

Alternator

Screen 1:

Welcome Screen:

Welcome to the Alternator module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Alternator:

In this module, you will learn how to inspect, maintain, remove, and install the alternator.

At the end of this module, you will be able to:

- State the purpose and location of the alternator.
- Explain the basic operation of the alternator.
- Describe how to perform running maintenance related to the alternator.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspecting and maintaining the components of the alternator in a running repair environment, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Alternator Overview:

Contrary to popular belief, a locomotive is not directly powered by the mechanical energy produced by the diesel engine. Instead, there is a conversion of mechanical energy from the diesel engine to electrical energy and once again back to mechanical energy by the traction motors. This conversion process is necessary because the use of mechanical energy alone would require a transmission system the size of a house to handle the power of the diesel engine! The ES44AC locomotives are typically equipped with either a 5GMG203 or 5GMG205 alternator. These alternators connect to the crankshaft through an externally-mounted flex plate. The flex plate is first mounted to the crankshaft, and then the alternator's rotor is bolted to the flex plate. The ES44DC locomotives are typically equipped with a 5GMG206 alternator. The 5GMG206 is different from the 5GMG203 and 5GMG205 in the fact that its traction alternator is sized according to the application requirements. Although these alternators are not identical, the basic operation and maintenance is the same for all. Regardless of the alternator model, the alternator's purpose is to convert the rotational mechanical energy from the diesel engine into electrical power that will be used to power the traction motors and the locomotive's systems.

Screen 5:

Alternator Overview (Cont'd):

The 5GMG203, 5GMG205, and 5GMG206 alternators all consist of two main sub-assemblies: the Traction Alternator (TA) and the Auxiliary Alternator (AA). The TA produces the electrical energy required to power the traction motors, while the AA produces the electrical energy required to power the locomotive systems. Both assemblies are salient-pole, 3-phase, Y-connected machines mounted on a common frame in the blower cab. They are configured as a single unit attached to the rear, #1 end of the diesel engine. For the specific purposes of this module, we will discuss both the TA and AA as a single, unified machine. The alternator is a single bearing machine with the rotor mechanically coupled to the flex plate on the engine's crankshaft. Approximately half of the alternator's weight is supported by the collector end roller bearing, while the other half is supported by the crankshaft. The alternator can be removed as either a separate component or along with the diesel engine. After the alternator is coupled to the diesel engine, it is important to ensure that the web deflection of the crankshaft is within specific limits. Otherwise, too much weight on the end of the crankshaft may cause excess crankshaft stress and lead to damage.

Screen 6:

Alternator Operation:

On ES44AC/DC locomotives, rotational mechanical energy is produced by a GEVO diesel engine. Using the alternator, the locomotive converts the engine's rated 4400 hp into 3.3 MW of electrical power. The diesel engine crankshaft is mechanically coupled to the alternator rotor. The AA's field windings are excited by the Auxiliary Alternator Field Controller (AAC) and produce a magnetic field of force. As the engine's mechanical energy turns the rotor, electrical energy is induced into each set of the AA stator windings. These three windings produce 3-phase AC voltages that are directly proportional to the field excitation current for a given engine RPM. Two of the three output windings, the excitation supply windings and the battery charger supply windings, cable the AC power to the power converter panels where it is converted to DC power. The DC power is used to excite both alternators and to recharge the locomotive's batteries, respectively. The third set of output windings, the auxiliary motor supply windings, provides AC power to run seven AC motors on the locomotive.

Screen 7:

Alternator Operation (Cont'd):

The TA's field windings are excited by the Traction Alternator Field Controller (TAC) and produce a magnetic field of force. As the engine's mechanical energy turns the rotor, electrical energy is induced into the TA stator windings. These windings produce a 3-phase AC voltage output that is directly proportional to the field excitation current for a given engine RPM. The induced 3-phase AC voltage is then fed to rectifier modules and converted to DC power. On an ES44DC locomotive, this DC power is directly distributed to the six DC traction motors. On an ES44AC locomotive, the rectified DC power is inverted back into 3-phase AC power by the traction inverters and then distributed to the six AC

traction motors. The traction motors convert the electrical power back into mechanical power to pull a train.

Screen 8:

Scheduled Maintenance:

Every 92 days, the 5GMG203, 5GMG205, and 5GMG206 alternators should be inspected. Brushes, brush length, and the surface condition of the collector rings should be checked. Annually, the alternator main bearing should be lubricated, with the recommended grease through a single grease fitting located on the inside wall of the collector ring compartment. The initial lubrication is sufficient for the first two years of service. Thereafter, 1-2 oz. (28-57 g) of grease should be applied at one-year increments. A standard shop grease gun may be used. Every time the alternator is removed and reinstalled, confirm proper engine and alternator alignment by setting and recording the web deflection of the crankshaft to ensure that the weight on the end of the crankshaft is within limits.

Screen 9:

Brush Inspection:

Engineering recommends that all alternator brushes should be replaced at each maintenance interval.

Warning:

- Rotating equipment is present in the alternator. To prevent physical injury, stay clear of all rotating equipment, and be sure to observe all railroad and government safety precautions.
- Electrocution Hazard - Before performing any maintenance on the electrical equipment, ensure that there is no power on the traction or auxiliary alternator circuits.
- For ES44AC locomotives, capacitors in the inverter circuits may not be fully discharged and lethal voltages may exist. Before entering the auxiliary cab, raise and lock the barrier bar in the vertical position by securing a padlock in the supplied hole. Wait until the LEDs on the Common Power Indicator (CPI) are extinguished before entering. If the LEDs do not go off, then run the Crank Transfer Switch (CTS) self-test and move the CTS into the "CENTER" or propulsion position. If the LEDs remain lit, open the Battery Switch (BS) located in CA1 and verify that the LEDs on the CPI panel are extinguished.
- For ES44DC locomotives, lethal voltages may be present. Follow all railroad operating procedures. Before entering the auxiliary cab, raise and secure the barrier bar in the discharge position. Ensure that all lights on the CPI panel above the auxiliary cab door are extinguished. Using a voltmeter, verify a zero voltage. Failure to do so may result in serious injury or death.

When inspecting brushes:

- Ensure that the pigtailed are positioned correctly. They must be parallel with, but not rubbing against, the pressure arm.

- Ensure that the pigtail terminal bolts are tight.
- Move the brushes up and down several times in the brush holders to release any carbon dust or foreign matter in the carbon ways that could prevent free movement of the brushes.

Note: When replacing brushes because of wear, always replace the complete set of brushes even though some may still be long enough to pass the minimum length test. Often a long brush is a high resistance brush and does not share current properly.

Screen 10:

Brush Removal:

Typical steps to remove a brush are as follows:

1. Unlatch the brush pressure spring thumb loop.
2. Loosen the terminal bolt on the brush holder.
3. Slide the brush out of the brush holder.

Screen 11:

Brush Installation:

Caution: When installing new brushes, use the recommended grade. Do not mix brush grades. Mixing grades in the same alternator or changing to another grade can seriously affect the collector-ring surface film and result in short brush life.

Typical steps to install a brush are as follows:

1. Insert each brush into a brush holder so that the contour of the brush or its riding surface matches that of the collector ring.
2. Position the pigtail terminal under the terminal screw and parallel to the brush pressure arm.
3. Tighten the terminal screw, and torque it to 6-8 lb-ft (8.13-10.85 Nm).
4. Latch the brush pressure spring thumb loop over the detent in the brush holder body.
5. Dress the pigtail leads such that the pigtail wires do not interfere with the action of the pressure arm, rub against each other, or rub against adjacent brush holders.

Note: Ensure that the pigtails clear the pressure arm by gently pressing them.

Screen 12:

Brush Holder Inspection:

When inspecting the brush holders:

- Check for loose, broken, bent, or overheated pressure arms. Overheating will cause the arms to discolor and result in improper brush arm pressure.
- Annually verify brush arm force. If it is below 4.25-4.75 lb (1.93-2.15 kg), replace the brush holder.
- Ensure that the thumb loop on the coiled brush pressure spring is in position with the spring end placed into the detent.

- Inspect the brush holder mounting arrangement, and ensure the clamp pads are in place and tight against the brush holder stud. If they are not in place, locate the clamp pads and torque the clamp bolts to 16-18 lb-ft (22-24 Nm).
- Check the brush holder-to-collector ring clearance. If the clearance is not between 0.089 and 0.091 inches (2.2-2.3 mm), adjust the clearance as discussed in the Brush Holder and Stud Assembly Alignment section of this module.
- Inspect the brush holder assembly for broken connection straps or bus rings. Replace, if necessary, as discussed in the Brush Holder and Stud Assembly Removal and the Brush Holder and Stud Assembly Installation sections of this module.
- Check by hand the tightness of the bus ring to the brush holder bolts. If loose, torque the bolts to 22-24 lb-ft (30-33 Nm).

Screen 13:

Brush Holder Stud Inspection:

When inspecting the brush holder studs:

- Wipe the brush holder studs clean.
- Inspect the brush holder stud for cracked, discolored, or worn insulation. Replace the complete stud if insulation is found to be faulty.
- If brush holders are found to be loose or are moveable by hand, inspect the stud for discoloration and wear. Replace the stud, if damaged. If there is no damage, reinstall the stud as discussed in the Brush Holder and Stud Assembly Installation section of this module.

Note: All studs should have a “W” stamped on the end of the center bar. If this is not present, replace the assembly.

Screen 14:

Brush Holder and Stud Assembly Maintenance:

If a single brush holder or a brush holder stud needs to be replaced, remove the entire brush holder and stud assembly from the alternator, replace the faulty component, and return the whole assembly to the alternator.

Warning: When using compressed air for cleaning purposes, an environment that is potentially hazardous to personnel in the immediate area is created. To prevent physical injury due to flying debris, observe all railroad and government safety regulations.

Cleaning solvents may be toxic or flammable. They can cause serious or fatal injury if used without proper precautions. For safety:

- Do not inhale solvent fumes.
- Use solvents only in adequately ventilated areas.
- Avoid contact of solvent with skin.
- Observe caution statements issued by the manufacturer of the solvent.

Typical steps to clean the brush holder and stud assembly are as follows:

1. With the brush holder/collector ring cover removed, blow out the compartment with clean, dry compressed air.
2. Wipe off the insulation between the collector rings and the collector ring studs with a clean, dry rag.
3. Using an appropriate solvent, wipe away any residue from the brush holders with a clean, dry lint-free cloth.

Screen 15:

Brush Holder and Stud Assembly Removal:

Typical steps to remove a brush holder and stud assembly are as follows:

1. Remove all brushes from each of the assemblies.
2. Disconnect the field cables from the bus rings at the 9 o' clock position of the brush holder stud.
3. Slide a 0.06 inch (1.52 mm) thick sheet of heavy paper between the brush holders and the collector rings to protect the collector ring surfaces from damage.
4. Loosen and remove four of the eight bolts securing the brush holder yoke to the mounting block.
5. Insert a 0.5 - 13 alignment pin into two of the four exposed bolt holes and remove the four remaining bolts.
6. Slide the yoke with all three brush holder and stud assemblies off the alignment pins and carefully transport it to a bench.

Screen 16:

Brush Holder and Stud Assembly Removal (Cont'd):

7. Clean and replace any components, as required.
8. Remove the bolts and washers holding the bus rings to the brush holders of the brush holder and stud assembly to be removed.
9. Remove the mounting bolt and washer holding the brush holder stud to the brush holder yoke.
10. Remove the brush holder and stud assembly from the yoke.
11. Loosen the brush holder clamp bolt and remove the brush holder clamp pad.
12. Remove the brush holder body from the brush holder stud.
13. Repeat, as necessary, until the faulty brush holder body has been removed.

Screen 17:

Brush Holder and Stud Assembly Installation:

Typical steps to install a brush holder and stud assembly are as follows:

Note: When mounting brush holders onto the stud, adhere to the following:

- To ensure proper brush holder installation, the brush holder and stud **MUST** be assembled before installation into the alternator.

- Dimensions shown are measured on the inside surface of the brush holder, not on the outside edge of the brush holder.
- The brush holder-to-stud locating dimensions must be carefully held within tolerances. Check locations before proceeding.
- Older epoxy brush holder studs are completely interchangeable with the newer molded stud; however, the molded stud is preferred.
- If provided with a pre-assembled new brush holder-stud assembly (red stud with brush holders already mounted and torque marked), skip steps 1-7. The steps have already been performed by the brush holder manufacturer.
- If the stud is going to be reused and only a brush holder is being replaced, skip steps 5-7.
 1. Mount the brush holder bodies on the brush holder stud.
 2. Verify that the brush holder is properly oriented on the brush holder stud.
 3. Tighten the brush holder clamp bolt to 16-18 lb-ft (22-24 Nm).
 4. Verify that the clamp pad is in place.
 5. Heat the brush holder and stud assembly to 302° F (150° C) for two hours.
 6. Cool the brush holder and stud assembly to room temperature.

Note: Ensure that the steel portion of the stud is no more than 18° F (10° C) above ambient temperature.

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Brush Holder and Stud Assembly Installation (Cont'd):

7. Re-torque the bolts to 16-8 lb-ft (22-24 Nm).
8. Assemble the brush holder and stud assembly to the brush holder yoke but do not tighten the mounting bolt.
9. Ensure that the 0.06 inch (1.52 mm) thick paper is in place to protect the collector ring surfaces.
10. Using the 0.5 - 13 alignment pins, slide the yoke with all three brush holder assemblies into position, then start six of the brush holder yoke to mounting block fixing bolts.
11. Tighten the six fixing bolts until the yoke assembly does not move, then remove the two alignment pins and insert the two remaining fixing bolts.
12. Torque all eight bolts to 165-185 lb-ft (223.7-250.8 Nm).
13. Align the new brush holder and stud assembly as discussed in the Brush Holder and Stud Assembly Alignment section of this module.

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Brush Holder and Stud Assembly Alignment:

Typical steps to align the brush holder and stud assembly are as follows:

Note: The brush holder to stud clamp must not be loosened during this process.

1. Assemble the brush holder and stud assembly to the brush holder yoke but do not tighten the mounting bolt.
2. Place a 0.089-0.091 inch (2.2-2.3 mm) thick fiberboard shim between the brush holders and the collector rings.
3. Slide the brush holder against the fiberboard shim and tighten the brush holder stud mounting bolt.
4. Torque the mounting bolt to 165-185 lb-ft (223.7-250.8 Nm).

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Brush Holder and Stud Assembly Alignment (Cont'd):

5. Remove the shim.
6. Install the bus ring bolts and washers that hold the bus rings to the brush holders.
7. Torque the bus ring bolts to 22-24 lb-ft (30-33 Nm).

Note: The large diameter washers are assembled on the 10:30 and 12 o'clock brush holder stud positions.

8. Install the brushes as discussed in the Brush Installation section of this module.

Note: Each brush must ride in the center of the collector ring. If it does not, adjust the location of the brush holder on the stud as discussed in the Brush Holder and Stud Assembly Installation section of this module.

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Brush Holder Cover Hose and Clamps Inspection:

When inspecting the brush holder cover hose and clamps:

- Verify that the hose clamps are tight. If they are loose, assemble them as discussed in the Brush Holder Cover Hose and Clamp Installation section of this module.
- Verify that there are no tears or holes in the hose itself. If there are, replace the hose.
- Ensure that the hose is not bunched or pinched under the clamp.
- Inspect the clamps for cracks or stripped adjusters. Replace clamps as required.

Screen 22:

Brush Holder Cover Hose and Clamps Removal:

Typical steps to remove the brush holder cover hose and clamps are as follows:

1. Using a correctly sized nut driver or a straight blade screwdriver with a heavy spade, loosen the bolt on the hose clamp until the clamp can be moved around freely.
2. Twist the hose to break it free of the flange pipe, and remove the hose from the flange pipe.
3. Repeat the steps with the other end of the hose.

Screen 23:

Brush Holder Cover Hose and Clamps Installation:

Typical steps to install the brush holder cover hose and clamps are as follows:

1. Position the hose onto the upper flange pipe.
2. While holding the hose in place, tighten the clamp using a correctly sized nut driver or a straight blade screwdriver with a heavy spade.

Note: Repeat the step with the brush holder cover end of the hose.

3. Attempt to twist the hose and if it moves, tighten the clamp until it is secured on both ends.

Note: The clamp should be torqued to 1.0-1.5 lb-ft (1.4-2.0 Nm).

Screen 24:

Brush Holder/Collector Ring Cover Inspection:

When inspecting the brush holder/collector ring cover:

- Inspect for damage and missing mounting hardware. Repair or replace the cover, as necessary.
- Inspect the field cables for broken or overheated insulation and wires.
- Inspect for loose hardware and terminals. Replace as necessary.
- Inspect the field cable terminal insulators for loose hardware, burning, cracking, or other damage. Replace as necessary.

Screen 25:

Collector Ring Inspection:

Warning: Electrocution Hazard - Before performing any maintenance on the electrical equipment, ensure that there is no power on the traction or auxiliary alternator circuits.

When inspecting the collector rings:

- Check each collector ring for looseness on the insulation and the associated stud rings for shorted studs or damaged insulation. Replace the collector ring hub assembly if defects are noticed.
- Look for yellow or white dust around the base of the ring and a measurable gap between the ring base and the insulation. A gap between the collector ring bore and the insulation will cause movement of the collector ring on the insulation when pressure is applied by hand on the collector ring. Replace the collector ring assembly if the collector ring is loose.
- Look for ribbons of Teflon® at the location where the studs pass through the rings and for indications of arcing or other damage to the rings or studs. Ribbons of Teflon® are an early sign of fretting between the stud insulation and the rings. Replace the collector ring assembly if signs of fretting are noticed.

- Check the depth of the spiral grooves machined in the rings. When the alternator is new, the grooves are 0.140-0.180 inches (3.6-4.6 mm) deep. If they measure less than 0.020 inches (0.5 mm) deep, replace the collector ring hub assembly.
- Inspect the condition of the collector ring surfaces. Check for evidence of discoloration, etching, grooving, threading, or other signs of distress that require repair or replacement.

Screen 26:

Collector Ring Resurfacing:

Typical steps to resurface the collector rings are as follows:

1. With the engine shut off, gain access to the brush and collector ring area by removing the top cover from the brush holder/collector ring cover.
2. Remove the stone from the packaging. The stone should be of medium coarseness (Grainger item number 3GD69).
3. Cut off a one-inch long section of the stoning material using a hacksaw and a vise.

Note: Additional sections of stone material may be cut if more than one collector ring needs resurfacing.

4. Lift up the brush assembly on the collector ring that needs resurfacing. Set the brush off to the side without disconnecting the wires.
5. Set the cut piece of stone down inside the brush holder, place the brush back on top of the piece of stone, and reposition the tensioning clip on top of the brush assembly.

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Collector Ring Resurfacing (Cont'd):

6. Start the engine and run it at idle speed, then allow the stone to resurface the collector ring.

Note: When the stone wears down to a very small portion, it will crumble and fall out of the brush assembly.

7. Shut down the engine and re-inspect the collector rings.

Note: Additional segments of stone may be re-inserted into the brush holder if it is determined that additional resurfacing is necessary. Some pitting of the collector ring is normal and does not constitute a collector ring failure. Resurfacing will not remove all the pits. Continue with the process on other collector rings that require resurfacing.

8. When the resurfacing is complete, clean up the collector ring and the surrounding area with compressed air.

Warning: When using compressed air for cleaning purposes, an environment that is potentially hazardous to personnel in the immediate area is created. To prevent physical injury due to flying debris, observe all Railroad and Government Safety Precautions.

Screen 28:

Alternator Removal:

Warning: A Tier 2 non-variable speed (non-VSPD) alternator weighs approximately 16,500 lbs. (7,484 kg). Before use, each component in the lift rigging system must be inspected, qualified, and confirmed to have an adequate lift capacity rating. Failure to perform these tasks may result in personal injury or death.

Note: An adjustable turnbuckle-type rigging system can be used to evenly lift the various alternator models. Ask your local rigging supplier to build a similar system with all components appropriately rated for the lifts anticipated.

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine components. Open all circuit breakers on the EC panel. Open the Battery Switch (BS) and then the Maintenance Battery Switch (MBS) or Maintenance Battery Disconnect (MBD), if equipped, to prevent starting attempts. Apply a warning tag to the Engine Control (EC) switch. Open the Maintenance Relief Valve (MRV) in order to ensure that any residual fuel pressure in the system is relieved.

Note: To ensure correct tracking procedures, record the serial numbers of the alternator being removed and the one being installed.

Note: A typical 12-cylinder Tier 2 engine is often coupled to a 5GMG205, 5GMG206, or 5GMG210 alternator.

Typical steps to remove the alternator from the diesel engine are as follows:

Note: The following steps are applicable for the removal of an alternator on the locomotive platform with the engine rear supported on blocks.

1. Disconnect the alternator wiring, including:
 - a. The main output and input wiring.
 - b. The auxiliary output and input wiring.
2. Prepare the blower cab for removal.
 - a. Remove all applicable bolts.
 - b. Remove all cooling air connections to the blower cab.

Screen 29:

Alternator Removal (Cont'd):

Warning: The corner air duct weighs approximately 260 lbs. (120 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

3. Remove the corner air duct from the B-side of the locomotive and save all hardware.
 - a. Loosen the clamping bolt and the large washer under the air duct.
 - b. Loosen the four bolts, the washers, and the lockwashers connecting the duct to the blower cab.
 - c. Remove the mounting spring latch hardware at the top and bottom of the corner duct.
 - d. Remove the clamping bolt and large washer under the air duct.
 - e. Remove the remaining bolts, washers, and lockwashers connecting the duct to the blower cab.
 - f. Properly attach the duct to the lifting device and remove it from the locomotive.
4. Remove the hidden bolt located near the short hood end of the cab.

Warning: The blower cab weighs approximately 4,000 lbs. (1,814 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

5. Remove the blower cab.

Screen 30:

Alternator Removal (Cont'd):

6. While leaving the conical mount buffer stud and lock nuts tight, use a 15/16-inch wrench to remove the four alternator conical mount base plate bolts at the four corners of each conical mount, and save all hardware for re-use.

Note: Alternator Conical Mounting Plate Bolt Wrench (TESCO T85891) may be used to access the inside conical mount base plate bolts.

Note: Removal of the inside, aux cab end, conical base plate bolt is accomplished by first removing the inside, engine end, base plate bolt.

Warning: Improper handling of the hydraulic wrenches or use of an incorrect reaction arm may result in serious injury or death. Follow all tool manufacturer safety procedures when operating these tools.

Caution: While loosening the torsion bar nuts, to prevent hydraulic tool damage, wood blocks may need to be inserted between the tool and the platform.

Note: Changing the hydraulic wrench from tightening to loosening and vice versa is accomplished by flipping the wrench by 180°.

7. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head rated for higher than 1,600 lb.-ft. (2,169 Nm), loosen the alternator bottom flange nuts and remove the 1-3/8-inch torsion bar base bolts, and save all hardware for re-use.

Note: It may be possible to remove the torsion bar without disturbing the wedges. After removing the base bolts and loosening the nuts, attempt to move the torsion bar base with a pry bar. If the base can be moved free of its wedges, while lifting the engine-alternator, push the bar towards the engine until it disengages from the wedges.

8. Using If the torsion bar base cannot be freed of wedge engagement by prying inboard, cut off the tack welds holding the torsion bar base fixed mark each wedge with its location, remove the torsion bar from its base, and save all hardware for reuse.

Caution: Do not position the engine support blocks on the platform weld seam.

9. With the conical base plate bolts removed and the torsion bar disengaged from its wedged base, from the rear engine centerline lifting eye, lift the engine rear and alternator just enough to install the 4- to 6-inch blocks.
10. After installing the blocks, lower the engine-alternator onto the blocks, remove the alternator bottom flange nuts, and completely remove or slide the torsion bars back far enough that they no longer engage the alternator bottom flanges.

Screen 31:

Alternator Removal (Cont'd):

Caution: Do not allow dirt, water, or other contamination to enter the crankcase through the removed covers. Contamination can cause engine damage. Ensure the open crankcase is safeguarded against contamination.

11. Remove the alternator guards, also referred to as the alternator ventilation grates, from both sides of the engine to provide access to the engine-alternator coupling.

Warning: Improper handling of the hydraulic wrenches or use of an incorrect reaction arm may result in serious injury or death. Follow all tool manufacturer safety procedures when operating these tools.

Warning: Before rotating the crankshaft with the engine barring-over device, always check that all personnel and tooling are safely clear of engine movement.

12. Install the barring-over device and open the compression release valves.

13. Bar over the engine as needed to access and remove the 30 bolts coupling the engine to the alternator rotor using either a 20-inch (508-mm) long or longer $\frac{3}{4}$ -inch (19.05-mm) drive breaker bar and a 1-1/8-inch socket or a 24-inch (610-mm) long or longer 1-1/8-inch heavy-duty tubular box end wrench to initially loosen the bolts and a 90° air ratchet for rapid removal.

Warning: A Tier 2 non-VSPD alternator weighs approximately 16,500 lbs. (7,484 kg). Before use, each component in the lift rigging system must be inspected, qualified, and confirmed to have an adequate lift capacity rating. Failure to perform these tasks may result in personal injury or death.

14. To a properly rated crane, attach an adjustable three-leg rigging system or, more preferably, a turnbuckle-equipped rigging system that allows for a level lift of the alternator, then attach the rigging to the alternator and adjust the hooks or turnbuckle for a level lift.
15. With crane tension applied to lift the rigging, remove the four alternator top flange mounting bolts using a $\frac{3}{4}$ -inch air impact wrench and a 2-1/16-inch socket.

Screen 32:

Alternator Removal (Cont'd):

16. Install 1-3/8-inch -12 jack bolts into both top flange threaded holes and tighten the jack bolts evenly to pry the alternator away from the engine and off the engine-to-alternator top flange alignment dowel pins.
17. After jacking enough to clear the engine-to-alternator top flange alignment dowel pins, lift the alternator away from the engine.
18. For later use in the same location, keep the hardware with the platform mounting pads from which they were removed.

Warning: An approximate 1-inch gap exists between the rotor and the stator. When installing or removing the rotor support, carefully operate the rated crane and rigging to lift the rotor only enough to provide sufficient clearance for installing the rotor support or only enough to relieve the rotor's weight for removing the support. Lifting the rotor too much may unexpectedly result in the entire alternator being lifted, which could result in serious bodily injury or death.

Caution: To remove or install rotor supports and cardboard shipping shims on EVO engine style alternators, only use the EVO Alternator Stator Lifter (TESCO T67471) designed and rated for lifting these rotors (30 bolt flex plate). Sling lifts from coupling bolts screwed into the rotor will bend the bolts. Hoist rings designed with coarse thread bolts must never be modified with fine thread flex plate-to-alternator rotor bolts.

Caution: To avoid damaging the stator windings, never lift the rotor with a hook.

19. If the removed alternator will be processed for off-site repair, transfer the wooden rotor brace and cardboard spacers, the rotor-stator gap cardboard shims, and the EVO12 rotor support 84C602271ABP2 from the replacement alternator to the alternator being returned.

Note: When an alternator is resting on the shop floor without a rotor support installed, it is normal for the carbon brushes not to be centered on the slip rings.

Note: Refer to customer-specific documentation for additional information on rotor support usage.

Screen 33:

Alternator Installation: Preparing the Engine:

Typical steps to prepare the engine on the locomotive platform for alternator installation, are as follows:

1. Ensure the engine is mounted on the platform with its rear end supported on blocks.

Note: The large rectangular bar bolted to the end of the crankshaft may be left applied. Doing so will not affect crankshaft balance.

Note: If loose, the engine-to-alternator top flange alignment dowel pins should be reinstalled with Loctite® 222 applied to the threads.

Note: Dirty engine-alternator mating surfaces can hinder proper alignment.

Note: Threaded insert repair is allowed for a maximum of 2 of the 30 alternator rotor bolt holes so long as those 2 bolt holes are not adjacent.

Caution: Avoid using a wire wheel grinder to clean surfaces. Using one can be unsafe as the strands of wire may break free during high speed rotation. Also, strands of wire entering the alternator winding have the potential for creating circuit defects.

2. Using an aluminum oxide flap wheel of not greater than 120 grit, polish and clean the engine coupling and mounting surfaces.

Caution: When using a grinder to remove burrs or raised metal, limit the area being ground to the defect itself. Grinding large portions of the pad surface may change the precision reference plane to which all four pads have been machined.

3. After polishing, with an ungloved hand, feel the four mounting pads and crankshaft flange face for nicks, raised metal, and burrs and remove any high spots with a file or light grinder.

Caution: Potential damage of the bottom mounting pad surfaces from shipping chains requires close inspection. Residual burrs and metal will create problems when attempting to align the alternator to the engine.

4. Use compressed air to blow surfaces and bolt holes free of debris.

Screen 34:

Alternator Installation: Preparing the Engine (Cont'd):

5. Apply WD40 or equivalent rust inhibitor to polished areas and wipe down with a clean dry cloth, then apply Lubriplate® 630AA.
6. Using a paint marker, mark the flex plate-to-alternator rotor bolt torque pattern on the outside diameter of the flex plate flange.

Screen 35:

Alternator Installation: Preparing the Alternator:

Typical steps to prepare the alternator for installation are as follows:

Caution: To remove or install rotor supports and cardboard shipping shims on EVO engine style alternators, only use the EVO Alternator Stator Lifter (TESCO T67471) designed and rated for lifting these rotors (30 bolt flex plate). Sling lifts from coupling bolts screwed into the rotor will bend the bolts. Hoist rings designed with coarse thread bolts must never be modified with fine thread flex plate-to-alternator rotor bolts.

Caution: To avoid damaging the stator windings, never lift the rotor with a hook.

Note: If guide pins are not available to aid in coupling bolt alignment, the rotor support may remain installed with the mounting bolts left hand tight so that the support may be easily removed once the coupling is complete. Alternatively, the cardboard shims may be installed in a double-folded manner. The shims and/or support must be removed once the rotor is coupled to the engine.

1. Lift the rotor (30 bolt flex plate) using the EVO Alternator Stator Lifter (TESCO T67471) and remove the cardboard shipping shims from between the coils and stator.

Note: Qualify the rotor bolt hole threads by fully hand threading into and out of each bolt hole.

2. As necessary, apply cutting tap fluid to the flex plate-to-alternator rotor bolt hole threads and chase the threads using the $\frac{3}{4}$ -16 tap.
3. Using compressed air, blow the surfaces and bolt holes free of debris.

Note: Dirty engine-alternator mating surfaces can hinder proper alignment.

Caution: Avoid using a wire wheel grinder to clean surfaces. Using one can be unsafe as the strands of wire may break free during high speed rotation. Also, strands of wire entering the alternator winding have the potential for creating circuit defects.

4. Using an aluminum oxide flap wheel of no greater than 120 grit, polish and clean the alternator coupling and mounting surfaces.

Caution: When using a grinder to remove burrs or raised metal, limit the area being ground to the defect itself. Grinding large portions of the pad surface may change the precision reference plane to which all four pads have been machined.

5. After polishing, with an ungloved hand, feel the four mounting pad surfaces and rotor yoke face for nicks, raised metal, and burrs and remove any high spots with a file, emery cloth, or light grinder.

Screen 36:

Alternator Installation: Preparing the Alternator (Cont'd):

Caution: To avoid alignment difficulties, ensure that the left and right bottom shim thicknesses are equal to within 0.001 inches (0.0254 mm).

6. Remove the bottom shims.
7. If the alternator is re-used, perform the following steps a through e; however, If the alternator is new, only perform steps d and e.
 - a. Clean and polish both sides of shims and the alternator mounting face surface using an aluminum oxide flap sanding wheel no coarser than 120 grit.
 - b. Use emery cloth or a file to remove any raised metal or burrs on the bottom flanges.
 - c. Apply a rust inhibitor to the polished flanges and shims.
 - d. Measure and confirm each bottom flange shim is approximately 0.090 inches (2.286 mm) thick, and the thicknesses of both shims are equal to within 0.001 inches (0.0254 mm).
 - e. Re-apply the shims to the alternator and then torque the 1/2-13 x 0.75-inch grade 5 bolts to 55-62 lb.-ft. (75-84 Nm).
8. Use compressed air to clean all of the prepared surfaces and bolt holes.

Screen 37:

Alternator Installation: Preparing the Alternator (Cont'd):

9. Apply WD40 or other rust inhibitor to the polished areas and wipe down with a clean dry cloth.

Caution: Failure to properly clean and lubricate the flywheel-rotor yoke fit can result in an improper coupling that forces the alternator bearing out of its housing.

10. Apply Lubriplate® 630AA to the following surfaces:

- Alternator top flange bolt holes, jack bolt hole threads, and dowel alignment holes, including the back side washer mounting surfaces.
- Torsion bar washer load surfaces.
- Flex plate to alternator rotor bolt hole threads and rabbet fit.

Caution: When the rotor support and alignment guide pins (GPM060) are not used and the alternator is not completely square with the flex plate, the coupling bolts can often be difficult to get started.

Caution: Failure to fully apply the guide pins until no threads are showing may result in damage to the crank sensor box while barring the engine to apply the coupling bolts.

11. Install two rotor support and coupling alignment guide pins (GPM060) in the fourth bolt holes to the left and right of the 12 o'clock position in the flex plate-to-alternator rotor.

Screen 38:

Alternator Installation: Preparing the Alternator (Cont'd):

12. Prepare the conicals for transfer to the replacement alternator by cleaning and inspecting them.

Note: The alternator conicals should be returned for complete inspection and overhaul every 9 years.

Caution: Failing to fully unscrew the buffer stud before placing the alternator on the platform may allow the stud to press hard against the platform mounting pad. This will complicate setting conical clearance and recording accurate indicator readings during alignment.

13. Install the conicals on the replacement alternator ensuring that the buffer stud is screwed completely counterclockwise.

Caution: While cleaning the alternator plenum, take the necessary precautions to prevent debris from entering the alternator.

14. Prepare the air duct adapter for transfer to the replacement alternator by removing any old sealant, dirt, grime, or rust.
15. Install the adapter using grade 5 1/2 inch-13 x 1.75-inch bolts.

Note: No sealant is required for a flat, clean surface.

16. Torque the mounting bolts to 59 +3/-4 lb.-ft. (80 +4/-5 Nm).

Screen 39:

Alternator Installation: Hardware Preparation:

Typical steps to prepare the hardware for alternator installation are as follows:

1. Prepare the flex plate to alternator rotor bolts for installation as follows:
 - a. If re-using the bolts, clean them thoroughly.
 - b. Inspect the bolt threads and chase as needed.
 - c. Apply Lubriplate® 630AA to the bolt threads, washer faces, and contact face of bolt heads.
2. Apply Lubriplate® 630AA to the torsion bar threads, nut threads, and washer faces.

Caution: Measure and add shims individually to obtain the correct total shim pack thickness. Do not assume an overall shim pack thickness accurately reflects a compressed shim pack thickness.

Caution: Taking accurate measurements with an outside diameter mechanical micrometer is critical in the alignment process.

3. Build two shim packs with a thickness of 0.075 inches (1.905 mm).
4. When building the shim packs, ensure the following:
 - Do not use wrinkled shims.
 - Build the shim pack with the thickest shim against the engine and the thinnest shims sandwiched between thicker shims.
 - For greater accuracy, measure individual shim thicknesses with a 0 - 1-inch (0 - 25-mm) micrometer, not a blade-type caliper.

Note: Measurement errors of as little as 0.001 inches (0.0254 mm) slow the alignment process.

- Never reuse shims removed from an in-service alternator.
The displayed table shows the part numbers for the shims and their sizes.

Note: If ordering shims, the shim pack part number 119X1061 contains one each of the shims shown in the table. The shims may also be ordered individually.

Screen 40:

Alternator Installation: Engine Alternator Coupling:

Typical steps to couple the engine and the alternator are as follows:

Note: The following steps are applicable for the coupling of an alternator to an engine that is already mounted on the locomotive platform with its rear supported on blocks.

1. Install the engine barring over motor and open the compression release valves.

Caution: Do not allow dirt, water, or other contamination to enter the crankcase through the removed covers. Engine damage can result from contamination. Ensure the open crankcase is safeguarded against contamination.

2. If not already removed, remove the alternator guards from both sides of the engine to make the engine-alternator coupling accessible.
3. Prepare the alternator conical mount base plate as follows:
 - a. Clean the conical mount base plate with a 120 grit flap wheel.
 - b. Apply Lubriplate® 630AA to the base plate surface.
 - c. Apply Molykote® 77 paste to the base plate bolt hole threads and to the bolt threads.

Screen 41:

Alternator Installation: Engine Alternator Coupling (Cont'd):

Warning: A Tier 2 non-VSPD alternator weighs approximately 16,500 lbs. (7,484 kg). Before use, each component in the lift rigging system must be inspected, qualified, and confirmed to have an adequate lift capacity rating. Failure to perform these tasks may result in personal injury or death.

Note: For alternators with conical base plates mounted to a removable platform plate, if the platform plate was removed, clean the platform surface with a flap wheel, apply Lubriplate® 630AA to the surface, and apply Molykote® 77 paste to the bolt hole threads and bolt threads. Install the platform plate to the prepared platform surface and then torque the 7/8 inch-9 X 3.25-inch plate bolts with hardened washers to 465 ± 25 lb.-ft. (630 ± 34 Nm).

4. To a properly rated crane, attach an adjustable three-leg rigging system or, more preferably, a turnbuckle-equipped rigging system that allows for a level lift of the alternator.
5. With the rotor support loosely installed or, more preferably, rotor support and alignment guide pins installed in two of the coupling bolt holes and the conical mount buffer studs fully unscrewed, attach the rigging to the alternator and adjust for a level lift.

Note: The more level the lift of the alternator, the easier the coupling bolts will align to the threaded holes and be started.

Warning: Before rotating the crankshaft with the engine barring device, always check that all personnel and tooling are safely clear of engine movement.

6. Lift and move the alternator toward the engine, adjusting the lift as needed, to align the engine top pad alignment dowel pins with the corresponding alternator top pad holes and, pause the lift as needed, to bar the engine to align the rotor yoke alignment pins with the engine flex plate bolt holes.

Screen 42:

Alternator Installation: Engine Alternator Coupling (Cont'd):

7. When coupling guide pins are being used:
 - a. With the pins aligned to the flex plate holes, continue advancing the alternator toward the engine to align the engine dowels with the corresponding alternator top flange holes.

Note: The simultaneous alignment of pins and dowels to their holes strongly depends on a level lift of the alternator.

- b. Once the pins and dowels are aligned to their holes, apply the four top flange bolts to the top flanges and then, using a $\frac{3}{4}$ -inch air impact gun, tighten the four top flange bolts evenly, while alternating sides, so as to draw the pins and dowels completely through their holes until no gap exists between the rotor and the flex plate.
8. If guide pins are not being used:
 - a. When the engine dowels are aligned with the top pad holes, move the alternator close enough to apply the four top flange bolts and then, using a $\frac{3}{4}$ -inch air impact gun, tighten the four top flange bolts evenly, while alternating sides, until the tips of the engine mounting pad alignment dowels have entered and are within $\frac{1}{8}$ th inch of the outside edge of the alternator top flange holes.

Note: At this point, if the alternator is level, the engine should still be barrable without the rotor also turning.

- b. Bar the engine as needed until three adjacent coupling bolts can be loosely started by hand through the vent screen openings on opposite sides of the alternator.

Caution: Screw the flex plate-to-alternator rotor bolts in far enough that they will not interfere with the crank speed sensor housing when the engine is barred over.

Caution: When the rotor support and alignment guide pins (GPM060) are not used and the alternator is not level, the rotor yoke bolt holes often will not properly align with the flex plate bolt holes.

9. Install the previously assembled 0.075-inch (1.905-mm) shim packs in the top left and right mounting flanges.
10. Using a $\frac{3}{4}$ -inch air impact wrench, continue to tighten the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides, to draw the alternator tight against the engine.

Caution: Threaded insert repair is allowed for a maximum of 2 of the 30 alternator rotor bolt holes so long as those 2 bolt holes are not adjacent.

Caution: Do not tighten the flex plate-to-alternator rotor bolts until the alternator top flange mounting bolts have been tightened. Doing so may strip the rotor bolt hole threads.

11. Tighten the previously installed coupling bolts with a 90° air ratchet.

Screen 43:

Alternator Installation: Engine Alternator Coupling (Cont'd):

Caution: Top flange torque values influence web deflection readings. Never use an impact wrench as a substitute for a torque wrench. Consistency in dial indicator readings depends on consistent alternator top flange mounting bolt tightness.

Caution: Setting a desired torque using the 0 - 1000 lb.-ft. (0 – 1356 Nm), 1-inch Square Drive Torque Wrench (TESCO T18250) is unique compared to most other torque wrenches. Ensure the correct dial face scale is used.

Caution: The final torque of the flange bolts must be with a torque wrench or torque controlled tool. Over torquing or under torquing with an impact wrench could result in the premature failure of the bolts.

12. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.

13. After adjusting the conical mount central buffer lock nuts to lower the plates enough to install the 5/8-inch conical mount base plate bolts to the platform mounting pads, loosely apply the base plate bolts with a 15/16-inch wrench.

Note: The conical mount base plate bolts will be torqued after the alignment is complete.

14. Apply Molykote® 77 paste to the torsion bar base hole and the bolt threads.

15. Install the torsion bars through the alternator bottom flange hole leaving the nuts loosely applied.

16. With the conical mount central buffer nuts fully backed off and ample thread showing on the loosely applied conical mount base plate bolts, slightly lift the rear of the engine from the centerline lifting eye just high enough to remove the support blocks.

Screen 44:

Alternator Installation: Engine Alternator Coupling (Cont'd):

Caution: Prevent bending or binding the torsion bar as the engine is lowered. If the wedges were not removed from the torsion bar base when the alternator was removed,

while lowering the engine-alternator, slightly pry the torsion bar towards the engine so that the torsion bar slot properly engages the inboard side of the wedges.

17. With the support blocks removed, lower the engine-alternator assembly to fully rest on the conical mounts.

Caution: The conical mounts need a minimum of 90 minutes under the weight of the alternator to completely settle to a final position.

18. After a minimum of 90 minutes, inspect the conical mounts to ensure full engagement with the alternator flange.

Note: Replace conical mounts if found defective.

Caution: Never begin the alignment process without first setting the conical clearance and torquing the buffer stud locknut.

Caution: If the alternator was lowered to the platform without the conical buffer stud fully unscrewed, it may not be possible to adjust the clearance due to the stud being bound tight against the platform. Enable stud adjustment by relieving pressure on the stud. Do this by slightly lifting the engine-alternator assembly from the engine rear lifting lug.

19. If 90 minutes have passed since setting the alternator, before proceeding with alignment, adjust the conical mount clearances with the 4-mm GEVO Conical Mount Stud Clearance Check Set Gauge (TESCO T85500).
20. After adjusting the conical mount clearance, torque the conical stud locknut to 185 lb.-ft. (251 Nm).

Note: For more information on checking and setting the conical clearance, refer to customer-specific documentation.

21. Using a torque wrench and a 2-1/16-inch socket, torque the torsion bar base bolts to the platform to 100 lb.-ft. (136 Nm).

Warning: Improper handling of the hydraulic wrenches or use of an incorrect reaction arm may result in serious injury or death. Follow all tool manufacturer safety procedures when operating these tools.

22. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head with pressure set for 1,600 lb.-ft. (2,169 Nm), torque the torsion bar nuts.
23. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head with pressure set for 1,500 lb.-ft. (2,034 Nm), tighten the 1-3/8-inch torsion bar base bolts.

Caution: Do not disturb the torsion bar bolts or flange nuts from this point forward in the alignment process.

24. If previously removed, re-apply wedges to the torsion bar base block and tack weld in place.

Screen 45:

Alternator Installation: Engine Alternator Coupling (Cont'd):

Warning: Before rotating the crankshaft with the barring-over device, always check that all personnel and tooling are safely clear of engine movement.

25. Replace the two rotor support and alignment guide pins with flex plate-to-alternator rotor bolts.
26. Install the remaining 22 flex plate to alternator rotor bolts in a 10-point pattern and tighten the bolts with an air ratchet.

Warning: Improper handling of the hydraulic wrenches or use of an incorrect reaction arm may result in serious injury or death. Follow all tool manufacturer safety procedures when operating these tools.

27. Torque all 30 flex plate to alternator rotor bolts in a 10-point pattern to 367 ± 37 lb.-ft. (498 ± 50 Nm).

Caution: To prevent damage to the alternator, do not leave the rotor support installed with loose bolts.

28. Unbolt the rotor support, allowing it to drop to the platform beneath the alternator, then remove the rotor support from beneath the alternator.
29. Install the alternator guards to both sides of the engine.

Note: Leave the barring over motor installed and crankcase inspection covers removed to support tasks now required to align the alternator to the engine.

Screen 46:

Alternator Installation: Alternator- Engine Alternator Coupling (Cont'd):

Caution: Before completing the alternator electrical connections, inspect the alternator collector rings, brushes, and brush holders as discussed in the Collector Ring Inspection, Brush Inspection, Brush Holder/Collector Ring Cover Inspection sections, respectively. Bus bars, insulated studs, and brush holder mounting posts should also be closely examined. Failure to perform final inspections may result in premature failure and/or equipment damage.

30. Re-connect the electrical connections, including the main and auxiliary output and input wiring.

31. Torque the aux stator cable terminals to 23 +2/-1 lb.-ft. (31 +3/-1 Nm) and torque all other hardware to the correct torque value.

Warning: The blower cab weighs approximately 4,000 lbs. (1,814 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

32. Reinstall the blower cab.
33. Reinstall the hidden bolt removed earlier and torque to appropriate torque values.

Warning: The corner air duct weighs approximately 260 lbs. (120 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

34. Reinstall the corner duct to the B-side of the locomotive as follows:
 - a. Properly attach the lifting device to the duct, then lift and place it in position.
 - b. Reinstall the mounting latch hardware and torque to appropriate torque values.
 - c. Reinstall the bolt, washers and lockwashers connecting the duct to the blower cab and torque to appropriate torque values.
35. Reinstall all applicable bolts and cooling air connections to the blower cab.

Screen 47:

Alternator Installation: Alternator-Engine Alignment:

The alternator alignment to the engine is sometimes called setting the web deflection because it involves adjusting the flexure of the crankshaft webbing. This flexure or bending of the crankshaft reflects how well or poorly the alternator is aligned to the engine and is measured by the total travel of a dial indicator needle as the crankshaft is rotated. The total needle travel is called Total Indicated Runout (TIR). As the crankshaft rotates, when the distance between the two crankshaft webs decreases as measured by a dial indicator mounted between the webs, the webbing is described as in compression. When the distance increases, the webbing is described as having spread. When the total movement of the indicator needle sums to less than 0.0005 inches (0.0127 mm), the webbing is described as having a TIR of less than 0.0005 inches (0.0127 mm). EVO alternator alignment is a two-step process. Shims are first added and removed from the top mounting flanges as needed to achieve a web TIR of less than 0.0005 inches (0.0127 mm). The next step is to reduce pressure on the engine #7 main bearing. The web is placed in compression by inserting 0.015-inch (0.381-mm) shims in both top left and right mounting flanges. This step is done after all bending has been removed, i.e. the TIR is less than 0.0005 inches (0.0127 mm). Once the 0.015-inch (0.381-mm) shims are inserted, the web compression will be indicated by a direct gauge reading at position C of negative 0.003 inches (0.076 mm).

Caution: Do not skip setting of TIR to zero, before setting C to -0.003 inches

(-0.076 mm). All crankshaft web runout or wobble needs to be verified as having been removed before putting the web in compression at position C by the insertion of 0.015-inch (0.381-mm) shims.

Screen 48:

Alternator Installation: Alternator-Engine Alignment (Cont'd):

Typical steps to align the alternator and engine are as follows:

Note: Crankshaft Deflection Gauge Kit (TESCO T81254) contains a dial indicator with the necessary 0.0001-inch (0.00254-mm) resolution.

Caution: Do not use a dial indicator with insufficient resolution such as the 0.001-inch (0.0254-mm) dial indicator. Using this type of indicator will result in a poorly aligned alternator.

Caution: Do not confuse the +/- signs on some gauge faces while recording web deflection readings. Regardless of the dial face sign, record as negative (-) the values located to the side of zero where the needle moves when pushing in on the probe tip. Record as positive (+) the values to the side of zero where the needle moves when releasing the probe tip.

1. Rotate the gauge's outer ring to zero the gauge to the needle, then press the probe tip in and out to ensure the needle returns to zero without binding.

Note: Replace the gauge as needed.

2. Observe the needle movement direction as the probe is pressed and released.
 - a. Regardless of "+" and "-" markings or no markings on the indicator face, the clockwise needle movement when the probe is pressed in is considered to be increasing the compression of the web.
 - b. The needle movement in a counterclockwise direction as the probe is released is considered to be increasing the spread of the web.
3. After mounting the probe with a pre-load and zeroing the gauge, record the face-on indicator readings to the right of zero as negative values and face-on readings to the left of zero as positive values.

Screen 49:

Alternator Installation: Alternator-Engine Alignment (Cont'd):

Note: Engine-alternator coupling may be performed on the shop floor with the understanding that final alignment on the floor can only be accomplished with a webbing stand that allows for torquing of both ends of the torsion bars. Initial alignment (TIR less than 0.0005 in.) on the shop floor with the engine supported by stands and torsion bar nuts tightened may be attempted, but only after jacking the alternator enough to raise the engine off the rear engine support stands. Failure to support the engine weight in the

same manner as if on the locomotive platform will result in alignment errors. Final alignment (web in compression with position C at -0.003 in.) must be obtained after the engine-alternator assembly weight is fully supported by the locomotive platform with the torsion bars fully mounted and torqued and top flange bolts properly torqued.

Caution: Do not take the dial indicator web deflection measurements while the engine is cooling down from recent operation. The engine must be at shop temperature when the web deflection measurements are taken and engine-alternator alignment is adjusted. On a warm engine, over the span of less than a minute, the displayed reading on a mounted, undisturbed 0.0001-inch (0.00254-mm) resolution dial indicator will change appreciably as the crankshaft contracts with engine cooling.

4. Drape the cloth across an oil pan to catch the indicator should it fall.

Warning: Before rotating the crankshaft with the engine barring over device, always check that all personnel and tooling are safely clear of engine movement.

5. Bar over the engine to set the cam-gear timing window-pointer to 110, setting the crankshaft to position A.

Caution: If two sets of prick punch marks are noticed on the crankshaft web, use the larger set. The smaller set is associated with crankshaft manufacturing.

Note: Only a single set of prick punch holes will be found on crankshafts with machined webs.

6. Through the R6 crankcase inspection cover opening, mount the dial indicator in the webbing prick punch holes.
7. With the gauge mounted, gently rock the gauge until the indicator needle no longer moves.
8. Rotate the dial face outer ring to zero the gauge.

Screen 50:

Alternator Installation: Alternator-Engine Alignment (Cont'd):

9. Bar over the engine to the cam gear positions B, C, D and E stopping each time to record the gauge reading with the proper signage.
10. Calculate the TIR.

Note: If the TIR is greater than 0.0005 inches (0.0127 mm), adjustment to the shim pack thickness is required. If the TIR is less than 0.0005 inches (0.0127 mm), no adjustment is required.

11. Calculate the top right (engine right/locomotive left) and the top left (engine left/locomotive right) shim pack adjustment, by using the formulas:

- a. Top Left (TL) = $(-13.3 \times E) + (5.4 \times C)$
- b. Top Right (TR) = $(5.29 \times E) + (6.4 \times C)$

Note: The negative solutions to the formulas require removing that amount of shim thickness and the positive solutions require adding shims.

Note: For the EVO12 diesel engine, a limited number of shim adjustment values for various C and D readings have been tabulated. For values of C and E not in the tables, revert to the formulas.

Screen 51:

Alternator Installation: Alternator-Engine Alignment (Cont'd):

Caution: Precision is critical in measuring the shims that are either removed or added. Carefully keep track of the work by documenting gauge readings, TIR and shim adjustments.

Caution: Accurate reading of an outside diameter mechanical micrometer is critical in the alignment process. For instance, 0.100 inches (2.54 mm) is four complete turns of the adjustment handle. Each graduation line on the stationary scale is 0.025 inches (0.635 mm). Each graduation line on the rotating scale is 0.001 inches (0.0254 mm).

Note: Precision measurements will reduce the number of times the shim pack needs adjusting to achieve TIR less than 0.0005 inches (0.0127 mm). Measurement errors as small as 0.001 inches (0.0254 mm) slow the alignment process.

12. If the formulas require that shims be added, prepare to do so by using a 0-1-inch outside diameter micrometer, not a blade caliper, to measure and identify individual shims that add up to the thickness calculated by the formula.

Note: Minimize the risk around accidentally installing shims in the wrong top flange by staging them near the corresponding top left or right flange.

13. Without disturbing the bottom flange torsion bar nuts, use an air impact wrench to evenly loosen the four top flange mounting bolts.
14. Use a jack bolt at either one of the top ear flanges to slightly pry the alternator away from the engine far enough to remove the shim pack.
15. Remove the shim packs with a spare thick shim or a piece of bent wire.

Caution: Never assume to know a shim's thickness. Verify each shim thickness when adjusting total shim pack thickness. Measure the shims individually and add together for a total shim pack thickness. Never decide pack thickness based on an overall measurement of shim pack thickness.

16. Remove or add shims from or to the pack to adjust the thickness in accordance with the shim adjustment formulas.

Note: When making adjustments, adhere to the following shim pack rules:

- a. For each top mounting flange, do not exceed 0.135 inches (3.429 mm) in shim pack thickness.
- b. The difference between the top left and right flange shim pack thickness must be less than 0.060 inches (1.524 mm).
- c. Never reuse shim packs or install wrinkled shims.
- d. Build the shim pack with the thickest shim against the engine and the thinnest shims sandwiched between thicker shims.

Screen 52:

Alternator Installation: Alternator-Engine Alignment (Cont'd):

17. Install the adjusted shim packs.

Note: The shape of the shims only allows them to be inserted in one direction between the bolts of the top mounting flanges.

18. Remove the jack bolt.
19. Using a $\frac{3}{4}$ -inch air impact wrench, tighten the four alternator top flange mounting bolts evenly (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides.

Caution: Top flange torque values influence web deflection readings. Never use an impact wrench as a substitute for a torque wrench. Consistency in dial indicator readings depends on consistent alternator top flange mounting bolt tightness.

Caution: Setting a desired torque using the 0 - 1000 lb.-ft. (0 - 1356 Nm), 1-inch Square Drive Torque Wrench (TESCO T18250) is unique compared to most other torque wrenches. Ensure the correct dial face scale is used.

20. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.
21. Until TIR is less than 0.0005 inches (0.0127 mm), repeat the above-mentioned steps of rocking the gauge at position A (until the needle stops moving before zeroing the gauge), re-measuring web deflection, recalculating TIR, and adjusting the shim pack thickness.

Screen 53:

Alternator Installation: Compressing the Web:

After achieving a TIR of less than 0.0005 inches (0.0127 mm), apply 0.015-inch

(0.381-mm) shims to both top right and left mounting flanges. This will put position C in compression and relieve pressure on the #7 main bearing.

Caution: Do not take the dial indicator web deflection measurements while the engine is cooling down from recent operation. The engine must be at shop temperature when the web deflection measurements are taken and engine-alternator alignment is adjusted. On a warm engine, over the span of less than a minute, the displayed reading on a mounted, undisturbed 0.0001-inch (0.00254-mm) resolution dial indicator will change appreciably as the crankshaft contracts with engine cooling.

Typical steps to compress the crankshaft web are as follows:

1. Use the air impact wrench to loosen all four alternator top flange mounting bolts.
2. Install and tighten a jack bolt on either the right or left mounting flange to slightly pry the alternator apart from the engine.
3. Install 0.015-inch (0.381-mm) shims to both the top right and top left flanges.
4. Remove the jack bolt.

Screen 54:

Alternator Installation: Compressing the Web (Cont'd):

5. Using a $\frac{3}{4}$ -inch air impact wrench, tighten the four alternator top flange mounting bolts evenly (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides.

Caution: Top flange torque values influence web deflection readings. Never use an impact wrench as a substitute for a torque wrench. Consistency in dial indicator readings depends on consistent alternator top flange mounting bolt tightness.

Caution: Setting a desired torque using the 0 - 1000 lb.-ft. (0 - 1356 Nm), 1-inch Square Drive Torque Wrench (TESCO T18250) is unique compared to most other torque wrenches. Ensure the correct dial face scale is used.

6. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.
7. Verify that the crank-position dial indicator gauge readings are within the ranges.

Note: These are direct-dial indicator readings and not TIR calculations.

8. If needed, equally add or remove the shims at the top right and left flanges to achieve a reading of -0.003 ± 0.0005 inches (-0.076 ± 0.0127 mm) in position C.

Note: The minus sign indicates web compression.

Note: When using the alternator conical mounting plate bolt wrench (TESCO T85891) to torque the inboard conical mount base plate bolts, adjust the torque value to compensate for the tool length. This is best accomplished with a torque wrench testing device such as TESCO T67490 or T67500. Apply the tool to the torque wrench at the same angle as needed to tighten the bolt. Adjust the torque wrench setting to the value needed to register 175 ± 10 lb.-ft. (237 ± 14 Nm) on the tester. If a tester is not available, refer to customer-specific documentation for a method to manually calculate the correct torque wrench setting.

Note: Tightening and torquing of the inboard, aux cab end conical mount bolt is accomplished by first removing the inboard, engine end conical mount bolt.

9. After alignment is complete, torque the 5/8 -11 x 2-inch alternator conical plate mounting bolts and hardened washers to 166 - 185 lb.-ft. (225 - 250 Nm).

Note: If the conicals mount to a removable plate that mounts to the platform, torque the 7/8 - 9 X 3.25-inch plate bolts and hardened washers to 440 - 490 lb.-ft. (596 - 664 Nm) and then torque the conicals to the plate to 166 - 185 lb.-ft. (225 - 250 Nm).

Screen 55:

Alternator Installation: Troubleshooting Alignment Issues:

Typical steps to perform if unable to achieve a TIR of less than 0.0005 inches (0.0127 mm) even after many attempts are as follows:

1. Verify that the engine is at room temperature when taking the web deflection measurement as a cooling engine prevents accurate indicator readings.
2. Verify that the torsion bar nuts are correctly torqued and have not been disturbed during the alignment process.

Note: There are no separate deflection tolerances for new or used combinations of engines and alternators.

3. Verify that the correct point of reference is made regarding the flange where shims are applied.

Note: The shim adjustment formulas referencing left correspond to the engine left or locomotive right alternator top mounting flange, and the formulas referencing right correspond to the engine right or locomotive left alternator top mounting flange.

4. Verify that a calibrated 0 - 1-inch (0 - 25-mm) micrometer is being used to measure the shim thickness, not a blade-type caliper.
5. Verify each shim thickness when adjusting the total shim pack thickness and never assume to know a shim's thickness.
6. Verify that used shim packs or wrinkled shims are not being used.

7. Verify that the shim pack is being built with the thickest shim against the engine and the thinnest shims sandwiched between thicker shims.
8. Verify that the shims are being measured individually and added together for the total shim pack thickness.

Note: Never decide the pack thickness based on an overall measurement of the shim pack thickness.

Screen 56:

Alternator Installation: Troubleshooting Alignment Issues (Cont'd):

9. Verify that the shim pack thickness at each top mounting flange does not exceed 0.135 inches (3.429 mm).
10. Verify that the difference between the top left flange shim pack thickness and the top right flange shim pack thickness is less than 0.060 inches (1.524 mm).
11. Between every shim pack adjustment and before taking deflection readings, verify that the top flange mounting bolts are being consistently torqued to 650 lb.-ft. (881 Nm).

Note: Never use a pneumatic impact gun to torque the flange bolts. Precision torque is required for accurate web deflection readings and alignment.

12. Verify that the correct +/- signs are being applied to values read on the dial indicator, especially for positions D and E, when reading in a reverse direction with a mirror.
13. Verify that the correct crank position references are being made as position A is via the R6 crankcase cover opening and not L6.
14. Verify the integrity of the dial indicator by confirming the needle returns to the same location after pushing in and releasing the probe.
15. Verify the integrity of the dial indicator by duplicating the results with a second dial indicator.
16. Verify that the dial indicator is installed in the larger set of the web prick punch marks, not the smaller set.

Screen 57:

Alternator Installation: Troubleshooting Alignment Issues (Cont'd):

17. Verify at position A that the dial indicator is being rocked until the needle stops moving and that this is being done with each new set of readings.
18. While rotating the crankshaft between the reading positions, identify a defective dial indicator by watching the needle for momentary, rapid spinning which is possible even if the issue cannot be replicated and observed when manipulating the indicator by hand.
19. Verify that the full weight of the alternator is on the conical mounts or the alternator is lifted off the jack stands (floor web stand).

20. Confirm that the conical mounts meet the 4-mm clearance requirement and are not bottomed out either against the elastomer on the top side or against the platform on the bottom side.
21. On Tier 2 engines, inspect the low-pressure fuel line support brackets for interference with the alternator frame.

Note: Bracket fouling prevents proper torque between the engine and alternator (loose shims) and creates difficulty achieving alignment and/or alignment drift after operation. If interference is suspected, disassemble the bracket from the hoses, rotate the bracket 180°, re-assemble the bracket and hoses, and torque the M12 and M8 bolts.

22. Uncouple the engine from the alternator and check for raised metal or burrs on the mounting faces and coupling fit.

Caution: Because of torsion and stress that may be introduced to the engine coupling flex plate, adjustment of bottom flange shim thickness is not permitted for alignment purposes. The EVO flex plate coupling design only allows for 0.090 ± 0.001 inch (2.286 ± 0.0254 mm) bottom flange shims.

23. Remove and verify with a 0 - 1-inch (0 - 25-mm) micrometer that the bottom left and right shim thicknesses are 0.090 inches (2.286 mm).

Note: Shim thickness can vary greatly. Mismatches in bottom shim thicknesses have been known to create difficulty achieving the less than 0.0005 inches (0.0127 mm) TIR specification. The left and right bottom shims being of the same thickness is more important than the actual thickness. If unequal shim thicknesses are found, use the top flange shims to build up the smaller-thickness bottom shim to equal the larger shim thickness.

24. Rotate the alternator rotor by 180° and try setting the alignment from the beginning.

Screen 58:

Alternator Installation: Troubleshooting Alignment Issues (Cont'd):

25. If excessive vibration is detected after starting, evaluate the problem as follows:
 - a. Use a dial indicator to confirm that the alternator alignment is within specification.

Note: For EVO engine-alternators, the in-service condemning limits for web compression are the same as the initial compression limits. There is no in-service allowance separate from the initial web compression specification of -0.003 inches (-0.0762 mm).

- b. Check for the excessive rabbet-fit clearance between the rotor flange and the engine flex plate.
- c. Check the clearance on all conical mount buffer studs.

Note: TIR is the difference between the maximum and minimum readings. A TIR over 0.008 inches (0.203 mm) indicates a problem with the assembly or a quality issue with the parts. The cause must be found and corrected.

- d. After the rotor yoke-to-flex plate bolts are fully torqued, measure the runout of the outer diameter of the rotor yoke flange as the engine is barred over 360°.

Note: The TIR should be 0.008 inches (0.203 mm) or less.

- e. Measure the vibration in Notch 8 Self-Load and, if the vibration is greater than the upper limits, uncouple the alternator from the engine, bar the engine crankshaft by 180°, recouple and re-align the alternator and the engine, and then re-measure the Notch 8 Self-Load vibration.
- f. Lower the #7 main bearing cap and inspect for bearing failure.

Screen 59:

Alternator Installation: Engine Preparation for Starting:

Typical steps to prepare the engine for starting after successful engine-alternator alignment in the locomotive are as follows:

Warning: Starting the engine without removing the barring-over device could result in serious personal injury and/or damage to the engine.

After setting web compression measures within specification:

1. Remove the barring-over device.
2. Reapply the barring device cover and the cam gear timing.
3. Reapply all crankcase inspection covers.
4. Close all compression release valves and torque to 59 lb.-ft. (80 Nm).

Screen 66:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the alternator.
 - The ES44AC/DC locomotives are equipped with an alternator that converts rotational mechanical energy from the diesel engine into electrical power that is used by the traction motors and the locomotive's systems. The ES44AC

- locomotives are typically equipped with a 5GMG203 or 5GMG205 alternator. The ES44DC locomotives are typically equipped with a 5GMG206 alternator.
- The alternators consist of two main sub-assemblies: the Traction Alternator (TA) and the auxiliary alternator (AA). Both assemblies are salient-pole, 3-phase, Y-connected machines mounted on a common frame in the blower cab. They are configured as a single unit attached to the rear, #1 end of the diesel engine.
 - Explain the basic operation of the alternator.
 - On ES44AC/DC locomotives, rotational mechanical energy is produced by a GEVO diesel engine. Using the alternator, the locomotive converts the engine's rated 4400 hp into 3.3 MW of electrical power.
 - The diesel engine crankshaft is mechanically coupled to the alternator rotor. The AA's field windings are excited by the Auxiliary Alternator Field Controller (AAC) and produce a magnetic field of force. As the engine's mechanical energy turns the rotor, electrical energy is induced into each set of the AA stator windings. These three windings produce 3-phase AC voltages that are directly proportional to the field excitation current for a given engine RPM.
 - Two of the three output windings, the excitation supply windings and the battery charger supply windings, cable the AC power to power converter panels where it is converted to DC power. The DC power is used to excite both alternators and to recharge the locomotive's batteries, respectively. The third set of output windings, the auxiliary motor supply windings, provides AC power to run seven AC motors on the locomotive.
 - The TA's field windings are excited by the Traction Alternator Field Controller (TAC) and produce a magnetic field of force. As the engine's mechanical energy turns the rotor, electrical energy is induced into the TA stator windings. These windings produce a 3-phase AC voltage output that is directly proportional to the field excitation current for a given engine RPM.
 - The induced 3-phase AC voltage is then fed to rectifier modules and converted to DC power. On an ES44DC locomotive, this DC power is directly distributed to the six DC traction motors. On an ES44AC locomotive, the rectified DC power is inverted back into 3-phase AC power by the traction inverters and then distributed to the six AC traction motors. The traction motors convert the electrical power back into mechanical power to pull a train.

Screen 67:

Summary (Cont'd):

- Describe how to perform running maintenance related to the alternator.
 - Every 92 days, the 5GMG203, 5GMG205, and 5GMG206 alternators should be inspected. Brushes, brush length, and the surface condition of the collector rings should be checked.

- Brush Inspection
 - Ensure that the pigtails are positioned correctly. They must be parallel with, but not rubbing against, the pressure arm.
 - Ensure that the pigtail terminal bolts are tight.
 - Move the brushes up and down several times in the brush holders to release any carbon dust or foreign matter in the carbon ways that could prevent free movement of the brushes.
- Brush Removal
 1. Unlatch the brush pressure spring thumb loop.
 2. Loosen the terminal bolt on the brush holder.
 3. Slide the brush out of the brush holder.
- Brush Installation
 1. Insert each brush into a brush holder so that the contour of the brush or its riding surface matches that of the collector ring.
 2. Position the pigtail terminal under the terminal screw and parallel to the brush pressure arm.
 3. Tighten the terminal screw, and torque it to 6-8 lb-ft (8.13-10.85 Nm).
 4. Latch the brush pressure spring thumb loop over the detent in the brush holder body.
 5. Dress the pigtail leads such that the pigtail wires do not interfere with the action of the pressure arm, rub against each other, or rub against adjacent brush holders.
- Brush Holder Inspection
 - Check for loose, broken, bent, or overheated pressure arms. Overheating will cause the arms to discolor and result in improper brush arm pressure.
 - Annually verify brush arm force. If it is below 4.25-4.75 lb (1.93-2.15 kg), replace the brush holder.
 - Ensure that the thumb loop on the coiled brush pressure spring is in position with the spring end placed into the detent.
 - Inspect the brush holder mounting arrangement, and ensure the clamp pads are in place and tight against the brush holder stud. If they are not in place, locate the clamp pads and torque the clamp bolts.
 - Check the brush holder-to-collector ring clearance. If the clearance is not between 0.089 and 0.091 inches (2.2-2.3 mm), adjust the clearance as discussed in the Brush Holder and Stud Assembly Alignment section of this module.
 - Inspect the brush holder assembly for broken connection straps or bus rings. Replace, if necessary, as discussed in the Brush Holder and Stud Assembly Removal and the Brush Holder and Stud Assembly Installation sections of this module.
 - Check by hand the tightness of the bus ring to the brush holder bolts. If loose, torque the bolts.
- Brush Holder Stud Inspection
 - Wipe the brush holder studs clean.

- Inspect the brush holder stud for cracked, discolored, or worn insulation. Replace the complete stud if insulation is found to be faulty.
- If brush holders are found to be loose or are moveable by hand, inspect the stud for discoloration and wear. Replace the stud, if damaged. If there is no damage, reinstall the stud as discussed in the Brush Holder and Stud Assembly Installation section of this module.
- Brush Holder and Stud Assembly Maintenance
 - If a single brush holder or a brush holder stud needs to be replaced, remove the entire brush holder and stud assembly from the alternator, replace the faulty component, and return the whole assembly to the alternator.
 1. With the brush holder/collector ring cover removed, blow out the compartment with clean, dry and compressed air.
 2. Wipe off the insulation between the collector rings and the collector ring studs with a clean, dry rag.
 3. Using an appropriate solvent, wipe away any residue from the brush holders with a clean, dry and lint-free cloth.

Screen 68:

Summary (Cont'd):

- Brush Holder and Stud Assembly Removal
 1. Remove all brushes from each of the assemblies.
 2. Disconnect the field cables from the bus rings at the 9 o' clock position of the brush holder stud.
 3. Slide a 0.06 inch (1.52 mm) thick sheet of heavy paper between the brush holders and the collector rings to protect the collector ring surfaces from damage.
 4. Loosen and remove four of the eight bolts securing the brush holder yoke to the mounting block.
 5. Insert a 0.5 - 13 alignment pin into two of the four exposed bolt holes and remove the four remaining bolts.
 6. Slide the yoke with all three brush holder and stud assemblies off the alignment pins and carefully transport it to a bench.
 7. Clean and replace any components, as required.
 8. Remove the bolts and washers holding the bus rings to the brush holders of the brush holder and stud assembly to be removed.
 9. Remove the mounting bolt and washer holding the brush holder stud to the brush holder yoke.
 10. Remove the brush holder and stud assembly from the yoke.
 11. Loosen the brush holder clamp bolt and remove the brush holder clamp pad.
 12. Remove the brush holder body from the brush holder stud.
 13. Repeat, as necessary, until the faulty brush holder body has been removed.
- Brush Holder and Stud Assembly Installation
 1. Mount the brush holder bodies on the brush holder stud.

2. Verify that the brush holder is properly oriented on the brush holder stud.
 3. Tighten the brush holder clamp bolt.
 4. Verify that the clamp pad is in place.
 5. Heat the brush holder and stud assembly to 302° F (150° C) for two hours.
 6. Cool the brush holder and stud assembly to room temperature.
 7. Re-torque the bolts.
 8. Assemble the brush holder and stud assembly to the brush holder yoke but do not tighten the mounting bolt.
 9. Ensure that the 0.06 inch (1.52 mm) thick paper is in place to protect the collector ring surfaces.
 10. Using the 0.5 - 13 alignment pins, slide the yoke with all three brush holder assemblies into position, then start six of the brush holder yoke to mounting block fixing bolts.
 11. Tighten the six fixing bolts until the yoke assembly does not move, then remove the two alignment pins and insert the two remaining fixing bolts.
 12. Torque all eight bolts.
 13. Align the new brush holder and stud assembly as discussed in the Brush Holder and Stud Assembly Alignment section of this module.
- Brush Holder and Stud Assembly Alignment
 1. Assemble the brush holder and stud assembly to the brush holder yoke but do not tighten the mounting bolt.
 2. Place a 0.089-0.091 inch (2.2-2.3 mm) thick fiberboard shim between the brush holders and the collector rings.
 3. Slide the brush holder against the fiberboard shim and tighten the brush holder stud mounting bolt.
 4. Torque the mounting bolt.
 5. Remove the shim.
 6. Install the bus ring bolts and washers that hold the bus rings to the brush holders.
 7. Torque the bus ring bolts.
 8. Install the brushes as discussed in the Brush Installation section of this module.
 - Brush Holder Cover Hose and Clamp Inspection
 - Verify that the hose clamps are tight. If they are loose, assemble them as discussed in the Brush Holder Cover Hose and Clamp Installation section of this module.
 - Verify that there are no tears or holes in the hose itself. If there are, replace the hose.
 - Ensure that the hose is not bunched or pinched under the clamp.
 - Inspect the clamps for cracks or stripped adjusters. Replace clamps as required.

- Brush Holder Cover Hose and Clamp Removal
 1. Using a correctly sized nut driver or a straight blade screwdriver with a heavy spade, loosen the bolt on the hose clamp until the clamp can be moved around freely.
 2. Twist the hose to break it free of the flange pipe, and remove the hose from the flange pipe.
 3. Repeat the steps with the other end of the hose.
- Brush Holder Cover Hose and Clamp Installation
 1. Position the hose onto the upper flange pipe.
 2. While holding the hose in place, tighten the clamp using a correctly sized nut driver or a straight blade screwdriver with a heavy spade.
 3. Attempt to twist the hose. If it moves, tighten the clamp until it is secured on both ends.

Screen 69:

Summary (Cont'd):

- Brush Holder/Collector Ring Cover Inspection
 - Inspect for damage and missing mounting hardware. Repair or replace the cover, as necessary.
 - Inspect the field cables for broken or overheated insulation and wires.
 - Inspect for loose hardware and terminals. Replace as necessary.
 - Inspect the field cable terminal insulators for loose hardware, burning, cracking, or other damage. Replace as necessary.
- Collector Ring Inspection
 - Check each collector ring for looseness on the insulation and the associated stud rings for shorted studs or damaged insulation. Replace the collector ring hub assembly if defects are noticed.
 - Look for yellow or white dust around the base of the ring and a measurable gap between the ring base and the insulation. A gap between the collector ring bore and the insulation will cause movement of the collector ring on the insulation when pressure is applied by hand on the collector ring. Replace the collector ring assembly if the collector ring is loose.
 - Look for ribbons of Teflon® at the location where the studs pass through the rings and for indications of arcing or other damage to the rings or studs. Ribbons of Teflon® are an early sign of fretting between the stud insulation and the rings. Replace the collector ring assembly if signs of fretting are noticed.
 - Check the depth of the spiral grooves machined in the rings. When the alternator is new, the grooves are 0.140-0.180 inches (3.6-4.6 mm) deep. If they measure less than 0.020 inches (0.5 mm) deep, replace the collector ring hub assembly.
 - Inspect the condition of the collector ring surfaces. Check for evidence of discoloration, etching, grooving, threading, or other signs of distress that require repair or replacement.

- Collector Ring Resurfacing
 1. With the engine shut off, gain access to the brush and collector ring area by removing the top cover from the brush holder/collector ring cover.
 2. Remove the stone from the packaging. The stone should be of medium coarseness (Grainger Item Number 3GD69).
 3. Cut off a one-inch long section of the stoning material using a hacksaw and a vise.
 4. Lift up the brush assembly on the collector ring that needs resurfacing. Set the brush off to the side without disconnecting the wires.
 5. Set the cut piece of stone down inside the brush holder, place the brush back on top of the piece of stone, and reposition the tensioning clip on top of the brush assembly.
 6. Start the engine and run it at idle speed, then allow the stone to resurface the collector ring.
 7. Shut down the engine and re-inspect the collector rings.
 8. When the resurfacing is complete, clean up the collector ring and the surrounding area with compressed air.

Screen 70:

Summary (Cont'd):

- Alternator Removal
 1. Disconnect the main and alternator output and input wiring.
 2. Prepare the blower cab for removal.
 3. Remove the corner air duct from the B-side of the locomotive and save all hardware.
 4. Remove the hidden bolt located near the short hood end of the blower cab and remove the cab.
 5. While leaving the conical mount buffer stud and lock nuts tight, use a 15/16-inch wrench to remove the four alternator conical mount base plate bolts at the four corners of each conical mount, and save all hardware for re-use.
 6. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head rated for higher than 1,600 lb.-ft. (2,169 Nm), loosen the alternator bottom flange nuts and remove the 1-3/8-inch torsion bar base bolts, and save all hardware for re-use.
 7. If the torsion bar base cannot be freed of wedge engagement by prying inboard, cut off the tack welds holding the torsion bar base fixed, mark each wedge with its location, remove the torsion bar from its base, and save all hardware for reuse.
 8. With the conical base plate bolts removed and the torsion bar disengaged from its wedged base, from the rear engine centerline lifting eye, lift the engine rear and alternator just enough to install the 4- to 6-inch blocks.
 9. After installing the blocks, lower the engine-alternator onto the blocks, remove the alternator bottom flange nuts and completely remove or slide

the torsion bars back far enough that they no longer engage the alternator bottom flanges.

10. Remove the alternator guards, also referred to as the alternator ventilation grates, from both sides of the engine to provide access to the engine-alternator coupling.
 11. Install the barring-over device and open the compression release valves.
 12. Bar over the engine as needed to access and remove the 30 bolts coupling the engine to the alternator rotor using either a 20-inch (508-mm) long or longer $\frac{3}{4}$ -inch (19.05-mm) drive breaker bar and a 1-1/8-inch socket or a 24-inch (610-mm) long or longer 1-1/8-inch heavy-duty tubular box end wrench to initially loosen the bolts and a 90° air ratchet for rapid removal.
 13. To a properly rated crane, attach an adjustable three-leg rigging system or, more preferably, a turnbuckle-equipped rigging system that allows for a level lift of the alternator, then attach the rigging to the alternator and adjust the hooks or turnbuckle for a level lift.
 14. With crane tension applied to lift the rigging, remove the four alternator top flange mounting bolts using a $\frac{3}{4}$ -inch air impact wrench and a 2-1/16-inch socket.
 15. Install 1-3/8-inch -12 jack bolts into both top flange threaded holes and tighten the jack bolts evenly to pry the alternator away from the engine and off the engine-to-alternator top flange alignment dowel pins.
 16. After jacking enough to clear the engine-to-alternator top flange alignment dowel pins, lift the alternator away from the engine.
 17. For later use in the same location, keep the hardware with the platform mounting pads from which they were removed.
 18. If the removed alternator will be processed for off-site repair, transfer the wooden rotor brace and cardboard spacers, the rotor-stator gap cardboard shims, and the EVO12 rotor support 84C602271ABP2 from the replacement alternator to the alternator being returned.
- Alternator Installation: Preparing the Engine:
 1. Ensure the engine is mounted on the platform with its rear end supported on blocks.
 2. Using an aluminum oxide flap wheel of not greater than 120 grit, polish and clean the engine coupling and mounting surfaces.
 3. After polishing, with an ungloved hand, feel the four mounting pads and crankshaft flange face for nicks, raised metal, and burrs and remove any high spots with a file or light grinder.
 4. Use compressed air to blow surfaces and bolt holes free of debris.
 5. Apply WD40 or equivalent rust inhibitor to polished areas and wipe down with a clean dry cloth, then apply Lubriplate® 630AA.
 6. Using a paint marker, mark the flex plate-to-alternator rotor bolt torque pattern on the outside diameter of the flex plate flange.

Screen 71:

Summary (Cont'd):

- Alternator Installation: Preparing the Alternator:
 1. Lift the rotor (30 bolt flex plate) using the EVO Alternator Stator Lifter (TESCO T67471) and remove the cardboard shipping shims from between the coils and stator.
 2. As necessary, apply cutting tap fluid to the flex plate-to-alternator rotor bolt hole threads and chase the threads using the $\frac{3}{4}$ -16 tap.
 3. Using compressed air, blow the surfaces and bolt holes free of debris.
 4. Using an aluminum oxide flap wheel of no greater than 120 grit, polish and clean the alternator coupling and mounting surfaces.
 5. After polishing, with an ungloved hand, feel the four mounting pad surfaces and rotor yoke face for nicks, raised metal, and burrs and remove any high spots with a file, emery cloth, or light grinder.
 6. Remove the bottom shims.
 7. If the alternator is re-used, perform the following steps a through e; however, if the alternator is new, only perform steps d and e.
 - a. Clean and polish both sides of shims and the alternator mounting face surface using an aluminum oxide flap sanding wheel no coarser than 120 grit.
 - b. Use emery cloth or a file to remove any raised metal or burrs on the bottom flanges.
 - c. Apply a rust inhibitor to the polished flanges and shims.
 - d. Measure and confirm each bottom flange shim is approximately 0.090 inches (2.286 mm) thick, and the thicknesses of both shims are equal to within 0.001 inches (0.0254 mm).
 - e. Re-apply the shims to the alternator and then torque the 1/2-13 x 0.75-inch grade 5 bolts to 55-62 lb.-ft. (75-84 Nm).
 8. Use compressed air to clean all of the prepared surfaces and bolt holes.
 9. Apply WD40 or other rust inhibitor to the polished areas and wipe down with a clean dry cloth.
 10. Apply Lubriplate® 630AA to the following surfaces:
 - Alternator top flange bolt holes, jack bolt hole threads, and dowel alignment holes, including the back side washer mounting surfaces.
 - Torsion bar washer load surfaces.
 - Flex plate to alternator rotor bolt hole threads and rabbet fit.
 11. Install two rotor support and coupling alignment guide pins (GPM060) in the fourth bolt holes to the left and right of the 12 o'clock position in the flex plate-to-alternator rotor.
 12. Prepare the conicals for transfer to the replacement alternator by cleaning and inspecting them.
 13. Install the conicals on the replacement alternator ensuring that the buffer stud is screwed completely counterclockwise.

14. Prepare the air duct adapter for transfer to the replacement alternator by removing any old sealant, dirt, grime, or rust.
15. Install the adapter using grade 5 1/2 inch-13 x 1.75-inch bolts.
16. Torque the mounting bolts to 59 +3/-4 lb.-ft. (80 +4/-5 Nm).
- Alternator Installation: Hardware Preparation:
 1. Prepare the flex plate-to-alternator rotor bolts for installation as follows:
 - a. If re-using the bolts, clean them thoroughly.
 - b. Inspect the bolt threads and chase as needed.
 - c. Apply Lubriplate® 630AA to the bolt threads, washer faces, and contact face of bolt heads.
 2. Apply Lubriplate® 630AA to the torsion bar threads, nut threads, and washer faces.
 3. Build two shim packs with a thickness of 0.075 inches (1.905 mm).
 4. When building the shim packs, ensure the following:
 - Do not use wrinkled shims.
 - Build the shim pack with the thickest shim against the engine and the thinnest shims sandwiched between thicker shims.
 - For greater accuracy, measure individual shim thicknesses with a 0 - 1-inch (0 - 25-mm) micrometer, not a blade-type caliper.
 - Never reuse shims removed from an in-service alternator.

Screen 72:

Summary (Cont'd):

- Alternator Installation: Engine Alternator Coupling
 1. Install the engine barring over motor and open the compression release valves.
 2. If not already removed, remove the alternator guards from both sides of the engine to make the engine-alternator coupling accessible.
 3. Prepare the alternator conical mount base plate as follows:
 - a. Clean the conical mount base plate with a 120 grit flap wheel.
 - b. Apply Lubriplate® 630AA to the base plate surface.
 - c. Apply Molykote® 77 paste to the base plate bolt hole threads and to the bolt threads.
 4. To a properly rated crane, attach an adjustable three-leg rigging system or, more preferably, a turnbuckle-equipped rigging system that allows for a level lift of the alternator.
 5. With the rotor support loosely installed or, more preferably, rotor support and alignment guide pins installed in two of the coupling bolt holes and the conical mount buffer studs fully unscrewed, attach the rigging to the alternator and adjust for a level lift.
 6. Lift and move the alternator toward the engine, adjusting the lift as needed, to align the engine top pad alignment dowel pins with the corresponding alternator top pad holes and, pause the lift as needed, to bar the engine to align the rotor yoke alignment pins with the engine flex plate bolt holes.

7. When coupling guide pins are being used:
 - a. With the pins aligned to the flex plate holes, continue advancing the alternator toward the engine to align the engine dowels with the corresponding alternator top flange holes.
 - b. Once the pins and dowels are aligned to their holes, apply the four top flange bolts to the top flanges and then, using a $\frac{3}{4}$ -inch air impact gun, tighten the four top flange bolts evenly, while alternating sides, so as to draw the pins and dowels completely through their holes until no gap exists between the rotor and the flex plate.
8. If guide pins are not being used:
 - a. When the engine dowels are aligned with the top pad holes, move the alternator close enough to apply the four top flange bolts and then, using a $\frac{3}{4}$ -inch air impact gun, tighten the four top flange bolts evenly, while alternating sides, until the tips of the engine mounting pad alignment dowels have entered and are within $\frac{1}{8}$ th inch of the outside edge of the alternator top flange holes.
 - b. Bar the engine as needed until three adjacent coupling bolts can be loosely started by hand through the vent screen openings on opposite sides of the alternator.
9. Install the previously assembled 0.075-inch (1.905-mm) shim packs in the top left and right mounting flanges.
10. Using a $\frac{3}{4}$ -inch air impact wrench, continue to tighten the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides, to draw the alternator tight against the engine.
11. Tighten the previously installed coupling bolts with a 90° air ratchet.
12. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.
13. After adjusting the conical mount central buffer lock nuts to lower the plates enough to install the $\frac{5}{8}$ -inch conical mount base plate bolts to the platform mounting pads, loosely apply the base plate bolts with a $\frac{15}{16}$ -inch wrench.
14. Apply Molykote® 77 paste to the torsion bar base hole and the bolt threads.
15. Install the torsion bars through the alternator bottom flange hole leaving the nuts loosely applied.
16. With the conical mount central buffer nuts fully backed off and ample thread showing on the loosely applied conical mount base plate bolts, slightly lift the rear of the engine from the centerline lifting eye just high enough to remove the support blocks.
17. With the support blocks removed, lower the engine-alternator assembly to fully rest on the conical mounts.
18. After a minimum of 90 minutes, inspect the conical mounts to ensure full engagement with the alternator flange.

19. If 90 minutes have passed since setting the alternator, before proceeding with alignment, adjust the conical mount clearances with the 4-mm GEVO Conical Mount Stud Clearance Check Set Gauge (TESCO T85500).
20. After adjusting the conical mount clearance, torque the conical stud locknut to 185 lb.-ft. (251 Nm).
21. Using a torque wrench and a 2-1/16-inch socket, torque the torsion bar base bolts to the platform to 100 lb.-ft. (136 Nm).
22. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head with pressure set for 1,600 lb.-ft. (2,169 Nm), torque the torsion bar nuts.
23. Using a 2-1/16-inch socket and either a HYTORC Stealth 2 or other hydraulic head with pressure set for 1,500 lb.-ft. (2,034 Nm), tighten the 1-3/8-inch torsion bar base bolts.
24. If previously removed, re-apply wedges to the torsion bar base block and tack weld in place.
25. Replace the two rotor support and alignment guide pins with flex plate-to-alternator rotor bolts.
26. Install the remaining 22 flex plate-to-alternator rotor bolts in a 10-point pattern and tighten the bolts with an air ratchet.
27. Torque all 30 flex plate-to-alternator rotor bolts in a 10-point pattern to 367 ± 37 lb.-ft. (498 ± 50 Nm).
28. Unbolt the rotor support, allowing it to drop to the platform beneath the alternator, then remove the rotor support from beneath the alternator.
29. Install the alternator guards to both sides of the engine.
30. Re-connect the electrical connections, including the main and auxiliary output and input wiring.
31. Torque the aux stator cable terminals to $23 +2/-1$ lb.-ft. ($31 +3/-1$ Nm) and torque all other hardware to the correct torque value.
32. Reinstall the blower cab.
33. Reinstall the hidden bolt removed earlier and torque to appropriate torque values.
34. Reinstall the corner duct to the B-side of the locomotive.
35. Reinstall all applicable bolts and cooling air connections to the blower cab.

Screen 73:

Summary (Cont'd):

- Alternator Installation: Alternator-Engine Alignment
 1. Rotate the gauge's outer ring to zero the gauge to the needle, then press the probe tip in and out to ensure the needle returns to zero without binding.
 2. Observe the needle movement direction as the probe is pressed and released.

3. After mounting the probe with a pre-load and zeroing the gauge, record the face-on indicator readings to the right of zero as negative values and face-on readings to the left of zero as positive values.
 4. Drape the cloth across an oil pan to catch the indicator should it fall.
 5. Bar over the engine to set the cam-gear timing window-pointer to 110, setting the crankshaft to position A.
 6. Through the R6 crankcase inspection cover opening, mount the dial indicator in the webbing prick punch holes.
 7. With the gauge mounted, gently rock the gauge until the indicator needle no longer moves.
 8. Rotate the dial face outer ring to zero the gauge.
 9. Bar over the engine to the cam gear positions B, C, D and E stopping each time to record the gauge reading with the proper signage.
 10. Calculate the TIR.
 11. Calculate the top right (engine right/locomotive left) and the top left (engine left/locomotive right) shim pack adjustment, by using the formulas.
 12. If the formulas require that shims be added, prepare to do so by using a 0-1-inch outside diameter micrometer, not a blade caliper, to measure and identify individual shims that add up to the thickness calculated by the formula.
 13. Without disturbing the bottom flange torsion bar nuts, use an air impact wrench to evenly loosen the four top flange mounting bolts.
 14. Use a jack bolt at either one of the top ear flanges to slightly pry the alternator away from the engine far enough to remove the shim pack.
 15. Remove the shim packs with a spare thick shim or a piece of bent wire.
 16. Remove or add shims from or to the pack to adjust the thickness in accordance with the shim adjustment formulas.
 17. Install the adjusted shim packs.
 18. Remove the jack bolt.
 19. Using a $\frac{3}{4}$ -inch air impact wrench, tighten the four alternator top flange mounting bolts evenly (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides.
 20. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.
 21. Until TIR is less than 0.0005 inches (0.0127 mm), repeat the above-mentioned steps of rocking the gauge at position A (until the needle stops moving before zeroing the gauge), re-measuring web deflection, recalculating TIR, and adjusting the shim pack thickness.
- Alternator Installation: Compressing the Web
 1. Use the air impact wrench to loosen all four alternator top flange mounting bolts.
 2. Install and tighten a jack bolt on either the right or left mounting flange to slightly pry the alternator apart from the engine.

3. Install 0.015-inch (0.381-mm) shims to both the top right and top left flanges.
4. Remove the jack bolt.
5. Using a $\frac{3}{4}$ -inch air impact wrench, tighten the four alternator top flange mounting bolts evenly (the inner top flange bolts first followed by the outer top flange bolts), while alternating sides.
6. Torque the four alternator top flange mounting bolts (the inner top flange bolts first followed by the outer top flange bolts) to 650 ± 25 lb.-ft. (881 ± 34 Nm) and repeat this torque pattern to confirm the proper torque.
7. Verify that the crank-position dial indicator gauge readings are within the ranges.
8. If needed, equally add or remove the shims at the top right and left flanges to achieve a reading of -0.003 ± 0.0005 inches (-0.076 ± 0.0127 mm) in position C.
9. After alignment is complete, torque the $\frac{5}{8}$ -11 x 2-inch alternator conical plate mounting bolts and hardened washers to 166 - 185 lb.-ft. (225 - 250 Nm).

Screen 74:

Summary (Cont'd):

- Describe how to perform running maintenance related to the alternator.
 - Alternator Installation: Troubleshooting Alignment Issues
 1. Verify that the engine is at room temperature when taking the web deflection measurement as a cooling engine prevents accurate indicator readings.
 2. Verify that the torsion bar nuts are correctly torqued and have not been disturbed during the alignment process.
 3. Verify that the correct point of reference is made regarding the flange where shims are applied.
 4. Verify that a calibrated 0 - 1-inch (0 - 25-mm) micrometer is being used to measure the shim thickness, not a blade-type caliper.
 5. Verify each shim thickness when adjusting the total shim pack thickness and never assume to know a shim's thickness.
 6. Verify that used shim packs or wrinkled shims are not being used.
 7. Verify that the shim pack is being built with the thickest shim against the engine and the thinnest shims sandwiched between thicker shims.
 8. Verify that the shims are being measured individually and added together for the total shim pack thickness.
 9. Verify that the shim pack thickness at each top mounting flange does not exceed 0.135 inches (3.429 mm).
 10. Verify that the difference between the top left flange shim pack thickness and the top right flange shim pack thickness is less than 0.060 inches (1.524 mm).

11. Between every shim pack adjustment and before taking deflection readings, verify that the top flange mounting bolts are being consistently torqued to 650 lb.-ft. (881 Nm).
12. Verify that the correct +/- signs are being applied to values read on the dial indicator, especially for positions D and E, when reading in a reverse direction with a mirror.
13. Verify that the correct crank position references are being made as position A is via the R6 crankcase cover opening and not L6.
14. Verify the integrity of the dial indicator by confirming the needle returns to the same location after pushing in and releasing the probe.
15. Verify the integrity of the dial indicator by duplicating the results with a second dial indicator.
16. Verify that the dial indicator is installed in the larger set of the web prick punch marks, not the smaller set.
17. Verify at position A that the dial indicator is being rocked until the needle stops moving and that this is being done with each new set of readings.
18. While rotating the crankshaft between the reading positions, identify a defective dial indicator by watching the needle for momentary, rapid spinning, which is possible even if the issue cannot be replicated and observed when manipulating the indicator by hand.
19. Verify that the full weight of the alternator is on the conical mounts or the alternator is lifted off the jack stands (floor web stand).
20. Confirm that the conical mounts meet the 4-mm clearance requirement and are not bottomed out either against the elastomer on the top side or against the platform on the bottom side.
21. On Tier 2 engines, inspect the low-pressure fuel line support brackets for interference with the alternator frame.
22. Uncouple the engine from the alternator and check for raised metal or burrs on the mounting faces and coupling fit.
23. Remove and verify with a 0 - 1-inch (0 - 25-mm) micrometer that the bottom left and right shim thicknesses are 0.090 inches (2.286 mm).
24. Rotate the alternator rotor by 180° and try setting the alignment from the beginning.
25. If excessive vibration is detected after starting, evaluate the problem as follows:
 - a. Use a dial indicator to confirm that the alternator alignment is within specification.
 - b. Check for the excessive rabbet-fit clearance between the rotor flange and the engine flex plate.
 - c. Check the clearance on all conical mount buffer studs.
 - d. After the rotor yoke-to-flex plate bolts are fully torqued, measure the runout of the outer diameter of the rotor yoke flange as the engine is barred over 360°.

- e. Measure the vibration in Notch 8 Self-Load and, if the vibration is greater than the upper limits, uncouple the alternator from the engine, bar the engine crankshaft by 180°, recouple and re-align the alternator and the engine, and then re-measure the Notch 8 Self-Load vibration.
 - f. Lower the #7 main bearing cap and inspect for bearing failure.
- Alternator Installation: Engine Preparation for Starting
After setting web compression measures within specification:
 - 1. Remove the barring-over device.
 - 2. Reapply the barring device cover and the cam gear timing window cover, if removed.
 - 3. Reapply all crankcase inspection covers.
 - 4. Close all compression release valves and torque to 59 lb.-ft. (80 Nm).