INTRODUCTION

CONVERSION CHART

Conversion Units			Multiply By:
Length Calculations			
Inches (in)	to	Millimeters (mm)	25.40
Inches (in)	to	Centimeters (cm)	2.540
Feet (ft)	to	Centimeters (cm)	30.48
Feet (ft)	to	Meters (m)	0.3048
Yards (yd)	to	Centimeters (cm)	91.44
Yards (yd)	to	Meters (m)	0.9144
Miles	to	Kilometers (km)	1.609
Millimeters (mm)	to	Inches (in)	0.03937
Centimeters (cm)	to	Inches (in)	0.3937
Centimeters (cm)	to	Feet (ft)	0.0328
Centimeters (cm)	to	Yards (yd)	0.0109
Meters (m)	to	Feet (ft)	3.281
Meters (m)	to	Yards (yd)	1.094
Kilometers (km)	to	Miles	0.6214
Area Calculations			
Square Inches (sq-in)	to	Square Millimeters (sq-mm)	645.2
Square Inches (sq-in)	to	Square Centimeters (sq-cm)	6.452
Square Feet (sq-ft)	to	Square Centimeters (sq-cm)	929.0
Square Feet (sq-ft)	to	Square Meters (sq-m)	0.0929
Square Yards (sq-yd)	to	Square Meters (sq-m)	0.8361
Square Miles (sq-miles)	to	Square Kilometers (sq-km)	2.590
Square Millimeters (sq-mm)	to	Square Inches (sq-in)	0.00155
Square Centimeters (sq-cm)	to	Square Inches (sq-in)	0.155
Square Centimeters (sq-cm)	to	Square Feet (sq-ft)	0.001076
Square Meters (sq-m)	to	Square Feet (sq-ft)	10.76
Square Meters (sq-m)	to	Square Yards (sq-yd)	1.196
Square Kilometers (sq-km)	to	Square Miles (sq-miles)	0.3861
Volume Calculations			
Cubic Inches (cu-in)	to	Cubic Centimeters (cu-cm)	16.387
Cubic Inches (cu-in)	to	Liters (L)	0.01639
Quarts (qt)	to	Liters (L)	0.9464
Gallons (gal)	to	Liters (L)	3.7854
Cubic Yards (cu-yd)	to	Cubic Meters (cu-m)	0.7646
Cubic Centimeters (cu-cm)	to	Cubic Inches (cu-in)	0.06102
Liters (L)	to	Cubic Inches (cu-in)	61.024
Liters (L)	to	Quarts (qt)	1.0567
Liters (L)	to	Gallons (gal)	0.2642
Cubic Meters (cu-m)	to	Cubic Yards (cu-yd)	1.308

VISUAL IDENTIFICATION

Item 9 — PowerLeash™ Engine Brake

- An X in block 9 indicates the engine was built with a PowerLeash™ engine brake camshaft.

Figure 1 illustrates the location of the information plate and Figure 2 illustrates its content. Figure 3 illustrates a completed sample information plate to be used as an example.

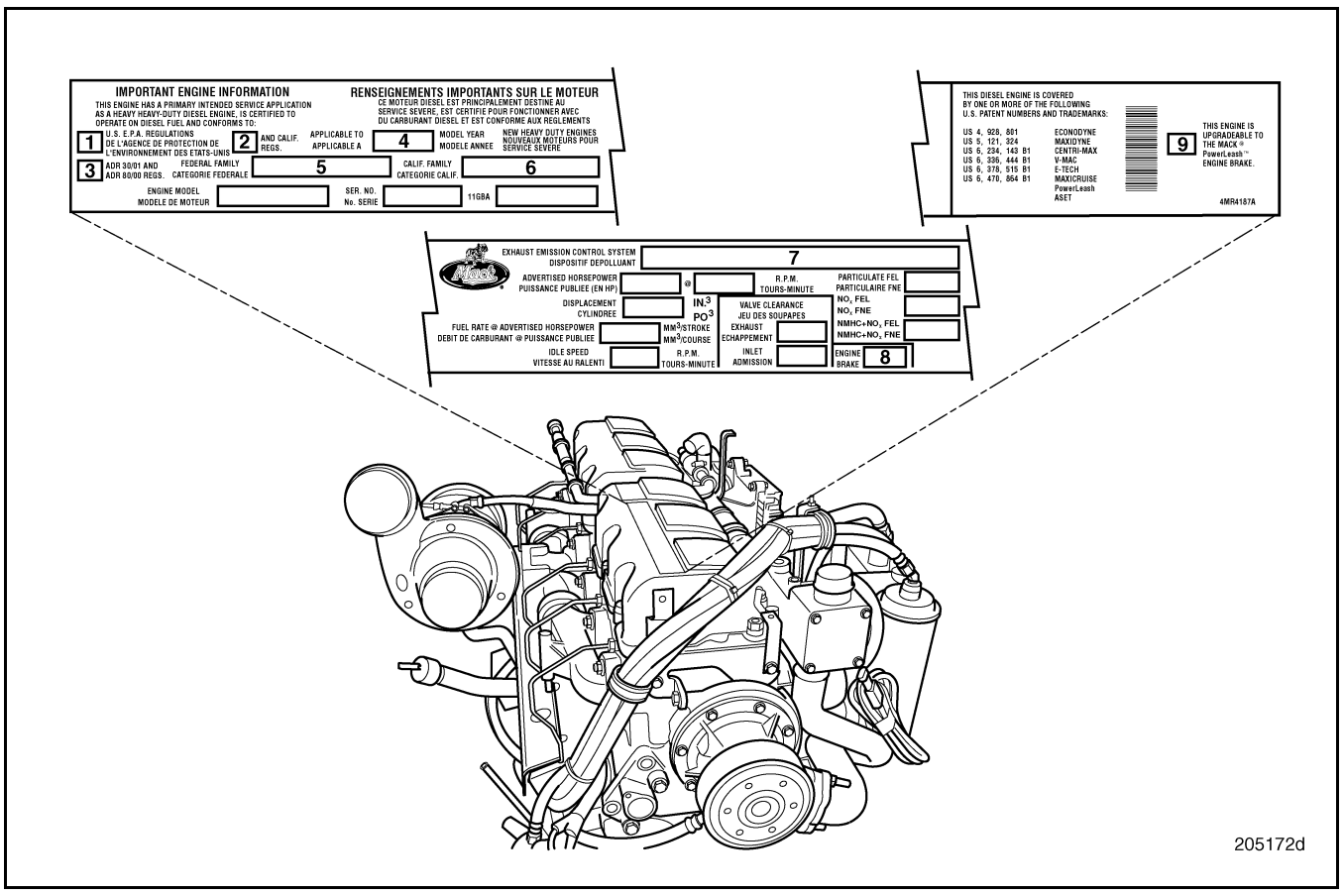

Figure 1 — Engine Information Plate Location (ASET™ AI Engine Shown, AC Same Location)

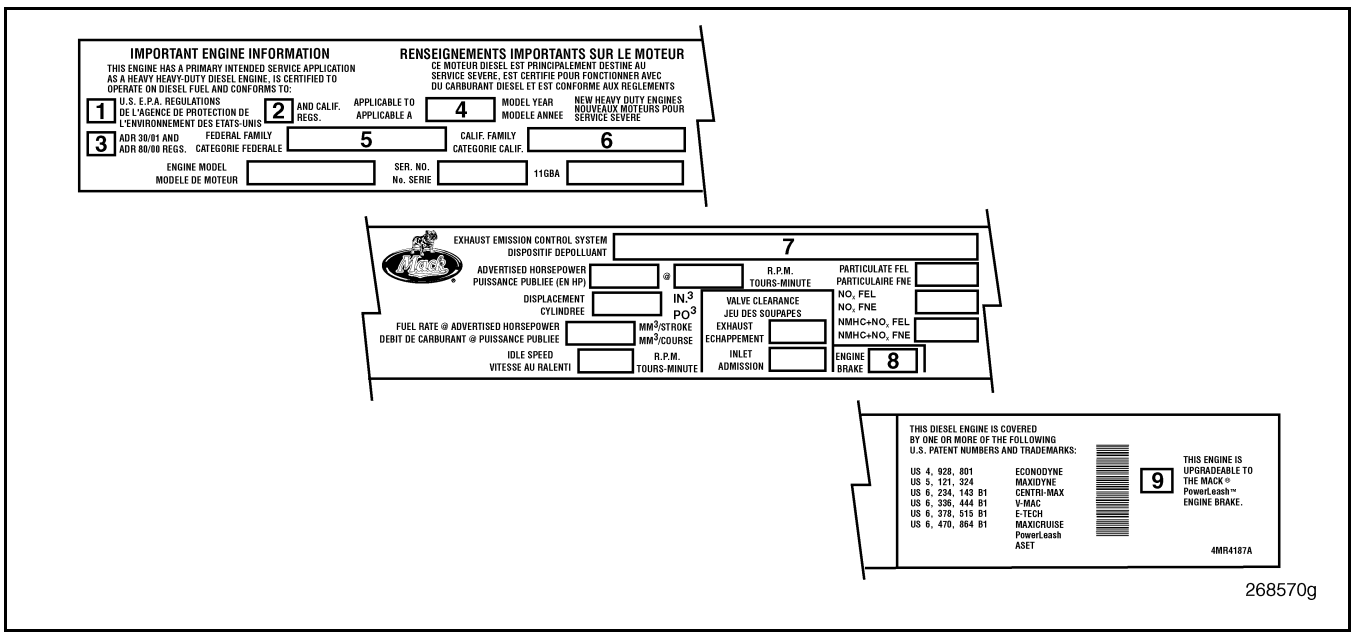

Figure 2 — Engine Information Plate

DESCRIPTION AND OPERATION

The VTG Position Control Valve, which is located on the intake manifold at the No. 4 cylinder position, provides the modulated air pressure required for opening and closing the turbine vanes. The control valve is an electrically controlled pneumatic assembly (Figure 18) that either increases, decreases or maintains air pressure based on commands sent by the EECU. An air valve having this capability must constantly bleed air pressure. This bleed air is released directly to the atmosphere from a 1-inch diameter port on the lower front side of the valve assembly.

Figure 18 — VTG Position Control Valve

On early-production engines (prior to May 4, 2004), supply air enters the control valve directly from the chassis air system. As a result, small amounts of oil mist in the chassis air system can condense inside the valve. It is a normal condition to notice some oil seepage from the bleed port.

Engines produced after May 4, 2004 have an oil coalescing air filter (Figure 19) incorporated into the air line supplying the control valve to prevent oil condensation and possible “coking” inside the VTG position control valve. The filter is mounted on a bracket at the lower side of the cylinder block, to the rear of the oil filters. A service parts kit is available to retrofit early-production engines if conditions warrant it.

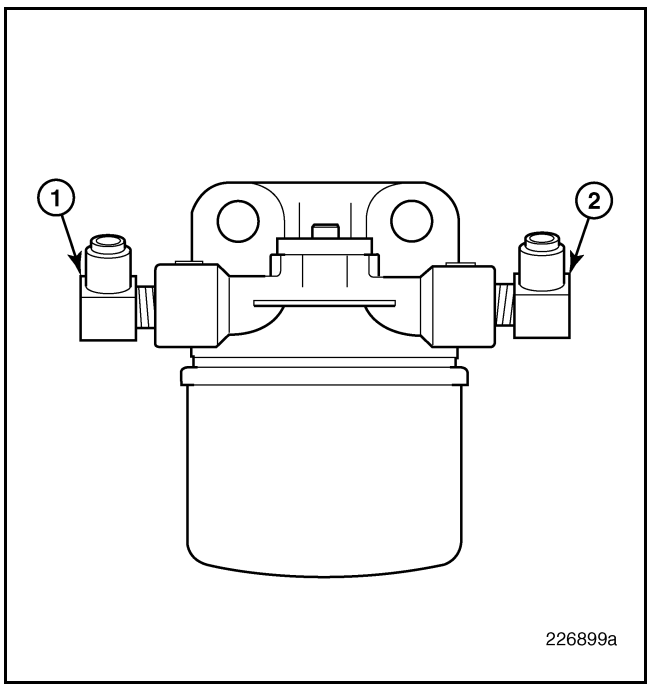

Figure 19 — Coalescing Air Filter

1. Outlet Port	2. Inlet Port

Pinless Valve Yokes — Inlet and Non-Brake Exhaust Valve Locations

Approximately two years prior to ASET™ engine introduction, MACK standardized the use of pinless valve yokes at all inlet valve locations, together with standard push rods. Effective May, 2003, pinless yokes are also used at exhaust valve positions of non-brake engines with spring-loaded push rods. As a result, valve yoke guide pins at the inlet and non-brake exhaust valve locations have been eliminated from the cylinder heads.

NOTE

For pinless yokes at the exhaust positions of non-brake engines, the spring-loaded push rods are mandatory.

The pinless yoke is self-leveling in operation and does not have a yoke leveling adjustment screw. Inlet and non-brake exhaust valve lash adjustments are performed in the normal manner with the rocker arm adjusting screw. For the engine brake exhaust valves, it is still necessary to adjust the valve yoke first, then the rocker arm lash.

The bottom of the valve yoke that bridges the two valves has a round hole and an elongated hole that fit over the valve stems. The nose of the yoke with the elongated hole has two notches in the casting. When installing the pinless yokes, it is important that the end of the yoke with the two notches faces away from the valve rocker shaft. If the yoke is installed incorrectly, the yoke will contact the rocker arm.

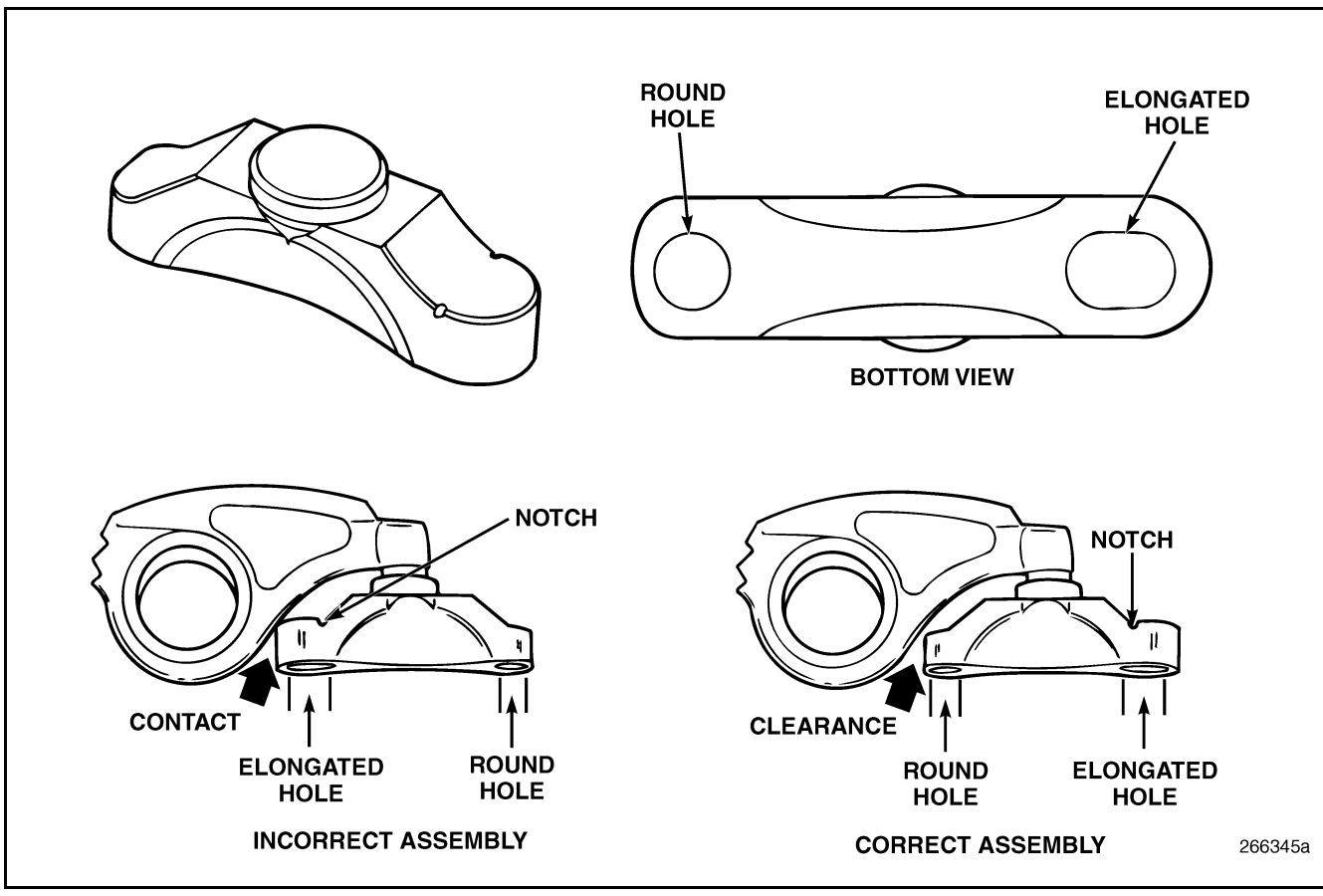

Figure 63 — Proper Assembly of the Pinless Valve Yoke

ENGINE SYMPTOM DIAGNOSIS FOR MACK ASET™ ENGINES

V-MAC III Diagnostics

NOTE

When operating in cold weather, fuel waxing can cause many of the problems described below. Also, water in the fuel can damage unit pumps and nozzles. Be sure to check for water in the fuel and/or fuel congealing before proceeding to troubleshoot a problem.

Also refer to the V-MAC III Service Manual, 8-211, for applicable blink code information.

ENGINE WILL NOT CRANK

Possible Cause	Correction
1. Batteries have low output.	1. Check the batteries. Charge or replace as required.
2. Loose or corroded battery or ground connections.	2. Clean and tighten battery and ground connections.
3. Broken or corroded wires.	3. Check voltage at the following connections: — Switch to starter — Battery to starter Replace as required.
4. Faulty starter or starter solenoid.	4. Check operation of starter and solenoid. Repair as required.
5. Faulty key switch.	5. Replace key switch.
6. Internal seizure.	6. Bar the engine over one complete revolution. If the engine cannot be turned, internal damage is indicated. Disassemble engine and repair as required.

REPAIR INSTRUCTIONS, PART 1

Water Pump Housing Removal

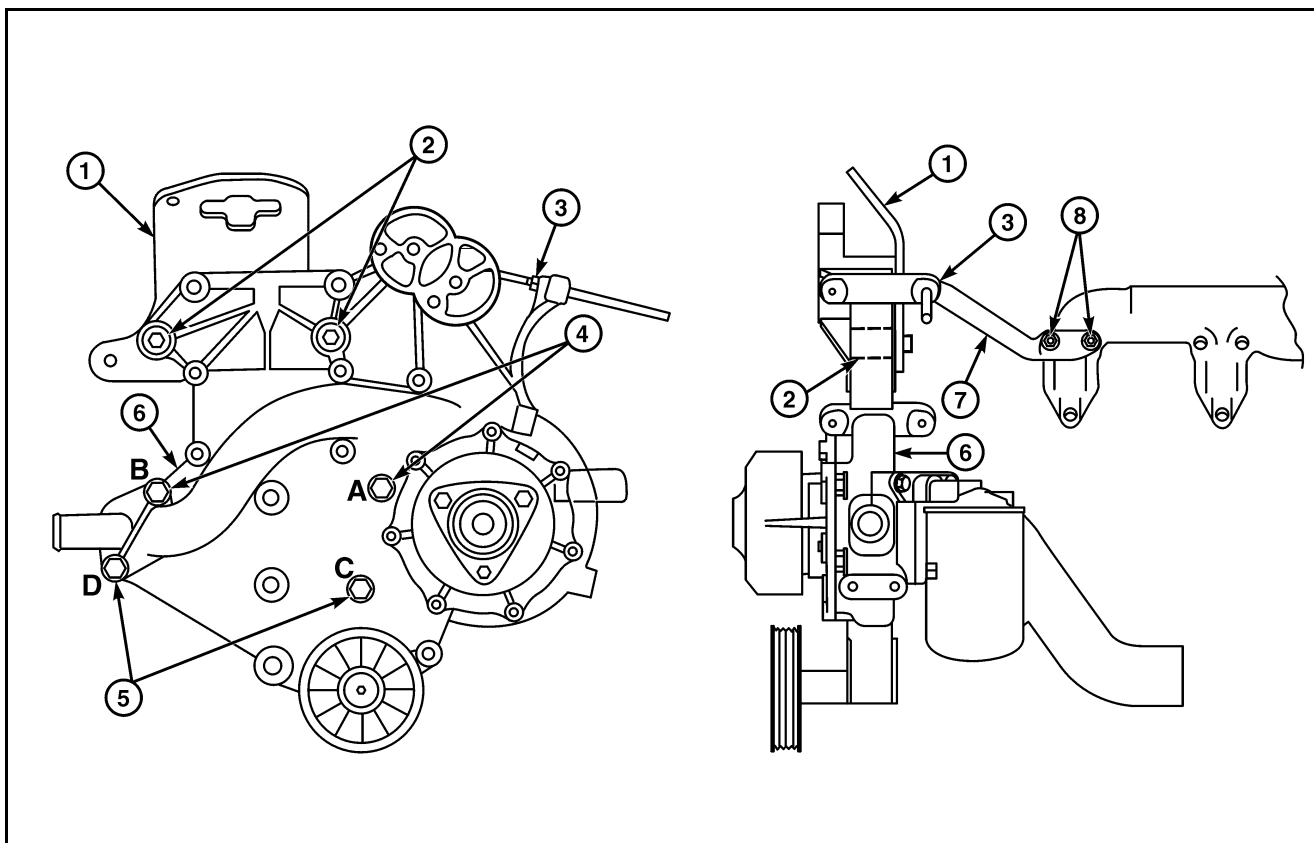

Figure 148 — Water Pump Assembly

1. Engine Lifting Bracket 2. Threaded Inserts and Upper Mounting Capscrews 3. Stiffening Bracket Forward Mount 4. Mid-Position Mounting Capscrews	5. Low-Position Mounting Capscrews 6. Water Pump Assembly 7. Water Pump Stiffening Bracket 8. Stiffening Bracket Rear Mount

If not already removed, first remove the coolant conditioner as follows:

1. Place a suitable container below the coolant filter area to catch any spilled coolant.
2. Using a suitable filter wrench, J 29927, or equivalent, remove the coolant conditioner filter element. Discard the element.
3. Remove the coolant conditioner head assembly from the pump housing by removing the mounting capscrews.
4. Remove and discard the O-rings.
5. Carefully remove and examine each check valve assembly. Depress the check ball. If the ball resists movement and does not return to its seat freely, the check valve assembly must be replaced.

To remove the pump housing, refer to Figure 149 as required to identify parts referenced in the steps below.

1. Remove the three mounting capscrews and remove the fan drive hub from the water pump housing (Figure 149).

AUXILIARY SHAFT AND CAMSHAFT BENCH PROCEDURES

Auxiliary Shaft Inspection

[212 CV]

The auxiliary shaft is identified by three machined circumferential cuts in front of the stamped part number.

INSPECTION

Refer to Figure 226.

1. Thoroughly clean the auxiliary shaft.
2. Inspect the shaft journals and splines, and gear teeth and splines for evidence of cracks, pitting, scoring or severe wear. If any of these conditions exist, replace the auxiliary shaft.
3. Make sure the orificed cup plug is in place in the internal passage at the front of the auxiliary shaft.

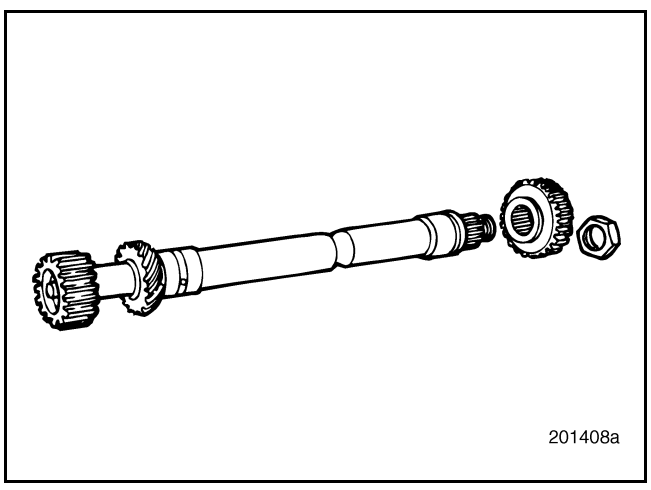

Figure 226 — Auxiliary Shaft

Camshaft Inspection

[213 CH]

GENERAL INSTRUCTIONS

All ASET™ engine models use a **straight** key, P/N 43AX9, in the camshaft-to-gear keyway. The offset key used in earlier MACK engine models no longer applies.

CAMSHAFT GEAR REMOVAL

An extremely tight interference fit holds the cam gear on the camshaft. Typically, 10 tons of force is required to remove the gear. When cam gear removal or installation is required, use the following procedures.

⚠ DANGER

A considerable amount of force may be necessary to remove damaged or spun gears. DO NOT apply more than 25 tons (22.7 metric tons) of force to gears. Doing so may shatter the gears and result in severe personal injury.

Refer to Figure 227.

1. Position two adequate steel plates on the press to support the camshaft gear. The plates should have a 4-inch (101.6 mm) hole cut out in the center when placed side-by-side, or similar size V-grooves, to allow clearance for the shaft journals while providing optimum support for the gear.
2. Set the camshaft, supported by the gear, into the press.
3. Using a suitable arbor, press the camshaft out of the gear.

⚠ CAUTION

Make sure there is enough clearance between the end of the camshaft and the floor while removing the gear. Do not let the camshaft fall or strike the floor when pressed through the gear. The camshaft can be bent easily, and may go unnoticed. Installing a bent camshaft in the engine could result in cam bushing failure.

4. Remove the thrust washer.

4. **Current Design Valve Stem Seal**

   Following valve stem-to-guide and valve stem-to-seal lip lubrication, install the current-production valve stem seals using valve seal installer J 45730.

   It is essential that the valve stem seal installation tool, J 45730, be used to install the seals. This tool ensures that the seal installs over the guide and to the proper depth on the valve guide.

⚠ CAUTION

When installing valve seals, it is essential that the proper valve seal installation tool (J 45730) be used. This tool bottoms on the cylinder head rocker arm mounting bracket surface when the seal is installed to the proper depth on the valve guide. Using any non-bottoming type seal driver (such as a socket) may result in distorting the top surface of the seal casing which permanently distorts the seal lip and prevents proper sealing. It can also result in the top rubber portion of the seal being cut off.

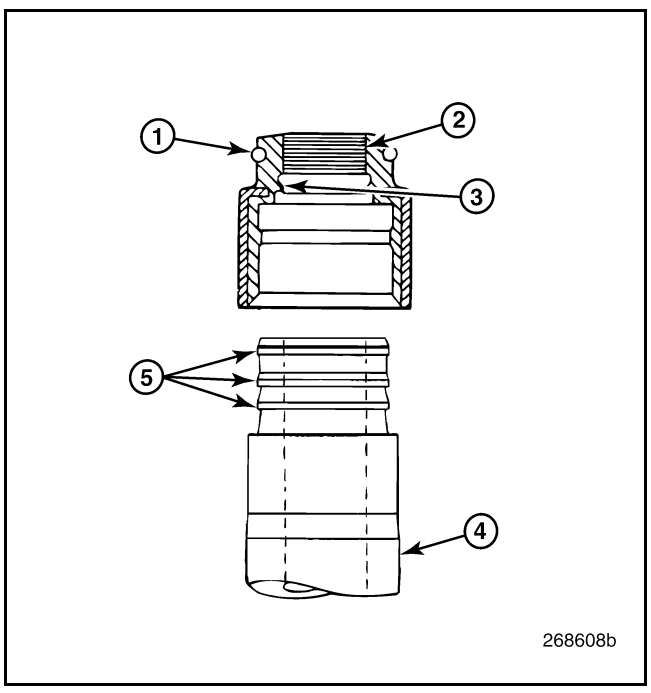

Figure 280 — Valve Stem Seal

1. Steel Retainer Band 2. Multi-Lip Section 3. Primary Lip	4. Valve Guide 5. Three Sharp Edges

5. Check the valve stem tip for nicks or burrs that may damage the valve stem seal upon installation.
6. Install the valve and either install the bottom rotator or the hardened spring washer if tip-end rotators are used. Place the valve springs over the valve stem and onto either valve rotator or hardened spring washers. Intake valves use a single outer spring and the exhaust valves use a combination of inner and outer springs.

SERVICE HINT

Current-production exhaust location inner springs are now being painted white. These springs are completely interchangeable with the former bare steel springs. The white paint was added to help verify that the inner spring is present after the cylinder head is built-up.

REPAIR INSTRUCTIONS, PART 1

Flywheel Installation

[212 VC]

TIMING SCALE

The flywheel has a stamped timing scale of top center (TC) to 45 degrees of engine travel (engine timing) and three stamped locations, 120 degrees apart, for valve settings as shown in Figure 346. The flywheel still has pump timing marks for application to both current and older engines; the marks are not needed for current engines.

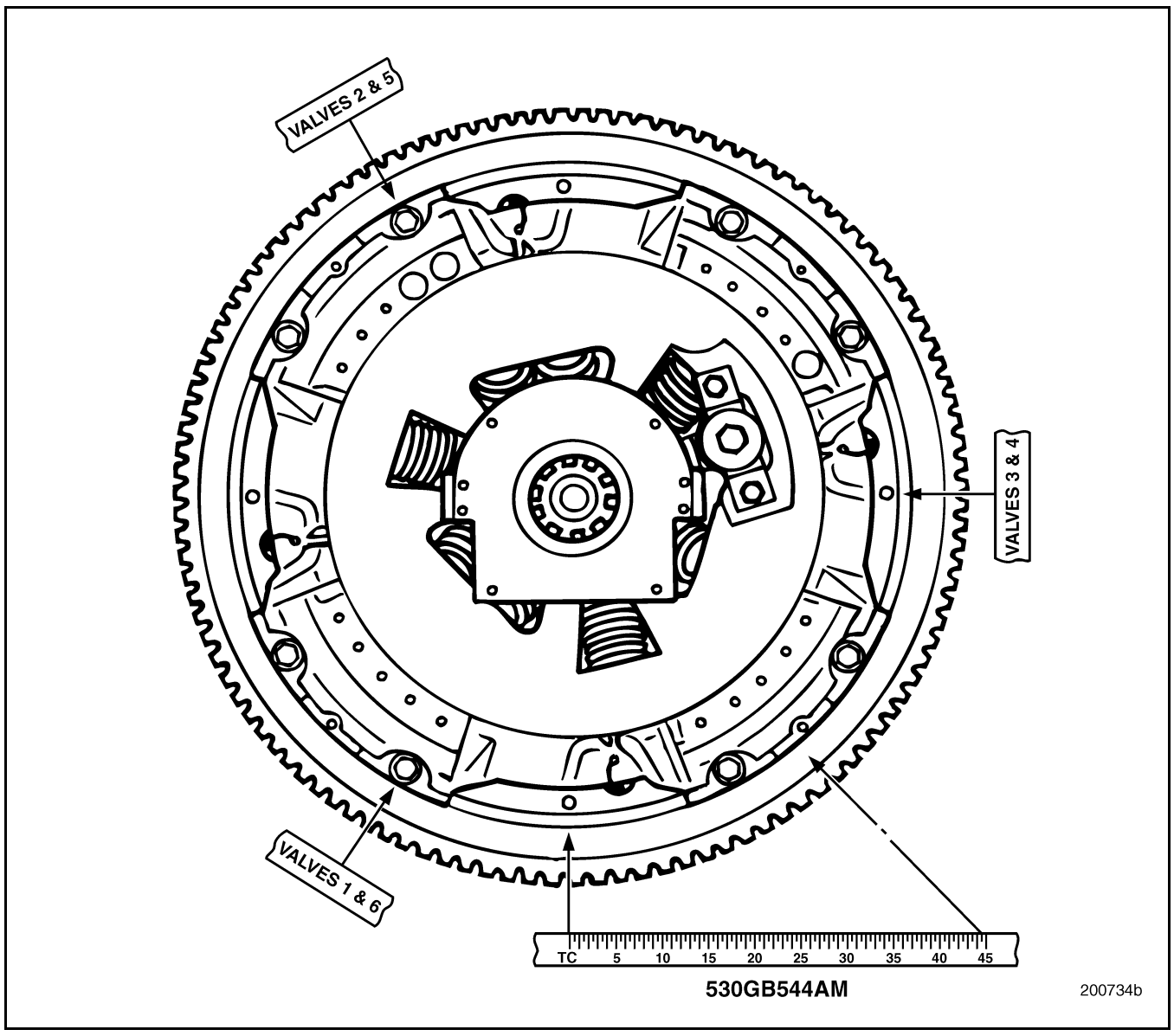

Figure 346 — Flywheel Markings

6. Install the cab heater coolant return hose and valve into the thermostat housing (if applicable). Also install the optional fuel heater coolant return hose into the thermostat housing (if equipped). The cab heater and optional fuel heater coolant return hoses were relocated from the thermostat housing to the radiator lower tube in mid-2004.
7. Reconnect the bypass and radiator hoses at the front of the thermostat housing (Figure 426) and reconnect the surge tank hose. Tighten all hose clamps to specifications.

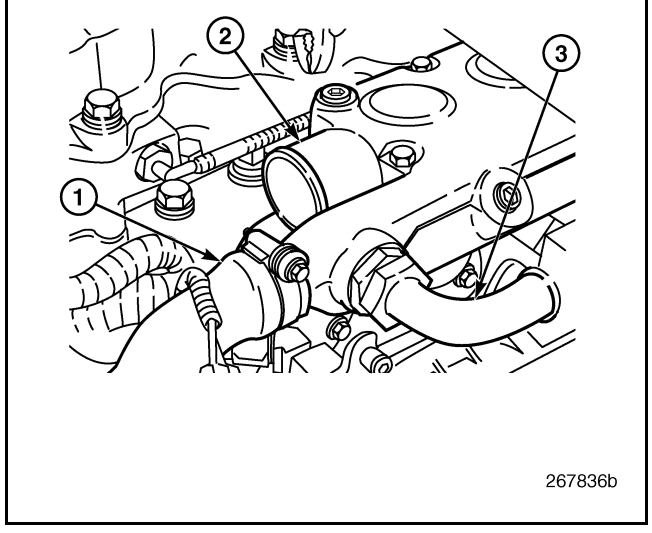

Figure 426 — Thermostat Housing Hose Connections

1. Bypass Hose 2. Radiator Hose Port	3. Surge Tank Port

8. Refill the surge tank with the coolant removed at disassembly.

EGR Mixer Tube Installation [214 HL]

1. Clean and inspect the mating flange for the EGR cool tube. Install a **new** graphite wire-mesh seal in the flange.
2. Clean and inspect the mounting collar on the inlet manifold. Then, install a **new** O-ring on the collar (Figure 427).

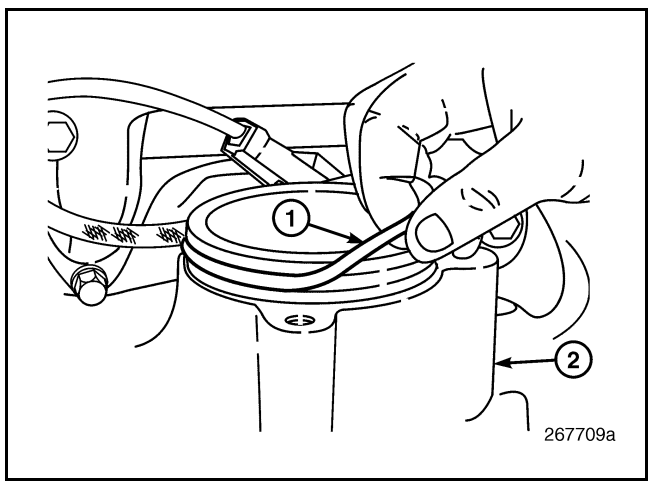

Figure 427 — O-Ring Installation

1. O-Ring	2. Inlet Manifold

3. Place the mixer tube in position on the inlet manifold (Figure 428) and install the two mounting capscrews. Tighten the capscrews to specification, 40 lb-ft (55 N•m).

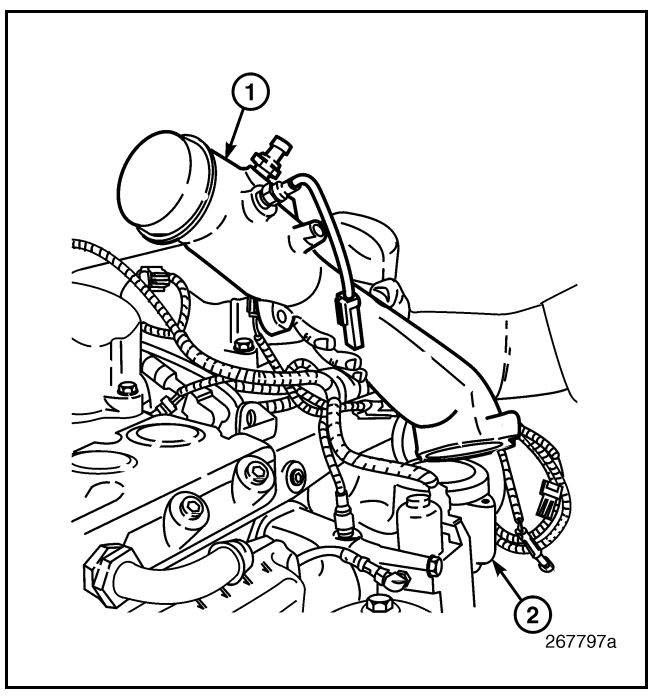

Figure 428 — EGR Mixer Tube Installation

1. EGR Mixer Tube	2. Inlet Manifold

4. Install the capscrew attaching the support bracket to the side of the mixer tube. Tighten the capscrew to specification, 40 lb-ft (55 N•m).

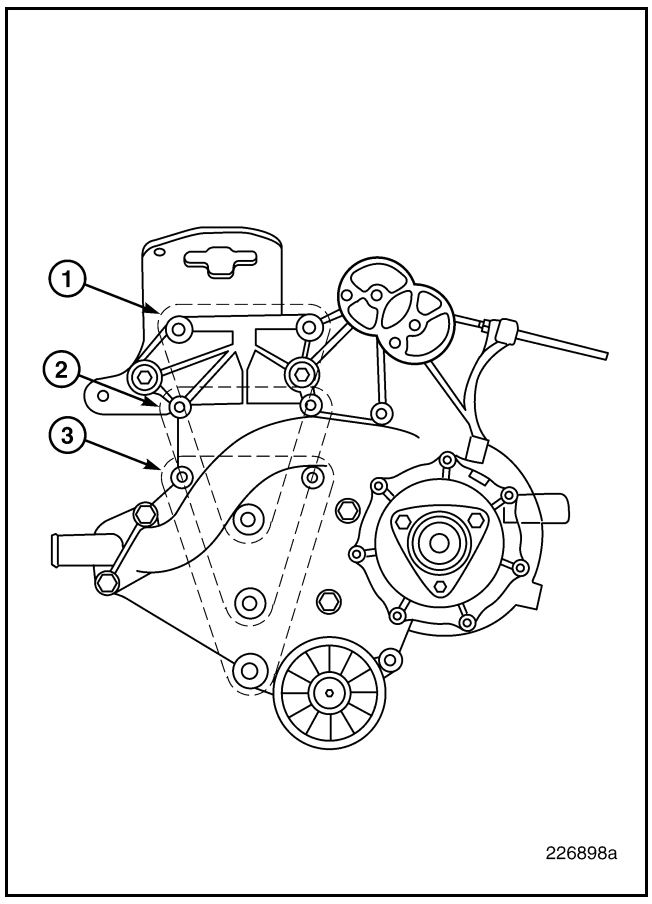

Figure 445 — Fan Clutch Assembly Bracket Mounting Locations

1. Bracket Upper Mounting Location 2. Bracket Middle Mounting Location	3. Bracket Lower Mounting Location

16. Install the accessory drive belts and adjust the belts to specification.
17. Using a lifting device, place the radiator in position at the front of the engine.
18. Install the retaining capscrews to the lower radiator support mounts.
19. Install the retaining capscrews to the radiator support rods.
20. Position the fan clutch air solenoid valve, if so equipped, on the radiator support and install the retaining fastener.
21. Locate the engine coolant temperature sensor, if applicable, and connect it to the wiring harness. Fasten the sensor harness to the radiator support.
22. Install the chassis-mounted charge air cooler (CMCAC) outlet tube and hoses between the cooler and EGR mixer tube.

⚠ CAUTION

Be sure to position the CMCAC hose clamps with the bolts on the underside of the hose connection at the EGR mixer tube. If the clamp bolts are installed at the top position, the bolts could rub against the air cleaner duct causing damage to the duct.

COOLING SYSTEM SERVICE PROCEDURES (IN-CHASSIS)

Thermostat Replacement

[215 NU, NG & LD]

The EGR mixer tube must be removed to gain access to the thermostat housing for replacement of the thermostats. Once the mixer tube is removed, proceed as follows:

⚠ WARNING

Allow the cooling system to cool completely before attempting to remove the thermostat or thermostat housing. To avoid injury when removing the pressure cap from the surge tank, turn the cap counterclockwise to the first stop, but do not depress. Allow pressure to dissipate completely, and then press on the cap downward and continue turning to remove.

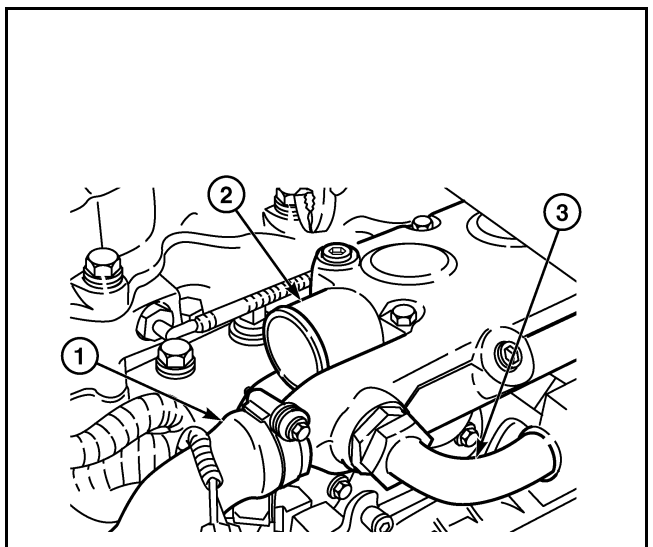

Figure 465 — Thermostat Housing Hose Connections

1. Bypass Hose 2. Radiator Hose Port	3. Surge Tank Port

THERMOSTAT HOUSING REMOVAL

[215 NG & NU]

1. Loosen the hose clamp for the surge tank port at the side of the thermostat housing. Allow the surge tank to drain into an approved container and save the coolant for reuse.
2. Loosen the hose clamps and disconnect the bypass and radiator hoses at the front of the thermostat housing (Figure 465).
3. Remove the cab heater and optional fuel heater coolant return hoses from the thermostat housing (if applicable). The cab heater and optional fuel heater coolant return hoses were relocated from the thermostat housing to the radiator lower tube in mid-2004.
4. Loosen and remove the three mounting capscrews from the thermostat housing.

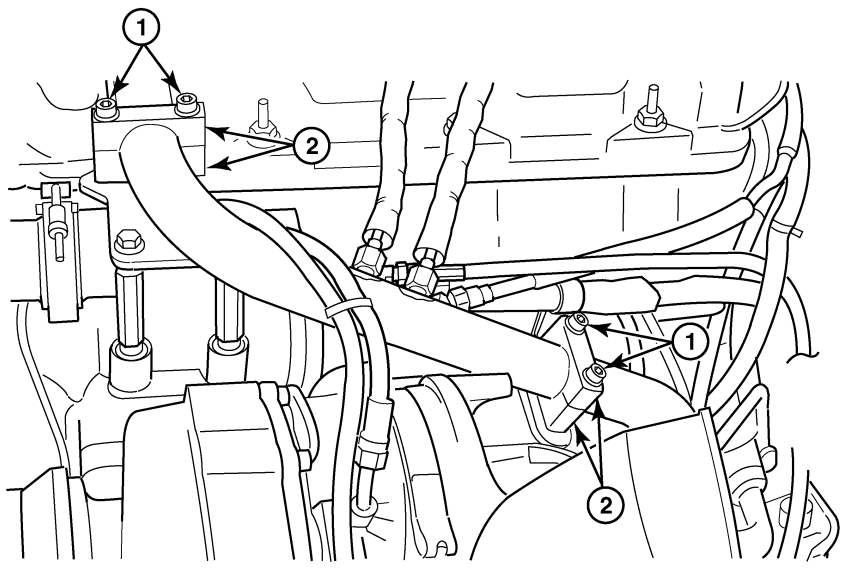

Figure 491 — Cool Tube Clamp Installation

1. Mounting Bolts	2. Clamps, Upper and Lower Halves

5. Start the engine and allow it to warm up. Check for leaks in the EGR system.
6. Stop the engine. Allow it to cool down and then retorque the clamps.

2. Using spanner wrench J 47019, install the spanner nut securing the actuator assembly to the mounting flange. Tighten the nut to specification, 92 lb-ft (125 N•m).

NOTE

To ensure that the spanner nut is tightened to the proper torque value, spanner wrench J 47019 (Figure 525) is required.

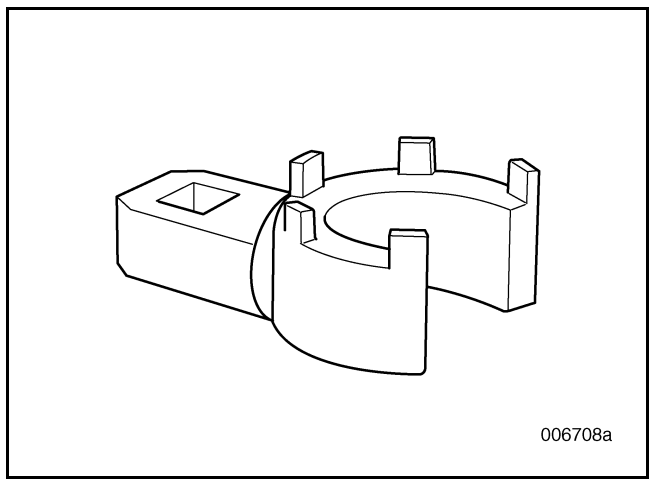

Figure 525 — Spanner Wrench (J 47019)

3. When tightening the spanner nut, make sure that the spanner wrench fully engages the nut as shown in the Figure 526. If not properly engaged, the wrench tangs can be damaged if the wrench slips out of engagement when torque is applied.

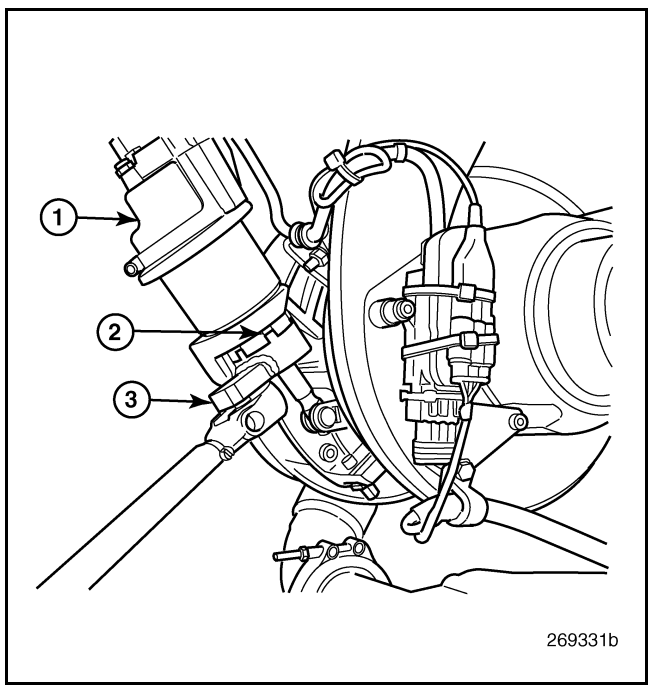

Figure 526 — Using Spanner Wrench to Tighten Spanner Nut

1. VTG Actuator Assembly 2. Spanner Nut	3. Spanner Wrench (J 47019)

4. Adjust and verify actuator rod length as follows:
   a. Manually move the VTG lever arm clevis against the upper stop (vanes fully opened).
   b. With the actuator rod fully retracted and the lever arm clevis against the upper stop, note the alignment of the hole in the lever arm clevis with the hole in the actuator rod end. If not in alignment, release the lever arm clevis and allow it to rest on the lower stop, then loosen the actuator rod end jam nut and adjust the rod end until the holes are in alignment (when the lever arm clevis is against the upper stop). The adjusted actuator rod length can be verified by inserting the rod end pin and making sure the clevis remains against the upper stop.

NOTE

- The torque screwdriver may allow the adjusting screw to loosen slightly when it “clicks” at the pre-set torque. It is important to develop a “feel” for when the screwdriver click occurs and feel for the actual setting of the lash. To develop a feel for when the screwdriver will click, slowly turn the screwdriver through the function once or twice, and for the third time, bring the screwdriver just to the point before it clicks. Also, at no time should the screwdriver be turned clockwise after the click has occurred. Always recheck the adjustment.
- When tightening the adjusting screw, it is important to make sure that the adjusting screw jam nut is NOT bottomed against the rocker arm, and that the swivel-head adjusting screw at the nose end of the rocker arm is NOT in contact with the valve yoke.
- If either the push rod spring or the brake actuator plunger are not compressed, brake lash is not set correctly and the adjustment procedure must be repeated.

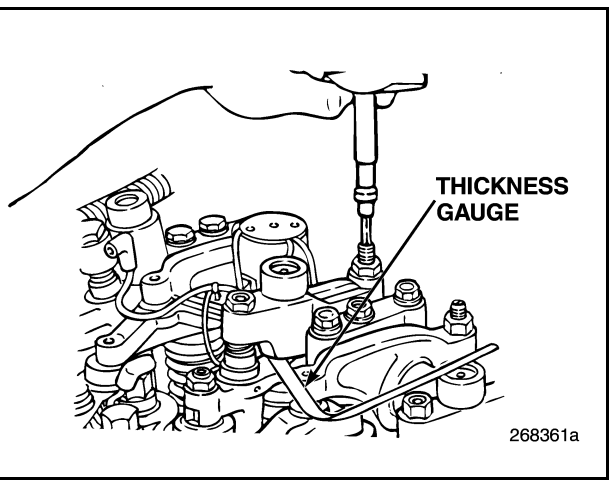

Figure 571 — Adjusting Engine Brake Hydraulic Actuator Lash

5. Remove the T-handle torque screwdriver, then use a hex-bit screwdriver to hold the adjusting screw in position. Use an accurately calibrated torque wrench to tighten the jam nut to 45 lb-ft (61 N•m).

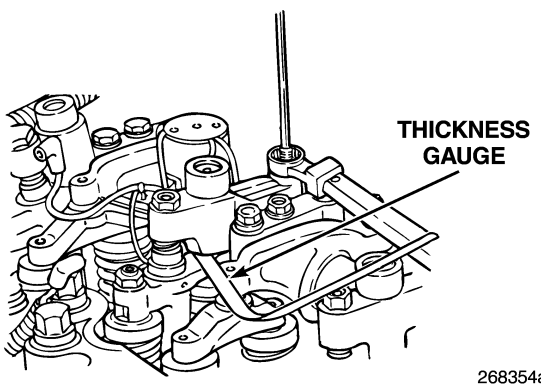

Figure 572 — Tightening Adjusting Screw Jam Nut

NOTE

After completing the brake plunger lash adjustment, leave the 0.045-inch (1.14 mm) thickness gauge in place. This keeps the plunger and push rod spring compressed so that the exhaust valve lash can be adjusted.

Exhaust Valve Lash Adjustment (PowerLeash™ Brake Engine)

1. With the 0.045-inch (1.14 mm) thickness gauge in place between the valve yoke and the hydraulic actuator plunger, insert a 0.024-inch (0.610 mm) thickness gauge between the adjusting screw “foot” and the valve yoke. Using a 5 mm Allen wrench, turn the adjusting screw until a light “drag” is felt on the thickness gauge.

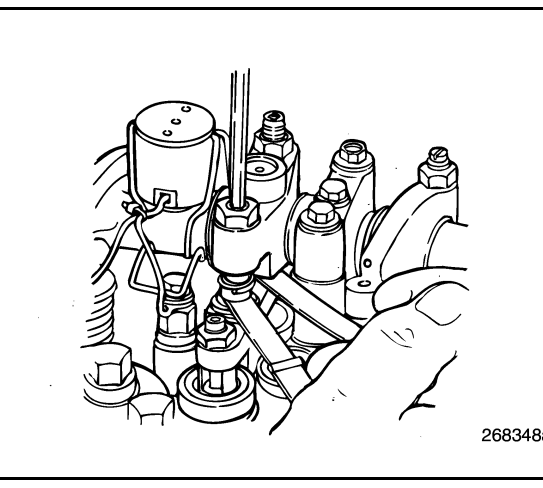

Figure 573 — Adjusting Exhaust Valve Lash