Section 1.33  
Bull Gear and Camshaft Idler Gear Assembly

The bull gear and camshaft idler gear assembly is centrally located beneath the gear case cover. The larger bull gear is directly driven by the crankshaft timing gear. The bull gear directly drives all of the gear-driven engine accessories (except the oil pump), meshing with drive gears for the fuel pump drive, air compressor drive and power steering pump (if so equipped), raw water pump (if so equipped), water pump and accessory and alternator drive. See Figure "Engine Gear Train".

**Figure 1. Engine Gear Train**

The smaller camshaft idler gear is located behind the bull gear on the same carrier, and turns at the same speed as the bull gear. The camshaft idler gear drives an adjustable idler gear, mounted on a separate hub in the gear case. The adjustable idler gear drives the camshaft drive gear. The gear ratio of each gear in relationship to the crankshaft timing gear is shown directly below the gear title.

The bull gear and camshaft idler gear are a press-fit to the bull gear and camshaft idler gear carrier. See Figure "Bull Gear and Related Parts".
Both gears are keyed to the carrier by the same key. For units built prior to 6R11886, a spacer ring fits in a groove in the carrier between the bull gear and the camshaft idler gear. For units built after 6R11887, this spacer was incorporated in the carrier. The carrier is supported by two tapered roller bearing assemblies that ride on a hub bolted to the engine block by four bolts. A selective-size spacer between the two bearing assemblies is used to obtain the correct bearing preload.

**Note:** The bull gear and camshaft idler gear assembly is retained to the hub by a left-hand threaded nut.

The camshaft must be in time with the crankshaft timing gear. Since there are three gears between them, timing marks have been stamped or etched on the face of the gears to facilitate correct gear train timing. Refer to "1.24.2.1 Check Engine Timing" for gear train timing procedures. See Figure "Engine Gear Train and Timing Marks".

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**Figure 2. Bull Gear and Related Parts**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Woodruff Key</td>
</tr>
<tr>
<td>2.</td>
<td>Camshaft, Idler Gear</td>
</tr>
<tr>
<td>3.</td>
<td>Bearing Race, Outer</td>
</tr>
<tr>
<td>4.</td>
<td>Spacer Ring, Small</td>
</tr>
<tr>
<td>5.</td>
<td>Hub</td>
</tr>
<tr>
<td>6.</td>
<td>Bearing, Inner</td>
</tr>
<tr>
<td>7.</td>
<td>Bearing Race, Inner</td>
</tr>
<tr>
<td>8.</td>
<td>Snap Ring, Inner</td>
</tr>
<tr>
<td>9.</td>
<td>Snap Ring, Outer</td>
</tr>
<tr>
<td>10.</td>
<td>Bearing, Outer</td>
</tr>
<tr>
<td>11.</td>
<td>Spacer Ring, Large</td>
</tr>
<tr>
<td>12.</td>
<td>Carrier</td>
</tr>
<tr>
<td>13.</td>
<td>Bull Gear</td>
</tr>
<tr>
<td>14.</td>
<td>Thread Nut, Left Hand</td>
</tr>
</tbody>
</table>
Figure 3. Engine Gear Train and Timing Marks

The backlash between the various mating gears in the gear train should be 0.051-0.229 mm (0.002 - 0.009 in.), and should not exceed 0.305 mm (0.012 in.) backlash between worn gears. Refer to "1.24.2.1 Check Engine Timing".

**Note:** All gear lash measurements should be taken with engine in an upright position.

The bull gear and camshaft idler gear assembly is pressure-fed lubricating oil through two holes in the bull gear recess area of the engine block. See Figure "Bull Gear and Camshaft Idler Gear Lubricating Oil Hole Locations".
Figure 4. Bull Gear and Camshaft Idler Gear Lubricating Oil Hole Locations

These two holes are drilled into a main oil gallery. An internal oil passage, cast into the bull gear and camshaft idler gear hub relief at the rear of the hub indexes with these two oil holes to supply oil through a drilled passage to the two roller bearing assemblies.

Section 1.33.1
Repair or Replacement of Bull Gear and Camshaft Idler Gear Assembly

To determine if repair or replacement of the bull gear and camshaft idler gear assembly is necessary, perform the following procedure. See Figure "Flowchart for Repair or Replacement of Bull Gear and Camshaft Idler Gear Assembly".

Figure 5. Flowchart for Repair or Replacement of Bull Gear and Camshaft Idler Gear Assembly

Section 1.33.2
Removal of Bull Gear and Camshaft Idler Gear Assembly
Remove the bull gear and camshaft idler gear assembly as follows:

1. Remove the engine gear case cover. Refer to "1.10.2 Removal of Engine Gear Case Cover".
2. Install J–35994 to the oil seal contact area of the crankshaft. See Figure "Bull Gear Guide Studs".

![Figure 6. Bull Gear Guide Studs](image1)

**NOTICE:**

Use care when removing the bull gear and camshaft idler gear assembly from the engine so that it does not come in contact with the oil seal contact surface of the crankshaft. If this sealing surface is scratched, an oil leak may result.

3. Working through the four access holes in the bull gear carrier, loosen and remove two of the four bolts that secure the bull gear assembly to the cylinder block. See Figure "Removing Bull Gear Assembly Retaining Bolts".

![Figure 7. Removing Bull Gear Assembly Retaining Bolts](image2)
4. Install J-35785 into the holes the bolts from where they were removed.
5. Remove the two remaining bull gear retaining bolts.
6. Grasp the bull gear and pull the assembly straight out of the recess in the cylinder block.

Section 1.33.2.1
Inspection of Bull Gear and Camshaft Idler Gear Assembly

Inspect the bull gear and camshaft idler gear assembly as follows:

1. Clean the bull gear and idler gear assembly in clean fuel oil.

**WARNING:**

To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 276 kPa (40 psi) air pressure.

2. Dry the bull gear and idler gear assembly with compressed air.
3. Visually examine the gear teeth on both the bull gear and idler gear for evidence of scoring, cracking, pitting, and wear.
   a. If either gear is damaged, replace the bull gear and idler gear assembly.
   b. If either gear is not damaged, reuse the bull gear and idler gear assembly.
4. Visually examine the inner diameter of both gears, where they are pressed on the carrier for evidence of gear movement.
   a. If there is any evidence of gear movement, replace the bull gear and idler gear assembly.
   b. If damage is not found, reuse the bull gear and idler gear assembly.
5. Place the bull gear and idler gear assembly on a bench, resting on the hub. Inspect the bearings for signs of distress or overheating.
   a. If there is any bearing distress, replace the bull gear and idler gear assembly.
   b. If damage is not found, reuse the bull gear and idler gear assembly.
6. Coat the bearings with clean engine oil.
7. Slowly rotate the gears on the hub looking for binding of the bearing.
   a. If the gears do not rotate freely on the hub, replace the bull gear and idler gear assembly.
   b. If the gears rotate freely, reuse the bull gear and idle gear assembly.

**NOTICE:**

Care should be taken not to damage or dislocate the pin. The pin is installed at a set dimension which is used by the Synchronous Reference Sensor (SRS). Damage to pin will cause loss of engine performance.

Inspect the SRS pin in the bull gear as follows. See Figure "SRS Pin Location".
Figure 8. SRS Pin Location

1. Check the SRS pin for damage or looseness. If the SRS pin is damaged or dislodged, replace the pin as follows:
   a. Press the SRS pin from the bull gear. Discard pin.
   b. Apply Loctite 609 (PT 7260) to pin.
   c. Press pin flush to 0.25 mm (0.010 in.) below bull gear surface.
   d. If no damage is found, reuse the bull gear assembly.

2. Using straight edge and thickness gages, measure recess of SRS pin.
   a. If pin is not flush to 0.25 mm (0.010 in.) below bull gear surface, replace the pin.
   b. If the pin is to specifications 0.25 mm (0.010 in.), reuse the part.

**NOTICE:**
Do NOT reuse or readjust a pin once it has been installed. Damage to pin will cause loss of engine performance.

Section 1.33.3
Installation of Bull Gear and Camshaft Idler Gear Assembly

Install bull gear assembly and camshaft assembly as follows:

1. Inspect the bull gear and camshaft idler gear access opening in the gear case and remove any foreign material. Be sure the lubrication oil holes are clear and free.
2. Install two Bull Gear Guide Studs (J–35785) to the cylinder block. See Figure "Bull Gear Guide Stud Installation".
3. Install J–35994 to the oil seal contact area of the crankshaft.

**Note:** The crankshaft seal surface will be protected using J–35994, when installing the bull gear and camshaft idler gear assembly to the cylinder block.

4. Install the bull gear and camshaft idler gear assembly to the guide studs in the cylinder block.

5. Bar the engine over until the timing mark on the crankshaft timing gear is at the 12 o'clock position. See Figure "Engine Gear Train and Timing Marks".

6. Align the timing marks on the camshaft drive gear and the adjustable idler gear as shown. See
7. Slide the bull gear and camshaft idler gear assembly towards the engine, but do not engage any of the gears on the engine.

8. Looking through the access hole in the bull gear, align the timing marks on the adjustable idler gear and the camshaft idler gear as shown. See Figure "Engine Gear Train and Timing Marks".

9. Check the timing marks on the bull gear and crankshaft timing gear to ensure they will align when the bull gear assembly is seated in the cylinder block.

Note: The injector and valve spring pressures will not allow easy rotation of the camshaft and adjustable idler gears. Therefore, it may be necessary to remove the rocker arm shaft assemblies to facilitate aligning all three sets of timing marks. Refer to "1.3.2 Removal of Rocker Arm Assembly".

10. When all three sets of timing marks are aligned, slide the bull gear and camshaft idler gear towards the engine completely and seat it in the recess in the gear case and cylinder block.

11. Working through the lightening holes in the bull gear, install two of the bull gear assembly mounting bolts through the hub and into the cylinder block. Tighten the bolts finger-tight.

12. Remove the two bull gear guide studs.

13. Install the remaining two bull gear assembly mounting bolts. Torque all four mounting bolts to 101-116 N·m (75-86 lb·ft) in a clockwise direction.

14. Check the timing marks on the gears to ensure the gear train is properly timed. See Figure "Engine Gear Train and Timing Marks".

15. Check the gear lash for all of the gears that mate with the bull gear and camshaft idler gear. Refer to "1.24 Gear Train and Engine Timing".

16. Install the gear case cover. Refer to "1.10.3 Installation of Gear Case Cover".

17. Check bull gear to accessory drive gear lash. Refer to "1.24.2.1 Check Engine Timing".

18. Refer to "12.7 Engine Run-in Instructions" for verification of proper bull gear and camshaft idler gear assembly installation.

NOTICE:

Use care when installing the bull gear and camshaft idler gear assembly to prevent damaging the crankshaft oil seal contact surface.