2.4.6.1 Check Injector Tip Protrusion

To check the injector tip protrusion:

1. Insert J 33880-3 part of J 33880, into injector tube bore of cylinder head. See Figure 2-22.
2. Insert J 33880-7 part of J 33880, into pilot. See Figure 2-27.

Figure 2-27 Checking Injector Tip Protrusion

3. Check injector tip protrusion using J 22273-01. Hold protrusion gage against pilot while measuring tip protrusion. This measurement should be flush to -0.20 mm (-0.008 in.).
2.4A N3 ELECTRONIC UNIT INJECTOR

Engine models built after December 1, 2003 will use the N3 Electronic Unit Injector (EUI). See Figure 2-27a. The N3 injector is designed as an inline concept. The fuel metering unit or module is positioned under the plunger, so the overall envelope of the N3 is smaller than previous injectors. The N3 has an inwardly opening of solenoid valve which controls beginning of injection and end of injection. The solenoid valve closing point defines the beginning of injection (BOI) and the solenoid valve opening point defines the end of injection (EOI). Pressure is generated by the downward movement of the plunger in combination with the closed solenoid valve. Fuel quantity is metered by the length of time the solenoid valve remains closed. A magnetic core is incorporated into the module. The electrical leads from the core are brought to an external position on the injector through a modular two-pin connector socket.

The advantages of the N3 injector are:

- Improved strength.
- Reduced external leakage potential.
- Compact design.
- Reduced weight.

The amount of fuel injected and the beginning of injection timing is determined by the ECU. The ECU sends a command pulse which activates the injector solenoid. The N3 EUI performs four functions:

- Creates the high-fuel pressure required for efficient injection.
- Meters and injects the exact amount of fuel to handle the load.
- Atomizes the fuel for mixing with the air in the combustion chamber.
- Permits continuous fuel flow for component cooling.

Engine combustion is obtained by injecting, under pressure, a small quantity of accurately metered and finely atomized fuel oil into the cylinder. Metering and timing of the fuel is accomplished by the ECU which actuates the solenoid control valve to stop the free flow of fuel through the injector. When the solenoid control valve closes, fuel is trapped in the injector body and under the plunger. The continuous fuel flow through the injector prevents air pockets in the fuel system and cools those injector parts subjected to high combustion temperatures.
1. Injector Follower
2. Plunger
3. Module
4. Injector Nut
5. Injector Spring Cage
6. Nozzle

Figure 2-27a  N3 Electronic Unit Injector Cross-Section
Fuel enters the injector through the fuel inlet opening located around the injector body. See Figure 2-27b.

**Figure 2-27b  Fuel Injector Body**
Outlet openings through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, are located around the injector nut. See Figure 2-27c.

![Figure 2-27c](image)

**Figure 2-27c**  
**N3 Electronic Unit Injector**
After entering the nut cavity, the fuel passes through a drilled passage into the module and plunger area. See Figure 2-27a.

The plunger operates up and down in the body bore of the injector. The motion of the injector rocker arm is transmitted to the plunger and follower that bears against the follower spring.

As the piston moves approximately two-thirds of the way up in the cylinder on the compression stroke, the injector cam lobe begins to lift causing the injector rocker arm to push down on the follower and the plunger. Just before injection begins, the ECU sends an electronic pulse which turns on the injector solenoid. The energized solenoid creates a magnetic force which closes the control valve and traps fuel under the plunger and passages leading down to the needle valve. The fuel pressure increases as the plunger continues its downward stroke.

This fuel pressure acts on the needle valve. When it creates a force high enough to overcome the valve spring force holding the needle on its seat, the needle valve moves up, allowing the high pressure fuel to spray into the combustion chamber. The high pressure of the fuel passing through the small holes in the nozzle creates a finely atomized spray for combustion within the cylinder.

After the pulse width time has passed, the ECU turns off the current to the injector solenoid. The de-energized solenoid allows a spring to open the control valve, permitting the trapped fuel to spill down, dropping the pressure within the injector. When the pressure is low enough the needle valve closes and ends injection.

The beginning of injection and metering of the fuel in relation to the crankshaft position are controlled by the ECU. Injection begins soon after the control valve is closed. The valve closing point known as the injector response time is returned to the ECU. This information is used to monitor and adjust injection timing, thus removing injector-to-injector variation influences on timing. The amount of fuel injected depends on the pulse width stored in the calibration which determines how long the control valve remains closed; the larger the pulse width the longer the valve is closed and the more fuel is injected.

When the injector rocker arm has completed its downward travel the injector follower spring returns it to the starting position. As the plunger moves up fuel enters the injector pumping cavity for another injection cycle. The constant circulation of fuel through the injector renews the fuel supply in the chamber and aids the cooling of the injector.
2.4a.1 Replacement of N3 Electronic Unit Injector

To determine if replacement is necessary perform the following procedure. See Figure 2-27d.

**NOTICE**

If the solenoid on N3 Electronic Unit Injector is faulty the injector must be replaced. The solenoid is not repairable.

![Flowchart for Replacement of N3 Electronic Unit Injector](43666)

**Figure 2-27d** Flowchart for Replacement of N3 Electronic Unit Injector

2.4a.2 Removal of N3 Electronic Unit Injector

The following steps must be performed prior to removing an injector:

1. Clean the valve rocker cover around its seat on the head, and in the attaching bolt recesses.
   
   [a] To remove the *one-piece* rocker cover, refer to section 1.6.2.
[b] To remove the two-piece rocker cover, refer to section 1.6.3.
[c] To remove the three-piece rocker cover, refer to section 1.6.5.

⚠️ CAUTION:

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

NOTICE:

All the fuel must be removed from the cylinder head before removing an injector to prevent the fuel from entering the cylinder and causing hydrostatic lock or washdown. If the head is not thoroughly purged of fuel before an injector is removed, fuel remaining in the fuel manifold will drain into the cylinder filling the piston dome recess. It cannot drain from the dome and, if not removed, can cause hydrostatic lock and bend the connecting rod.

NOTICE:

Do not exceed 40 psi (276 kPa) when blowing compressed air into the cylinder head inlet fitting.

2. Drain the cylinder head fuel gallery by removing the inlet and outlet lines from the fittings at the rear of the cylinder head. Blow low pressure compressed air into the inlet fitting for 20 to 30 seconds or until all of the fuel is purged from the cylinder head. See Figure 2-27e.

NOTE:

Loosening the fuel line at the inlet fitting will allow fuel to flow faster. Carefully collect the drained fuel in an appropriate container.
3. Remove the two rocker shaft through-bolts and one nut for each rocker shaft assembly, and lift the rocker shaft assembly off the engine. Refer to section 1.3.2.

Remove the N3 injector as follows:

**NOTE:**
Do not pry on injector connector at anytime.

1. Disengage the locking tang on the harness plug connector. Grasp the connector and gently pull it from the socket.
2. Remove injector hold down bolt and washer.
NOTICE:
Extreme care should be used when handling an N3 EUI to avoid costly damage by dropping or otherwise mishandling the N3 EUI.

NOTICE
The N3 EUI must be removed from the cylinder head by applying force on the body surface as shown in Figure 2-27f. Removal force must not be applied to any other area on the N3 injector.

Figure 2-27f  N3 Injector Removal Surface
3. Lift the injector from its seat in the cylinder head by inserting a pry bar under the hold down clamp and remove as a assembly both clamp and injector. See Figure 2-27g.

![Figure 2-27g Removal of the N3 Injector](image)

**NOTICE:**
Avoid wire brushing the spray holes to prevent damage.

4. Cover the injector hole in the cylinder head to keep out foreign material. Remove carbon from the injector exterior in the area where the tip joins the nut, using wire buffing wheel, J 7944.

**2.4a.3 Disassembly of N3 Electronic Unit Injector**

On a Series 60 engine that uses the N3 EUI, only the injector seal rings and copper washer are servicable. The injector must not be disassembled.

**2.4a.4 Installation of the N3 Electronic Unit Injector**

Perform the following steps:

1. If the fuel system is contaminated with coolant:
   - [a] Drain the fuel tanks and refill with clean fuel. Refer to section 13.13.2.
   - [b] Replace both filters with new, and clean the fuel/water separator, if equipped. Refer to section 2.8.2.
   - [c] Inspect fuel injectors for damage and replace as required.
2. If the coolant system is contaminated with fuel, flush and reverse flush the system. Refer to section 13.13.4.

<table>
<thead>
<tr>
<th>CAUTION:</th>
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<tbody>
<tr>
<td>To avoid injury from flying debris when using compressed air, wear adequate eye protection (face shield or safety goggles) and do not exceed 40 psi (276 kPa) air pressure.</td>
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<table>
<thead>
<tr>
<th>NOTICE:</th>
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<tbody>
<tr>
<td>Leftover fuel must be removed from the injector bore before injector installation. If fuel is trapped between the top of the injector hole tube and the lower injector O-ring seal, it may seep down to the injector hole tube seal ring, causing swelling and possible seal leakage.</td>
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3. Using clean compressed air, blow out any fuel remaining in the injector bore.

<table>
<thead>
<tr>
<th>NOTICE:</th>
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<tbody>
<tr>
<td>Injector O-ring seals and copper seals are considered one-use items and cannot be reused. Any time an injector is removed, all three injector O-ring seals and copper seal must be replaced with new parts. Failure to replace O-ring seals and copper seal can result in leakage.</td>
</tr>
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4. Check to make sure the injector bore is thoroughly clean.

<table>
<thead>
<tr>
<th>NOTE:</th>
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<tbody>
<tr>
<td>The injector tube bore should be cleaned and inspected for damage before installation of the N3 Electronic Unit Injector. Refer to section 2.4b.1.1.</td>
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</tbody>
</table>

5. Install new copper seal on injector, ensure contured side faces toward the injector.

<table>
<thead>
<tr>
<th>NOTE:</th>
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<tbody>
<tr>
<td>All external O-rings must be lubricated prior to installation into the cylinder head.</td>
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</tbody>
</table>
6. Apply a thin coat of clean fuel oil to the injector seal rings and install them in the injector nut ring grooves. Make sure the seals are properly seated see Figure 2-27h.

Figure 2-27h  N3 Injector Seal Rings
7. Install the injector and hold down clamp as an assembly into its respective injector tube bore. Align the hold down clamp over the retaining stud, install the washer and bolt into injector clamp and torque to 55-65 N·m (40-48 lb·ft). See Figure 2-27i.
8. Install the N3 EUI harness plug into the injector connector making sure the locking tang clicks into place. See Figure 2-27j.

![Figure 2-27j](image)

**Figure 2-27j**  N3 Injector and Harness Connection

9. Install the rocker arm shafts, with rocker arms in place. Refer to section 1.3.3.

10. Adjust the intake and exhaust valve clearances and injector height. Refer to section 12.2.

11. Install the inlet and outlet fuel lines to the fittings at the rear of the cylinder head. See Figure 2-6.

12. On DDEC V engines, record the injector calibration code from the name plate with the proper cylinder location see Figure 2-27j.

13. Install the valve rocker cover. Refer to section 1.6.7.

14. For one-piece valve rocker cover, refer to section 1.6.8. For two-piece and three piece valve rocker cover, refer to section 1.6.9.

15. Verify installation of N3 Electronic Unit Injector. Refer to section 11.8.
2.4B FUEL INJECTOR TUBE

The bore in the cylinder head for the N3 EUI is directly through the cylinder head water jacket. To prevent coolant from contaminating the injector and still maintain maximum cooling of the injector, a stainless steel tube is screwed into the injector bore. The tube has a O-ring installed to create a water and gas-tight seal.

NOTE:
It is recommended that the injector tube be replaced with new a O-ring at the time of engine over haul. The injector tube is reusable.

NOTE:
Do not remove the injector tube for inspection unless a fault in the tube is suspected.

2.4b.1 Removal of the Injector Tube

Perform the following steps to remove the injector tube:

1. Remove Rocker Shaft assemblies. Refer to section 1.3.2.
2. Remove N3 injector. Refer to section 2.4a.2.

NOTICE:
Engine coolant must be drained prior to injector tube removal.


NOTICE:
Do not use excessive force on the injector tube during removal, cracking of the injector tube may occur requiring replacement.

4. Install tool J 46904 into injector bore and align tool with slots in tube and turn counter clockwise to remove.

2.4b.1.1 Inspection of Injector Tube

Inspect the injector tube as follows:

1. Inspect injector tube for cracks or defects. If defective replace injector tube.
2. Clean injector tube threads with a fine wire brush, being careful not to abrade the cylinder head to injector tube sealing surface.
3. Clean the injector tube interior sealing surface, a chemical solvent maybe used for cleaning interior sealing surface.
2.4b.2 Installation of Injector Tube and Seal

Perform the following steps for injector tube installation:

1. Clean injector bore of debris.

**NOTE:**
Replace with new O-ring when injector tube is removed or replaced.

2. Install O-ring in groove on injector tube, a small amount of silicone based O-ring lubrication will aid in the installation. See Figure 2-27k.

3. Coat the threads of injector tube with a high temperature nickel based antiseize lubricant.

![Figure 2-27k Injector Tube and O-ring](image)
4. Install the injector tube on tool J 46904. See Figure 2-271.

![Figure 2-271 Installation of Injector Tube on Tool J 46904](image1)

5. Using tool J 46904 install injector tube in injector bore. See Figure 2-27m.

![Figure 2-27m Installation of Injector Tube in Cylinder Head](image2)
6. Torque injector tube to 35-45 N·m (26-33 lb·ft).

7. Release torque approximately 180 degrees.

8. Torque injector tube to 35-45 N·m (26-33 lb·ft) ensure the tip of the injector tube is flush or below the fire deck, the tube should not protrude.
2.5 FUEL PUMP WITH SEPARATE DRIVE SHAFT AND HUB

The former fuel pump system consists of the following components:

☐ Barnes positive displacement type fuel pump; separate drive shaft
☐ Air compressor drive hub
☐ Gear train mounting adaptor

This pump has been replaced, effective July 1995, with an improved fuel pump. The pumps are similar, except the improved pump has a one-piece drive. These pump assemblies are completely interchangeable. Components are not interchangeable.