fuel injector assembly (6)
3. Low-pressure fuel rail (cast in intake manifold)
4. Transfer pump outlet tube assembly
5. Low-pressure fuel supply pump
6. Primer pump assembly
7. Water drain valve
8. Drain valve (strainer)
9. Transfer pump inlet tube assembly
10. Fuel filter module
11. Fuel piping from tank(s)
12. Fitting (service port)
13. Fuel inlet ports (4)

The high-pressure oil system (Figure 485) consists of components carrying oil from the front cover reservoir to the oil inlet at the top of each fuel injector. It is at the injector where hydraulic force on each fuel charge is magnified seven times.

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Figure 485 High-pressure oil system

1. High-pressure oil manifold
2. Fuel injector assembly (6)
3. High-pressure pump assembly
4. Oil inlet from front cover reservoir
5. High-pressure hose
6. Oil inlet from high-pressure oil manifold
7. Oil outlet (2)
8. Fuel inlet ports (4)

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Removal

Low-Pressure Fuel Supply Pump and Tubing

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

Figure 486 Draining the fuel filter assembly

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, comply with the following when draining fuel:

- **Do not smoke.**
- **Keep away from open flames and sparks.**

1. Drain the fuel filter assembly of all water and fuel into a suitable container before removing assembly. Dispose of properly.

Figure 487 Removing the transfer pump inlet tube assembly

2. Remove the transfer pump inlet tube assembly.

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Figure 488 Removing the transfer pump outlet tube assembly

3. Remove the transfer pump outlet tube assembly. Cap all pump openings to the fuel filter and low-pressure fuel supply pump.

Figure 489 Removing the low-pressure fuel pump

1. Low-pressure fuel supply pump
2. Seal

4. Remove three mounting bolts (M6 x 16) and the low-pressure fuel supply pump from high-pressure oil pump. Discard seal.

5. Check the low-pressure fuel supply pump tappet for cracks, burrs and straightness. Replace low-pressure fuel supply pump if necessary.

6. Check all fuel lines for kinks, obstructions, or other damage. Replace individual fuel lines as necessary.

Fuel Filter Header Assembly and Intake Manifold

1. Drain fuel filter assembly (Figure 486), if not done so already.

2. Drain fuel bowl by performing the following steps:

   a. Have a suitable container handy to catch draining fuel. Open drain valve completely. In most cases, the portion of fuel **below** the fuel strainer will pour out.

   b. Turn primer pump assembly knob counter-clockwise to unlock. Pump primer knob approximately 3-4 times to force fuel through strainer.

   c. Turn primer pump assembly knob clockwise to lock.

Figure 490 Removing fuel bowl and strainer

   d. Use a 24 mm or 15/16 inch open end wrench to unthread the bowl from the housing.

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Figure 491 Strainer and heater assembly

1. Fuel strainer
2. Heater assembly (optional equipment)
3. Fuel bowl O-ring

3. Remove both the fuel bowl and strainer for cleaning replacement. Discard fuel bowl O-ring.

Figure 492 Fuel filter assembly mounting bolts

1. Bolts, M8 x 100

4. Remove three mounting bolts (M8 x 100) and fuel filter assembly from intake manifold.

Figure 493 Removing the fuel filter outlet gasket

5. Discard the fuel filter outlet gasket between fuel filter assembly and intake manifold.

Figure 494 Removing the fuel rail plug assembly (2)

6. Remove the plug assembly (M12) from each end of the intake manifold and discard O-ring seal. You may also need to remove the rear engine lifting eye to gain access to remove the rear plug.

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Figure 495 Removing the fuel valve assembly (air bleed and pressure test port)

7. Remove the fuel valve assembly (air bleed and pressure test port), located at the front end of the intake manifold. Discard O-ring seal.

High-Pressure Oil Pump

Figure 496 Removing the high-pressure oil hose assembly

1. Remove the high-pressure oil hose assembly between the high-pressure pump assembly and cylinder head.
2. Remove and discard O-ring at each fitting.
3. If necessary, remove high-pressure hose fitting located at cylinder head.

Figure 497 Removing the high-pressure pump assembly

4. Remove two bolts (M8 x 100) behind pump and two (M8 x 30) bolts securing the high-pressure pump to the front cover. Remove pump assembly and discard seal.

Figure 498 Removing the IPR valve

5. Use an IPR removal / installation tool (Table 47) to remove the IPR valve. Check inlet screen for restrictions. Remove O-rings and discard.

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Figure 499 Removing the IPR valve assembly

High-Pressure Oil Manifold Assembly

NOTE: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- Valve cover (See Valve Cover, page 104)

Figure 500 Removing the injector harness connector

1. Disconnect the injector harness connector at the top of each injector.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, have an assistant help remove or install the high-pressure oil manifold assembly, especially when working within chassis, due to its heavy weight and limited access.

2. Remove 12 bolts (M8 x 90) securing high-pressure oil manifold or brake assembly to cylinder head.

Figure 501 Removing the high-pressure oil manifold or brake assembly

3. Lift assembly up and away from engine.
4. Drain high-pressure oil manifold of any remaining oil.

Figure 502 High-pressure oil manifold or brake assembly oil inlet O-ring

5. Discard oil inlet O-ring seal.

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Figure 503 High-pressure oil manifold injector oil inlet adapter seal

1. Backup ring
2. Seal

6. Discard the seal from each of the injector oil inlet adapters.

Figure 504 End plug assembly (AWA)

7. Remove two AWA end plug assemblies (2) and two bottom AWA fitting assemblies (2) as required, depending on extent of service procedures.

Figure 505 ICP sensor assembly

8. Remove ICP sensor assembly and discard O-ring.

Fuel Injector Assemblies

Figure 506 Removing the injector clamp and injector

1. Use the fuel injector remover tool (#40 Torx®) (Table 47) to extract the injector clamp and injector.

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Figure 507 Removing the injector assembly

2. Remove each injector assembly carefully, and place into the fuel injector rack cups (Table 47) and holder to drain.
3. Remove the two external O-rings and nozzle gasket from each injector and discard.

NOTE: If any nozzle gaskets were missing on any of the removed injectors, look for them at the bottom of the injector sleeves. Remove gaskets, if any, and discard as required.

Disassembly

Fuel Filter Header Assembly

It is not recommended to disassemble the fuel filter beyond circumstances involving periodic servicing that include the following:

- Fuel filter element replacement
- Fuel strainer
- Sensor replacements (if determined by a DTC)

The fuel filter assembly can and should be disassembled if any of the following issues have been observed:

- Contaminated fuel has been introduced to the engine, resulting in poor performance.
- Fuel or air leaks involving the priming pump assembly.

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Figure 508 Fuel filter assembly

1. Housing cover
2. O-ring gasket
3. Fuel filter element
4. Post
5. Fuel pressure regulator assembly
6. Outlet gasket
7. Plug or EFP sensor (optional)
8. Fuel filter housing
9. Fuel strainer
10. Bowl O-ring
11. Fuel bowl (with heater option)
12. Drain valve
13. Fuel fitting
14. Primer pump seal
15. Water drain valve assembly
16. Self tapping screw (4)
17. Cartridge check valve
18. Retainer ring
19. Primer pump assembly
20. Bolt, M8 x 20 (2)
21. Water In Fuel (WIF) sensor
22. Fitting assembly

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NOTE: If the fuel filter header assembly is to be disassembled, the following assembly details should be noted in accordance with the above illustration:

- Lubricate threads of fuel bowl (item 11).
- Lubricate O-ring gasket (item 2).
- Lubricate threads and O-ring of Water In Fuel (WIF) sensor (item 21).
- Lubricate threads and O-ring on drain valve (item 12).
- Torque values for illustration items appear in (Table 46) .

Installation

Fuel Injectors

Figure 509 Injector upper O-ring

1. Upper O-ring (black)
2. O-ring recess
3. Fuel inlet port

1. Lubricate a new upper O-ring with clean engine oil and slide it into the recess just above the four fuel inlet ports.

Figure 510 Injector lower O-ring

1. Lower O-ring (yellow)
2. Fuel inlet port
3. O-ring recess

2. Lubricate a new lower O-ring with clean engine oil and slide it into the recess just below the four fuel inlet ports.

Figure 511 Installing injector nozzle gasket

1. Injector nozzle gasket
2. Gasket location

CAUTION: To avoid engine damage, do not nick, scratch or mar nozzle gasket in any way.

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3. Install new injector nozzle gasket onto end of nozzle. It can go on either way.

Figure 512 Install injector assembly

4. Align injector assembly slot with hold down clamp assembly.

Figure 513 Installing the injector clamp

5. Using the fuel injector remover tool (Table 47), install injector hold down clamp assembly. Injector will be placed at the correct height. Tighten bolt to the special torque value (Table 46).

Figure 514 Injector connector

6. Connect each injector harness connector to each injector.

High-Pressure Oil Manifold Assembly

Figure 515 High-pressure oil manifold injector oil inlet adapter seal

1. Backup ring
2. Seal

1. Coat six new injector oil inlet adapter seals with clean engine oil and install onto the adapters.

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Figure 516 High-pressure oil manifold assembly O-ring

2. Coat new oil inlet O-ring with clean engine oil and install onto cylinder head recess.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, have an assistant help remove or install the high-pressure oil manifold assembly, especially when working within chassis, due to its heavy weight and limited access.

Figure 517 Installing the high-pressure oil manifold assembly

3. Lift assembly up and place onto engine. Align injector oil supply nozzles with oil inlet adapters.

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Figure 518 High-pressure oil manifold bolt torque sequence (typical)

4. Install and hand tighten 12 bolts (M8 x 90) to secure the high-pressure oil manifold to the cylinder head. Tighten bolts to the special torque value (Table 46) and in the circular pattern, beginning from the center.

High-Pressure Oil Pump

Figure 519 IPR valve assembly

1. O-ring seal #015 (green)
2. Back-up ring seal
3. O-ring seal #016 (green)
4. O-ring
5. IPR valve assembly

1. Install new O-rings onto IPR valve assembly.

Figure 520 Installing the IPR valve assembly

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Figure 521 IPR orientation

1. Fitting assembly, M18
2. Bolt, M8 x 100 (2)
3. Bolt, M8 x 30 (2)

Figure 522 Installing the IPR valve

2. Install the IPR valve into the high-pressure pump assembly finger tight. Use the IPR removal / installation tool (Table 47) and a torque wrench to tighten IPR valve to the special torque value (Table 46).
3. Use petroleum jelly to hold a new O-ring gasket into the recessed groove, located on the backside of the front cover.
4. Position high-pressure oil pump making sure gear meshes with upper idler gear.
5. Install two bolts (M8 x 100) behind pump and two bolts (M8 x 30) outside, securing the high-pressure pump to the front cover. Tighten bolts to the special torque value (Table 46).

Figure 523 Installing the high-pressure oil hose

6. Install a new O-ring seal onto the high-pressure pump assembly before installing the high-pressure hose assembly. Tighten swivel nut by hand.
7. Install a new O-ring seal onto the high-pressure fitting (M18) at the cylinder head prior to installing the high-pressure hose assembly.
8. Orient hose fitting assembly towards the front of engine at 0°± 7° relative to horizontal. Tighten swivel nut by hand.
9. Using a crowfoot, tighten both swivel nuts to the special torque value (Table 46) making sure hose is not under any excess tension.

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Fuel Filter Header Assembly and Intake Manifold

Figure 524 Installing the fuel rail plug assembly (2)

1. Install a new O-ring seal onto the plug assembly (M12) and install into each end of intake manifold. Tighten plug to the special torque value (Table 46).

Figure 525 Installing the fuel valve assembly (air bleed and pressure test port)

2. Install a new O-ring seal onto the fuel valve assembly (air bleed and pressure test port) and install into port located towards the front of the intake manifold. Tighten to the special torque value (Table 46).

Figure 526 Installing the fuel filter outlet gasket

3. Coat the fuel filter outlet gasket with petroleum jelly and set into recess located on backside of fuel filter header. The petroleum jelly will help it stay in position while the filter header is being oriented into position.

Figure 527 Installing fuel filter header

4. Install the fuel filter header and three mounting bolts (M8 x 100) to the intake manifold.

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Figure 528 Fuel filter mounting bolts

5. Tighten mounting bolts to the special torque value (Table 46).

Figure 529 Installing the fuel strainer

6. If removed, install the fuel strainer into the filter header with the open end of strainer facing the bowl.

Figure 530 Installing the fuel filter

1. Housing cover
2. O-ring
3. Fuel filter housing
4. Fuel filter element

7. Install a new fuel filter element into the fuel filter housing.

Low-Pressure Fuel Supply Pump and Tubing

1. Apply clean engine oil to a new seal and place into low-pressure fuel pump recess.

Figure 531 Installing the low-pressure fuel supply pump

1. Low-pressure fuel supply pump
2. Seal

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2. Install the low-pressure fuel supply pump and three mounting bolts onto the high-pressure oil pump. Tighten mounting bolts to the special torque value (Table 46).

Figure 532 Transfer pump inlet tube assembly (typical)

1. Coupling nut fittings
2. ⅜ Viton® sleeve with red stripe
3. Transfer pump inlet tube

3. Replace the Viton® sleeves at each end of both transfer tubes (inlet and outlet).

Figure 533 Connecting the transfer pump outlet tube assembly

4. Connect transfer pump outlet tube assembly.

Figure 534 Connecting fuel lines

5. Connect transfer pump inlet tube assembly and tighten all fittings.

NOTE: There are no specific torque values associated with the inlet or outlet transfer pump tubing.

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Priming Fuel System After Out of Fuel

Figure 535 Fuel filter components and schrader valve

1. Water drain valve
2. Fuel filter cover
3. Fuel filter header
4. Drain valve (fuel)
5. Fuel primer pump assembly
6. Fuel valve assembly (air bleed and pressure test port)

WARNING: To avoid personal injury, possible death or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

CAUTION: Do not add fuel to the fuel filter header, this can add contaminates to the fuel.

If the engine runs out of fuel, do the following:

1. Set parking brake and place transmission control lever to NEUTRAL or PARK.
2. Unlock the fuel primer pump assembly by turning the knob counter-clockwise.
3. Fill the fuel filter header with fuel by pumping the fuel primer pump.
4. To aid in filling the fuel filter header and bleed the fuel rail, do the following:

- Bleed the fuel rail by pressing down on the stem of the schrader valve and pumping the fuel primer pump until fuel starts coming out of the schrader valve.
- Once the air has bled out of the fuel rail, release the stem of the schrader valve and push the fuel primer pump a couple of more times.
- Push the fuel primer pump in one more time and turn the knob clockwise to lock in place.

5. Refer to specific starting procedures in the *Engine Operation and Maintenance Manual*.

Periodic Servicing

Fuel Strainer

1. Loosen drain valve below strainer and drain fuel into a suitable container. Dispose of properly.

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Figure 536 Removing the fuel strainer

2. Use a 24 mm or 15/16 inch open end wrench to remove the fuel strainer from fuel filter assembly.

Figure 537 Strainer and heater assembly

1. Fuel strainer
2. Heater assembly (optional)
3. Fuel bowl O-ring

3. Remove strainer for cleaning or replacement and discard fuel bowl O-ring.
4. Clean all debris from fuel bowl or heater bowl.
5. Place new or cleaned strainer into fuel bowl.
6. Coat fuel bowl threads and a new O-ring and with clean fuel. Thread fuel bowl into fuel filter header assembly and torque to the special torque value (Table 46).

Fuel Filter

Figure 538 Fuel drain valve in open position

1. Move yellow water drain valve assembly to the open position and drain fuel into a suitable container.

Figure 539 Fuel filter element

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2. Unthread housing cover and fuel filter as an assembly.
3. Pull fuel filter from housing cover and discard O-ring gasket.
4. Place a new O-ring gasket onto housing cover.
5. Install a new fuel filter onto housing cover.
6. Lubricate housing cover threads and O-ring gasket with diesel fuel.
7. Thread fuel filter and housing cover in as an assembly. Torque to the special value (Table 46).

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SPECIFICATIONS

Table 45 Fuel System Specifications

Fuel heater switching points	**On**: 2 °C (36 °F)
	Off: 24 °C (75 °F)
Fuel pressure regulator assembly opening pressure	448-517 kPa (65-75 psi)
Fuel strainer	150 micron
High-pressure oil manifold, range	5 - 28 MPa (725 - 4,075 psi)

Special Torque

Table 46 Fuel System Special Torques

Bolt, M8 x 20	29 N·m (21 lbf·ft)
Bottom fitting assembly (AWA)	204 N·m (150 lbf·ft)
Drain valve	0.5-1 N·m (5-10 lbf·in)
End plug assembly (AWA)	204 N·m (150 lbf·ft)
Fitting assembly, ⅜ tube	27 N·m (20 lbf·ft)
Fuel bowl	39 N·m (29 lbf·ft)
Fuel drain plug	24 N·m (18 lbf·ft)
Fuel fitting	27 N·m (20 lbf·ft)
Fuel filter header mounting bolts, M8 x 100	27 N·m (20 lbf·ft)
Fuel filter housing cover	25 N·m (18 lbf·ft)
Fuel pressure regulator	1-1.7 N·m (10-15 lbf·in)
Fuel valve assembly (air bleed and pressure test port)	15 N·m (132 lbf·in)
High-pressure oil hose fitting, M18 (at head)	54 N·m (40 lbf·ft)
High-pressure oil hose (swivel nuts)	46 N·m (34 lbf·ft)
High-pressure oil manifold bolts, M8 x 90	27 N·m (20 lbf·ft)
High-pressure oil pump assembly bolts	30 N·m (22 lbf·ft)
High-pressure oil pump assembly (gear)	231-279 N·m (170-205 lbf·ft)
Injector hold down clamp assembly	41 N·m (30 lbf·ft)
IPR valve assembly	50 N·m (37 lbf·ft)
Low-pressure fuel supply pump bolts, M6 x 16	15-18 N·m (132-160 lbf·in)
Plug assembly, M12 (intake manifold fuel rail)	24 N·m (18 lbf·ft)
Post	8 N·m (72 lbf·in)
Self tapping screw	5 N·m (41 lbf·in)
Water In Fuel (WIF) sensor	1.7 N·m (15 lbf·in)

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SPECIAL SERVICE TOOLS

Table 47 Fuel System Special Service Tools

Cap kit, injectors	ZTSE4660
Fuel injector rack cups	ZTSE4645
Fuel injector remover tool (#40 Torx®)	ZTSE4524
IPR removal / installation tool	ZTSE4666

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