Section 1.2 Cylinder Head

The single-piece cylinder head is made of cast iron. The cylinder head gasket is a three-layer, adjustment-free seal with Viton sealing elements.

Section 1.2.1 Cylinder Head Removal

Remove cylinder head as follows:

![Diagram](image1)

**Figure 1. Coolant Hoses at the Surge Tank**

1. Drain the coolant from the radiator.
2. Remove the coolant delivery hoses from the surge tank. See Figure "Coolant Hoses at the Surge Tank".

![Diagram](image2)

**Figure 2. Charge-Air Pipes and Hoses**

3. Remove the coolant hose standoff bracket.
4. Remove the air cleaner, charge-air inlet, and turbocharger outlet pipes and hoses. See Figure "Charge-Air Pipes and Hoses".

Note: Clean the cylinder head cover before removing it.

7. Remove the cylinder head cover. Refer to "1.1.1 Cylinder Head Cover Removal".
8. Remove the sensor cover and disconnect the intake manifold pressure/temperature sensor.
9. Remove the charge-air manifold and gasket. See Figure "Cylinder Head Exposed".

---

To avoid injury from scalding, drain the radiator when the engine and coolant are cool.
Figure 3. Cylinder Head Exposed

10. Disconnect the turbocharger oil inlet line.
11. Remove the exhaust brake cylinder and heat shield.
12. Using the exhaust manifold socket J-46379, remove the exhaust manifold bolts.

Note: Use the short socket for the rearmost bolt. Use the long socket for the other bolts.

13. Pull the exhaust manifold away from the engine towards the frame rail and remove the gaskets.
14. Remove the front connector housing assembly.
   a. Disconnect the temperature sensor from the engine wiring harness connector.
   b. Disconnect the coolant line.
   c. Remove the front connector housing and gasket from the cylinder head.
   d. Remove the water pump connector fitting from the water pump.
15. Remove the rocker arm assembly. Mark the pushrods in order of removal.
16. Remove the valve bridges. Mark the valve bridges in order of removal.

NOTICE:

Do not move the thrust bolt, because there is danger of causing a change in the position of the transfer tube within the cylinder head. If the position of the fuel transfer tube is changed, engine damage could result.

17. Using two wrenches, loosen the high pressure line fittings. The procedure that follows will need to be performed on each high pressure line fitting. See Figure "High Pressure Line Fittings".

Figure 4. High Pressure Line Fittings

a. Using a paint pen, mark the location of the thrust bolt.
b. Place one wrench on the thrust bolt to secure the transfer tube. Place the other wrench on the high pressure line fitting.
c. Turn the wrench on the high pressure line fitting while holding the other wrench on the thrust bolt.
18. Remove the high pressure injection line from the head and unit pump.
19. To prevent any dirt from entering, cover the openings in the unit pump and the transfer tube.
20. Remove the heater hose from the back of the cylinder head.
21. Disconnect the fuel return line from the cylinder head.
22. Remove the constant-throttle valve line.
23. Disconnect the coolant delivery line from the cylinder head to the air compressor.
24. Using the head bolt impact socket J-45390, remove the cylinder head bolts.
25. Attach the cylinder head lifting device J-46387.
26. Remove the cylinder head, see Figure "Cylinder Head Removed", and set it on wooden blocks or on its side.

27. Remove the head gasket,
28. Thoroughly clean the cylinder head and head mating surface of excess oil, grime, and paint chips.
29. With a straightedge, check the cylinder head surface for warpage. The warpage limits on the 6-cylinder engine are listed in Table "Head Warpage Limits, 6-Cylinder Engine" and the allowable warpage limits on the 4-cylinder engine are listed in Table "Head Warpage Limits, 4-Cylinder Engine".

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over entire length</td>
<td>0.07 mm (0.003 in.)</td>
</tr>
<tr>
<td>Over a length of 150 mm (6 in.)</td>
<td>0.02 mm (0.001 in.)</td>
</tr>
</tbody>
</table>

Table 9. Head Warpage Limits, 6-Cylinder Engine

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over entire length</td>
<td>0.05 mm (0.002 in.)</td>
</tr>
<tr>
<td>Over a length of 150 mm (6 in.)</td>
<td>0.02 mm (0.001 in.)</td>
</tr>
</tbody>
</table>

Table 10. Head Warpage Limits, 4-Cylinder Engine

30. With a straightedge, check the cylinder block mating surface for warpage. The cylinder block warpage is listed in Table "Cylinder Block Warpage Limits, 4- and 6-Cylinder Engines".

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over entire length</td>
<td>0.030 mm (0.0012 in.)</td>
</tr>
<tr>
<td>Over a length of 150 mm (6 in.)</td>
<td>0.15 mm (0.006 in.)</td>
</tr>
</tbody>
</table>

Table 11. Cylinder Block Warpage Limits, 4- and 6-Cylinder Engines

31. Inspect the cylinder head for cracks or signs of damage. Replace if necessary.

**Section 1.2.2 Cylinder Head Installation**

Install the cylinder head as follows:

1. Install a new head gasket,
2. Lower the cylinder head back into place. Remove the cylinder head lifting device.
3. Using a dial caliper, measure the length of the cylinder head bolts from the end of the bolt to the bottom of the flange. See Figure "Measuring Head Bolts". The acceptable bolt length is listed in Table "Cylinder Head Bolts, Length".
Figure 6. Measuring Head Bolts

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft length when new 149.0 mm (5.87 in.)</td>
<td></td>
</tr>
<tr>
<td>Maximum shaft length 151.0 mm (5.94 in.)</td>
<td></td>
</tr>
</tbody>
</table>

Table 13. Cylinder Head Bolts, Length

4. Lubricate the cylinder head bolts with engine oil.
5. Using the head bolt impact socket J 45390, install the cylinder head bolts. The specific stages in the tightening sequence are listed in Table "Tightening Stages, Cylinder Head". See Figure "Tightening Sequence, 6-Cylinder Engine" for the torque sequence on the 6-cylinder engine and see Figure "Tightening Sequence, 4-Cylinder Engine" for the torque sequence on the 4-cylinder engine.

<table>
<thead>
<tr>
<th>Size</th>
<th>Max. Shaft Length</th>
<th>Tightening Stage</th>
<th>Torque Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stage 1</td>
<td>20 N·m (15 lb·ft)</td>
</tr>
<tr>
<td>M16 151.0 mm (5.94 inches)</td>
<td></td>
<td>Stage 2</td>
<td>70 N·m (52 lb·ft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 3</td>
<td>170 N·m (125 lb·ft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 4</td>
<td>280 N·m (207 lb·ft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 5</td>
<td>additional 90 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 6</td>
<td>additional 90 degrees</td>
</tr>
</tbody>
</table>

Table 14. Tightening Stages, Cylinder Head

Figure 7. Tightening Sequence, 6-Cylinder Engine
6. Connect the coolant delivery line from the cylinder head to the air compressor.
7. Replace the seal and connect the fuel return line to the cylinder head.
8. Replace the seal and install the constant-throttle valve supply line.
9. Install the heater hose to the back of the cylinder head.

**NOTICE:**
Correct torque on the high pressure fuel lines is critical. Incorrect torques could result in leaks or lack of power due to restricted fuel flow.

10. Without turning the transfer tube thrust bolts, install the high pressure fuel injection lines in the as-removed positions.
   a. Tighten the high pressure fuel injection line fittings 25 N·m (18 lb·ft).
11. Install new exhaust manifold gaskets.
12. Using the exhaust manifold socket set J-46379 , install the exhaust manifold bolts.

**Note:** Use the short socket for the rearmost bolt. Use the long socket for the other bolts.

13. Install the exhaust manifold and tighten the bolts. The specific torque stages and values are listed in Table "Tightening Stages, Exhaust Manifold Bolts".

<table>
<thead>
<tr>
<th>Size</th>
<th>Maximum Shaft Length</th>
<th>Tightening Stage</th>
<th>Torque Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M10</td>
<td>47.5 mm (1.87 in.)</td>
<td>Stage 1</td>
<td>10 N·m (7 lb·ft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 2</td>
<td>55 N·m (41 lb·ft)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stage 3</td>
<td>additional 90 degrees</td>
</tr>
</tbody>
</table>

**Table 16. Tightening Stages, Exhaust Manifold Bolts**

15. Using new gaskets, install the charge-air manifold. Tighten the fasteners to 25 N·m (18 lb·ft).
16. Connect the charge-air pressure/temperature sensor to the back of the charge-air manifold. Install the charge-air sensor cover.
17. Lubricate the pushrods with a light coating of engine oil and install the pushrods, in the as-removed locations.
18. Install the valve bridges in the as-removed locations.
19. Install the rocker arm assembly in the as-removed locations. Tighten each rocker arm mounting bolt 30 N·m (22 lb·ft).
20. Install the front connector housing assembly.
   a. Install the water pump connector fitting on the water pump.
   b. Install a new gasket on the cylinder head.
   c. Install the front connector housing.
   d. Install the coolant line.
   e. Connect the engine wiring harness to the coolant temperature sensor.
21. Install the crankshaft turning tool and adjust the valves. Refer to "1.17.3 Adjusting Valve Lash".
22. Remove the crankshaft turning tool.
23. Install the inspection hole end cover on the flywheel housing. Tighten the fasteners 25 N·m (18 lb·ft).
24. Install the air cleaner, charge-air inlet, and turbo outlet pipes and hoses.
25. Install the coolant delivery hoses that connect to the surge tank. See Figure "Coolant Hoses at the Surge Tank".
26. Check that the coolant drain plug is tight and not leaking.
27. Fill the radiator with coolant.
28. Install the cylinder head cover. Refer to "1.1.2 Cylinder Head Cover Installation".
29. Install the engine trim panel.

**Note:** Bleed the fuel system.

---

**WARNING:**

**PERSONAL INJURY**

To avoid injury before starting and running the engine, ensure the vehicle is parked on a level surface, parking brake is set, and the wheels are blocked.

**WARNING:**

**PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- Always start and operate an engine in a well ventilated area.
30. Turn on the ignition key switch and run the engine. Observe the oil pressure gauge to verify the correct oil pressure. The minimum oil pressure reading at idle speed is listed in Table "Oil Pressure Readings". Pay attention to the coolant temperature gauge, warning lights, fluid leaks, and any other signs of a problem.

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum Oil Pressure Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine at Idle Speed</td>
<td>50 kPa (7 psi)</td>
</tr>
<tr>
<td>Engine at Max. rpm</td>
<td>250 kPa (36 psi)</td>
</tr>
</tbody>
</table>

*Table 19: Oil Pressure Readings*

31. Stop the engine, check the coolant level, and top off if necessary.

Section 1.2.2.1

Cylinder Head Inspection

Inspect the cylinder head as follows:

1. Measure cylinder-head overall height and variation of parallelism from top-to-bottom contact surfaces. See Figure "Measuring the Cylinder Head". If the measurement is less than the permissible minimum height, replace the cylinder head.

![Figure 9. Measuring the Cylinder Head](image)

2. Inspect the bottom contact surface of the cylinder head for the permissible difference of flatness in the longitudinal direction. The specifications for cylinder head height and mating surface warpage are listed in Table "Cylinder Head Height Specifications" and in Table "Cylinder Head Mating Surface Warpage".

<table>
<thead>
<tr>
<th>Height of Cylinder Head</th>
<th>6-Cylinder</th>
<th>4-Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>When New</td>
<td>107.9 to 108.1 mm (4.25 to 4.26 in.)</td>
<td>107.9 to 108.1 mm (4.25 to 4.26 in.)</td>
</tr>
<tr>
<td>After Machining</td>
<td>106.9 mm (4.21 in.)</td>
<td>106.9 mm (4.21 in.)</td>
</tr>
</tbody>
</table>

*Table 20: Cylinder Head Height Specifications*

<table>
<thead>
<tr>
<th>Maximum Lengthwise Head Mating Surface Warpage</th>
<th>6-Cylinder</th>
<th>4-Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Entire Length</td>
<td>0.07 mm (0.003 in.)</td>
<td>0.05 mm (0.002 in.)</td>
</tr>
<tr>
<td>Over a Length of 150 mm (6 in.)</td>
<td>0.02 mm (0.0008 in.)</td>
<td>0.02 mm (0.0008 in.)</td>
</tr>
</tbody>
</table>

*Table 21: Cylinder Head Mating Surface Warpage*

Section 1.2.2.2

Compression Testing

To do compression testing the nozzle holder will need to be removed and the compression tester installed.

1. Set the parking brake and chock the tires.

Note: To do this procedure, coolant temperature must be between 70 to 95°C (158 and 203°F).
2. Turn on the ignition key switch and run the engine until it reaches operating temperature.
3. Shut down the engine.
4. Remove the nozzle holder. See Figure "Removing the Nozzle Holder".

Figure 10. Removing the Nozzle Holder

5. Insert the compression test adaptor J-46386 into the cylinder head. See Figure "Installing the Connector". Use the hold-down clamp and bolt included in the kit.

Figure 11. Installing the Connector

a. Make sure the smooth surface on the O-ring is pointing toward the test adaptor J-46386.
b. Install the hold-down clamp with the two prongs around the test adaptor. Turn the hold-down clamp (at the cylinder head) until the button in the base of the hold-down clamp is aligned with the locating element in the end cover of the constant throttle valve end cover.
c. Tighten the hold-down clamp bolt 38 N m (22 lb-ft) for a hex-head bolt, or 35 N m (26 lb-ft) for the 12-point head with the spherical collar.

Note: Follow the equipment manufacturer's operating instructions to connect the compression tester.

6. Attach the compression tester J-6692-B to the test adaptor J-46386. Thread the fitting at the end of the tester to the top of the test adaptor. See Figure "Testing Compression Pressure".

Figure 12. Testing Compression Pressure
Test as follows:

1. Remove either of the electrical connectors from the DDEC ECU control unit. When this is done, the engine will not start.
2. For each cylinder, use the starter to crank the engine at least 8 engine revolutions. The results will be recorded on the gauge of the tester.
3. Compare measurements on the gauge with the values listed in Table "Compression Testing".

<table>
<thead>
<tr>
<th>Description</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Pressure at Starter Speed</td>
<td>2800 kPa (406 psi)</td>
</tr>
<tr>
<td>Permissible Difference Between Individual Cylinders</td>
<td>400 kPa (58 psi)</td>
</tr>
</tbody>
</table>

| Table 27. Compression Testing |

4. If the pressure measured is below the chart compression pressure or above the permissible difference, determine the cause and correct the problem.

Install the nozzle holder as follows:

1. Connect the DDEC ECU control unit.
2. Connect minidiag2 to the vehicle and clear all inactive fault codes.

**Note:** Follow the equipment manufacturer’s operating instructions.

3. Disconnect the compression tester from the test adaptor. See Figure "Testing Compression Pressure".
4. Remove the compression test adaptor. See Figure "Installing the Connector".
5. Install the nozzle holder. See Figure "Removing the Nozzle Holder".
6. Install and adjust the hold-down clamp.
   a. Position the hold-down clamp on the nozzle holder and install the hold-down clamp bolt.
   b. Tighten the hold-down bolt 30 N·m (22 lb-ft) for a hex-head bolt, or 35 N·m (26 lb-ft) for the 12-point head with the spherical collar.
7. Repeat this procedure for each cylinder.
8. Remove the chocks from the tires.

**Section 1.2.3 Oil Separator Removal**

Remove oil separator as follows:

1. Apply the parking brakes, and chock the tires.
2. Open the hood.
3. Remove the engine trim panel.
4. Remove the cylinder head cover.
5. Remove the oil separator front cover from the cylinder head cover. See Figure "Oil Separator and Components".

![Diagram of Oil Separator and Components](image)

1. Cylinder Head Cover
2. Wire Filter (Short)
3. Wire Filter (Long)
4. Oil Separator Front Cover Screws
5. Oil Separator Front Cover
6. Oil Separator Front Cover Gasket/Diaphragm
7. Spring

| Figure 13. Oil Separator and Components |

6. Remove the oil separator front cover gasket/diaphragm and spring.
7. Remove both wire filters from inside the cylinder head cover.

**Section 1.2.3.1 Oil Separator Inspection**

Inspect and clean the wire filters and the sealing surfaces. Replace, if necessary.

**Section 1.2.4 Oil Separator Installation**

Install the oil separator as follows:
1. Install both wire filters into the cylinder head cover. First insert the shorter filter, then the longer one.
2. Install the spring and the oil separator front cover gasket/diaphragm.
3. Install the oil separator front cover and bolts. Torque bolts to 25 N·m (18 lb·ft).
4. Install the cylinder head cover. Refer to "1.1.2 Cylinder Head Cover Installation".
5. Install the engine trim panel.
6. Close the hood and remove the chocks from the tires.