

Running Maintenance Torques

Screen 1:

Welcome Screen:

Welcome to the Running Maintenance Torques module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Running Maintenance Torques:

In this module, we will discuss different types of bolts and tightening methods, as well as special tools and torque values commonly used for the different tightening methods.

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

- Identify the different types of bolts based on thread profile, strength, and size.
- Identify the forces that operate on a bolted joint.
- Describe the different tightening methods used for locomotive maintenance.
- Describe special tools commonly used for different tightening methods.
- Define the recommended tightening sequences on the GEVO diesel engine.
- Identify the sources of documentation for standard bolt torque values.
- Convert torque values from U.S. Customary to Metric and vice versa.

Screen 3:

Disclaimer:

The standards discussed in this module are not comprehensive. They present some of the most common principles that are applicable to our locomotives.

Screen 4:

Introduction to Bolt Identification:

Threaded fasteners are classified by shape, material, and finish, which are specified by industry standards. In the United States, the American Society for Testing Materials (ASTM) sets the standards, which are often referred to as Unified, American, or Inch standards. In Europe, the International Standards Organization (ISO) sets the standards. The Metric fasteners are specified by the ISO. Both the Inch and Metric standards use a symmetrical V-shaped thread profile. The angle of the threads is 60 degrees with flat crests and rounded roots. The pitch of a thread has been standardized for coarse, fine, and extra fine threads, for various diameters. The Inch standard identifies pitch as the number of threads per inch, and the Metric standard identifies pitch as the distance between corresponding points on adjacent threads.

Screen 5:

Bolt Strength:

Strength is an important consideration when applying a bolt. Bolt material strength is determined by the alloy and the processing methods, such as cold working and heat

treating. The two important material properties are yield strength and tensile strength. Yield strength is the stress level at which the material yields or permanently deforms. Tensile strength, sometimes called ultimate strength, is the stress level at which the material breaks. The tensile strength is always higher than the yield strength. Materials with a large difference between the yield and tensile strength are considered ductile, meaning they will stretch substantially before breaking. For inch-size fasteners, the material strength is specified by the "grade". A grade 8 bolt is stronger than a grade 5, which is stronger than a grade 2. The grade is indicated by a series of marks on the bolt head. For metric fasteners, the term "property class" is used and is stamped directly on the head. When you replace a bolt, it is important to identify its grade correctly. If bolts are not replaced with the same grade, a failure can occur that could endanger lives and equipment.

Screen 6:

Size Identification:

Metric standard bolts are identified using a standard naming convention that includes an "M" followed by three numbers. In the example displayed, the first number is the diameter, the second number is the thread pitch, and the third number is the length. All three numbers are in millimeters. The example is therefore a Metric bolt with a 10 mm diameter and a 1.25 mm thread pitch, and it is 35 mm long. Inch standard bolts are named differently. The first number is the diameter, the second number is the number of threads per inch or thread pitch, and the third number is the length. The first and last numbers are in inches. The example shows a 5/8 inch diameter bolt with 11 threads per inch that is 1-3/4 inches long.

Screen 7:

Tightening Process:

Threaded fasteners are tightened for the obvious reasons of clamping parts together and transmitting loads. In gasket joints, tightened fasteners prevent leakage. In other joints, the clamping force is developed to prevent the parts from separating or shaking loose. A screw or bolt thread is an extension of one of the basic machines: the inclined plane. This inclined plane, however, is wrapped around a shaft. When the thread is turned, it moves the mating part or nut up the inclined plane. When more turning force, or torque, is applied to the shaft, the more force is exerted on the nut. This force creates tension in the bolt, which clamps the mating parts together. Preload is the technical term for the tension caused by tightening the fastener that holds the assembled parts together. Generating sufficient preload force is the key to strong and reliable bolted joints that do not loosen or break under load.

Screen 8:

Forces Operating on a Bolted Joint:

You can think of the fastener as a spring. It may seem odd to think of the engine as being held together by springs, but this analogy helps show what happens when the bolt and nut are tightened. Rotating the bolt or nut, which in turn stretches the spring,

generates preload force. The more the bolt or nut is rotated, the more the bolt stretches and generates more preload or spring tension. When no tension load (F_t) is applied to the joint, the clamping force (F_c) equals the preload force (F_p). If the tension load is equal to the preload, there is no clamping force. If the tension load is increased beyond the initial preload force, the joint separates. Even after the joint separates, it continues to take increased tensile loads until the ultimate tensile strength of the fastener is reached and the fastener breaks. From a practical standpoint, joint failure occurs well before the fastener actually breaks because the parts being held together will loosen and not function properly.

Screen 9:

Effect of Tension Forces:

Joints are loaded with shear force (F_s), tension force (F_t), or a combination of both. In a joint loaded with tension forces, the preload force on the bolt opposes the joint-separating forces. A cylinder head is a good example of this. For a joint with stiff mating parts, the load on the bolt remains constant at F_p until the tensile load is greater than the preload force. A simplistic view is that the ultimate strength of the joint is limited by the strength of the bolt. However, the higher the preload force, the better the joint, because it prevents the assembled parts from moving and the joint from loosening. A highly preloaded joint is also more resistant to cycling loads because less of the cyclic portion of the load is experienced by the fastener.

Screen 10:

Effect of Preload Forces:

In general, the preload force determines the strength of the joint. Joints are stronger and more fatigue resistant with greater preload force. It is important that the preload force be maintained in the fastener during operation. Highly loaded or critical fasteners tend to be long and they must be stretched a relatively large amount to generate the preload force. This allows them to maintain their preload, even if they expand a little or the mating parts shrink. An example of this includes the connecting rod bolts.

Screen 11:

Effect of Shear Forces:

The other type of joint is loaded by shear force (F_s). In a joint loaded in shear forces, the friction between the parts keeps them from moving when subject to a shear force. The friction between the parts carries the load, not the fastener. An example of this type of joint would be a shock absorber mount. The greater the preload force the greater the clamping force, the greater the friction, and the stronger the joint. With a properly designed and tightened joint, the bolt will not experience a direct shear load.

Screen 12:

Mating Surfaces of Fasteners:

The mating parts also act like a spring, but a much stiffer spring. Ideally, the mating parts are much stiffer than the fastener. Joints with soft gaskets are an exception to the

"More Preload is Better" rule. High loads can deform the gasket or mating surface, which causes leaks. Proper preload is the key to reliable bolted joints.

Screen 13:

Ensuring Reliability of Bolted Joints:

The drive for improved reliability has had a direct impact on assembly processes. To ensure satisfactory performance of mechanical equipment and avoid costly failures, it is important to tighten all nuts on vital bolts and studs according to values given in the appropriate maintenance instructions. It is also important to use the proper length bolt in all applications.

Screen 14:

Torque:

It is no longer sufficient just to run a nut down a bolt until it stops and hope that it is tight enough. The critical weakness in many products is found in the design of the joints – bolted joints in particular. One incorrectly tightened bolt can lead to the failure of the complete assembly. Too high a tightening torque can cause a bolt shank or thread stripping failure. Too low a tightening torque can cause inadequate bolt tension, allowing the joint to come apart.

Screen 15:

Length:

If the bolt is too long, it can bottom in the hole, damaging the bolt or associated parts. If the bolt is too short, enough thread engagement may not occur. Always clean out tapped holes and ensure that threads are in good condition. In some cases, you may need to retap the hole.

Screen 16:

Tightening Methods:

To set the correct, precise preload in bolted joints, you must choose the appropriate bolt tightening method. Insufficient preload caused by an inaccurate tightening method is a frequent cause of bolted joint failure. Four main methods are used to control the preload of a threaded fastener:

- Torque control
- Angle control (also known as turn-of-the-nut)
- Bolt stretch or elongation measurement
- Tensioning

Screen 17:

Torque Control:

The most prevalent controlled method of tightening threaded fasteners is tightening to a specified torque value. In this method, generally known as torque control, rotary force is applied to the nut as it moves down the threads of the bolt. Once the nut contacts a

surface, it begins to act like a screw jack, forcing the bolt to stretch. The problem is determining exactly how much clamping force that the applied torque generates. A torque wrench can indicate how much force is being applied to the nut, but not how much stretching or clamping power is really being generated. This is because some of the torque we are measuring is being absorbed by friction between the nut and the threads or mating surface, or by twisting in the bolt.

Screen 18:

Applied Torque and Friction:

So what is applied torque? If you tighten a bolt and nut with a torque wrench, the applied torque is dispersed to stretch the bolt and to overcome friction. Somewhere between 50% and 80% of the applied torque is needed just to overcome friction. The types of friction experienced when applying torque to the nut and bolt include nut face friction, thread friction, and thread torsion. Nut face friction is caused by the metal-to-metal contact between the nut face and the mating surface as the nut is being turned; and sometimes by dirt and corrosion. Thread friction is caused by irregularities in the thread surfaces, dirt, and corrosion. Thread torsion, also referred to as twist, occurs when the bolt begins to twist under the applied torque. So, how can we reduce this friction?

Ensure that the hardware is clean, free of dirt and rust. In some cases, you may need a tap and die set to clean the threads of the bolt and nut. Apply proper lubrication to the threads and the faces of the bolt and nut. If a washer is used, apply lubrication to both sides of the washer. Always use the lubricant specified in the maintenance manual instructions. Lubricants are not interchangeable; each type of lubricant can affect the clamping load differently. The physical makeup of the parts may influence the torque values being applied. Always refer to the maintenance manual for the correct torque values and proper lubricant for each application.

Screen 19:

Angle-Control Tightening Method:

Another tightening method often used is the Angle-Control method. This method is also known as the turn-of-the-nut method. The nut or bolt is turned a predetermined number of degrees after all play has been removed from the joint. The main disadvantage of this method is the precision required to determine the angle, usually through experimentation. An advantage of this method is that, because of the predetermined angle, the friction factor is eliminated. However, the accuracy of the maintainer measuring the angle directly affects the accuracy of this method.

Screen 20:

Bolt Stretch or Elongation Measurement Tightening Method:

Bolt elongation measurement is a tightening method that still depends on torque to stretch a bolt, but provides improved measurement of the actual clamping force that is produced. In this method, accuracy is achieved by measuring the length of the bolt before torque is applied, and then measuring it again after the torque has been applied. Once you measure the amount of stretch in the bolt, you can estimate the amount of

clamping force produced. A disadvantage of this type of tightening is that it allows only one bolt to be tightened at a time, which can lead to uneven clamping and point loading along gaskets and surfaces that are being joined. Also, bolt elongation measurement cannot account for variations in bolt shank size, which will change the amount of clamping force that is produced. When a 2 inch diameter bolt and a 7/8 inch diameter bolt are stretched an identical distance, the larger of the two bolts produces more clamping force.

Screen 21:

Tensioning Method:

Tightening large bolts requires very high tensioning torques that can be difficult to achieve. You can overcome this problem by using a hydraulic torque wrench. Hydraulic tensioning devices are commonly used for bolts over 20 mm in diameter. The tension method uses a small hydraulic ram, which fits over the nut. The threaded portion of the bolt or stud protrudes well past the nut, and a threaded puller is attached. Hydraulic oil from a small pump acts on the hydraulic ram, which in turn acts on the puller. The puller stretches the bolt or stud. The nut can then be rotated by hand with an integral socket aided by a bar or pin. Control of the hydraulic pressure effectively controls the preload in the bolt. However, a small amount of preload reduction occurs when the pressure is removed as the nut elastically deforms under the load. It can also be difficult to remove nuts corroded to bolts with this method. The tensioning method solves most of the problems with torque control and bolt elongation measurement tools. In addition, hydraulic tensioning devices eliminate the problem of thread galling and allow all the bolts or studs on that part of the assembly to be tightened with identical amounts of force, all at the same time. This eliminates the danger of uneven pressure distribution on parts and gaskets.

Screen 22:

Special Tools:

Special tools often used to maintain the Evolution Series locomotives include torque wrenches, adapters, and tensioning tools. The clicker torque wrench, sometimes called a digital wrench, works by preloading a "snap" mechanism with a spring to release at a specified torque. When the mechanism releases, the ratchet head makes a "click" noise. Rotating the handle until the desired torque is shown in the window sets the torque. Older clicker wrenches have a micrometer-style scale along the handle instead of a window. The ratchet head makes it easy to use in confined spaces. It is a good practice to set a clicker wrench to its lowest setting before putting it away to prevent the spring from permanently stretching. Avoid rough handling and dropping the torque wrench because it can damage the mechanism. Do not use the torque wrench to loosen fasteners; this may damage the calibration mechanism. Torque wrenches should be calibrated on a regular schedule depending on tool usage.

Screen 23:

Adapters:

With a torque wrench, you may need to use adapters to reach inaccessible bolts or nuts. When adapters are used, the reading of the torque wrench dial is different from the actual torque exerted. The additional torque exerted on the nut or bolt over that shown on the dial depends on:

- The length of the adapter and
- The angle at which the adapter is positioned on the wrench.

When you apply an adapter to a torque wrench, you increase the mechanical advantage. Therefore, you must make an adjustment to the torque wrench setting to apply the correct torque value to the fastener.

Note: When using a torque wrench adapter, a 90-degree torquing angle is recommended. If unable to torque at a 90-degree angle, apply the adapter to the torque wrench at the angle needed to tighten the fastener; however, the torque wrench setting must be adjusted to the proper value as discussed in GEI-81913, TORQUE WRENCH APPLICATION AND VALUES, which provides details to manually calculate the correct torque wrench setting.

The torque wrench setting must be formulated by using the torque wrench length and the adapter length measurements. The length of the adapter (A) is added to the length of the wrench from the wrench head to the midpoint of your grip on the handle (B), to get the overall length (C). The actual torque wrench setting is calculated by dividing dimension B by dimension C, then multiplying the answer by the torque specification. When the torque adapter is offset, the measurement must still be taken in a straight line with the torque wrench. Let's try an example. In this example, the wrench length (B) is 3' and dimension A is 6". Therefore, overall length (C) would be 3.5' (3' + 6"). Using the formula from before, will give you the necessary torque setting. With the added mechanical advantage provided by this adapter, a torque wrench setting of 86 lb.-ft. will apply 100 lb.-ft. of torque to the fastener. It is important that the pull on the torque wrench handle be concentrated at the pull point position, marked as "P" in the figure. A shift in this position causes a considerable discrepancy between the torque reading and the effective torque. The threads of both parts must also be clean, free of burrs, and properly lubricated, using the same lubricant as was applied to the contact face of the nut or bolt.

Screen 24:

Tensioning Tools:

Each tensioner is designed for a specific application. For example, the cylinder head bolt tensioner is designed to fit the four cylinder head bolts. Regardless of the specific application, all tensioner tools contain the same basic elements:

- A base that rests on the component, providing an anchor for the pulling force.
- A hydraulic cylinder that threads onto the bolt and stretches it to its recommended tension.
- A cap that mates with the nut and allows the operator to apply or remove the nut.

Screen 25:

Recommended Tightening Sequences:

Two types of tightening sequences are used to minimize bolt preload variations due to elastic interactions. In some instances, a pre-torque/final torque sequence is used. With this sequence, each bolt is tightened to a pre-torque value on the first pass, and then the final torque value on the second pass. This reduces the preload reduction caused by tightening the other bolts in the joint.

Screen 26:

Standard Torque Values:

When maintaining the locomotive, it is essential that you apply the correct torque values to all fasteners. Different types of hardware have different standard torque values. Use standard bolt torque tables when a specified value is not listed in the maintenance manual instructions for a particular application. Most torque wrenches have both units of measurement, Pound-Foot (or Foot-Pounds) and Newton-Meters. If a conversion has to be made, the conversion table provides the conversion factors. The metric equivalent uses a comma instead of a decimal point in some documentation. When doing conversions, use a decimal point in place of a comma.

Screen 27:

Specified Torque Values:

Each type of locomotive has its own documentation where you can find torque data and the many ways that our engineering group specifies torque values. Each Running Maintenance and Backshop Manual publication has a Data or Torque Values section located at the back. The torque value for a particular application is listed as part of the procedural step. There are two ways in which torque values are specified: Pre-torque vs. Final Torque, and Range of Torque Values. Some fasteners have a pre-torque and a final torque value. The reason for this is to minimize the variations caused by friction between fasteners. What this means is that all fasteners are first torqued to the pre-torque value and then to the final torque value. Pre-torque and final torque values are indicated by separating them with a "/". For example, for the crankshaft drive gear bolt values 300/970 Nm, the first number is the pre-torque value and the second number is the final torque value. A fastener can have a higher specified pre-torque value than a final torque value. Always torque the fastener to the values specified in the maintenance manual. Our engineering group indicates a Range of Torque Values in two ways: by using a range of values, and a plus-or-minus value. For example, in 50 to 60 lb.-ft. (commonly read as ft.-lb.), any torque value of 50 through 60 lb.-ft. is valid. For 90 plus or minus 9 lb.-ft., a valid torque is 81 through 99 lb.-ft.

Screen 38:

Summary:

You have reached the end of this module!

In this module, you learned to:

- Identify the different types of bolts based on thread profile, strength, and size.
 - Bolts are classified by shape, material and finish, which are specified by industry standards, such as the American Society for Testing Materials (ASTM) and the International Standards Organization (ISO). Inch standards are set by ASTM and Metric standards by ISO.
 - Both the Inch and Metric standards use a symmetrical V-shaped thread profile.
 - The Inch standard identifies pitch as the number of threads per inch and the Metric standard identifies pitch as the distance between corresponding points on adjacent threads.
 - For inch-size fasteners, the material strength is specified by the "grade".
 - For metric fasteners, the term "property class" is used.
- Identify the forces that operate on a bolted joint.
 - Threaded fasteners are tightened for clamping parts together and transmitting loads.
 - A screw or bolt thread is an extension of an inclined plane. This inclined plane has been wrapped around a shaft. When the thread is turned, it moves the mating part or nut up the inclined plane.
 - When more turning force, or torque is applied to the shaft, the more force is exerted on the nut. This force creates a tension in the bolt, which clamps the mating parts together.
 - Generating sufficient preload force is the key to strong and reliable bolted joints that will not loosen or break under load.
 - Rotating the bolt or nut, which in turn stretches the spring, generates the preload force. The more the bolt or nut is rotated, the more the bolt stretches and generates more preload.
 - When there is no tension load (F_t) applied to the joint, the clamping force (F_c) equals the preload force (F_p).
 - If the tension load is equal to the preload, there is no clamping force.
 - If the tension load is increased beyond the initial preload force, the joint will separate.
 - Joints are loaded with shear forces (F_s), tension forces (F_t) or a combination of both. In general, the preload force determines the strength of the joint.
 - The mating parts act like a spring, but a much stiffer spring. In the ideal case, the mating parts are much, much stiffer than the fastener.

- To ensure satisfactory performance of mechanical equipment and to avoid costly failures, it is important to tighten all nuts on vital bolts and studs according to values given in the appropriate maintenance instructions.
- Describe the different tightening methods used for locomotive maintenance.
 - Insufficient preload, caused by an inaccurate tightening method, is a frequent cause of bolted joint failure.
 - There are four main methods that our engineering group utilizes to control the preload of a threaded fastener:
 - Torque control
 - Angle control (also known as turn-of-the-nut)
 - Bolt stretch or elongation measurement
 - Tensioning
 - In torque control method, a rotary force is applied to the nut as it moves down the threads of the bolt. Once the nut contacts a surface, it begins to act like a screw jack, forcing the bolt to stretch.
 - Angle control is also known as the “turn-of-the-nut” method. The nut or bolt is turned a predetermined number of degrees after all play has been removed from the joint.
 - Bolt elongation measurement is a tightening method that still depends on torque to stretch a bolt, but it does allow for improved measurement of the actual clamping force that is being produced.
 - A method which solves most of the stated problems with torque control and bolt elongation measurement tools is the tensioning method.
- Describe special tools commonly used for different tightening methods.
 - Some of the special tools commonly used include:
 - Torque wrenches
 - Adapters
 - Tensioning tools
 - The clicker torque wrench, sometimes called a digital wrench, works by preloading a "snap" mechanism with a spring to release at a specified torque.
 - It is often necessary to use adapters with a torque wrench to reach inaccessible bolts or nuts. When adapters are used, the reading of the torque wrench dial is not the actual torque exerted.
 - The additional torque exerted on the nut or bolt depends on:
 - Length of the adapter.
 - Angle at which the adapter is positioned on the wrench.
 - Each tensioner is designed for a specific application. The basic elements of a tensioner are:
 - A base that rests on the component, providing an anchor for the pulling force.
 - A hydraulic cylinder that will thread onto the bolt, then stretch it to its recommended tension.

- A cap that mates with the nut and allows the operator to turn it on or off.
- Define the recommended tightening sequences on the GEVO diesel engine.
 - The tightening sequences used are:
 - Criss-cross tightening sequence for circular bolt patterns.
 - Spiral tightening sequence starting in the middle for non-circular bolt patterns.
 - Tightening sequences result in minimizing bolt preload variations due to elastic interactions.
 - In some instances a pre-torque/final torque sequence is used. With this sequence, each bolt is tightened to a pre-torque value for the first pass and then the second pass at the final torque value. This will reduce the preload reduction caused by the tightening of the other bolts in the joint.
- Identify the sources of documentation for standard bolt torque values.
 - It is essential when maintaining the locomotive to apply the correct torque values to all fasteners.
 - The standard bolt torque value tables should be used when a specified value is not listed in the maintenance manual instructions for the particular application.
 - Each Running Maintenance and Backshop Manual publication that contains maintenance procedures has a Data or Torque Values section located at the back of the publication. Also, the torque value for a given application is listed as part of the procedural step.
 - Some fasteners have a pre-torque and a final torque value. The reason for this is to minimize the variations caused by friction between fasteners. This means that all fasteners are first torqued to the pre-torque value and then to the final torque value.
 - One way our engineering group indicates a pre-torque and final torque is by separating the two values by a "/".
 - There are two ways that our engineering group indicates a range for the torque: For example, in 50 to 60 lb.-ft (commonly read as ft-lb), any torque value of 50 through 60 lb.-ft is valid. For 90 plus or minus 9 lb.-ft, a valid torque is 81 through 99 lb.-ft.
- Convert torque values from U.S. Customary to Metric and vice versa.
 - Most torque wrenches have both units of measurement, Pound-Foot (or Foot-Pounds) and Newton-Meters.
 - If a conversion has to be made, 1 lb.-ft. = 1.3558 Nm.
 - The metric equivalent uses a comma instead of a decimal point in some documentation. When doing conversions, use a decimal point in place of a comma.

Lubricating Oil System

Screen 1:

Welcome Screen:

Welcome to the Lubricating Oil System module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Lubricating Oil System:

In this module, you will learn how to inspect and maintain the components of the lubricating oil system in a running repair environment.

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

- State the purpose and location of the lubricating oil system.
- State the purpose and location of the major components of the lubricating oil system.
- State the purpose and location of the instrumentation devices of the lubricating oil system.
- Describe how the lubricating oil system operates.
- Describe the protection strategies used with the lubricating oil system.
- Describe how to perform scheduled maintenance related to the lubricating oil system.

Screen 3:

Disclaimer:

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

Screen 4:

Overview of the Lubricating Oil System:

The lubricating oil system, commonly referred to as the lube oil system, provides pressurized lubrication to engine components and carries away heat produced by friction and combustion. The lube oil system components are located along the engine and the radiator cabs.

Screen 5:

Major Components of the Lubricating Oil System:

The lubricating oil system comprises the following major components:

- Diesel Engine Oil Pan
- Lubricating Oil Pump
- Lubricating Oil Cooler

- Lubricating Oil Filter

Screen 6:

Diesel Engine Oil Pan:

The diesel engine oil pan is located on the underside of the engine. The oil pan is bolted to the diesel engine mainframe and forms the reservoir that holds the lubricating oil.

Screen 7:

Lubricating Oil Pump:

The lubricating oil pump, or lube oil pump, is located on the Integrated Front End (IFE) cover of the engine. The lubricating oil pump circulates the oil through the lubricating oil system.

Screen 8:

Lubricating Oil Cooler:

The lubricating oil cooler, or lube oil cooler, is located in the radiator cab on the helper's side (B-side) of the locomotive just aft of the engine. The lubricating oil cooler removes heat from the lubricating oil system.

Screen 9:

Lubricating Oil Filter:

The lubricating oil filter, or lube oil filter, is located in the radiator cab on the helper's side (B-side) of the locomotive just aft of the engine and oil cooler. The lubricating oil filter removes contaminants larger than 30 microns from the engine oil.

Screen 10:

Major Components of the Lubricating Oil System (Cont'd):

Let's look at some of the other major components of the lubricating oil system.

Screen 11:

Pre-Lube Oil Pump:

The pre-lube oil pump is located in the radiator cab on the engineer's side (A-side) of the locomotive just aft of the engine. It pre-lubricates the engine before cranking.

Screen 12:

Check Valve:

The check valve is located in the engine cab on the helper's side (B-side) of the locomotive. It is physically a part of the piping that connects the lubricating oil pump outlet pipe and the pre-lube pump outlet pipe. The check valve protects the pre-lube pump from excessive reverse oil flow (backflow) from the outlet to the inlet when the pump is not operating.

Screen 13:**Coalescer:**

The coalescer is mounted on the IFE cover of the diesel engine and is accessible from the engineer's side (A-side) of the locomotive. The coalescer removes combustible gases from the engine crankcase.

Screen 18:**Instrumentation Devices of the Lubricating Oil System:**

The major sensors of the lubricating oil system are:

- Engine Lube Out Temperature (ELOT) sensor
- Engine Lube In Temperature (ELIT) sensor
- Engine Lube In Pressure (ELIP) sensor
- Engine Lube Pump Pressure (ELPP) sensor
- Crankcase Overpressure (COP) sensor

Screen 19:**ELOT Sensor:**

The ELOT sensor is located in the oil discharge pipe from the lubricating oil pump. It measures the temperature of the lubricating oil exiting the engine and provides the information to the Engine Control Unit (ECU).

Screen 20:**ELIT Sensor:**

The ELIT sensor is located in the IFE cover next to the oil inlet pipe to the engine. It measures the temperature of the lubricating oil entering the engine and provides the information to the ECU.

Screen 21:**ELIP Sensor:**

The ELIP sensor is located on the rear of the engine crankcase just behind the left-six power assembly. It measures the pressure of the lubricating oil at the left-seven cam bearing in the engine and provides the information to the ECU.

Screen 22:**ELPP Sensor:**

The ELPP sensor is located in the oil discharge pipe from the lubricating oil pump. It measures the pressure of the lubricating oil at the outlet of the lubricating oil pump and provides the information to the ECU.

Screen 23:**COP Sensor:**

The COP sensor is located on the rear of the engine crankcase just behind the left-six power assembly. It measures the pressure in the crankcase and provides the information to the ECU.

Screen 26:**Operation of the Lubricating Oil System:**

The lubricating oil system is a full-flow type system, which means that all oil must circulate through the lubricating oil filter. In the event of filter obstruction, unfiltered lubricating oil is not permitted to circulate through the system through an oil filter bypass valve or other bypass provision. This full-flow lubricating oil system design prevents unfiltered oil and the harmful foreign materials it might contain from contaminating the engine and its components.

Screen 27:**Operation of the Lubricating Oil System (Cont'd):**

Oil is drawn from the engine oil pan through a perforated metal strainer by the lubricating oil pump. The strainer prevents large contaminants from reaching the lubricating oil pump. The lubricating oil pump is gear-driven off of the engine by an auxiliary drive gear. The oil pump moves approximately 475 GPM of oil at notch 8 engine speed and normal operating temperature. An internal relief valve protects the pump from overload conditions, such as a clogged filter assembly or oil cooler. The relief valve fully opens at 150 psi.

Screen 28:**Operation of the Lubricating Oil System (Cont'd):**

The pump forces the oil through the oil cooler. The oil cooler contains metal plates that allow oil to flow on one side and cooling water from the split cooling water system to flow on the other side. Heat from the oil is transferred through the plates to the cooling water. The cooled oil flows out of the oil cooler to the oil filter housing. The oil filter housing contains 10 filter elements, which filter contaminant particles down to 27–30 microns in size. From the oil filter housing, the oil is piped to the IFE cover of the engine. From the IFE cover, the pressurized oil is distributed to the turbocharger and to the moving parts of the engine. The oil cools and lubricates the moving parts and then returns to the engine oil pan.

Screen 29:**Normal Oil Flow Path in the Lubricating Oil System:**

The lubricating oil system includes a pre-lube pump and a check valve. The pre-lube pump operates prior to engine cranking to circulate lubricating oil through the engine. This is critical to engine protection at low temperature operation, when the oil viscosity is high and oil flow characteristics are poor. Pre-lube pump operation is automatic and is controlled by the locomotive control system. Once the pump is activated, the ELIT

and ELIP sensors in the ECU monitor the temperature and pressure of the lubricating oil entering the engine.

Screen 30:

Normal Oil Flow Path in the Lubricating Oil System (Cont'd):

If the engine lubricating oil inlet temperature is greater than 150°F, the pre-lube pump operates for two minutes, and then the diesel engine cranks. If the oil inlet temperature is less than 150°F, the pre-lube pump operates for four minutes before the diesel engine cranks. During the four-minute pre-lube cycle, if ELIP pressure does not rise 0.5-psi or greater for 10 continuous seconds, a non-restrictive incident is logged. If the engine does not start, a second pre-lube cycle is initiated. If the oil pressure fails to build again, a restrictive Automatic Engine Start/Stop (AESS) incident is logged. The pre-lube pump is driven directly by a coupled compound-wound DC motor. The input power flows from the locomotive battery through a contactor to the motor.

Screen 31:

Normal Oil Flow Path in the Lubricating Oil System (Cont'd):

A take-off in the engine oil suction pipe is connected between the engine oil pan and the engine lubricating oil pump. The engine lubricating oil is pulled by the pre-lube pump from this take off. From the pre-lube pump, the oil is sent to the engine through the check valve, which is connected to the oil inlet pipe to the oil cooler. The check valve protects the pre-lube pump from excessive reverse oil flow from the outlet to the inlet when the pre-lube pump is not operating.

Screen 32:

Normal Oil Flow Path in the Lubricating Oil System (Cont'd):

In addition, the check valve has a 9/64-inch (3.5 mm) diameter hole that allows a small flow of lubricating oil to rotate the pre-lube pump and motor backwards after the engine is started. This prevents Brinelling or damage to the bearings caused by sitting for a long period without rotating. The lubricating oil passes through the oil cooler and oil filter before being sent into the engine. A coalescer collects oil mist from the crankcase gases. The collected oil is returned to the crankcase, and the gases are vented to atmosphere through the exhaust stack.

Screen 35:

Protection Strategies:

Protection strategies protect the diesel engine from damage that could be caused by operating at the extremes of the operating range or by abnormal conditions. Appropriate derations or restrictions are applied by each strategy, as necessary, based on monitored operating conditions.

Low Lube Oil Pressure Protection: Twenty seconds after the engine reaches 180 RPM, the ECU compares the inlet engine lubricating oil pressure, as read by the ELIP sensor, to a table that defines the minimum required pressure. If the lubricating oil pressure

drops below the minimum pressure, the ECU signals the Engine Management System (EMS) software to take appropriate action. If the lubricating oil pressure is below the minimum threshold value for 1 second at N8, N7, or N6 engine speed, the engine speed decreases to N5. If the lubricating oil pressure continues to stay below the threshold value, every 10 seconds the engine notch speed decreases by one notch until the engine goes to IDLE.

Screen 36:

Protection Strategies (Cont'd):

If the lubricating oil pressure increases and remains above the threshold value for more than five-minutes, the engine notch speed increases by one notch. As long as the lubricating oil pressure stays above the threshold value, the notch speed increases by one notch every 10 minutes until the engine returns to the notch speed currently selected by the throttle handle. The table lists the oil pressure thresholds based on engine speed in 50 RPM increments and typical engine notch speeds for given ELIT inputs.

Screen 37:

Protection Strategies (Cont'd):

Very Low Lube Oil Pressure Protection: When the engine is running, the ECU compares the inlet engine lubricating oil pressure, as read by the ELIP sensor, to a table that defines a very low lubricating oil pressure trip level for a given engine speed. The trip level is 3 psi at 270 RPM linearly interpolated up to 27 psi at 1050 RPM. If the lubricating oil pressure drops to the trip level, the EMS software shuts down the engine. The table displays very low lubricating oil pressure trip levels for typical engine notch speeds.

Screen 38:

Protection Strategies (Cont'd):

Low Oil Pressure Count Protection: The low oil pressure count protection restricts engine speed to Notch 2 if five or more low oil pressure incidents occur in a 14-day period.

Cold Engine Protection: When the engine is cold, such as immediately after starting in cold ambient temperatures, engine speed is limited as a function of lubricating oil outlet temperature, as read by the ELOT sensor. This protection prevents damage to the engine, lubricating oil pump, and external oil piping. When the engine is just started, engine speed is limited to 795 RPM or less until the lubricating oil outlet temperature is 140°F or greater for three minutes.

Screen 39:

Protection Strategies (Cont'd):

Engine Water Inlet Temperature and Engine Lube Oil Outlet Temperature ΔT Protection: The engine horsepower derates or shuts down if the delta temperature (ΔT) between the engine water inlet, as measured by the Engine Water In Temperature

(EWIT) sensor, and the engine lubricating oil outlet, as measured by the ELOT sensor, exceeds an allowable limit. The allowable ΔT limit is dependent on the engine lubricating oil outlet temperature as listed in the table. If the maximum allowable ΔT limit is exceeded, the engine horsepower is derated as listed in the table. If the ΔT is not within the limit five minutes after the initial violation, the engine goes to IDLE. If the ΔT is not within the limit 10 minutes after the initial violation, the engine shuts down. If at any time the ΔT returns to an allowable limit, the engine horsepower resets to 100%.

Screen 40:

Protection Strategies (Cont'd):

Loss of Both Engine Oil Temperature Sensors Protection: If both engine oil temperature sensors (ELIT and ELOT) are declared as bad, the engine shuts down. If one of the sensors is bad, the ECU models the good sensor to provide a substitute value for the bad sensor. If the ELIT sensor is bad, the equation used to obtain the substitute value is $ELIT = ELOT - 15^{\circ}F$. If the ELOT sensor is bad, the equation used is $ELOT = ELIT + 15^{\circ}F$.

Crankcase Overpressure Protection: In the event that crankcase pressure, as measured by the COP sensor, exceeds a primary limit for 0.5 seconds or a secondary limit for 10 seconds, the engine shuts down. The engine cannot be restarted until the fault has been reset by means of a smart display in Level 3. The primary limit is equal to 2 inches of water plus the ambient pressure delta. The secondary limit is equal to the value from the secondary limit table plus the ambient pressure delta. If a sudden change in ambient pressure occurs, as measured by the BAP sensor, the delta (or spike) is factored into the COP calculation. Adding the ambient pressure delta keeps a sudden change in outside ambient pressure from tripping the COP sensor. For example, if the locomotive is in a tunnel and the doors at the end of the tunnel open, the pressure in the tunnel suddenly changes. In this case, the outside pressure changed and not the internal crankcase pressure of the engine.

Screen 41:

Protection Strategies (Cont'd):

Hot Oil Protection: The hot oil protection strategy protects the engine from overheating due to tunnel operation, cooling system malfunction, and other factors that might raise the engine oil inlet temperature. The target oil inlet temperature is normally controlled to maintain $180^{\circ}F$ or less. The two types of oil inlet temperature control that exist are Standard control and Over-target control.

Screen 42:

Standard Control:

In standard control, changing the radiator fan speed controls the cooling water temperature and changing the cooling mode, by switching the univalve, controls the oil temperature.

Screen 43:**Over-Target Control:**

In over-target control, if the engine inlet lubricating oil (as read by the ELIT sensor) is five degrees above the target temperature, the split cooling water system lowers the water temperature reference. This change in reference temperature controls when the univalve switches from Mode 2 to Mode 1. If the ELIT value is 10 degrees above the target temperature, the engine speed modulates depending on the desired engine speed (as selected by the throttle handle or through the trainline). Engine speed modulation optimizes the oil flow to the engine. The engine runs at one of three engine speeds: 580, 888, or 1050 RPM. Generally, if the desired engine speed is below 580 RPM, engine speed will go to 580 RPM. If the desired engine speed is between 580 and 888 RPM, engine speed will go to 888 RPM. If the desired engine speed is above 888 RPM, engine speed will go to 1050 RPM. However, if the ELIT value continues to rise in a given speed step, the engine speed will go to the next step until 1050 RPM is reached. If the ELIT value is 15 degrees above the target temperature (also referred to as the hot oil set point), the available horsepower is derated to prevent damage to the engine. Horsepower deration occurs to the point necessary to maintain the target temperature plus 15°F. If the available horsepower reduces to zero for five minutes, the locomotive will go to idle. If the ELIT value rises above 240°F, the engine will shut down and stay locked out for two hours.

Screen 44:**Protection Strategies (Cont'd):**

To provide additional engine protection, the engine can only run with the ELIT value above 185°F for limited periods and conditions. These conditions include periods of transients, when in a tunnel, during hot days, and when the cooling water system has malfunctioned. The EMS software uses the hot oil set point value to help govern this function. If the locomotive runs for a week with an unhealthy cooling system, the hot oil set point value decreases by 10 degrees. When this occurs, the smart display indicates an incident, and the hot oil set point remains at 185°F. To reset this incident requires Level 3 access of the smart display. The following conditions determine the health of the cooling system:

- The locomotive is running at Notch 8, and
- The ambient temperature < 90°F, and
- The average ELIT > 185°F, and
- All of the above are true for 24 hours (the duty cycle of Notch 8 is 24 hours of operation in a week).

Screen 45:**Protection Strategies (Cont'd):**

To enable the 24-hour timer function, the locomotive must be in Notch 8 and the ambient temperature must be less than 90°F. When enabled, the timer increments when the ELIT value is greater than 185°F and decrements when the ELIT value is less than

185°F. Tunnel operation is in effect when the turbocharger inlet air temperature, as read by the Ambient Air Temperature (AAT) sensor, is equal to or greater than 150°F. Tunnel operation clears when:

- AAT < 145°F and ELIT < 195°F, or
- Half an hour has elapsed.

During tunnel operation, the hot oil set point increases to 220°F for a maximum of 30 minutes. If two or more locomotives are set up in the consist, the maximum horsepower on the trail locomotives is limited to 2500 HP, and maximum engine speed is limited to 995 RPM. This prevents fast overheating of the engine. The lead locomotive keeps the full horsepower capability until the ELIT value is equal or greater than 212°F. At this point, the maximum horsepower of the lead unit is restricted to 2500 HP and the maximum engine speed is restricted to 995 RPM. The position of the reverser handles (forward or reverse position equals lead and centered position equals trail) differentiates a lead unit from a trail unit.

Screen 48:

Operational Details:

Lubricating oil system operational data, system self-tests, and normal operating temperatures and pressures are valuable tools when trying to diagnose problems.

Screen 49:

System Capacities:

The lubricating oil system holds approximately 400 gallons of oil. Approximately 130 gallons fill the lubricating oil cooler, lubricating oil filter, piping, and the upper areas of the engine; the rest is contained in the engine oil pan.

Screen 50:

Monitor Parameters:

To aid maintenance personnel in monitoring the lubricating oil system, monitor parameters are available on a smart display in Level 3 access. The table displays the monitor parameters available on the Smart Display in Level 3 access.

Screen 51:

Self-Tests:

Self-Test 314, initiated by means of a smart display, can be used to test the pre-lube pump. When this test is run, the fuel transfer pump also turns on and runs. Self-Test 315 is used for AC Pre-production Locomotives only. The self-test runs for 10 minutes unless the test is manually stopped.

Screen 52:**Normal Operating Temperatures and Pressures:**

The table displays the normally expected operating temperatures and pressures for oil flowing in and out of the engine and the normal and condemning pressure drops across the oil cooler and oil filter.

Screen 53:**Running Maintenance Schedule:**

The table displays the recommended running maintenance schedule for the lubricating oil system and its major components.

Screen 54:**Lubricating Oil Level Check and Fill:**

Typical steps to perform the lubricating oil level check and oil addition, if required, are as follows:

Note: Always check the lubricating oil level with the engine running in IDLE. This ensures that the lubricating oil system is completely charged.

Note: The dipstick FULL and ADD marks are calibrated for use when the engine is at IDLE. If the oil filter housing was drained, as when the oil is changed, the engine will need more oil than the dipstick V12 ENGINE IDLING marked side indicates. If the engine is inside a building or cannot be started for any other safety reason, the Pre-Lube Self- Test should be run to fill the filter housing.

Note: The Pre-Lube Self-Test checks the low-pressure fuel system also. To prevent leaks, ensure that all fuel and oil connections are secure and that all fuel and oil drain or vent connections are closed.

Note: Verify that the proper dipstick is installed in the engine by referring to the latest revision of the parts catalog for the specific locomotive.

1. With the engine running in IDLE, remove one of the dipsticks located on either side of the IFE cover and wipe it clean.
2. Re-insert the dipstick to its full length in the dipstick pipe.
3. Remove the dipstick and read the indication, which should be between the FULL and ADD marks.

Note: For some engine dipsticks, the indication may show FULL and LOW, with the LOW mark indicating the same approximate level as the ADD mark.

Screen 55:**Lubricating Oil Level Check and Fill (Cont'd):**

Note: In addition to the FULL and ADD marks on the V12 ENGINE IDLING marked side of the dipstick, the opposite ENGINE STOPPED marked side contains graduated markings for use when the engine is stopped. The capacity between each mark equals approximately 20 gallons of oil.

Caution: Do NOT add lubricating oil above the FULL mark on the dipstick. An oil level above the dipstick FULL mark can cause potential component damage and possibly result in a false crankcase overpressure indication. If an overfill occurs, the oil level must be drained back below the FULL mark.

Note: For a list of approved lubricating oils, reference the RECOMMENDED FUELS, OILS AND LUBRICANTS publication.

4. If the lubricating oil level is below the ADD mark on the dipstick with the engine at IDLE, remove the fill cap and add the proper quantity of new approved lubricating oil through the fill pipe adjacent to the dipstick until the oil indication is at, or near, the FULL mark on the V12 ENGINE IDLING marked side of the dipstick.
5. Replace and secure the oil fill cap.

Screen 56:**Lubricating Oil System Drain and Initial Fill:**

Typical steps to drain the lubricating oil system and complete the initial fill of lubricating oil for a shutdown engine are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the Battery Switch (BS) in the OFF position to prevent starting attempts. Also, place the Fuel Pump Circuit Breaker (FPB), Local Control Circuit Breaker (LCCB), and Battery Charging Circuit Breaker (BCCB) in the OFF position, and apply a warning tag on the Engine Control (EC) switch.

1. Open the lubricating oil filter housing vent valve on the inlet pipe to the oil filter housing, then open the lubricating oil filter drain back valve.

Note: Allow 15 minutes for the hot oil to drain. If the oil is cold, draining takes much longer.

2. With barrels arranged or a hose system to collect the oil, remove the pipe plug from the lubricating oil drain pipe under the platform on the helper's side (B-side)

of the locomotive, then open the under-platform drain valve to begin draining the oil.

Screen 57:

Lubricating Oil System Drain and Initial Fill (Cont'd):

3. When the lubricating oil is completely drained, close the under-platform lubricating oil drain valve and replace the drain pipe plug.

Note: The lubricating oil filter elements should be replaced whenever the lubricating oil is changed as discussed in the Lubricating Oil Filter Element Replacement section of this module.

4. Close the lubricating oil filter housing vent and drain back valves.

Note: The engine cab door cannot be closed with the filter drain back valve handle in the OPEN position.

Screen 58:

Lubricating Oil System Drain and Initial Fill (Cont'd):

Caution: Do NOT add lubricating oil above the FULL mark on the dipstick. Oil above the FULL mark on the dipstick can cause potential component damage.

Note: Verify the proper dipstick is installed in the engine by referencing the latest revision of the parts catalog for the specific locomotive.

Note: The V12 ENGINE IDLING marked side of the dipstick is calibrated for use when the engine is at IDLE. If the oil filter housing was drained, as when the oil is changed, the engine will need more oil than the dipstick indicates. If the engine is inside a building or cannot be started for any other safety reason, the Pre-Lube Self-Test should be run to fill the filter housing.

Note: For a list of approved lubricating oils, reference the RECOMMENDED FUELS, OILS AND LUBRICANTS publication.

5. Fill the crankcase to the FULL mark on the dipstick with the proper quantity of new approved lubricating oil through one of the oil fill pipes located on either side of the IFE cover.
6. Close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
7. With the engine at IDLE, check and fill the crankcase lubricating oil level as discussed in the Lubricating Oil Level Check and Fill section of this module.

Screen 59:**Lubricating Oil Sample Collection:**

Engineering recommends that oil samples be collected for analysis at a minimum frequency of 7 to 10 days. Take a sample from the lubricating oil vent and sampling valve or quick-disconnect on the inlet pipe to the oil filter housing or on the filter housing door. Have the sample analyzed by a qualified laboratory, and then take the appropriate action based on the analysis. For example, it may become necessary to find and correct the cause of oil dilution by diesel fuel or water; or to find and correct the cause of an increase of metals in the oil, such as copper, iron, chromium, and aluminum.

Screen 60:**Lubricating Oil Sample Collection (Cont'd):**

Before collecting an oil sample, write all pertinent information on the sampling bottle. Print the information clearly and keep the label clean so that a lab technician can read it. The preferred methods of collecting an oil sample are by using the oil sampling valve or quick-disconnect on the inlet pipe to the oil filter housing or on the filter housing door. The oil sample should be taken while the engine is at IDLE. Fill the oil sample bottle two-thirds to three-quarters full.

Screen 61:**Lubricating Oil Sample Collection (Cont'd):**

If the locomotive is not equipped with an oil sampling valve or quick-disconnect, an alternative method of collection is the use of a suction-type device to extract oil through the oil fill pipe while the engine is shut down. The suction device should be fitted with clean tubing. The length of the tube should be sufficient to allow the sample to be extracted from the mid-level of the oil, not from the bottom of the oil pan or from the top surface of the oil. If possible, the oil sample should be collected within 15 minutes after shutting down the engine.

Note: Be careful not to overstroke the plunger when using the suction device. This causes oil to enter the pump and leads to cross-contamination of future oil samples.

Screen 62:**Lubricating Oil Sample Collection (Cont'd):**

The pump should be held in a position that keeps the oil sample bottle vertical so that oil is not allowed to flow from the oil sample bottle into the pump plunger and contaminate the pump.

Note: If extracting samples from multiple locomotives, use a new clean suction tube for each unit to prevent cross-contamination of oil samples. If the pump is overstroked and oil enters the pump plunger, the pump must be replaced with a clean pump to prevent cross-contamination of future oil samples.

Screen 63:**Lubricating Oil System Inspection and Running Maintenance:**

The inspection and running maintenance requirements for the lubricating oil system include both visual inspections and periodic maintenance for the following key components:

- Lubricating Oil Pump
- Lubricating Oil Cooler
- Lubricating Oil Filter
- Pre-Lube Pump and Motor Assembly
- Victaulic Couplings
- Coalescer

The lubricating oil pump circulates oil through the lubricating oil system. The pump has a positive displacement design and an internal relief valve. The oil pump is mounted on the engine's IFE cover and is gear driven from the engine crankshaft by means of an auxiliary drive gear. The oil pump moves approximately 475 GPM of oil at Notch 8 engine speed and normal operating temperature. An internal relief valve protects the pump from overload conditions, such as those caused by a clogged filter assembly or oil cooler. The relief valve fully opens at 150 psi.

Screen 64:**Lubricating Oil System Inspection and Running Maintenance (Cont'd):**

Visually inspect the oil pump for any leaks or cracks. Closely check around the joint areas, such as the oil pump suction and discharge lines. If any leaks are found in the piping joints, try tightening the joint first. If this fails to stop a leak, remove the pump and replace the gaskets. Listen for any unusual noises coming from the pump, and correct as needed. For removal and installation of the lubricating oil pump, refer to the Lubricating Oil Pump Removal and Installation module of the GEVO Diesel Engine Advanced course for instructions. Inspection and maintenance related activities for the other lubricating oil system key components are discussed in the following sections.

Screen 65:**Lubricating Oil Cooler Inspection and Running Maintenance:**

The lubricating oil cooler removes heat that is produced in the engine by combustion and friction. The lubricating oil cooler is a plate heat exchanger design, with metal plates separating the oil, flowing in one direction, from the cooling water, which flows in the opposite direction. The plates not only separate the two fluids but also form the medium to transfer heat from the oil to the cooling water.

Screen 66:**Lubricating Oil Cooler Inspection and Running Maintenance (Cont'd):**

Visually inspect the oil cooler and the piping connections to the cooler for any leaks. Correct any leaks in the piping system as necessary. Any leaks in the oil cooler require

that the oil cooler be replaced. If lubricating oil is visible in the water sight glass, an internal leak probably exists in the oil cooler. Because the oil pressure in the lubricating oil system is higher than the cooling water pressure in the split cooling water system, leaks between the two systems usually appear first in the cooling water system.

Screen 67:

Lubricating Oil Cooler Removal:

Typical steps to remove the lubricating oil cooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Drain all water from the split cooling water system, including from the water tank.

Note: To remove the lubricating oil cooler, it is first necessary to drain the lubricating oil from the oil filter housing. However, it is not necessary to drain the lubricating oil from the engine crankcase.

2. Drain the oil from the lubricating oil filter housing as follows:
 - a. Open the lubricating oil filter housing vent valve on the inlet pipe to the oil filter housing.
 - b. Open the lubricating oil filter drain back valve to allow the oil to drain to the engine crankcase.

Note: Allow 15 minutes for the hot oil to drain. If the oil is cold, draining takes much longer.

Warning: Ensure that oil from the system has completely cooled before any maintenance is performed. Lubricating oil cooler replacement includes steps in which the oil cooler connections must be covered with blanking plates or plugged. Oil will remain in the oil cooler until it can be completely removed from the locomotive. Failure to allow the oil to cool could result in serious burns and personal injury.

3. Remove the applicable locomotive handrail section to allow for oil cooler removal.

Screen 68:**Lubricating Oil Cooler Removal (Cont'd):**

4. Disconnect the oil cooler from the oil filter housing as follows:

Note: As oil pipes are disconnected from the lubricating oil cooler, blanking plates must be placed on the oil cooler openings. The oil and water pipe openings should be plugged or blocked to prevent oil and water from spilling out of the cooler or draining from the disconnected pipes.

Note: The cooler holds approximately 11 gallons of oil, which cannot be drained until the oil cooler is removed and tipped at an angle.

- a. Disconnect the pipe sections connecting the oil cooler to the oil filter housing, bolt a blanking plate to the oil cooler outlet flange opening, plug or block all pipe openings, and save all removed hardware.
- b. To aid in oil cooler removal, disconnect the pipe sections that are on the back of the oil filter housing and crossing over the oil cooler, plug or block all pipe openings, and save all removed hardware.
- c. To allow oil cooler removal, disconnect the oil filter housing drain back valve drain flange and drain piping assembly, plug or block all flange and pipe openings, and save all removed hardware.

Screen 69:**Lubricating Oil Cooler Removal (Cont'd):**

5. Disconnect the water pipes connected to the oil cooler by removing the four couplings and the two pipes, then plug or block all pipe openings.
6. Disconnect the clamps holding the fuel hoses, plug or block all hose openings, and save all removed hardware.
7. Remove the oil inlet pipe flange assembly from the left side of the oil cooler and bolt a blanking plate to the oil cooler inlet flange opening.
8. Remove the four mounting bolts that secure the oil cooler to the floor of the radiator cab.

Screen 70:**Lubricating Oil Cooler Removal (Cont'd):**

Warning: The oil cooler weighs approximately 820 lbs. (372 kg). Ensure the lifting device, cables, and straps used are adequate. Failure to do so may result in personal injury or death.

9. Attach lifting slings or cables to the holes of the lubricating oil cooler.
10. With the appropriate lifting device, gently slide and then lift the lubricating oil cooler to remove it from the radiator cab.

Note: The oil cooler needs to be angled using a come-along, or a similar device, to maneuver the oil cooler past the support bar of the radiator cab.

Screen 71:

Lubricating Oil Cooler Installation:

Typical steps to install the lubricating oil cooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: The oil cooler weighs approximately 820 lbs. (372 kg). Ensure the lifting device, cables, and straps used are adequate. Failure to do so may result in personal injury or death.

1. Attach lifting slings or cables to the holes of the lubricating oil cooler.

Note: The oil cooler needs to be angled using a come-along, or a similar device, to maneuver the oil cooler past the support bar of the radiator cab.

2. Lift the lubricating oil cooler and manually rotate the lubricating oil cooler to pass through the support bar of the radiator cab.
3. Place the lubricating oil cooler on the radiator cab floor and gently slide it through the radiator cab to the mounting location.
4. Install the four mounting bolts securing the oil cooler to the floor of the radiator cab, then torque the bolts to 200-220 lb.-ft. (271-298 Nm) in a crisscross pattern.
5. Remove the plugs from the fuel hose openings, then re-install the fuel hoses and secure with the previously removed clamps.
6. Remove the plugs from the water pipe openings, then reconnect the two water pipes to the lubricating oil cooler and secure with the previously removed couplings.

Note: For complete information on removal and installation of the couplings, refer to the Victaulic Couplings Removal and Installation sections of this module.

Screen 72:

Lubricating Oil Cooler Installation (Cont'd):

7. Connect the oil cooler to the oil filter housing as follows:

- a. Remove the plugs and unblock all flange and pipe openings, then reconnect the oil filter housing drain back valve flange and drain piping assembly and install the previously removed hardware.
 - b. Remove the plugs and unblock all flange and pipe openings, then reconnect the pipe sections on the back of the oil filter housing crossing over the oil cooler and install the previously removed hardware.
 - c. Remove the blanking plate and plugs and then reconnect the piping connecting the oil cooler to the oil filter housing and install the previously removed hardware.
8. Install the previously removed handrail section.
 9. Refill the cooling water system and visually inspect the intercooler and associated piping for signs of leakage or damage.
 10. Once the lubricating oil cooler is installed, close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
 11. With the engine at IDLE, check and fill the crankcase lubricating oil level as discussed in the Lubricating Oil Level Check and Fill section of this module.

Screen 73:

Lubricating Oil Filter Inspection and Running Maintenance:

The lubricating oil filter removes contaminants from the lubricating oil so that they do not cause damage to the diesel engine. The lubricating oil system is a full-flow type system, meaning all oil flowing to the engine must pass through the oil filter. The oil filter tank contains 10 filter elements. Obstructed filter elements will not allow oil to circulate through the rest of the system.

Screen 74:

Lubricating Oil Filter Inspection and Running Maintenance (Cont'd):

When the filter elements are changed or the oil filter housing is replaced, a filter drain back valve can be opened to drain the oil from the filter tank back to the engine crankcase. Opening a vent and sampling valve or quick-disconnect on either the inlet pipe to the oil filter housing or on the filter housing door allows air to enter the tank as the oil drains, thus reducing the time to drain the filter tank.

Note: Do not use pressurized air to "force purge" oil from the system. A pressure relief valve within the pump prevents an overpressure condition by routing the excess pressure back to the engine crankcase, which could introduce water or other contaminants into the lubricating oil system.

Screen 75:

Lubricating Oil Filter Housing Removal:

Typical steps to remove the lubricating oil filter housing are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Drain the oil from the lubricating oil filter housing as follows:
 - a. Open the lubricating oil filter housing vent valve on the inlet pipe to the oil filter housing.
 - b. Open the lubricating oil filter drain back valve to allow the oil to drain to the engine crankcase.

Note: Allow 15 minutes for the hot oil to drain. If the oil is cold, draining takes much longer.

Warning: Ensure that oil from the system has completely cooled before any maintenance is performed. Lubricating oil filter housing replacement includes steps in which the oil cooler connections must be covered with blanking plates or plugged. Failure to allow the oil to cool could result in serious burns and personal injury.

2. Remove the applicable locomotive handrail section to allow for oil filter housing removal.

Screen 76:

Lubricating Oil Filter Housing Removal (Cont'd):

3. Disconnect the oil filter housing from the oil cooler as follows:

Note: As oil pipes are disconnected from the lubricating oil cooler, blanking plates must be placed on the oil cooler openings. The oil cooler, oil filter housing, and pipe openings should be plugged or blocked to prevent oil from spilling out of the oil cooler or draining from the disconnected pipes.

- a. Disconnect the pipe sections connecting the oil cooler to the oil filter housing, bolt a blanking plate to the oil cooler outlet flange opening, plug or block all pipe openings, and save all removed hardware.
- b. Disconnect the pipes that are on the back of the oil filter housing, plug or block all pipe openings, and save all removed hardware.
- c. Disconnect the oil filter housing drain back valve drain flange and drain piping assembly, plug or block all flange openings, and save all removed hardware.

Screen 77:

Lubricating Oil Filter Housing Removal (Cont'd):

1. Remove the ten mounting bolts that secure the oil filter housing to the floor of the radiator cab.

Warning: The oil filter housing weighs approximately 760 lbs. (345 kg). Ensure that the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

2. Attach lifting slings or cables to the holes on the lubricating oil filter.
3. With the appropriate lifting device, gently slide and then lift the oil filter housing to remove it from the radiator cab.

Note: The oil filter housing needs to be angled using a come-along, or a similar device, to maneuver the oil filter housing past the support bar of the radiator cab.

Screen 78:

Lubricating Oil Filter Housing Installation:

Typical steps to install the lubricating oil filter housing are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: The oil filter housing weighs approximately 760 lbs. (345 kg). Ensure that the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

1. Attach lifting slings or cables to the holes on the lubricating oil filter.

Note: The oil filter housing needs to be angled using a come-along, or a similar device, to maneuver the oil filter housing past the support bar of the radiator cab.

2. Lift the lubricating oil filter housing and manually rotate the filter housing to pass through the support bar of the radiator cab.
3. Place the oil filter housing on the radiator cab floor and gently slide it through the radiator cab to the mounting location.

4. Install the ten mounting bolts that secure the filter housing to the floor of the radiator cab, then torque the bolts to 105-115 lb.-ft. (142-156 Nm) in a crisscross pattern.
5. Connect the oil cooler to the oil filter housing as follows:
 - a. Remove the plugs and unblock all flange and pipe openings, then reconnect the oil filter housing drain back valve drain flange and drain piping assembly and install the previously removed hardware.
 - b. Remove the plugs and unblock all flange and pipe openings, then reconnect the pipe sections on the back of the oil filter housing and install the previously removed hardware.
 - c. Remove the blanking plate and plugs and then reconnect the piping connecting the oil cooler to the oil filter housing and install the previously removed hardware.

Screen 79:

Lubricating Oil Filter Housing Installation (Cont'd):

6. Install the previously removed handrail section.
7. Fill the lubricating oil system, if required, as discussed in the fill portion of the Lubricating Oil System Drain and Initial Fill section of this module.
8. Once the oil filter housing is installed, close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
9. With the engine at IDLE, check and fill the crankcase lubricating oil level as discussed in the Lubricating Oil Level Check and Fill section of this module.

Screen 80:

Lubricating Oil Filter Element Inspection and Running Maintenance:

Lubricating oil filter elements must be replaced periodically on a planned schedule or when the pressure drop across the lubricating oil filter becomes too high. Water in the lubricating oil system permanently degrades the performance of the filter elements. Therefore, if the lubricating oil cooler or an engine cylinder is replaced due to an internal water leak, the lubricating oil and filter elements should also be changed. It is ideal to replace lubricating oil filter elements when the oil temperature is greater than 160 °F (71 °C). When the filter elements are changed, a filter drain back valve can be opened to drain the oil from the filter tank back to the engine crankcase or, if the under-platform oil drain plug is removed and manual drain valve is opened, to barrels or a hose system for collection. Opening a vent and sampling valve or quick-disconnect on either the inlet pipe to the oil filter housing or the filter housing door allows air to enter the tank as the oil drains, thus reducing the time to drain the filter tank.

Screen 81:

Lubricating Oil Filter Element Replacement:

Typical steps to replace the lubricating oil filter elements are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Caution: Do not use pressurized air to "force purge" oil from the system. A pressure relief valve within the pump prevents an overpressure condition by routing the excess pressure back to the engine crankcase, which could introduce water or other contaminants into the lubricating oil system.

1. If the lubricating oil system is not already drained, as discussed in the Lubricating Oil System Drain and Initial Fill section of this module, drain the oil from the lubricating oil filter housing as follows:
 - a. Open the lubricating oil filter housing vent valve on the inlet pipe to the oil filter housing.
 - b. Open the lubricating oil filter drain back valve to allow the oil to drain to the engine crankcase or, if the under-platform oil drain plug is removed and the drain valve is opened, to barrels or a hose system for collection.

Note: Allow 15 minutes for the hot oil to drain. If the oil is cold, draining takes much longer.

2. Loosen the 10 nuts securing the filter housing door and crack the door seal.

Note: If the housing has been drained properly, very little oil will drip from the housing. Absorb any dripping oil with shop rags.

Screen 82:

Lubricating Oil Filter Element Replacement (Cont'd):

3. Further loosen the nuts securing the filter housing door, if required, and fully open the door.
4. Remove the 10 used filter elements and inspect the outer surfaces of the used elements for metal particles.

Note: If metal particles are found, immediately determine and correct the source of the particles.

5. Discard the used elements.

Caution: During engine operation, filtered oil flows through holes in the filter guide tubes directly to the engine. Do NOT allow particles of sludge or dirt to pass through these holes during cleaning, or damage to critical components can occur.

6. Wipe clean the inside of the filter housing to prevent the old oil in the housing from contaminating the new oil.

Screen 83:

Lubricating Oil Filter Element Replacement (Cont'd):

Caution: Use only approved filter elements. Using other filter elements, such as cotton waste filters, could result in damage to critical components.

7. Install new approved filter elements.
8. Ensure all filter elements are properly seated and clamped.
9. Inspect the filter housing door O-ring gasket and replace if needed.

Note: The O-ring is flat on one surface; install the flat surface at the bottom of the groove.

10. Close the filter housing door and torque the clamping nuts in a crisscross pattern to the torque indicated on the label.
11. Close the lubricating oil filter housing vent and drain back valves.

Note: The engine cab door cannot be closed with the filter drain back valve handle in the OPEN position.

12. If the oil filter housing was drained to the engine crankcase and the lubricating oil system was not fully drained, complete the following:
 - a. Close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
 - b. With the engine at IDLE, check and fill the crankcase lubricating oil level as discussed in the Lubricating Oil Level Check and Fill section of this module.
13. If the lubricating oil system was fully drained prior to replacing the lubricating oil filter elements, fill the lubricating oil system as discussed in the fill portion of the Lubricating Oil System Drain and Initial Fill section of this module.

Screen 84:

Pre-Lube Pump Inspection and Running Maintenance:

The pre-lube pump operates prior to engine cranking to circulate lubricating oil through the engine, which is critical to engine protection at low temperatures when the oil viscosity is high and oil flow characteristics are poor. Pre-lube pump operation is automatic and controlled by the locomotive control system. The pump is a self-priming, positive displacement design that moves at least 30 GPM of oil when operating. Although no specific inspection checks are required for the pre-lube pump, a visual

inspection is recommended to verify that there are no oil leaks in the piping and piping connections.

Screen 85:

Pre-Lube Pump and Motor Assembly Removal:

Typical steps to remove the pre-lube pump and motor assembly are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: Ensure that the lubricating oil has completely cooled before any maintenance is performed. Failure to allow the oil to cool could result in serious burns and/or personal injury.

Note: The removal steps in this demonstration are applicable to pre-lube pumps manufactured by both Paragon and Viking. The pre-lube pump shown in this demonstration is a Paragon pump.

1. Drain the oil from the lubricating oil system as discussed in the drain portion of the Lubricating Oil System Drain and Initial Fill section of this module.
2. Remove the applicable locomotive handrail section to allow for pre-lube pump and motor assembly removal.
3. Disconnect the inlet and outlet hoses from the pre-lube pump JIC fittings.
4. Remove the terminal junction box cover on the side of the pre-lube motor by removing the six screws.
5. Disconnect the wire lugs from the terminals inside the terminal junction box.
6. Disconnect the conduit fitting on the top of the terminal junction box and pull the plastic conduit and wires from the pre-lube pump and motor assembly.

Screen 86:

Pre-Lube Pump and Motor Assembly Replacement (Cont'd):

7. Re-install the cover on the terminal junction box and torque the six screws to 20-25 lb.-in (2.26-2.82 Nm).
8. Remove the four mounting bolts that secure the pre-lube pump and motor assembly to the floor of the radiator cab.

Warning: The pre-lube pump and motor assembly weighs approximately 125 lbs. (57 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

9. With the appropriate lifting device, gently slide the pre-lube pump and motor assembly from the radiator cab, and then lift and remove the assembly from the walkway.

Screen 87:

Pre-Lube Pump and Motor Assembly Installation:

Typical steps to install the pre-lube pump and motor assembly are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: The installation steps in this demonstration are applicable to pre-lube pumps manufactured by both Paragon and Viking. The pre-lube pump shown in this demonstration is a Paragon pump.

Warning: The pre-lube pump and motor assembly weighs approximately 125 lbs. (57 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

1. With an appropriate lifting device, place the pre-lube pump assembly on the radiator cab.
2. Install the four mounting bolts that secure the pre-lube pump and motor assembly to the floor of the radiator cab.
3. Torque the four mounting bolts to 55-62 lb.-ft. (74.5-84 Nm).
4. Re-install the inlet and outlet hoses to the JIC fittings on the pre-lube pump and tighten until snug.
5. Torque the inlet hose to the inlet JIC fitting to 210-220 lb.-ft. (284-298 Nm).
6. Torque the outlet hose to the outlet JIC fitting to 140-150 lb.-ft. (190-203 Nm).

Screen 88:

Pre-Lube Pump and Motor Assembly Installation (Cont'd):

7. Remove the terminal junction box cover on the side of the pre-lube motor by removing the six screws.

8. Insert the wires and plastic conduit through the top conduit hole in the terminal junction box and tighten the conduit fitting.
9. Connect the wire lugs into the terminals inside the terminal junction box and tighten to 120-140 lb.-in (13.56-15.82 Nm).
10. Re-install the cover on the terminal junction box and torque the six screws to 20-25 lb.-in (2.26-2.82 Nm).
11. Install the locomotive handrail section that was removed during pre-lube pump and motor assembly removal.
12. Fill the lubricating oil system as discussed in the fill portion of the Lubricating Oil System Drain and Initial Fill section of this module.

Screen 89:

Pre-Lube Check Valve Replacement:

Typical steps to replace the pre-lube check valve are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: Ensure that the lubricating oil has completely cooled before any maintenance is performed. Failure to allow the oil to cool could result in serious burns and/or personal injury.

Note: Lower than expected oil pressure may be due to a pre-lube check valve that is binding in the open position. Main lube oil pressure is supposed to close the valve once the engine starts. With the valve closed, a small orifice in the valve plate allows some oil to flow back to the pre-lube pump to spin it slowly and prevent motor bearing brinelling. This may be observed on pump styles that have a removable end cover by observing the motor fan blades slowly rotating. However, if the check valve remains fully open after the engine is running, oil pressure will be lost as a large amount of oil drains back to the oil pan through the pre-lube pump.

1. Remove the pre-lube supply hose from the check valve using a TESCO T87340 2 ¼-inch crow's foot and breaker bar.
2. Remove the old check valve using a TESCO T87330 2-inch crow's foot and breaker bar.
3. Insert and rotate the new check valve a few turns by hand to verify that the thread-o-let is not oval.

Screen 90:**Pre-Lube Check Valve Replacement (Cont'd):**

4. If the check valve binds or if the thread-o-let has an oval shape, either replace the pipe or re-tap the thread-o-let with a 1.5-inch NPT tap as follows:
 - a. Remove the Victaulic coupling, as discussed in the Victaulic Coupling Removal section of this module, then remove the oil inlet pipe flange assembly from the left side of the oil cooler, as discussed in the Lubricating Oil Cooler Removal section of this module.
 - b. If re-tapping the thread-o-let, use the 1.5-inch NPT tap to re-tap the threads, then clean the pipe of metal shavings before reinstalling.
 - c. With Vic-Lube applied to the Victaulic coupling seals, as discussed in the Victaulic Coupling Installation section of this module, and with the Victaulic coupling mounted horizontally with respect to the split line of the coupling, reinstall the re-tapped or replacement oil inlet pipe flange assembly to the left side of the oil cooler, as discussed in the Lubricating Oil Cooler Installation section of this module.

Caution: Hold the check valve with a 2-inch crow's foot so that it does not turn as the hose is tightened.

Caution: To avoid distorting the shape of the check valve, it is important that the check valve is not over-torqued and does not turn while installing the hose.

5. Install the replacement check valve, then torque to 115 ± 5 lb.-ft. (156 ± 7 Nm) with a TESCO T87330 2-inch open end crow's foot.
6. With no Vic-Lube applied to the JIC hose fitting, use a TESCO T87340 2 ¼-inch crow's foot to torque the hose to the check valve to $163 +4/-5$ lb.-ft. ($221 +5/-7$ Nm).
7. Start the locomotive and re-evaluate oil pressure to ensure proper operation of the replacement check valve.

Screen 91:**Victaulic Couplings:**

Pipes between the major components of the lubricating oil system are joined together by Victaulic couplings. Victaulic couplings reduce pipe stress by absorbing vibration and allowing for minor pipe misalignment. In addition, Victaulic couplings make it easier for maintenance personnel to remove and install system components. The coupling consists of two outer steel coupling halves held together by bolts and gaskets. The gasket material is selected to withstand the effects of the liquids passing through the piping. The pipes that the couplings connect to are machined to accept the lip of the coupling. No routine running maintenance is required for the piping system. However, any time a system component has to be removed, Victaulic couplings must be disassembled.

Note: Victaulic couplings must be properly installed to ensure reliability.

Screen 92:

Victaulic Coupling Removal:

Typical steps to remove a Victaulic coupling on the lubricating oil system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: When replacing a leaking or defective Victaulic coupling on the lubricating oil cooler and oil filter housing piping, depending on the location of the oil leak, it may be necessary to drain lubricating oil to the engine crankcase.

1. If required, drain oil from the lubricating oil filter housing as follows:
 - a. Open the lubricating oil filter housing vent valve on the inlet pipe to the oil filter housing.
 - b. Open the lubricating oil filter drain back valve to allow the oil to drain to the engine crankcase.
2. After the oil from the lubricating oil system is drained or the pipe from which the Victaulic coupling is to be removed is empty, remove the bolts and nuts that hold the coupling halves together and remove the coupling.
3. While supporting the pipe with one hand, slide the gaskets (one on each end of the pipe) onto the removable pipe. After the gaskets and the body of the coupling have cleared the fixed pipe, the pipe can be removed.
4. Remove the gaskets from the pipe.
5. Protect the pipe ends after disassembly.

Page 93:

Victaulic Coupling Installation:

Typical steps to install a Victaulic coupling on the lubricating oil system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Couplings used in the cooling water system have a seal made of EPDM rubber. EPDM rubber is indicated by a green mark on the inside of the gasket. Couplings used in the lubricating oil system have a seal. Seals are indicated by a blue mark on the inside of the gasket. Couplings used in the compressed air system are completely red and made from silicon gasket.

1. Inspect the gaskets for cuts, holes, or embedded foreign material.
2. Inspect the sealing surfaces of the pipe.

Note: Rough or non-machined surfaces do not indicate a defective pipe. However, there must not be scratches or gouges that cross more than 50% of the sealing surface. If scratches or gouges are present, use sandpaper or a fine file to dress the pipe surfaces. If defects cannot be removed without excessive sanding, the pipe should be replaced.

3. Inspect the cleanliness of the pipe and ensure it is clean and free of debris.

Note: Coupling seals used in both oil and water systems should be thoroughly lubricated. This prevents tearing or cutting the gasket when it is assembled.

4. Slide both gaskets onto the fixed end of the pipe ensuring that each gasket is flush with the end.

Screen 94:

Victaulic Coupling Installation (Cont'd):

5. Insert the pipe with one person holding the pipe in position while another person carefully slides the gasket into place.

Note: To ensure that the gasket is properly located on the pipe, both corners of the gasket's sealing surface must be exposed.

Note: There should be approximately a 0.125-inch (3.18-mm) gap between the pipe ends to allow for expansion. The gap between the lubricating oil piping lengths can be adjusted by loosening the four 0.5-inch (12.7-mm) bolts at the flange at one end of the pipe, moving the pipe into the desired location. Re-tighten the bolts to seal the pipe.

6. Install the coupling halves, then install the bolts and nuts ensuring that the oval under each bolt head is mated into the recessed oval in the coupling half.
7. Tighten the nuts until there is a metal-to-metal contact between the coupling halves.

8. Once the Victaulic coupling is replaced, close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.

Screen 95:

Victaulic Coupling Installation (Cont'd):

9. With the engine at IDLE, check and fill the crankcase lubricating oil level as discussed in the Lubricating Oil Level Check and Fill section of this module.
10. With the engine at IDLE, visually inspect the engine, lubricating oil pump, oil cooler, oil filter, pre-lube pump, and all system piping for oil leaks.
11. Torque the Victaulic coupling bolts to the recommended specification for the particular application.
12. Ensure that the Victaulic couplings are pointed out, mounted horizontally with respect to the split line of the coupling.

Note: Some dripping of lubricant from pipe joints may occur as the engine and piping warms up. This should not cause a concern unless you see evidence of joint leakage.

Screen 96:

Coalescer:

The coalescer, located on the IFE cover of the engine, removes oil-saturated air from the engine crankcase. The air is drawn from the crankcase into the coalescer by a vacuum created by exhaust gas flow through the exhaust system. Once the air is drawn into the coalescer, the oil is removed and directed back to the engine sump. The filtered air is then vented through another flexible hose into the exhaust stack.

Screen 97:

Coalescer Inspection and Running Maintenance:

Maintenance for the coalescer is condition-based except for annual eductor tube cleaning. If a problem does occur and the coalescer system is suspected, check these five basic areas:

- Hoses: Hole in the hose, crushed or damaged hose, leaky connection
- Coalescer canister: Damaged or hole in the canister
- O-ring seal: Missing or damaged O-ring seal between coalescer canister halves
- Filter element: Dirty or clogged filter element
- Eductor tube: Carbon buildup in the tube

Screen 98:

Coalescer Inspection and Running Maintenance (Cont'd):

The coalescer hoses are attached such that no part of the hoses makes contact with the engine or other components except where they are attached at the ends and where the hoses are secured by clamps. This decreases the chance of wear caused by the hoses rubbing against another component. Inspect the hoses for obvious signs of

damage, such as crushing, holes, deterioration, and rubbing. Check and ensure that all clamps and hose connections are secure. Repair, replace, or tighten as necessary. Inspect the canister for damage and holes. Replace the coalescer if necessary.

Screen 99:

Coalescer Hoses Removal:

Typical steps to remove the coalescer hoses are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: The coalescer has been designed to have no contact with the engine or the components except for the coalescer hose connections. This decreases the chance for wear.

Warning: Do not remove the hoses while the engine is running or hot.

1. If removing the upper hose, remove the P-clamps and disconnect the steel braided boost hose from the eductor and the tee fitting in the turbocharger casing.
2. If replacing the hose, cut the tie-wraps that connect the steel braided boost hose to the coalescer hose.
3. Loosen the 9/16-inch (15-mm) clamp bolts that secure the ends of the upper and lower hoses to their attachment pipes.
4. Rotate the ends of the hoses back and forth at the attachment points just enough to break any bonding that may have occurred between the hose and the attachment pipe.
5. Pull the free ends of the hoses off the pipes, taking care not to scrape the hoses against other components that may damage them.
6. Cover the openings to the coalescer and both ends of the coalescer hoses.

Note: For the upper hose, an additional 3/4-inch (19-mm) bolt must be removed from the P-clamp that supports the hose near its center.

Screen 100:

Coalescer Hoses Installation:

Typical steps to install the coalescer hoses are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Inspect the coalescer hoses for cracks, holes, or other defects, and replace if needed.
2. Apply anti-seize compound to the exterior of the attachment pipes.
3. Ensure that the clamps are located loosely around the hose cuffs at both ends of the hoses, and then install the hose ends over the attachment pipes.
4. Rotate the clamps around the hoses such that the bolt is in a convenient position for adjustment.
5. Position the hoses so that they will not make contact with the engine or other engine components, then torque each 9/16-inch (15-mm) clamp bolt to 5 lb.-ft. (7 Nm).

Screen 101:

Coalescer Hoses Installation (Cont'd):

6. When installing the upper coalescer hose, perform the following additional steps:
 - a. Attach the P-clamps to the upper coalescer hose. Ensure that the P-clamp bolts are torqued so that the hose does not get twisted or damaged.
 - b. Connect the steel braided boost hose to the eductor and the tee fitting in the turbocharger casing.
 - c. Install the tie-wraps and spacer blocks.

Note: The spacer blocks should be used at the lowest tie-wrap location.

- d. Ensure that the spacer block located opposite to the steel braided boost hose on the lowest tie-wrap is in contact with the turbo case to prevent premature coalescer hose failure.

Caution: Missing P-clamps or failure to install the spacer blocks at the lowest tie-wrap location may cause premature equipment failure.

Note: When installing the upper hose, upon completion of the installation of the end clamps, re-fasten the P-clamp around the center of the hose to the turbo flange with the 3/4-inch (19-mm) bolt and torque the bolt to 140 lb.-ft. (190 Nm).

Screen 102:

Coalescer Removal:

Typical steps to remove the coalescer are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Before the coalescer can be removed from the engine, all coalescer hoses must be disconnected.

Warning: Do not remove the coalescer hoses while the engine is running or hot.

1. Remove the upper and lower coalescer hoses as discussed in the Coalescer Hose Removal section of this module.
2. Disconnect the coalescer drain line.
3. Support the coalescer to prevent it from falling.
4. Remove the retaining strap bolts from the retaining straps.
5. Remove the coalescer from its installed position.

Screen 103:

Coalescer Installation:

Typical steps to install the coalescer are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Proper orientation of the coalescer is important to ensure that the coalescer, the hoses, and other components work properly and do not become damaged.

1. Inspect the coalescer for cracks or defects, replace if needed.

2. Position the coalescer in its mounting bracket on the IFE cover such that the inlet hose attachment is parallel to the front of the IFE cover.
3. With the coalescer held in place, position the retaining straps around the coalescer, replace the retaining strap bolts, and torque to 17 lb.-ft. (23 Nm).
4. Connect the coalescer drain line.
5. Re-attach the upper and lower coalescer hoses as discussed in the Coalescer Hose Installation section of this module.

Screen 104:

Coalescer and Coalescer Filter Element Cleaning:

A poorly maintained coalescer or coalescer filter element may cause additional pressure loss through the coalescer system. This could result in an incorrect crankcase pressure and cause the engine to shut down due to crankcase overpressure faults.

Typical steps to clean the coalescer and coalescer filter element are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Remove the coalescer as discussed in the Coalescer Removal section of this module.

Note: The inside of the coalescer, the hoses, and the filter element may have a dirty engine oil coating.

2. Remove the clamp securing the top and bottom halves of the coalescer, then separate the top and bottom halves by rotating and pulling up on the top half of the coalescer, with the bottom half supported.
3. Remove the filter element from the coalescer shell and the sealing ring from the bottom half of the coalescer.
4. Clean the filter element and the coalescer halves with an approved solvent to remove the oil residue and contaminants that may have built up in or on them.

Screen 105:

Coalescer and Coalescer Filter Element Cleaning (Cont'd):

5. Replace the sealing ring and the filter element.
6. Reassemble the coalescer halves.

7. Ensure that the coalescer halves are properly aligned with each other. Then, replace the clamp and torque the clamp nut to 4.4 lb.-ft. (6 Nm).
8. Install the coalescer on the IFE cover as discussed in the Coalescer Installation section of this module.

Screen 106:

Coalescer Eductor Tube:

The eductor tube assembly, mounted to the exhaust stack, consists of an air inlet section and an air outlet section. The upper coalescer hose connects to the air inlet section of the eductor tube assembly, which is bolted to the support assembly. The air outlet section, which fits inside a welded sleeve on the support assembly, slides through the sleeve and into the exhaust stack.

Screen 107:

Coalescer Eductor Tube Removal:

Typical steps to remove the coalescer eductor tube are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: Do not remove the eductor while the engine is running or hot.

1. Remove the upper coalescer hose from the eductor tube, as discussed in the Coalescer Hose Removal section of this module.
2. Remove the steel braided hose from the fitting on the eductor tube.

Note: Do not remove the straight fitting installed in the eductor.

3. Remove the eductor tube and the eductor gasket by removing the eductor tube mounting bolts.

Note: Once the eductor is removed, the eductor gasket and doughnut seal should also be replaced.

4. Scrap the removed eductor gasket and save the mounting bolts and washers for reuse.
5. Remove the eductor bracket front bolts and spacers.

Screen 108:**Coalescer Eductor Tube Removal (Cont'd):**

6. Re-install the two front left-side eductor mounting bolts without the spacers, leaving a gap to allow the bracket to move for doughnut seal change out.
7. Remove the right rear bolts and spacers completely.
8. Remove the eductor doughnut seal, ensuring that the eductor bracket is secured, which prevents the eductor tube from supporting the bracket weight or position.
9. Clean the mating surfaces and install a new doughnut seal.
10. Reinstall all eductor bracket bolts and spacers, and torque the bolts to 90 lb.-ft. (122 Nm).

Screen 109:**Coalescer Eductor Tube Cleaning:**

Typical steps to clean the coalescer eductor tube are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Remove the straight fitting.
2. Inspect the boost nozzle threads for damage or debris, then cap the boost nozzle threads to protect them from damage.

Warning: Failure to protect the boost nozzle threads from damage may prevent the adapter fitting from being properly installed.

3. Clean the interior and exterior of the eductor tube and the boost nozzle.
4. Inspect the cleaned eductor tube for cracks or other damage prior to reuse.

Note: Ensure that there is no debris plugging the boost nozzle.

Caution: Installing the incorrect fitting will cause an inaccurate crankcase pressure reading which could lead to a false shutdown or failure to prevent additional engine damage.

5. Apply thread sealant to the steel braided boost line thread side only on the steel braided boost line to the straight fitting.
6. Install and tighten the straight fitting into the eductor tube.

Screen 110:

Coalescer Eductor Tube Installation:

Typical steps to install the coalescer eductor tube are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB, LCCB, and BCCB in the OFF position, and apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Inspect the eductor tube bracket bolts and the eductor tube mounting bolts for proper installation.

Note: If any defects are found, record and repair the defects.

2. Install the eductor tube and the new gasket on to the eductor bracket using the 1/2 -13 - 1 1/2 grade 8 eductor tube mounting bolts and washers.
3. Pre-torque the eductor tube mounting bolts to 55 lb.-ft. (75 Nm), then final torque the bolts to 90 lb.-ft. (122 Nm).
4. Attach the coalescer hose to the eductor tube and tighten the clamp to 5 lb.-ft. (7 Nm).
5. Attach the P-clamps to the coalescer hose.

Note: Verify that the correct pipe thread to JIC adapter is installed into the muffler. The old-style muffler requires a through adapter and the new muffler requires an orifice adapter.

Caution: Installing the incorrect adapter will cause an inaccurate crankcase pressure reading. It could lead to a false shutdown or failure to prevent additional engine damage. Apply thread sealant to the pipe thread side only on the pipe to JIC adapter.

6. Connect the elbow side of the steel braided hose to the fitting on the eductor tube, then torque the fitting to 60 lb.-ft. (81 Nm).

Screen 113:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the lubricating oil system.
 - The lubricating oil system, commonly referred to as the lube oil system, provides pressurized lubrication to engine components and carries away heat produced by friction and combustion.
 - The lube oil system components are located along the engine and the radiator cabs.
- State the purpose and location of the major components of the lubricating oil system.
 - The diesel engine pan is located on the underside of the engine. The oil pan is bolted to the diesel engine mainframe and forms the reservoir that holds the lubricating oil.
 - The lubricating oil pump is located on the IFE cover of the engine and circulates the oil through the lubricating oil system.
 - The lubricating oil cooler is located in the radiator cab on the helper's side (B-side) of the locomotive just aft of the engine. It removes heat from the lubricating oil system.
 - The lubricating oil filter is located in the radiator cab on the helper's side (B-side) of the locomotive just aft of the engine and oil cooler. It removes contaminants larger than 30 microns.
 - The pre-lube oil pump is located in the radiator cab on the engineer's side (A-side) of the locomotive just aft of the engine. It pre-lubricates the engine before cranking.
 - The check valve is located in the engine cab on the helper's side (B-side) of the locomotive. It protects the pre-lube pump from excessive reverse oil flow (backflow) from the outlet to the inlet when the pump is not operating.
 - The coalescer is mounted to the IFE cover of the diesel engine and is accessible from the engineer's side (A-side) of the locomotive. It removes combustible gases from the engine crankcase.
- State the purpose and location of the instrumentation devices of the lubricating oil system.
 - The Engine Lube Out Temperature (ELOT) sensor is located in the oil discharge pipe from the lubricating oil pump. It measures the temperature of the lubricating oil exiting the engine and provides the information to the ECU.
 - The Engine Lube In Temperature (ELIT) sensor is located in the IFE cover next to the oil inlet pipe to the engine. It measures the temperature of the lubricating oil entering the engine and provides the information to the ECU.

- The Engine Lube In Pressure (ELIP) sensor is located on the rear of the engine crankcase just behind the left-six power assembly. It measures the pressure of the lubricating oil at the left-seven cam bearing in the engine and provides the information to the ECU.
- The Engine Lube Pump Pressure (ELPP) sensor is located in the oil discharge pipe from the lubricating oil pump. It measures the pressure of the lubricating oil at the outlet of the lubricating oil pump and provides the information to the ECU.
- The Crankcase Overpressure (COP) sensor is located on the rear of the engine crankcase just behind the left-six power assembly. It measures the pressure in the crankcase and provides the information to the ECU.
- Describe how the lubricating oil system operates.
 - Oil is drawn from the engine oil pan through a perforated metal strainer by the lubricating oil pump.
 - The pump forces the oil through the oil cooler. The cooled oil flows out of the oil cooler to the oil filter housing.
 - From the oil filter housing, the oil is piped to the IFE cover of the engine. From the IFE cover, the pressurized oil is distributed to the turbocharger and the moving parts of the engine. The oil cools and lubricates the moving parts and then returns to the oil pan.
 - The pre-lube pump operates prior to engine cranking to circulate lubricating oil through the engine and is critical to engine protection.
 - The lubricating oil is pulled by the pre-lube pump from a take-off in the engine oil suction pipe.
 - From the pre-lube pump, the oil is sent to the engine through the check valve. The lubricating oil passes through the oil cooler and oil filter before being sent into the engine.
 - The coalescer collects oil mist from the crankcase gases. The collected oil is returned to the crankcase, and the gases are vented to the atmosphere through the exhaust stack.

Screen 114:

Summary (Cont'd):

- Describe the protection strategies used with the lubricating oil system.
 - Low Lube Oil Pressure Protection: 20 seconds after the engine reaches 180 RPM, the ECU compares the inlet engine lubricating oil pressure to a value that defines the minimum required lubricating oil pressure. If the lubricating oil pressure drops below or increases above the indicated values, the ECU signals the EMS software to take appropriate action to decrease or increase engine speed, as required.
 - Very Low Lube Oil Pressure Protection: When the engine is running, the ECU compares the inlet engine lubricating oil pressure, as read by the ELIP sensor, to a value that defines a very low lubricating oil pressure trip level for a given

- engine speed. If the lubricating oil pressure drops to the trip level, the EMS software shuts down the engine.
- Low Oil Pressure Count Protection: This function restricts the engine to Notch 2 if five or more low oil pressure incidents occur in a 14-day period.
 - Cold Engine Protection: This function prevents damage to the engine, the lubricating oil pump, and the external oil piping.
 - Hot Oil Protection: This protects the engine from overheating due to tunnel operation, cooling system malfunction, and other factors that can raise the engine oil inlet temperature.
 - Engine Water Inlet Temperature and Engine Lube Oil Outlet Temperature ΔT Protection: The engine horsepower derates or the engine shuts down if the delta temperature (ΔT) between the engine water inlet (as measured by the EWIT sensor) and the engine lubricating oil outlet (as measured by the ELOT sensor) exceeds an allowable limit.
 - Loss of Both Engine Oil Temperature Sensors Protection: This function provides protection when both engine oil temperature (ELIT and ELOT) sensors are determined to be bad. In this case, the engine will shut down.
 - Crankcase Overpressure Protection: This function provides protection when crankcase pressure exceeds a primary limit for 0.5 seconds or a secondary limit for 10 seconds. In this case, the engine shuts down.
- Describe how to perform scheduled maintenance related to the lubricating oil system.
 - Lubricating oil system:
 - Daily or during trip maintenance, with the engine at IDLE, make a visual inspection of the engine, lubricating oil pump, oil cooler, oil filter, pre-lube pump, and all system piping for oil leaks. Make corrections as necessary.
 - Check the oil level with the engine at IDLE. Collect an oil sample every 7 to 10 days and analyze it. If the oil is suitable for continued use, fill the oil to the FULL mark on the dipstick with the approved lubricating oil. If not acceptable, find and fix the root cause of the contaminated oil, and then change the oil and filters.
 - Every 184 days, drain the oil from the lubricating oil system. Remove the 10 filter elements from the oil filter tank, clean the inside of the tank, install new filters, and fill the engine with oil to the proper level on the dipstick.
 - Lubricating oil pump: Visually inspect the oil pump for any leaks or cracks. If leaks are present in the piping joints, try tightening the joint first. If this fails to stop a leak, remove the pump and renew the gaskets. Listen for unusual noises coming from the pump and correct as needed. For instructions on lubricating oil pump removal and installation, refer to the Lubricating Oil Pump Removal and Installation module of the GEVO Diesel Engine Advanced course.

- Lubricating oil cooler: Visually inspect the oil cooler and the piping connections to the cooler for any leaks. Correct any leaks in the piping system as necessary. Any leaks in the oil cooler require that the oil cooler be replaced.

Screen 115:

Summary (Cont'd):

- Lubricating Oil Cooler Removal
 1. Drain all water from the split cooling water system, from including the water tank.
 2. Drain the oil from the lubricating oil filter housing.
 3. Remove the applicable locomotive handrail section to allow for oil cooler removal.
 4. Disconnect the oil cooler from the oil filter housing.
 5. Disconnect the water pipes connected to the oil cooler by removing the four couplings and the two pipes, then plug or block all pipe openings.
 6. Disconnect the clamps holding the fuel hoses, plug or block all hose openings, and save all removed hardware.
 7. Remove the oil inlet pipe flange assembly from the left side of the oil cooler and bolt a blanking plate to the oil cooler inlet flange opening.
 8. Remove the four mounting bolts that secure the oil cooler to the floor of the radiator cab.
 9. Attach lifting slings or cables to the holes of the lubricating oil cooler.
 10. With the appropriate lifting device, gently slide and then lift the lubricating oil cooler to remove it from the radiator cab.
- Lubricating Oil Cooler Installation
 1. Attach lifting slings or cables to the holes of the lubricating oil cooler.
 2. Lift the lubricating oil cooler and manually rotate the lubricating oil cooler to pass through the support bar of the radiator cab.
 3. Place the lubricating oil cooler on the radiator cab floor and gently slide it through the radiator cab to the mounting location.
 4. Install the four mounting bolts securing the oil cooler to the floor of the radiator cab, then torque the bolts to 200-220 lb.-ft. (271-298 Nm) in a crisscross pattern.
 5. Remove the plugs from the fuel hose openings, then re-install the fuel hoses and secure with the previously removed clamps.
 6. Remove the plugs from the water pipe openings, then reconnect the two water pipes to the lubricating oil cooler and secure with the previously removed couplings.
 7. Connect the oil cooler to the oil filter housing as follows:
 - a. Remove the plugs and unblock all flange and pipe openings, then reconnect the oil filter housing drain back valve flange and drain piping assembly and install the previously removed hardware.

- b. Remove the plugs and unblock all flange and pipe openings, then reconnect the pipe sections on the back of the oil filter housing crossing over the oil cooler and install the previously removed hardware.
 - c. Remove the blanking plate and plugs and then reconnect the piping connecting the oil cooler to the oil filter housing and install the previously removed hardware.
8. Install the previously removed handrail section.
9. Refill the cooling water system and visually inspect the intercooler and associated piping for signs of leakage or damage.
10. Once the lubricating oil cooler is installed, close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
11. With the engine at IDLE, check and fill the crankcase lubricating oil level.

Screen 116:

Summary (Cont'd):

- Lubricating Oil Filter Housing Removal
 1. Drain the oil from the lubricating oil filter housing.
 2. Remove the applicable locomotive handrail section to allow for oil filter housing removal.
 3. Disconnect the oil filter housing from the oil cooler.
 4. Remove the ten mounting bolts that secure the oil filter housing to the floor of the radiator cab.
 5. Attach lifting slings or cables to the holes on the lubricating oil filter.
 6. With the appropriate lifting device, gently slide and then lift the oil filter housing to remove it from the radiator cab.
- Lubricating Oil Filter Housing Installation
 1. Attach lifting slings or cables to the holes on the lubricating oil filter.
 2. Lift the lubricating oil filter housing and manually rotate the filter housing to pass through the support bar of the radiator cab.
 3. Place the oil filter housing on the radiator cab floor and gently slide it through the radiator cab to the mounting location.
 4. Install the ten mounting bolts that secure the filter housing to the floor of the radiator cab, then torque the bolts to 105-115 lb.-ft. (142-156 Nm) in a crisscross pattern.
 5. Connect the oil cooler to the oil filter housing as follows:
 - a. Remove the plugs and unblock all flange and pipe openings, then reconnect the oil filter housing drain back valve drain flange and drain piping assembly and install the previously removed hardware.
 - b. Remove the plugs and unblock all flange and pipe openings, then reconnect the pipe sections on the back of the oil filter housing and install the previously removed hardware.

- c. Remove the blanking plate and plugs and then reconnect the piping connecting the oil cooler to the oil filter housing and install the previously removed hardware.
- 6. Install the previously removed handrail section.
- 7. Fill the lubricating oil system, if required.
- 8. Once the oil filter housing is installed, close the BS and then close the LCCB, FPB, and BCCB on the EC panel, remove the warning tag from the EC switch, and start the engine.
- 9. With the engine at IDLE, check and fill the crankcase lubricating oil level.
- Lubricating Oil Filter Element Replacement
 - 1. Drain the oil from the lubricating oil filter housing.
 - 2. Loosen the 10 nuts securing the filter housing door and crack the door seal.
 - 3. Further loosen the nuts securing the filter housing door and fully open the door.
 - 4. Remove the 10 used filter elements and inspect the outer surfaces of the used elements for metal particles.
 - 5. Discard the used elements.
 - 6. Wipe clean the inside of the filter housing to prevent the old oil in the housing from contaminating the new oil.
 - 7. Install new approved filter elements.
 - 8. Ensure all filter elements are properly seated and clamped.
 - 9. Close the filter housing door and torque the clamping nuts in a crisscross pattern to the torque indicated on the label.
 - 10. Close the lubricating oil filter housing vent and drain back valves.
 - 11. Restore the locomotive and check and fill oil in the engine crankcase.

Screen 117:

Summary (Cont'd):

- Pre-Lube Pump and Motor Assembly Removal
 - 1. Drain the oil from the lubricating oil system.
 - 2. Remove the applicable locomotive handrail section to allow for pre-lube pump and motor assembly removal.
 - 3. Disconnect the inlet and outlet hoses from the pre-lube pump JIC fittings.
 - 4. Remove the terminal junction box cover on the side of the pre-lube motor by removing the six screws.
 - 5. Remove the wire lugs from the terminals inside the terminal junction box.
 - 6. Disconnect the conduit fitting on the top of the terminal junction box and pull the plastic conduit and wires from the pre-lube pump and motor assembly.
 - 7. Re-install the cover on the terminal junction box and torque the six screws to 20-25 lb.-in (2.26-2.82 Nm).
 - 8. Remove the four mounting bolts that secure the pre-lube pump and motor assembly to the floor of the radiator cab.

9. With the appropriate lifting device, gently slide the pre-lube pump and motor assembly from the radiator cab, and then lift and remove the assembly from the walkway.
- Pre-Lube Pump and Motor Assembly Installation
 1. With an appropriate lifting device, place the pre-lube pump assembly on the radiator cab.
 2. Install the four mounting bolts that secure the pre-lube pump and motor assembly to the floor of the radiator cab.
 3. Torque the four mounting bolts to 55-62 lb.-ft. (74.5-84 Nm).
 4. Re-install the inlet and outlet hoses to the JIC fittings on the pre-lube pump and tighten until snug.
 5. Torque the inlet hose to the inlet JIC fitting to 210-220 lb.-ft. (284-298 Nm).
 6. Torque the outlet hose to the outlet JIC fitting to 140-150 lb.-ft. (190-203 Nm).
 7. Remove the terminal junction box cover on the side of the pre-lube motor by removing the six screws.
 8. Insert the wires and plastic conduit through the top conduit hole in the terminal junction box and tighten the conduit fitting.
 9. Connect the wire lugs into the terminals inside the terminal junction box and tighten to 120-140 lb.-in (13.56-15.82 Nm).
 10. Re-install the cover on the terminal junction box and torque the six screws to 20-25 lb.-in (2.26-2.82 Nm).
 11. Install the locomotive handrail section that was removed during pre-lube pump and motor assembly removal.
 12. Fill the lubricating oil system.
- Pre-Lube Check Valve Replacement
 1. Remove the pre-lube supply hose from the check valve using a TESCO T87340 2 ¼-inch crow's foot and breaker bar.
 2. Remove the old check valve using a TESCO T87330 2-inch crow's foot and breaker bar.
 3. Insert and rotate the new check valve a few turns by hand to verify that the thread-o-let is not oval.
 4. If the check valve binds or if the thread-o-let has an oval shape, either replace the pipe or re-tap the thread-o-let with a 1.5-inch NPT tap as follows:
 - a. Remove the Victaulic coupling, and then remove the oil inlet pipe flange assembly from the left side of the oil cooler.
 - b. If re-tapping the thread-o-let, use the 1.5-inch NPT tap to re-tap the threads, then clean the pipe of metal shavings before reinstalling.
 - c. With Vic-Lube applied to the Victaulic coupling seals, and the Victaulic coupling mounted horizontally with respect to the split line of the coupling, reinstall the re-tapped or replacement oil inlet pipe flange assembly to the left side of the oil cooler.

5. Install the replacement check valve, then torque to the appropriate value with a TESCO T87330 2-inch open end crow's foot.
6. With no Vic-Lube applied to the JIC hose fitting, use a TESCO T87340 2 ¼-inch crow's foot to torque the hose to the check valve to the correct torque value.
7. Start the locomotive and re-evaluate oil pressure to ensure proper operation of the replacement check valve.
- Victaulic Coupling Removal
 1. If required, drain oil from the lubricating oil filter housing.
 2. Remove the bolts and nuts holding the coupling halves together and remove the coupling.
 3. Slide the gaskets (one on each end of the pipe) onto the removable pipe.
 4. After the gaskets and the body of the coupling have cleared the fixed pipe, remove the pipe.
 5. Remove the gaskets from the pipe.
 6. Protect the pipe ends after disassembly.
- Victaulic Coupling Installation
 1. Inspect the gaskets, sealing surfaces of the pipe, and cleanliness of the pipe.
 2. Insert the pipe with one person holding the pipe in position while another person carefully slides the gasket into place.
 3. Install the coupling halves, then install the bolts and nuts ensuring that the oval under each bolt head is mated into the recessed oval in the coupling half.
 4. Tighten the nuts until there is a metal-to-metal contact between the coupling halves, then torque the Victaulic coupling bolts.
 5. Restore the locomotive, and with the engine at IDLE, check for oil leaks.
 6. Torque the Victaulic coupling bolts to the appropriate value.

Screen 118:

Summary (Cont'd):

- Coalescer: Maintenance for the coalescer is condition-based except for annual eductor tube cleaning. Inspect the coalescer and the eductor tubes. Clean the filter element and if necessary, replace the coalescer.
 - Coalescer Inspection
 - Inspect the hoses for obvious signs of damage, such as crushing, holes, deterioration, and rubbing.
 - Inspect the canister for damage and holes. Replace the coalescer, if necessary.
 - Check for missing or damaged O-ring seal between coalescer canister halves.
 - Check and ensure that all clamps and hose connections are secure. Repair, replace, or tighten as necessary.
 - Check for dirty or clogged filter element.

- Check for carbon buildup in the eductor tube.
- Coalescer Hoses Removal
 1. If removing the upper hose, remove the P-clamps and disconnect the steel braided boost hose from the eductor and the tee fitting in the turbocharger casing. If replacing the hose, cut the tie-wraps that connect the steel braided boost hose to the coalescer hose.
 2. Loosen the 9/16-inch (15-mm) clamp bolts that secure the ends of the upper and lower hoses to their attachment pipes.
 3. Rotate the ends of the hoses back and forth at the attachment points just enough to break any bonding that may have occurred between the hose and the attachment pipe.
 4. Pull the free ends of the hoses off the pipes, taking care not to scrape the hoses against other components that may damage them.
 5. Cover the openings to the coalescer and all ends of the coalescer hoses.
- Coalescer Hose Installation
 1. Inspect the coalescer hoses for cracks, holes, or other defects, and replace if needed.
 2. Apply anti-seize compound to the exterior of the attachment pipes.
 3. Ensure that the clamps are located loosely around the hose cuffs at both ends of the hoses, and then install the hose ends over the attachment pipes.
 4. Rotate the clamps around the hoses such that the bolt is in a convenient position for adjustment.
 5. Position the hoses so that they will not make contact with the engine or other engine components, then torque each 9/16-inch (15-mm) clamp bolt.
 6. When installing the upper coalescer hose, perform the following additional steps:
 - a. Attach the P-clamps to the upper coalescer hose. Ensure that the P-clamp bolts are torqued so that the hose does not get twisted or damaged.
 - b. Connect the steel braided boost hose to the eductor and the tee fitting in the turbocharger casing.
 - c. Install the tie-wraps and spacer blocks.
 - d. Ensure that the spacer block located opposite the steel braided boost hose on the lowest tie-wrap is in contact with the turbo case to prevent premature coalescer hose failure.
- Coalescer Removal
 1. Remove the coalescer hoses.
 2. Disconnect the coalescer drain line.
 3. Support the coalescer to prevent it from falling.
 4. Remove the retaining strap bolts from the retaining straps.
 5. Remove the coalescer from its installed position.

- Coalescer Installation
 1. Inspect the coalescer for cracks or defects, replace if needed.
 2. Position the coalescer in its mounting bracket on the IFE cover such that the inlet hose attachment is parallel to the front of the IFE cover.
 3. With the coalescer held in place, position the retaining straps around the coalescer, replace the retaining strap bolts, and torque the retaining strap bolts.
 4. Connect the coalescer drain line.
 5. Re-attach all coalescer hoses.

Screen 119:

Summary (Cont'd):

- Coalescer and Coalescer Filter Element Cleaning
 1. Remove the coalescer.
 2. Remove the clamp securing the top and bottom halves of the coalescer, then separate the top and bottom halves by rotating and pulling up on the top half of the coalescer, with the bottom half supported.
 3. Remove the filter element from the coalescer shell and the sealing ring from the bottom half of the coalescer.
 4. Clean the filter element and the coalescer halves with an approved solvent.
 5. Replace the sealing ring and the filter element.
 6. Reassemble the coalescer halves.
 7. Ensure that the coalescer halves are properly aligned with each other. Then, replace the clamp and torque the clamp nut.
 8. Install the coalescer on the IFE cover.
- Coalescer Eductor Tube Removal
 1. Remove the upper coalescer hose from the eductor tube.
 2. Remove the steel braided hose from the fitting on the eductor tube.
 3. Remove the eductor tube and the eductor gasket by removing the eductor tube mounting bolts.
 4. Scrap the removed eductor gasket and save the mounting bolts and washers for reuse.
 5. Remove the eductor bracket front bolts and spacers.
 6. Re-install the two front left-side eductor mounting bolts without the spacers, leaving a gap to allow the bracket to move for doughnut seal change out.
 7. Remove the right rear bolts and spacers completely.
 8. Remove the eductor doughnut seal, ensuring that the eductor bracket is secured, which prevents the eductor tube from supporting the bracket weight or position.
 9. Clean the mating surfaces and install a new doughnut seal.

10. Re-install all eductor bracket bolts and spacers, and torque the bolts.

- Coalescer Eductor Tube Cleaning
 1. Remove the straight fitting.
 2. Inspect the boost nozzle threads for damage or debris, then cap the boost nozzle threads to protect them from damage.
 3. Clean the interior and exterior of the eductor tube and boost nozzle.
 4. Inspect the cleaned eductor tube for cracks or other damage prior to reuse.
 5. Apply thread sealant to the steel braided boost line thread side only on the steel braided boost line to the straight fitting.
 6. Install and tighten the straight fitting into the eductor tube.
 7. Inspect the eductor tube for cracks or other signs of damage prior to reuse.
- Coalescer Eductor Tube Installation
 1. Inspect the eductor tube bracket bolts and the eductor tube mounting bolts for proper installation.
 2. Install the eductor tube and the new gasket on to the eductor bracket using the 1/2 -13 - 1 1/2 grade 8 eductor tube mounting bolts and washers.
 3. Torque the eductor tube mounting bolts.
 4. Attach the coalescer hose to the eductor tube and tighten the clamp.
 5. Attach the P-clamps to the coalescer hose.
 6. Connect the elbow side of the steel braided hose to the fitting on the eductor tube, then torque the fitting.

Split Cooling Water System

Screen 1:

Welcome Screen:

Welcome to the Split Cooling Water System module of the ES44AC/DC Mechanical Systems Advanced course. The split cooling water system is also referred to as the cooling water system.

Screen 2:

Introduction to Split Cooling Water System

In this module, you will learn how to inspect and maintain the components of the split cooling water system in a running repair environment.

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

- State the purpose and location of the major components of the split cooling water system.
- Describe how water flows through the split cooling water system.
- Describe the protection strategies used with the split cooling water system.
- Describe the running maintenance required for the split cooling water system.
- Summarize the steps to remove and install the major components of the split cooling water system.

Screen 3:

Disclaimer:

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

Screen 4:

Overview of the Split Cooling Water System:

The split cooling water system maintains a nearly constant engine operating temperature throughout the load range of the engine, even with wide variations in outside temperature and throttle call. The split cooling water system also provides additional cooling for the water-based intercooler and the oil cooler at higher load conditions. Additional cooling of the water-based intercooler helps reduce the temperature of the intake manifold air that enters the engine cylinders. The reduced manifold air temperature decreases the amount of harmful emissions from the exhaust stack and decreases fuel consumption. Increased cooling of the oil cooler in higher load conditions helps improve the life of the engine's bearings.

Screen 5:

Major Components of the Split Cooling Water System:

The major components of the split cooling water system are displayed.

Screen 6:**Water Storage Tank:**

Located in the radiator cab directly below the air-based intercooler assembly, the water storage tank is a round flow-through tank that holds the majority of water for the cooling water system. The water tank allows for thermal expansion of water in the system during operation.

Screen 7:**Water Pump:**

Located on the Integrated Front End (IFE) cover of the engine, the water pump circulates water throughout the cooling water system.

Screen 8:**Lubricating Oil Cooler:**

Located in the radiator cab on the B-side (left side) of the locomotive just aft of the engine, the lubricating oil cooler removes heat from the lubricating oil and transfers it to the cooling water.

Screen 9:**Major Components of the Split Cooling Water System (Cont'd):**

Additional components of the split cooling water system are displayed.

Screen 10:**Water-Based Intercooler:**

Located in the upper section of the radiator cab, adjacent to the turbocharger, the water-based intercooler provides the first stage of cooling for the air discharged from the turbocharger.

Screen 11:**Univalve:**

Located in the upper section of the radiator cab, above the water-based intercooler, the univalve directs water flow through the cooling system to maintain system temperature during different operating conditions.

Screen 12:**Univalve Control Magnet Valves:**

Located in the combustion air filter compartment on the A-side (right side) of the locomotive, the univalve control magnet valves control the air that switches the univalve from one mode position to another.

Screen 13:**Radiators:**

Located on the top of the radiator cab, at the back end of the locomotive, the radiators transfer heat from the cooling water to the ambient air.

Screen 14:**Radiator Fan:**

Located directly below the radiators, the radiator fan cools the cooling water in the radiators by forcing air across the radiator sections.

Screen 15:**Fuel Manifold:**

Located in the radiator cab, mounted to the back of the fuel filter assembly, the fuel manifold contains a heater that heats the fuel when its temperature is below 85°F. The fuel heater uses the warmer cooling water as the source of heat.

Screen 16:**Automatic Water Drain Valve:**

Located in the engine cab, below the water pump, the automatic water drain valve provides freeze protection for the cooling water system components. If the engine is shut down, the automatic water drain valve opens to empty the cooling water system when the water temperature reaches a preset value, typically around 40°F.

Screen 17:**Sensors of the Split Cooling Water System:**

The split cooling water system also includes several sensors that provide feedback for diagnostics, control, and protection.

Screen 18:**EWIT Sensor:**

Located in the water pipe that connects the IFE cover of the engine and the water pump, the Engine Water In Temperature (EWIT) sensor measures the temperature of the cooling water entering the engine and provides this information to the Engine Control Unit (ECU).

Screen 19:**EWOT Sensor:**

Located in the water pipe that connects the engine and the univalve, the Engine Water Out Temperature (EWOT) sensor measures the temperature of the cooling water exiting the engine and provides this information to the ECU.

Screen 20:**EWIP Sensor:**

Located on the rear of the engine crankcase just behind the left-6 power assembly, the Engine Water In Pressure (EWIP) sensor measures the pressure of the cooling water at the left-6 power assembly of the engine and provides this information to the ECU.

Screen 21:**MAT Sensor:**

Located at the end of the engine's intake air manifold, the Manifold Air Temperature (MAT) sensor measures the temperature of the air in the intake manifold and provides this information to the ECU.

Screen 22:**Sensors of the Split Cooling Water System (Cont'd):**

Additional sensors of the split cooling water system are displayed.

Screen 23:**ATT Sensor:**

Located in the combustion air filter compartment wall, the Ambient True Temperature (ATT) sensor measures the temperature of the air entering the turbocharger and provides this information to the ECU.

Screen 24:**BAP Sensor:**

Located on the wall of Control Area 4 (CA4) in the auxiliary cab, the Barometric Air Pressure (BAP) sensor measures the pressure of the atmosphere and provides this information to the ECU.

Screen 25:**ELIT Sensor:**

Located in the IFE cover next to the oil inlet to the engine, the Engine Lube In Temperature (ELIT) sensor measures the temperature of the lube oil entering the engine and provides this information to the ECU.

Screen 28:**Operation of the Split Cooling Water System:**

The split cooling water system uses a pressurized, wet-dry radiator system. The amount of heat transferred from the engine and other components to the cooling water is regulated by changing the flow of the cooling water through the cooling water system and by changing the speed of the radiator fan. The cooling water system operates within established conditions referred to as Modes:

- Mode 3,
- Mode 2, and
- Mode 1.

The mode determines the path of the cooling water through the system, the radiator fan speed, and the strategies that protect the engine when abnormal operating conditions occur.

Screen 29:**Cooling Water Flow Paths – Mode 3:**

Mode 3 is utilized during low load or low ambient operating conditions. Usually, Mode 3 is entered immediately after starting the engine. Mode 3 operation heats the engine water, lubricating oil, and intake manifold air. During Mode 3 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. The combustion process in the engine heats the water. The heated water exits the engine and flows to the univalve.

Screen 30:**Cooling Water Flow Paths – Mode 3 (Cont'd):**

The univalve directs the heated water from the engine through two paths. The first path is through the oil cooler and the water-based intercooler and back to the storage tank, and the second path is directly to the water storage tank. The water that flows through the oil cooler and the water-based intercooler heats the lube oil and intake manifold air, respectively.

Screen 31:**Cooling Water Flow Paths – Mode 2:**

Mode 2 cools the engine water and provides a small temperature adjustment to the lubricating oil and intake manifold air. During Mode 2 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. From the engine, the heated water flows to the univalve. The univalve directs the heated water from the engine through two paths.

Screen 32:**Cooling Water Flow Paths – Mode 2 (Cont'd):**

The first path is through the oil cooler and the water-based intercooler, and then back to the water storage tank. This path either warms or cools the lubricating oil and intake manifold air. The second path is through the radiator and its sub-coolers, and then back to the water storage tank. A motor-driven radiator fan pushes air through the radiator to cool the engine water. Varying the fan motor speed from off to 1/4, 1/2, or full engine speed controls the amount of cooling that occurs. For more information on manifold air temperature control, refer to the Combustion Air System module.

Screen 33:**Cooling Water Flow Paths – Mode 1:**

Mode 1 is utilized during high load or high ambient operating conditions. Mode 1 provides maximum cooling for the engine water, lubricating oil, and intake manifold air. During Mode 1 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. From the engine, the water flows to the univalve. The univalve directs all of the water from the engine to

the radiator. The radiator has two sections: main and sub-cooler. The majority of the water flows through the "one-pass" main section back to the water storage tank.

Screen 34:

Cooling Water Flow Paths – Mode 1 (Cont'd):

The remaining water continues through the "two-pass" sub-cooler section for further cooling. Water from the sub-cooler section is then channeled by the univalve to flow through the oil cooler and the water-based intercooler to provide additional cooling. A motor-driven radiator fan pushes air through the radiator to cool the engine water. Varying the fan motor speed from off to 1/4, 1/2, or full engine speed controls the amount of cooling that occurs. For more information on manifold air temperature control, refer to the Combustion Air System module.

Screen 35:

Conditions that Determine Mode Selection and Radiator Fan Speed:

The split cooling water system maintains the cooling water within a certain range of temperatures. To accomplish this, the water temperature (as read by the EWIT sensor) and lube oil temperature (as read by the ELIT sensor) are monitored, and then the water flow path or the radiator fan speed is changed accordingly. Changing the flow path for the cooling water is accomplished with the univalve and can be thought of as making a course adjustment (or Mode selection) to the cooling process. Changing the radiator fan speed is done within a course adjustment, or Mode. This can be thought of as making a fine adjustment to the cooling process.

Screen 36:

Conditions that Determine Mode Selection and Radiator Fan Speed (Cont'd):

Because ambient temperature and engine horsepower production can radically affect the cooling requirements, the following temperature set points or triggers are used to determine when switching of the univalve or radiator fan speed needs to be adjusted upward or downward to account for these conditions:

- Ambient Temperature Adjustment Strategy
- Horsepower (HP) Adjustment Strategy
- Mode (or Univalve) Switching Control
- Radiator Fan Speed Switching Control

Screen 37:

Ambient Temperature Adjustment Strategy:

Ambient temperature affects how much heat can be transferred to the atmosphere and the rate at which that heat transfer can occur. Adjustments to the cooling process are divided into two regions, low and high ambient. Transition between regions is based on the True Ambient Temperature as read by the ATT sensor. For example, the strategy switches from Low Ambient Strategy to High Ambient Strategy when the temperature rises above 48°F.

Screen 38:**Horsepower Adjustment Strategy:**

The amount of horsepower (HP) produced by the engine affects how much heat is generated and the rate at which that heat is generated. Horsepower is a computed value and is divided into three regions: low horsepower, medium horsepower, and high horsepower. Transition between regions is based on set values of horsepower. Note that there are different transition times for the univalve and radiator fan.

Screen 39:**Mode (or Univalve) Switching Control:**

Transition between Mode 3 and Mode 2 is based on the temperature of the water entering the engine (as read by the EWIT sensor). Transition between Mode 2 and Mode 1 is based on the temperature of the lube oil entering the engine (as read by the ELIT sensor). In addition to the EWIT and ELIT temperature set points or triggers, transition from Mode 2 is also dependent on a minimum dwell time.

Screen 40:**Mode (or Univalve) Switching Control (Cont'd):**

A minimum dwell time is required for two reasons. The first is to ensure continuous water flow through the lubricating oil cooler and water-based intercooler. The second is to ensure that the radiator is approximately the same temperature as the fluid flowing inside. This minimizes the possibility of the radiator freezing when switching from Mode 2 to Mode 3 (radiator draining).

Screen 41:**Mode (or Univalve) Switching Control (Cont'd):**

When the radiator is not flooded and water is not flowing through it for an extended period of time (i.e., ambient temperature dependent), the radiator metal temperature approaches the ambient temperature. When water is again diverted to the radiator, especially during low ambient operation, the temperature difference induces significant heat transfer from the water to the radiator. The temperature of the water at the exit of the radiator is low enough that, even after mixing with the water in the tank, it is still below the Mode 2 to Mode 3 transition temperature set point. An immediate transition would stop the flow of water to the radiator.

Screen 42:**Mode (or Univalve) Switching Control (Cont'd):**

Although the radiator is warmer because of the energy transfer from the water, the temperature difference between the water and the metal is still large enough that the rate of heat transfer from the water to the metal may cause the water to freeze while the radiator is draining. When the computer software adjusts the cooling process to account for ambient temperature and horsepower, the following flow control strategies are used:

- Low Ambient Flow Control Using Water Temperature Set Points
- High Ambient Flow Control Using Water Temperature Set Points
- Flow Control Using Lube Oil Temperature Set Points

Screen 43:

Radiator Fan Speed Switching Control:

Radiator fan speed transition is based on the temperature of the water entering the engine (as read by the EWIT sensor).

Note: There is a minimum dwell time before the speed changes. This prevents unnecessary cycling of the radiator fan speed, which would cause the radiator fan assembly to wear faster.

When the computer software adjusts the cooling process to account for ambient temperature and horsepower, the following radiator fan control strategies are used:

- Low Ambient Radiator Fan Control and
- High Ambient Radiator Fan Control.

Screen 44:

Protection Strategies:

The following protection functions protect the diesel engine from damage that could be caused by operating at the extremes of the operating range or by abnormal conditions. Appropriate derations or restrictions are applied by each function as necessary.

Screen 45:

Low Water Pressure Protection:

The Engine Management System (EMS) software uses water pressure information (as read by the EWIP sensor) to prevent damage to the engine caused by a low water pressure condition. If water pressure is below a threshold value for 10 seconds at a given engine notch speed, a 20-second timer is started. If the water pressure continues to stay below the threshold value for the 20-second duration, the engine notch speed decreases by one notch. This action occurs every 20 seconds until the engine goes to IDLE. If at any point the water pressure increases to above the threshold value for 10 seconds, the engine notch speed restriction is removed. The table displays the water pressure thresholds for each engine notch speed. To prevent nuisance faults, low water pressure protection is inactive for engine speeds below 400 RPM.

Screen 46:

Cold Engine Protection:

When the engine is cold, such as immediately after starting and in extremely cold ambient temperatures, engine speed is limited as a function of the lubricating oil outlet temperature (as read by the ELOT sensor). This protection prevents damage to

the engine, the lube oil pump, and external oil piping. If the engine was just started, the engine speed is limited to 795 RPM or less until the lubricating oil outlet temperature is 140°F or greater for three minutes.

Screen 47:

Hot Water Protection:

When the engine inlet water temperature (as read by the EWIT sensor) is hot, the available horsepower from the engine is reduced to protect the engine from damage. At the same time, the engine speed increases to 1050 RPM to provide the highest radiator fan speed and maximum cooling. When the engine inlet water temperature exceeds 230°F for two seconds, the engine speed increases to 1050 RPM (an EMS_HOT_ENGINE_1050_INC is logged) and the available horsepower is modulated to hold the engine inlet water temperature at 230°F. If the available horsepower has been reduced to 80% or less for one minute, an EMS_HOT_WATER_DERATION_INC is logged. If the attempt to control the water temperature fails, and the available horsepower has been reduced to 0% for five minutes, the engine shuts down and an EMS_HOT_WATER_SHUTDOWN_INC will be logged.

Screen 48:

Cannot Cool Protection:

If the radiator fan is unable to run, the engine is limited to Notch 2. This protects the engine from overheating.

Screen 49:

Engine Water Inlet Temperature and Engine Lube Oil Outlet Temperature ΔT Protection:

The engine horsepower derates or shuts down if the delta temperature (ΔT) between the engine water inlet (as read by the EWIT sensor) and the engine lube oil outlet (as read by the ELOT sensor) exceeds an allowable limit. The allowable ΔT limit is dependent on the engine lube oil outlet temperature as displayed in the table.

Screen 50:

Engine Water Inlet Temperature and Engine Lube Oil Outlet Temperature ΔT Protection (Cont'd):

If the maximum allowable ΔT limit is exceeded, the engine horsepower will be derated as displayed in the table. If the ΔT is not within the limit five minutes after the initial violation, the engine goes to IDLE. If the ΔT is not within the limit 10 minutes after the initial violation, the engine is shut down. If at any time the ΔT returns to an allowable limit, the engine horsepower is restored to 100%.

Screen 51:**Loss of Both Engine Water Temperature Sensors Protection:**

If both engine water temperature sensors (EWIT and EWOT) are bad, the engine shuts down. If one of the two sensors is bad, the ECU models the good sensor to provide a substitute value for the bad sensor. If the EWIT sensor is bad, the substitute value is $EWIT = EWOT - 6^{\circ}F$. If the EWOT sensor is bad, the substitute value is $EWOT = EWIT + 10^{\circ}F$.

Screen 55:**System Capacities:**

It is important to know where to find operational data about the split cooling water system, any pertinent self-tests, and normal operating temperatures and pressures. Knowing how the system normally operates can be a very valuable tool when trying to diagnose problems. The split cooling water system holds 430 gallons of treated water. The bulk of the water, which is approximately 327 gallons, fills the water storage tank.

Screen 56:**Monitor Parameters:**

The following monitor parameters are available on a Smart Display (in Level 3 access) to aid maintenance personnel in monitoring the split cooling water system.

Screen 57:**Normal Operating Temperatures and Pressures:**

The table displays normal expected operating temperatures and pressures for the water flowing in and out of the engine.

Screen 58:**Operational Details:**

Self-Test 309, initiated by means of a Smart Display, can be used to test the green LED. When illuminated, the green LED normally indicates that the water is out of the radiators and is in the water storage tank. Self-Test 309 is used to test that the computer system can turn on and off the green LED only. This self-test does not test the operation of the water flow control magnet valves. Self-Test 320, initiated by means of a Smart Display, can be used to test the univalve and water flow control magnet valves (WV1, WV2, and WV3). This self-test is used to place the split cooling water system in a Mode of operation (Mode 1, 2, or 3) and then verify that the proper switching has occurred. In Mode 1, the univalve mode indicator should be in the 12 o'clock position, and WV1, WV2, and WV3 should be energized. In Mode 2, the univalve mode indicator should be in the 2 o'clock position, and WV2 should be energized. In Mode 3, the univalve mode indicator should be in the 4 o'clock position, and all WV's should be de-energized. Self-Test 404, initiated by means of a Smart Display, can be used to test the radiator fan operation.

Screen 59:**Running Maintenance Schedule:**

The table displays the recommended running maintenance schedule associated with the cooling water system and its major components.

Screen 62:**System Checks and Adjustments:**

Check the cooling water level by using the water sight glass, but only after the engine has been idling for at least ten minutes with the green LED on. This delay ensures that all water has drained from the radiators back into the water storage tank. At IDLE, the correct water level is between the FULL AT IDLE and LOW AT IDLE marks on the water sight glass.

Note: It is recommended to fill the cooling system with pretreated water at the supplied water fill pipe connection. It is not recommended to remove the pressure cap or blanking plate from the fill pipe. Follow all Railroad Regulations and Rules concerning the addition of cooling water and water treatment compound.

Screen 63:**Filling the Cooling Water System:**

Typical steps to fill the cooling water system with pretreated water are as follows:

Caution: Do not check or add cooling water until the engine has been idling for at least ten minutes with the green LED on. Do not fill the cooling water system above the FULL AT IDLE mark, because the system may run cold, causing serious engine damage and possibly frozen radiators. Do not allow the level to go below the LOW AT IDLE mark, because water pump cavitation will take place, resulting in low water pressure, poor cooling, and a hot engine.

1. Attach the water supply hose to the water fill pipe connection.
2. Turn on the water supply.
3. Vent pressure from the system by holding the flag vent valve down for at least 60 seconds.

Screen 64:**Filling the Cooling Water System (Cont'd):**

4. Pull down and hold the spring-loaded handle of the water fill valve until the sight glass water level is at the FULL AT IDLE mark.
5. Slowly return the spring-loaded handle of the water fill valve to its normal closed position.
6. Shut off the water supply.
7. Remove the water supply hose from the water fill pipe connection.

Screen 65:**Draining the Cooling Water System and Taking Cooling Water Samples:**

To drain the cooling water system, first, shut down the engine. Then, open the manual water drain valve located by the water pump.

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the Battery Switch (BS) to prevent starting attempts. Also, place the Fuel Pump Circuit Breaker (FPB) and the Local Control Circuit Breaker (LCCB) in the OFF position. Apply a warning tag to the Engine Control (EC) switch.

It is recommended to collect water samples for analysis at a minimum frequency of seven to ten days. Have the sample analyzed by a qualified laboratory, and then take the appropriate action based on the analysis. Before taking a water sample, write all pertinent information on the sampling bottle. Print the information clearly and keep the label clean so that a lab technician can read it. Collect the water sample by using one of the water-sampling valves on the water sight glass housing. Fill the water sample bottle 2/3 to 3/4 full.

Screen 66:**Water Pump:**

The centrifugal water pump, mounted on the engine's IFE cover, circulates water through the cooling water system. The pump, gear-driven from the engine crankshaft by means of an auxiliary drive gear, draws water directly from the water storage tank and moves approximately 545 GPM of water at Notch 8 engine speed.

Screen 67:**Running Maintenance for Water Pump:**

During daily inspections of the diesel engine, visually inspect the water pump for any leaks or cracks. Closely check around the joint areas, such as the water pump suction and discharge lines. If any leaks are found in the piping joints, try tightening the joint first. If this fails to stop a leak, remove the pump and replace the gaskets. Listen for any unusual noises coming from the pump, and correct as needed. For removal and installation of the water pump, refer to the Diesel Engine Advanced course for instructions.

Screen 68:**Lubricating Oil Cooler:**

The lubricating oil cooler removes heat produced in the engine by combustion and friction from the lubricating oil. The lubricating oil cooler is a plate heat exchanger design, with metal plates separating the oil, flowing in one direction, from the cooling water, which flows in the opposite direction. The plates not only separate the two fluids but also form the medium to transfer heat from the oil to the cooling water.

Screen 69:**Running Maintenance for Lubricating Oil Cooler:**

Visually inspect the oil cooler and the piping connections to the cooler for any leaks. Repair any leaks in the piping system as necessary. Any leaks in the oil cooler require that the oil cooler be replaced. If lube oil is visible in the water sight glass, an internal leak probably exists in the oil cooler. Because the oil pressure in the lube oil system is higher than the cooling water pressure in the split cooling water system, leaks between the two systems usually appear first in the cooling water system. For removal and installation of the oil cooler, refer to the Lubricating Oil System module of this course.

Screen 70:**Water-Based Intercooler:**

As part of a two-stage manifold air-cooling process, the water-based intercooler (WBIC) provides the first stage of cooling. The WBIC cools the air discharged from the turbocharger. At Notch 8 engine speed, the outlet air temperature from the WBIC is typically around 200°F. Factors such as engine load, altitude, and ambient air temperature can significantly affect this value. The WBIC is made up of a core and an outer shell. The core is a mechanically bonded tube-and-fin design. The cooling water flows inside the tubes and makes two passes through the shell before exiting. The turbocharger discharge air flows over the tubes and fins in one pass. The outer shell, which may be either fabricated or cast, provides the rigid frame for mounting the intercooler core. To distinguish between the two designs, which are referred to as the fabricated WBIC and the cast WBIC, consider the following:

- For the fabricated WBIC design, the outside diameter of the water inlet and outlet pipes is 3.5 inches (88.9 mm). It has a B-side rectangular cover casing door that is secured using hex bolts.
- In the cast WBIC design, the outside diameter of the water inlet and outlet pipes is 2.8 inches (71.12 mm). It has a B-side rectangular cover casing door that is secured using socket (Allen) head screws.

Screen 71:**Fabricated WBIC Core Removal:**

Note: This demonstration displays the steps to remove a core from a fabricated WBIC. For details of removing the core from a cast WBIC, refer to the Cast WBIC Core Removal section of this module.

Typical steps to remove the fabricated WBIC core are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with Auto Engine Start/Stop (AESS), the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Shut down the diesel engine.
2. Depressurize the cooling water system by holding the water fill assembly vent valve open for approximately one minute.
3. With the engine shutdown and the cooling water system depressurized, ensure the radiators contain no water.
4. Drain the water from the cooling water system below the level of the water-based intercooler.
5. From the A-side (right side) of the locomotive:
 - a. Open, but do not remove, the access door.
 - b. Remove the drain line and fitting from the drain pipe.
 - c. Remove the two 5/8-inch hex bolts and washers near the top of the cover.
 - d. Remove the 20, 3/8-inch hex bolts holding the A-side (right side) cover.
 - e. Remove the four 3/8-inch hex bolts and seal plate surrounding the drain fitting and save all hardware for re-use.

Screen 72:

Fabricated WBIC Core Removal (Cont'd):

6. From the B-side (left side) of the locomotive:
 - a. Remove the maintenance access panel from underneath the wing of the radiator cab, then set the panel aside and save all hardware for re-use.
 - b. Disassemble and remove the Victaulic couplings securing the piping to the water-based intercooler.

Note: For additional information on disassembly and removal of the Victaulic couplings, refer to the Victaulic Coupling Removal section of this module.

- c. Disconnect the vent fitting.
- d. Loosen and remove the 10 hex bolts and washers that secure the core access plate to the intercooler shell, then set aside the plate and all related hardware for re-use.

Note: Depending on the fabricated WBIC shell design, it may also be necessary to remove Allen bolts from the front end of the intercooler shell in order to remove the intercooler core.

Screen 73:**Fabricated WBIC Core Removal (Cont'd):**

Warning: The WBIC core weighs approximately 550 lbs. (250 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

7. Install the puller tool (PSB P5205) onto the B-side of the locomotive for removing the intercooler core, as follows:
 - a. Install the support plate to the locomotive carbody.
 - b. Set the support stand on the handrail allowing it to sit on the catwalk.

Warning: The intercooler core cradle support weighs approximately 100 lbs. (45 kg). Ensure that the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

- c. Install the cradle support legs using ball lock pins.
 - d. Install the cradle support using ball lock pins, then adjust the support so it is level with the bottom of the intercooler core.
 - e. Install the puller tool puller bar onto the end of the intercooler core.

Screen 74:**Fabricated WBIC Core Removal (Cont'd):**

8. Using a 1/2-inch air ratchet with a 3/4-inch socket, turn the worm gear and remove the core attached to the puller tool puller bar.
9. After the core has fully cleared the wing of the radiator cab and is stationary on the cradle support, install the four, 1/2-inch lifting eye bolts.
10. Lift the core off the cradle.

Note: Ensure that the movement of the core is away from the radiator cab. Do not simply lift the core straight up.

11. Place the core on a stable work surface.

Screen 75:**Fabricated WBIC Core Installation:**

Note: This demonstration displays the steps to install a fabricated WBIC core. For details of installing a cast WBIC core, refer to the Cast WBIC Core Installation section of this module.

Typical steps to install the fabricated WBIC core are as follows:

Note: After the fabricated WBIC core has been placed in the locomotive, re-install the A-side covers using new O-rings as applicable.

Warning: The fabricated WBIC core weighs approximately 550 lbs. (250 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

1. Ensure that the fabricated WBIC core is being installed by confirming the water inlet and outlet pipe outside diameter measurements are 3.5 inches (88.9 mm) and the B-side rectangular cover casing door is attached with hex bolts.
2. If required, install the puller tool (PSB P5205) onto the B-side of the locomotive for installing the intercooler core as discussed in the Fabricated WBIC Core Removal section of this module.
3. Install the four ½-inch lifting eye bolts on the intercooler core.
4. Using a suitable lifting device, slowly lift the core and place it on the puller tool cradle, ensuring the core does not impact the side of the radiator cab while lifting.
5. Using the attached puller tool puller bar and a 1/2-inch air ratchet with 3/4-inch socket, turn the worm gear and install the intercooler core in position in the radiator cab.

Screen 76:

Fabricated WBIC Core Installation (Cont'd):

6. After the intercooler core has been placed in the radiator cab, install the rectangular cover using the 20, 3/8-inch hex bolts, then torque the bolts to 22-24 lb.-ft. (30-33 Nm).
7. Install the seal plate around the drain fitting using the four 3/8-inch hex bolts, then torque the bolts to 22-24 lb.-ft. (30-33 Nm).
8. Install the two bolts and washers near the top of the cover, then torque the bolts to 110-120 lb.-ft. (149-163 Nm).
9. Attach the drain hose and fitting and close the access door.
10. Remove and disassemble the puller tool (PSB P5205) from the B-side of the locomotive.

Screen 77:

Fabricated WBIC Core Installation (Cont'd):

11. Install the B-side access plate cover with a new air side O-ring.
12. Torque the 10, 1/2-inch hex bolts to 55-62 lb.-ft. (75-84 Nm).

Note: Depending on the fabricated WBIC shell design, it may also be necessary to install Allen bolts that were previously removed from the front end of the intercooler shell in order to remove the intercooler core. If so, install and torque the Allen bolts to 31-33 lb.-ft. (42-45 Nm).

13. Using new gaskets, re-install the Victaulic couplings that secure the piping to the intercooler on the B-side.

Note: For additional information on assembly and installation of the Victaulic couplings, refer to the Victaulic Coupling Installation section of this module.

14. Reconnect the vent fitting.
15. Refill the cooling water system, if required as discussed in the Filling the Cooling Water System section of this module, and visually inspect the intercooler and associated piping for signs of leakage or damage.
16. Re-install the maintenance access panel underneath the wing of the radiator cab.

Screen 78:

Cast WBIC Core Removal:

Note: This demonstration displays the steps to remove a core from a cast WBIC. For details of removing the core from a fabricated WBIC, refer to the Fabricated WBIC Core Removal section of this module. Before replacing the core, check for leaks from the tell-tale holes to ensure that there is no water leak.

Typical steps to remove the cast WBIC core are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Shut down the diesel engine.
2. De-pressurize the cooling water system by holding the water fill assembly vent valve open for approximately one minute.
3. Remove the maintenance access panel underneath the wing of the radiator cab, then set the panel aside and retain the hardware.

Note: Ensure that the radiators contain no water.

4. Drain the water from the cooling system, below the level of the cast WBIC.
5. From the A-side (right side) of the locomotive:
 - a. Open, but do not remove, the access door.
 - b. Remove the drain line and the fitting from the drain pipe.
 - c. Remove the 28, 3/8-inch hex bolts from the outer end fastening plate that secures the intercooler core and attached end cover to the shell, and save all hardware for re-use.
 - d. Remove the outer end fastening plate and discard the O-ring.

Note: If desired, the intercooler core end cover may also be removed by removing the 16 Allen bolts; however, the cover may remain attached during the cast WBIC core removal and installation.

Screen 79:

Cast WBIC Core Removal (Cont'd):

6. From the B-side (left side) of the locomotive:
 - a. Disassemble and remove the couplings securing the piping to the cast WBIC.

Note: For additional information on disassembly and removal of the Victaulic couplings, refer to the Victaulic Coupling Removal section of this module.

- b. Disconnect the vent fitting and discard the gaskets.
 - c. Loosen and remove the 16 Allen bolts that secure the core access plate with end tank to the outer end fastening plate.

Note: Depending on the cast WBIC B-side end plate design, M10 bolts either with or without hard lock (Nord-Lock) washers may have been used instead of Allen bolts to secure the core access plate with end tank to the outer end fastening plate.

- d. Set the core access plate with end tank aside and save all hardware for re-use.
 - e. Discard the O-ring.
 - f. Loosen and remove the 16, 1/2-inch hex bolts and washers that secure the outer end fastening plate to the intercooler shell.
 - g. Remove the outer end fastening plate and save all hardware for re-use.

Screen 80:

Cast WBIC Core Removal (Cont'd):

Warning: The approximate nominal weight of the cast WBIC core is 1428 lbs. (648 kg) and the approximate dry core weight is 518 lbs. (235 kg). Ensure that the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

Caution: While lifting the core, ensure that the movement of the core is away from the radiator cab. Do not simply lift the core straight up. Failure to do so may result in damage to the components.

7. Install the cast WBIC core removal tool (TESCO T85373) onto the B-side (left side) of the locomotive.
8. Install a lifting eye bolt on the B-side outer end fastening plate.
9. Attach a sling to the B-side eye bolt to pull the core out from the radiator cab and onto the cast WBIC core removal tool (TESCO T85373).

10. After the core has fully cleared the wing of the radiator cab and is stationary on the cast WBIC core removal tool (TESCO T85373), install the other lifting eye bolt on the A-side outer end fastening plate or the intercooler core end cover, if still installed.
11. Attach lifting slings to the two eye bolts, then lift the core and place it on a stable (level) work surface.

Screen 81:

Cast WBIC Core Installation:

Note: This demonstration displays the steps to install a cast WBIC core. For details of installing a fabricated WBIC core, refer to the Fabricated WBIC Core Installation section of this module.

Typical steps to install the cast WBIC core are as follows:

Warning: The approximate nominal weight of the cast WBIC core is 1428 lbs. (648 kg) and the approximate dry core weight is 518 lbs. (235 kg). Ensure that the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

Caution: While lifting the core, ensure that the movement of the core is away from the radiator cab. Do not simply lift the core straight up. Failure to do so may result in damage to the components.

1. If required, install the cast WBIC core removal tool (TESCO T85373) onto the B-side (left side) of the locomotive.
2. Install a lifting eye bolt to the new intercooler core on the A-side outer end fastening plate or the intercooler core end cover, if installed, and another lifting eye bolt on the B-side outer end fastening plate.
3. Attach slings to the lifting eye bolts and carefully lift the core from the stable work surface.
4. Place the intercooler core on the cast WBIC core removal tool (TESCO T85373), then remove the slings and lifting eye bolts from the sides of the core.
5. Using the cast WBIC core removal tool (TESCO T85373), install the intercooler core into the radiator cab, sliding the core through the wing and into the intercooler shell.
6. After the core is properly positioned in the intercooler shell, perform the following on the B-side (left side) of the locomotive:
 - a. Remove the cast WBIC core removal tool (TESCO T85373).
 - b. Install the outer end fastening plate with the 16, 1/2-inch hex bolts and washers, then torque to 55-62 lb.-ft. (75-84 Nm).
 - c. Re-install the core access plate with end tank to the outer end fastening plate with a new O-ring and the 16 Allen bolts, then torque to 31-33 lb.-ft. (42-45 Nm).

Note: Depending on the cast WBIC B-side end plate design, M10 bolts either with or without hard lock (Nord-Lock) washers may have been used instead of Allen bolts to secure the core access plate with end tank to the outer end fastening plate. If so, install and torque the M10 bolts with hard washers to 36 lb.-ft. (49 Nm) or, for M10 bolts without hard washers, to 31 lb.-ft. (42 Nm).

- d. Re-install the vent fitting with a new gasket.
- e. Re-install the couplings to secure the piping to the intercooler on the B-side (left side).

Note: For additional information on assembly and installation of the Victaulic couplings, refer to the Victaulic Coupling Installation section of this module.

Screen 82:

Cast WBIC Core Installation (Cont'd):

7. On the A-side (right side) of the locomotive:
 - a. Re-install the outer end fastening plate and, if required, the intercooler core end cover using new O-rings as applicable.
 - b. If required, secure the intercooler core end cover with the 16 Allen bolts, then torque to 31-33 lb.-ft. (42-45 Nm).
 - c. Secure the outer end fastening plate to the shell using the 28, 3/8-inch hex bolts, then torque to 29.5 lb.-ft. (40 Nm).

Caution: Torque the side plate bolts in a star pattern to prevent side loading and possible O-ring damage.

- d. Re-attach the drain hose and fitting to the drain pipe.
 - e. Close the access door.
8. Refill the water in the cooling system as discussed in the Filling the Cooling Water System section of this module.
9. Visually inspect the intercooler and the associated piping for signs of leakage or damage.
10. Re-install the maintenance access panel underneath the radiator cab wing.

Screen 83:

WBIC Core, Seal, and O-Ring Inspection:

Inspect the intercooler core for signs of damage, including the core, water seals, and O-rings. If found, replace the applicable components, as necessary, in accordance with site specific locomotive maintenance instructions. If the water seals are damaged, corrosion will be found on the outside of the core. Clean the corrosion from the sides of the core using pressurized water.

Screen 84:**Univalve Assembly:**

Note: Not all Evolution Series locomotives are equipped with a univalve assembly.

The univalve assembly changes the cooling water flow paths through the cooling system to regulate the water temperature during different operating conditions. The univalve assembly consists of a rotary flow control valve assembly shafted to a three-position pneumatic actuator. The three univalve control magnet valves (WV1, WV2, and WV3) are used to switch the actuator. To troubleshoot the univalve, an indicator on the actuator provides a visual indication of what mode of operation the assembly is in.

Screen 85:**Univalve Assembly (Cont'd):**

In Mode 1, the univalve mode indicator should be in the 12 o'clock position, and WV1, WV2, and WV3 should be energized. In Mode 2, the univalve mode indicator should be in the 2 o'clock position, and WV2 should be energized. In Mode 3, the univalve mode indicator should be in the 4 o'clock position, and all WVs should be de-energized. In addition, the solenoid on each univalve control magnet valve can be manually overridden. The magnet valve picks up when the manual override plunger is pressed down. The illustration indicates which magnet valve needs to be on or off to switch the univalve to a particular mode.

Screen 86:**Univalve Assembly Removal:**

Typical steps to remove the univalve assembly are as follows:

Note: Not all Evolution Series locomotives are equipped with a univalve assembly.

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: To ensure successful univalve maintenance, note the pin position on the valve. The replacement valve must be inserted in the same configuration as the removed valve. Also, mark the ports of the copper air tubing that supply operating air to the univalve's rotary actuator. The tubing will be removed and must be reattached to the correct ports.

1. Shut down the diesel engine.
2. Depressurize the cooling water system by holding the water fill assembly vent valve open for approximately one minute.
3. With the engine shutdown and the cooling water system depressurized, ensure the radiators contain no water.
4. Remove the bulkhead and radiator cab top covers to allow access to the univalve.

Note: Steps 5 through 8 are applicable only for univalve model 84D709452G1RSM and do not specifically apply to univalve models 84A214652ABP2 and 84A214652ABP3, which may or may not include a vent manifold assembly. Refer to customer-specific drawings, manuals, and procedures for removal and installation of these models, which include a newly designed mounting bracket and may or may not include the necessary mounting brackets for the vent manifold assembly.

5. Disconnect the three copper air tubes that supply actuating air to the univalve rotary actuator.

Screen 87:

Univalve Assembly Removal (Cont'd):

6. Remove the Victaulic couplings that connect the various water flowpaths to the univalve.

Note: For additional information on disassembly and removal of the Victaulic couplings, refer to the Victaulic Coupling Removal section of this module.

7. Remove and save the four bolts, washers, and lockwashers that secure the univalve mounting clamps.
8. Remove and save the two univalve mounting clamps and cushion inserts.

Warning: The univalve assembly weighs approximately 250 lbs. (113 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

9. Remove the univalve assembly with an appropriate lifting device.

Screen 88:

Univalve Assembly Installation:

Typical steps to install the univalve assembly are as follows:

Note: Not all Evolution Series locomotives are equipped with a univalve assembly.

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components.

Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: To ensure successful univalve maintenance, note the pin position on the valve. The replacement valve must be inserted in the same configuration as the removed valve. Also, mark the ports of the copper air tubing that supply operating air to the univalve's rotary actuator. The tubing will be removed and must be reattached to the correct ports.

Warning: The univalve assembly weighs approximately 250 lbs. (113 Kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

1. Use an appropriate lifting device and place the univalve assembly in position on the radiator cab.

Note: Steps 2 through 5 are applicable only for univalve model 84D709452G1RSM and do not specifically apply to univalve models 84A214652ABP2 and 84A214652ABP3, which may or may not include a vent manifold assembly. Refer to customer-specific drawings, manuals, and procedures for removal and installation of these models, which include a newly designed mounting bracket and may or may not include the necessary mounting brackets for the vent manifold assembly.

2. Install the two univalve mounting clamps and cushion inserts.
3. Install the four bolts, washers, and lockwashers that were removed during removal to secure the univalve mounting clamps.
4. Install the Victaulic couplings that connect the various water flowpaths to the univalve and torque the bolts to 70-80 lb.-ft. (95-108 Nm).

Note: For additional information on assembly and Installation of the Victaulic couplings, refer to the Victaulic Coupling Installation section of this module.

5. Connect the three copper air tubes that supply actuating air to the univalve rotary actuator.
6. Install the bulkhead and radiator cab top covers.

Screen 89:

Radiators:

The mechanically bonded radiators have been specially designed to maximize the transfer of heat from the cooling water to the ambient air. Heat transfer can occur by

natural convection or by forcing air across sections of the radiators. There are two radiators: one forms the left bank and the other forms the right bank. Each bank consists of a main section and a sub-cooler section. When the cooling system is in Mode 3 operation, the water in the radiators automatically drains back to the water storage tank by gravity.

Screen 90:

Cleaning Radiators:

Steam Jet Cleaner or Locomotive Wash Facility and Radiator Lifting Fixture TESCO 58901 (upgraded version used on the Dash 9/AC4400) are required to clean, remove, and install the radiators.

Warning: Before cleaning, removing, and installing radiators, shut down the diesel engine, depressurize the cooling water system, and ensure the radiators contain no water.

Warning: Comply with all Railroad safety procedures before proceeding to the top of the radiator cab. The radiator rock guards were not designed to be walked on by more than one person. Use the supplied walkway cover. Failure to do so could result in serious personal injury.

Screen 91:

Cleaning Radiators (Cont'd):

Typical steps to clean the radiators are as follows:

1. Standing on the walkway cover, clean any dirt accumulation or debris on the cores of the radiators by directing pressurized air from the top down.

Note: If the cores have grease deposits, use a steam jet to clean.

Caution: Ensure that the fins or tubes are not damaged from rough brushing or excessive jet pressure of either steam or air.

Warning: Always use extreme caution when working with compressed air or steam. Do not direct the flow of compressed air or steam at any human being. Discharge compressed air or steam only toward areas to be cleaned.

2. Clean the radiator inlet V-screens from the inside out and remove all visible debris using pressurized air.

Screen 92:

Cleaning Radiators (Cont'd):

3. Force out any remaining debris in the radiator cab.

4. If required, clean the radiators and the inlet screens by running the locomotive through a high-pressure washer with appropriate cleaning agents.
5. If rust has developed on the steel frame, clean and repaint as necessary.

Screen 93:

Radiator Bank Removal:

Typical steps to remove one of the radiator banks from the locomotive are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: Before removing the radiators, shut down the diesel engine, depressurize the cooling water system and ensure the radiators contain no water.

Warning: Comply with all Railroad safety procedures before proceeding to the top of the radiator cab. The radiator rock guards were not designed to be walked on by more than one person. Use the supplied walkway cover. Failure to do so could result in serious personal injury.

1. Ensure that the radiator assembly has been fully drained and is cool to the touch before attempting to remove the radiator bank.
2. Remove and save the hex-head bolts, washers, and lockwashers, and remove the walkway cover, then place the walkway cover in an area where it will not be damaged.
3. Remove and save the four hold-down hex-head bolts, washers, and plates from the center-vee mounting channel.
4. Remove and save the hex-head bolts, washers, and lockwashers, and remove the short-hood end covers, then place the end covers in an area where they will not be damaged.

Screen 94:

Radiator Bank Removal (Cont'd):

5. Remove the outboard Victaulic couplings and disconnect the outlet pipe from the radiator bank to be removed.

Note: For additional information on disassembly and removal of the Victaulic couplings, refer to the Victaulic Coupling Removal section of this module.

6. Disconnect the short-hood vent lines of the radiator bank to be removed.

Note: The air lines should be labeled before they are removed from the shutter cylinders so that they will not be reversed when re-installing the shutters.

7. Disconnect the air lines, two per shutter, attached to the shutter cylinders.

Note: All Evolution Series locomotives are not equipped with the radiator shutter assembly. Some, in place of the radiator shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

8. Remove and save the hex-head bolts, washers, and lockwashers, and remove the long-hood end covers, then place the end covers in an area where they will not be damaged.
9. Remove the two outboard Victaulic couplings to disconnect the inlet pipes from the radiator bank to be removed.

Note: For additional information on disassembly and removal of the Victaulic couplings, refer to the Victaulic Coupling Removal section of this module.

Screen 95:

Radiator Bank Removal (Cont'd):

10. While standing on the locomotive walkway, remove the radiator access plates from the underside of the wing.
11. Remove and save the eight hex-head bolts, washers, and plates that fasten the radiators to the radiator cab frame.

Warning: A radiator bank with shutter mounted to it weighs approximately 2355 lbs. (1070 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

12. Attach the lifting device to the two lifting lugs. Carefully remove the radiator bank from the radiator cab.

Screen 96:

Radiator Bank Installation:

Typical steps to install one of the radiator banks on the locomotive are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: A radiator bank with the shutter assembly mounted to it weighs approximately 2355 lbs. (1070 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

1. Attach the lifting device to the two lifting lugs, then carefully lift the radiator bank and place it into the radiator cab.
2. Install and align the Victaulic couplings and pipes in the inlet and discharge headers.

Note: For additional information on assembly and installation of the Victaulic couplings, refer to the Victaulic Coupling Installation section of this module.

3. Connect the short-hood vent lines.
4. Reconnect the air lines, two per shutter, attached to the shutter cylinders.

Note: All Evolution Series locomotives are not equipped with the radiator shutter assembly. Some, in place of the radiator shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

5. Using the four previously removed and saved hold-down hex-head bolts, washers, and plates, fasten the radiator bank to the center-vee mounting channel, then tighten the bolts to 110-120 lb.-ft. (150-162 Nm).

Screen 97:

Radiator Bank Installation (Cont'd):

6. From the outside of the radiator cab, install the previously removed and saved radiator hold-down hex-head bolts, washers, and plates, then tighten the bolts to 110-120 lb.-ft. (150-162 Nm).
7. Install the access plates on the radiator cab.
8. Using the previously removed and saved hex-head bolts, washers, and lockwashers, install the end covers to the radiator cab frame.
9. Using the previously removed and saved hex-head bolts, washers, and lockwashers, install and fasten the walkway covers.
10. Fill the cooling water system, if required as discussed in the Filling the Cooling Water System section of this module.

Screen 98:

Radiator Shutter Removal:

Typical steps to remove the radiator shutter are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components.

Open the BS to prevent starting attempts. Also, place the FPB, the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Remove and save the hex-head bolts, washers, and lockwashers, then remove the walkway cover.
2. Place the walkway cover in an area where it will not be damaged.

Note: The air lines should be labeled before they are removed from the shutter cylinders. This will ensure that they will not be reversed when re-installing the shutters.

3. Disconnect the air lines, two per shutter, attached to the shutter cylinders.
4. Remove and save all bolts, washers, and lockwashers that hold the shutter to the radiator.
5. Attach a proper lifting device to the attachment holes located on the end plates, then carefully remove the shutter.

Screen 99:

Radiator Shutter Installation:

Typical steps to install the radiator shutter are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB, the LCCB in the OFF position. Apply a warning tag to the EC switch.

1. Attach a proper lifting device to the attachment holes located on the end plates, then carefully lift the shutter and set it in place.
2. Install and fasten the shutter to the radiator using the previously removed and saved bolts, washers, and lockwashers.
3. Connect the air lines attached to the shutter cylinders following the labels applied at the time of removal.

Note: Check the radiator shutter air lines to ensure the proper tap blocks are installed. If the radiator tap blocks are missing, install the two shutter airline brackets, then install the radiator shutter air lines such that the air lines are at a downward angle. Refer to site specific maintenance instructions for specific details and part numbers.

4. Install and fasten the walkway cover using the previously removed and saved hex-head bolts, washers, and lockwashers.

Screen 102:**Radiator Fan:**

The radiator fan cools the engine cooling water flowing through the radiators by forcing air across the radiator sections. The radiator fan assembly consists of an AC motor and a fan blade assembly. The radiator fan motor is controlled by a solid-state regulator, which controls the fan speed (i.e., off, 1/4, 1/2, or full engine speed). The engine cooling water temperature, detected by the EWIT sensor, is the primary input used to control the radiator fan speed.

Screen 103:**Running Maintenance for Radiator Fan:**

A Radiator Fan Lifting Fixture is required to remove and install the radiator fan. The radiator fan bearings should be lubricated on a yearly basis. The upper bearing requires 4.5 oz. (128 g) of grease, and the lower bearing requires 1.3 oz. (37 g) of grease. Bearings should be lubricated with a grease meeting D6A2C10.

Screen 104:**Radiator Fan Removal:**

Typical steps to remove the radiator fan are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Remove and save the eight bolts that hold the large screen on the left side of the radiator cab.
2. Carefully, remove the large cab screen assembly and set it aside.
3. Disconnect the three lead wires from the terminal block located on the underside of the radiator fan motor.
4. Note carefully the identification of the lead on each terminal for subsequent reassembly, then install the hardware back on the terminal block studs.

Screen 105:**Radiator Fan Removal (Cont'd):**

Note: Both halves of the radiator fan shroud can be removed to facilitate the radiator fan removal, but it is only necessary to remove the half on the side from which the fan will be removed.

5. Remove and save the two bolts holding the two halves of the fiberglass radiator fan shroud together at the front and rear of the shroud.
6. Remove and save the eight bolts holding the shroud half and metal pan to the cover plate on the side from which the radiator fan and motor are to be removed.
7. Set the shroud half and metal pan aside.

Screen 106:

Radiator Fan Removal (Cont'd):

8. Remove and save the two long bolts holding the radiator fan and motor and the radiator fan support to the radiator cab structure.

Warning: The radiator fan weighs approximately 1,645 lbs. (746 kg). Ensure that the lifting device is adequate.

Caution: Use extreme care when removing the radiator fan assembly to prevent damaging the fan blades and the shroud.

9. With a forklift or a lifting fixture suspended from a crane, reach into the side of the radiator cab structure through the opening from where the screens and shroud were removed.
10. Insert the forks into the two hollow box sections across the bottom of the radiator fan motor.

Screen 107:

Radiator Fan Removal (Cont'd):

11. If using a crane and lifting fixture, switch the crane hook from the empty lifting location to the loaded lifting location.
12. Remove and save the two remaining mounting bolts.
13. Lift the radiator fan and motor and remove it from the side of the cab.
14. Set the fan and motor down on wooden blocks; ensure that enough clearance exists under the motor to protect the terminal block and the bottom bearing cap.

Screen 108:

Radiator Fan Installation:

Typical steps to install the radiator fan are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the BS to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Apply a warning tag to the EC switch.

Warning: The radiator fan weighs approximately 1,645 lbs. (746 kg). Ensure that the lifting device is adequate.

Caution: Use extreme care when removing the radiator fan assembly to prevent damaging the fan blades and the shroud.

1. Place the forks of a forklift or a lifting fixture suspended from a crane into the two hollow box sections across the bottom of the radiator fan motor.
2. Lift the fan and motor, and insert it through the opening from where the screens and shroud were removed in the side of the radiator cab structure.
3. Lower the motor onto the support, aligning the fan and support with the mounting bolt holes in the radiator cab structure.

Screen 109:

Radiator Fan Installation (Cont'd):

Note: If using a crane and lifting fixture, switch the crane hook from the loaded lifting location to the empty lifting location.

4. Carefully remove the forks from the radiator fan motor box sections, preventing the radiator fan and motor or radiator fan support from shifting position.
5. Install the previously removed and saved four long mounting bolts with a lockwasher under each head through the radiator fan motor box sections and the radiator fan support into the radiator cab structure.
6. Torque the four bolts to 440-490 lb.-ft. (597-665 Nm).

Screen 110:

Radiator Fan Installation (Cont'd):

7. Ensure that the fan tips have clearance around the shroud; if they do not, adjust as necessary.
8. Rotate the fan.

Note: The fan motor must rotate freely with no rubbing sounds.

9. Install the shroud half and metal pan on the side from which the radiator fan and motor was installed, and bolt it to the cover plate with the eight previously removed and saved bolts.
10. Install the two previously removed and saved bolts holding the two halves of the fiberglass radiator fan shroud together at the front and the rear of the shroud, then tighten all ten bolts.

Screen 111:

Radiator Fan Installation (Cont'd):

11. Connect the three lead wires on the terminal block located on the underside of the radiator fan motor, ensuring that each lead is on the correct terminal, then tighten the nuts on the terminal block studs.

Caution: When the power leads to the radiator fan motor or the Radiator Fan Motor Controller (RFC) have been disconnected at either end, it is very important to reconnect the leads correctly at re-installation. If any two power leads are swapped at either end, the fan may still operate, but it will rotate backwards. Running the radiator fan backwards greatly decreases the air flow. This reduced air flow can allow the diesel engine cooling water to become excessively hot, causing the locomotive to gradually derate until the engine goes to IDLE.

12. Install the large screen on the left side of the radiator cab.
13. Install and tighten the eight previously removed and saved bolts to hold the screen in place.

Screen 112:

Running Maintenance for the Automatic Water Drain Valve:

Note: The automatic water drain valve hex body and cartridge (actuating portion) can be inspected, tested, and replaced without disconnecting any pipe connections.

When replacing the automatic water drain valve cartridge and the associated hex nut, ensure that the color of the installed automatic water drain valve cartridge handle and hex nut stripe match the color code for the year. If the entire flanged valve body with the tee fitting is to be removed from the piping, the engine cooling water system must be drained. For more information on replacing the valve along with the tee fitting, refer to the Automatic Water Drain Valve Assembly Replacement section of this module. The table displays the color of the automatic water drain valve cartridge handle and the hex nut stripe for the years 2022-2036.

Screen 113:

Automatic Water Drain Valve Actuating Portion Removal and Testing:

Typical steps to remove and test the actuating portion of the automatic water drain valve are as follows:

Warning: To avoid personal injury from engine cooling water burns, do NOT attempt to service the automatic water drain valve when the water temperature is over 100 °F (37.7 °C). Perform maintenance only when the engine cooling water system is cooled down.

1. Carefully loosen and remove the hex body and cartridge from the pipe tee, using a 1-7/8-inch wrench.

Note: The internal check valve closes, keeping water from draining from the cooling water system; however, with the hex body and cartridge removed, it is normal for a small amount of water to continue to leak from the pipe tee.

Note: The hex nut and valve cartridge must be changed out together. Changing only the cartridge can result in debris accumulation in the hex nut and deterioration of the cartridge O-ring nose seal. This results in a leak path where water can freeze prohibiting the cartridge from dropping out when required.

2. With the hex body and cartridge removed, the functionality of the actuating portion may be tested, if desired, as follows:
 - a. Intermittently spray canned coolant (available from Therm-O-Tech, Part Number MS-242N) onto the brass sensor at the cartridge tip, keeping a layer of frost on the metal surface.

Note: The cartridge should release from the hex body in less than one minute; if not, replace the entire unit as discussed in the Automatic Water Drain Valve Assembly Replacement section of this module.

- b. Reinstall the cartridge in the hex body after reheating to above 40 °F (4.4 °C).

Screen 114:

Automatic Water Drain Valve Actuating Portion Installation:

Typical steps to install the actuating portion of the automatic water drain valve are as follows:

Caution: Failure to install the hex body and cartridge properly will cause insufficient opening of the internal check valve, resulting in little or no drainage from the valve.

1. Chase the internal threads of the pipe tee to remove any rust or debris.
2. Using an approved low strength thread sealant (Loctite® 567), screw the new hex body and cartridge into the leg of the pipe tee.
3. Tighten the hex body into the pipe tee to a torque value of 80 lb.-ft. (108 Nm).

Screen 115:

Automatic Water Drain Valve Assembly Replacement:

Typical steps to replace the automatic water drain valve assembly are as follows:

1. Drain the locomotive cooling water system.
2. Remove the two screws, lockwashers, and nuts from each connecting flange and remove the entire automatic water drain valve body from the piping.
3. Discard the O-ring seals and replace with new O-rings.

Note: When reassembling, apply a small amount of grease (Dow Corning 55M or equivalent) to the O-ring seals.

4. Install the replacement water drain valve assembly to the connecting flanges by securing with screws, lockwashers, and nuts.

Screen 116:

Victaulic Couplings:

Pipes between the major components of the cooling water system are joined together by Victaulic couplings. Victaulic couplings reduce pipe stress by absorbing vibration and allowing for minor pipe-to-pipe misalignment. Victaulic couplings also make it easier for maintenance personnel to remove and install components in the system. The Victaulic coupling consists of two outer steel coupling halves, which are held together by bolts and gaskets. The gasket material is selected to withstand the effects of the liquids passing through the piping. The pipes that the Victaulic couplings connect to are machined to accept the lip of the Victaulic coupling. No running maintenance is required on the piping system. However, any time a component of the system is removed, Victaulic couplings must be disassembled.

Note: Victaulic couplings must be properly installed to ensure reliability.

Screen 117:

Victaulic Coupling Removal:

Typical steps to remove a Victaulic coupling on the cooling water system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

Note: When replacing a leaking or defective Victaulic coupling, depending on the location of the leaking or defective coupling, it may be necessary to drain the cooling water system to ensure water is removed from the section of piping containing the leaking or defective coupling.

1. If required, drain the cooling water system as discussed in the Draining the Cooling Water System and Taking Cooling Water Samples section of this module.

2. After the water from the cooling water system is drained or the pipe from which the Victaulic coupling is to be removed is empty, remove the bolts and nuts that hold the coupling halves together and remove the coupling.
3. While supporting the pipe with one hand, slide the gaskets (one on each end of the pipe) onto the removable pipe.

Note: After the gaskets and the body of the coupling have cleared the fixed pipe, the pipe can be removed to allow gasket removal.

4. Remove the gaskets from the pipe.
5. Protect the pipe ends after disassembly.

Screen 118:

Victaulic Coupling Installation:

Typical steps to install a Victaulic coupling on the cooling water system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Note: Couplings used in the cooling water system have a seal made of EPDM rubber. EPDM rubber is indicated by a green mark on the inside of the gasket. Couplings used in the lubricating oil system are indicated by a blue mark on the inside of the gasket. Couplings used in the compressed air system are completely red and made from silicon gasket.

1. Inspect the gaskets for cuts, holes, or embedded foreign material.
2. Inspect the sealing surfaces of the pipe.

Note: Rough or non-machined surfaces do not indicate a defective pipe. However, there must not be scratches or gouges that cross more than 50% of the sealing surface. If scratches or gouges are present, use sandpaper or a fine file to dress the pipe surfaces. If defects cannot be removed without excessive sanding, the pipe should be replaced.

3. Inspect the cleanliness of the pipe and ensure it is clean and free of debris.

Note: Coupling seals used in both oil and water systems should be thoroughly lubricated. This prevents tearing or cutting the gasket when it is assembled.

4. Slide both gaskets onto the fixed end of the pipe ensuring that each gasket is flush with the end.

Screen 119:

Victaulic Coupling Installation (Cont'd):

5. Insert the pipe with one person holding the pipe in position while another person carefully slides the gasket into place.

Note: To ensure that the gasket is properly located on the pipe, both corners of the gasket's sealing surface must be exposed.

Note: There should be approximately a 0.125-inch (3.18 mm) gap between the pipe ends to allow for expansion. The gap between the piping lengths can be adjusted by loosening the four 0.5-inch (12.7 mm) bolts at the flange at one end of the pipe, moving the pipe into the desired location, then retightening the bolts to seal the pipe.

6. Install the coupling halves, then install the bolts and nuts ensuring that the oval under each bolt head is mated into the recessed oval in the coupling half.
7. Tighten the nuts until there is a metal-to-metal contact between the coupling halves.
8. Check the system for leaks.
9. Torque the Victaulic coupling bolts to 70-80 lb.-ft. (95-108 Nm).
10. Ensure that the Victaulic couplings are pointed out, mounted horizontally with respect to the split line of the coupling.

Note: Some dripping of lubricant from pipe joints may occur as the engine and piping warms up. This should not cause a concern unless you see evidence of joint leakage.

Screen 120:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the major components of the split cooling water system.
 - The split cooling water system maintains a nearly constant engine operating temperature throughout the load range of the engine, even with wide variations in outside temperature and throttle call.
 - The split cooling water system provides additional cooling for the water-based intercooler and oil cooler at higher load conditions. The additional cooling of the water-based intercooler helps reduce the intake manifold air temperature into the engine cylinders, which in turn decreases the amount of harmful emissions from the exhaust stack and fuel consumption. The added cooling of the oil cooler in higher load conditions helps improve the life of the engine's bearings.

- The major components of the split cooling water system are the water storage tank, water pump, lubricating oil cooler, water-based intercooler, univalve, univalve control magnet valves, radiator, radiator fan, fuel manifold, and automatic and manual water drain valves.
- The split cooling water system also includes several sensors: Engine Water In Temperature, Engine Water Out Temperature, Engine Water In Pressure, Manifold Air Temperature, Ambient True Temperature, Barometric Air Pressure, and Engine Lube In Temperature.

Screen 121:

Summary (Cont'd):

- Describe how water flows through the split cooling water system.
 - The split cooling water system operates within established conditions referred to as Modes.
 - During Mode 3 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. The combustion process in the engine heats the water. The heated water exits the engine and flows to the univalve. The univalve directs the heated water from the engine through two paths. The first path is through the oil cooler and the water-based intercooler, and then back to the storage tank, and the second path is directly to the water storage tank. The water through the oil cooler and the water-based intercooler heats the lube oil and intake manifold air, respectively.
 - During Mode 2 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. From the engine, the heated water flows to the univalve. The univalve directs the heated water from the engine through two paths. The first path is through the oil cooler and the water-based intercooler, and then back to the water storage tank. This path either warms or cools the lubricating oil and intake manifold air. The second path is through the radiator and its sub-coolers, and then back to the water storage tank. A motor-driven radiator fan pushes air through the radiator to cool the engine water. Varying the fan motor speed from off to 1/4, 1/2, or full engine speed controls the actual amount of cooling that occurs.
 - During Mode 1 operation, the engine water pump draws water from the water storage tank and forces it through the turbocharger and engine. From the engine, the water flows to the univalve. The univalve directs water from the engine to the radiator. The radiator has two sections: main and sub-cooler. The majority of the water flows through the "one-pass" main section back to the water storage tank. The remaining water continues through the "two-pass" sub-cooler section for further cooling. Water from the sub-cooler section is then channeled by the univalve to flow through the oil cooler and the water-based intercooler to provide additional cooling. A motor-driven radiator fan pushes air through the radiator to cool the engine

water. Varying the fan motor speed from off to 1/4, 1/2, or full engine speed controls the amount of cooling.

Screen 122:

Summary (Cont'd):

- Describe the protection strategies used with the split cooling water system.
 - Low Water Pressure Protection: The Engine Management System (EMS) software uses water pressure information (as read by the EWIP sensor) to prevent damage to the engine caused by a low water pressure condition.
 - Low Water Pressure Thresholds: This strategy prevents damage to the engine when the water pressure drops below the specified threshold value for each engine notch speed.
 - Cold Engine Protection: When the engine is cold, engine speed is limited as a function of lubricating oil outlet temperature (as read by the ELOT sensor). This prevents damage to the engine, lube oil pump, and external oil piping.
 - Hot Water Protection: When the engine inlet water (as read by the EWIT sensor) is hot, the available horsepower from the engine is reduced to protect the engine from damage. At the same time, the engine speed increases to 1050 RPM to provide the highest radiator fan speed and maximum cooling.
 - Cannot Cool Protection: If the radiator fan is unable to run, the engine is limited to Notch 2, thereby protecting the engine from overheating.
 - Engine Water Inlet Temperature and Engine Lube Oil Outlet Temperature ΔT Protection: The engine horsepower derates or shuts down if the delta temperature (ΔT) between the engine water inlet (as read by the EWIT sensor) and the engine lube oil outlet (as read by the ELOT sensor) exceeds an allowable limit.
 - Loss of Both Engine Water Temperature Sensors Protection: If both engine oil temperature sensors (ELIT and ELOT) are bad, the engine shuts down.
- Describe the running maintenance required for the split cooling water system.
 - Split Cooling Water System: Visually inspect the engine, water pump, oil cooler, water-based intercooler, fuel manifold, univalve, radiators, and all system piping for water leaks and correct as needed.
 - Cooling Water: Check the cooling water level after the engine has been idling for at least ten minutes with the green LED on.
 - Radiators: Clean as necessary. Run the radiator fan backwards to clean debris from screens every 184 days.
 - Univalve: Inspect for any water leakage. Run Self-Test 320 and observe that the univalve switches correctly for each mode of operation every 184 days.
 - Water-Based Intercooler: Every 184 days, inspect for any water (or oil) leakage at the weep holes at each end of the intercooler and check the two weep holes in the engine IFE cover.

- Radiator Fan: Lubricate the bearings every year. Clean radiator fan blades and closely inspect the blades for cracks every two years. If any cracks are found, replace the radiator fan.
- Victaulic Coupling: No routine running maintenance on the piping system is required.

Screen 123:

Summary (Cont'd):

- Summarize the steps to remove and install the major components of the split cooling water system.
 - Water Pump Removal and Installation
 - For instructions on water pump removal and installation, refer to the Water Pump Removal and Installation module of the Diesel Engine Advanced course.
 - Lubricating Oil Cooler Removal and Installation
 - For instructions on lubricating oil cooler removal and installation, refer to the Lubricating Oil System module of the Mechanical Systems Advanced course.
 - Fabricated WBIC Removal
 1. Shut down the diesel engine.
 2. Depressurize the cooling water system.
 3. Ensure the radiators contain no water.
 4. Drain the water from the cooling water system below the level of the water-based intercooler.
 5. From the A-side (right side) of the locomotive:
 - a. Open, but do not remove, the access door.
 - b. Remove the drain line and fitting from the drain pipe.
 - c. Remove the two 5/8 inch hex bolts and washers near the top of the cover.
 - d. Remove the 20, 3/8 inch hex bolts holding the A-side (right side) cover.
 - e. Remove the four 3/8 inch hex bolts and seal plate surrounding the drain fitting and save all hardware for re-use.
 6. From the B-side (left side) of the locomotive:
 - a. Remove the maintenance access panel from underneath the wing of the radiator cab, then set the panel aside and save all hardware for re-use.
 - b. Disassemble and remove the Victaulic couplings securing the piping to the water-based intercooler.
 - c. Disconnect the vent fitting.
 - d. Loosen and remove the hex bolts and washers that secure the core access plate to the intercooler shell, then set aside the plate and all related hardware for re-use.
 - e. Using an appropriate tool (Grainger Part 5MK13), remove all Allen bolts from the front end of the intercooler shell.

7. Install the puller tool (PSB P5205) onto the B-side of the locomotive for removing the intercooler core, as follows:
 - a. Install the support plate to the locomotive carbody.
 - b. Set the support stand on the handrail allowing it to sit on the catwalk.
 - c. Install the cradle support legs using ball lock pins.
 - d. Install the cradle support using ball lock pins, then adjust the support so it is level with the bottom of the intercooler core.
 - e. Install the puller tool puller bar onto the end of the intercooler core.
8. Using a ½-inch air ratchet with a ¾ inch socket, turn the worm gear and remove the core attached to the puller tool puller bar.
9. After the core has fully cleared the wing of the radiator cab and is stationary on the cradle support, install the four, 1/2 inch lifting eye bolts.
10. Lift the core off the cradle.
11. Place the core on a stable work surface.

Screen 124:

Summary (Cont'd):

- Fabricated Water-Based Intercooler Seal Inspection and Replacement
 1. Ensure that the fabricated WBIC core is being installed by confirming the water inlet and outlet pipe outside diameter measurements are 3.5 inches (88.9 mm) and the B-side rectangular cover casing door is attached with hex bolts.
 2. If required, install the puller tool (PSB P5205) onto the B-side of the locomotive for installing the intercooler core.
 3. Install the four ½-inch lifting eye bolts on the intercooler core.
 4. Using a suitable lifting device, slowly lift the core and place it on the puller tool cradle, ensuring the core does not impact the side of the radiator cab while lifting.
 5. Using the attached puller tool puller bar and a 1/2-inch air ratchet with ¾-inch socket, turn the worm gear and install the intercooler core in position in the radiator cab.
 6. After the intercooler core has been placed in the radiator cab, install the rectangular cover using the 20, 3/8-inch hex bolts, then torque the bolts to 22-24 lb.-ft. (30-33 Nm).
 7. Install the seal plate around the drain fitting using the four 3/8-inch hex bolts, then torque the bolts to 22-24 lb.-ft. (30-33 Nm).
 8. Install the two bolts and washers near the top of the cover, then torque the bolts to 110-120 lb.-ft. (149-163 Nm).
 9. Attach the drain hose and fitting, and close the access door.
 10. Remove and disassemble the puller tool (PSB P5205) from the B-side of the locomotive.
 11. Install the B-side access plate cover with a new air side O-ring.
 12. Torque the 10, 1/2-inch hex bolts to 55-62 lb.-ft. (75-84 Nm).

13. Using new gaskets, re-install the Victaulic couplings that secure the piping to the intercooler on the B-side.
14. Reconnect the vent fitting.
15. Refill the cooling water system and visually inspect the intercooler and associated piping for signs of leakage or damage.
16. Re-install the maintenance access panel underneath the wing of the radiator cab.
- Cast Water-Based Intercooler Core Removal
 1. Shut down the diesel engine.
 2. De-pressurize the cooling water system by holding the water fill assembly vent valve open for approximately one minute.
 3. Remove the maintenance access panel underneath the wing of the radiator cab, then set the panel aside and retain the hardware.
 4. Drain the water from the cooling system, below the level of the cast WBIC.
 5. From the A-side (right side) of the locomotive:
 - a. Open, but do not remove, the access door.
 - b. Remove the drain line and the fitting from the drain pipe.
 - c. Remove the 28, 3/8-inch hex bolts from the outer end fastening plate that secures the intercooler core and attached end cover to the shell, and save all hardware for re-use.
 - d. Remove the outer end fastening plate and discard the O-ring.
 6. From the B-side (left side) of the locomotive:
 - a. Disassemble and remove the couplings securing the piping to the cast WBIC.
 - b. Disconnect the vent fitting and discard the gaskets.
 - c. Loosen and remove the 16 Allen bolts that secure the core access plate with end tank to the outer end fastening plate.
 - d. Set the core access plate with end tank aside and save all hardware for re-use.
 - e. Discard the O-ring.
 - f. Loosen and remove the 16, 1/2-inch hex bolts and washers that secure the outer end fastening plate to the intercooler shell.
 - g. Remove the outer end fastening plate and save all hardware for re-use.
 7. Install the cast WBIC core removal tool (TESCO T85373) onto the B-side (left side) of the locomotive and install the lifting eye bolt on the header plate.
 8. Install a lifting eye bolt on the B-side outer end fastening plate.
 9. Attach a sling to the B-side eye bolt to pull the core out from the radiator cab and onto the cast WBIC core removal tool (TESCO T85373).
 10. After the core has fully cleared the wing of the radiator cab and is stationary on the cast WBIC core removal tool (TESCO T85373), install the other lifting eye bolt on the A-side outer end fastening plate or the intercooler core end cover, if still installed.

11. Attach lifting slings to the two eye bolts, then lift the core and place it on a stable (level) work surface.

Screen 125:

Summary (Cont'd):

- Cast Water-Based Intercooler Core Installation
 1. If required, install the cast WBIC core removal tool (TESCO T85373) onto the B-side (left side) of the locomotive.
 2. Install a lifting eye bolt to the new intercooler core on the A-side outer end fastening plate or the intercooler core end cover, if installed, and another lifting eye bolt on the B-side outer end fastening plate.
 3. Attach slings to the lifting eye bolts and carefully lift the core from the stable work surface.
 4. Place the intercooler core on the cast WBIC core removal tool (TESCO T85373), then remove the slings and lifting eye bolts from the sides of the core.
 5. Using the cast WBIC core removal tool (TESCO T85373), install the intercooler core into the radiator cab, sliding the core through the wing and into the intercooler shell.
 6. After the core is properly positioned in the intercooler shell, perform the following on the B-side (left side) of the locomotive:
 - a. Remove the cast WBIC core removal tool (TESCO T85373).
 - b. Install the outer end fastening plate with the 16, 1/2-inch hex bolts and washers, then torque to 55-62 lb.-ft. (75-84 Nm).
 - c. Re-install the core access plate with end tank to the outer end fastening plate with a new O-ring and the 16 Allen bolts, then torque to 31-33 lb.-ft. (42-45 Nm).
 - d. Re-install the vent fitting with a new gasket.
 - e. Re-install the couplings to secure the piping to the intercooler on the B-side (left side).
 7. To the A-side (right side) of the locomotive:
 - a. Re-install the outer end fastening plate and, if required, the intercooler core end cover using new O-rings as applicable.
 - b. If required, secure the intercooler core end cover with the 16 Allen bolts, then torque to 31-33 lb.-ft. (42-45 Nm).
 - c. Secure the outer end fastening plate to the shell using the 28, 3/8-inch hex bolts, then torque to 29.5 lb.-ft. (40 Nm).
 - d. Re-attach the drain hose and fitting to the drain pipe.
 - e. Close the access door.
 8. Refill the water to the cooling system.
 9. Visually inspect the intercooler and the associated piping for signs of leakage or damage.
 10. Re-install the maintenance access panel underneath the radiator cab wing.

- Cast Water-Based Intercooler Core Seals and O-Rings Inspection
 - Inspect the intercooler core for signs of damage, including the core, water seals, and O-rings. If found, replace the applicable components, as necessary, in accordance with site specific locomotive maintenance instructions. If the water seals are damaged, corrosion will be found on the outside of the core. Clean the corrosion from the sides of the core using pressurized water.

Screen 126:

Summary (Cont'd):

- Univalve Assembly Removal
 1. Shut down the diesel engine.
 2. Depressurize the cooling water system.
 3. Ensure the radiators contain no water.
 4. Remove the bulkhead and radiator cab top covers to allow access to the univalve.
 5. Disconnect the three air supply tubes from the univalve rotary actuator.
 6. Remove the Victaulic couplings connected to the univalve.
 7. Remove and save the four bolts, washers, and lockwashers that secure the univalve mounting clamps.
 8. Remove and save the two univalve mounting clamps and cushion inserts.
 9. Remove the univalve assembly with an appropriate lifting device.
- Univalve Assembly Installation
 1. Use an appropriate lifting device and place the univalve assembly in position on the radiator cab.
 2. Install the two univalve mounting clamps and cushion inserts.
 3. Install the four bolts, washers, and lockwashers that were removed during removal to secure the univalve mounting clamps.
 4. Install the Victaulic couplings that connect the various water flowpaths to the univalve and torque the bolts to 70-80 lb.-ft. (95-108 Nm).
 5. Connect the three copper air tubes that supply actuating air to the univalve rotary actuator.
 6. Install the bulkhead and radiator cab top covers.
- Radiator Bank Removal
 1. Ensure that the radiator assembly has been fully drained and is cool to the touch before attempting to remove the radiator bank.
 2. Remove and save the hex-head bolts, washers, and lockwashers, and remove the walkway cover, then place walkway cover in an area where it will not be damaged.
 3. Remove and save the four hold-down hex-head bolts, washers, and plates from the center-vee mounting channel.
 4. Remove and save the hex-head bolts, washers, and lockwashers, and remove the short-hood end covers, then place the end covers in an area where they will not be damaged.

5. Remove the outboard Victaulic couplings and disconnect the outlet pipe from the radiator bank to be removed.
 6. Disconnect the short-hood vent lines of the radiator bank to be removed.
 7. Disconnect the air lines, two per shutter, attached to the shutter cylinders.
 8. Remove and save the hex-head bolts, washers, and lockwashers, and remove the long-hood end covers, then place the end covers in an area where they will not be damaged.
 9. Remove the two outboard Victaulic couplings to disconnect the inlet pipes from the radiator bank to be removed.
 10. While standing on the locomotive walkway, remove the radiator access plates from the underside of the wing.
 11. Remove and save the eight hex-head bolts, washers, and plates that fasten the radiators to the radiator cab frame.
 12. Attach the lifting device to the two lifting lugs, then carefully remove the radiator bank from the radiator cab.
- Radiator Bank Installation
 1. Attach the lifting device to the two lifting lugs, then carefully lift the radiator bank and place it into the radiator cab.
 2. Install and align the Victaulic couplings and pipes in the inlet and discharge headers. Refer to the Victaulic couplings section for more information.
 3. Connect the short-hood vent lines.
 4. Reconnect the air lines, two per shutter, attached to the shutter cylinders.
 5. Using the four hold-down hex-head bolts, washers, and plates, fasten the radiator bank to the center-vee mounting channel, then tighten the bolts to 110-120 lb.-ft. (150-162 Nm).
 6. From the outside of the radiator cab, install the radiator hold-down hex-head bolts, washers, and plates, then tighten the bolts to 110-120 lb.-ft. (150-162 Nm).
 7. Install the access plates on the radiator cab.
 8. Using the hex-head bolts, washers, and lockwashers, install the end covers to the radiator cab frame.
 9. Using the hex-head bolts, washers, and lockwashers, install and fasten the walkway covers.
 10. Fill the cooling water system.
 - Radiator Shutter Removal
 1. Remove and save the hex-head bolts, washers, and lockwashers, then remove the walkway cover.
 2. Place the walkway cover in an area where it will not be damaged.
 3. Disconnect the air lines, two per shutter, attached to the shutter cylinders.

4. Remove and save all bolts, washers, and lockwashers that hold the shutter to the radiator.
5. Attach a proper lifting device to the attachment holes located on the end plates, then carefully remove the shutter.
- Radiator Shutter Installation
 1. Attach a proper lifting device to the attachment holes located on the end plates, then carefully, lift the shutter and set it in place.
 2. Install and fasten the shutter to the radiator using the bolts, washers, and lockwashers.
 3. Connect the air lines attached to the shutter cylinders following the labels applied at the time of removal.
 4. Install and fasten the walkway cover using the hex-head bolts, washers, and lockwashers.

Screen 127:

Summary (Cont'd):

- Radiator Fan Removal
 1. Remove and save the eight bolts that hold the large screen on the left side of the radiator cab.
 2. Carefully, remove the large cab screen assembly and set it aside.
 3. Disconnect the three lead wires from the terminal block located on the underside of the radiator fan motor.
 4. Note carefully the identification of the lead on each terminal for subsequent reassembly, then install the hardware back on the terminal block studs.
 5. Remove and save the two bolts holding the two halves of the fiberglass radiator fan shroud together at the front and rear of the shroud.
 6. Remove and save the eight bolts holding the shroud half and metal pan to the cover plate on the side from which the radiator fan and motor are to be removed.
 7. Set the shroud half and metal pan aside.
 8. Remove and save the two long bolts holding the radiator fan and motor and the radiator fan support to the radiator cab structure.
 9. With a forklift or a lifting fixture suspended from a crane, reach into the side of the radiator cab structure through the opening from where the screens and shroud were removed.
 10. Insert the forks into the two hollow box sections across the bottom of the radiator fan motor.
 11. If using a crane and lifting fixture, switch the crane hook from the empty lifting location to the loaded lifting location.
 12. Remove and save the two remaining mounting bolts.
 13. Lift the radiator fan and motor and remove it from the side of the cab.

14. Set the fan and motor down on wooden blocks; ensure that enough clearance exists under the motor to protect the terminal block and the bottom bearing cap.
- Radiator Fan Installation
 1. Place the forks of a forklift or a lifting fixture suspended from a crane into the two hollow box sections across the bottom of the radiator fan motor.
 2. Lift the fan and motor, and insert it through the opening from where the screens and shroud were removed in the side of the radiator cab structure.
 3. Lower the motor onto the support, aligning the fan and support with the mounting bolt holes in the radiator cab structure.
 4. Carefully remove the forks from the radiator fan motor box sections, preventing the radiator fan and motor or radiator fan support from shifting position.
 5. Install the four long mounting bolts with a lockwasher under each head through the radiator fan motor box sections and the radiator fan support into the radiator cab structure.
 6. Torque the four bolts to 440-490 lb.-ft. (597-665 Nm).
 7. Ensure that the fan tips have clearance around the shroud; if they do not, adjust as necessary.
 8. Rotate the fan. The fan motor must rotate freely with no rubbing sounds.
 9. Install the shroud half and metal pan on the side from which the radiator fan and motor was installed, and bolt it to the cover plate with the eight bolts.
 10. Install the two bolts holding the two halves of the fiberglass radiator fan shroud together at the front and the rear of the shroud, then tighten all ten bolts.
 11. Connect the three lead wires on the terminal block located on the underside of the radiator fan motor, ensuring that each lead is on the correct terminal, then tighten the nuts on the terminal block studs.
 12. Install the large screen on the left side of the radiator cab.
 13. Install and tighten the eight bolts to hold the screen in place.

Screen 128:

Summary (Cont'd):

- Running Maintenance for the Automatic Water Drain Valve Actuating Portion
 - When replacing the automatic water drain valve cartridge and the associated hex nut, ensure that the color of the installed automatic water drain valve cartridge handle and hex nut stripe match the color code for the year. If the entire flanged valve body with the tee fitting is to be

removed from the piping, the engine cooling water system must be drained.

- Automatic Water Drain Valve Actuating Portion Removal and Testing
 1. Carefully loosen and remove the hex body and cartridge from the pipe tee, using a 1-7/8-inch wrench.
 2. With the hex body and cartridge removed, the functionality of the actuating portion may be tested, if desired, as follows:
 - a. Intermittently spray canned coolant (available from Therm-O-Tech, Part Number MS-242N) onto the brass sensor at the cartridge tip, keeping a layer of frost on the metal surface.
 - b. Reinstall the cartridge in the hex body after reheating to above 40 °F (4.4 °C).
- Automatic Water Drain Valve Installation
 1. Chase the internal threads of the pipe tee to remove any rust or debris.
 2. Using an approved low strength thread sealant (Loctite® 567), screw the new hex body and cartridge into the leg of the pipe tee.
 3. Tighten the hex body into the pipe tee to a torque value of 80 lb.-ft. (108 Nm).
- Automatic Water Drain Valve Assembly Replacement
 1. Drain the locomotive cooling water system.
 2. Remove the two screws, lockwashers, and nuts from each connecting flange and remove the entire automatic water drain valve body from the piping.
 3. Discard the O-ring seals and replace with new O-rings.
 4. Install the replacement water drain valve assembly to the connecting flanges by securing with screws, lockwashers, and nuts.
- Victaulic Coupling Removal
 1. Drain the cooling water system.
 2. Remove the bolts and nuts that hold the coupling halves together and remove the coupling.
 3. Slide the gaskets onto the removable pipe, then remove the pipe to allow gasket removal.
 4. Remove the gaskets from the pipe.
 5. Protect the pipe ends after disassembly.
- Victaulic Coupling Installation
 1. Inspect the gaskets.
 2. Inspect the sealing surfaces of the pipe.
 3. Inspect the cleanliness of the pipe and ensure it is clean and free of debris.
 4. Slide both gaskets onto the fixed end of the pipe ensuring that each gasket is flush with the end.
 5. Insert the pipe with one person holding the pipe in position while another person carefully slides the gasket into place.

6. Install the coupling halves, then install the bolts and nuts ensuring that the oval under each bolt head is mated into the recessed oval in the coupling half.
7. Tighten the nuts until there is a metal-to-metal contact between the coupling halves.
8. Check the system for leaks.
9. Torque the Victaulic coupling bolts to 70-80 lb.-ft. (95-108 Nm).
10. Ensure that the Victaulic couplings are pointed out, mounted horizontally with respect to the split line of the coupling.

Fuel System

Screen 1:

Welcome Screen:

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

Screen 2:

Introduction to Fuel System:

In this module, you will learn how to inspect and maintain the components of the fuel system in a running repair environment.

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

- State the purpose and location of the major components of the fuel system.
- Describe how diesel flows through the fuel system.
- Describe the abnormal operating condition detection strategies used in the fuel system.
- Describe how to check and adjust the fuel supply pressure.
- Describe how to remove and install the fuel filter elements.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspecting and maintaining the components of the fuel system, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Components of the Fuel System:

The fuel system in an ES44AC/DC locomotive serves two purposes. The primary purpose is to provide fuel to the engine for combustion, and the secondary purpose is to lubricate and cool the high-pressure fuel equipment. A few major components that comprise the fuel system are the fuel tank, fuel transfer pump, fuel manifold.

Screen 5:

Fuel Tank:

Located on the underside of the locomotive platform between the trucks, the fuel tank holds the fuel supply for the diesel engine.

Screen 6:

Fuel Transfer Pump:

Located in the radiator cab on the Engineer's side, the fuel transfer pump circulates a near-constant supply of fuel through the fuel system.

Screen 7:**Fuel Manifold:**

Mounted on the end of the fuel filter assembly, the fuel manifold contains a heater and a thermostatic valve to heat cold diesel fuel. Diesel fuel tends to gel when cold, and the fuel manifold helps to prevent the filters from clogging caused by this condition.

Screen 8:**Components of the Fuel System (Cont'd):**

The other major components of the fuel system are fuel filter assembly, high-pressure fuel equipment, regulating valve.

Screen 9:**Fuel Filter Assembly:**

Located in the radiator cab adjacent and below the combustion air filter compartment, the fuel filter assembly removes contaminants larger than 5 microns from the fuel. This protects the engine's high-pressure fuel equipment.

Screen 10:**High-Pressure Fuel Equipment:**

Located on each power assembly on the engine, the high-pressure equipment includes high-pressure pumps, high-pressure lines, and injectors. This equipment takes the low-pressure fuel from the fuel tank, increases the pressure, and supplies it to the power assemblies as governed by the Engine Control Unit (ECU).

Screen 11:**Regulating Valve:**

Mounted on the left side of the engine below the L1 power assembly, the regulating valve provides backpressure in the fuel lines for the high-pressure fuel pumps. This ensures sufficient filling of the high-pressure pumps and helps prevent cavitation in the pumps.

Screen 12:**Sensors of the Fuel System:**

The fuel system consists of two sensors.

Screen 13:**Engine Fuel Temperature Sensor (EFT):**

Located in the fuel line that crosses over the Integrated Front End (IFE) cover of the engine, the EFT sensor measures the temperature of the fuel supplied to the engine and provides the temperature information to the ECU.

Screen 14:**Engine Fuel Pressure Sensor (EFP):**

Located in the fuel line connected to the regulating valve, the EFP sensor measures the pressure of the fuel supplied to the engine and provides the pressure information to the ECU.

Screen 15:**Fuel Flow Path through the Fuel System:**

So, how does fuel flow through the fuel system of an ES44AC/DC locomotive? The fuel system can be divided into four functional sections: suction, low-pressure supply, high-pressure supply, and return/regulating section. First, an electrically driven fuel transfer pump draws the fuel from the fuel tank in the suction section. The fuel pump is turned on prior to the engine running to prime, or pressurize, the fuel system. All of the fuel system is normally pressurized except for the suction side of the fuel transfer pump. If there is a leak on the suction side of the piping, the result would be air entering the fuel supply, which could be indicated by a loss of suction pressure. The location of the leak would be in the suction or supply side piping that runs between the fuel tank connection, which is located on the Engineer's side of the locomotive, and the fuel transfer pump inlet connection. A leak anywhere else in the system would be indicated by the presence of leaking fuel.

Screen 16:**Fuel Flow Path through the Fuel System (Cont'd):**

Under normal operating conditions, the fuel transfer pump provides an output flow rate of 12.75 GPM at Low Idle engine speed.

Note: The fuel transfer pump contains an internal pressure relief valve, which protects the pump if the output pressure exceeds 130 psi.

For example, if the fuel filter elements become dirty or clogged, the pressure at the pump outlet rises. When the pressure exceeds 130 psi, the relief valve opens and diverts approximately 4.75 to 8.75 GPM of fuel back to the tank. From the fuel transfer pump outlet, the low-pressure fuel is sent to the fuel manifold. The manifold contains a fuel heater and a thermostatic mixing valve. The fuel first flows through the fuel heater, which uses water from the split cooling water system to heat the fuel. This is necessary because the cold diesel fuel tends to wax and become thick and slushy. The thermostatic mixing valve regulates the outlet fuel temperature. The thermostatic valve is normally open, and the fuel flows from the fuel heater through the valve until the main flow temperature reaches 75°F. At this point, the valve starts to close, causing cold fuel from the fuel tank to mix with the warmer fuel from the fuel heater. When the fuel temperature reaches 85°F to 87°F, the valve closes fully, and the fuel flow bypasses the fuel heater. From the fuel manifold, the fuel flows to the fuel filter assembly. The fuel filter assembly consists of two tanks, or canisters, and each tank contains a three-piece filter element. The filter elements remove contaminants larger than 5 microns from the

fuel. From the fuel filter assembly, the fuel flows to each of the 12 high-pressure pumps on the engine by means of a circular low-pressure supply header. The supply header ensures that the fuel is equally distributed to each high-pressure pump.

Screen 17:

Fuel Flow Path through the Fuel System (Cont'd):

The high-pressure (HP) pumps are piston-type pumps that are driven from the camshaft at each power assembly. These pumps take fuel from the low-pressure supply header, pressurize it up to 23,000 psi, and send it to the injectors through the high-pressure fuel lines. The ECU governs the timing and amount of fuel delivered by each HP pump by opening and closing a solenoid located on the pump. When an HP pump is not pressurizing the fuel for the injection process, the solenoid on the HP pump is open. This allows the fuel from the low-pressure supply header to pass through the HP pump to the low-pressure return header. The return header runs parallel and under the low-pressure supply header to a regulating valve. The regulating valve is normally set to 90 psi with the engine at low idle. It provides backpressure in the low-pressure fuel lines to the HP pumps. A certain amount of pressure or restriction ensures sufficient filling of the HP pumps and helps prevent cavitation or loss of suction in the HP pumps. Fuel from the regulating valve drains back to the fuel tank. In addition, two gravity drain headers are located on each side of the engine. A small amount of fuel flows through each HP pump to lubricate and cool its internal parts. This fuel then drains through the drain header back to the fuel tank.

Screen 18:

Detection Strategies:

Unlike protection strategies used with the split cooling water system and the lubricating oil system, abnormal operating condition detection strategies for the fuel system do not protect the diesel engine from damage. Instead, they detect an abnormal condition and report the incident. No restriction is placed on the locomotive or the diesel engine.

Screen 19:

Low Fuel Supply Temperature Detection:

If the fuel supply temperature measured by the EFT sensor is below 60°F for 30 seconds, and the engine water inlet temperature measured by the EWIT sensor has been above 140°F for 60 minutes, an Engine Fuel Temperature Low Incident is logged. This incident clears if the fuel temperature is above 65°F for 30 seconds.

Screen 20:

Low Fuel Supply Pressure Detection:

If the fuel supply pressure measured by the EFP sensor is below 30 psi for 30 seconds with the engine running, an Engine Fuel Pressure Low Incident is logged. This incident clears if the fuel pressure is above 50 psig for 30 seconds with the engine running.

Screen 21:**Operational Details:**

Let's now look at the operational data for the fuel system.

Screen 22:**System Capacities:**

The fuel tank can hold 5300 gallons of fuel. Of this, 4826 gallons is considered usable capacity. 90 to 95 gallons is sectioned off for waste fluid retention, and the remaining space is for any fuel expansion due to temperature changes.

Screen 23:**Monitored Parameters:**

To aid maintenance personnel in monitoring the fuel system, monitored parameters are available on a Smart Display in Level 3 access.

Screen 24:**Self-Tests:**

Self-Test 300, initiated by means of a Smart Display, can be used to test and activate the fuel transfer pump.

Screen 25:**Normal Operating Temperatures and Pressures:**

The table displays normal expected operating temperatures and pressures for the low-pressure fuel flowing to the engine.

Screen 26:**Running Maintenance Schedule:**

Engineering recommends that you inspect the fuel system daily to ensure trouble-free operation. During daily maintenance of the system, with the engine at idle, make a visual inspection of the fuel tank, engine, fuel transfer pump, fuel manifold, fuel filter tanks, regulating valve, high-pressure equipment, including HP pumps, HP fuel lines, and injectors, and all system piping for fuel leaks. Make corrections as necessary. Replace the fuel filter elements every 184 days.

Screen 27:**System Pressure Checks:**

A normal fuel supply pressure reading is between 88 and 92 psi when the engine is running in low idle (i.e., at 335 RPM) and the fuel filters are new. The pressure reading decreases as the engine load increases or as the filters become dirty or clogged. Check the pressure of the low-pressure fuel supply to the high-pressure pumps in two ways.

Screen 28:**Pressure Gauge:**

Read the pressure by attaching a pressure gauge of 0 to 200 psi range to the quick-disconnect fitting that is located next to the fuel regulating valve.

Screen 29:**Smart Display:**

Read the pressure by viewing the Locomotive Monitor Screen on a Smart Display.

Screen 30:**System Pressure Adjustments:**

Typical steps to adjust the pressure of the low-pressure fuel supply are as follows: Ensure that new fuel filter elements have been installed in the fuel filter canisters. Make sure that the fuel system is primed and free of air. Let the engine run until it drops to Low Idle speed (335 RPM).

1. Attach a pressure gauge of 0 to 200 psi range to the quick-disconnect fitting that is located next to the fuel regulating valve.
2. With the engine operating at Low Idle, loosen the adjusting locknut on the regulating valve, then turn the adjusting screw in to increase pressure or out to decrease pressure until 88 to 92 psi is displayed on the gauge.
3. Tighten the adjusting locknut on the regulating valve, then recheck the reading on the gauge.

Note: If the reading is incorrect, repeat steps 2 and 3. If the reading is correct, remove the gauge from the quick-disconnect fitting.

Screen 31:**Fuel Filter Element Removal:**

The fuel filter assembly removes contaminants larger than 5 microns from the fuel. This protects the engine's high-pressure fuel equipment. The fuel filter assembly is made up of two tanks, or canisters, and each tank contains a 45-inch, three-piece filter element. The two parallel fuel filter tanks are located in the radiator cab adjacent and below the combustion air filter or baggy filter compartment. Access is from the Helper's side of the locomotive. Typical steps to remove the fuel filter elements are as follows:

1. Shut down the engine and open the fuel pump circuit breaker.

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started. Open the Locomotive Battery Switch. Also, open the Fuel Pump Circuit Breaker, and apply a warning tag to the Engine Control Switch.

2. Open the fuel filter drain valve, then open the vent valve, which is located above the top fuel filter canister.

Note: Allow sufficient time for the fuel filters to drain.

3. Loosen the nuts holding the fuel filter doors in place, swing the fasteners outward, and remove the fuel filter doors.
4. Remove the old filter elements.

Screen 32:

Fuel Filter Element Installation:

Typical steps to install new filter elements are as follows:

Note: Wipe a small amount of clean lubricating oil on the O-rings on all new GE fuel filter sections to prevent O-ring damage during assembly.

1. Install new approved filter elements.
2. Check the condition of the O-ring seal on each filter tank door and replace the O-ring, if needed.
3. Close and seal the filter tank doors and ensure that the vent valve is closed.
4. Close the fuel filter drain valve.
5. Place the locomotive in Self-Test 300 and prime the fuel system for five minutes.
6. Start the engine, inspect the entire fuel system for leaks, and make corrections as necessary.

Screen 33:

High-pressure Fuel Equipment:

The high-pressure fuel equipment includes the HP pumps, high-pressure lines, and the fuel injectors. The HP pumps take fuel from the low-pressure inlet supply header, greatly increase the pressure, and then send it to the injectors through the high-pressure fuel lines. Each power assembly on the diesel engine has an HP pump, HP fuel line, and a fuel injector. The ECU governs the timing and amount of the fuel delivered by each HP pump by opening and closing a solenoid located on the pump. For removal and installation instructions for the high-pressure equipment, refer to the GEVO Diesel Engine Advanced course.

Screen 44:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the major components of the fuel system.
 - The primary purpose is to provide fuel for combustion.
 - The secondary purpose is lubricating and cooling high-pressure fuel equipment.
 - The major components of the fuel system are:

- Fuel Tank
 - Fuel Transfer Pump
 - Fuel Filter Assembly
 - High-Pressure Fuel Equipment
 - Fuel Manifold
 - Regulating Valve
 - Engine Fuel Temperature Sensor
 - Engine Fuel Pressure Sensor
- Describe how diesel flows through the fuel system.
 - The four functional sections of fuel system are:
 - Suction
 - Low-Pressure Supply
 - High-Pressure Supply
 - Return/Regulating Valve
 - An electrically driven fuel transfer pump draws fuel from the fuel tank.
 - The pump provides a normal output flow rate of 12.75 GPM.
 - It contains an internal pressure relief valve, which protects the pump if pressure exceeds 130 psi.
 - The low-pressure fuel is then sent to the fuel manifold, which contains a fuel heater and a thermostatic mixing valve.
 - The fuel heater prevents the cold diesel fuel from becoming thick and slushy.
 - The thermostatic valve regulates the outlet fuel temperature.
 - The thermostatic valve is normally open until the main flow temperature reaches 75°F.
 - At this point, the valve starts closing and fully closes when the fuel temperature reaches 85° to 87°F.
 - The fuel then flows to the fuel filter assembly, which consists of two tanks, each containing a three-piece filter element.
 - The filter elements remove contaminants larger than 5 microns from the fuel.
 - From the fuel filter assembly, fuel flows to each of the 12 high-pressure pumps.
 - The circular supply header ensures equal distribution of fuel to each pump.
 - The piston-type high-pressure pumps pressurize the fuel to 23,000 psi, and send it to the injectors.
 - The Engine Control Unit governs the timing and amount of fuel delivered by each HP pump by opening and closing a solenoid on the pump.
 - When HP pump is not pressurizing, the solenoid is open, which allows the fuel to pass to the low-pressure return header.
 - The regulating valve provides back pressure in the low-pressure fuel lines to the HP pumps.
 - Two gravity drain headers are on each side of the engine.
 - After flowing through each HP pump, the fuel drains to the drain header and then back to the fuel tank.

- Describe the abnormal operating condition detection strategies used in the fuel system.
 - The two detection strategies are:
 - Low fuel supply temperature detection - If the fuel supply temperature measured by the EFT sensor is below 60°F for 30 seconds, and the water inlet temperature measured by the EWIT sensor is above 140°F for 60 minutes, an engine fuel temperature low incident is logged. This incident will clear if the fuel temperature is above 65°F for 30 seconds.
 - Low fuel supply pressure detection - If the fuel supply pressure measured by the EFP sensor is below 30 psi for 30 seconds with the engine running, an engine fuel pressure low incident is logged. This incident will clear if the fuel pressure is above 50 psig for 30 seconds with the engine running.

- Describe how to check and adjust the fuel supply pressure.
 - A normal fuel supply pressure reading is between 88 and 92 psi when the engine is running in Low Idle and fuel filters are new.
 - The pressure reading decreases as the load increases or as the filters become dirty.
 - A pressure gauge of 0 to 200 psi range can be connected to the quick-disconnect fitting to measure the pressure.
 - The pressure can also be read by viewing the locomotive monitor screen on a Smart Display.
 - To adjust the fuel supply pressure, loosen the regulating valve and adjust the locknut in or out to increase or decrease the pressure.
 - Tighten the locknut and recheck the reading on the gauge.

- Describe how to remove and install the fuel filter elements.
 - Fuel Filter Element Removal:
 1. Shut down the engine and open the fuel pump circuit breaker.
 2. Open the fuel filter drain valve, then open the vent valve, which is located above the top fuel filter canister.
 3. Loosen the nuts holding the fuel filter doors in place, swing the fasteners outward, and remove the fuel filter doors.
 4. Remove the old filter elements.
 - Fuel Filter Element Installation:
 1. Install new approved filter elements.
 2. Check the condition of the O-ring seal on each filter tank door and replace the O-ring, if needed.
 3. Close and seal the filter tank doors and ensure that the vent valve is closed.
 4. Close the fuel filter drain valve.
 5. Place the locomotive in Self-Test 300 and prime the fuel system for five minutes.

6. Start the engine, inspect the entire fuel system for leaks, and make corrections as necessary.

Combustion Air System

Screen 1:

Welcome Screen:

Welcome to the Combustion Air System module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Combustion Air System:

In this module, you will learn how to inspect and maintain the components of the combustion air system in a running repair environment.

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

- State the purpose and location of the combustion air system.
- State the purpose and location of the major components of the combustion air system.
- State the purpose and location of the instrumentation devices of the combustion air system.
- Describe how the combustion air system operates.
- Describe the protection strategies used with the combustion air system.
- Describe how to perform running maintenance related to the combustion air system.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspecting and maintaining the components of the combustion air system, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Overview of the Combustion Air System:

The combustion air system provides sufficient air to the engine during the combustion process and maintains the temperature of that air below a certain range. The components of the combustion air system are located in the engine cab and radiator cab.

Screen 5:

Major Components of the Combustion Air System:

Major components of the combustion air system include the following:

- V-Screens
- Plastic Air Cleaner Panels
- Baggy Air Filters

- Turbocharger

Screen 6:

V-Screens:

Located on both sides of the radiator cab, the V-screens are perforated and “V” shaped to provide a large cross section to allow outside air to enter, but also to block large items, such as leaves and trash, from entering the system.

Screen 7:

Plastic Air Cleaner Panels:

Located directly behind the V-screens, the plastic air cleaner panels, also referred to as spin cleaner panels, provide the primary stage of air filtration for the combustion air system. Each air cleaner panel contains 54 individual vortex tubes. These tubes contain spiral vanes that cause the air to swirl like a tornado as it passes through the tube. The swirling action forces heavier dirt particles to the outside of the air stream. This “dirty” air is separated at the output of the tubes and discharged from the air cleaner panels into a bleed air duct.

Screen 8:

Baggy Air Filters:

Located in the combustion air filter compartment, also referred to as the baggy air filter compartment and engine air filter compartment, the baggy air filters clean the fine particles from the intake air as it comes from the spin cleaner panels.

Screen 9:

Turbocharger:

Located on the Integrated Front End (IFE) cover of the diesel engine, the turbocharger compresses the air for use by the engine during the combustion process.

Screen 10:

Major Components of the Combustion Air System (Cont'd):

Additional major components of the combustion air system include the following:

- Water-Based Intercooler
- Air-Based Intercooler
- Exhauster Blower
- Winter-Summer Door

Screen 11:

Water-Based Intercooler:

Located in the upper section of the radiator cab adjacent to the turbocharger, the water-based intercooler provides the first stage of cooling for the air discharged from the turbocharger.

Screen 12:**Air-Based Intercooler:**

Located in the upper section of the radiator cab adjacent to the water-based intercooler, the air-based intercooler, which consists of two symmetrical air-to-air heat exchangers mounted in a V-shaped configuration, provides the second stage of cooling for the turbocharged or compressed air.

Screen 13:**Exhauster Blower:**

Located in the radiator cab on the engineer's side (A-side) of the locomotive, the exhauster blower removes the dirty air from the spin cleaner panel bleed air duct, continuously discharging the bleed air and dirt out the top of the unit and into the radiator cab. From the radiator cab, the radiator fans pull the air out, discharging the dirty air through the top of the locomotive.

Screen 14:**Winter-Summer Door:**

Located in the combustion air filter compartment, the winter-summer door prevents ice crystals from clogging the baggy air filters. In cold weather conditions, the door can be positioned to block some of the air coming through the plastic air cleaner panels, while opening a new path for air from the engine cab.

Screen 15:**Major Components of the Combustion Air System (Cont'd):**

In addition to the major components discussed earlier, other components of the combustion air system include the following:

- Shutter Control Magnet Valves
- Turbo Discharge Ducts
- Return Air Ducts
- Intermediate Ducts

Screen 16:**Shutter Control Magnet Valves:**

Located in the combustion air filter compartment on the helper's side (B-side) of the locomotive, the shutter control magnet valves control the air-flow for opening and closing the shutters on the air-based intercooler.

Screen 17:**Turbo Discharge Ducts:**

The flexible silicon hose turbo discharge ducts transport the combustion air from the turbocharger to the water-based intercooler.

Screen 18:**Return Air Ducts:**

The return air ducts are hard pipe ducts that transport the cooled combustion air from the air-based intercooler to the engine intake manifold.

Screen 19:**Intermediate Ducts:**

The intermediate ducts, consisting of a set of aluminum Victaulic couplings and aluminum hard pipe sections, transport the combustion air from the water-based intercooler to the air-based intercooler.

Screen 20:**Instrumentation Devices of the Combustion Air System:**

The sensors of the combustion air system include the following:

- Manifold Air Temperature (MAT) Sensor
- Ambient True Temperature (ATT) Sensor
- Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors
- Turbocharger Right Speed (TRS) Sensor

Screen 21:**Manifold Air Temperature (MAT) Sensor:**

Located at the end of the engine's intake air manifold, the MAT sensor provides manifold air temperature information to the Engine Control Unit (ECU).

Screen 22:**Ambient True Temperature (ATT) Sensor:**

Located in the combustion air filter compartment wall, the ATT sensor measures the temperature of the air entering the turbocharger and provides the information to the ECU.

Screen 23:**Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors:**

Located in each exhaust manifold at the connection points to the turbocharger, the PTRT and PTLT sensors measure the temperature of the exhaust air going into the turbocharger and provide the information to the ECU.

Screen 24:**Turbocharger Right Speed (TRS) Sensor:**

Located in the turbocharger, the TRS sensor measures the rotational speed of the turbocharger and provides the information to the ECU.

Screen 25:**Instrumentation Devices of the Combustion Air System (Cont'd):**

Additional sensors of the combustion air system include the following:

- Barometric Air Pressure (BAP) Sensor
- Manifold Air Pressure (MAP) Sensor
- Engine Air Filter Pressure (EAFP) Sensor

Screen 26:**Barometric Air Pressure (BAP) Sensor:**

Located on the wall of Control Area 4 (CA4) in the Auxiliary Cab, the BAP sensor measures the atmospheric pressure and provides the information to the ECU.

Screen 27:**Manifold Air Pressure (MAP) Sensor:**

Located at the end of the engine's intake air manifold, the MAP sensor measures the air pressure in the intake manifold and provides the information to the ECU.

Screen 28:**Engine Air Filter Pressure (EAFP) Sensor:**

Located in the combustion air filter compartment just above the fuel filter tanks, the EAFP sensor measures the pressure of the air at the outlet of the filters and before entering the turbocharger. This information is provided to the ECU, where the BAP sensor pressure is compared to the EAFP sensor pressure to determine if the engine air filters need to be replaced.

Screen 33:**Operation of the Combustion Air System:**

The combustion air system, in conjunction with the split cooling water system, provides a regulated manifold intake temperature to the engine to meet strict government emissions requirements. At high load and/or high ambient conditions, a lower intake temperature decreases the amount of harmful emissions from the exhaust stack and decreases fuel consumption. At low load and/or low ambient conditions, a warmer intake temperature decreases other regulated emissions, such as carbon monoxide (CO) and white smoke. A two-stage hybrid intercooler design regulates the manifold air temperature. The intake manifold air is cooled or heated through an air-to-water (or water-based) intercooler, where water cools or heats the intake air. When additional cooling is required, the manifold air is cooled through a V-shaped air-to-air (or air-based) intercooler configuration. Two separate fans provide cooling air for the air-to-air intercooler. Shutters on the air-to-air intercooler provide additional control of the amount of cooling air flow, thus allowing a more controlled manifold air temperature.

Screen 34:**Air Flow Through the Combustion Air System:**

The turbocharger creates a vacuum that draws air into the combustion air system through V-screens. The air flows through eight plastic air cleaner panels. An exhaust blower, connected to the bleed air duct, provides a drawing force to discharge the dirty air from the air cleaner panels into the radiator cab. The clean air from the air cleaner panels fills the combustion air filter compartment. Five baggy filters provide the final filtration of the air entering the turbocharger. The turbocharger compresses the filtered air and sends it to the water-based intercooler. The compressed air from the turbocharger is very hot, and the water-based intercooler provides the first stage of cooling. At Notch 8, full load, the compressed air from the turbocharger can exceed 425°F. The water-based intercooler brings the compressed air temperature down below 210°F.

Screen 35:**Air Flow Through the Combustion Air System (Cont'd):**

When further cooling of the air is necessary, the air-based intercooler provides the second stage of cooling. If additional cooling is not required, the air just passes through the air-based intercooler to the intake air manifold on the engine. The air-based intercooler contains two fans and two shutters to regulate the outlet air temperature below 125°F. The intake air manifold distributes the cooled, compressed air to each power assembly on the engine. The exhaust air from the power assemblies spins the turbine blades in the turbocharger before exiting the exhaust stack.

Screen 38:**Air-Based Intercooler Fan and Shutter Control:**

The Engine Management System (EMS) software monitors the intake manifold air temperature on the engine by means of the MAT sensor. Based on this information, the EMS controls each shutter and fan separately to regulate the temperature. There are eight possible cooling configurations. To avoid over-cycling of a single fan or shutter, each device is cycled ON/OFF or OPEN/CLOSED in an alternating manner. As manifold air temperature increases, each shutter position (both closed, one open, or both open) is commanded sequentially with both fans OFF until the shutters are completely open. Note that there is a minimum holding time between each change of shutter position. If the manifold air temperature exceeds the set point with the shutters fully open, one intercooler fan is turned ON and both shutters are closed to limit the increase in intercooler air flow. If additional air flow is required, the first shutter is opened. If the temperature continues to rise, the second shutter is opened. If the temperature again exceeds the set point, the second intercooler fan is turned ON and one shutter is closed. If additional air flow is required, the second shutter is opened, resulting in both fans in service and both shutters in the fully open position to provide maximum cooling.

Screen 39:**Air-Based Intercooler Fan and Shutter Control (Cont'd):**

The sequence of shutter positions and fan speeds is based on the resulting air flow through the air-to-air intercooler and the subsequent manifold air temperature. With the shutters both open and the fans both off, some energy transfer occurs due to natural convection. Significantly more air flow and thus energy transfer occurs when one of the fans is on and both shutters are open. To limit the magnitude of the air flow change, the shutters are both closed when the first fan is turned on. The sequence explained above works in reverse for decreasing manifold air temperature. With both fans in service and both shutters initially open, as the temperature decreases, the first shutter is commanded closed. If the temperature is less than the lower set-point with the shutters at a minimum position (one shutter open, one shutter closed), the first fan to start is turned OFF, and both shutters are opened. If less cooling air flow is required, both shutters are then closed. When the temperature again drops below the lower set-point, the second fan is turned OFF and both shutters are commanded to the fully open position. The shutter position is then reduced from both open to one open, or to both closed or until manifold air temperature is no longer below the lower set point. To minimize the probability of fan motor bearing deformation and pitting on either fan due to inactivity, a condition referred to as brinelling, a fan is commanded to run for 10 seconds if the fan has been off for 30 minutes and the locomotive is not in the self-test mode. The table displays the air-based intercooler shutter and fan configuration.

Screen 40:**Protection Strategies:**

The following functions protect the diesel engine from damage caused by operating at extremes of the operating range or by abnormal conditions. Appropriate derations or restrictions are applied by each function as necessary.

Screen 41:**Hot Pre-Turbine Protection:**

When either pre-turbine temperature signal, as read by the PTRT or PTLT sensor, is hot, the available horsepower from the engine is reduced to protect the turbocharger from damage. When either pre-turbine temperature signal exceeds 1325°F, the available horsepower is modulated to hold the pre-turbine temperature at a maximum of 1325°F. If the available horsepower is reduced to 80% because of a high pre-turbine temperature for one minute, a Hot Pre-turbine Deration incident is logged. If the pre-turbine temperature cannot be controlled, and the available horsepower has been reduced to zero for five minutes, the engine shuts down and logs a Hot Pre-turbine Shutdown incident.

Screen 42:**Turbo Overspeed Protection:**

When the turbo speed signal, as read by the TRS sensor, is high, the available horsepower is reduced to prevent damage to the turbocharger bearings. If the TRS

signal exceeds 23,500 RPM for five seconds, the available horsepower is reduced to 3660 and an Engine Turbocharger Overspeed Incident is logged. The restriction clears after 60 minutes.

Screen 43:

Turbo Surge Protection:

A turbo surge is defined as a 6 psi drop followed by a 3 psi rise in manifold air pressure in one second. When a turbo surge is detected, the engine speed is raised or the available horsepower is lowered to prevent damage to the turbocharger. If three surge events are detected in one minute, the available horsepower is limited to 3660, the engine speed is set to 1050 RPM, and a Notch 7 Surge Incident is logged. Additional turbo surge events are ignored for one minute while the engine is in transition. If no more surge events are detected in one hour, the restriction is cleared. If three more surge events are detected in a one minute interval before the hour has expired, the available horsepower is limited to 2940, and engine speed is set to 1050 RPM. The one hour timer is then restarted. If surge events are detected, no further action is taken until the one hour timer has expired and all restrictions are cleared. The High Air Filter Differential Pressure Protection function protects the turbocharger from excessive speed caused by clogged baggy filters.

Screen 44:

High Air Filter Differential Pressure Protection:

The High Air Filter Differential Pressure Protection function protects the turbocharger from excessive speed caused by clogged baggy filters. The EAFP sensor measures the pressure in the combustion air filter compartment in units of psia. The EAFP sensor value is compared with the BAP sensor value to determine the difference. When the EAFP sensor value is lower than the BAP sensor value, air flow through the baggy filters is being restricted, indicating dirty filters. The EMS software converts the measurement to inches of water using the following formula and sensor readings: $\text{Air Filter Pressure} = 27.7 \times (\text{BAP sensor} - \text{EAFP sensor})$ If the pressure in the combustion air filter compartment is greater than 14 inches of water at Notch 8, the engine horsepower is derated to a maximum of Notch 7 horsepower.

Screen 46:

Operational Details:

Recognizing and understanding operational data, pertinent self-tests, and normal operating temperatures and pressures is important when diagnosing problems.

Screen 47:

Monitor Parameters:

The table displays a list of monitor parameters. To help maintenance personnel monitor the combustion air system, these parameters are available on the Smart Display, in Level 3 access.

Screen 48:**Self-Tests:**

Self-Tests 325 and 326 are used to test the air-based intercooler fan contactors. These self-tests pick up or drop out the contactors that apply AC power to the fans and are used to test the contactor feedback circuits. Self-Tests 407 and 408 are used to test the operation of the air-based intercooler fans. These self-tests apply AC power to the fans. Self-Tests 327 and 328 are used to test the air-based intercooler shutters. These self-tests energize or de-energize the magnet valves that apply compressed air to open or close the shutters. All of these self-tests are initiated through the Smart Displays.

Screen 49:**Normal Operating Temperatures and Pressures:**

The table provides normal expected operating temperatures and pressures for air flowing in the system.

Screen 50:**Running Maintenance Schedule:**

The table displays the recommended running maintenance schedule associated with the combustion air system and its major components.

Screen 51:**Plastic Air Cleaner Panels:**

The plastic air cleaner panels provide the primary stage of air filtration for the combustion air system. After going through the V-screens, the air is drawn into the plastic air cleaner panels. The combustion air system uses eight air cleaner panels. The air cleaner panels require no routine running maintenance other than a visual inspection to see if they are intact and free of debris. If they are cracked or broken, they must be replaced. If panels are plugged with debris, remove and clean them and return them to service.

Screen 53:**Winter-Summer Door:**

The winter-summer door provides a means to mix warm air from the engine cab with cold outside air to prevent ice crystals from clogging the baggy air filters as well as to maintain warmer engine manifold air temperatures during cold ambient temperatures. The winter-summer door is located in the floor area of the combustion air filter compartment. In warm weather conditions, the door is in the down position and closed to block the air passage that leads to the engine cab area. This allows full flow of air through the plastic air cleaner panels. In cold weather conditions, the door is in the raised position to partially block the incoming air from the plastic air cleaner panels while opening the path for the warm air to travel from the engine cab area. The winter-summer door requires no routine running maintenance. However, if the door is not in the correct position for the climate, locomotive performance may suffer.

Screen 54:**Baggy Air Filters:**

The baggy air filters clean fine particles from the intake air as it comes from the air cleaner panels. The five baggy filters are located in the combustion air filter compartment, which is located in the radiator cab. Access to the compartment and filters is through doors located on both sides of the locomotive.

Screen 55:**Baggy Air Filters Removal and Installation:**

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the Battery Switch (BS) in the OFF position to prevent starting attempts. Also, place the Fuel Pump Circuit Breaker (FPB) and the Local Control Circuit Breaker (LCCB) in the OFF position. Also, apply a warning tag on the Engine Control (EC) switch.

Typical steps to remove and install new baggy air filters are as follows:

1. Shut down the diesel engine.
2. Open the door to access the combustion air filter compartment from the engineer's side (A-side) of the radiator cab.
3. Remove the bar clamp and the wire cages that are accessible from this side.
4. Remove and replace the used air filters with new approved baggy air filters.
5. Install the wire cages.

Screen 56:**Baggy Air Filters Removal and Installation (Cont'd):**

6. Open the door to access the combustion air filter compartment from the helper's side (B-side) of the radiator cab.
7. Remove the wire cages that are accessible from this side and replace the used air filters with new approved baggy air filters.
8. Install the wire cages.
9. Close and secure the door to the combustion air filter compartment.
10. On the engineer's side (A-side), install the bar clamp to hold the air filters in place.
11. Close and secure the door to the combustion air filter compartment.

Screen 57:**Turbocharger:**

The turbocharger compresses air for use by the engine during the combustion process. Driven by engine exhaust gases, the turbocharger compresses the clean filtered air and feeds it to the engine by way of intercoolers. The turbocharger has no mechanical driving gear. Engine exhaust gases drive the turbocharger's turbine, which in turn rotates the turbocharger's compressor attached to the same shaft. Perform the removal and

installation steps as discussed in the Turbocharger Removal and Installation module of the GEVO Diesel Engine Advanced course.

Screen 58:

Water-Based Intercooler:

As part of a two-stage manifold air-cooling process, the Water-Based Intercooler (WBIC) provides the first stage of this cooling. The WBIC cools the air discharged from the turbocharger. At Notch 8 engine speed, the outlet air temperature from the WBIC is typically around 200°F.

Note: Engine load, altitude, and ambient air temperature can significantly affect this value.

The WBIC consists of a core and an outer shell. The core is a mechanically bonded tube and fin design. The cooling water flows inside the tubes and makes two passes through the shell before exiting. The turbocharger discharge air flows over the tubes and fins in one pass. Perform the removal and installation steps as discussed in the Split Cooling Water System module of this course.

Screen 59:

Air-Based Intercooler:

The air-based intercooler provides the second stage of the manifold air-cooling process. The turbocharged air (or combustion air) leaving the water-based intercooler flows through two symmetrical air-to-air heat exchangers, which are mounted in a "V"-shaped configuration. Two 16 HP, suction-type fans are turned on or off individually to control the cooling air that flows across the heat exchangers. Two shutters, located at the inlet side of the cooling air paths, can also be opened or closed to provide additional cooling control. Four shutter control magnet valves are used to open and close the shutters. The magnet valves are located in the combustion air filter compartment on the helper's side (B-side). When cooling is not required, both fans are turned off and both shutters are closed. At Notch 8 engine speed, the outlet air temperature from the air-based intercooler is typically below 122°F.

Note: Engine load, altitude, and ambient air temperature can significantly affect this value.

The air-based intercooler is located in the upper section on the radiator cab adjacent to the univalve assembly.

Screen 60:

Air-Based Intercooler Package Removal:

Typical steps to remove the air-based intercooler package are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine

component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with Auto Engine Start/Stop (AESS), the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Shut down the diesel engine.
2. Depressurize the locomotive cooling system as discussed in the Split Cooling Water System module of this course.
3. Disconnect the battery switch.
4. Unbolt and remove all top covers over the air-based intercooler package.
5. Unbolt and remove the side screens on both sides of the locomotive.

Screen 61:

Air-Based Intercooler Package Removal (Cont'd):

Note: The intermediate ducts connect the water-based intercooler and the air-to-air heat exchangers. Access the ducts through the top and inside the combustion air filter compartment.

6. Unbolt the intermediate ducts at the lower "V" area of the air-based intercooler.

Note: The return ducts connect the air-to-air heat exchangers and the engine.

7. Unbolt the return ducts at the 8-inch Victaulic couplings on the top outboard connections of the air-based intercooler package.
8. Remove and retain the fasteners from the clamp of the return duct bracket on both the A-side and B-side of the locomotive.
9. Remove the return ducts from the IFE cover of the engine.
10. Attach the lifting hook and strap at each pipe assembly and lift the return ducts from the locomotive.
11. Disconnect the wiring at the six "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
12. Cut the fasteners holding these wires to the tape rail on the radiator cab structure.

13. Disconnect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.

Screen 62:

Air-Based Intercooler Package Removal (Cont'd):

Note: The air lines should be labeled before being removed from the shutter cylinders to ensure they will not be reversed when re-installing the shutters.

14. For a top-mounted shutter assembly, remove the shutter actuator cover to allow access to the air lines, then disconnect the air lines on the shutter cylinders.
15. For side-mounted shutter assemblies, disconnect the air lines from the two shutter cylinders.

Note: Not all Evolution Series locomotives are equipped with an air-to-air shutter assembly. Some locomotives have a covering grate in place of the air-to-air shutter assembly.

16. Unbolt the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.

Warning: The air-based intercooler weighs approximately 3375 lbs. (1530 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

17. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package from the locomotive.
18. Align and place the air-based intercooler package in the support stand on the shop floor.

Screen 63:

Air-Based Intercooler Package Installation:

Typical steps to install an air-based intercooler package are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: The air-based intercooler weighs approximately 3375 lbs. (1531 kg). Use a crane or appropriate lifting device to avoid personal injury.

Note: Comply with all railroad safety procedures before proceeding to the top of the radiator cab. The radiator rock guards were not designed to be walked on by more than one person. Use the supplied walkway covers.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package into place on the radiator cab.
2. Align the mounting holes and install the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
3. For side-mounted shutter assemblies, connect the air lines to the two shutter cylinders.
4. For a top-mounted shutter assembly, connect the air lines to the shutter cylinders and install the shutter actuator cover.
5. Connect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
6. Connect the six wires to the correct "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
7. Secure the wires to the tape rail on the radiator cab structure with fasteners.

Screen 64:

Air-Based Intercooler Package Installation (Cont'd):

8. Using an appropriate lifting device, lift and install the return ducts to the IFE cover of the engine.
9. Place the return ducts in the air-to-air frame and attach the return pipe brackets with fasteners that were removed during removal.

Note: Ensure that the B-side of the return duct flange is installed as far to the center of the cab as possible (towards the A-side) to avoid interference with the B-side turbo discharge duct during operation.

10. Connect the return ducts to the top outboard connections of the air-based intercooler package.

Note: Access the ducts through the top and inside the combustion air filter compartment.

11. Connect the intermediate ducts at the lower "V" area of the air-based intercooler.
12. Install the side screens on both sides of the locomotive.
13. Install the top covers over the air-based intercooler package.
14. With the air-based intercooler package installed, re-fill the locomotive cooling water system as discussed in the Split Cooling Water System module of this course in preparation for returning the locomotive to service.

Screen 65:**Air-to-Air Heat Exchanger Removal:**

Typical steps to remove one of the air-to-air heat exchangers from the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on the ground on an appropriate support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Unbolt and remove the close off angles that secure the top of the air-to-air heat exchanger in place.
2. Unbolt the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.

Note: It is not necessary to unbolt the shutter mounting bolts.

Warning: Each individual air-to-air heat exchanger weighs approximately 620 lbs. (281 kg). Use a crane or appropriate lifting device to avoid personal injury or death.

3. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
4. Using the lifting fixture, lift and slide the old air-to-air heat exchanger out of the sheet metal pocket support frame.

Screen 66:**Air-to-Air Heat Exchanger Installation:**

Typical steps to install one of the air-to-air heat exchangers to the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on the ground on an appropriate support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
2. Using the lifting fixture, lift and slide the air-to-air heat exchanger into the sheet metal pocket support frame.
3. Install the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
4. When re-installing the air-to-air heat exchanger on the air-based intercooler frame, only replace the two mounting bolts at the lower inlet air corner and leave out the mounting bolts at the other three remaining corners.

Note: Replacing the two bolts at the lower inlet air corner only and leaving out the other three pairs of bolts allows for thermal growth of the intercooler cores.

5. Install the close off angles that secure the top of the air-to-air heat exchanger in place.

Screen 67:

Shutter Removal – Side-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The removal of a side-mounted shutter assembly is explained in this section.

Typical steps to remove a side-mounted shutter assembly from the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Not all Evolution Series locomotives are equipped with the air-to-air shutter assembly. Some, in place of the air-to-air shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. If required, disconnect the air lines attached to the shutter cylinders on both shutter assemblies.
2. Loosen the ten ½-13 x 1.50-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler frame.
3. Loosen the four ½-13 x 1.25-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler heat exchanger.
4. Remove and save the top two ½-13 x 1.50-inch hex bolts, split lockwashers, and flatwashers, then attach swivel clevis lifting lugs in the bolt holes.

Warning: The air-to-air shutter assembly weighs approximately 225 lbs. (102 kg). With the lifting device connected to the swivel clevis lifting lugs, ensure the lifting device is adequately supporting the assembly weight before removing the remaining hardware. Failure to do so may result in personal injury or death.

5. With the air-to-air shutter assembly properly supported, remove and save all previously loosened hex bolts, split lockwashers, and flatwashers.
6. Once all the bolts have been removed and the shutter assembly is supported by the lifting lugs, support the bottom of the shutter so it does not swing out as the support stand is removed.

Note: The shutter assembly may also be supported by sitting on the forks of a fork lift as well to ensure it is secure.

7. Remove the shutter assembly from the air-based intercooler frame.

Screen 68:

Shutter Installation – Side-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The installation of a side-mounted shutter assembly is explained in this section.

Typical steps to install a side-mounted shutter assembly to the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Not all Evolution Series locomotives are equipped with the air-to-air shutter assembly. Some, in place of the air-to-air shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

Warning: The air-to-air shutter assembly weighs approximately 225 lbs. (102 kg). With the lifting device connected to the swivel clevis lifting lugs, ensure the lifting device is adequately supporting the assembly weight before removing the remaining hardware. Failure to do so may result in personal injury or death.

1. Attach the lifting lugs to the shutter assembly and place the shutter assembly on the air-based intercooler frame.
2. Install the four ½-13 x 1.25 inch hex bolts, ½ split lockwashers, and ½ flatwashers retained during removal.
3. Install the ten ½-13 x 1.50 inch hex bolts, ½ split lockwashers, and ½ flatwashers retained during removal securing the air-to-air shutter assembly to the top of the air-based intercooler frame.
4. If required, connect the air lines attached to the shutter cylinders on both shutter assemblies.

Screen 69:

Shutter Removal – Top-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The removal of the top-mounted shutter assembly is explained in this section.

Typical steps to remove the top-mounted shutter assembly from the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Not all Evolution Series locomotives are equipped with the air-to-air shutter assembly. Some, in place of the air-to-air shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. Remove and save the four bolts, washers, and lockwashers securing the actuator cover to the shutter assembly.
2. Remove the shutter actuator cover to allow access to the air lines.
3. Disconnect the air lines attached to the shutter cylinders.
4. Remove and save the hex bolts, washers, and lockwashers securing the air-to-air shutter assembly to the top of the air-based intercooler frame.

Warning: The air-to-air shutter assembly weighs approximately 273 lbs. (124 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

5. Attach lifting lugs to the holes in all four corner gussets of the shutter assembly.
6. Lift the shutter assembly from the top of the air-based intercooler frame.

Screen 70:

Shutter Installation – Top-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The installation of the top-mounted shutter assembly is explained in this section.

Typical steps to install the top-mounted shutter assembly from the air-based intercooler are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: Not all Evolution Series locomotives are equipped with the air-to-air shutter assembly. Some, in place of the air-to-air shutter assembly, have a covering grate. For these locomotives, remove all sets of clamps, lockwashers, washers, and bolts that secure the grate to the assembly.

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an

appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. Attach the lifting lugs to the holes in all four corner gussets of the shutter assembly.
2. Place the air-to-air shutter assembly on the top of the air-to-air frame.
3. Install the hex bolts, washers, and lockwashers retained during its removal.
4. Connect the air lines to the shutter cylinders.
5. Place the shutter actuator cover on the air-to-air frame.
6. Install the four bolts, washers, and lockwashers to secure the shutter actuator cover.

Screen 71:

Air-to-Air Fan Assembly Removal:

Typical steps to remove an air-to-air fan assembly for locomotives with a top-mounted air-to-air shutter assembly from the locomotive cooling system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: This process can be performed while the air-based intercooler is installed in or removed from the locomotive.

1. Remove the air-to-air shutter assembly as discussed in the Shutter Removal – Top-Mounted Shutter Assembly section of this module.
2. Disconnect the grease fittings from the fan to be removed.

Screen 72:

Air-to-Air Fan Assembly Removal (Cont'd):

3. Disconnect all fan motor leads.
4. Remove and save all bolts and washers that secure the air-to-air fan assembly to the air-based intercooler frame.

Note: Save all hardware for reuse.

Warning: The air-to-air fan assembly weighs approximately 300 lbs. (136 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

5. Attach a crane or lifting device to the lifting hooks on the fan assembly.
6. Remove the air-to-air fan assembly from the locomotive.

Screen 73:

Air-to-Air Fan Assembly Installation:

Typical steps to install an air-to-air fan assembly for locomotives with a top-mounted air-to-air shutter assembly to the locomotive cooling system are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

Note: This process can be performed while the air-based intercooler is installed in the locomotive.

Warning: The air-to-air fan assembly weighs approximately 300 lbs. (136 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

1. Attach a crane or lifting device to the lifting hooks on the air-to-air fan assembly.
2. Install the air-to-air fan assembly in position on the air-to-air intercooler.
3. Install all bolts and washers retained during removal to secure the air-to-air fan assembly to the air-to-air intercooler.
4. Connect all fan motor leads.
5. Connect the grease fittings.
6. Install the air-to-air shutter assembly as discussed in the Shutter Installation – Top-Mounted Shutter Assembly section of this module.

Screen 74:

Exhauster Blower:

The exhauster blower is an 8.5 horsepower, AC motor-driven exhauster that removes dirty air (or bleed air) from the spin cleaners and discharges it into the radiator cab. The AC motor is electrically connected through an Exhauster Motor Breaker (EMB) to the auxiliary alternator. As long as the auxiliary alternator is functioning, the exhauster blower will also function. The exhauster blower runs at engine speed. The EMB provides overload protection for the AC source (auxiliary alternator) to the exhauster motor.

Screen 75:

Exhauster Blower Removal:

Typical steps to remove the exhauster blower are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Open the connection box cover located on the blower motor and disconnect the three motor leads from the terminal block located on the blower motor. Note the identification of each lead on each terminal for subsequent reconnection.
2. Disconnect the flexible conduit at the exhauster blower motor connection box and save all hardware.
3. Remove the section of handrail opposite the exhauster blower on the engineer's side (A-side) of the locomotive and save all hardware.
4. Remove and save all exhauster blower mounting bolts and hardened washers.
5. Remove and save the bolt, washer, lockwasher, and nut fastening the blower duct assembly to the blower assembly.
6. Place a steel pry bar between the blower duct assembly and the exhauster blower base, and carefully pry the blower toward the short-hood end of the locomotive until the blower clears the duct assembly.

Warning: The exhauster blower weighs approximately 530 lbs. (240 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

7. Using a crane lifting hook attached to the single lifting lug, carefully lift the blower from the base and remove the blower assembly from the locomotive.
8. Carefully set the blower assembly on a skid in a level position.

Screen 76:

Exhauster Blower Installation:

Typical steps to install the exhauster blower are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any engine component. Place the BS in the OFF position to prevent starting attempts. Also, place the FPB and the LCCB in the OFF position. Also, apply a warning tag on the EC switch.

Warning: The exhauster blower weighs approximately 530 lbs. (240 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

Note: When installing the exhauster blower, inspect and remove any loose hardware or objects that may have fallen into the exhauster blower upward-pointing discharge opening.

1. Carefully position the blower assembly onto the mounting base with a crane, then slide the blower into position, aligning the blower with the duct assembly and the mounting holes.
2. Install the blower mounting hardware and torque the bolts to 155 to 170 lb.-ft. (210 to 231 Nm).
3. Carefully pull the three exhauster blower motor leads back into the connection box.

Caution: When the power leads to the exhauster blower motor have been disconnected at either end for any reason, it is possible to incorrectly connect the leads at reinstallation. If any two power leads are swapped at either end, the blower may still operate; but it will rotate backwards. Backward running of the equipment blower will greatly decrease the air filtering of the equipment blower and engine air filters. This reduced ventilation can shorten the life and/or do serious damage to the traction motors and diesel engine. To check rotation, with the engine at IDLE, place a tie wrap on top of the motor shaft exposed between the motor end bell and the drive-end shaft guard. If the tie wrap moves outward, the motor rotation is correct.

4. Connect the motor lead wires to the terminals in the box, ensuring that each lead is on the correct terminal.
5. Connect the flexible conduit to the connection box.
6. Install the bolt, washer, lockwasher, and nut to secure the blower to the blower duct assembly.
7. Install the section of handrail previously removed.

Screen 79:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the combustion air system.
 - The combustion air system provides sufficient air to the engine during the combustion process and maintains the temperature of that air.
 - The components of the combustion air system are located in the engine cab and radiator cab.

- State the purpose and location of the major components of the combustion air system.
 - V-Screens: Located on both sides of the radiator cab, the V-screens block large items from entering the combustion air system.
 - Plastic Air Cleaner Panels: Located behind the V-screens, the panels provide the primary stage of air filtration for the combustion air system.
 - Baggy Air Filters: Located in the combustion air filter compartment, these filters clean the fine particles from the intake air as it comes from the air cleaner panels.
 - Turbocharger: Located on the Integrated Front End (IFE) cover of the diesel engine, the turbocharger compresses the air for use by the engine during the combustion process.
 - Water-Based Intercooler: Located in the upper section of the radiator cab adjacent to the turbocharger, the water-based intercooler provides the first stage of cooling for the air discharged from the turbocharger.
 - Air-Based Intercooler: Located in the upper section of the radiator cab adjacent to the water-based intercooler, the air-based intercooler provides the second stage of cooling for the turbocharged air.
 - Exhauster Blower: Located in the radiator cab on the engineer's side (A-side) of the locomotive, the exhauster blower removes the dirty air from the spin cleaner panel bleed air duct, continuously discharging the bleed air and dirt out the top of the unit and into the radiator cab. From the radiator cab, the radiator fans pull the air out, discharging the dirty air through the top of the locomotive.
 - Winter-Summer Door: Located in the combustion air filter compartment, the winter-summer door prevents ice crystals from clogging the baggy air filters.
 - Shutter Control Magnet Valves: Located in the combustion air filter compartment on the helper's side (B-side) of the locomotive, these magnet valves control the air-flow for opening and closing the shutters on the air-based intercooler.
 - Turbo Discharge Ducts: These ducts transport the combustion air from the turbocharger to the water-based intercooler.
 - Return Air Ducts: These ducts transport the cooled combustion air from the air-based intercooler to the engine intake manifold.
 - Intermediate Ducts: These ducts transport the combustion air from the water-based intercooler to the air-based intercooler.

- State the purpose and location of the instrumentation devices of the combustion air system.
 - Manifold Air Temperature (MAT) Sensor: Located at the end of the engine's intake air manifold, the MAT sensor measures the manifold air temperature and provides the information to the ECU.

- Ambient True Temperature (ATT) Sensor: Located in the combustion air filter compartment wall, the ATT sensor measures the temperature of the air entering the turbocharger and provides the information to the ECU.
- Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors: Located in each exhaust manifold at the connection points to the turbocharger, these sensors measure the temperature of the exhaust air going into the turbocharger and provide the information to the ECU.
- Turbocharger Right Speed (TRS) Sensor: Located in the turbocharger, the TRS sensor measures the rotational speed of the turbocharger and provides the information to the ECU.
- Manifold Air Pressure (MAP) Sensor: Located at the end of the engine's intake air manifold, the MAP sensor measures the air pressure in the intake manifold and provides the information to the ECU.
- Barometric Air Pressure (BAP) Sensor: Located on the wall of Control Area 4 in the Auxiliary Cab, the BAP sensor measures the atmospheric pressure and provides the information to the ECU.
- Engine Air Filter Pressure (EAFP) Sensor: Located in the combustion air filter compartment just above the fuel filter tanks, the EAFP sensor measures the pressure of the air at the outlet of the filters and before entering the turbocharger and provides the information to the ECU.

Screen 80:

Summary (Cont'd):

- Describe how the combustion air system operates.
 - The turbocharger draws air into the combustion air system through V-screens.
 - The air flows through eight plastic air cleaner panels.
 - An exhauster blower discharges the dirty air from the air cleaner panels into the radiator cab.
 - The clean air from the air cleaner panels fills the combustion air filter compartment.
 - Five baggy filters provide the final filtration of the air entering the turbocharger.
 - The turbocharger compresses the filtered air and sends it to the water-based intercooler which provides the first stage of cooling.
 - If necessary, the air-based intercooler provides the second stage of cooling. If not, the air passes through the air-based intercooler to the intake air manifold on the engine.
 - The intake air manifold distributes the cooled, compressed air to each power assembly on the engine.
 - The exhaust air from the power assemblies spins the turbine blades in the turbocharger before exiting the exhaust stack.

- Describe the protection strategies used with the combustion air system.
 - Hot Pre-Turbine Protection: When either pre-turbine temperature signal as read by the PTRT or PTLT sensor is hot, the available horsepower from the engine is reduced to protect the turbocharger from damage.
 - Turbo Overspeed Protection: When the turbo speed signal as read by TRS sensor is high, the available horsepower is reduced to prevent damage to the turbocharger bearings.
 - Turbo Surge Protection: When a turbo surge is detected, the engine speed is raised or the available horsepower is lowered to prevent damage to the turbocharger.
 - High Air Filter Differential Pressure Protection: The EAFP sensor measures the pressure in the combustion air filter compartment. When the EAFP sensor value falls below the BAP sensor value, air flow through the baggy filters is being restricted, indicating dirty filters.

- Describe how to perform running maintenance related to the combustion air system.
 - The recommended running maintenance schedule associated with the combustion air system and its major components are as follows:
 - Inspect the combustion air system and the diesel engine daily or after every trip. While the engine is idling, make a visual inspection of all system piping, the water-based intercooler, and the air-based intercooler for air leaks. Make corrections as necessary. Then, check the exhaust manifolds for leaks, cracks, and broken welds. Visually inspect the turbocharger discharge ducts for tears or holes in the silicone layer. Replace if any damage is found.
 - Inspect the air-based intercooler every 184 days. Inspect the intercooler for any air leakage. Check for any debris or dirt on the heat exchangers. Run Self-Test 407 and 408 to verify that the fans operate properly. Inspect the shutter mechanism for looseness or wear. Run Self-Test 327 and 328 to verify that the shutters operate properly.
 - Replace the engine baggy filters every 184 days.
 - Every year, lubricate the air-based intercooler fan bearings, following the specifications.
 - Lubricate the bearings of the exhauster blower every three years.

Screen 81:

Summary (Cont'd):

- V-Screens
 - The V-screens require no routine running maintenance other than a visual inspection to see if they are intact and free of debris. If the V-screens are covered with debris, remove the debris before dispatching the locomotive.

- Plastic Air Cleaner Panels
 - The air cleaner panels require no routine running maintenance other than a visual inspection to see if they are intact and free of debris.
 - If a panel is cracked or broken, it must be replaced. If plugged with debris, remove the panel, clean it, and return it to the locomotive.
- Winter-Summer Door
 - The winter-summer door requires no routine running maintenance. If the door is not in the correct position for the climate, locomotive performance may suffer.
- Baggy Air Filters Removal and Installation
 1. Shut down the diesel engine.
 2. Open the door to access the combustion air filter compartment from the engineer's side (A-side) of the radiator cab.
 3. Remove the bar clamp and the wire cages that are accessible from this side.
 4. Remove and replace the used air filters with new approved baggy air filters.
 5. Install the wire cages.
 6. Open the door to access the combustion air filter compartment from the helper's side (B-side) of the radiator cab.
 7. Remove the wire cages that are accessible from this side and replace the used air filters with new approved baggy air filters.
 8. Install the wire cages.
 9. Close and secure the door to the combustion air filter compartment.
 10. On the engineer's side (A-side), install the bar clamp to hold the air filters in place.
 11. Close and secure the door to the combustion air filter compartment.
- Turbocharger Removal and Installation
 - Perform the removal and installation steps as discussed in the Turbocharger Removal and Installation module of the GEVO Diesel Engine Advanced course.
- Water-Based Intercooler Removal and Installation
 - Perform the removal and installation steps as discussed in the Split Cooling Water System module of this course.
- Air-Based Intercooler Package Removal
 1. Shut down the diesel engine.
 2. Depressurize the locomotive cooling system.
 3. Disconnect the battery switch.
 4. Unbolt and remove all top covers over the air-based intercooler package.
 5. Unbolt and remove the side screens on both sides of the locomotive.
 6. Unbolt the intermediate ducts at the lower "V" area of the air-based intercooler.
 7. Unbolt the return ducts at the 8-inch Victaulic couplings on the top outboard connections of the air-based intercooler package.

8. Remove and retain the fasteners from the clamp of the return duct bracket on both the A-side and B-side of the locomotive.
9. Remove the return ducts from the IFE cover of the engine.
10. Attach the lifting hook and strap at each pipe assembly and lift the return ducts from the locomotive.
11. Disconnect the wiring at the six "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
12. Cut the fasteners holding these wires to the tape rail on the radiator cab structure.
13. Disconnect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
14. For a top-mounted shutter assembly, remove the shutter actuator cover to allow access to the air lines, then disconnect the air lines on the shutter cylinders.
15. For side-mounted shutter assemblies, disconnect the air lines from the two shutter cylinders.
16. Unbolt the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
17. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package from the locomotive.
18. Align and place the air-based intercooler package in the support stand on the shop floor.

Screen 82:

Summary (Cont'd):

- Air-Based Intercooler Package Installation
 1. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package into place on the radiator cab.
 2. Align the mounting holes and install the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
 3. For side-mounted shutter assemblies, connect the air lines to the two shutter cylinders.
 4. For a top-mounted shutter assembly, connect the air lines to the shutter cylinders and install the shutter actuator cover.
 5. Connect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
 6. Connect the six wires to the correct "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
 7. Secure the wires to the tape rail on the radiator cab structure with fasteners.
 8. Using an appropriate lifting device, lift and install the return ducts to the IFE cover of the engine.

9. Place the return ducts in the air-to-air frame and attach the return pipe brackets with fasteners that were removed during removal.
 10. Connect the return ducts to the top outboard connections of the air-based intercooler package.
 11. Connect the intermediate ducts at the lower "V" area of the air-based intercooler.
 12. Install the side screens on both sides of the locomotive.
 13. Install the top covers over the air-based intercooler package.
 14. With the air-based intercooler package installed, re-fill the locomotive cooling water system in preparation for returning the locomotive to service.
- Air-to-Air Heat Exchanger Removal
 1. Unbolt and remove the close off angles that secure the top of the air-to-air heat exchanger in place.
 2. Unbolt the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
 3. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
 4. Using the lifting fixture, lift and slide the old air-to-air heat exchanger out of the sheet metal pocket support frame.
 - Air-to-Air Heat Exchanger Installation
 1. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
 2. Using the lifting fixture, lift and slide the air-to-air heat exchanger into the sheet metal pocket support frame.
 3. Install the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
 4. When re-installing the air-to-air heat exchanger on the air-based intercooler frame, only replace the two mounting bolts at the lower inlet air corner and leave out the mounting bolts at the other three remaining corners.
 5. Install the close off angles that secure the top of the air-to-air heat exchanger in place.
 - Shutter Removal – Side-Mounted Shutter Assembly
 1. If required, disconnect the air lines attached to the shutter cylinders on both shutter assemblies.
 2. Loosen the ten ½-13 x 1.50-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler frame.
 3. Loosen the four ½-13 x 1.25-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler heat exchanger.
 4. Remove and save the top two ½-13 x 1.50-inch hex bolts, split lockwashers, and flatwashers, then attach swivel clevis lifting lugs in the bolt holes.

5. With the air-to-air shutter assembly properly supported, remove and save all previously loosened hex bolts, split lockwashers, and flatwashers.
6. Once all the bolts have been removed and the shutter assembly is supported by the lifting lugs, support the bottom of the shutter so it does not swing out as the support stand is removed.
7. Remove the shutter assembly from the air-based intercooler frame.
- Shutter Installation – Side-Mounted Shutter Assembly
 1. Attach the lifting lugs to the shutter assembly and place the shutter assembly on the air-based intercooler frame.
 2. Install the four ½-13 x 1.25 inch hex bolts, ½ split lockwashers , and ½ flatwashers retained during removal.
 3. Install the ten ½-13 x 1.50 inch hex bolts, ½ split lockwashers , and ½ flatwashers retained during removal securing the air-to-air shutter assembly to the top of the air- based intercooler frame.
 4. If required, connect the air lines attached to the shutter cylinders on both shutter assemblies.

Screen 83:

Summary (Cont'd):

- Shutter Removal– Top-Mounted Shutter Assembly
 1. Remove and save the four bolts, washers, and lockwashers securing the actuator cover to the shutter assembly.
 2. Remove the shutter actuator cover to allow access to the air lines.
 3. Disconnect the air lines attached to the shutter cylinders.
 4. Remove and save the hex bolts, washers, and lockwashers securing the air-to-air shutter assembly to the top of the air-based intercooler frame.
 5. Attach lifting lugs to the holes in all four corner gussets of the shutter assembly.
 6. Lift the shutter assembly from the top of the air-based intercooler frame.
- Shutter Installation – Top-Mounted Shutter Assembly
 1. Attach the lifting lugs to the holes in all four corner gussets of the shutter assembly.
 2. Place the air-to-air shutter assembly on the top of the air-to-air frame.
 3. Install the hex bolts, washers, and lockwashers retained during its removal.
 4. Connect the air lines to the shutter cylinders.
 5. Place the shutter actuator cover on the air-to-air frame.
 6. Install the four bolts, washers, and lockwashers to secure the shutter actuator cover.
- Air-to-Air Fan Assembly Removal
 1. Remove the air-to-air shutter assembly.
 2. Disconnect the grease fittings from the fan to be removed.
 3. Disconnect all fan motor leads.

4. Remove and save all bolts and washers that secure the air-to-air fan assembly to the air-based intercooler frame.
5. Attach a crane or lifting device to the lifting hooks on the fan assembly.
6. Remove the air-to-air fan assembly from the locomotive.
- Air-to-Air Fan Assembly Installation
 1. Attach a crane or lifting device to the lifting hooks on the air-to-air fan assembly.
 2. Install the air-to-air fan assembly in position on the air-to-air intercooler.
 3. Install all bolts and washers retained during removal to secure the air-to-air fan assembly to the air-to-air intercooler.
 4. Connect all fan motor leads.
 5. Connect the grease fittings.
 6. Install the air-to-air shutter assembly.
- Exhauster Blower Removal
 1. Open the connection box cover located on the blower motor and disconnect the three motor leads from the terminal block located on the blower motor. Note the identification of each lead on each terminal for subsequent reconnection.
 2. Disconnect the flexible conduit at the exhauster blower motor connection box and save all hardware.
 3. Remove the section of handrail opposite the exhauster blower on the engineer's side (A-side) of the locomotive and save all hardware.
 4. Remove and save all blower mounting bolts and hardened washers.
 5. Remove and save the bolt, washer, lockwasher, and nut fastening the blower duct assembly to the blower assembly.
 6. Place a steel pry bar between the blower duct assembly and the exhauster blower base, and carefully pry the blower toward the short-hood end of the locomotive until the blower clears the duct assembly.
 7. Using a crane lifting hook attached to the single lifting lug, carefully lift the blower from the base and remove the blower assembly from the locomotive.
 8. Carefully set the blower assembly on a skid in a level position.
- Exhauster Blower Installation
 1. Carefully position the blower assembly onto the mounting base with a crane, then slide the blower into position, aligning the blower with the duct assembly and the mounting holes.
 2. Install the blower mounting hardware and torque the bolts to 155 to 170 lb.-ft. (210 to 231 Nm).
 3. Carefully pull the three exhauster blower motor leads back into the connection box.
 4. Connect the motor lead wires to the terminals in the box, ensuring that each lead is on the correct terminal.
 5. Connect the flexible conduit to the connection box.
 6. Close the connection box.

7. Install the bolt, washer, lockwasher, and nut to secure the blower to the blower duct assembly.
8. Install the section of handrail previously removed.

High Adhesion Truck

Screen 1:

Welcome Screen:

Welcome to the High Adhesion Truck module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to High Adhesion Truck:

In this module, you will learn how to inspect and maintain the high adhesion truck in a running repair environment.

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

- State the purpose and location of the high adhesion truck.
- Describe the basic operation of a high adhesion truck.
- Describe the major components of a high adhesion truck.
- Describe how to perform running maintenance inspections on the truck and its major components.
- Summarize the major steps to remove and install the truck and its major components.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspection and maintenance of a high adhesion truck, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Purpose of High Adhesion Truck:

The purpose of the high adhesion truck, also referred to as the HiAd truck, is to distribute the locomotive's weight equally over the axles, transferring the tractive effort (pulling force) and braking effort (stopping force) from the locomotive to the rail. The truck has three axles, which are individually powered by traction motors. Two high adhesion trucks support the entire locomotive. The trucks are commonly referred to as the front truck or number 1 truck and the rear truck or number 2 truck. A locomotive's two truck assemblies are located directly underneath the locomotive platform. The high adhesion truck contains 3 axles and wheel sets. A traction motor powers each axle and is coupled to the axle through a U-Tube assembly and a reduction gear arrangement. The U-Tube wraps around the axle and is mounted to the traction motor. Two roller bearing assemblies within the U-Tube allow the axle to rotate freely. The reduction gear arrangement consists of a small pinion gear and a large bull gear. A gear case, which is attached to the traction motor, surrounds the pinion gear to keep out dirt and moisture and to retain necessary gear lubricant.

Screen 5:**Major Components of High Adhesion Truck:**

When electrical power is applied to the traction motor, the pinion gear, which is part of the traction motor's shaft, turns the bull gear. The bull gear, which is pressed onto the axle, turns the axle. The axle, in turn, causes the wheels to rotate. One side of each traction motor is physically mounted to the truck frame by means of a motor nose support. The truck frame is also supported at each end of each axle by means of two coil springs, an axle or journal housing and an axle or journal bearing. The bearing is pressed onto the end of the axle. The axle housing surrounds the bearing and holds the two coil springs. The other end of the coil springs hold up the truck frame.

Screen 6:**Major Components of High Adhesion Truck (Cont'd):**

Two vertical snubbers, also referred to as primary shock absorbers, are located on one side of the truck to reduce unwanted vertical oscillations. Forces between the truck and the locomotive platform are transmitted through the truck's traction pin bearing assembly to the platform's traction pin. Four loadbearers support the vertical load of the locomotive and also allow for lateral motion between the platform and truck frame. Unwanted movement is lessened by the primary shock absorbers, lateral shock absorbers, and yaw shock absorbers. Finally, brake cylinders, brake rigging, and brake shoes provide braking at each of the six truck wheels.

Screen 9:**Wheels Inspection and Maintenance:**

The wheels on a high adhesion truck transfer the torque generated by the traction motor and apply it to the rails. They are also designed to keep the locomotive on the rail. Periodically inspect the wheels for damage or excessive wear in accordance with Federal Railroad Administration Regulations. The FRA rule for wheel inspection states, "The diameter of the wheels on the same axle shall not vary more than 3/32 inch (0.0938 inches or 2.38 mm); this is equivalent to approximately 2-1/2 tapes." The term "tape", as originally used in measuring locomotive wheels, is the measurement of the circumference of the wheel, where each 1/8ths of an inch (0.125 inches) equals a number on a steel tape measure. In the FRA rule above, the diameter is stated as the actual measurement, while the approximate conversion from "diameter" to "circumference" is also included. The "tape" measurement is provided because it is easier to measure the circumference than the diameter due to the axle and bearing being located in the center of the wheel. Wheels should be turned or replaced if not within the limits listed in the table.

Screen 10:**Wheels Inspection and Maintenance (Cont'd):**

Note: For optimum performance, Engineering recommends that wheels should not vary more than (a) 0.0188 inches (1/2 tape) on the same axle, (b) 0.0750 inches (2 tapes) in the same truck, and (c) 0.3002 inches (8 tapes) under the same locomotive. The diameter of the wheel set is the average diameter of the two wheels on an axle. Keep the following points in mind when inspecting and maintaining wheels: To measure wheel diameter,

flange thickness, and flange height, use a wheel gauge. The wheel diameter is measured by reading the scale on the long arm of the gauge in relation to the top of the witness mark on the wheel and using a conversion chart. Each mark on the scale is a one-eighth inch increase in wheel diameter. The flange height is measured by reading the scale on the pivot arm in relation to the marks on the bend of the gauge. The zero mark on the pivot is used to determine the height. The flange thickness is measured by reading the scale on the pivot arm in relation to the 0 mark on the stationary arm. The mark on the pivot is used to measure the thickness.

Screen 11:

Wheels Inspection and Maintenance (Cont'd):

Do NOT attempt to repair wheels by welding. Turn or mill the wheel set to restore tread and flange contour. Wheels should be removed from service and scrapped when 3 inches (76.2 mm) of wheel diameter material has worn off, or when rim thickness has decreased to 1 inch (25.4 mm). Ensure that the surface finish on reworked wheel flanges does not exceed 250 μ in. (6.35 μ m). This is important because a wheel with a rough flange surface tends to climb the rail.

Screen 12:

Shimming:

Wear and wheel change-outs may cause wheel diameters to become unequal, resulting in greater differences in weight distribution between the axles. Using shims allows greater differences in wheel diameters between wheel sets while keeping axle loading more uniform. Shims are inserted between the coil springs and the spring pads.

Note: FRA Rule 229.73b limits differences in diameter between any two wheel sets in a truck to 3/4 inch (19.1 mm) if shimming is not used. If shims are used at the axle bearing housing springs, the rule permits a difference up to 1-1/4 inches (31.8 mm). The same 1-1/4 inch (31.8 mm) difference is allowed between any two wheel sets on different trucks.

Note: Although 1-1/4 inch (31.8 mm) difference in wheel diameter is acceptable as an FRA limit, wheel diameter variations greater than 1 inch (25 mm) can reduce locomotive performance.

Screen 13:

Shimming (Cont'd):

Typical steps to determine the proper amount of shimming at each axle are as follows:

1. Measure all the wheels on the locomotive.

Note: The average RADIUS for each wheel set is used.

2. Determine the RADIAL difference between the largest wheel set and each of the other wheel sets.

Note: No shims will be applied to the largest diameter wheel set.

3. Using the RADIAL differences, determine the thickness of shims to be used on each of the other axles.

Note: The same size shim combination must be used on both ends of each axle. Consult the displayed table for shim dimensions and part numbers.

Screen 14:

Inserting Shims:

Typical steps to insert shims between the coil spring and spring pads are as follows:

1. Position the traction motor combo over a drop table.
2. Remove the axle bearing housing retainers.
3. Lower the drop table until the space between the top of the axle bearing housing and the truck frame is approximately 7 inches (178 mm).
4. At each of the four coil springs, place a spring retaining strap around the truck frame, UNDER the air piping, and THROUGH the spring coils at approximately the fifth coil.

Screen 15:

Inserting Shims (Cont'd):

5. Lower the drop table until the axle bearing housing is clear of the springs.
6. Place the shims as required between the coil springs and spring pads.

Note: Ensure that the ears of the shims are pointing towards the axle.

7. Raise the traction motor combo into position and remove the coil spring retaining straps.
8. Reapply the axle bearing housing retainers, then torque the bolts to the value provided in the Running Maintenance Manual.

Screen 16:

Pedestal Liners Inspection:

Axle bearing housings fit over the axle bearings, providing platforms to hold the coil springs. A pedestal liner is inserted between each axle bearing housing and the truck frame to keep the axle bearing housing and truck frame from rubbing, thus increasing the life of the truck frame. The nylon plastic liner is a wearable item that can be easily replaced. Inspect each pedestal liner for cracks or broken pieces. If they appear to be visually intact, measure the clearances between pedestal liners and the bearing housing using the specification displayed. If the pedestal liners are damaged or if clearances exceed the maximum worn limits, replace the pedestal liners.

Screen 17:**Pedestal Liners Clearance Measurement:**

Note: Because straight-on access is blocked when checking longitudinal clearance, access for the gauge is from the top of the journal housing — the area between the journal housing and the truck frame.

To check the longitudinal clearance, with a tapered gauge, measure the gap between the long-side face of each pedestal liner and the journal housing. The sum of both measurements is called the total longitudinal gap and it should not exceed 1/2 inch.

Note: When checking lateral clearance, access for the gauge is difficult. The truck must be on raised rails, and the access point is from underneath the journal housing.

To check the lateral clearance, with a tapered gauge, measure the gap between the short-side face of each pedestal liner and the journal housing. This is called the lateral gap.

Screen 18:**Pedestal Liners Clearance Measurement and Replacement:**

For end traction motor locations (TM1, TM3, TM4, and TM6), no lateral gap measurement should exceed 3/8 inch. For center traction motor locations (TM2 and TM5), no lateral gap measurement should exceed 7/8 inch. If the pedestal liners are damaged or if clearances exceed the maximum limits, replace them as follows:

1. Remove the bearing housing retainer and then remove the damaged or worn liner.
2. Install the new pedestal liner and retainer, then torque the retainer bolts to the proper value.

Screen 21:**Brake Shoes and Rigging Inspection:**

Working together, the brake cylinders, brake rigging, and brake shoes apply a stopping force to the wheels. The brake shoes are a high-wear item and must be inspected on a regular schedule. This schedule varies from railroad to railroad and is based on FRA requirements. As you check for brake shoe wear in accordance with your employer's inspection schedule or required federal regulation, look at the adjustment and condition of brake rigging components.

Screen 22:**Brake Shoes and Rigging Inspection (Cont'd):**

The following are key items to look for on brake rigging and shoes: When inspecting the brake shoes for wear, see if the brake pad thickness is worn to less than 1/2 inch (13 mm) at any point on the shoe. If it is, replace it. Ensure that the brake shoes are not binding against the wheel tread surface or flange. If they are, correct this condition. Verify that brake hangers are not causing misalignment of the brake shoe. Repair or replace rigging parts as needed to restore proper brake shoe alignment.

Screen 23:**Brake Shoes and Rigging Inspection (Cont'd):**

Inspect brake linkage for missing, broken, or loose parts. Also inspect for badly worn pins, bushings, or wear plates. Repair or replace parts as necessary. Check the brake rigging wear plates located on the hangers and truck frame pads. Replace the wear plates when the working clearance between the wear plate and the mating wear surface exceeds 3/16 inch (4.8 mm). Check the clearance between the brake shoes and wheels. If clearance is more than 7/8 inch (22.2 mm), readjust according to steps discussed in the Brake System Adjustment section. Check brake cylinder piston-rod travel. If piston-rod travel is 6-1/2 inches (165 mm) or more, readjust according to steps discussed in the Brake System Adjustment section.

Caution: Grease or oil on exposed wear surfaces, collect sand, dirt, and grit, causing surfaces to wear faster. Do NOT lubricate brake rigging pins, bushings, or wear plates.

Screen 24:**Brake Shoes Replacement:**

Typical steps for replacing brake shoes are as follows:

Note: Ensure that the locomotive is on straight, flat track before any adjustment or replacement is made.

1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
2. Release the hand brake (if set), and allow time for the truck wheels to seat against the wheel chocks.

Warning: Ensure that the truck wheels are chocked and the hand brake is released before cutting out the air to the truck that you are going to work on. Ensure that you only cut out one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at the same time. Unexpected rolling of the locomotive can cause serious injury or death.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being worked on.

4. Move the brake shoe as far as possible from the wheel tread, then remove the retaining key and worn brake shoe from the brake head.

Note: If more clearance is necessary to remove the worn brake shoe, remove the slack adjuster pin.

Screen 25:

Brake Shoes Replacement (Cont'd):

Caution: Brake shoes and the linkage design are matched for proper braking according to locomotive weight. Do NOT replace composition type brake shoes with cast iron shoes. Failure to use the proper replacement shoes may result in over-braking, under-braking, or an unbalanced braking condition.

5. Install a new shoe in the brake head, line up the keyway, and then drive the retaining key to seat tight in the keyway, then check the brake shoe for a tight fit in the brake head.

Note: If the shoe is loose with the key tight in the keyway, the brake head is probably worn and should be replaced.

Note: Newly installed brake shoes must hang true in the brake head. Brake head pins must be snug enough to keep the top end of the brake shoe from flopping onto the wheel, but loose enough to allow the shoe to conform to the wheel surface. The wheels should be free to move up and down in relation to the truck frame and brake shoes.

6. Reinstall any pins that were removed and lock them into place.

Note: Adjust the manual slack adjuster as required.

7. Open the truck air cut-out cock.

Screen 26:

Brake System Adjustment:

Typical steps to adjust the brake system are as follows:

Note: Ensure that the locomotive is on a straight, flat track before any adjustment or replacement is made.

1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
2. Release the hand brake (if set), and allow time for the truck wheels to seat against the wheel chocks.

Warning: Ensure that the truck wheels are chocked and the hand brake is released before cutting out the air to truck that you are going to work on. Ensure that you only cut out one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at the same time. Unexpected rolling of the locomotive can cause serious injury or death.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being worked on.

4. To adjust the brake system, lift and rotate the pin retainer and remove the slack adjuster pin.

Warning: Do NOT set the slack adjuster pin in the fully extended position as doing so may cause the slack adjuster to buckle and the brake to fail.

Screen 27:

Brake System Adjustment (Cont'd):

5. With the piston rod fully retracted, adjust the slack adjuster to provide 1/4 inch (6.4 mm) clearance between the brake shoe and wheel, then replace the slack adjuster pin and rotate the pin retainer into place over the pin.

Note: If a slack adjuster is near the adjustment limit, check for excessively worn brake shoes or brake linkage components. Replace worn or damaged parts as needed.

6. Open the truck air cut-out to supply air pressure to the brake system.

Note: Apply and release the air brakes at least twice to check for proper operation of the adjusted air brakes.

Warning: Verify that cylinder piston-rod travel does not exceed 6-1/2 inches (165 mm). Piston rod travel beyond 6-1/2 inches (165 mm) may cause inadequate braking force against the wheels.

7. Check the brake-cylinder piston-rod travel and brake shoe-to-wheel clearances at ALL truck wheels.

Note: Nominal piston-rod travel range is between 2-1/2 and 4-1/2 inches (64 and 114 mm). Brake shoe-to-wheel clearance is 1/4 inch (6.4 mm).

8. If readjustment is required, repeat steps 3 through 7.

Screen 28:

AC Traction Motor Nose Suspension - Inspection and Replacement:

The traction motor nose suspension provides support for the traction motor between the motor and the truck frame. There is one traction motor nose suspension assembly connecting each traction motor nose to the truck frame. There are two types of traction motor nose suspension. The AC Traction Motor uses a "dog bone" shaped suspension, and the DC Traction Motor uses a laminated rubber-steel stack suspension. Let's first discuss how to inspect and replace an AC traction motor nose suspension. Inspect each suspension assembly for defective rubber mounting bushings. If the mounting bushings are worn, bushing rubber extrudes from the cast link, or bushing rubber appears damaged in any way, replace the suspension assembly. Also, check for loose or missing mounting

hardware.

Note: A mounting bushing is worn if there is any clearance between the crossbar and cast link because of missing rubber.

Caution: Remove the suspension link by using a special socket tool to remove the CAMCAR bolts or by cutting the CAMCAR bolts with a torch or hydraulic splitter. If a torch is used, form a shield to protect the rubber parts of the suspension link from heat damage, and use extreme care. Do NOT reuse the bolts, washers, or nuts. Do NOT replace CAMCAR bolts and nuts with ordinary fastener bolts and nuts. Bolts and nuts may loosen during locomotive operation and cause traction motor failure or other equipment damage.

Note: Refer to the applicable Parts Bulletin for recommended replacement parts.

Screen 29:

DC Traction Motor Nose Suspension - Inspection and Replacement:

Typical steps to inspect, remove and replace a DC traction motor nose suspension assembly are as follows:

1. Remove the DC traction motor nose suspension as follows:
 - a. Jack or lift the traction motor nose to compress the suspension assembly approximately 0.5 inches (13 mm).
 - b. Install a 1/2-13 x 6.5 inch (165 mm) long bolt and nut between the U-channels on both sides of the suspension assembly.
 - c. Tighten the nuts to compress the suspension assembly to 11.7 inches (297 mm) or less.
 - d. Lower the traction motor slightly, then remove the cotter pins and retaining pins that secure the vertical keeper pins in the suspension assembly.

Note: The vertical keeper pins should drop out of the suspension assembly when the retaining pins are removed.

- e. Slide the suspension assembly sideways, removing the assembly from the truck frame.
 - f. Inspect the traction motor nose suspension assembly for separation of laminations, badly eroded rubber laminations, or cracked or broken cast members and, if defective, remove and replace the traction motor nose suspension assembly.

Screen 30:

DC Traction Motor Nose Suspension - Inspection and Replacement (Cont'd):

2. Install the DC traction motor nose suspension as follows:
 - a. Slide the nose suspension assembly sideways, into the truck frame.

- b. Lower the traction motor combo slightly, and install the cotter pins and retaining pins, securing the vertical keeper pins in the nose suspension assembly.
- c. Loosen the nuts to de-compress the nose suspension assembly.
- d. Remove the 1/2-13 x 6.5 inch (165 mm) long bolt and nuts previously installed between the U-channels on both sides of the nose suspension assembly.
- e. Lower the traction motor nose into position.

Screen 31:

Loadbearers Inspection:

The rubber loadbearers transfer the weight from the locomotive platform to the truck frame and reduce the vibrations transmitted from the truck frame to the platform. The four loadbearers on the topside of the truck frame consist of alternate layers of steel laminations and rubber, which are bonded together. Typical steps to inspect loadbearers are as follows:

1. Ensure that the loadbearer is centered under the locomotive loadbearer pad.
2. Inspect for evidence of motion between the loadbearer and locomotive loadbearer pad.
3. Inspect loadbearers for extreme wear or severe separation of rubber and steel laminations.
 - a. Look for bent or cracked metal.

Note: Bending and cracking of some of the plates is acceptable if rubber is not trapped, and if no sharp cutting edges are in contact with the rubber.

- b. Look for bonding defects.

Note: Separations of rubber and metal plate laminations are acceptable if gaps are less than 3/4 inch (19.1 mm) and no one separation extends beyond 2 inches (51 mm).

Screen 32:

Loadbearers Inspection (Cont'd):

- c. Inspect for damage to rubber.

Note: Cuts or splits in rubber surfaces are acceptable if length of damage does not exceed 2 inches (51 mm), depth of damage does not exceed 1/2 inch (13 mm), and no more than two cuts or splits occur on any one side of a single lamination.

- d. Inspect for oil and grease contamination.

Note: Some softening of the rubber surface from contamination is acceptable, but the loadbearer should be replaced if swelling increases the length or width of a rubber lamination 1/4 inch (6.4 mm) greater than normal.

4. Replace any defective or displaced loadbearers.

Screen 33:**Loadbearers Replacement:**

Normally, loadbearers are replaced in a Backshop facility when the truck has been removed from the locomotive. However, in some cases, a loadbearer must be replaced in a Running Repair Service Shop. Typical steps to replace loadbearers are as follows:

1. Remove the safety hooks.
2. Jack up the locomotive high enough so that the loadbearer can be removed.

Caution: Ensure that cables and traction motor air ducts are not damaged or stretched too far while the locomotive is being jacked.

Screen 34:**Loadbearers Replacement (Cont'd):**

3. Remove and replace ALL four loadbearers as a set.
 - a. Remove and save the four bolts and lockwashers.

Warning: A loadbearer weighs approximately 90 lbs. (41 kg). Use an adequate lifting device.

- b. Remove and replace the loadbearer.
 - c. Fasten the loadbearer to the truck frame using the four saved bolts and lockwashers.

Screen 37:**Lateral and Yaw Shock Absorbers Inspection:**

Most high adhesion trucks have two lateral and two yaw shock absorbers. The lateral shock absorbers reduce unwanted lateral motion of the locomotive as the truck moves along the track while the yaw shock absorbers reduce side to side sway of the truck and help prevent the truck from "hunting the rail" as the locomotive moves along a straight track. Note that the shock absorber arrangement can vary by customer.

Note: Lateral and yaw hydraulic shock absorbers are sealed by the manufacturer and cannot be refilled with fluid. Leaky shock absorbers must be replaced.

Inspect each lateral and yaw hydraulic shock absorber for leakage or defective rubber mounting bushings. A light film of hydraulic fluid on the body is normal. If the body is wet with fluid, the mounting bushings are worn, or bindings are badly eroded or missing, replace the shock absorber.

Note: Refer to the applicable PARTS BULLETIN for the recommended replacement part number.

Screen 38:**Lateral and Yaw Shock Absorbers Replacement:**

Typical steps to replace lateral and yaw shock absorbers are as follows:

1. Remove all four bolts and associated washers and nuts securing the shock absorber.
2. Remove and discard the hydraulic shock absorber.
3. Install new shock absorber.

Note: The mating surfaces and threads of the shock absorbers must be clean and free of oil.

4. Install the bolts and washers on the shock absorber bosses, then torque the bolts to the proper value.

Screen 39:

Vertical Shock Absorbers - Inspection:

A high adhesion truck has two or four vertical snubbers depending on the customer. These vertical snubbers, also referred to as primary shock absorbers, are mounted parallel to the outside axle springs to reduce unwanted movement and vibrations between the axle and the truck frame.

Note: Vertical hydraulic snubbers are sealed at manufacture and cannot be refilled with fluid. Leaky snubbers must be replaced.

Inspect each vertical hydraulic snubber for leakage or defective rubber mounting bushings. A light film of hydraulic fluid on the body is normal. If the body is wet with fluid, the mounting bushings are worn, or the bindings badly eroded or missing, replace both snubbers on that axle.

Screen 40:

Vertical Shock Absorbers - Replacement:

Typical steps to replace vertical snubbers are as follows:

Caution: If one vertical hydraulic snubber is defective and there is another snubber on the same axle, replace both snubbers on that axle. Use only recommended snubbers on the truck to ensure the proper match with locomotive load conditions. Replacement of only one snubber or failure to use the recommended replacement snubbers creates an incorrect damping condition, and may shorten the useable life of snubbers, springs, and other load-support equipment.

1. Remove all four bolts and associated washers and nuts securing each snubber.
2. Remove and discard both used vertical hydraulic snubbers.
3. Install new snubbers.

Note: The mating surfaces and threads of the snubbers must be clean and free of oil.

4. Reinstall the bolts and washers to secure the snubbers in place, then torque the bolts to the proper value.

Screen 41:

Coil Springs – Inspection and Replacement:

There are two coil springs per axle bearing housing. The purpose of the coil springs is to transfer the weight from the truck frame to the wheels and axles, cushion the impact load, and improve ride quality. To visually inspect the coil springs, raise the weight of the locomotive and truck from the axles to expose the springs. Visually inspect each coil spring for breaks, cracks, vertical wear flats, deep nicks, gouges, or other signs of damage. If visible damage to a coil spring indicates that the useful life or performance of the spring may be limited, replace the spring. Remove the coil springs as directed in the Traction Motor Removal section of this module.

Screen 42:

Safety Hooks – Inspection and Replacement:

Located on each side of the truck, the purpose of the safety hooks is to ensure the truck does not become separated from the locomotive in the event of a derailment. Inspect the safety hooks for proper clearances. If the safety hooks do not meet clearances, identify and replace the defective hooks. Typical steps to replace safety hooks are as follows:

1. Remove and save the four bolts and hardened washers from the safety hook.
2. Remove the safety hook.

Warning: Safety hooks weigh approximately 117 lbs. (53 kg). Use an adequate lifting device.

Screen 43:

Safety Hooks – Inspection and Replacement (Cont'd):

3. Re-tap, clean, and lubricate the truck frame mounting holes, then use copper anti-seize to lubricate the frame mounting holes.

Note: The mounting surface must be clean and free of paint.

4. Clean and lubricate previously saved safety hook mounting hardware, then use copper anti-seize to lubricate the hardware.
5. Position the new or repaired safety hook on the truck frame.
6. Install mounting hardware.

Note: Before tightening, ensure that $1\text{-}3/4 \pm 1/4$ inch (44.5 ± 6.4 mm) clearance exists between each safety hook and the platform.

7. Torque safety hook bolts to 350–400 lb.-ft. (474–542 Nm).

Screen 46:**Traction Motor:**

Each high adhesion truck contains three axles and wheel sets. This traction motor assembly, also referred to as a traction motor combo, includes the traction motor, U-Tube, wheels, and gear case. The traction motor is coupled to the axle through a U-Tube assembly and a reduction gear arrangement. The reduction gear arrangement consists of a small pinion gear and a large bull gear. When electrical power is applied to the traction motor, the pinion gear, which is part of the traction motor's shaft, turns the bull gear. The bull gear, which is pressed onto the axle, turns the axle. The axle, in turn, causes the wheels to rotate, thus moving the locomotive.

Screen 47:**Traction Motor Combo Removal:**

Typical steps to remove the traction motor combo from the high adhesion truck are as follows:

Note: The steps in this demonstration are applicable to both AC and DC traction motors, unless mentioned otherwise. The AC traction motor has been used to depict the steps in this demonstration.

Warning: To ensure the safety of personnel, before proceeding, ensure that the truck and locomotive are securely supported and that the electrical power to the traction motors is OFF.

Warning: On AC locomotives, capacitors in the inverter circuits may not be fully discharged and may contain lethal voltages. Before performing any maintenance on a traction motor or traction motor power cables, open the auxiliary cab door and raise the barrier bar to the vertical position. Raising the barrier bar closes the Capacitor Discharge Switch (CDS). Wait until all lights on the Capacitor Discharge Indicator (CDI) are extinguished before proceeding with any maintenance.

1. Position the traction motor combo to be removed over a single-axle drop table.

Note: If the axle to be removed is at either end of the truck, support the truck frame with suitable blocks to prevent it from tilting.

2. Set the locomotive wheel brakes and chock the wheels on the truck not being worked on, then manually release the brakes on the wheels of the traction motor combo to be removed by closing the cut-out cock in the air line for that truck.

Note: Ensure that all traction motor leads and connection cables are properly marked to ensure correct reconnection.

3. Disconnect all power cables and the motor ground cable of the traction motor combo to be removed from the truck, then secure the cables to prevent damage during traction motor combo removal.

Screen 48:

Traction Motor Combo Removal (Cont'd):

4. Unplug the speed sensor cable of the traction motor combo to be removed, then remove the cable clamp.

Note: Do NOT disconnect the speed sensor from the traction motor.

5. If equipped, disconnect the bearing temperature sensor cables of the traction motor combo being removed.
6. Remove the pins from the slack adjusters of the traction motor combo to be removed, and adjust the slack adjusters to the shortest length.
7. Remove the brake shoes by removing the keys from the brake heads.

Screen 49:

Traction Motor Combo Removal (Cont'd):

8. If the traction motor combo to be removed is one of the end assemblies on the truck, loosen and remove all but one of the sand bracket bolts at both ends of the axle, and swing the sand brackets away to prevent fouling when the combo is lowered.
9. Disconnect the traction motor air duct from the top of the traction motor.

Note: Cover the traction motor air intake opening to prevent foreign material from entering the traction motor.

10. Remove the pedestal liner and axle journal bearing housing retaining bolts, retainers, and any free pedestal liners.

Caution: When the pedestal liner retaining bolts have been removed, the pedestal liners are free floating and may drop out. Remove any free floating pedestal liners.

11. If the traction motor combo to be removed is in positions 1, 3, 4, or 6:
 - a. Disconnect the axle snubbers from the journal box adapters at both ends of the axle.
 - b. Support the truck frame with wooden blocks and hydraulic jacks from the floor adjacent to the traction motor combo being removed.

Note: If the axle has an optional axle alternator, remove the entire axle journal bearing housing as part of the snubber removal step.

Screen 50:

Traction Motor Combo Removal (Cont'd):

12. Disconnect the AC traction motor nose suspension as follows:

- a. Place a suitable jack under the lugs or motor frame, and ensure the jack cannot slip off if the motor moves or tries to rotate.

Caution: Disconnect the suspension link by removing the CAMCAR bolts with a special socket or by cutting the bolts with a torch or hydraulic splitter. If a torch is used, form a shield to protect the rubber parts of the suspension link from heat damage and use extreme care. Do not reuse the bolts, washers, or nuts.

- b. Disconnect the suspension link from the motor.

Warning: Do not pull the suspension link away from the motor until the motor is secured properly. Otherwise, the motor will drop.

Note: For AC traction motors located in positions 1, 2, 5, or 6 in locomotives with generation 1 and generation 2 steerable trucks, the suspension link will contact the motor nose bracket. This bracket is attached to rubber mounts and will move to permit the suspension link to clear the motor frame.

- c. Pull the suspension link away from the motor by using a come-along or similar chain rigging.
- d. Lower the drop table by a few inches while raising the jack to allow the motor safety nose to clear the truck frame.

Screen 51:

Traction Motor Combo Removal (Cont'd):

13. Remove the DC traction motor nose suspension as follows:

- a. Jack or lift the traction motor nose to compress the suspension assembly approximately 0.5 inches (13 mm).
- b. Install a 1/2-13 x 6.5 inch (165 mm) long bolt and nut between the U-channels on both sides of the suspension assembly.
- c. Tighten the nuts to compress the suspension assembly to 11.7 inches (297 mm) or less.
- d. Lower the traction motor slightly, then remove the cotter pins and retaining pins that secure the vertical keeper pins in the suspension assembly.

Note: The vertical keeper pins should drop out of the suspension assembly when the retaining pins are removed.

- e. Slide the suspension assembly sideways, removing the assembly from the truck frame.
- f. Inspect the traction motor nose suspension assembly for separation of laminations, badly eroded rubber laminations, or cracked or broken cast

members and, if defective, remove and replace the traction motor nose suspension assembly.

Screen 52:

Traction Motor Combo Removal (Cont'd):

14. In a DC traction motor, check the suspension lugwear plates on the traction motor and, if excessively worn, replace the plates.
15. Lower the drop table by approximately 5 inches (125 mm), place chocks over the rail, and nip the securing bolts to secure the traction motor combo in place.
16. Raise the drop table by 2 inches (50 mm) to compress the coil springs.
17. For the four coil springs at the traction motor combo, place a spring retaining strap around the truck frame, under the air piping and through the spring coils at approximately the fifth coil, then join the strap ends, leaving at least 12 inches (300 mm) of slack in the straps.

Note: Verify that the wooden blocks and hydraulic jacks supporting the truck frame are securely in place if the combo to be removed is in positions 1, 3, 4, or 6.

Screen 53:

Traction Motor Combo Removal (Cont'd):

18. Apply C-clamps on each wheel rim below each side of the axle journal bearing housing to prevent the housing from rotating during traction motor combo removal.
19. Raise the traction motor nose up to clear the nose suspension or the truck frame as the traction motor is lowered.
20. Support the traction motor nose with blocks suitably placed under the frame, such that it cannot slip off if the traction motor moves or rotates.
21. Lower the drop table until the space between the top of the axle journal bearing housing and the truck frame is approximately 7 inches (175 mm), then tighten the coil spring retaining straps to remove any remaining slack.

Screen 54:

Traction Motor Combo Removal (Cont'd):

22. Lower the drop table until the traction motor combo clears the truck and remove any remaining truck pedestal liners.
23. Move the traction motor combo from beneath the truck and locomotive.

Caution: If the gear case is still filled with oil, it cannot be tilted more than 4 inches (102 mm) end to end from horizontal because the oil will run around the seals and drain into the traction motor.

Warning: The AC traction motor combo weighs approximately 13,270 lbs. (6,019 kg), and the DC traction motor combo weighs approximately 12,000 lbs. (5,443 kg). Ensure that an adequate crane and cables are used to lift and move the traction motor combo.

24. Using a suitable hoist, lift the traction motor combo from the drop table and move it to the area assigned for cleaning, maintenance, or storage.
25. Set the traction motor frame in the normal horizontal position on blocks high enough so that the wheels clear the floor.

Caution: After the combo is removed from the truck, if it is not broken down immediately, the rotor (on the AC motor) or armature (on the DC motor) should be locked to prevent possible shipping damage to bearings in the motor.

Screen 55:

Traction Motor Combo Installation:

Warning: The AC traction motor combo weighs approximately 13,270 lbs. (6,019 kg), and the DC traction motor combo weighs approximately 12,000 lbs. (5,443 kg). Ensure that an adequate crane and cables are used to lift and move the combo.

Warning: To ensure the safety of personnel, before proceeding, ensure that the truck and locomotive are securely supported and that the electrical power to the traction motors is OFF.

Warning: On AC locomotives, capacitors in the inverter circuits may not be fully discharged and may contain lethal voltages. Before performing any maintenance on a traction motor or traction motor power cables, open the auxiliary cab door and raise the barrier bar to the vertical position. Raising the barrier bar closes the CDS. Wait until all lights on the CDI are extinguished before proceeding with any maintenance.

Caution: If the gear case is filled with oil, it cannot be tilted more than 4 inches (102 mm) end to end from horizontal because the oil will run around the seals and drain into the traction motor. Use a three-point lift to lift the combo.

Screen 56:

Traction Motor Combo Installation (Cont'd):

Typical steps to install the traction motor combo into the high adhesion truck are as follows:

1. Remove all dirt and weld splatter from the traction motor nose suspension lugs and the traction motor nose suspension area of the truck frame.
2. Transfer the traction motor combo to the drop table, and place suitable blocking under the motor frame to raise the motor lugs.

Note: The traction motor nose must be raised so that the motor safety lugs engage the truck frame, and the traction motor nose suspension lugs clear the truck frame.

3. Position the drop table and the traction motor combo under the truck with the axle journal bearing housings aligned with the journal bearing housings in the truck frame.

4. Level the axle journal bearing housings, and apply C-clamps on each wheel rim below each side of the axle journal bearing housings to prevent it from rotating during traction motor combo installation.

Note: Ensure that the coil spring seats are in position on the axle journal bearing housings.

5. Raise the drop table with the traction motor combo.

Screen 57:

Traction Motor Combo Installation (Cont'd):

6. Install the truck pedestal liners, and ensure that the coil springs seat properly as the traction motor combo is raised.
7. Raise the drop table until the axle journal bearing housings are completely in place, with the drop table assuming part of the weight of the truck.
8. Install the four axle journal bearing housing retainers on the truck pedestal legs.
9. Torque the retainer bolts to 296 to 329 lb.-ft. (401 to 446 Nm).
10. Remove the four coil spring retaining straps.
11. Lower the hydraulic jacks and remove all wooden blocks from under the traction motor and the truck.

Screen 58:

Traction Motor Combo Installation (Cont'd):

12. Connect the AC traction motor nose suspension as follows:
 - a. Release the come-along or chain rigging.

Note: The suspension link should spring back under the motor lugs.

- b. Lower the motor frame until the suspension link is supporting the weight of the traction motor combo.

Note: For AC traction motor combos in positions 1, 2, 5, or 6, the suspension link bracket should be on top of the motor lugs.

- c. Insert CAMCAR bolts through the suspension link motor lugs and hand-tighten the nuts.

Note: On generation 1 and 2 steerable trucks only, if the traction motor combo is being installed in positions 1, 2, 5, or 6, verify truck alignment as described in official publications, before tightening the CAMCAR bolts.

Note: It may be necessary to twist the motor nose bracket, using rubber mounts, to align the bolt holes.

Caution: Do NOT replace CAMCAR bolts and nuts or HUCK pins and collars with ordinary fastener bolts and nuts. Ordinary bolts and nuts may loosen during locomotive operation

and cause the traction motor to fail or cause other equipment damage. Refer to the applicable Parts Bulletin for recommended replacement parts.

- d. Tighten the CAMCAR bolts with the special socket until the head shears off each bolt.

Screen 59:

Traction Motor Combo Installation (Cont'd):

13. Install the DC traction motor nose suspension as follows:
 - a. Slide the nose suspension assembly sideways, into the truck frame.
 - b. Lower the traction motor combo slightly, and install the cotter pins and retaining pins, securing the vertical keeper pins in the nose suspension assembly.
 - c. Loosen the nuts to de-compress the nose suspension assembly.
 - d. Remove the 1/2-13 x 6.5 inch (165 mm) long bolt and nuts previously installed between the U-channels on both sides of the nose suspension assembly.
 - e. Lower the traction motor nose into position.

Screen 60:

Traction Motor Combo Installation (Cont'd):

14. For traction motor combos in positions 1, 3, 4, and 6, connect axle snubbers to the journal box adapters at both ends of the axle, then torque the snubber bolts to 197 to 219 lb.-ft. (267 to 297 Nm).
15. Connect the traction motor air duct to the top of the motor.
16. Lubricate the air duct bolts with a Wabtec approved Moly-based lubricant (84B565364A1) or light machine oil.
17. Install the bolts and then torque to 50 to 55 lb.-ft. (68 to 75 Nm).
18. If the traction motor combo installed is one of the end assemblies on the truck, return the sand brackets at both ends of the axle, then install and torque the sand bracket bolts to the proper value.
19. Install the brake shoes and the slack adjuster pins, then adjust the slack adjusters.

Screen 61:

Traction Motor Combo Installation (Cont'd):

20. Connect the speed sensor cable of the traction motor combo to its connection under the locomotive platform.
21. If equipped, connect the bearing temperature sensor cables.
22. Connect all power cables and the traction motor ground cable to their connections under the locomotive platform.
23. Release and remove all jacks and chocks used to support or secure the truck for traction motor combo removal.
24. Activate the brakes by opening the truck cut-out cock.
25. Check the level of lubricant in the gear case, and add lubricant as required.

Screen 62:

High Adhesion Truck Removal:

Typical steps to remove the high adhesion truck from under the locomotive are as follows:

1. Chock at least two sets of truck wheels on both trucks to prevent the locomotive from rolling in either direction.
2. Release the hand brake if set, and allow time for the truck wheels to seat against the wheel chocks.

Warning: Ensure that the truck wheels are chocked and release the hand brake before cutting out the brake cylinder air. Ensure that air is cut out to only one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at one time. Unexpected rolling of the locomotive can cause serious injury or death.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being removed. Disconnect the hose to that truck's brake cylinders only after all air has been exhausted from the truck air lines.

Screen 63:

High Adhesion Truck Removal (Cont'd):

4. Under the locomotive platform, disconnect the traction motor leads, ground cables, and speed-sensor cables leading to each traction motor.
5. Disconnect the ground cable between the truck and the platform.
6. Disconnect the traction motor air ducts from the top of the traction motors, then cover the traction motor openings to prevent entrance of foreign material.
7. If an axle alternator is installed on the truck being removed, disconnect the alternator cable from the junction box on the alternator, then coil and secure the cable so it will not be damaged.
8. Disconnect all sander hoses from the sander brackets on the truck and disconnect the hoses for the flange lubricators if used.

Screen 64:

High Adhesion Truck Removal (Cont'd):

9. Disconnect the hand brake chain if the long-hood end truck is being removed.
10. Remove the lateral and yaw shock absorbers.
11. Remove both safety hooks from the truck frame.
12. Raise the locomotive platform clear of the truck with jacks or a crane, or lower the truck on a drop table.

Note: Ensure that the cables, air ducts, and hoses are not damaged. If the truck is to be pulled out sideways, the locomotive platform must be raised (or truck lowered) at least 10 inches (254 mm).

13. After the truck is removed from under the locomotive, cover the truck center-pin bearing to prevent contamination with dirt and other foreign materials.

Screen 65:**High Adhesion Truck Installation:**

Typical steps to install the high adhesion truck under the locomotive are as follows:

1. Space the trucks approximately 50 ft. (15.2 m) between traction pin bearing assemblies.

Note: When installed on the locomotive, the transom ends of the trucks must be facing each other.

2. Remove the temporary dust covers from the traction motor air duct openings.
3. Inspect the traction motor air ducts between the locomotive platform and the truck and replace any air ducts that are cracked or torn.
4. Coat the center pin on the underside of the locomotive platform with grease.
5. Lower the platform onto the truck (or raise the truck on the drop table), then carefully mate the center pin with the center pin bearing.

Note: Ensure that the two tangs on top of each of the four loadbearers per truck register properly in the locomotive platform.

Screen 66:**High Adhesion Truck Installation (Cont'd):**

6. Install both safety hooks on the truck frame.
7. Install the lateral and yaw shock absorbers.
8. Connect the hand brake chain if the long-hood end truck is being installed.
9. Install the hoses from the sand pipes on the platform to the sander brackets on the trucks, and install the hoses for the flange lubricators if used.

Screen 67:**High Adhesion Truck Installation (Cont'd):**

10. Connect the axle alternator cable to the junction box on the alternator if used.
11. Install the traction motor air duct to each of the traction motors.
12. Connect the ground cable between the truck and the platform.
13. Connect the speed sensor cable, traction motor leads, and the ground cable at each traction motor.

Screen 68:**High Adhesion Truck Installation (Cont'd):**

14. Connect the air brake hoses from the locomotive platform to the brake cylinder piping on the truck.

Note: Before returning the locomotive to service, the truck cut-out cocks (located under the platform) must be opened.

15. Adjust the truck brake rigging.

Caution: Ensure that the journal bearing housings, traction motor gear cases, and traction motor support bearings have been lubricated before moving the locomotive.

16. Check the traction motor rotation.

Screen 71:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the high adhesion truck.
 - The purpose of the high adhesion truck is to distribute the locomotive's weight equally over the axles, transferring the tractive effort (pulling force) and braking effort (stopping force) from the locomotive to the rail.
 - Two high adhesion trucks support the entire locomotive.
- Describe the basic operation of a high adhesion truck.
 - The high adhesion truck contains 3 axles and wheel sets. A traction motor powers each axle and is coupled to the axle through a U-Tube assembly and a reduction gear arrangement.
 - The U-Tube wraps around the axle and is mounted to the traction motor. Two roller bearing assemblies within the U-Tube allow the axle to rotate freely.
 - The reduction gear arrangement consists of a small pinion gear and a large bull gear.
 - A gear case surrounds the pinion gear to keep out dirt and moisture and to retain necessary gear lubricant.
 - When electrical power is applied to the traction motor, the pinion gear turns the bull gear.
 - The bull gear turns the axle which in turn, causes the wheels to rotate.
- Describe the major components of a high adhesion truck.
 - One side of each traction motor is physically mounted to the truck frame by means of a motor nose support.
 - The truck frame is supported at each end of each axle by means of two coil springs, an axle or journal housing, and an axle or journal bearing.
 - The bearing is pressed onto the end of the axle. The axle housing surrounds the bearing and holds the two coil springs. The other end of the coil springs hold up the truck frame.
 - Two vertical snubbers, also referred to as primary shock absorbers, are located on one side of the truck to reduce unwanted vertical oscillations.
 - Forces between the truck and the locomotive platform are transmitted through the truck's traction pin bearing assembly to the platform's traction pin.

- Four loadbearers support the vertical load of the locomotive and also allow for lateral motion between the platform and truck frame.
- Unwanted movement is lessened by the primary shock absorbers, lateral shock absorbers, and yaw shock absorbers.
- Brake cylinders, brake rigging, and brake shoes provide braking at each of the six truck wheels.
- Describe how to perform running maintenance inspections on the truck and its major components.
 - Wheels
 - Periodically inspect the wheels for damage or excessive wear, in accordance with Federal Railroad Administration Regulations.
 - Shimming
 - The use of shims allows greater differences in wheel diameters between wheel sets while keeping axle loading more uniform.
 - Shims are inserted between the coil springs and the spring pads.
 - Pedestal Liners
 - To check the longitudinal clearance, with a tapered gauge, measure the gap between the long-side face of each pedestal liner and the journal housing. The sum of both measurements is called the total longitudinal gap and it should not exceed 1/2 inch.
 - To check the lateral clearance, with a tapered gauge, measure the gap between the short-side face of each pedestal liner and the journal housing. This is called the lateral gap.
 - If the pedestal liners are damaged or if clearances exceed the maximum limits, replace them as follows:
 1. Remove the bearing housing retainer and then remove the damaged or worn liner.
 2. Install the new pedestal liner and retainer, then torque the retainer bolts to the proper value.
 - Brake Shoes and Rigging
 - The brake shoes are a high-wear item and must be inspected on a regular schedule and replaced as follows:
 1. Chock at least two sets of truck wheels and release the hand brake.
 2. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.
 3. Move the brake shoe as far as possible from the wheel tread, then remove the retaining key and worn brake shoe from the brake head.
 4. Install a new shoe in the brake head.
 5. Reinstall any pins that were removed and lock them into place.
 6. Open the truck air cut-out cock.
 - Adjust the brake system as follows:
 1. Chock at least two sets of truck wheels and release the hand brake.
 2. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

3. Adjust the slack adjuster, replace the slack adjuster pin, and rotate the pin retainer.
4. Open the truck air cut-out cock.
5. Apply and release the air brakes at least twice to check for proper operation of adjusted air brakes.
6. Check the brake-cylinder piston-rod travel and brake shoe-to-wheel clearances at ALL truck wheels.

Screen 72:

Summary (Cont'd):

- AC Traction Motor Nose Suspension
 - Inspect each suspension assembly for defective rubber mounting bushings. Also, check for loose or missing mounting hardware.
- DC Traction Motor Nose Suspension
 - Typical steps to inspect, remove and replace a DC traction motor nose suspension assembly are as follows:
 1. Jack or lift the motor nose to compress the suspension assembly.
 2. Install and tighten the bolts and nuts between the U-channels of the suspension assembly.
 3. Lower the traction motor slightly, then remove the cotter pins and retaining pins.
 4. Slide the suspension assembly sideways, removing the assembly from the truck frame.
 5. Inspect the traction motor nose suspension assembly for separation of laminations, badly eroded rubber laminations, or cracked or broken cast members and, if defective, remove and replace the traction motor nose suspension assembly.
 6. Slide the nose suspension assembly sideways, into the truck frame.
 7. Lower the traction motor combo slightly, and install the cotter pins and retaining pins, securing the vertical keeper pins in the nose suspension assembly.
 8. Loosen and remove the bolts and nuts between the U-channels of the suspension assembly.
 9. Lower the traction motor nose into position
- Loadbearers
 - Inspect the loadbearers as follows:
 1. Ensure that the loadbearer is centered under the locomotive loadbearer pad.
 2. Inspect for evidence of motion between the loadbearer and locomotive loadbearer pad.
 3. Inspect loadbearers for extreme wear or severe separation of rubber and steel laminations.
 - Replace any defective or displaced loadbearers as follows:
 1. Remove the safety hooks.
 2. Jack up the locomotive high enough so that the loadbearer can be removed.

3. Remove and replace ALL four loadbearers as a set.
- Lateral and Yaw Shock Absorbers
 - Inspect each lateral and yaw hydraulic shock absorber for leakage or defective rubber mounting bushings.
 - Replace lateral and yaw shock absorbers as follows:
 1. Remove all four bolts and associated washers and nuts securing the shock absorber.
 2. Remove and discard the hydraulic shock absorber.
 3. Install new shock absorber.
 4. Install and torque the bolts and washers on the shock absorber bosses.
 - Vertical Shock Absorbers
 - Inspect each vertical hydraulic snubber for leakage or defective rubber mounting bushings.
 - Replace vertical snubbers as follows:
 1. Remove all four bolts and associated washers and nuts securing each snubber.
 2. Remove and discard both used vertical hydraulic snubbers.
 3. Install new snubbers.
 4. Reinstall and torque the bolts and washers to secure the snubbers in place.
 - Coil Springs
 - Visually inspect each coil spring for breaks, cracks, vertical wear flats, deep nicks, gouges, or other signs of damage. If visible damage to a coil spring indicates that the useful life or performance of the spring may be limited, replace the spring.
 - Remove the coil springs as directed in the Traction Motor Removal section of this module.
 - Safety Hooks
 - Inspect the safety hooks for proper clearances. If the safety hooks do not meet clearances, identify and replace the defective hooks.
 - Replace safety hooks as follows:
 1. Remove and save the four bolts and hardened washers from the safety hook.
 2. Remove the safety hook.
 3. Position the new or repaired safety hook on the truck frame.
 4. Install mounting hardware and torque the safety hook bolts.

Screen 73:

Summary (Cont'd):

- Summarize the major steps to remove and install the truck and its major components.
 - Traction Motor Combo Removal
 1. Position the traction motor combo to be removed over a single-axle drop table.

2. Set the locomotive wheel brakes and chock the wheels on the truck not being worked on, then manually release the brakes on the wheels by closing the cut-out cock in the air line.
 3. Disconnect all power cables, the motor ground cable, the speed sensor cable, and, if equipped, the bearing temperature sensor cables.
 4. Remove the pins from the slack adjusters and shorten the slack adjusters to the shortest length.
 5. Remove the brake shoes by removing the keys from the brake heads.
 6. Disconnect the traction motor air duct from the top of the traction motor.
 7. Remove the pedestal liner retaining bolts, axle journal bearing housing, and any free pedestal liners.
 8. Disconnect the nose suspension for an AC traction motor or remove the nose suspension for a DC traction motor.
 9. In a DC traction motor, check the suspension lugwear plates and, if excessively worn, replace the plates.
 10. Lower the drop table and place chocks over the rail and nip the securing bolts to secure the combo in place.
 11. Raise the drop table to compress the coil springs.
 12. Place a spring retaining strap around the truck frame, under the air piping and through the spring coils, then join the strap ends.
 13. Apply C-clamps on each wheel rim to prevent the housing from rotating during the traction motor combo removal.
 14. Raise the traction motor nose up to clear the nose suspension or the truck frame as the motor is lowered.
 15. Lower the drop table and tighten the coil spring retaining straps to remove any remaining slack.
 16. Lower the drop table until the traction motor combo clears the truck and remove any remaining truck pedestal liners.
 17. Move the traction motor combo from beneath the truck and locomotive.
 18. Lift the traction motor combo from the drop table and set it aside for cleaning, maintenance, or storage.
- Traction Motor Combo Installation
 1. Transfer the traction motor combo to the drop table, and place suitable blocking under the motor frame to raise the motor lugs.
 2. Position the drop table and the traction motor combo under the truck.
 3. Level the axle journal bearing housings, and apply C-clamps on each wheel rim below each side of the axle journal bearing housings.
 4. Raise the drop table and install the truck pedestal liners.
 5. Install the four axle journal bearing housing retainers on the truck pedestal legs.
 6. Remove the four coil spring retaining straps.
 7. Lower the hydraulic jacks and remove all wooden blocks from under the traction motor and the truck.
 8. Connect the nose suspension for an AC traction motor or install the nose suspension for a DC traction motor.

9. Connect the traction motor air duct to the top of the motor.
 10. Lubricate the air duct bolts with a Wabtec approved Moly-based lubricant (84B565364A1) or light machine oil.
 11. Install the bolts and then torque to 50 to 55 lb.-ft. (68 to 75 Nm).
 12. Install the brake shoes and the slack adjuster pins, then adjust the slack adjusters.
 13. Connect all power cables, the motor ground cable, the speed sensor cable, and, if equipped, the bearing temperature sensor cables to their connections under the locomotive platform.
 14. Release and remove all jacks and chocks used to support or secure the truck and for traction motor combo removal.
 15. Activate the brakes by opening the truck cut-out cock.
 16. Check the level of lubricant in the gear case, and add lubricant as required.
- High Adhesion Truck Removal
 1. Chock at least two sets of truck wheels and release the hand brake.
 2. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.
 3. Disconnect the traction motor leads, ground cables and speed-sensor cables leading to each traction motor.
 4. Disconnect the ground cable between the truck and the platform.
 5. Disconnect the traction motor air ducts from the top of the traction motors, then cover the traction motor openings to prevent entrance of foreign material.
 6. If an axle alternator is installed on the truck being removed, disconnect the alternator cable from the junction box on the alternator, then coil and secure the cable so it will not be damaged.
 7. Disconnect all sander hoses from the sander brackets on the truck and disconnect the hoses for the flange lubricators if used.
 8. Disconnect the hand brake chain if the long-hood end truck is being removed.
 9. Remove the lateral and yaw shock absorbers.
 10. Remove both safety hooks from the truck frame.
 11. Raise the locomotive platform clear of the truck with jacks or crane, or lower the truck on a drop table.
 12. After the truck is removed from under the locomotive, cover the truck center-pin bearing to prevent contamination with dirt and other foreign materials.
 - High Adhesion Truck Installation
 1. Space the trucks between traction pin bearing assemblies.
 2. Remove the temporary dust covers from the traction motor air duct openings.
 3. Inspect the traction motor air ducts between the locomotive platform and the truck and replace any air ducts that are cracked or torn.
 4. Coat the center pin on the underside of the locomotive platform with grease.
 5. Lower the platform onto the truck, then carefully mate the center pin with the center pin bearing.
 6. Install both safety hooks on the truck frame.

7. Install the lateral and yaw shock absorbers.
8. Connect the hand brake chain if the long-hood end truck is being installed.
9. Install the hoses from the sand pipes on the platform to the sander brackets on the trucks.
10. Connect the axle alternator cable to the junction box on the alternator if used.
11. Install the traction motor air duct to each of the traction motors.
12. Connect the ground cable between the truck and the platform.
13. Connect the speed sensor cable, traction motor leads, and the ground cable at each traction motor.
14. Connect the air brake hoses from the locomotive platform to the brake cylinder piping on the truck.
15. Adjust the truck brake rigging.
16. Check the traction motor rotation.

Steerable Truck

Screen 1:

Welcome Screen:

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

Screen 2:

Introduction to Steerable Truck:

In this module, you will learn how to inspect and maintain a three-motor, three-axle, high adhesion steerable type truck in a running repair environment.

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

- State the purpose and location of the steerable trucks.
- Describe the major components of a steerable truck.
- Describe the basic operation of a steerable truck.
- Describe how to perform running maintenance inspections related to the truck and its major components.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspection and maintenance of a steerable truck, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Overview of the Steerable Truck:

The three-axle G1 model steerable truck is a three-motor, three-axle, high-adhesion, steerable type truck designed to carry one-half the weight of the locomotive. The high adhesion truck of an ES44AC/DC locomotive is designed to increase the adhesion between the wheels and the rail. Although the high adhesion truck performs as designed on a straight track, a loss of tractive effort occurs when the locomotive encounters a curve. To maximize the tractive effort on a curved track, the steerable truck was developed.

Note: The steerable truck can only be used on an AC locomotive.

Screen 5:

Overview of the Steerable Truck (Cont'd):

The entire locomotive is supported by two steerable trucks, commonly called the front truck and the rear truck. These truck assemblies are located directly underneath the locomotive platform. Each steerable truck, designed to carry one-half of the weight of the locomotive, has three axles that are individually powered by traction motors. The

steerable trucks distribute the locomotive weight equally over the axles, and transfer the tractive effort or pulling force, and braking effort or stopping force, from the locomotive to the rails.

Screen 6:

Major Components of the Steerable Truck:

The major components of the steerable truck include:

- Truck Frame
- Wheels
- Lateral Liners
- Brake Shoes and Rigging
- Traction Motor Nose Suspension
- Side bearers
- Traction Pads
- Center Pin and Bearing Assembly
- Lateral and Yaw Dampers
- Vertical Hydraulic Dampers
- Coil Springs
- Steering Assembly and Inter-Motor Linkage Assembly
- Safety Hooks

Screen 7:

Truck Frame:

The truck frame is the backbone and foundation for the steerable truck assembly. It is a C-shaped steel casting that provides the mounting for all of the steerable truck's components.

Screen 8:

Wheels:

The wheels transfer the torque generated by the traction motor and apply it to the rails. The wheels are designed to keep the locomotive on the rails.

Screen 9:

Lateral Liners:

The lateral liners, two per axle bearing housing, provide a wear surface between the axle bearing housing and the truck frame. The axle bearing housings move vertically between nylon liners. These liners float laterally on retaining bolts that are inserted into the truck frame.

Screen 10:

Brake Shoes and Rigging:

Working together, the brake cylinders, brake rigging, and brake shoes apply stopping force to the wheels.

Screen 11:**Traction Motor Nose Suspension:**

The traction motor nose suspension, also referred to as the dog bone or suspension link, provides support for the traction motor between the motor and the truck frame.

Screen 12:**Side Bearers:**

The rubber side bearers, also referred to as loadbearers, consist of alternate layers of steel laminations and rubber, which are bonded together. There are four side bearers on the topside of the truck. The side bearers transmit the locomotive weight to the trucks, while permitting controlled lateral motion of the trucks relative to the locomotive platform.

Screen 13:**Traction Pads:**

The rubber traction pads, consisting of alternate layers of steel and rubber that are bonded together, function to transmit the tractive effort from the truck to the locomotive, while permitting controlled lateral motion of the trucks relative to the locomotive platform. The traction pads also absorb the shock between the center pin bearing assembly and the truck frame during acceleration and braking.

Screen 14:**Center Pin and Bearing Assembly:**

A center pin, located on the underside of the locomotive platform, fits into a center pin bearing assembly mounted in the truck frame. The center pin is welded to the underside of the platform and mates with the truck by way of the center block. The bearing assembly and the center pin allow the truck to pivot with respect to the locomotive platform and transmit the tractive force from the truck to the locomotive platform.

Screen 15:**Lateral and Yaw Dampers:**

The lateral and yaw dampers are used to dampen unwanted movement and vibrations between the truck and the locomotive platform. There are two lateral and two yaw dampers per truck.

Screen 16:**Vertical Hydraulic Dampers:**

There are four primary or vertical dampers on a steerable truck. The primary dampers are used to dampen unwanted movement and vibrations between the wheel axle assembly and the truck.

Screen 17:**Coil Springs:**

The coil springs transfer the weight of the locomotive to the wheel and axle assembly, dampen vertical forces, and improve ride quality. There are twelve coil-compression springs, one spring located on each side of each journal bearing housing.

Screen 18:**Safety Hooks:**

Safety hooks ensure that the truck does not become separated from the locomotive. They are located on both sides of each truck frame.

Screen 19:**Steering Assembly:**

The steering assembly is a series of mechanical linkages that cause the axles to adjust to the curvature of the track. There are several components that make up the steering assembly. These include:

- Equalizer Bar and Equalizer Arms
- Bell Cranks
- Equalizer Bar Damper
- Reaction Arms and Wing Plate Assembly
- Traction Link and Center Link

Screen 20:**Equalizer Bar and Equalizer Arms:**

The equalizer bar, also referred to as a "Marty" bar, and equalizer arms are attached to the open end of the bell cranks. The equalizer arms are heat-shrink fitted to the top of the bell cranks. The equalizer bar is attached to the equalizer arms by a close tolerance hardened pin with hardened bushings.

Screen 21:**Bell Cranks:**

The bell crank is a vertically oriented shaft that rotates within the truck frame through two rubber laminated bearings. The bell crank permits the traction motor combination yaw rotation to be transmitted to the externally mounted reaction arms.

Screen 22:**Equalizer Bar Damper:**

G1 steerable trucks have an equalizer bar damper attached between the steering arrangement and the truck frame. The damper reduces vibration induced by the steerable arrangement in the lateral direction.

Screen 23:**Reaction Arms and Wing Plate Assembly:**

The reaction arms and wing plate assembly arrangement helps to ensure that the two axles are acting in equal and opposite direction. As the end axles rotate in equal and opposite direction in yaw, the reaction arms rotate relatively. The wing plate assembly will displace inward or outward relative to the truck frame depending upon the direction of steering. For example, if the left-side wing plate assembly displaces inward, the right-side wing plate assembly will displace outward.

Note: As the end axles rotate in equal and opposite direction, wheel/rail flange forces are reduced. This reduction in flange forces reduces wheel flange and rail gage face wear. Also, pulling adhesion in curves is increased.

Screen 24:**Traction Link and Center Link:**

The traction and center links transmit and react to the tractive, braking, and steering forces from the wheel set journal box to the truck frame. Links are connected to the axle bearing housing, also known as the journal box. The other ends are attached to the truck frame through a smaller casting called a traction cap. These links have non-wearing elastomer bushings, which are securely fastened with nuts and bolts at both ends through the bushings.

Screen 25:**Operation of Steerable Trucks:**

The 3-axled steerable truck has a series of steering linkages that force the first and third axles in equal and opposite directions, while the second axle moves laterally, towards the outside of the curve. Each set of wheels is powered by its own traction motor. The truck frame is supported by coil springs with primary dampers, which dampen vertical spring oscillations. A center pin and center pin bearing assembly transmit the tractive force from the truck to the locomotive platform. The side bearers support the vertical load and provide controlled lateral motion between the locomotive and the truck. The journal bearing housings transfer vertical loads from the frame to the axles and wheels.

Screen 26:**Operation of Steerable Trucks (Cont'd):**

The primary, lateral, and yaw dampers reduce unwanted movement. The primary dampers reduce the motion between the truck frame and the axle. The lateral dampers reduce unwanted lateral motion of the truck as the locomotive moves along the track. The yaw dampers prevent the truck from "hunting the rail" as the locomotive moves along a straight track. Finally, brake cylinders, brake rigging, and brake shoes provide braking at each of the six truck wheels.

Screen 29:

Wheel Inspection:

The wheels on the steerable truck transfer the torque generated by the traction motor and apply it to the rails. The wheels are designed to keep the locomotive on the rails.

Caution: Shimming of truck springs to correct for differences in wheel diameters is not recommended on the steerable trucks. Shimming reduces spring travel and causes unbalanced spring loading conditions. Unbalanced loading conditions will shorten the life of other load-supporting components.

Periodically inspect the wheels for damage or excessive wear in accordance with Federal Railroad Administration (FRA) Regulations. The FRA rule for wheel inspection states, "The diameter of the wheels on the same axle shall not vary more than 0.0938 inches (2.38 mm); this is equivalent to approximately 2-1/2 tapes."

Note: The term "tape", as originally used in measuring locomotive wheels, is the measurement of the circumference of the wheel, where each one-eighth of an inch equals a specific number on a steel tape measure. The "tape" measurement is provided because it is easier to measure the circumference than the diameter due to the axle and bearing being located in the center of the wheel.

Screen 30:

Wheel Inspection (Cont'd):

FRA limits the differences in diameter between any two wheel sets in a truck to 0.75 inches (19.1 mm). However, for steerable trucks, Engineering recommends that wheels should not continue in service if the diameters in the same truck vary by more than 0.5 inches (12.7 mm) or under the same locomotive if they vary more than 1 inch (25.4 mm). These measurements are equivalent to 12-1/2 and 25 tapes, respectively.

Note: Engineering recommends that wheels should not vary more than 0.0188 inches (1/2 tape) on the same axle, 0.0750 inches (2 tapes) in the same truck, and 0.3002 inches (8 tapes) under the same locomotive for optimum locomotive performance.

Note: If the recommendations listed above are not met, excessive wear on truck components and reduced locomotive performance can result.

Screen 31:

Wheel Repair:

Do not attempt to repair wheels by welding. Turn or mill the wheel to restore the necessary tread and flange contour. Wheels should be removed from service and scrapped when 3 inches (76.2 mm) of material on the wheel diameter has worn off or when the rim thickness has decreased to 1 inch (25.4 mm). Ensure that the surface finish on reworked wheel flanges does not exceed 250 μ in. (6.35 μ m). This is important because a wheel with a rough flange surface tends to climb the rail. Refer to the WHEEL

AND AXLE manual, published by the Association of American Railroads, for further details on wheel wear tolerances and wheel turning practices.

Screen 32:

Wheel Inspection and Maintenance:

To measure wheel diameter, flange thickness, and flange height, use a wheel gauge. The wheel diameter is measured by reading the scale on the long arm of the gauge in relation to the top of the witness mark on the wheel using a conversion chart. Each mark on the scale is a one-eighth inch increase in wheel diameter. The flange thickness is measured by reading the scale on the pivot arm in relation to the 0 mark on the stationary arm. The mark on the pivot is used to determine the thickness. The flange height is measured by reading the scale on the pivot arm in relation to the marks on the bend of the gauge. The zero mark on the pivot is used to determine the height.

Screen 33:

Lateral Liner Inspection:

The lateral liners, with two liners per axle bearing housing, provide a wear surface between the axle bearing housing and the truck frame. The axle bearing housings move vertically between the lateral nylon liners. These liners float laterally on retaining bolts that are inserted into the truck frame. Using a step gauge or equivalent, measure the clearances between the lateral liners and the bearing housing tee. Ensure that the axles are aligned straight. If the lateral liner clearances exceed the maximum worn limits, replace the liners.

Note: The center axle has a wider clearance than the end axles. To reduce clearances, the end axles have a spacer between the truck frame and the outboard lateral liner. When replacing the lateral liner, ensure that the spacer is not placed between the liner and the tee. The wear item will always be the lateral liner.

Screen 34:

Lateral Liner Replacement:

Typical steps to replace the lateral liners are as follows:

1. At the pin retainer assembly, remove the bolts, the hardened washers, and the journal box retainer pin from the truck frame, then save the hardware for re-assembly.
2. Remove both journal box retainer pins.

Note: The end journal box tee pins are shorter than the center tee bolts. Do not mix them.

3. The liners should fall out but, if not, remove them with an appropriate tool.

Note: A hydraulic ram may be used to laterally remove the motor combo.

4. Position the new liners in place and return the correct tee bolts.

Note: The lateral liners on each end axle are similar on the inboard and outboard sides. The liners on the central axles are different. Do not mix them.

5. Re-install the pin retainer assembly, with the raised portion toward the truck frame, and fasten using the previously saved hardware.
6. Torque the retainer assembly bolts to 58 ± 3 lb.-ft. (80 ± 5 Nm).

Screen 37:

Brake Shoe and Rigging Inspection:

Working together, the brake cylinders, brake rigging, and brake shoes apply a stopping force to the wheels. The brake shoes are a high-wear item and need to be inspected on a regular schedule. This schedule varies from railroad to railroad and is based on FRA requirements.

Caution: Do not lubricate brake rigging pins, bushings, or wear plates. Grease or oil on exposed wear surfaces collect sand, dirt and grit, causing wear surfaces to wear faster.

Note: Ensure that the locomotive is on a straight, flat track before any inspection, adjustment, or replacement is made.

Inspect adjustment and condition of the brake rigging components as follows and make adjustments and repairs as required:

- Periodically check all brake shoes for wear. If the brake pad thickness is worn to less than 0.5 inches (13 mm) at any point, replace the brake shoe.
- Ensure that the brake shoes are not binding against the wheel thread surface or flange. If they are, correct this condition.
- Verify that the brake hangers are not causing misalignment of the brake shoe. Repair or replace rigging parts as needed to restore proper brake shoe alignment.

Screen 38:

Brake Shoe and Rigging Inspection (Cont'd):

- Inspect brake linkage for missing, broken, or loose parts. Also, inspect for badly worn pins, bushings, or wear plates. Repair or replace parts, as necessary.
- Check the brake rigging wear plates on the hangers and the truck frame pads. Replace wear plates when the working clearance between the wear plate and the mating wear surface exceeds 0.19 inches (4.8 mm).
- Check the clearance between brake shoes and wheels. If clearance is more than 0.75 inches (19 mm), readjust the brake system as discussed in the Brake System Adjustment section of this module.

Note: The 0.75 inch (19 mm) clearance is needed to ensure that the brake shoes do not ride on the wheels while the truck is steering through curves.

Note: The maximum allowable brake-cylinder piston-rod travel is 6.5 inches (165 mm).

- Check the brake cylinder piston-rod travel that is required to engage the brake. If the piston-rod travel is 6.5 inches (165 mm) or more, readjust the brake system as discussed in the Brake System Adjustment section of this module.

Screen 39:

Brake Shoe Replacement:

Typical steps to replace a brake shoe are as follows:

Note: Ensure that the locomotive is on a straight, flat track before any adjustment or replacement is made.

1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.

Warning: Ensure that the truck wheels are chocked and the hand brake is released before cutting out the air to the truck that you are going to work on. Make sure that you only cut out one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at the same time. Unexpected rolling of the locomotive can cause serious injury or death.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being worked on and exhaust air from the brake cylinders of that truck.

4. Move the brake shoe as far as possible from the wheel tread, then remove the retaining key and worn brake shoe from the brake head.

Note: Temporary removal of a pin is very helpful sometimes in securing adequate clearance. Also, the middle axle brake shoe retaining keys are installed from below for ease of maintenance.

Screen 40:

Brake Shoe Replacement (Cont'd):

Caution: Brake shoes and the linkage design are matched for proper braking according to locomotive weight. Do not replace composition type brake shoes with cast iron

shoes. Failure to use the proper replacement shoes may result in over-braking, under-braking, or an unbalanced braking condition.

5. Install a new shoe in the brake head, line-up the keyway, and then drive the retaining key to seat tight in the keyway.
6. Check the brake shoe for a tight fit in the brake head.

Note: If the shoe is loose with the key tight in the keyway, the brake head is probably worn and should be replaced.

Note: Newly installed brake shoes must hang true in the brake head. Brake head pins must be snug enough to keep the top end of the brake shoe from flopping onto the wheel, but loose enough to allow the shoe to conform to the wheel surface. The wheels should be free to move up and down in relation to the truck frame and the brake shoes.

7. Adjust the manual slack adjuster as required, then reinstall any pins that were removed and lock them into place.
8. Open the truck air cut-out cock.

Screen 41:

Brake System Adjustment:

Typical steps to adjust the brake system are as follows:

Note: Ensure that the locomotive is on a straight, flat track before any adjustment or replacement is made.

1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.

Warning: Ensure that the truck wheels are chocked and the hand brake is released before cutting out the air to the truck that you are going to work on. Make sure that you only cut out one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at the same time. Unexpected rolling of the locomotive can cause serious injury or death.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being worked on and exhaust air from the brake cylinders of that truck. If necessary, push the brake-cylinder piston rods back into the air brake cylinders.

4. To adjust the brake system, lift and rotate the pin retainer and remove the slack adjuster pin.

Warning: Do not set the slack adjuster pin in the fully extended position as doing so may cause the slack adjuster to buckle and the brake to fail.

Screen 42:

Brake System Adjustment (Cont'd):

Caution: When adjusting the tandem brake slack adjuster, ensure that there is no more than one pin hole difference between the slack adjuster settings on opposite sides of the truck. If the slack adjuster settings differ by more than the length of one pin hole, the chocked brake linkage may shorten the usable life of brake components.

5. With the piston rod fully retracted, adjust the slack adjuster to provide a minimum clearance of 0.75 inches (19 mm) between the brake shoe and the wheel.

Note: If adjusting tandem brakes, ensure that the slack adjusters on the opposite side of the truck are pinned to the same length, plus or minus the length of one pin hole. If settings differ by the length of two or more pin holes, replace worn shoes or linkage parts to balance out the slack adjuster settings.

6. Replace the slack adjuster pin and rotate the pin retainer in place over the pin.

Note: If a slack adjuster is near the adjustment limit, check for excessively worn brake shoes or brake linkage components. Replace worn or damaged parts as needed.

7. Check adjustments and the brake clearance at all other truck wheels.

Warning: When adjusting the brakes, check the cylinder piston rod travel required to apply the brakes. Brake cylinder piston rod travel must not exceed 6.5 inches (165 mm). Piston rod travel beyond 6.5 inches (165 mm) may cause inadequate braking force against the wheels.

8. Open the truck air cut-out cock to supply air pressure to the brake system, then check for proper operation of the adjusted air brakes.

Screen 43:

AC Traction Motor Nose Suspension Inspection:

The traction motor nose suspension provides support for the traction motor between the motor and the truck frame. Inspect each suspension assembly for defective rubber mounting bushings. If the mounting bushings are worn, the bushing rubber is extruded from the cast link, or appears damaged in any way, replace the suspension assembly. Also, check for loose or missing mounting hardware.

Caution: The suspension link is disconnected by cutting the CAMCAR bolts with a torch, a hydraulic splitter, or a removal socket. If a torch is used, form a shield to protect the rubber parts of the suspension link from heat damage, and use extreme care. Do not reuse the bolts, washers, or nuts.

Caution: Do not replace CAMCAR bolts and nuts with ordinary fastener bolts and nuts. Bolts and nuts may loosen during locomotive operation, and cause the traction motor to fail and/or cause other equipment damage. Refer to the applicable Parts Bulletin for recommended replacement parts.

Screen 44:

Side Bearer Inspection:

The rubber side bearers consist of alternate layers of steel laminations and rubber which are bonded together. The side bearers transmit the weight of the locomotive to the trucks, while permitting controlled lateral motion of the trucks relative to the locomotive platform.

Inspect the side bearers as follows:

- Ensure that the side bearer is centered under the locomotive side bearer pad.
- Inspect for evidence of motion between the side bearer and the locomotive side bearer pad.
- Inspect the side bearers for extreme wear or severe separation of rubber and steel laminations.
- Replace any defective or displaced side bearers. Contact a Field Service representative for correct defective side bearer replacement procedures.

Screen 47:

Traction Pad Inspection:

The rubber traction pads consist of alternate layers of steel and rubber bonded together. The pads transmit the tractive effort from the truck to the locomotive and permit controlled lateral motion of the truck relative to the locomotive platform. Inspect the traction pads as follows:

- Ensure that the pads are seated in the truck frame and properly retained. In a proper installation, the pads are compressed by approximately 0.62 inches (15.7 mm), and the rubber is bulged upward by approximately 0.125 - 0.5 inches (3.18 - 12.70 mm).
- Inspect the traction pads for extreme wear or severe separation of the rubber and steel laminations.

Note: Cracks or unbonded rubber indicate that the pad needs to be replaced.

- Replace any defective or displaced traction pads as directed in the Backshop Manual.

Screen 48:**Visual Inspection of the Dampers:**

When visually inspecting the dampers, note the following:

- Dirt and oil: Rail operations expose locomotive dampers to dirt, oil, and particulates from outside sources. The accumulation covering the outer surface of the damper is normal and has no adverse effects on the damper's performance. The damper's dust cover and rubber bellow protect the piston rod and rod seals.
- Oil leakage: New locomotive dampers will show oil loss during the first service period and, as a result, are suspected of leakage. In most cases, this is assembly lubricant, which has nothing to do with oil leakage.

Screen 49:**Visual Inspection of the Dampers (Cont'd):**

- Assembly oil: Several different lubricants and fluids are used in the construction of locomotive dampers. Assembly oils or greases are yellow, black, or white in color, and can be easily distinguished from the red hydraulic damping fluid. When the damper is new, the assembly lubricant may cause a slightly moist rod or body. If this occurs, simply wipe off the excess oil and return the damper to service. If a new damper has red oil droplets, the damper should not be installed.
- Sweating: For a long service life, it is necessary for the rod oil seal to remain lubricated. The continuous inward and outward movement of the piston rod may cause oil "sweat" from the rod oil seal. This loss of oil can be recognized by the outside of the damper being slightly moist and dirty. A slight oil sweating will not affect the damping force and the damper may remain in service.
- Droplets: If red droplets of oil are clearly formed or the damper body is wet with hydraulic fluid, the damper must be replaced.

Screen 50:**Visual Inspection of the Lateral and Yaw Dampers:**

The lateral and yaw dampers dampen unwanted movement and vibrations between the truck and the locomotive platform. There are two lateral and two yaw dampers per truck.

Note: The lateral and yaw hydraulic dampers are sealed by the manufacturer and cannot be refilled with fluid. Leaky dampers must be replaced.

Screen 51:**Visual Inspection of the Lateral and Yaw Dampers (Cont'd):**

Inspect each lateral and yaw hydraulic damper for leakage or defective rubber mounting bushings. A light film of hydraulic fluid on the body is normal. If the body is wet with fluid, the mounting bushings are worn, or bindings are badly eroded or missing, replace the lateral damper.

Note: Refer to the applicable Parts Bulletin for the recommended replacement part number. Also, some damper manufacturers require the damper bottom end to be at a minimum of 2° below the top end for effective operation. These manufacturers mark this bottom position as “BELOW.”

Ensure that “BELOW”, stamped onto the body, is on the bottom side of the lowest end of the damper. If “BELOW” is at the 12 o’clock or top position, unbolt the small end of the damper and rotate the end by 180°. If it is at any other position, remove and replace the damper.

Screen 52:

Vertical Hydraulic Dampers Inspection:

The four vertical hydraulic dampers, mounted between the truck frame and the axle bearing housing, provide damping forces as a result of vertical and lateral motions between axles and the truck frame.

Note: The vertical hydraulic dampers are sealed by the manufacturer and cannot be refilled with fluid. Leaky vertical hydraulic dampers must be replaced. Inspect each vertical hydraulic damper for leakage or defective rubber mounting bushings.

Typical steps to inspect the vertical hydraulic dampers are as follows:

Caution: If one vertical hydraulic damper is found to be defective, replace both dampers on that axle as a matched set. Use only the recommended dampers on the truck to ensure a proper match with the locomotive load conditions. Replacement of only one damper or failure to use the recommended replacement dampers will create an incorrect damping condition, and may shorten the usable life of the dampers, the springs, and other load supporting the components.

1. Clean the lower body of the primary damper.
2. Visually inspect the lower body for clearly formed droplets of hydraulic fluid.
3. Clean all the dampers around the locomotive and return to the first one to begin inspection.
4. Inspect the damper mounting bushings for wear, binding, badly eroded or missing parts.
5. Inspect the structure for cracks, missing sections, or severe beating.

Screen 53:

Vertical Hydraulic Dampers Replacement Criteria:

Note: Normal damper operation results in a light film of hydraulic fluid on the lower body of the damper. A light film, which is not a droplet, is acceptable.

Replace the vertical hydraulic dampers, if any of the following are found during the visual inspection:

- Droplets of hydraulic fluid formed at the lower body.
- Signs of wearing, binding, or badly eroded bushings.
- Broken parts.

Screen 54:

Vertical Hydraulic Damper Replacement:

Typical steps to replace the vertical hydraulic dampers on the axle are as follows:

1. Remove all four bolts and washers from each set of damper mounting blocks.
2. Remove and discard both used vertical hydraulic dampers.
3. Install new dampers.

Note: Refer to the applicable Parts Bulletin for recommended replacement part number.

Note: Mating surfaces and threads of dampers must be clean and free of any oil.

4. Reinstall the bolts and washers on each set of damper mounting blocks, then torque the bolts to 312 ± 16 lb.-ft. (422 ± 22 Nm).

Screen 55:

Coil Springs: Inspection and Replacement:

The coil springs transfer the weight of the locomotive to the wheel and axle assembly, dampen vertical forces, and improve ride quality. There are twelve coil-compression springs, one spring located on each side of each journal bearing housing.

Note: Removal of the coil springs requires disassembly of the steering arrangement. Obtain the correct procedures from a Field Service representative. For purposes of visual inspection, raise the weight of the locomotive and the truck from the axles to expose the springs for viewing.

Visually inspect the spring coils for breaks, cracks, vertical wear flats, deep nicks, gouges, or other signs of spring damage. If visible damage to the spring coils indicates that the useful life or performance of the springs may be limited, replace the springs.

Screen 56:

Equalizer Bar Damper Inspection:

The equalizer bar damper, attached between the equalizer bar damper support and the truck frame, reduces vibration induced by the steerable arrangement in a lateral direction.

Typical steps to inspect the equalizer bar damper are as follows:

1. Clean the lower body.
2. Clean all the dampers around the locomotive and return to the first one to begin inspection.
3. Perform a visual inspection of the lower body for clearly formed droplets of hydraulic fluid.

4. Inspect damper mounting bushings for wear, binding, badly eroded, or missing parts.
5. Inspect the structure for cracks, missing sections, or severe beating.

Screen 57:

Equalizer Bar Damper Replacement Criteria:

Note: Normal damper operation results in a light film of hydraulic fluid on the lower body of the damper. A light film, which is not a droplet, is acceptable.

Replace the equalizer bar dampers, if any of the following are found during the visual inspection:

- Droplets of hydraulic fluid formed at the lower body.
- Signs of wearing, binding, or badly eroded bushings.
- Broken parts.

Screen 58:

Equalizer Bar Damper Replacement:

Typical steps to replace the equalizer bar damper on the axle are as follows:

1. Remove the four bolts, nuts, and washers attaching the equalizer bar damper to the equalizer bar damper support bracket and the truck frame.
2. Remove and discard the equalizer bar damper.
3. Install a new damper.

Note: Refer to the applicable Parts Bulletin for the recommended replacement part number.

Note: Mating surfaces and threads of dampers must be clean and free of any oil.

4. Orient the damper correctly by ensuring that the larger diameter upper body of the damper is toward the equalizer bar damper support bracket and the smaller diameter lower body is toward the truck frame casting.
5. Ensure that "BELOW" is stamped on the bottom side of the lowest end of the damper.

Note: If "BELOW" is at the 12 o'clock or the top position, unbolt the small end of the damper and rotate the end by 180°. If it is in any other position, remove and replace the damper.

6. Reinstall the four bolts, nuts, and washers connecting the equalizer bar damper to the damper support bracket and the truck frame damper mounting block, then torque the mounting bolts to 755 ± 40 lb.-ft. (1022 ± 55 Nm).

Screen 59:**Bell Crank Assembly Inspection:**

Inspect the bell crank assembly for minimum clearance between the bell crank and the traction cap. Use a feeler gauge to check that there is a minimum clearance of 0.06 inches (1.5 mm) between the bell crank and the traction cap. If the clearance is less than 0.06 inches (1.5 mm), the thrust washers might be defective. Note that there are two thrust washers in the bell crank assembly, one is inside the retainer lower bearing and the other is outside of the retainer lower bearing.

Screen 60:**Bell Crank Assembly Inspection: Thrust Washer Replacement:**

Typical steps to replace the thrust washer are as follows:

1. Remove the retainer thrust washer and spacer by unscrewing the four bolts and save the hardware for re-installation.
2. Remove and discard the first thrust washer.

Note: Do not discard the spacer. Save it for re-installation.

3. Remove the four bolts and washers from the retainer lower bearing cap and save the hardware for re-installation.
4. Replace the second thrust washer with a new thrust washer.

Screen 61:**Bell Crank Assembly Inspection: Thrust Washer Replacement (Cont'd):**

5. Install the retainer lower bearing cap and the four washers and the four bolts on opposite corners, then torque the bolts to 88 ± 5 lb.-ft. (40 ± 2.3 Nm).
6. Install a new thrust washer on top of the retainer lower bearing cap.
7. Install the thrust washer spacer in the center of the thrust washer.

Note: Ensure that both the washers are concentric.

8. Install the thrust washer retainer on top of the thrust washer spacer using four washers and four bolts, then torque the bolts to 58 ± 3 lb.-ft. (26 ± 1.4 Nm).

Screen 62:**Visual Inspection of the Traction Link and the Center Link:**

Visually inspect the traction link and the center link for missing nuts and bolts. Apply new fasteners if they are missing.

Screen 63:**Visual Inspection of the Wing Plate Assembly:**

Typical steps to inspect the wing plate assembly are as follows:

1. Visually inspect for missing hardware fastened on links.
2. Visually inspect wing plate shear pads and rubber bushings for cracks or delamination of the bonded rubber and metal.

Note: No unbonded rubber or cracks are acceptable.

3. Inspect the wing plate pins for indications of wear and/or clearance.

Note: Pins are designed to be press fit into the reaction arm and the wing plate.

4. Ensure that the shear pad is properly seated in the wing plate, the reaction arm, and the reaction arm cover.

Screen 64:

Visual Inspection of the Equalizer Arm and the Equalizer Bar:

Typical steps to inspect the equalizer arm and equalizer bar are as follows:

1. Check the match marks on the equalizer arm to verify that the arm has NOT moved relative to the bell crank.

Note: Replace the equalizer arm if it has moved.

2. Visually inspect the equalizer bar rubber bushing for swelling, delamination, and wear.

Caution: Do not contaminate the rubber bushing with oil, paint, or grease.

3. Visually inspect the equalizer bar for any signs of wear or cracking.
4. Visually inspect the equalizer bar for missing nuts and bolts and apply new fasteners, if missing.

Screen 65:

Equalizer Bar Replacement:

Typical steps to replace the equalizer bar are as follows:

Warning: Ensure that the truck wheels are chocked and then release the hand brake before cutting out the brake cylinder air. Also, cut out the air to only one truck at a time. Unexpected motion can occur if the wheels are not chocked, or if the hand brake is set when the brake air is released, or if the air is cut off to both trucks at the same time. Unexpected rolling of the locomotive can cause serious personal injuries or death.

Warning: Ensure that the cut-out cock of the truck that is being worked is closed to eliminate air braking force.

Warning: To avoid pinching, be careful not to put fingers between parts.

1. Remove the equalizer bar assembly as follows:
 - a. Remove the bolts, nuts, and washers connecting the equalizer bar damper and the damper support bracket on the equalizer bar and retain the hardware for re-installation.
 - b. Remove the two bolts, nuts, and washers connecting the equalizer bar and the equalizer arms and retain the hardware for re-installation.

Warning: Use an appropriate lifting device to handle the equalizer bar assembly that weighs approximately 160 lbs. (73 kg).

- c. Slide out the equalizer bar assembly.

Screen 66:

Equalizer Bar Replacement (Cont'd):

2. Dismantle the equalizer bar assembly as follows:
 - a. When the equalizer bar assembly is out of the truck frame, remove the damper support bracket from the equalizer bar by removing the three bracket mounting bolts, nuts, and washers.
 - b. Save the hardware and the damper support bracket for re-installation.
 - c. Save the equalizer bar for repair.
3. Assemble the subassembly by using a new equalizer bar and re-using the damper support bracket and mounting hardware.
4. Connect the damper support bracket to the new equalizer bar, then torque the three bracket mounting bolts to 755 ± 40 lb.-ft. (1022 ± 54 Nm).

Screen 67:

Equalizer Bar Replacement (Cont'd):

5. Install the equalizer bar assembly as follows:

Warning: Use an appropriate lifting device to handle the equalizer bar assembly that weighs approximately 160 lb (73 kg).

- a. Slide the equalizer bar assembly between the truck and the platform.
 - b. Connect the equalizer bar damper support bracket with the damper, then torque the two damper mounting bolts to 175 ± 10 lb.-ft. (237 ± 14 Nm).
 - c. Connect the equalizer bar assembly to the equalizer arms, then torque the two connecting bolts to 312 ± 16 lb.-ft. (423 ± 22 Nm).

Note: A pinch bar might be needed to align the equalizer arm with the equalizer bar.

Screen 68:**Safety Hook Inspection and Replacement:**

Safety hooks, located on each side of both trucks, ensure that the truck does not become separated from the locomotive in the event of derailment. Inspect the safety hooks for proper clearances. If the safety hooks do not meet clearances, identify and replace the defective hooks. Obtain the correct replacement procedure from a Field Service representative.

Screen 71:**Steerable Truck Removal:**

Typical steps to remove the steerable truck from under the locomotive are as follows:

Note: Ensure that the locomotive is on a straight track before any adjustment or replacements are made.

1. Chock at least two sets of truck wheels on both trucks to prevent the locomotive from rolling in either direction.
2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.

Warning: To eliminate air braking force, ensure that the cut-out cock of the truck that is being worked is closed.

Warning: Ensure that the truck wheels are chocked and release the hand brake before cutting out the brake cylinder air. Ensure that air is cut out to only one truck at a time. Unexpected motion can occur if the wheels are not chocked, if the hand brake is set when brake air is released, or if the air is cut off to both trucks at one time. Unexpected rolling of the locomotive can cause serious injury or death.

Warning: Follow all Railroad Operating Procedures governing compressed air and air lines.

3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.

Note: Close only the truck cut-out cock for the truck being removed. Disconnect the hose to the brake cylinders of that truck only after all air has been exhausted from the truck air lines.

Screen 72:**Steerable Truck Removal (Cont'd):**

Warning: For AC 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 located in CA1 and verify that the LEDs on the CPI panel are extinguished.

4. For each traction motor, disconnect the traction motor leads, ground cable, and speed sensor cable and, if equipped, the hot bearing detector probe on the U-tube.
5. Disconnect the ground cable between the truck and the platform.
6. Disconnect the traction motor air ducts from the top of the traction motors.
7. If an axle alternator is installed on the truck being removed, disconnect the alternator cable from the junction box on the alternator, then coil and secure the cable so it will not be damaged.
8. Disconnect all sander hoses from the sander brackets on the truck.

Screen 73:

Steerable Truck Removal (Cont'd):

9. Disconnect the hoses for the flange lubricators if used, and cover the opening to prevent the entry of foreign materials.
10. Disconnect the hand brake chain if the long-hood end truck is being removed.
11. Remove the lateral and yaw dampers from the platform and save the hardware.
12. Remove both safety hooks from the truck frame, mark as right or left, and save the hardware.

Warning: The locomotive weighs approximately 440,000 lbs. (199581 kg) and the truck weighs approximately 62,000 lbs. (28123 kg). Ensure that the lifting or jacking device is adequate.

13. Raise the locomotive platform clear of the truck with jacks or a crane, or lower the truck on a drop table.

Note: Ensure that the cables, air ducts, and hoses are not damaged. If the truck is to be pulled out sideways, the locomotive platform must be raised, or the truck lowered, at least 10 inches (254 mm).

14. After the truck is removed from under the locomotive, cover the truck center pin bearing and traction motor openings to prevent contamination with dirt and other foreign materials.

Screen 74:

Steerable Truck Installation:

Typical steps to install the steerable truck under the locomotive are as follows:

1. Space the trucks for a truck center-block to center-block spacing of 50 feet and 4.24 inches (15.3477 m).

Note: When installed on the locomotive, the transom ends of the trucks must face each other.

2. Remove the temporary dust covers from the traction motor air duct and center pin bearing openings.
3. Inspect the traction motor air ducts between the locomotive platform and the truck and replace any air ducts that are cracked or torn.
4. Coat the center pin on the underside of the locomotive platform with grease before lowering the platform onto the truck.

Warning: The locomotive weighs approximately 440,000 lbs. (199581 kg) and the truck weighs approximately 62,000 lbs. (28123 kg). Ensure that the lifting or jacking device is adequate.

5. Lower the platform onto the truck or raise the truck on the drop table.

Note: Carefully mate the center pin with the center pin bearing. Ensure that the two tongs on top of each of the four side bearers per truck register properly in the locomotive platform.

6. Check and align the trucks, if required.
7. Install both safety hooks to the correct sides on the truck frame and torque the bolts to 208 ± 11 lb.-ft. (282 ± 15 Nm).

Screen 75:

Steerable Truck Installation (Cont'd):

8. Install the lateral dampers to the platform, with the shorter bolt at the bottom, and torque the bolts to 118 ± 6 lb.-ft. (160 ± 8 Nm).

Note: Ensure that "BELOW" stamped onto the body is on the bottom side of the lowest end of the damper.

9. Install the yaw dampers to the platform and torque the bolts to 208 ± 11 lb.-ft. (282 ± 15 Nm).

Note: Ensure that "BELOW" stamped onto the body is on the bottom side of the lowest end of the damper.

10. If installing the long-hood end truck, connect the hand brake chain.
11. Install the hoses from the sand pipes on the platform to the sander brackets on the trucks and install the hoses for flange lubricators, if used.

12. Connect the axle alternator cable to the junction box on the alternator, if used.
13. Install the traction motor air duct to each of the traction motors and torque the bolts to 58 ± 3 lb.-ft. (80 ± 5 Nm).
14. Connect the ground cable between the truck and the platform.

Screen 76:

Steerable Truck Installation (Cont'd):

Warning: For AC 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 located in CA1 and verify that the LEDs on the CPI panel are extinguished.

15. For each traction motor, connect the speed sensor cable, ground cable, and traction motor leads, and, if equipped, the hot bearing detection probe on the U-tube.
16. Connect the air brake hoses from the locomotive platform to the brake cylinder piping on the truck.
17. Verify that the truck cut-out cocks located under the platform are open before returning the locomotive to service.
18. Adjust the truck brake rigging.
19. Ensure that the journal bearing housings, traction motor gear cases, and traction motor support bearings have been lubricated before moving the locomotive.
20. Check the traction motor rotation.

Screen 77:

Truck Alignment Verification:

Truck alignment is required if any of the following components have been replaced:

- Traction motor assembly
- Dog bone motor nose suspension
- Inter-motor link (A-frame) assembly
- U-tube cover
- Equalizer arm
- Long bell crank
- Any bell crank bearing
- Three or more steering components

To ensure that the steerable truck is in proper alignment for operation, verify that the truck is properly aligned and check the lateral alignment of the wheel.

Screen 78:**Truck Alignment Verification (Cont'd):**

Typical steps to verify truck alignment are as follows:

1. Ensure that the locomotive is on a straight, level track.
2. Release the brakes on the truck being aligned by closing the truck air brake cut-out cock and bleeding air from the brake cylinders.
3. Check the axle distance between the center and each end axle.

Note: Measure from the bearing seat vertical machined surface, just above the bottom cap, to the same location on the adjacent bearing housing. Ensure that the measurement is taken on the same side of the bearing housing; left side to left side, right side to right side. Take measurements on both sides of the truck. Axle center distances should be as follows:

Note: Because of the steering linkages, moving one wheel will move the wheels at the opposite ends of the truck.

Screen 79:**Wheel Lateral Alignment Verification:**

Typical steps to check the wheel lateral alignment are as follows:

1. Align the end axle wheels with the truck frame as follows:
 - a. Install 5.125 inch (13.018 cm) blocks to the journal box tees on the non-gearcase side of both end axles.

Note: This provides the distance between the outside face of the journal box tee and the machined face of the truck frame between both retainer pins.

- b. Install airbags between the truck frame and the wheel on the non-gearcase side of the end wheel sets, then apply air to the airbags and move each wheel set until there is contact between the blocks and the truck frame.
2. Use wedges to block the end axles in respect to the frame and remove the airbags from the end axles.

Screen 80:**Wheel Lateral Alignment Verification (Cont'd):**

3. Align the center axle wheels with the end axle wheels as follows:
 - a. Use a long straight edge or a wire stretched tight against the backside face of the non-gearcase wheels of both the end axles.

Note: The backside face of the wheel is the face near the wheel flange. Do not use the outside face.

- b. Use airbags to align the center axle wheel with the straight edge or wire.

Note: The deviation between the straight edge or wire and the exact location of the center axle wheel should not exceed 0.06 inches (0.15 cm) in either direction.

4. If the center axle wheel is not aligned with the straight edge or wire, loosen the CAMCAR bolt connections on the two inter-motor links at traction motor positions 1, 2, 5, and 6 to allow the center axle to be laterally aligned.

Note: There are two inter-motor links (A-frames) per truck. One side of each A-frame is connected to a suspension link (dog bone) and traction motor by two CAMCAR bolts.

5. If the CAMCAR bolts are not already loosened and hand-tightened, remove and install new CAMCAR bolts one at a time.

Caution: The CAMCAR bolts are removed by cutting the CAMCAR bolts with a torch or hydraulic splitter. If a torch is used, protect the rubber parts of the suspension link from heat damage.

6. Hand-tighten the nuts and tag the bolts as loose, then repeat steps 3a and 3b.

Screen 83:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the steerable trucks.
 - The three-axle G1 model steerable truck is a three-motor, three-axle, high-adhesion, steerable type truck designed to carry one-half the weight of the locomotive.
 - The entire locomotive is supported by two steerable trucks, commonly called the front truck and the rear truck. These truck assemblies are located directly underneath the locomotive platform. Each steerable truck, designed to carry one-half of the weight of the locomotive, has three axles that are individually powered by traction motors.
 - The steerable trucks distribute the locomotive weight equally over the axles, and transfer the tractive effort or pulling force, and braking effort or stopping force, from the locomotive to the rails.
- Describe the major components of a steerable truck.
 - The truck frame is the backbone and foundation for the steerable truck assembly. It is a C-shaped steel casting that provides the mounting for all of the steerable truck's components.
 - The wheels transfer the torque generated by the traction motor and apply it to the rails. The wheels are designed to keep the locomotive on the rails.

- The lateral liners, two per axle bearing housing, provide a wear surface between the axle bearing housing and the truck frame.
- Working together, the brake cylinders, brake rigging, and brake shoes apply stopping force to the wheels.
- The traction motor nose suspension, also referred to as the dog bone or suspension link, provides support for the traction motor between the motor and the truck frame.
- The rubber side bearers, also referred to as loadbearers, consist of alternate layers of steel laminations and rubber, which are bonded together. The side bearers, mounted on the topside of the truck, transmit the locomotive weight to the trucks, while permitting controlled lateral motion of the trucks relative to the locomotive platform.
- The rubber traction pads, consisting of alternate layers of steel and rubber that are bonded together, function to transmit the tractive effort from the truck to the locomotive, while permitting controlled lateral motion of the trucks relative to the locomotive platform. The traction pads also absorb the shock between the center pin bearing assembly and the truck frame during acceleration and braking.
- A center pin, located on the underside of the locomotive platform, fits into a center pin bearing assembly mounted in the truck frame. The center pin is welded to the underside of the platform and mates with the truck by way of the center block. The bearing assembly and the center pin allow the truck to pivot with respect to the locomotive platform and transmit the tractive force from the truck to the locomotive platform.
- The lateral and yaw dampers are used to dampen unwanted movement and vibrations between the truck and the locomotive platform. There are two lateral and two yaw dampers per truck.
- There are four primary or vertical dampers on a steerable truck. The primary dampers are used to dampen unwanted movement and vibrations between the wheel axle assembly and the truck.
- The coil springs transfer the weight of the locomotive to the wheel and axle assembly, dampen vertical forces, and improve ride quality. There are twelve coil-compression springs, one spring located on each side of each journal bearing housing.
- Safety hooks ensure that the truck does not become separated from the locomotive. They are located on both sides of each truck frame.
- The steering assembly is a series of mechanical linkages that cause the axles to adjust to the curvature of the track. There are several components that make up the steering assembly.
 - The equalizer bar, also referred to as a "Marty" bar, and equalizer arms are attached to the open end of the bell cranks. The equalizer arms are heat-shrink fitted to the top of the bell cranks. The equalizer bar is attached to the equalizer arms by a close tolerance hardened pin with hardened bushings.

- The bell crank is a vertically oriented shaft that rotates within the truck frame through two rubber laminated bearings. The bell crank permits the traction motor combination yaw rotation to be transmitted to the externally mounted reaction arms.
- G1 steerable trucks have an equalizer bar damper attached between the steering arrangement and the truck frame. The damper reduces vibration induced by the steerable arrangement in the lateral direction.
- Reaction arms and wing plate assembly arrangement helps to ensure that the two axles are acting in equal and opposite direction. As the end axles rotate in equal and opposite direction in yaw, the reaction arms rotate relatively. The wing plate assembly will displace inward or outward relative to the truck frame depending upon the direction of steering.
- The traction link and the center link transmit and react to the tractive, braking, and steering forces from the wheel set journal box to the truck frame. Links are connected to the axle bearing housing, also known as the journal box. The other ends are attached to the truck frame through a smaller casting called a traction cap.

Screen 84:

Summary (Cont'd):

- Describe the basic operation of a steerable truck.
 - The 3-axled steerable truck has a series of steering linkages that force the first and third axles in equal and opposite directions, while the second axle moves laterally, towards the outside of the curve. Each set of wheels is powered by its own traction motor.
 - The truck frame is supported by coil springs with primary dampers, which dampen vertical spring oscillations.
 - A center pin and center pin bearing assembly transmit the tractive force from the truck to the locomotive platform.
 - The side bearers support the vertical load and provide controlled lateral motion between the locomotive and the truck.
 - The journal bearing housings transfer vertical loads from the frame to the axles and wheels.
 - The primary, lateral, and yaw dampers reduce unwanted movement. The primary dampers reduce the motion between the truck frame and the axle. The lateral dampers reduce unwanted lateral motion of the truck as the locomotive moves along the track. The yaw dampers prevent the truck from "hunting the rail" as the locomotive moves along a straight track.
 - Finally, brake cylinders, brake rigging, and brake shoes provide braking at each of the six truck wheels.
- Describe how to perform running maintenance inspections related to the truck and its major components.
 - Wheels

- Periodically inspect the wheels for damage or excessive wear, in accordance with Federal Railroad Administration (FRA) Regulations.
- To measure wheel diameter, flange thickness, and flange height, use a wheel gauge.
- The wheel diameter is measured by reading the scale on the long arm of the gauge in relation to the top of the witness mark on the wheel using a conversion chart.
- The flange thickness is measured by reading the scale on the pivot arm in relation to the 0 mark on the stationary arm. The mark on the pivot is used to determine the thickness.
- The flange height is measured by reading the scale on the pivot arm in relation to the marks on the bend of the gauge.
- Lateral Liners
 - If the lateral liner clearances exceed the maximum worn limits, replace them as follows:
 1. At the pin retainer assembly, remove the bolts, the hardened washers, and the journal box retainer pin from the truck frame, then save the hardware for re-assembly.
 2. Remove both journal box retainer pins.
 3. The liners should fall out but, if not, remove them with an appropriate tool.
 4. Position the new liners in place and return the correct tee bolts.
 5. Re-install the pin retainer assembly, with the raised portion toward the truck frame, and fasten using the previously saved hardware.
 6. Torque the retainer assembly bolts.
- Brake Shoes and Rigging
 - The brake shoes are a high-wear item and need to be inspected on a regular schedule.
 - Inspect adjustment and condition of the brake rigging components as follows and make adjustments and repairs as required:
 - Periodically check all brake shoes for wear.
 - Ensure that the brake shoes are not binding against the wheel tread surface or flange.
 - Verify that the brake hangers are not causing misalignment of the brake shoe.
 - Inspect brake linkage for missing, broken, or loose parts. Also, inspect for badly worn pins, bushings, or wear plates.
 - Check the brake rigging wear plates on the hangers and the truck frame pads.
 - Check the clearance between brake shoes and wheels.
 - Check the brake cylinder piston-rod travel that is required to engage the brake.

Screen 85:

Summary (Cont'd):

- Replace the brake shoe as follows:
 1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
 2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.
 3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.
 4. Move the brake shoe as far as possible from the wheel tread, then remove the retaining key and worn brake shoe from the brake head.
 5. Install a new shoe in the brake head, line-up the keyway, and then drive the retaining key to seat tight in the keyway.
 6. Check the brake shoe for a tight fit in the brake head.
 7. Adjust the manual slack adjuster as required, then reinstall any pins that were removed and lock them into place.
 8. Open the truck air cut-out cock.
- Adjust the brake system as follows:
 1. Chock at least two sets of truck wheels to prevent the locomotive from rolling in either direction.
 2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.
 3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.
 4. To adjust the brake system, lift and rotate the pin retainer and remove the slack adjuster pin.
 5. With the piston rod fully retracted, adjust the slack adjuster to provide a minimum clearance of 0.75 inches (19 mm) between the brake shoe and the wheel.
 6. Replace the slack adjuster pin and rotate the pin retainer in place over the pin.
 7. Check adjustments and the brake clearance at all other truck wheels.
 8. Open the truck air cut-out cock to supply air pressure to the brake system, then check for proper operation of the adjusted air brakes.
- Traction Motor Nose Suspension
 - Inspect each suspension assembly for defective rubber mounting bushings. If the mounting bushings are worn, the bushing rubber is extruded from the cast link, or appears damaged in any way, replace the suspension assembly. Also, check for loose or missing mounting hardware.
- Side Bearer Inspection
 - Inspect the side bearers as follows:
 - Ensure that the side bearer is centered under the locomotive side bearer pad.

- Inspect for evidence of motion between the side bearer and the locomotive side bearer pad.
- Inspect the side bearers for extreme wear or severe separation of rubber and steel laminations.
- Replace any defective or displaced side bearers.

Screen 86:

Summary (Cont'd):

- Traction Pad Inspection
 - Ensure that the pads are seated in the truck frame and properly retained. In a proper installation, the pads are compressed by approximately 0.62 inches (15.7 mm), and the rubber is bulged upward by approximately 0.125 - 0.5 inches (3.18 - 12.70 mm).
 - Inspect the traction pads for extreme wear or severe separation of the rubber and steel laminations.
 - Replace any defective or displaced traction pads as directed in the Backshop Manual.
- Dampers
 - Visually inspect the dampers for signs of any oil leakage, dirt or droplets, and sweating.
- Lateral and Yaw Dampers
 - Inspect each lateral and yaw hydraulic damper for leakage or defective rubber mounting bushings. A light film of hydraulic fluid on the body is normal. If the body is wet with fluid, the mounting bushings are worn, or bindings are badly eroded or missing, replace the lateral damper.
- Vertical Hydraulic Dampers Inspection
 1. Clean the lower body of the primary damper.
 2. Visually inspect the lower body for clearly formed droplets of hydraulic fluid.
 3. Clean all the dampers around the locomotive and return to the first one to begin inspection.
 4. Inspect the damper mounting bushings for wear, binding, badly eroded or missing parts.
 5. Inspect the structure for cracks, missing sections, or severe beating.
 6. Replace the vertical hydraulic dampers, if any of the following are found during the visual inspection: Droplets of hydraulic fluid formed at the lower body, signs of wearing, binding, or badly eroded bushings and broken parts.
- Vertical Hydraulic Damper Replacement
 1. Remove all four bolts and washers from each set of damper mounting blocks.
 2. Remove and discard both used vertical hydraulic dampers.
 3. Install new dampers.

4. Reinstall the bolts and washers on each set of damper mounting blocks, then torque the bolts to 312 ± 16 lb.-ft. (422 ± 22 Nm).
- Coil Springs Inspection
 - Visually inspect the spring coils for breaks, cracks, vertical wear flats, deep nicks, gouges, or other signs of spring damage. If visible damage to the spring coils indicates that the useful life or performance of the springs may be limited, replace the springs.
- Equalizer Bar Damper Inspection
 1. Clean the lower body.
 2. Clean all the dampers around the locomotive and return to the first one to begin inspection.
 3. Perform a visual inspection of the lower body for clearly formed droplets of hydraulic fluid.
 4. Inspect damper mounting bushings for wear, binding, badly eroded, or missing parts.
 5. Inspect the structure for cracks, missing sections, or severe beating.
- Equalizer Bar Damper Replacement
 1. Remove the four bolts, nuts, and washers attaching the equalizer bar damper to the equalizer bar damper support bracket and the truck frame.
 2. Remove and discard the equalizer bar damper.
 3. Install a new damper.
 4. Orient the damper correctly by ensuring that the larger diameter upper body of the damper is toward the equalizer bar damper support bracket and the smaller diameter lower body is toward the truck frame casting.
 5. Ensure that "BELOW" is stamped on the bottom side of the lowest end of the damper.
 6. Reinstall the four bolts, nuts, and washers connecting the equalizer bar damper to the damper support bracket and the truck frame damper mounting block, then torque the mounting bolts.

Screen 87:

Summary (Cont'd):

- Bell Crank Assembly Inspection
 - Inspect the bell crank assembly for minimum clearance between the bell crank and the traction cap. Use a feeler gauge to check that there is a minimum clearance of 0.06 inches (1.5 mm) between the bell crank and the traction cap. If the clearance is less than 0.06 inches (1.5 mm), the thrust washers might be defective.
 - Thrust Washer Replacement
 1. Remove the retainer thrust washer and spacer by unscrewing the four bolts and save the hardware for re-installation.
 2. Remove and discard the first thrust washer.

3. Remove the four bolts and washers from the retainer lower bearing cap and save the hardware for re-installation.
 4. Replace the second thrust washer with a new thrust washer.
 5. Install the retainer lower bearing cap and the four washers and the four bolts on opposite corners, then torque the bolts to 88 ± 5 lb.-ft. (40 ± 2.3 Nm).
 6. Install a new thrust washer on top of the retainer lower bearing cap.
 7. Install the thrust washer spacer in the center of the thrust washer.
 8. Install the thrust washer retainer on top of the thrust washer spacer using four washers and four bolts, then torque the bolts to 58 ± 3 lb.-ft. (26 ± 1.4 Nm).
- Visual Inspection of the Traction Link and the Center Link
 - Visually inspect the traction link and the center link for missing nuts and bolts. Apply new fasteners if they are missing.
 - Visual Inspection of the Wing Plate Assembly
 1. Visually inspect the wing plate assembly for missing hardware fastened on links.
 2. Visually inspect the wing plate shear pads and rubber bushings for cracks or delamination of the bonded rubber and metal.
 3. Inspect the wing plate pins for indications of wear and/or clearance.
 4. Ensure that the shear pad is properly seated in the wing plate, the reaction arm, and the reaction arm cover.
 - Visual Inspection of the Equalizer Arm and the Equalizer Bar
 1. Check the match marks on the equalizer arm to verify that the arm has NOT moved relative to the bell crank.
 2. Visually inspect the equalizer bar rubber bushing for swelling, delamination, and wear.
 3. Visually inspect the equalizer bar for any signs of wear or cracking.
 4. Visually inspect the equalizer bar for missing nuts and bolts and apply new fasteners, if missing.
 - Equalizer Bar Replacement
 1. Remove the equalizer bar assembly.
 2. Dismantle the equalizer bar assembly.
 3. Assemble the subassembly by using a new equalizer bar and re-using the damper support bracket and mounting hardware.
 4. Connect the damper support bracket to the new equalizer bar, then torque the three bracket mounting bolts.
 5. Install the equalizer bar assembly.
 - Safety Hook Inspection and Replacement
 - Inspect the safety hooks for proper clearances. If the safety hooks do not meet clearances, identify and replace the defective hooks.

Screen 88:

Summary (Cont'd):

- Steerable Truck Removal
 1. Chock at least two sets of truck wheels on both trucks to prevent the locomotive from rolling in either direction.
 2. Release the hand brake, if set, and allow time for the truck wheels to seat against the wheel chocks.
 3. With the locomotive secure, locate and close the truck air cut-out cock on the underside of the locomotive frame.
 4. For each traction motor, disconnect the traction motor leads, ground cable, and speed sensor cable and, if equipped, the hot bearing detector probe on the U-tube.
 5. Disconnect the ground cable between the truck and the platform.
 6. Disconnect the traction motor air ducts from the top of the traction motors.
 7. If an axle alternator is installed on the truck being removed, disconnect the alternator cable from the junction box on the alternator, then coil and secure the cable so it will not be damaged.
 8. Disconnect all sander hoses from the sander brackets on the truck.
 9. Disconnect the hoses for the flange lubricators if used, and cover the opening to prevent the entry of foreign materials.
 10. Disconnect the hand brake chain if the long-hood end truck is being removed.
 11. Remove the lateral and yaw dampers from the platform and save the hardware.
 12. Remove both safety hooks from the truck frame, mark as right or left, and save the hardware.
 13. Raise the locomotive platform clear of the truck with jacks or a crane, or lower the truck on a drop table.
 14. After the truck is removed from under the locomotive, cover the truck center pin bearing and traction motor openings to prevent contamination with dirt and other foreign materials.
- Steerable Truck Installation
 1. Space the trucks for a truck center-block to center-block spacing.
 2. Remove the temporary dust covers from the traction motor air duct and center pin bearing openings.
 3. Inspect the traction motor air ducts between the locomotive platform and the truck and replace any air ducts that are cracked or torn.
 4. Coat the center pin on the underside of the locomotive platform with grease before lowering the platform onto the truck.
 5. Lower the platform onto the truck or raise the truck on the drop table.
 6. Check and align the trucks, if required.
 7. Install both safety hooks to the correct sides on the truck frame and torque the bolts.

8. Install the lateral dampers to the platform, with the shorter bolt at the bottom, and torque the bolts.
9. Install the yaw dampers to the platform and torque the bolts.
10. If installing the long-hood end truck, connect the hand brake chain.
11. Install the hoses from the sand pipes on the platform to the sander brackets on the trucks and install the hoses for flange lubricators, if used.
12. Connect the axle alternator cable to the junction box on the alternator, if used.
13. Install the traction motor air duct to each of the traction motors and torque the bolts.
14. Connect the ground cable between the truck and the platform.
15. For each traction motor, connect the speed sensor cable, ground cable, and traction motor leads, and, if equipped, the hot bearing detection probe on the U-tube.
16. Connect the air brake hoses from the locomotive platform to the brake cylinder piping on the truck.
17. Verify that the truck cut-out cocks located under the platform are open before returning the locomotive to service.
18. Adjust the truck brake rigging.
19. Ensure that the journal bearing housings, traction motor gear cases, and traction motor support bearings have been lubricated before moving the locomotive.
20. Check the traction motor rotation.

Screen 89:

Summary (Cont'd):

- Truck Alignment Verification
 1. Ensure that the locomotive is on a straight, level track.
 2. Release the brakes on the truck being aligned by closing the truck air brake cut-out cock and bleeding air from the brake cylinders.
 3. Check the axle distance between the center and each end axle.
- Wheel Lateral Alignment Verification
 1. Align the end axle wheels with the truck frame as follows:
 - a. Install 5.125 inch (13.018 cm) blocks to the journal box tees on the non-gearcase side of both end axles.
 - b. Install airbags between the truck frame and the wheel on the non-gearcase side of the end wheel sets, then apply air to the airbags and move each wheel set until there is contact between the blocks and the truck frame.
 2. Use wedges to block the end axles in respect to the frame and remove the airbags from the end axles.
 3. Align the center axle wheels with the end axle wheels as follows:
 - a. Use a long straight edge or a wire stretched tight against the backside face of the non-gearcase wheels of both the end axles.

- b. Use airbags to align the center axle wheel with the straight edge or wire.
- 4. If the center axle wheel is not aligned with the straight edge or wire, loosen the CAMCAR bolt connections on the two inter-motor links at traction motor positions 1, 2, 5, and 6 to allow the center axle to be laterally aligned.
- 5. If the CAMCAR bolts are not already loosened and hand-tightened, remove and install new CAMCAR bolts one at a time.
- 6. Hand-tighten the nuts and tag the bolts as loose, then repeat steps 3a and 3b.

Traction Motor Combo

Screen 1:

Welcome Screen:

Welcome to the Traction Motor Combo module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Traction Motor Combo:

In this module, you will learn how to inspect and maintain a traction motor combo in a running repair environment. The traction motor combo includes the traction motor, U-tube, axle, wheels, bull gear, and gear case.

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

- State the purpose of the traction motor combo.
- Describe the major components of a traction motor combo.
- Identify the running maintenance requirements for the traction motor combo.
- Describe the basic operation of a traction motor combo.
- Summarize the major steps to remove and install a traction motor combo.
- Summarize the major steps to disassemble and assemble an AC traction motor combo.
- Summarize the major steps to disassemble and assemble a DC traction motor combo.

Screen 3:

Disclaimer:

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

Screen 4:

Purpose of Traction Motor Combo:

The main purpose of the traction motor combo is to convert electrical energy to mechanical energy for driving the locomotive wheels, a process referred to as motoring. The traction alternator supplies the electrical energy. The secondary purpose of the traction motor combo is to convert the mechanical energy of slowing a moving locomotive to electrical energy utilizing a process referred to as dynamic braking. In dynamic braking, the traction motors function as generators with the electrical energy that they produce dissipated as heat in the dynamic braking resistor grids.

Screen 5:**Major Components of Traction Motor Combo:**

The major components of the traction motor combo are:

- Traction Motor
- Bull Gear
- Axle
- Wheels
- U-Tube
- Gear Case

Screen 6:**Traction Motor:**

The traction motor takes electrical energy from the propulsion system and converts it into mechanical energy for driving the locomotive wheels.

Screen 7:**Bull Gear:**

The bull gear, pressed onto the axle, meshes with the pinion gear on the traction motor rotor to transfer the torque of the traction motor to the axle.

Screen 8:**Axle:**

The axle is used to transfer the rotational force of the traction motor to the wheels. Journal bearings, located on each end of the axle, allow the axle to turn with minimal friction when mounted inside the journal boxes attached to the truck frame.

Screen 9:**Wheels:**

The locomotive rides on the tread of the wheel, and the wheel flange keeps the locomotive on the rails.

Screen 10:**U-Tube:**

The U-tube, mounted to the traction motor, wraps around and houses the axle. The U-tube contains two roller bearing assemblies that support the traction motor and allow axle rotation within the U-tube.

Screen 11:**Gear Case:**

The gear case protects the pinion and bull gears from the outside environment. Additionally, the gear case contains the oil used to lubricate the two gears. On AC traction motors, the oil also lubricates the pinion-end bearing in the traction motor. The

gear case consists of two halves, a top or upper half and a bottom or lower half, which are bolted together.

Screen 14:

Operation of the Traction Motor Combo:

The high adhesion truck uses three AC (5GEB13) or DC (5GE752AH) traction motor combos. The nose of each combo is resiliently mounted to the truck frame with a motor nose suspension, and ends of the combo are allowed to float in the truck frame with a journal housing and nylon wear liners. This holds the combo in the truck in a triangle-shaped configuration. Electricity is supplied to the traction motor from the propulsion system. Coils in the traction motor create a magnetic field, which causes the rotor to turn. On the rotor, the small pinion gear meshes with the larger bull gear on the axle. Depending on the traction motor design, the pinion gear may either be formed as an integral part of the rotor or may be pressed onto the rotor. The bull gear is pressed onto the axle along with the two wheels and the U-tube. Two roller-bearing assemblies allow the axle to rotate freely within the U-tube while the two journal bearings allow the axle to rotate freely within the journal box mounted to the truck. With the traction motor powered, the pinion and bull gears mesh, causing the axle and wheels to turn and power the locomotive.

Screen 15:

Gear Case Oil:

This section provides information on the oil capacity in the gear case and steps for checking, adding, and draining oil in the gear case. The table displays the traction motor gear case oil capacities for the DC (5GE752AH) and AC (5GEB13) traction motor types.

Note: Before checking the gear case lubricant level, the locomotive should be motionless for at least 30 minutes for AC traction motors and 15 minutes for DC traction motors to get an accurate reading.

Caution: NEVER permit the gear case lubrication level to run low, as this could result in pinion end bearing (on an AC traction motor), bull gear, and pinion gear failure. Do NOT use any lubricant other than the recommended gear case lubricant as this also could result in component failure.

The gear case has a fill opening that is either a solid-fill plug or a spring-loaded plug, located in the lower half of the gear case. Check the lubricant level by looking in the fill opening. If the lubricant is below the fill opening, use the proper dipstick to determine how much lubricant to add. Wipe the dipstick with a clean cloth to remove oil, dirt, and sand before inserting it into the gear case. For AC traction motors, if the gear case requires more than 6.5 quarts (6 L) of lubricant, remove and replace the traction motor combo. For DC traction motors, if the gear case requires more than 4 quarts (3.8 L) of lubricant, remove and replace the traction motor combo.

Screen 16:**Gear Case Oil (Cont'd):**

Top off the required quantity of lubricant in the gear case. Allow the lubricant to redistribute and level out, and then recheck the lubricant level. Clean the plug to remove any dirt and particles. Apply an approved sealant to the pipe plug, and then torque the plug to the appropriate torque value. Lock wire the plug so that it does not vibrate loose. To drain the gear case lubricant, remove the drain plug located at the side of the bottom gear case. After draining the gear case, clean the plug to remove any dirt and particles. Apply an approved sealant to the pipe plug, and then torque the plug to the appropriate torque value. Lock wire the plug so that it does not vibrate loose.

Screen 17:**Connection-End Bearing Re-Greasing:**

The traction motor rotor anti-friction Connection-End (CE) ball bearing is packed with grease at motor assembly and requires no attention until wheel change.

Typical steps to re-grease the CE ball bearing during wheel change are as follows:

Note: For the GEB13EB traction motors, apply D50E34 grease or equivalent.

1. Carefully clean off the bearing cap, then remove the bearing cap by removing the bearing cap bolts.
2. Visually examine the bearing rivets, huck bolts, and cage for broken parts or other signs of damage.
3. Clean the old grease out of the bearing cap, then clean and dry the bearing cap.
4. For GEB13A, GEB13B, and GEB13EA traction motors, apply 5 oz. (142 g) of D6A2C17 grease or equivalent and, for GEB13EB traction motors, apply 7 oz. (199 g) of D50E34 grease or equivalent to the bearing cap cavity, then carefully re-install the bearing cap.
5. Torque the bearing cap bolts to the correct torque value.

Note: If the bearing is removed, it must be replaced with a new bearing as pulling the bearing off damages the cage.

Screen 18:**Running Maintenance Schedule:**

The table displays the recommended running maintenance schedule for the traction motor combo and its major components.

Screen 23:**Traction Motor Combo Removal:**

Typical steps to remove the traction motor combo from the high adhesion truck are as follows:

Note: The steps in this demonstration are applicable to both AC and DC traction motors, unless mentioned otherwise. The AC traction motor has been used to depict the steps in this demonstration.

Warning: To ensure the safety of personnel, before proceeding, ensure that the truck and locomotive are securely supported and that the electrical power to the traction motors is OFF.

Warning: On AC locomotives, capacitors in the inverter circuits may not be fully discharged and may contain lethal voltages. Before performing any maintenance on a traction motor or traction motor power cables, open the auxiliary cab door and raise the barrier bar to the vertical position. Raising the barrier bar closes the Capacitor Discharge Switch (CDS). Wait until all lights on the Capacitor Discharge Indicator (CDI) are extinguished before proceeding with any maintenance.

1. Position the traction motor combo to be removed over a single-axle drop table.

Note: If the axle to be removed is at either end of the truck, support the truck frame with suitable blocks to prevent it from tilting.

2. Set the locomotive wheel brakes and chock the wheels on the truck not being worked on, then manually release the brakes on the wheels of the traction motor combo to be removed by closing the cut-out cock in the air line for that truck.

Note: Ensure that all traction motor leads and connection cables are properly marked to ensure correct reconnection.

3. Disconnect all power cables and the motor ground cable of the traction motor combo to be removed from the truck, then secure the cables to prevent damage during traction motor combo removal.

Screen 24:

Traction Motor Combo Removal (Cont'd):

4. Unplug the speed sensor cable of the traction motor combo to be removed, then remove the cable clamp.

Note: Do NOT disconnect the speed sensor from the traction motor.

5. If equipped, disconnect the bearing temperature sensor cables of the traction motor combo being removed.
6. Remove the pins from the slack adjusters of the traction motor combo to be removed, and adjust the slack adjusters to the shortest length.
7. Remove the brake shoes by removing the keys from the brake heads.

Screen 25:

Traction Motor Combo Removal (Cont'd):

8. If the traction motor combo to be removed is one of the end assemblies on the truck, loosen and remove all but one of the sand bracket bolts at both ends of the axle, and swing the sand brackets away to prevent fouling when the combo is lowered.
9. Disconnect the traction motor air duct from the top of the traction motor.

Note: Cover the traction motor air intake opening to prevent foreign material from entering the traction motor.

10. Remove the pedestal liner and axle journal bearing housing retaining bolts, retainers, and any free pedestal liners.

Caution: When the pedestal liner retaining bolts have been removed, the pedestal liners are free floating and may drop out. Remove any free floating pedestal liners.

11. If the traction motor combo to be removed is in positions 1, 3, 4, or 6:
 - a. Disconnect the axle snubbers from the journal box adapters at both ends of the axle.
 - b. Support the truck frame with wooden blocks and hydraulic jacks from the floor adjacent to the traction motor combo being removed.

Note: If the axle has an optional axle alternator, remove the entire axle journal bearing housing as part of the snubber removal step.

Screen 26:

Traction Motor Combo Removal (Cont'd):

12. Disconnect the AC traction motor nose suspension as follows:
 - a. Place a suitable jack under the lugs or motor frame. Make sure that the jack cannot slip off if the motor moves or tries to rotate.

Caution: Disconnect the suspension link by removing the CAMCAR bolts with a special socket or by cutting the bolts with a torch or hydraulic splitter. If a torch is used, form a shield to protect the rubber parts of the suspension link from heat damage and use extreme care. Do not reuse the bolts, washers, or nuts.

- b. Disconnect the suspension link from the motor.

Warning: Do not pull the suspension link away from the motor until the motor is secured properly. Otherwise, the motor will drop.

Note: For AC traction motors located in positions 1, 2, 5, or 6 in locomotives with generation 1 and generation 2 steerable trucks, the suspension link will contact the

motor nose bracket. This bracket is attached to rubber mounts and will move to permit the suspension link to clear the motor frame.

- c. Pull the suspension link away from the motor by using a come-along or similar chain rigging.
- d. Lower the drop table by a few inches while raising the jack to allow the motor safety nose to clear the truck frame.

Screen 27:

Traction Motor Combo Removal (Cont'd):

13. Remove the DC traction motor nose suspension as follows:
 - a. Jack or lift the traction motor nose to compress the suspension assembly approximately 0.5 inches (13 mm).
 - b. Install a 1/2-13 x 6.5 inch (165 mm) long bolt and nut between the U-channels on both sides of the suspension assembly.
 - c. Tighten the nuts to compress the suspension assembly to 11.7 inches (297 mm) or less.
 - d. Lower the traction motor slightly, then remove the cotter pins and retaining pins that secure the vertical keeper pins in the suspension assembly.

Note: The vertical keeper pins should drop out of the suspension assembly when the retaining pins are removed.

- e. Slide the suspension assembly sideways, removing the assembly from the truck frame.
- f. Inspect the traction motor nose suspension assembly for separation of laminations, badly eroded rubber laminations, or cracked or broken cast members and, if defective, remove and replace the traction motor nose suspension assembly.

Screen 28:

Traction Motor Combo Removal (Cont'd):

14. In a DC traction motor, check the suspension lugwear plates on the traction motor and, if excessively worn, replace the plates.
15. Lower the drop table by approximately 5 inches (125 mm), place chocks over the rail, and nip the securing bolts to secure the traction motor combo in place.
16. Raise the drop table by 2 inches (50 mm) to compress the coil springs.
17. For the four coil springs at the traction motor combo, place a spring retaining strap around the truck frame, under the air piping and through the spring coils at approximately the fifth coil, then join the strap ends, leaving at least 12 inches (300 mm) of slack in the straps.

Note: Verify that the wooden blocks and hydraulic jacks supporting the truck frame are securely in place if the combo to be removed is in positions 1, 3, 4, or 6.

Screen 29:

Traction Motor Combo Removal (Cont'd):

18. Apply C-clamps on each wheel rim below each side of the axle journal bearing housing to prevent the housing from rotating during traction motor combo removal.
19. Raise the traction motor nose up to clear the nose suspension or the truck frame as the traction motor is lowered.
20. Support the traction motor nose with blocks suitably placed under the frame, such that it cannot slip off if the traction motor moves or rotates.
21. Lower the drop table until the space between the top of the axle journal bearing housing and the truck frame is approximately 7 inches (175 mm), then tighten the coil spring retaining straps to remove any remaining slack.

Screen 30:

Traction Motor Combo Removal (Cont'd):

22. Lower the drop table until the traction motor combo clears the truck and remove any remaining truck pedestal liners.
23. Move the traction motor combo from beneath the truck and locomotive.

Caution: If the gear case is still filled with oil, it cannot be tilted more than 4 inches (102 mm) end to end from horizontal because the oil will run around the seals and drain into the traction motor.

Warning: The AC traction motor combo weighs approximately 13,270 lbs. (6,019 kg), and the DC traction motor combo weighs approximately 12,000 lbs. (5,443 kg). Ensure that an adequate crane and cables are used to lift and move the traction motor combo.

24. Using a suitable hoist, lift the traction motor combo from the drop table and move it to the area assigned for cleaning, maintenance, or storage.
25. Set the traction motor frame in the normal horizontal position on blocks high enough so that the wheels clear the floor.

Caution: After the combo is removed from the truck, if it is not broken down immediately, the rotor (on the AC motor) or armature (on the DC motor) should be locked to prevent possible shipping damage to bearings in the motor.

Screen 33:

Traction Motor Combo Installation:

Warning: The AC traction motor combo weighs approximately 13,270 lbs. (6,019 kg), and the DC traction motor combo weighs approximately 12,000 lbs. (5,443 kg). Ensure that an adequate crane and cables are used to lift and move the combo.

Warning: To ensure the safety of personnel, before proceeding, ensure that the truck and locomotive are securely supported and that the electrical power to the traction motors is OFF.

Warning: On AC locomotives, capacitors in the inverter circuits may not be fully discharged and may contain lethal voltages. Before performing any maintenance on a traction motor or traction motor power cables, open the auxiliary cab door and raise the barrier bar to the vertical position. Raising the barrier bar closes the CDS. Wait until all lights on the CDI are extinguished before proceeding with any maintenance.

Caution: If the gear case is filled with oil, it cannot be tilted more than 4 inches (102 mm) end to end from horizontal because the oil will run around the seals and drain into the traction motor. Be sure to use a three-point lift to lift the combo.

Screen 34:

Traction Motor Combo Installation (Cont'd):

Typical steps to install the traction motor combo into the high adhesion truck are as follows:

1. Remove all dirt and weld splatter from the traction motor nose suspension lugs and the traction motor nose suspension area of the truck frame.
2. Transfer the traction motor combo to the drop table, and place suitable blocking under the motor frame to raise the motor lugs.

Note: The traction motor nose must be raised so that the motor safety lugs engage the truck frame, and the traction motor nose suspension lugs clear the truck frame.

3. Position the drop table and the traction motor combo under the truck with the axle journal bearing housings aligned with the journal bearing housings in the truck frame.
4. Level the axle journal bearing housings, and apply C-clamps on each wheel rim below each side of the axle journal bearing housings to prevent it from rotating during traction motor combo installation.

Note: Ensure that the coil spring seats are in position on the axle journal bearing housings.

5. Raise the drop table with the traction motor combo.

Screen 35:

Traction Motor Combo Installation (Cont'd):

6. Install the truck pedestal liners, and ensure that the coil springs seat properly as the traction motor combo is raised.
7. Raise the drop table until the axle journal bearing housings are completely in place, with the drop table assuming part of the weight of the truck.

8. Install the four axle journal bearing housing retainers on the truck pedestal legs.
9. Torque the retainer bolts to 296 to 329 lb.-ft. (401 to 446 Nm).
10. Remove the four coil spring retaining straps.
11. Lower the hydraulic jacks and remove all wooden blocks from under the traction motor and the truck.

Screen 36:

Traction Motor Combo Installation (Cont'd):

12. Connect the AC traction motor nose suspension as follows:
 - a. Release the come-along or chain rigging. The suspension link should spring back under the motor lugs.
 - b. Lower the motor frame until the suspension link is supporting the weight of the traction motor combo.

Note: For AC traction motor combos in positions 1, 2, 5, or 6, the suspension link bracket should be on top of the motor lugs.

- c. Insert CAMCAR bolts through the suspension link motor lugs and hand-tighten the nuts.

Note: On generation 1 and 2 steerable trucks only, if the traction motor combo is being installed in positions 1, 2, 5, or 6, verify truck alignment as described in the recommended maintenance publications before tightening the CAMCAR bolts.

Note: It may be necessary to twist the motor nose bracket, using rubber mounts, to align the bolt holes.

Caution: Do NOT replace CAMCAR bolts and nuts or HUCK pins and collars with ordinary fastener bolts and nuts. Ordinary bolts and nuts may loosen during locomotive operation and cause the traction motor to fail or cause other equipment damage. Refer to the applicable Parts Bulletin for recommended replacement parts.

- d. Tighten the CAMCAR bolts with the special socket until the head shears off each bolt.

Screen 37:

Traction Motor Combo Installation (Cont'd):

13. Install the DC traction motor nose suspension as follows:
 - a. Slide the nose suspension assembly sideways, into the truck frame.
 - b. Lower the traction motor combo slightly, and install the cotter pins and retaining pins, securing the vertical keeper pins in the nose suspension assembly.
 - c. Loosen the nuts to de-compress the nose suspension assembly.

- d. Remove the 1/2-13 x 6.5 inch (165 mm) long bolt and nuts previously installed between the U-channels on both sides of the nose suspension assembly.
- e. Lower the traction motor nose into position.

Screen 38:

Traction Motor Combo Installation (Cont'd):

14. For traction motor combos in positions 1, 3, 4, and 6, connect axle snubbers to the journal box adapters at both ends of the axle, then torque the snubber bolts to 197 to 219 lb.-ft. (267 to 297 Nm).
15. Connect the traction motor air duct boot to the top of the motor.
16. Lubricate the air duct bolts with a Wabtec approved Moly-based lubricant (84B565364A1) or light machine oil.
17. Install the bolts and then torque to 50 to 55 lb.-ft. (68 to 75 Nm).
18. If the traction motor combo installed is one of the end assemblies on the truck, return the sand brackets at both ends of the axle, then install and torque the sand bracket bolts to the proper value.
19. Install the brake shoes and the slack adjuster pins, then adjust the slack adjusters.

Screen 39:

Traction Motor Combo Installation (Cont'd):

20. Connect the speed sensor cable of the traction motor combo to its connection under the locomotive platform.
21. If equipped, connect the bearing temperature sensor cables.
22. Connect all power cables and the traction motor ground cable to their connections under the locomotive platform.
23. Release and remove all jacks and chocks used to support or secure the truck for traction motor combo removal.
24. Activate the brakes by opening the truck cut-out cock.
25. Check the level of lubricant in the gear case, and add lubricant as required.

Screen 42:

AC Rotor Locking Clamp with Hard Stop Installation:

Caution: The AC rotor must be locked when the motor is transported, other than from work station to work station during processing, to prevent damage to the rotor bearings caused by shock and vibration. This includes traction motors loose, in a combo, and in a truck.

Note: The rotor locking clamp is installed on the Connection End (CE), also referred to as the Opposite Pinion End (OPE), of the AC traction motor.

Typical steps to install the AC rotor locking clamp with a hard stop provided by the use of welded locking nuts on the locking bolts are as follows:

Caution: If the gear case is still filled with oil, the gear case cannot be tilted more than 4 inches (102 mm) end to end from the horizontal or the oil will run around the seals and drain into the traction motor itself.

Caution: Rotating the rotor while the rotor locking clamp is installed can damage the rotor and the rotor locking clamp and make removal of the rotor locking clamp difficult.

1. Remove the two CE bearing housing bolts opposite to the U-tube side.

Note: Do not remove the bearing cap.

2. Fully retract the two locking bolts of the rotor lock by positioning the inboard-side locking nut against the welded nut on each locking bolt and the outboard-side nut against each locking bolt head.
3. Install the rotor locking clamp by carefully inserting the clamp prong into the framehead exhaust openings, and position it behind the speed sensor gear, such that the two locking bolts line up squarely with the two vacant CE bearing housing bolt holes in the framehead.

Caution: Take care NOT to damage the gear teeth.

Screen 43:

AC Rotor Locking Clamp with Hard Stop Installation (Cont'd):

4. Hand thread the two locking bolts into the bearing housing until the welded nut on each locking bolt is positioned against the motor frame head.
5. Pull the rotor lock away from the motor until the clamp prong engages with the speed sensor gear, then back both inboard-side nuts up and away from the welded nuts, until they engage with the clamp bar.

Note: Ensure that both outboard-side locking nuts are not yet engaged.

6. For each locking bolt, hold the bolt head in place while tightening the inboard-side locking nut against the clamp bar to 27 to 31 lb.-ft. (36.6 to 42 Nm).
7. For each locking bolt, tighten the outboard-side locking nut against the clamp bar to 27 to 31 lb.-ft. (36.6 to 42 Nm) to serve as a jam nut to prevent loosening during shipment.
8. Put the two CE bearing housing bolts into a small cloth sack and attach to the rotor locking clamp, with instructions to re-install and torque to the proper value upon removal of the clamp assembly.

Screen 44:**AC Rotor Locking Clamp with Hard Stop Removal:**

Typical steps to remove the AC rotor locking clamp with a hard stop provided by the use of a welded locking nut on the locking bolt are as follows:

Caution: If the gear case is still filled with oil, the gear case cannot be tilted more than 4 inches (102 mm) end to end from the horizontal or the oil will run around the seals and drain into the traction motor itself.

Caution: Rotating the rotor while the rotor locking clamp is installed can damage the rotor and the rotor locking clamp and make removal of the rotor locking clamp difficult.

1. For each locking bolt, loosen the inboard-side locking nut away from the clamp and rotate it all the way up to the welded nut on the locking bolt.
2. For each locking bolt, loosen the outboard-side locking nut away from the clamp and rotate it all the way up to the locking bolt head.
3. Loosen both locking bolts by applying torque to the wrench flat on each locking bolt head, then completely unthread the locking bolts from the motor frame head by hand rotation.
4. Fully retract both locking bolts away from the motor.
5. Remove the rotor locking clamp from the frame-head exhaust opening.
6. Re-install the CE bearing housing bolts and washers in the two vacant CE OPE bearing housing bolt holes, then torque the bolts to 56 to 60 lb.-ft. (76 to 81 Nm).
7. Place the rotor locking assembly at the designated place and save for future use.

Caution: If there is any oil in the gear case, use a three-point lift to raise the combo assembly and keep the gear case level within 4 inches (102 mm) end to end from horizontal. If a traction motor combo with oil in the gear case is tilted, oil will flow past the seals and drains into the traction motor itself.

Screen 45:**AC Rotor Locking Clamp without Hard Stop Installation:**

Caution: The AC rotor must be locked when the motor is transported, other than from work station to work station during processing, to prevent damage to the rotor bearings caused by shock and vibration. This includes traction motors loose, in a combo, and in a truck.

Note: The rotor locking clamp is installed on the Connection End (CE), also referred to as the Opposite Pinion End (OPE), of the AC traction motor.

Typical steps to install the AC rotor locking clamp without a hard stop provided by the use of welded locking nuts on the locking bolts are as follows:

Caution: If the gear case is still filled with oil, the gear case cannot be tilted more than 4 inches (102 mm) end to end from the horizontal or the oil will run around the seals and drain into the traction motor itself.

Caution: Rotating the rotor while the rotor locking clamp is installed can damage the rotor and the rotor locking clamp and make removal of the rotor locking clamp difficult.

1. Remove the two CE bearing housing bolts and washers.
2. Insert the two locking bolts through the locking clamp and thread two nuts onto each bolt.
3. Install the rotor locking clamp prong into the framehead exhaust openings, and position it behind the speed sensor gear, such that the bolts line up squarely with the two vacant CE bearing housing bolt holes in the framehead.

Caution: Take care NOT to damage the gear teeth.

4. Thread the two rotor locking bolts into the CE bearing housing holes in the framehead for approximately ten turns to fully engage the bolts.

Screen 46:

AC Rotor Locking Clamp without Hard Stop Installation (Cont'd):

5. Tighten the first nut on each locking bolt evenly against the locking clamp to tighten it by pushing the clamp away from the framehead and pulling against the back of the speed sensor gear, then torque the nuts to 27 to 31 lb.-ft. (36.6 to 42 Nm).
6. While holding the first nut on each locking bolt in place with a wrench, torque the jam nut on each locking bolt to 27 to 31 lb.-ft. (36.6 to 42 Nm) to prevent loosening during shipment.
7. Put the two bearing housing bolts and washers into a bag-tag and fasten it to the rotor locking clamp, with instructions to re-install and torque to the proper value upon removal of the clamp assembly.

Note: Using a wood beam and threaded rod to force the pinion towards the motor frame is an acceptable alternate method of preventing rotor bearing damage while shipping a traction motor not in a combo.

Note: If both of the above configurations of rotor locking methods are available (clamp with a hard stop and clamp without a hard stop), the configuration with a hard stop (nuts welded to the locking bolts) is the preferred configuration.

Screen 47:

AC Rotor Locking Clamp without Hard Stop Removal:

Typical steps to remove the AC rotor locking clamp without a hard stop provided by the use of welded locking nuts on the locking bolts are as follows:

Caution: If the gear case is still filled with oil, the gear case cannot be tilted more than 4 inches (102 mm) end to end from the horizontal or the oil will run around the seals and drain into the traction motor itself.

Caution: The AC rotor must be locked when the motor is transported, other than from work station to work station during processing, to prevent damage to the rotor bearings caused by shock and vibration. This includes traction motors loose, in a combo, and in a truck.

Caution: Rotating the rotor while the rotor locking clamp is installed can damage the rotor and the rotor locking clamp and make removal of the rotor locking clamp difficult.

1. While holding the first nut on each locking bolt in place with a wrench, loosen the jam nut on each locking bolt.
2. Loosen the first nut away from the locking clamp.
3. Unthread both AC rotor locking clamp bolts from the framehead.
4. Remove the rotor locking bolts, the first nut, the jam nut, and the rotor locking clamp from the framehead exhaust opening.
5. Re-install the CE bearing housing bolts and washers in the two vacant CE bearing housing bolt holes.
6. Torque the CE bearing housing bolts to 56 to 60 lb.-ft. (76 to 81 Nm).
7. Place the rotor locking bolts, first nut, and jam nut into the bag-tag, tie the bag-tag to the rotor locking clamp, and save for future use.

Caution: If there is any oil in the gear case, use a three-point lift to raise the combo assembly and keep the gear case level within 4 inches (102 mm) end to end from horizontal. If a traction motor combo with oil in the gear case is tilted, oil will flow past the seals and drain into the traction motor itself.

Screen 48:

DC Armature Locking Bolt Installation:

Caution: The DC armature must be locked when the motor is transported, other than from work station to work station during processing, to prevent damage to the bearings caused by shock and vibration.

Note: A shipping kit, Part number 41B537934G1, may be ordered that contains two long bolts (with heads painted yellow), two jam nuts, and a caution tag. However, when a complete traction motor combo is shipped, the armature is locked using only one bolt.

The armature locking bolt is installed on the commutator end of the DC traction motor. Typical steps to install the DC armature locking bolt on a DC traction motor combo are as follows:

1. Remove one of the two 5/8-inch bolts that are diametrically opposite each other from the commutator end of the traction motor frame.

2. Screw a jam nut onto one of the long bolts from the kit.
3. Thread the long bolt into the traction motor frame until it bears on the commutator end cap.
4. Torque the bolt to 30 lb.-ft. (41 Nm), then secure it with the jam nut.
5. Place the regular bolt and washer into the bag, then tie the tag to the yellow locking bolt for shipment with the traction motor combo.

Caution: To avoid commutator damage, do NOT attempt to rotate the armature with the locking bolt in place.

Screen 49:

DC Armature Locking Bolt Removal:

Note: Before installing a traction motor combo with a set of wheels or a traction motor combo into the truck, the locking bolt must be removed. The proximity of the wheel to the motor makes it impossible to remove the locking bolt later.

Typical steps to remove the DC armature locking bolt from a DC traction motor combo are as follows:

1. Release the jam nut on the yellow bolt and back the bolt out completely.
2. Replace the regular bolt and washer found in the attached bag.
3. Torque the regular bolt to 110 to 120 lb.-ft. (149 to 163 Nm).
4. Place the locking bolt and jam nut into the bag, and save for future use.

Screen 50:

AC Traction Motor Combo: Gear Case Disassembly:

Note: The traction motor combo must be removed from the truck and placed on level ground before the gear case can be removed.

Typical steps to disassemble the gear case are as follows:

1. Drain the lubricant from the gear case by removing the drain plug located on the lower side of the gear case bottom half.
2. Remove the 16 gear case split line bolts and washers and the two gear case mounting bolts.

Warning: The upper gear case weighs approximately 150 lbs. (68 kg). Ensure that the crane and cables are adequate to lift and move the gear case.

3. Attach a lifting cable through the inverted "U-shaped" holes in each end of the upper gear case, and take up the slack in the cables with a hoist or crane.
4. With an overhead crane, lift off the upper gear case, guiding the center bolt pad, located between the axle and pinion bores, through the relief in the traction motor framehead.

Screen 51:

AC Traction Motor Combo: Gear Case Disassembly (Cont'd):

Caution: When prying the lower gear case from the gutter and pinion bore seal, be careful not to damage the gear or pinion teeth.

5. Pry the lower gear case loose from the gutter on one end and the pinion bore seal on the other end.

Warning: The motor, wheels, and axle assembly weighs approximately 13,000 lbs. (6,000 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

6. Attach axle slings. Use a lifting cable at the motor lifting eye and raise the motor, wheels, and axle assembly to approximately one foot.

Note: As the assembly is lifted, guide the center bolt pad through the relief on the framehead while freeing the gear case of the gutters.

7. Remove and discard the gutters and the pinion bore seal.
8. Carefully position the motor on the nose support.

Screen 52:

AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal:

Typical steps to remove the U-tube, wheels, and axle assembly are as follows:

1. Remove the gear case, as discussed in the AC Traction Motor Combo: Gear Case Disassembly section of this module.
2. Remove the eight bolts and washers that hold the U-tube to the traction motor frame.

Note: If equipped, remove the two 0.625-inch bolts (drain hole plugs) from the middle of the U-tube.

3. Attach a lifting strap to each axle journal bearing, then use jacking bolts, if necessary, to separate the assembly from the traction motor frame.

Warning: When the U-tube, wheels, gear, and axle assembly is lifted, the U-tube will quickly rotate to the open-end up position, and could injure nearby personnel. Support the assembly as it is lifted, allowing the U-tube to turn slowly to the open-end up position.

Warning: The assembly weighs approximately 5,200 lbs. (2,359 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

4. Using a crane or hoist, lift the assembly off the motor.

Screen 53:

AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal (Cont'd):

Caution: If a high-pressure spray washer is used to clean the U-tube, wheels, gear, and axle assembly, use extreme care to ensure that the spray does not enter the bearings. Do NOT submerge the assembly in liquid.

5. Thoroughly clean the U-tube, wheels, gear, and axle assembly of grease and dirt.
6. After cleaning, apply rust prohibitive to all machined surfaces except the wheels, then cover the assembly in plastic and tape shut until needed.
7. Install guide pins in the bearing cap before removing all the bolts.

Caution: Use the guide pins to keep the alignment of the inner bearing and gasket while the bearing cap is removed. Failure to use guide pins results in misalignment of the inner bearing housing and gasket.

8. Remove the pinion end bearing cap from the traction motor.

Screen 54:

AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal (Cont'd):

9. Inspect the bearing as follows:
 - a. Verify that the cage is not rubbing the inner ring flange.
 - b. Rotate the bearing by hand, listening for noise and feeling for roughness.

Note: The bearing should turn smoothly and easily. If you hear noise or feel roughness, replace the bearing.

- c. Inspect for metal debris from the bearing rollers, or any other visible defects. If any debris or defect is found, replace the bearing.
- d. Verify bearing clearance with a feeler gauge. It should be 0.012 to 0.016 inches (0.3048 to 0.4064 mm).

Note: If any roller does not fall within the clearance or if measurements between rollers are not equal, replace the bearing.

Screen 55:

AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal (Cont'd):

10. If no bearing defects are found, flush the bearings with HD 57 oil.
11. Inspect the oil metering hole and trough screen for debris. Flush the trough until no debris washes out.
12. Clean the bearing cap, apply a new gasket, and return the bearing cap to the traction motor.

Note: Ensure that grade 8 bolts are used and are properly torqued.

Screen 56:**AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Installation:**

Typical steps to install the U-tube, wheels, and the axle are as follows:

1. Clean the traction motor frame and U-tube mounting surfaces with a rag dipped in an approved solvent, then wipe the mounting surfaces with a clean rag to remove excess solvent.
2. Clean the mating surface and apply a gasket (Part Number 41A239176P317) at the pinion end (PE) of the traction motor, where the U-tube and the motor frame join.
3. Clean the mating surface and apply a gasket (Part Number 41A239176P317) at the connection end (CE) of the traction motor, where the U-tube and the motor frame join.
4. Clean the pinion end bearing cap groove with CRC Natural Degreaser.

Screen 57:**AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Installation (Cont'd):**

5. Install the pinion bore seal into the bearing cap groove as follows:
 - a. Start at the top and work the seal into the groove towards the bottom.

Note: Do NOT stretch the seal on installation; simply roll it over the edge.

Note: Ensure that the seal is not twisted and that it is seated all the way into the groove bottom.

- b. Seat the seal by tapping with a rubber mallet.
 - c. Place the Seating Ring Tool (84A206903P1) over the gasket and rotate it around the gasket.

Note: If the tool catches the gasket, the gasket is not properly seated. Use a rubber mallet to seat the seal until the tool can be rotated fully around the gasket without catching.

Screen 58:**AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Installation (Cont'd):**

Warning: The U-tube, wheels, gear, and axle assembly weighs approximately 5,200 lbs. (2,359 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Warning: When the U-tube, wheels, gear, and axle assembly is lifted, the U-tube quickly rotates to the open-end up position, and could injure nearby personnel. As the assembly is lifted, slowly rotate the U-tube to the open-end down position and hold it level to prevent it from returning to the open-end up position.

6. Lift the U-tube, wheels, gear, and axle assembly with a crane or hoist, and rotate the assembly so that the U-tube mounting surface faces downwards. Line up the mounting holes.

Caution: When lowering the U-tube, wheels, gear, and axle assembly, guide the bull gear past the bearing cap to prevent bearing cap damage.

7. Lower the assembly onto the traction motor frame.
8. Verify that the gear and the pinion are properly aligned and that the teeth are engaged.

Screen 59:

AC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Installation (Cont'd):

9. Lubricate the threads of the eight U-tube-to-motor mounting bolts and under the bolt heads and both faces of the associated washers with MOLYKOTE® D-321 R lubricant (Part Number 41A219134P9).
10. Start the eight mounting bolts by hand and then evenly torque the bolts to the proper torque value.
11. Install plastic plugs (Part Number 41A235989P5) in both U-tube jacking bolt holes.

Screen 60:

AC Traction Motor Combo: Gear Case Assembly:

Typical steps to assemble the gear case are as follows:

Warning: The motor, wheels, and axle assembly weighs approximately 13,000 lbs. (6,000 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Caution: Thoroughly clean all components in the gear case before assembly to ensure acceptable performance of the traction motor pinion end rotor bearings and gearing. The split line and pinion bore must be free of oil residue and residual sealant. The baffle and magnetic plugs must be free of dirt and debris.

Note: Use DOW 832 sealant to seal the metal and plastic joints. Full curing time for the sealant is 24 hours.

1. Position the nose of the traction motor down on wooden blocks.
2. Using the Guide Pin Kit (Part Number 41B539007G2), install the motor-side axle seal (gutter) on the axle with the lip of the seal located over the flinger.

Note: The gutter split line should be parallel to the ground with the latch located on the right in the bottom gear case half.

3. Apply a 0.125 to 0.25-inch (3.18 to 6.4-mm) bead of DOW 832 sealant in the groove and latch the seal.
4. Apply a 0.125-inch (3.18-mm) bead of sealant to the latch joint.

Note: Remove excess sealant. Ensure that the sealing surfaces are not pinched or folded.

Screen 61:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

5. Install the wheel-side axle seal (gutter) to the axle assembly with the lip of the seal located over the wheel and gear hubs.

Note: The gutter split line should be parallel to the ground with the latch located on the left in the bottom gear case half.

6. Apply a 0.125 to 0.25-inch (3.18 to 6.4-mm) bead of sealant in the groove and latch the seal.
7. Apply a 0.125-inch (3.18-mm) bead of sealant to the latch joint, then remove excess sealant.

Note: Ensure that the sealing surfaces are not pinched or folded.

Screen 62:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

8. Prior to installing the bottom gear case half, apply 0.25-inch (6.4-mm) bead of sealant to the groove of the pinion bore seal, continuously around the entire circumference of the seal.

Note: Using the dispensing nozzle, force the sealant into the groove as it is applied. Remove excess sealant.

Warning: The bottom gear case weighs approximately 180 lbs. (82 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

9. Install the bottom half of the gear case, then verify engagement of the gear case leg with the groove in the pinion bore seal, and the motor-side and wheel-side gutters with the gear case opening.
10. Use C-clamps to draw the bottom half of the gear case to within 0.50 inches (12.7 mm) of the U-tube and motor lugs.

Screen 63:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

11. Remove the adhesive backing from the Gortex tape (Part Number 41E903878P32) and apply the tape to the center bolt pad between the axle bore and pinion bore on the upper gear case half.
12. On the top gear case half, apply a 0.125-inch (3.18-mm) bead of sealant along the entire split line surface, just inside the bolt holes.

Warning: The top gear case half weighs approximately 150 lbs. (68 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Caution: Before installing the upper gear case half, inspect the pinion bore seal to verify that the seal has not bulged out of the groove. If it has, remove the bottom gear case half and reseal the pinion seal.

13. Install the top half of the gear case, then verify engagement of the gear case leg with the groove in the motor pinion end bore seal, and the motor-side and wheel-side axle seals (gutters) with the gear case opening.

Screen 64:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

14. Use C-clamps on the split line flanges at the gear case ends to draw the halves together evenly, then position C-clamps near the gear case center line to prevent misalignment.
15. Fasten the gear case halves as follows:
 - a. Install one split line bolt and washer at the axle end, then draw the gear case halves together but do not tighten.

Note: While the gear case is closing, ensure that the pinion end is properly engaging the pinion bearing cap by viewing the process at the open end.

- b. Install and hand-tighten a second bolt and washer on the motor side axle end.
- c. Install and hand-tighten a third bolt and washer between the axle and pinion bores.

Screen 65:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

- d. Install and hand-tighten a fourth bolt and washer between the axle and pinion bores.
- e. Install the remaining bolts and washers that hold the gear case halves together, and tighten all bolts evenly.
- f. Torque all bolts to the proper value.
- g. Verify closure of the upper gear case half by "shim checking" with a 0.010 inch (0.254 mm) shim in the wheel-side flange at the pinion end.

Note: If the shim fits, loosen all split line bolts, correct the problem, and then re-torque the bolts.

Screen 66:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

16. Remove the guide pins and install the mounting bolts (one at a time), then hand-tighten the bolts.
17. Torque the gear case-to-motor and gear case-to-U-tube bolts to the proper value, then, to seal out moisture, apply DOW 832 sealant to the open end of the threaded through holes for the gear case mounting bolts, completely filling the end of the bolt holes.

Note: On gear cases equipped with inspection covers, clean the cover and (without gasket) apply a 0.125-inch (3.2-mm) bead of DOW 832 sealant around and between the bolt holes. Install the cover, torque the bolts to the proper value, and apply a safety lock wire.

Warning: The motor, wheels, gear case, and axle assembly weighs approximately 13,270 lbs. (6,019 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

18. Attach a lifting strap to each axle journal bearing, then lift the traction motor, axle, and wheels assembly and rotate 90° to return the traction motor combo to the horizontal position.

Screen 67:

AC Traction Motor Combo: Gear Case Assembly (Cont'd):

19. On gear cases with solid-fill plugs, add lubricant to the gear case as follows:
 - a. Remove the fill plug.
 - b. Fill the gear case with 14.5 quarts (13.7 liters) of lubricant.

Caution: Do NOT overfill the gear case.

- c. Using a clean rag, wipe the magnet on the fill plug.
 - d. Apply Hylomar Thread Sealant to the fill plug threads and torque to the proper value.
 - e. Apply a safety lock wire to the fill plug and the drain plug.
20. On gear cases with spring-loaded fill plugs, add lubricant to the gear case as follows:
 - a. Pull on the plug cover and hold the fill plug open to add lubricant.

Note: The fill plug does not have to be removed to add lubricant.

- b. Fill the gear case with 14.5 quarts (13.7 liters) of lubricant.

Caution: Do NOT overfill the gear case.

- c. Release the plug and allow the spring loading to close the fill plug.

Note: The motor, wheels, gear case, and axle assembly may have to be leveled to completely charge with lubricant. Allow the lubricant to settle before checking against the fill line.

21. Assemble the breather to the top of the gear case.

Screen 70:

DC Traction Motor Combo: Gear Case Disassembly:

Note: The traction motor assembly must be removed from the truck and placed on level ground before the gear case can be removed.

Typical steps to disassemble the gear case are as follows:

1. Drain the gear case lubricant into a suitable container.
2. With the motor and axle assembly in the normal horizontal position, remove the eight split line bolts holding the top half of the gear case to the bottom half.
3. Lift off the top half of the gear case with a crane.
4. Remove the three gear case mounting bolts and washers or washer assemblies that secure the bottom half to the traction motor frame and drop the gear case to the floor.
5. If equipped, discard any Nord Lock or 4-component load washers.
6. Move the gear case to a suitable area.

Screen 71:

DC Traction Motor Combo: Gear Case Disassembly (Cont'd):

7. Carefully inspect the gear case mounting and split line bolts and replace or return to service depending on the following inspection criteria:
 - a. The bolt visually appears bent. Check for a bent bolt by laying it on a flat surface and rolling the bolt.
 - b. The threads are damaged to the point that the bolt cannot be installed by hand.
 - c. The bolts have visible cracks or deformation in shank and threads or underhead radius. Light surface rust is acceptable, but no corrosion pitting is acceptable in the shank, underhead radius, and threads.
 - d. The bolts are corroded to the extent that corrosion cannot be removed with a rag and solvent (such as brake cleaner or alcohol).

Note: All split line bolts that are less than grade 8 should be scrapped.

8. Thoroughly cleanse the gear case split line bolts that can be reused.

9. Clean hardened washers to remove all dirt and oil and return to service.

Note: Scrap any washers that are not visibly flat. Ensure that the surface mounted to the U-tube is free of paint.

Screen 72:

DC Traction Motor Combo: Gear Case Disassembly (Cont'd):

Warning: The traction motor, wheels, and axle assembly weighs approximately 12,000 lbs. (5,443 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Warning: When the U-tube, wheels, gear, and axle assembly is lifted, the U-tube will quickly rotate to the open-end up position, and could injure nearby personnel. Support the assembly as it is lifted, allowing the U-tube to turn slowly to the open-end up position.

10. Attach a nylon lifting strap to each axle journal bearing.
11. Lift the motor, wheels, and axle assembly and rotate it 90°.
12. Position the motor nose on wooden blocks.
13. Remove the motor-side and wheel-side axle bore seals (gutters) from the axle.

Note: The axle bore seals should be replaced when wheels are renewed.

Screen 73:

DC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal:

Typical steps to remove the U-tube, wheels, and axle are as follows:

1. Remove the gear case as discussed in the DC Traction Motor Combo: Gear Case Disassembly section of this module.
2. Remove the two bolts, plate, and cable cleat holding the traction motor cables to the U-tube.
3. Remove the eight bolts that hold the U-tube to the traction motor frame.
4. If equipped, remove the two 5/8-inch bolts (or drain hole plugs) from the middle of the U-tube.

Note: While removing the traction motor bolts, check the bolt head for the bolt grade. Discard all grade 5 bolts and replace them with grade 8 bolts.

5. Attach lifting cables around both ends of the wheels, gear, axle, and U-tube assembly.

Screen 74:

DC Traction Motor Combo: U-Tube, Wheels, and Axle Assembly Removal (Cont'd):

6. Use jacking bolts, if necessary, to separate the U-tube assembly from the traction motor frame.

Warning: The U-tube, wheels, gear, and axle assembly weighs approximately 6,000 lbs. (2,722 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Warning: When the wheels, gear, axle, and U-tube assembly is lifted, the U-tube will quickly rotate to the open-end up position and may injure personnel standing nearby. As the assembly is lifted, support it to allow the U-tube to slowly turn to the open-end up position.

7. Using a crane or hoist, lift the wheels, gear, axle, and U-tube assembly clear of the traction motor.

Caution: If a high-pressure spray washer is used to clean the U-tube, gear, wheels, and axle assembly, use extreme care that the spray does not enter the open labyrinth bearing seals. Do NOT submerge the assembly in liquid.

8. Thoroughly clean the U-tube, gear, wheels, and axle assembly to remove grease and dirt.
9. After cleaning, apply rust prohibitive to all machined surfaces except the wheels, then cover the assembly in plastic and tape shut until needed.

Screen 75:

DC Traction Motor Combo Assembly: U-Tube, Wheels, and Axle Assembly Installation:

Typical steps to install the U-tube, wheels, and axle are as follows:

1. Clean the traction motor frame and U-tube mounting surfaces with a rag dipped in an approved solvent, then wipe the mounting surfaces with a clean rag to remove any excess solvent.
2. Apply a gasket (Part Number 41A239176P317) to the commutator end of the traction motor frame where the U-tube mounts to the frame and trim the gasket to fit.
3. Apply another gasket (Part Number 41A239176P317) to the pinion end of the traction motor frame where the U-tube mounts to the frame and trim the gasket to fit.

Screen 76:

DC Traction Motor Combo Assembly: U-Tube, Wheels, and Axle Assembly Installation (Cont'd):

Warning: The U-tube, wheels, gear, and axle assembly weighs approximately 6,000 lbs. (2,722 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Warning: When the wheels, gear, axle, and U-tube assembly is lifted, the U-tube will quickly rotate to the open-end up position and may injure personnel standing nearby. As the assembly is being lifted, support it to allow the U-tube to slowly turn to the open-end up position.

4. Lift the U-tube, wheels, gear, and axle assembly with a crane or hoist; rotate the assembly so that the U-tube mounting surface is facing downward.
5. Line up the mounting holes and lower the assembly onto the traction motor.
6. Verify that the two gears are properly aligned and that the teeth are engaged.

Note: While installing the U-tube-to-motor mounting bolts, check the bolt head for the bolt grade. Discard all grade 5 bolts and replace them with grade 8 bolts.

7. Lubricate the threads of the eight U-tube-to-motor mounting bolts and under the bolt heads and both faces of the associated washers with a Wabtec approved Moly-based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly.
8. Start the eight mounting bolts by hand and then torque the bolts to 1325 ± 75 lb.-ft. (1797 ± 102 Nm).

Note: Follow the proper torque sequence to prevent the U-tube mounting bolts from loosening on the traction motor.

9. Install the two 5/8-inch bolts into the U-tube drain holes.

Screen 77:

DC Traction Motor Combo: Gear Case Assembly:

Typical steps to assemble the gear case after positioning the nose of the traction motor down on wooden blocks are as follows:

Note: Gear cases and U-tubes made prior to October 1989 may require modification to bring them to the latest revision level. Three pipe plugs should be installed on each gear case and a gear case to U-tube mounting lug should be welded to each U-tube. If required, contact your Field Services representative.

Warning: The traction motor, wheels, and axle assembly weighs approximately 12,000 lbs. (5,443 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Note: Only an approved sealant is to be used to seal the metal and plastic joints. The curing time for the sealant is 24 hours. In most cases, a 0.25-inch (6.4-mm) minimum bead of the approved sealant is required. However, at the gear case split line a 0.13-inch (3.2-mm) maximum bead should be used.

1. Clean the surface of the bull gear flinger on which the motor-side gear case seal (gutter) rides, then lubricate this surface with D50E25C gear oil or equivalent.
2. Install the motor-side axle seal to the axle assembly with the lip of the seal located over the flinger.

Note: The latch should be located on the left (bottom half of the gear case) and the cut-out notch should be located on the right (top half of the gear case).

3. Add a 0.25-inch (6.4-mm) minimum bead of the approved sealant in the groove and latch the seal.

Note: Do NOT apply sealant in excess of a 0.25-inch (6.4-mm) bead at the latch joint. Ensure that all sealing surfaces are not pinched or folded.

Screen 78:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

4. Clean the surfaces of the wheel and gear hubs on which the wheel-side gear case seal (gutter) rides, then lubricate these surfaces with D50E25C gear oil or equivalent.
5. Install the wheel-side axle seal to the axle assembly with the lip of the seal located over the wheel gear and gear hubs.

Note: The latch should be located on the left (bottom half of the gear case), and the cutout notch should be located on the right (top half of the gear case).

6. Add a 0.25-inch (6.4-mm) minimum bead of the approved sealant in the groove and latch the seal.
7. Add a 0.25-inch (6.4-mm) maximum bead of the approved sealant to the joint where the latch occurs, ensuring that all sealing surfaces are not pinched or folded.

Screen 79:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

8. Fill the groove in the bottom half of the gear case at the armature bearing cap bore with the approved sealant.
9. Apply an additional 0.25-inch (6.4-mm) bead by 3-inch (76.2-mm) long of the approved sealant to both sides of the split line. Repeat this step for the top half of the gear case, except apply the additional 0.25-inch (6.4-mm) bead of sealant to the entire semicircle.

Note: Ensure that sealant does not block or obstruct the armature bearing cap overboard drain slots.

Screen 80:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

10. Install the bottom half of the gear case, ensuring that the gear case groove engages with the bearing cap lip and the inner and outer axle seals in the gear case opening.
11. Mount a washer or washer assembly on a 12-point flanged 1.00-8 bolt, then install the first gear case mounting bolt and washer assembly as follows:

- a. If a Nord lockwasher is used, lubricate the threads of the gear case mounting bolt and both faces of the washer with a Wabtec approved Moly-based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly, and then install the bolt and washer in the top hole and hand tighten.
 - b. If a solid washer assembly is used, without lubrication, install the bolt and washers in the top hole and hand tighten.
 - c. If a 4-component load washer/spacer assembly is used, without lubrication and while ensuring that the chamfered (colored) side of the load washer is against the bolt head, install the bolt and washers/spacer assembly in the top hole and hand tighten.
12. On the top gear case half, apply a 0.13-inch (3.2-mm) maximum bead of the approved sealant along the engine joint face between the gear case halves and do not allow the approved sealant within 1 inch (25.4 mm) of the split line bolt holes.

Note: Be careful to keep the sealant away from the gear case bolt holes.

Screen 81:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

- 13. Install the top half of the gear case and verify engagement of the gear case groove with the bearing cap lip and the axle seals in the gear case opening.
- 14. Install in pairs and evenly tighten the eight bolts that hold the gear case halves together, starting at the top.
- 15. Torque the three 3/8-inch bolts to 22.5 ± 1.5 lb.-ft. (30.5 ± 2 Nm).
- 16. Torque the five 3/4-inch bolts to 198 ± 13 lb.-ft. (268 ± 18 Nm).
- 17. Install the gear case mounting bolts as follows as the preferred method of installation:
 - a. Lubricate the gear case mounting bolt threads and both faces of the washer with a Wabtec approved Moly-based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly.
 - b. Using a reduced shank, 1.00-8 threaded bolt (84B534558P1), and Nord lockwasher (84B534568P1) for each bolt position, install the two remaining bolts and install one Nord lockwasher on each of the bolts.
 - c. Using a Norbar torque/angle tool (or equivalent), apply a 425 ± 20 lb.-ft. (576 ± 27 Nm) torque plus a 45° angle to each of the three gear case mounting bolts.

Note: Ensure that the Nord lockwasher halves are properly aligned. If they are not aligned, the bolt must be removed and re-installed with a new Nord lockwasher.

- d. Using a paint pen, draw a line across the top and sides of each bolt head that extends onto the gear case on both sides of the bolt.

Screen 82:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

18. An alternate method to install the gear case mounting bolts is as follows:
 - a. Using a solid washer assembly on 1.00-8 bolts, mount the two remaining bolts and washer assemblies and hand tighten.
 - b. Torque the three gear case mounting bolts to 400 lb.-ft. (542 Nm) and then turn them to 55° using the torque/angle wrench.

Note: The torque accuracy should be within $\pm 3\%$ of its maximum torque. The angle accuracy should be within $\pm 3\%$ of its set value. The wrench repeatability should be within $\pm 2\%$ of its set value.

19. Another method to install the gear case mounting bolts is as follows:
 - a. Using 4-component load washer assemblies mounted on 12-point flanged 1.00-8 bolts, install the two remaining bolts and washer assemblies and hand tighten.

Note: For each bolt and washer assembly, ensure that the chamfered side (colored side) of the load washer is against the bolt head.

Screen 83:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

- b. Tighten all three load washer and bolt assemblies by inserting a pin or small Allen wrench in one of the holes in the outer ring of the load washer assembly, then tighten the bolt while rotating the ring back and forth.

Note: Stop tightening the bolt when the load washer is crushed enough that the outer ring no longer rotates easily.

Note: If the outer ring turns hard because of hand pressure on the small pin, it is acceptable. Do not try to turn the outer ring by backing the bolt out. If for any reason the bolt must be loosened or removed, the load washer assembly must be scrapped and a new load washer assembly used.

- c. Torque all three gear case mounting bolts until the inner ring of the load washer assembly compresses and the outer ring is just seized between the two flat washers.

Note: Once the load washer is compressed, do not tighten any further and do not use an impact wrench.

Note: The correct bolt tension will be obtained as follows:

- If a reduced shank bolt and Nord lockwasher are used, apply the correct torque plus the additional angle as specified in the steps.
- If a solid washer assembly is used, torque until the torque/angle reaches its set

value.

- If a 4-component load washer is used, stop torquing just as the outer ring stops rotating easily. Rotating hard means that it takes more than 4 lb.-ft. (5 Nm) of torque to rotate the outer ring; to achieve this approximately apply finger pressure on a 4 to 6-inch pin or Allen wrench. It is acceptable if the outer ring does not turn at all at up to 30 lb.-ft. (40 Nm) of torque. The bolt retaining force will still be within acceptable limits.

Screen 84:

DC Traction Motor Combo: Gear Case Assembly (Cont'd):

20. Verify that a bead of the approved sealant is visible at the joints after the bolts have been torqued and that a bead of sealant is visible around the pinion end armature bearing cap, and that the armature bearing cap overboard drain slots are free of sealant.

Warning: The traction motor, wheels, and axle assembly weighs approximately 12,000 lbs. (5,443 kg). Ensure that the crane and cables are adequate to lift and move the assembly.

Warning: When the traction motor, wheel, and axle assembly is lifted, the U-tube will quickly rotate to the open-end up position, and could injure nearby personnel. Therefore, as the assembly is being lifted, support the assembly by allowing the U-tube to turn slowly to the open-end up position.

21. Attach a nylon lifting strap to each axle journal bearing, then lift the traction motor, axle, and wheel assembly and rotate 90° to return the traction motor combo to the horizontal position.
22. After the 24 hours sealant cure time is over, apply D50E25C gear oil or equivalent to the gear case.

Note: The initial fill capacity of the gear case is 9 quarts (8.5 liters).

23. Check the gear case lubricant level using a dipstick (Part Number 41C637237G1), then install and torque all pipe plugs to 100 to 110 lb.-ft. (136 to 150 Nm).
24. Apply a safety lock wire to the fill plug and the drain plug.

Note: The gear case oil level should never be more than 1.75 inches (44 mm) below the bottom of the fill opening. One quart (1 L) of oil will raise the oil level by approximately 0.375 inches (10 mm).

Screen 87:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose of the traction motor combo.
 - The main purpose of the traction motor combo is to convert electrical energy to mechanical energy for driving the locomotive wheels, a process referred to as motoring. The traction alternator supplies the electrical energy.
 - The secondary purpose of the traction motor combo is to convert the mechanical energy of slowing a moving locomotive to electrical energy utilizing a process referred to as dynamic braking. In dynamic braking, the traction motors function as generators with the electrical energy that they produce dissipated as heat in the dynamic braking resistor grids.
- Describe the major components of a traction motor combo.
 - The traction motor takes electrical energy from the propulsion system and converts it into mechanical energy for driving the locomotive wheels.
 - The bull gear, pressed onto the axle, meshes with the pinion gear on the traction motor rotor to transfer the torque of the traction motor to the axle.
 - The axle is used to transfer the rotational force of the traction motor to the wheels. Journal bearings, located on each end of the axle, allow the axle to turn with minimal friction when mounted inside the journal boxes attached to the truck frame.
 - The locomotive rides on the tread of the wheel, and the wheel flange keeps the locomotive on the rails.
 - The U-tube, mounted to the traction motor, wraps around and houses the axle. The U-tube contains two roller bearing assemblies that support the traction motor and allow axle rotation within the U-tube.
 - The gear case protects the pinion and bull gears from the outside environment. Additionally, the gear case contains the oil used to lubricate the two gears. On AC traction motors, the oil also lubricates the pinion end bearing in the traction motor. The gear case consists of two halves, a top or upper half and a bottom or lower half, which are bolted together.
- Identify the running maintenance requirements for the traction motor combo.
 - Traction Motors
 - Every 92 days, in DC traction motors, check for loose or missing traction motor commutator covers, check commutator for discoloration and damage, and check for chipped, broken, or damaged brushes. For both AC and DC traction motors, check power leads for abrasion damage and rubbing against other cables or truck parts.
 - When renewing wheels, visually inspect and run traction motors with no load. Check armature bearings for unusual noises and binding and

vibration. Check commutator smoothness and resurface, if necessary, using jig grinding device. Clean insulators. Blow out debris with compressed air. Repair covers as required.

- Traction Motor Combo
 - Every 92 days, inspect gear cases for mechanical damage. Check for damaged or missing fill or drain plugs. Clean metal particles from drain plug if removed. Inspect the entire combo for excessive oil leakage. Check oil level in the gear case. Fill oil to the indicated level below the bottom of the fill opening. If oil loss is greater than limits, remove traction motor combo and inspect it.
 - Every 92 days, inspect gear case mounting bolts and U-tube to traction motor mounting bolts for tightness by hand or a wrench. Check for any gap in the joint visually, by performing a hammer test, or by using a 0.005-inch feeler gauge. If parts are loose, broken, or missing, replace with new parts. Tighten all the bolts to the specified torque values.
 - Every 92 days, check accessible gear case split line bolts for looseness by hand or wrench or perform an 8-ounce hammer test. If parts are loose, broken, or missing, replace with new parts. Tighten all the bolts to the specified torque values.
 - Annually, drain and refill the gear case.
 - When renewing wheels, renew gear case seals. Drain and refill the gear case. Clean and inspect the pinion and bull gears for wear and damage.
- Wheels
 - Daily or per trip, visually inspect the wheel rim versus the witness groove for wheel wear. Check for cracks, shelled treads, or flat spots. Make corrections as required.
- Describe the basic operation of a traction motor combo.
 - Electricity is supplied to the traction motor from the propulsion system.
 - Coils in the traction motor create a magnetic field, which causes the rotor to turn.
 - On the rotor, the small pinion gear meshes with the larger bull gear on the axle. Depending on the traction motor design, the pinion gear may either be formed as an integral part of the rotor or may be pressed onto the rotor.
 - The bull gear is pressed onto the axle along with the two wheels and the U-tube. Two roller-bearing assemblies allow the axle to rotate freely within the U-tube while the two journal bearings allow the axle to rotate freely within the journal box mounted to the truck.
 - With the traction motor powered, the pinion and bull gears mesh, causing the axle and wheels to turn and power the locomotive.

Screen 88:

Summary (Cont'd):

- Summarize the major steps to remove and install a traction motor combo.
 - Traction Motor Combo Removal
 1. Position the traction motor combo to be removed over a single-axle drop table.
 2. Set the locomotive wheel brakes and chock the wheels on the truck not being worked on, then manually release the brakes on the wheels of the traction motor combo to be removed by closing the cut-out cock in the air line for that truck.
 3. Disconnect all power cables and the motor ground cable of the traction motor combo to be removed from the truck, then secure the cables to prevent damage during traction motor combo removal.
 4. Unplug the speed sensor cable of the traction motor combo to be removed, then remove the cable clamp.
 5. If equipped, disconnect the bearing temperature sensor cables of the traction motor combo being removed.
 6. Remove the pins from the slack adjusters of the traction motor combo to be removed, and adjust the slack adjusters to the shortest length.
 7. Remove the brake shoes by removing the keys from the brake heads.
 8. If the traction motor combo to be removed is one of the end assemblies on the truck, loosen and remove all but one of the sand bracket bolts at both ends of the axle, and swing the sand brackets away to prevent fouling when the combo is lowered.
 9. Disconnect the traction motor air duct from the top of the traction motor.
 10. Remove the pedestal liner and axle journal bearing housing retaining bolts, retainers, and any free pedestal liners.
 11. If the traction motor combo to be removed is in positions 1, 3, 4, or 6:
 - a. Disconnect the axle snubbers from the journal box adapters at both ends of the axle.
 - b. Support the truck frame with wooden blocks and hydraulic jacks from the floor adjacent to the traction motor combo being removed.
 12. Disconnect the AC traction motor nose suspension as follows:
 - a. Place a suitable jack under the lugs or motor frame, and ensure the jack cannot slip off if the motor moves or tries to rotate.
 - b. Disconnect the suspension link from the motor.
 - c. Pull the suspension link away from the motor by using a come-along or similar chain rigging.
 - d. Lower the drop table by a few inches while raising the jack to allow the motor safety nose to clear the truck frame.
 13. Remove the DC traction motor nose suspension as follows:
 - a. Jack or lift the traction motor nose to compress the suspension assembly approximately 0.5 inches (13 mm).

- b. Install a 1/2-13 x 6.5 inch (165 mm) long bolt and nut between the U-channels on both sides of the suspension assembly.
 - c. Tighten the nuts to compress the suspension assembly to 11.7 inches (297 mm) or less.
 - d. Lower the traction motor slightly, then remove the cotter pins and retaining pins that secure the vertical keeper pins in the suspension assembly.
 - e. Slide the suspension assembly sideways, removing the assembly from the truck frame.
 - f. Inspect the traction motor nose suspension assembly for separation of laminations, badly eroded rubber laminations, or cracked or broken cast members and, if defective, remove and replace the traction motor nose suspension assembly.
14. In a DC traction motor, check the suspension lugwear plates on the traction motor and, if excessively worn, replace the plates.
 15. Lower the drop table by approximately 5 inches (125 mm), place chocks over the rail, and nip the securing bolts to secure the traction motor combo in place.
 16. Raise the drop table by 2 inches (50 mm) to compress the coil springs.
 17. For the four coil springs at the traction motor combo, place a spring retaining strap around the truck frame, under the air piping and through the spring coils at approximately the fifth coil, then join the strap ends, leaving at least 12 inches (300 mm) of slack in the straps.
 18. Apply C-clamps on each wheel rim below each side of the axle journal bearing housing to prevent the housing from rotating during traction motor combo removal.
 19. Raise the traction motor nose up to clear the nose suspension or the truck frame as the traction motor is lowered.
 20. Support the traction motor nose with blocks suitably placed under the frame, such that it cannot slip off if the traction motor moves or rotates.
 21. Lower the drop table until the space between the top of the axle journal bearing housing and the truck frame is approximately 7 inches (175 mm), then tighten the coil spring retaining straps to remove any remaining slack.
 22. Lower the drop table until the traction motor combo clears the truck and remove any remaining truck pedestal liners.
 23. Move the traction motor combo from beneath the truck and locomotive.
 24. Using a suitable hoist, lift the traction motor combo from the drop table and move it to the area assigned for cleaning, maintenance, or storage.
 25. Set the traction motor frame in the normal horizontal position on blocks high enough so that the wheels clear the floor.

Screen 89:

Summary (Cont'd):

- Traction Motor Combo Installation
 1. Remove all dirt and weld splatter from the traction motor nose suspension lugs and the traction motor nose suspension area of the truck frame.
 2. Transfer the traction motor combo to the drop table, and place suitable blocking under the motor frame to raise the motor lugs.
 3. Position the drop table and the traction motor combo under the truck with the axle journal bearing housings aligned with the journal bearing housings in the truck frame.
 4. Level the axle journal bearing housings, and apply C-clamps on each wheel rim below each side of the axle journal bearing housings to prevent it from rotating during traction motor combo installation.
 5. Raise the drop table with the traction motor combo.
 6. Install the truck pedestal liners, and ensure that the coil springs seat properly as the traction motor combo is raised.
 7. Raise the drop table until the axle journal bearing housings are completely in place, with the drop table assuming part of the weight of the truck.
 8. Install the four axle journal bearing housing retainers on the truck pedestal legs.
 9. Torque the retainer bolts to 296 to 329 lb.-ft. (401 to 446 Nm).
 10. Remove the four coil spring retaining straps.
 11. Lower the hydraulic jacks and remove all wooden blocks from under the traction motor and the truck.
 12. Connect the AC traction motor nose suspension as follows:
 - a. Release the come-along or chain rigging. The suspension link should spring back under the motor lugs.
 - b. Lower the motor frame until the suspension link is supporting the weight of the traction motor combo.
 - c. Insert CAMCAR bolts through the suspension link motor lugs and hand-tighten the nuts.
 - d. Tighten the CAMCAR bolts with the special socket until the head shears off each bolt.
 13. Install the DC traction motor nose suspension as follows:
 - a. Slide the nose suspension assembly sideways, into the truck frame.
 - b. Lower the traction motor combo slightly, and install the cotter pins and retaining pins, securing the vertical keeper pins in the nose suspension assembly.
 - c. Loosen the nuts to de-compress the nose suspension assembly.
 - d. Remove the 1/2-13 x 6.5 inch (165 mm) long bolt and nuts previously installed between the U-channels on both sides of the nose suspension assembly.
 - e. Lower the traction motor nose into position.
 14. For traction motor combos in positions 1, 3, 4, and 6, connect axle snubbers to the journal box adapters at both ends of the axle, then torque the snubber bolts to 197 to 219 lb.-ft. (267 to 297 Nm).
 15. Connect the traction motor air duct boot to the top of the motor.

16. Lubricate the air duct bolts with a Wabtec approved Moly-based lubricant (84B565364A1) or light machine oil.
17. Install the bolts and then torque to 50 to 55 lb.-ft. (68 to 75 Nm).
18. If the traction motor combo installed is one of the end assemblies on the truck, return the sand brackets at both ends of the axle, then install and torque the sand bracket bolts to the proper value.
19. Install the brake shoes and the slack adjuster pins, then adjust the slack adjusters.
20. Connect the speed sensor cable of the traction motor combo to its connection under the locomotive platform.
21. If equipped, connect the bearing temperature sensor cables.
22. Connect all power cables and the traction motor ground cable to their connections under the locomotive platform.
23. Release and remove all jacks and chocks used to support or secure the truck for traction motor combo removal.
24. Activate the brakes by opening the truck cut-out cock.
25. Check the level of lubricant in the gear case, and add lubricant as required.

Screen 90:

Summary (Cont'd):

- Summarize the major steps to disassemble and assemble an AC traction motor combo.
 - Gear Case Disassembly
 1. Drain the lubricant from the gear case by removing the drain plug located on the lower side of the gear case bottom half.
 2. Remove the 16 gear case split line bolts and washers and the two gear case mounting bolts.
 3. Attach a lifting cable through the inverted "U-shaped" holes in each end of the upper gear case, and take up the slack in the cables with a hoist or crane.
 4. With an overhead crane, lift off the upper gear case, guiding the center bolt pad, located between the axle and pinion bores, through the relief in the traction motor framehead.
 5. Pry the lower gear case loose from the gutter on one end and the pinion bore seal on the other end.
 6. Attach axle slings. Use a lifting cable at the motor lifting eye and raise the motor, wheels, and axle assembly to approximately one foot.
 7. Remove and discard the gutters and the pinion bore seal.
 8. Carefully position the motor on the nose support.
 - U-tube, Wheels, and Axle Assembly Removal
 1. Remove the gear case.
 2. Remove the eight bolts and washers that hold the U-tube to the traction motor frame.
 3. Attach a lifting strap to each axle journal bearing, then use jacking bolts, if necessary, to separate the assembly from the traction motor frame.
 4. Using a crane or hoist, lift the assembly off the motor.

5. Thoroughly clean the U-tube, wheels, gear, and axle assembly of grease and dirt.
 6. After cleaning, apply rust prohibitive to all machined surfaces except the wheels, then cover the assembly in plastic and tape shut until needed.
 7. Install guide pins in the bearing cap before removing all the bolts.
 8. Remove the pinion end bearing cap from the traction motor.
 9. Inspect the bearing as follows:
 - a. Verify that the cage is not rubbing the inner ring flange.
 - b. Rotate the bearing by hand, listening for noise and feeling for roughness.
 - c. Inspect for metal debris from the bearing rollers, or any other visible defects. If any debris or defect is found, replace the bearing.
 - d. Verify bearing clearance with a feeler gauge. It should be 0.012 to 0.016 inches (0.3048 to 0.4064 mm).
 10. If no bearing defects are found, flush the bearings with HD 57 oil.
 11. Inspect the oil metering hole and trough screen for debris. Flush the trough until no debris washes out.
 12. Clean the bearing cap, apply a new gasket, and return the bearing cap to the traction motor.
- U-tube, Wheels, and Axle Assembly Installation
1. Clean the traction motor frame and U-tube mounting surfaces with a rag dipped in an approved solvent, then wipe the mounting surfaces with a clean rag to remove excess solvent.
 2. Clean the mating surface and apply a gasket (Part Number 41A239176P317) at the pinion end (PE) of the traction motor, where the U-tube and the motor frame join.
 3. Clean the mating surface and apply a gasket (Part Number 41A239176P317) at the connection end (CE) of the traction motor, where the U-tube and the motor frame join.
 4. Clean the pinion end bearing cap groove with CRC Natural Degreaser.
 5. Install the pinion bore seal into the bearing cap groove as follows:
 - a. Start at the top and work the seal into the groove towards the bottom.
 - b. Seat the seal by tapping with a rubber mallet.
 - c. Place the Seating Ring Tool (84A206903P1) over the gasket and rotate it around the gasket.
 6. Lift the U-tube, wheels, gear, and axle assembly with a crane or hoist, and rotate the assembly so that the U-tube mounting surface faces downwards. Line up the mounting holes.
 7. Lower the assembly onto the traction motor frame.
 8. Verify that the gear and the pinion are properly aligned and that the teeth are engaged.
 9. Lubricate the threads of the eight U-tube-to-motor mounting bolts and under the bolt heads and both faces of the associated washers with MOLYKOTE® D-321 R lubricant (Part Number 41A219134P9).
 10. Start the eight mounting bolts by hand and then evenly torque the bolts to the proper torque value.

11. Install plastic plugs (Part Number 41A235989P5) in both U-tube jacking bolt holes.

Screen 91:

Summary (Cont'd):

- Gear Case Assembly
 1. Position the nose of the traction motor down on wooden blocks.
 2. Using the Guide Pin Kit (Part Number 41B539007G2), install the motor-side axle seal (gutter) on the axle with the lip of the seal located over the flinger.
 3. Apply a 0.125 to 0.25-inch (3.18 to 6.4-mm) bead of DOW 832 sealant in the groove and latch the seal.
 4. Apply a 0.125-inch (3.18-mm) bead of sealant to the latch joint.
 5. Install the wheel-side axle seal (gutter) to the axle assembly with the lip of the seal located over the wheel and gear hubs.
 6. Apply a 0.125 to 0.25-inch (3.18 to 6.4-mm) bead of sealant in the groove and latch the seal.
 7. Apply a 0.125-inch (3.18-mm) bead of sealant to the latch joint, then remove excess sealant.
 8. Prior to installing the bottom gear case half, apply 0.25-inch (6.4-mm) bead of sealant to the groove of the pinion bore seal, continuously around the entire circumference of the seal.
 9. Install the bottom half of the gear case, then verify engagement of the gear case leg with the groove in the pinion bore seal, and the motor-side and wheel-side gutters with the gear case opening.
 10. Use C-clamps to draw the bottom half of the gear case to within 0.50 inches (12.7 mm) of the U-tube and motor lugs.
 11. Remove the adhesive backing from the Gortex tape (Part Number 41E903878P32) and apply the tape to the center bolt pad between the axle bore and pinion bore on the upper gear case half.
 12. On the top gear case half, apply a 0.125-inch (3.18-mm) bead of sealant along the entire split line surface, just inside the bolt holes.
 13. Install the top half of the gear case, then verify engagement of the gear case leg with the groove in the motor pinion end bore seal, and the motor-side and wheel-side axle seals (gutters) with the gear case opening.
 14. Use C-clamps on the split line flanges at the gear case ends to draw the halves together evenly, then position C-clamps near the gear case center line to prevent misalignment.
 15. Fasten the gear case halves as follows:
 - a. Install one split line bolt and washer at the axle end, then draw the gear case halves together but do not tighten.
 - b. Install and hand-tighten a second bolt and washer on the motor side axle end.
 - c. Install and hand-tighten a third bolt and washer between the axle and pinion bores.
 - d. Install and hand-tighten a fourth bolt and washer between the axle and pinion bores.

- e. Install the remaining bolts and washers that hold the gear case halves together, and tighten all bolts evenly.
- f. Torque all bolts to the proper value.
- g. Verify closure of the upper gear case half by "shim checking" with a 0.010-inch (0.254-mm) shim in the wheel-side flange at the pinion end.
16. Remove the guide pins and install the mounting bolts (one at a time), then hand-tighten the bolts.
17. Torque the gear case-to-motor and gear case-to-U-tube bolts to the proper value, then, to seal out moisture, apply DOW 832 sealant to the open end of the threaded through holes for the gear case mounting bolts, completely filling the end of the bolt holes.
18. Attach a lifting strap to each axle journal bearing, then lift the traction motor, axle, and wheels assembly and rotate 90° to return the traction motor combo to the horizontal position.
19. On gear cases with solid-fill plugs, add lubricant to the gear case as follows:
 - a. Remove the fill plug.
 - b. Fill the gear case with 14.5 quarts (13.7 liters) of lubricant.
 - c. Using a clean rag, wipe the magnet on the fill plug.
 - d. Apply Hylomar Thread Sealant to the fill plug threads and torque to the proper value.
 - e. Apply a safety lock wire to the fill plug and the drain plug.
20. On gear cases with spring-loaded fill plugs, add lubricant to the gear case as follows:
 - a. Pull on the plug cover and hold the fill plug open to add lubricant.
 - b. Fill the gear case with 14.5 quarts (13.7 liters) of lubricant.
 - c. Release the plug and allow the spring loading to close the fill plug.
21. Assemble the breather to the top of the gear case.

Screen 92:

Summary (Cont'd):

- Summarize the major steps to disassemble and assemble a DC traction motor combo.
 - Gear Case Disassembly
 1. Drain the gear case lubricant into a suitable container.
 2. With the motor and axle assembly in the normal horizontal position, remove the eight split line bolts holding the top half of the gear case to the bottom half.
 3. Lift off the top half of the gear case with a crane.
 4. Remove the three gear case mounting bolts and washers or washer assemblies that secure the bottom half to the traction motor frame and drop the gear case to the floor.
 5. If equipped, discard any Nord Lock or 4-component load washers.
 6. Move the gear case to a suitable area.
 7. Carefully inspect the gear case mounting and split line bolts and replace or return to service depending on the following inspection criteria:
 - a. The bolt visually appears bent. Check for a bent bolt by laying it on a flat surface and rolling the bolt.
 - b. The threads are damaged to the point that the bolt cannot be installed by hand.

- c. The bolts have visible cracks or deformation in shank and threads or underhead radius. Light surface rust is acceptable, but no corrosion pitting is acceptable in the shank, underhead radius, and threads.
 - d. The bolts are corroded to the extent that corrosion cannot be removed with a rag and solvent (such as brake cleaner or alcohol).
- 8. Thoroughly cleanse the gear case split line bolts that can be reused.
- 9. Clean hardened washers to remove all dirt and oil and return to service.
- 10. Attach a nylon lifting strap to each axle journal bearing.
- 11. Lift the motor, wheels, and axle assembly and rotate it 90°.
- 12. Position the motor nose on wooden blocks.
- 13. Remove the motor-side and wheel-side axle bore seals (gutters) from the axle.
- U-tube, Wheels, and Axle Assembly Removal
 - 1. Remove the gear case.
 - 2. Remove the two bolts, plate, and cable cleat holding the traction motor cables to the U-tube.
 - 3. Remove the eight bolts that hold the U-tube to the traction motor frame.
 - 4. If equipped, remove the two 5/8-inch bolts (or drain hole plugs) from the middle of the U-tube.
 - 5. Attach lifting cables around both ends of the wheels, gear, axle, and U-tube assembly.
 - 6. Use jacking bolts, if necessary, to separate the U-tube assembly from the traction motor frame.
 - 7. Using a crane or hoist, lift the wheels, gear, axle, and U-tube assembly clear of the traction motor.
 - 8. Thoroughly clean the U-tube, gear, wheels, and axle assembly to remove grease and dirt.
 - 9. After cleaning, apply rust prohibitive to all machined surfaces except the wheels, then cover the assembly in plastic and tape shut until needed.
- U-tube, Wheels, and Axle Assembly Installation
 - 1. Clean the traction motor frame and U-tube mounting surfaces with a rag dipped in an approved solvent, then wipe the mounting surfaces with a clean rag to remove any excess solvent.
 - 2. Apply a gasket (Part Number 41A239176P317) to the commutator end of the traction motor frame where the U-tube mounts to the frame and trim the gasket to fit.
 - 3. Apply another gasket (Part Number 41A239176P317) to the pinion end of the traction motor frame where the U-tube mounts to the frame and trim the gasket to fit.
 - 4. Lift the U-tube, wheels, gear, and axle assembly with a crane or hoist; rotate the assembly so that the U-tube mounting surface is facing downward.
 - 5. Line up the mounting holes and lower the assembly onto the traction motor.
 - 6. Verify that the two gears are properly aligned and that the teeth are engaged.
 - 7. Lubricate the threads of the eight U-tube-to-motor mounting bolts and under the bolt heads and both faces of the associated washers with a Wabtec approved Moly-

based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly.

8. Start the eight mounting bolts by hand and then torque the bolts to 1325 ± 75 lb.-ft. (1797 ± 102 Nm).
9. Install the two 5/8-inch bolts into the U-tube drain holes.

Screen 93:

Summary (Cont'd):

- Gear Case Assembly
 1. Clean the surface of the bull gear flinger on which the motor-side gear case seal (gutter) rides, then lubricate this surface with D50E25C gear oil or equivalent.
 2. Install the motor-side axle seal to the axle assembly with the lip of the seal located over the flinger.
 3. Add a 0.25-inch (6.4-mm) minimum bead of the approved sealant in the groove and latch the seal.
 4. Clean the surfaces of the wheel and gear hubs on which the wheel-side gear case seal (gutter) rides, then lubricate these surfaces with D50E25C gear oil or equivalent.
 5. Install the wheel-side axle seal to the axle assembly with the lip of the seal located over the wheel gear and gear hubs.
 6. Add a 0.25-inch (6.4-mm) minimum bead of the approved sealant in the groove and latch the seal.
 7. Add a 0.25-inch (6.4-mm) maximum bead of the approved sealant to the joint where the latch occurs, ensuring that all sealing surfaces are not pinched or folded.
 8. Fill the groove in the bottom half of the gear case at the armature bearing cap bore with the approved sealant.
 9. Apply an additional 0.25-inch (6.4-mm) bead by 3-inch (76.2-mm) long of the approved sealant to both sides of the split line. Repeat this step for the top half of the gear case, except apply the additional 0.25-inch (6.4-mm) bead of sealant to the entire semicircle.
 10. Install the bottom half of the gear case, ensuring that the gear case groove engages with the bearing cap lip and the inner and outer axle seals in the gear case opening.
 11. Mount a washer or washer assembly on a 12-point flanged 1.00-8 bolt, then install the first gear case mounting bolt and washer assembly as follows:
 - a. If a Nord lockwasher is used, lubricate the threads of the gear case mounting bolt and both faces of the washer with a Wabtec approved Moly-based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly, and then install the bolt and washer in the top hole and hand tighten.
 - b. If a solid washer assembly is used, without lubrication, install the bolt and washers in the top hole and hand tighten.
 - c. If a 4-component load washer/spacer assembly is used, without lubrication and while ensuring that the chamfered (colored) side of the load washer is against the bolt head, install the bolt and washers/spacer assembly in the top hole and hand tighten.

12. On the top gear case half, apply a 0.13-inch (3.2-mm) maximum bead of the approved sealant along the engine joint face between the gear case halves and do not allow the approved sealant within 1 inch (25.4 mm) of the split line bolt holes.
13. Install the top half of the gear case and verify engagement of the gear case groove with the bearing cap lip and the axle seals in the gear case opening.
14. Install in pairs and evenly tighten the eight bolts that hold the gear case halves together, starting at the top.
15. Torque the three 3/8-inch bolts to 22.5 ± 1.5 lb.-ft. (30.5 ± 2 Nm).
16. Torque the five 3/4-inch bolts to 198 ± 13 lb.-ft. (268 ± 18 Nm).
17. Install the gear case mounting bolts as follows as the preferred method of installation:
 - a. Lubricate the gear case mounting bolt threads and both faces of the washer with a Wabtec approved Moly-based lubricant (84B565364A1) and wait until dry to touch (approximately 5 minutes) before assembly.
 - b. Using a reduced shank, 1.00-8 threaded bolt (84B534558P1), and Nord lockwasher (84B534568P1) for each bolt position, install the two remaining bolts and install one Nord lockwasher on each of the bolts.
 - c. Using a Norbar torque/angle tool (or equivalent), apply a 425 ± 20 lb.-ft. (576 ± 27 Nm) torque plus a 45° angle to each of the three gear case mounting bolts.
 - d. Using a paint pen, draw a line across the top and sides of each bolt head that extends onto the gear case on both sides of the bolt.
18. An alternate method to install the gear case mounting bolts is as follows:
 - a. Using a solid washer assembly on 1.00-8 bolts, mount the two remaining bolts and washer assemblies and hand tighten.
 - b. Torque the three gear case mounting bolts to 400 lb.-ft. (542 Nm) and then turn them to 55° using the torque/angle wrench.
19. Another method to install the gear case mounting bolts is as follows:
 - a. Using 4-component load washer assemblies mounted on 12-point flanged 1.00-8 bolts, install the two remaining bolts and washer assemblies and hand tighten.
 - b. Tighten all three load washer and bolt assemblies by inserting a pin or small Allen wrench in one of the holes in the outer ring of the load washer assembly, then tighten the bolt while rotating the ring back and forth.
 - c. Torque all three gear case mounting bolts until the inner ring of the load washer assembly compresses and the outer ring is just seized between the two flat washers.
20. Verify that a bead of the approved sealant is visible at the joints after the bolts have been torqued and that a bead of sealant is visible around the pinion end armature bearing cap, and that the armature bearing cap overboard drain slots are free of sealant.
21. Attach a nylon lifting strap to each axle journal bearing, then lift the traction motor, axle, and wheel assembly and rotate 90° to return the traction motor combo to the horizontal position.
22. After the 24 hours sealant cure time is over, apply D50E25C gear oil or equivalent to the gear case.

23. Check the gear case lubricant level using a dipstick (Part Number 41C637237G1), then install and torque all pipe plugs to 100 to 110 lb.-ft. (136 to 150 Nm).
24. Apply a safety lock wire to the fill plug and the drain plug.

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.
- Electrocutation 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 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.

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.

Screen 18:

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.

Screen 19:

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).

Screen 20:

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.

Screen 21:

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.

Screen 27:

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 ¾-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 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 ¾-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 ¾-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 1/8th 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 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.
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).

Equipment Cooling Air System

Screen 1:

Welcome Screen:

Welcome to the Equipment Cooling Air System module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Equipment Cooling Air System:

In this module, you will learn how to inspect and maintain the components of the equipment cooling air system on an ES44AC/DC locomotive in a running repair environment.

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

- State the purpose and location of the equipment cooling air system.
- State the purpose and location of the major components of the equipment cooling air system.
- State the purpose and location of the instrumentation devices of the equipment cooling air system.
- Describe how the equipment cooling air system operates.
- Describe how to perform running maintenance related to the equipment cooling air system.

Screen 3:

Disclaimer:

Please note that this module is for training use only. For complete details of inspecting and maintaining the components of the equipment cooling air system on an ES44AC/DC locomotive in a running repair environment, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

Overview of the Equipment Cooling Air System:

The primary purpose of the equipment cooling air system is to provide cooling air for critical components, including the alternator, the propulsion circuits, and the traction motors. A secondary purpose is to pressurize key areas of the locomotive to help keep out contamination. The equipment cooling air system contains two separate forced-air ventilation subsystems: the Traction Motor Cooling Air System and the Alternator and Auxiliary Cooling Air System. The major components of the traction motor cooling air system are located in the radiator cab. The major components of the alternator and auxiliary cooling air system are located in the blower cab.

Screen 5:**Major Components of the Traction Motor Cooling Air System:**

Components of the traction motor cooling air system include the V-screens, plastic air cleaner panels, traction motor blower and exhaustor blower.

Screen 6:**V-Screens:**

Located on both sides of the radiator cab, the V-screens provide the entry point for the air-to-traction motor cooling air system while blocking debris, such as leaves, twigs, and trash, from entering the system.

Screen 7:**Plastic Air Cleaner Panels:**

Located directly behind the V-screens in the radiator cab, the plastic air cleaner panels, also referred to as spin cleaner panels, clean the air entering the traction motor cooling air system. Vortex tubes in the spin cleaner panels contain spiral vanes that cause the air to swirl like a tornado as it passes through the tube. The swirling action forces heavier dirt particles to the outside of the air stream. This "dirty" air is separated at the output of the tubes and discharged from the air cleaner panels into a bleed air duct.

Screen 8:**Traction Motor Blower:**

Located in the radiator cab on the Helper's side, the traction motor blower or the equipment blower provides cooling air for all the traction motors on the locomotive.

Screen 9:**Exhaustor Blower:**

Located in the radiator cab on the Engineer's side of the locomotive, the exhaustor blower removes the dirty air from the spin cleaner panel bleed air duct, continuously discharging the bleed air and dirt out the top of the unit and into the radiator cab. From the radiator cab, the radiator fans pull the air out, discharging the dirty air through the top of the locomotive.

Screen 10:**Major Components of the Alternator and Auxiliary Cooling Air System:**

The components of the alternator and auxiliary cooling air system are the V-screens, plastic air cleaner panels, alternator blower with exhaustor, auxiliary cab air filters and corner air duct.

Screen 11:**V-Screens:**

Located on both sides of the blower cab, the V-screens provide the entry point for the air to the alternator and auxiliary cooling air system while blocking debris, such as leaves, twigs, and trash, from entering the system.

Screen 12:**Plastic Air Cleaner Panels:**

Located directly behind the V-screens in the blower cab, the plastic air cleaner panels clean the air entering the alternator and auxiliary cooling air system. Vortex tubes in the spin cleaner panels force heavier dirt particles to the outside of the air stream. This “dirty” air is separated at the output of the tubes and discharged from the air cleaner panels into a bleed air duct.

Screen 13:**Alternator Blower with Exhauster:**

Located in the blower cab, the alternator blower provides cooling air to the alternator and to the equipment in the auxiliary cab, Control Area 1 (CA1), and CA8. The exhauster portion of the alternator blower draws the dirty air from the spin cleaner panel bleed air duct and from the top of CA1 and the toilet compartment, and exhausts the air to the roof of the blower cab.

Screen 14:**Auxiliary Cab Air Filters:**

Located in a compartment directly above the alternator on the Helper’s side of the locomotive, the auxiliary cab air filters filter contaminants from the air that cools the equipment in the auxiliary cab.

Screen 15:**Corner Air Duct:**

Located on the Helper’s side of the locomotive and attached to the auxiliary cab, the corner air duct forms a conduit for the cooling air flowing in and out of CA3 in the auxiliary cab.

Screen 16:**Instrumentation Devices of the Equipment Cooling Air System:**

The instrumentation devices of the traction motor cooling air system include the Barometric Air Pressure (BAP) sensor and the Ambient Temperature (AT) sensor.

Screen 17:**Barometric Air Pressure Sensor:**

Located on the wall of CA4 in the auxiliary cab, the BAP sensor measures the pressure of the atmosphere and provides the pressure information to the Engine Control Unit (ECU).

Screen 18:**Ambient Temperature Sensor:**

Located in CA3, the AT sensor measures the temperature of the air flowing through CA3. That is, the sensor measures the ambient temperature, and provides the

temperature information to the Smart Displays by way of the Consolidated Input/Output (CIO) panel.

Screen 25:

Operation of the Traction Motor Cooling Air System:

The traction motor cooling air system supplies cooling air to the traction motors. The vacuum created by the traction motor blower first draws outside air in through the V-screens, where large items, such as leaves, paper, etc., are blocked from entering the system. Passing through the V-screens, the air and dirt are separated by 12 plastic air cleaner panels. Each air cleaner panel contains 54 individual vortex tubes. These tubes contain spiral vanes that cause the air to swirl like a tornado as it passes through the tube. The swirling action forces the heavier dirt particles to the outside of the air stream. This "dirty" air is separated at the output of the tubes and is discharged from the air cleaner panels into a bleed air duct.

Screen 26:

Operation of the Traction Motor Cooling Air System (Cont'd):

An exhaustor blower, connected to the bleed air duct, provides a drawing force to discharge the dirty air into the radiator cab. The clean air in the middle of the air stream exits each tube and enters the traction motor blower. The traction motor blower forces the clean, cooling air into an air plenum. The air plenum, constructed by welding a top and bottom plate to two I-beams that form the platform structure, runs the length of the locomotive. Baffles built into the air plenum help to equalize airflow from one end of the plenum to the other. The cooling air exits the platform air plenum through flexible air ducts. These flexible air ducts run from the platform down to each traction motor on both trucks. After cooling the traction motors, the air exhausts to the atmosphere through vents built into one end of each traction motor.

Screen 27:

Operation of the Alternator and Auxiliary Cooling Air System:

The alternator and auxiliary cooling air system is responsible for cooling the alternator and auxiliary cab. The alternator blower draws air into the blower cab through two V-screens and then through six plastic air cleaner panels. The V-screens, which are located on both sides of the blower cab, block large items such as leaves and paper from entering the system. The plastic air cleaner panels are identical to those used in the traction motor cooling air system. The clean air passes through the panels to the alternator blower, and dirty air is sent to the exhaustor blower, which is physically mounted on a common shaft with the alternator blower. A single AC motor powers both the alternator blower and the exhaustor blower through the common shaft arrangement. The exhaustor blower draws in the dirty air from the air cleaner panels and ejects it through the roof of the blower cab. The alternator blower receives the clean air and forces it down two paths.

Screen 28:**Operation of the Alternator and Auxiliary Cooling Air System – First Path:**

The first path is through a corner duct to the main propulsion system electrical components located in the auxiliary (aux) cab. For the AC locomotives, these main components include the nine rectifiers and six inverter stacks and, for the DC locomotives, the nine rectifiers and DC link. In this path, the air cools the main propulsion system electrical components and then flows back through another channel in the corner duct to the alternator. Next, the internal components of the alternator are cooled. The air exits one end of the alternator into the engine cab. As long as the engine cab doors are closed, the air pressurizes the area and helps keep contaminants out.

Screen 29:**Operation of the Alternator and Auxiliary Cooling Air System – Second Path:**

In the second path, air passes to the aux cab through the six auxiliary cab air filters. The filtered air is sent in two directions in the aux cab. One direction is into CA1, and the other is through the electronic panels in the aux cab. The air cools the electronic panels and then flows into the aux cab and CA8. This pressurizes the two areas to help keep contaminants out. In addition to discharging dirty air, the exhauster blower draws air from the top of CA1 and the toilet compartment and exhausts it through the roof of the blower.

Screen 32:**Self-Test 406:**

Self-Test 406, initiated through a Smart Display, can be used to test the half and full speeds of the traction motor blower. The self-test causes the Traction Blower Controller to drive the traction motor blower at the speed selected on the Smart Display.

Screen 33:**Monitor Parameters:**

This table displays the monitor parameters available on the Smart Display in Level 3 access that aid maintenance personnel in monitoring the equipment cooling air system. Scroll down to view the complete table.

Screen 34:**Running Maintenance:**

This table displays the recommended running maintenance schedule for the equipment cooling air system and its major components.

Screen 36:**Safety Precautions:**

To prevent personal injury and potential equipment damage when performing maintenance on cooling air system components, ensure the engine cannot be started.

Place the Locomotive Battery Switch (LBS) in the OFF position. Place the Fuel Pump Circuit Breaker (FCB) and the Local Control Circuit Breaker (LCCB) in the OFF position. Apply a warning tag to the Engine Control (EC) switch.

Screen 37:

Plastic Air Cleaner Panels:

The plastic air cleaner panels, referred to as spin cleaner panels, provide the initial filtration for the traction motor cooling air system and the alternator and auxiliary cooling air system. After passing through the V-screens, air is drawn into the plastic air cleaner panels. The traction motor cooling air system uses 12 air cleaner panels, six on each side of the radiator cab. The alternator and auxiliary cooling air system uses six air cleaner panels, two on the Helper's side of the blower cab and four on the Engineer's side of the blower cab. The air cleaner panels require no routine running maintenance other than a visual inspection to check if the panels are intact and free of debris. If the panels are cracked or broken, they must be replaced. If they are plugged with debris, remove the panels and clean and return them to the locomotive.

Screen 38:

Traction Motor Blower:

The traction motor blower is an 83-horsepower, AC motor-driven blower that provides cooling air of 18,600 to 20,000 CFM at Notch 8 engine speed for all the traction motors on the locomotive. A minimum flow of 2,775 CFM at Notch 8 engine speed is provided to each traction motor. Some of the cooling air also flows across the AC motor on the traction motor blower to keep it cool. Whenever the engine and the auxiliary alternator are operational, the traction motor blower runs to maintain positive pressure in the traction motors. This prevents dirt and moisture from contaminating the traction motors. The Traction Blower Controller determines the speed of the traction motor blower based on calculated motor temperatures and motor currents. Motor speed is either half or full engine speed.

Screen 39:

Traction Motor Blower Removal:

Typical steps to remove the traction motor blower are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the Battery Switch to prevent starting attempts. Also, open the Fuel Pump Circuit Breaker (FCB) and the Local Control Circuit Breaker (LCCB) in the OFF position. Apply a warning tag to the Engine Control (EC) switch.

Warning: If the locomotive is equipped with Auto Engine Start/Stop (AESS), the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that AESS is disabled before performing any maintenance on the locomotive. Failure to do so may result in death or serious personal injury.

1. Open the traction motor blower electrical connection box and disconnect the three motor leads.

Note: Lash the three motor leads to the motor cowl to prevent damage during handling, keeping in mind the arrangement for later reconnection.

2. Remove the bolts and lockwashers securing the connection box and support assembly to the platform, then move the assembly out of the way to facilitate later removal of the traction motor blower.
3. Remove the section of the handrail adjacent to the traction motor blower on the Helper's side of the locomotive, then remove the two criss-cross structural braces. Save all hardware.
4. Remove the eight traction motor blower mounting bolts and hardened washers.

Screen 40:

Traction Motor Blower Removal (Cont'd):

5. Loosen the two "push" bolts near the base of the traction motor blower and use the two "J" bolts to pull the traction motor blower away from the air filter assembly.

Warning: The traction blower weighs approximately 1,350 lbs. (613 kg) and the traction blower motor weighs approximately 872 lbs. (396 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

6. Attach a come-along to the blower housing removal lug and carefully line up a forklift with the mounting base with the forks extended under the base, then pull the blower from the radiator cab onto the forks.
7. Carefully set the traction motor blower on a skid in a level position.

Screen 41:

Traction Motor Blower Installation:

Typical steps to install the traction motor blower are as follows:

Warning: To prevent personal injury and potential equipment damage, ensure that the engine cannot be started before removing, installing, or adjusting any components. Open the Battery Switch to prevent starting attempts. Also, open the Fuel Pump Circuit Breaker (FCB) and the Local Control Circuit Breaker (LCCB) in the OFF position. Apply a warning tag to the Engine Control (EC) switch.

1. Clean the blower-mounting base in the radiator cab if needed.
2. Install a new gasket and seal on the bulkhead of the filter box assembly.

Warning: The traction blower weighs approximately 1,350 lbs. (613 kg) and the traction blower motor weighs approximately 872 lbs. (396 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

3. Place the traction motor blower into position on the mounting base using a forklift, then carefully slide the blower into position with a come-along attached to the pulling lug while aligning the blower with the opening in the air filter assembly.

Note: Ensure that the circular knife edge of the blower crushes the gasket in the filter box assembly bulkhead and a proper air sealing is achieved.

4. Near the base of the traction motor blower, use the two "push" bolts and "J" bolts to align the holes in the traction motor blower base with the holes in the radiator cab floor.

Screen 42:

Traction Motor Blower Installation (Cont'd):

5. Install the traction motor blower mounting hardware and torque the bolts to 280 to 300 lb.-ft. (380 to 407 Nm).
6. Install the electrical connection box and support assembly to the platform, then secure with bolts and lockwashers.
7. Connect the three motor leads to the traction motor blower electrical connection box terminals, ensuring that each lead is connected to the proper terminal, then tie-wrap the lead bundle to the tape rail.

Caution: When the power leads to the equipment blower motor or the equipment blower motor drive regulator (EBP), which controls the motor, have been disconnected at either end for any reason, it is possible to incorrectly connect the leads at reinstallation. If any two power leads are swapped at either end, the blower may still operate; but it will rotate backwards. Backward running of the equipment blower will greatly decrease the air flow. This reduced ventilation can shorten the life and/or do serious damage to the traction motors.

Note: The speed sensor gap should be 0.020 to 0.030 inches (0.51 to 0.76 mm). This gap is set at the factory and normally does not need to be readjusted.

8. Install the criss-cross structural braces, and torque bolts to 329 lb.-ft. (446 Nm).
9. Install the previously removed section of handrail.
10. Verify correct blower air output by checking the exhaust port of the blower to ensure correct blower motor wiring, and ensure the proper air flow direction.

Screen 43:

Checking Traction Motor Blower Operation:

Because the location of the traction motor blower makes visual inspection of the blower rotation difficult, you should perform the following test each time the equipment blower power leads are disconnected. Using a manometer with a hand-held, non-metallic probe, measure the air pressure at the Long-Hood Truck traction motor drain holes. The drain holes are located at the bottom of the traction motor, when mounted in the truck. Pressure should exceed 5.4 inches (137 mm) of water when the locomotive is operating in Self-Load, Notch 8. A lower pressure indicates that the power leads are connected incorrectly or that there is a problem with the blower or controller. If this happens, shut down the engine, inspect the terminals, and correct the faulty connections. Ensure that all traction motor flexible air ducts are in good condition and that they are properly bolted to the traction motors.

Screen 45:

Exhauster Blower:

The exhauster blower is an 8.5-horsepower, AC motor-driven exhauster that removes dirty air or bleed air from the spin cleaners and discharges it into the radiator cab. The AC motor is electrically connected through an Exhauster Motor Breaker (EMB) to the auxiliary alternator. If the auxiliary alternator is functioning, the exhauster blower is also functioning. The exhauster blower runs at engine speed. The EMB provides overload protection for the AC source to the exhauster motor, which is the auxiliary alternator. For removal and installation of the exhauster blower, refer to the Combustion Air System module of this course.

Screen 46:

Alternator Blower:

The main purpose of the alternator blower is to provide a minimum cooling airflow of 12,000 CFM at Notch 8 engine speed to the alternator and equipment in the auxiliary cab, CA1, and CA8. A secondary purpose is to draw bleed air from the spin cleaners and to exhaust the toilet compartment and CA1. The alternator blower consists of a 47-horsepower AC motor, a blower, and an exhauster. The AC motor drives the blower and exhauster, which are on the same shaft. The AC motor is electrically connected to the auxiliary alternator. As long as the auxiliary alternator is functioning, the alternator blower will also function. The alternator blower runs at engine speed.

Screen 47:

Alternator Blower Removal:

Typical steps to remove the alternator blower are as follows:

1. Remove the bolts securing the roof hatch on the blower cab roof, then lift off the hatch with a crane and set it aside.

Note: The alternator blower motor terminal block is mounted on the underside of the blower cab just below the alternator blower on the Engineer's side of the locomotive.

2. Disconnect the three motor leads from the terminal block, keeping in mind the arrangement for later reassembly, then install the hardware back onto the terminal block studs.
3. Remove the locknut from the motor lead flexible metal conduit near the terminal block.
4. Carefully pull the flexible metal conduit and three motor leads back inside the blower cab.

Screen 48:

Alternator Blower Removal (Cont'd):

5. Remove the two nuts securing the alternator blower grease fitting lines to the floor of the blower cab on the Engineer's side of the locomotive.
6. Remove the four alternator blower mounting bolts.

Note: An industrial-type putty strip is used between the blower and the mounting surface. A jacking bolt hole, located in one corner of the blower, may be used with one of the mounting bolts as a jacking bolt to break the seal between the alternator blower and the mounting surface.

Warning: The alternator blower weighs approximately 1090 lbs. (494 kg). Ensure that the lifting device is adequate.

7. Attach cable-lifting slings to the blower lifting lugs, and carefully lift the alternator blower out of the cab with a crane.
8. Set the blower upright on a skid in a level position.

Screen 49:

Alternator Blower Installation:

Warning – Falling Hazard: To prevent a falling hazard, comply with all Railroad safety procedures before proceeding to the top of the blower cab.

Typical steps to install the alternator blower are as follows:

1. Clean the old industrial-type putty strip from the alternator blower mounting surface in the blower cab, then apply a new strip to the mounting surface to ensure an airtight seal.
2. Lift the alternator blower with a crane and clean the bottom mounting surface of the blower.
3. Place the alternator blower into position in the blower cab ensuring that the dirty air exhauster inlet air flange engages the gasket on the cab duct.
4. Install the alternator blower mounting hardware and torque to 200 lb.-ft. (271 Nm).
5. Apply Mortite Sealant to the bottom of the connecting plate where the bolt holes are located and connect the grease fitting lines.

6. With the grease fitting lines reconnected, fill the grease lines with the recommended grease.

Screen 50:

Alternator Blower Installation (Cont'd):

7. Reconnect the metal plate to the bottom of the platform using the two bolts while ensuring the grease lines are not twisted, then torque the bolts to 100 lb.-ft. (136 Nm).
8. Carefully feed the three alternator blower motor leads and flexible metal conduit through the blower cab floor, then install the locknut to secure the motor lead conduit to the bottom of the blower cab.
9. Connect the motor leads to the terminal block, ensuring that each lead is connected to the correct terminal.

Caution: Be sure to connect the leads correctly. Improper connection may cause the blower to run backwards, which greatly decreases airflow. This can shorten the life of and seriously damage the alternator and control equipment.

10. Lift and set the roof hatch on the blower cab with a crane, then install the hardware to secure the hatch of the blower cab.

Screen 51:

Checking Alternator Blower Operation:

Because the location of the alternator blower makes visual inspection of blower rotation difficult, you should perform the following test each time the alternator blower power leads are disconnected. Connect a long hose and a water tube manometer, or equivalent, to the pressure tap located at the six o'clock position on the main alternator. Monitor the pressure from the walkway. The pressure should exceed 3.0 inches (76.2 mm) of water when the locomotive is operating in Self-Load, Notch 8. A lower pressure indicates that the power leads are connected incorrectly or that there is a problem with the blower. If this happens, shut down the engine, inspect the terminal block, and correct the faulty connections.

Screen 52:

Auxiliary Cab Air Filters:

The auxiliary cab air filters remove contaminants from the air that cools the equipment in the auxiliary cab. Six paper filters are located in a compartment directly above the alternator on the Helper's side of the locomotive. You can access the filters through a door on the blower cab. A wingnut, lockwasher, and washer hold each filter in place.

Screen 55:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the equipment cooling air system.
 - The primary purpose of the equipment cooling air system is to provide cooling air for critical components, including the alternator, the propulsion circuits, and the traction motors. A secondary purpose is to pressurize key areas of the locomotive to help keep out contamination.
 - The equipment cooling air system contains two separate forced-air ventilation subsystems: the traction motor cooling air system and the alternator and auxiliary cooling air system.
 - The major components of the traction motor cooling air system are located in the radiator cab. The major components of the alternator and auxiliary cooling air system are located in the blower cab.
- State the purpose and location of the major components of the equipment cooling air system.
 - The purpose and location of the major components of the traction motor cooling air system are as follows:
 - V-Screens: Located on both sides of the radiator cab, the V-screens provide the entry point for the air-to-traction motor cooling air system while blocking debris.
 - Plastic Air Cleaner Panels: Located directly behind the V-screens in the radiator cab, the plastic air cleaner panels, also referred to as spin cleaner panels, clean the air entering the traction motor cooling air system. Vortex tubes in the spin cleaner panels contain spiral vanes that cause the air to swirl like a tornado as it passes through the tube. The swirling action forces heavier dirt particles to the outside of the air stream. This “dirty” air is separated at the output of the tubes and discharged from the air cleaner panels into a bleed air duct.
 - Traction Motor Blower: Located in the radiator cab on the Helper’s side, the traction motor blower or the equipment blower provides cooling air for all the traction motors on the locomotive.
 - Exhauster Blower: Located in the radiator cab on the Engineer’s side of the locomotive, the exhauster blower removes the dirty air from the spin cleaner panel bleed air duct, continuously discharging the bleed air and dirt out the top of the unit and into the radiator cab. From the radiator cab, the radiator fans pull the air out, discharging the dirty air through the top of the locomotive.
 - The purpose and location of the major components of the alternator and auxiliary cooling air system are as follows:
 - V-Screens: Located on both sides of the blower cab, the V-screens provide

the entry point for the air to the alternator and auxiliary cooling air system while blocking debris.

- Plastic Air Cleaner Panels: Located directly behind the V-screens in the blower cab, the plastic air cleaner panels clean the air entering the alternator and auxiliary cooling air system. Vortex tubes in the spin cleaner panels force heavier dirt particles to the outside of the air stream. This “dirty” air is separated at the output of the tubes and discharged from the air cleaner panels into a bleed air duct.
 - Alternator Blower with Exhauster: Located in the blower cab, the alternator blower provides cooling air to the alternator and to the equipment in the auxiliary cab, CA1, and CA8. The exhauster portion of the alternator blower draws the dirty air from the spin cleaner panel bleed air duct and exhausts the air to the roof of the blower cab.
 - Auxiliary Cab Air Filters: Located in a compartment directly above the alternator on the Helper’s side of the locomotive, the auxiliary cab air filters filter contaminants from the air that cools the equipment in the auxiliary cab.
 - Corner Duct: Located on the Helper’s side of the locomotive and attached to the auxiliary cab, the corner air duct forms a conduit for the cooling air flowing in and out of CA3 in the auxiliary cab.
- State the purpose and location of the instrumentation devices of the equipment cooling air system.
 - Barometric Air Pressure (BAP) Sensor: Located on the wall of CA4 in the auxiliary cab, the BAP sensor measures the pressure of the atmosphere and provides the pressure information to the ECU.
 - Ambient Temperature (AT) Sensor: Located in CA3, the AT sensor measures the temperature of the air flowing through CA3 and provides this information to the Smart Displays by way of the CIO panel.
 - Describe how the equipment cooling air system operates.
 - Air flows through the following path in the traction motor cooling air system:
 - The vacuum created by the traction motor blower first draws outside air in through the V-screens, where large items are blocked from entering the system.
 - Passing through the V-screens, the air and dirt are separated by 12 plastic air cleaner panels.
 - An exhauster blower provides a drawing force to discharge the dirty air from the plastic air cleaner panels into the radiator cab.
 - The clean air in the middle of the air stream exits each tube and enters the traction motor blower.
 - The traction motor blower forces the clean, cooled air into an air plenum.
 - The cooling air exits the platform air plenum through flexible air ducts and cools the traction motors.
 - After cooling the traction motors, the air exhausts to the atmosphere

- through vents built into one end of each traction motor.
- Air flows through the following path in the alternator and auxiliary cooling air system:
 - The alternator blower draws air into the blower cab through two V-screens and then through six plastic air cleaner panels.
 - The clean air passes through the panels to the alternator blower, and dirty air is sent to the exhauster blower, which is physically mounted on a common shaft with the alternator blower.
 - The exhauster blower draws in the dirty air from the air cleaner panels and ejects it through the roof of the blower cab.
 - The alternator blower receives the clean air and forces it down two paths.
 - The first path is through a corner duct to the main propulsion system electrical components located in the aux cab. The air then flows back through another channel in the corner duct to the alternator and cools it. The air exits one end of the alternator into the engine cab. As long as the engine cab doors are closed, the air pressurizes the area and helps keep contaminants out.
 - In the second path, air passes to the aux cab through the six auxiliary cab air filters. The filtered air is sent in two directions in the aux cab. One direction is into CA1, and the other is through the electronic panels in the aux cab. The air cools the electronic panels and then flows into the aux cab and CA8. This pressurizes the two areas to help keep contaminants out. In addition to discharging dirty air, the exhauster blower draws air from the top of CA1 and the toilet compartment and exhausts it through the roof of the blower.

Screen 56:

Summary (Cont'd):

- Describe how to perform running maintenance related to the equipment cooling air system.
 - The air cleaner panels require no routine running maintenance other than a visual inspection to see if they are intact and free of debris.
 - Every 3 years, lubricate the bearings of the traction motor blower, the exhauster blower, and the alternator blower.
 - At 184 days, replace the six auxiliary cab air filters.
 - Traction Motor Blower Removal
 1. Open the traction motor blower electrical connection box and disconnect the three motor leads.
 2. Remove the bolts and lockwashers securing the connection box and support assembly to the platform, then move the assembly out of the way to facilitate later removal of the traction motor blower.
 3. Remove the section of the handrail adjacent to the traction motor blower on the Helper's side of the locomotive, then remove the two criss-cross structural braces. Save all hardware.

4. Remove the eight traction motor blower mounting bolts and hardened washers.
5. Loosen the two "push" bolts near the base of the traction motor blower and use the two "J" bolts to pull the traction motor blower away from the air filter assembly.
6. Attach a come-along to the blower housing removal lug and carefully line up a forklift with the mounting base with the forks extended under the base, then pull the blower from the radiator cab onto the forks.
7. Carefully set the traction motor blower on a skid in a level position.
- Traction Motor Blower Installation
 1. Clean the blower-mounting base in the radiator cab if needed.
 2. Install a new gasket and seal on the bulkhead of the filter box assembly.
 3. Place the traction motor blower into position on the mounting base using a forklift, then carefully slide the blower into position with a come-along attached to the pulling lug while aligning the blower with the opening in the air filter assembly.
 4. Near the base of the traction motor blower, use the two "push" bolts and "J" bolts to align the holes in the traction motor blower base with the holes in the radiator cab floor.
 5. Install the traction motor blower mounting hardware and torque the bolts to 280 to 300 lb.-ft. (380 to 407 Nm).
 6. Install the electrical connection box and support assembly to the platform, then secure with bolts and lockwashers.
 7. Connect the three motor leads to the traction motor blower electrical connection box terminals, ensuring that each lead is connected to the proper terminal, then tie-wrap the lead bundle to the tape rail.
 8. Install the criss-cross structural braces, and torque bolts to 329 lb.-ft. (446 Nm).
 9. Install the previously removed section of handrail.
 10. Verify correct blower air output by checking the exhaust port of the blower to ensure correct blower motor wiring, and ensure the proper air flow direction.
- Alternator Blower Removal
 1. Remove the bolts securing the roof hatch on the blower cab roof, then lift off the hatch with a crane and set it aside.
 2. Disconnect the three motor leads from the terminal block, keeping in mind the arrangement for later reassembly, then install the hardware back onto the terminal block studs.
 3. Remove the locknut from the motor lead flexible metal conduit near the terminal block.
 4. Carefully pull the flexible metal conduit and three motor leads back inside the blower cab.
 5. Remove the two nuts securing the alternator blower grease fitting lines to the floor of the blower cab on the Engineer's side of the locomotive.

6. Remove the four alternator blower mounting bolts.
7. Attach cable-lifting slings to the blower lifting lugs, and carefully lift the alternator blower out of the cab with a crane.
8. Set the blower upright on a skid in a level position.
- Alternator Blower Installation
 1. Clean the old industrial-type putty strip from the alternator blower mounting surface in the blower cab, then apply a new strip to the mounting surface to ensure an airtight seal.
 2. Lift the alternator blower with a crane and clean the bottom mounting surface of the blower.
 3. Place the alternator blower into position in the blower cab ensuring that the dirty air exhaust inlet air flange engages the gasket on the cab duct.
 4. Install the alternator blower mounting hardware and torque to 200 lb.-ft. (271 Nm).
 5. Apply Mortite Sealant to the bottom of the connecting plate where the bolt holes are located and connect the grease fitting lines.
 6. With the grease fitting lines reconnected, fill the grease lines with the recommended grease.
 7. Reconnect the metal plate to the bottom of the platform using the two bolts while ensuring the grease lines are not twisted, then torque the bolts to 100 lb.-ft. (136 Nm).
 8. Carefully feed the three alternator blower motor leads and flexible metal conduit through the blower cab floor, then install the locknut to secure the motor lead conduit to the bottom of the blower cab.
 9. Connect the motor leads to the terminal block, ensuring that each lead is connected to the correct terminal.
 10. Lift and set the roof hatch on the blower cab with a crane, then install the hardware to secure the hatch of the blower cab.

Compressed Air System

Screen 1:

Welcome Screen:

Welcome to the Compressed Air System module of the ES44AC/DC Mechanical Systems Advanced course.

Screen 2:

Introduction to Compressed Air System:

In this module, you will learn how to inspect and maintain the components of the compressed air system on an ES44AC/DC locomotive in a running repair environment.

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

- State the purpose and location of the compressed air system.
- State the purpose and location of the major components of the compressed air system.
- State the purpose and location of the compressed air system instrumentation devices.
- Describe how the compressed air system operates.
- Describe how to perform running maintenance related to the compressed air system.

Screen 3:

Disclaimer:

This module is for training use only. For complete details of inspecting and maintaining the components of the compressed air system on an ES44AC/DC locomotive in a running repair environment, refer to customer-specific drawings, manuals, and procedures.

Screen 4:

System Overview:

The compressed air system provides compressed air to the air brake system and the auxiliary air-operated devices on the locomotive, such as the horn and windshield wipers and, on earlier GEVO locomotives, a pneumatic crossing bell. The compressed air system and all its components, except the air compressor, are attached to or located under the platform. The air compressor is located in the radiator cab.

Screen 5:

Components of the Compressed Air System:

The compressed air system on an ES44AC/DC locomotive includes several major components, including the air compressor and the safety valve.

Screen 6:

Air Compressor:

Located in the radiator cab, the air compressor compresses ambient air and provides pressurized air to the system.

Screen 7:**Safety Valve:**

Located between the two main air reservoirs on the Engineer's side of the locomotive, the J1 safety valve protects the air compressor and the rest of the compressed air system from an overpressure condition.

Screen 8:**Components of the Compressed Air System:**

Other major components of the compressed air system include the main air reservoirs, air dryer, and final air filters.

Screen 9:**Main Air Reservoirs:**

Located on the Engineer's side of the locomotive in a notched area of the fuel tank, the main air reservoirs store compressed air for later use by other components of the locomotive.

Screen 10:**Air Dryer:**

Located on the Engineer's side of the locomotive between the fuel tank and the number 2 truck, the air dryer removes moisture from the compressed air.

Screen 11:**Final Air Filters:**

Located on the Engineer's side of the locomotive between the fuel tank and the number 1 truck under the walkway, the final air filters filter contaminants from the compressed air before it is distributed to the controlled components.

Screen 15:**System Instrumentation:**

A locomotive's instrumentation provides feedback for diagnostics, control, and protection.

Screen 16:**Air Reservoir Pressure Sensor (ARPS):**

The Air Reservoir Pressure Sensor (ARPS) measures the pressure of the air that is at the output of the first main air reservoir. The locomotive control system uses this information to turn the air compressor motor on and off and to control when the compressor is to load or unload. The end result is to regulate the air pressure in the system. This information is also presented on the smart displays for operator use. The ARPS is located on the air compressor control panel, which is in the radiator cab. Access to the panel is from the Engineer's side of the locomotive near the air compressor.

Screen 17:**Air Compressor Speed Sensor (ACS):**

The Air Compressor Speed Sensor (ACS) is used to detect the air compressor motor speed and send this information (a frequency) to the locomotive control system. The control system takes this information and uses it to determine if the compressor motor is

operating at the correct speed. The ACS sensor is located at the end of the air compressor motor.

Screen 18:

Operation of the Compressed Air System – Compression:

The typical compressed air system utilizes a WABCO 3CDCLAT air-cooled compressor to provide the main source of compressed air for the locomotive. The compressed air system has four basic functions: compression, storage, filtration, and distribution. During compression, the outside air passes through two paper air filters and enters the air compressor. The air compressor is an AC motor-driven, two-stage air compressor that provides regulated compressed air to the first main reservoir. The locomotive's control system regulates the compressed air from the air compressor by controlling the following:

- When the air compressor motor turns on and off,
- The motor's speed when operating, and
- When the compressor loads (compresses air) or unloads (stops compressing air).

Screen 19:

Operation of the Compressed Air System – Storage:

From the air compressor, the compressed air enters the first main reservoir where cooling and moisture condensation take place. The main reservoir is tilted so that water collects at one end, where a drain valve drains any accumulated condensation from moisture in the air. A safety valve is connected to the outlet of the first main reservoir. If air pressure exceeds 150 psi, the valve will open. This is to protect the air compressor and the rest of the system from an overpressure condition. Compressed air from the first main reservoir flows in two ways. One path is to the main air reservoir pressure sensor (ARPS), which provides a feedback signal of the air pressure to the locomotive's control system. The other path is to the second main air reservoir, with or without an air dryer, based on customer requirements.

Screen 20:

Operation of the Compressed Air System – Storage:

For customer locomotives without an air dryer, compressed air from the main reservoir flows to the second main air reservoir and to the auxiliary air filter. A check valve between the output of the first main reservoir and the MR equalizing pipe allows consist air from another locomotive to enter this locomotive's air system.

Screen 21:

Operation of the Compressed Air System – Storage (Cont'd):

For customer locomotives with an air dryer, the air flows through the air dryer, where moisture is removed, and then continues to the second main air reservoir and to the auxiliary air filter. From the air dryer, the air flows to the second main air reservoir and to the auxiliary air filter. A check valve is connected between the output of the first main reservoir and the MR equalizing pipe. This check valve allows consist air from another locomotive to enter this locomotive's air system. A second check valve is connected

between the output of the air dryer and the MR equalizing pipe, allowing air to flow to another locomotive in the consist. This path ensures that the air has passed through the dryer before being made available to another unit. Air enters the second main reservoir through a check valve and then flows to the MR air filter. The check valve prevents air from flowing backwards to the first main reservoir. This ensures that if the first main reservoir loses air, the second air reservoir will maintain enough supply air for the brake system to be able to provide one emergency air brake application.

Screen 22:

Operation of the Compressed Air System – Filtration and Distribution:

The MR air filter and the auxiliary air filter are also known as final air filters.

These devices filter the air before being distributed to the air brake system and the auxiliary air devices. Each filter is equipped with a drain valve that may be used to drain any accumulated condensation. During distribution, the filtered air from the auxiliary air filter (that is, the auxiliary supply air) is distributed to the horn, bell, windshield wipers, and sanding valves. Filtered air from the MR air filter (that is, the MR supply air) is distributed to the air brake system, shutter control magnet valves, univalve control magnet valves, and the compressor magnet valve.

Screen 25:

Operational Details:

You can test the air compressor from any of the Smart Displays using Self-Tests 401, 402, and 403. These self-tests are used to test the operation of the Compressor Drive Contactors (CDC1, CDC2, and CDC2A) and the Compressor Magnet Valve (CMV), all of which will be discussed later. The Smart Display software controls when the air compressor motor turns on or off and at what speed by energizing the correct compressor drive contactors and when to load or unload the air compressor. To protect the air compressor motor from high startup currents, the motor is turned on first, and then the air compressor is loaded. Typically, the air compressor starts loading when the main reservoir pressure, as read by the ARPS sensor, drops below 128 psi and stops loading when the pressure rises above 141 psi. These values may vary depending on the railroad's compressed air requirements.

Screen 26:

Running Maintenance Schedule:

The table displays the recommended scheduled maintenance recommendations for the compressed air system and its major components.

Screen 29:

Air Compressor:

The air compressor is a three-cylinder, two-stage, air-cooled machine with two low-pressure cylinders and one high-pressure cylinder. The high-pressure and low-pressure pistons are driven by connecting rods that rotate about a common crankshaft crankpin. The air compressor is driven by an electric motor, which is mounted directly to the compressor crankcase. Running maintenance for the air compressor involves checking the oil level, draining and filling the oil, taking an oil sample, testing the load/unload operation, and

removing and installing the air compressor.

Warning: When performing running maintenance, the air compressor motor could start at any time. Disable the compressor drive contactors by placing the Local Control Circuit Breaker (LCCB) on the Engine Control Panel in the OFF position before servicing the air compressor.

Screen 30:

Running Maintenance for Air Compressor – Checking the Air Compressor Oil Level:

Typical steps to check the air compressor oil level are as follows:

1. Place the LCCB in the OFF position to prevent the air compressor from running.
2. Check the air compressor oil level using the oil dipstick or oil level gauge located on the air compressor and add oil, if needed.

Note: When using the dipstick to take an oil level reading, the dipstick should first be removed and wiped clean, and then re-inserted. Ensure that the dipstick is fully seated, and then remove it and take the reading. Add oil as indicated on the dipstick or gauge.

3. Open the aftercooler petcocks each time the oil level is checked to allow accumulated moisture and small amounts of lubricant to be exhausted.
4. Close the petcocks when the moisture has been drained.

Screen 31:

Running Maintenance for Air Compressor – Draining Air Compressor Oil:

Typical steps to drain the air compressor oil are as follows:

1. Place the LCCB in the OFF position to prevent the air compressor from running.
2. Place a receptacle of sufficient capacity under the air compressor drain pipe to collect the oil.

Note: The WABCO Model 3CDCLAT air compressor has a lubricating oil capacity of 16 gallons (60.56 liters). The drain pipe is located on the Helper's side of the locomotive under the platform.

3. Open the two drain valves – one located near the base of the air compressor on the Helper's side, which should be tagged open, and the other located under the platform on the Helper's side of the locomotive.

Caution: When changing the air compressor oil, thoroughly clean the crankcase. Any dirt and sludge remaining in the crankcase could be picked up by the pump and, if allowed to accumulate, could eventually plug the pump suction. If such blockage occurs, the flow of lubricating oil will be obstructed, resulting in possible damage to the compressor's moving parts.

4. Wipe the air compressor crankcase using a railroad-approved solvent and clean, lint- free cloth.

5. Close the drain valve near the base of the air compressor and the drain valve under the platform.

Screen 32:

Running Maintenance for Air Compressor – Filling the Air Compressor with Oil:

Typical steps to fill the air compressor with oil are as follows:

1. Open the air compressor fill cap.
2. Fill the crankcase with the approved lubricating oil.

Note: The oil capacity of the air compressor is 16 gallons.

3. Check the crankcase lube oil level on the dipstick or gauge and add oil if needed.

Screen 33:

Running Maintenance for Air Compressor – Collecting Oil Samples for Laboratory

Analysis: Engineering recommends that oil samples be collected for analysis at a minimum frequency of 7 to 10 days. Have the sample analyzed by a qualified laboratory, and then take the appropriate action based on the analysis. Prior to taking an oil sample, run the air compressor to mix the oil in the crankcase. Some air compressors are equipped with a Test pushbutton located near the air compressor on the Engineer's side of the locomotive that when pushed will cause the air compressor motor to turn on for four minutes. After the air compressor motor turns off, place the LCCB in the OFF position to prevent the air compressor from turning back on. Next, write all pertinent information (such as road number, date, etc.) on the sampling bottle. Print the information clearly and keep the label clean so that a lab technician can read it. Connect an oil-sampling valve to the quick-disconnect fitting located on the air compressor. The oil sample bottle should be filled two-thirds to three-quarters full.

Screen 34:

Running Maintenance for Air Compressor – Compressor Loading and Unloading:

The air compressor must be manually loaded and unloaded to check the operation of the compressor load/unload system. When loaded, the compressor motor is running and the compressor is compressing air. When unloaded, the compressor motor is running but the compressor is not compressing air. This change from loading to unloading is accomplished through the operation of the Compressor Magnet Valve (CMV) and compressor unloader valves. Let's look at the role of the compressor magnet valve and the unloader valves during the process of loading and unloading.

Screen 35:

Air Compressor Loading Operation:

During compressor loading, the CMV is de-energized and opens, venting the air pressure supply to the unloader valves. The unloader valves then open, allowing the compressor intake valves to operate normally. When operating normally, air enters the compressor cylinders through the intake valves during the intake stroke, the intake valves then close, the compressor's pistons compress the air, exhausting the high-pressure air into the receiver, the compressor exhaust valves close and the process is repeated. With the

compressor drive motor running and the compressor building air pressure, the compressor is operating in a “loaded” condition.

Screen 36:

Air Compressor Unloading Operation:

During compressor unloading, the CMV, which is a solenoid-operated valve, is energized and closes to force air pressure to act on the compressor unloader valves. The unloader valves physically force the compressor intake valves to remain open, preventing the compressor from building pressure. Although the compressor drive motor may be running, since the compressor cannot build air pressure, the compressor is operating in an unloaded condition.

Note: For normal automatic operation of the air compressor, the compressor cut-out valve must be open, allowing air to flow to the ARPS, the CMV must be unlatched (that is, not locked in an energized position), and the governor test probe must be installed.

Screen 37:

Running Maintenance for Air Compressor – Checking Air Compressor Loading

Operation: To check the air compressor loading operation, the air compressor must be loaded manually. To manually load the air compressor, remove the governor test probe and leave the CMV unlatched.

Warning: Do not allow the air compressor to operate in this mode unattended. The ARPS will sense the low air pressure and the control system will continuously cause the air compressor to load. The J1 safety valve will open when pressure reaches 150 psi, but no other device will keep the main reservoir pressure within safe limits.

When the governor test probe is removed, the line to the ARPS is vented. The ARPS will indicate lower air pressure, the control system will cause the motor to start, and two seconds later, the CMV will de-energize, exhausting air. This action will cause the air compressor to load (i.e., the intake valves will close and the compressor will pump air, thus building air pressure). Ensure that the test probe is re-installed when testing is complete.

Screen 38:

Running Maintenance for Air Compressor – Checking Air Compressor Unloading

Operation: To check the air compressor unloading operation, the air compressor must be unloaded manually. To manually unload the air compressor, remove the governor test probe, allowing the line to the ARPS to be vented. Then, latch (that is, energize) the CMV. With the CMV energized, pressure acts on the compressor unloader valves, and the unloader valves physically force the compressor intake valves to remain open, preventing the compressor from building pressure. Return the CMV to the unlatched position. Fit the test probe before returning the locomotive to service.

Screen 39:

Running Maintenance for Air Compressor – Replacing Air Inlet Filters:

Proper air filtration is important to the life of the air compressor. When replacing the air inlet filters, ensure that the filters are properly seated and the mounting nuts are securely

tightened so that all air entering the compressor is filtered.

Screen 41:

Running Maintenance for Air Compressor – Air Compressor Removal:

Typical steps to remove the air compressor from the locomotive are as follows:

Note: Some Evolution Series locomotives are equipped with an oil free air compressor. If removing oil free air compressor, disregard steps 1 and 2.

1. Open the drain cock at the side of the locomotive to drain the lubricating oil from the air compressor.

Note: The end of the drainpipe is capped. Remove the cap to drain the oil into a suitable container. Refer to the appropriate air compressor publication for air compressor lubricating oil capacity.

2. Near the base of the air compressor, disconnect the lubricating oil drain piping at the pipe union.
3. Remove the channel section from the radiator cab structure at the end of the air compressor removal slides on the A side of the locomotive.
4. Remove the two bolts securing the door catch and remove the door catch.
5. Disconnect the air compressor motor power cables.
6. Disconnect the air compressor motor speed sensor.

Screen 42:

Running Maintenance for Air Compressor – Air Compressor Removal (Cont'd):

7. Disconnect the air compressor discharge piping at the aftercooler outlet flange.
8. Exhaust the unloader piping, and remove the unloader hose from the air compressor.

Warning: Reaching the air compressor base bolts is difficult.lb.-ft. Exercise caution when removing the air compressor base bolts. Failure to do so may result in sprains, strains, or personal injury.

Note: It is possible to remove the air compressor base bolts if the access door below the manual handbrake wheel is removed. A long extension may be necessary to access base bolts.

9. Remove the air compressor hold-down bolts at the four corners of the air compressor base.

Warning: The air compressor weighs approximately 2550 lbs. (1157 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

10. Use a come-along to move the air compressor to the walkway along the Engineer's side of the locomotive. Carefully lift the air compressor with a crane

and set it on the shop floor.

Screen 43:

Running Maintenance for Air Compressor – Air Compressor Installation:

Typical steps to install the air compressor into the locomotive are as follows:

Note: Some Evolution Series locomotives are equipped with an oil free air compressor. If installing an oil free air compressor, disregard steps 10 and 11.

Warning: The air compressor weighs approximately 2550 lbs. (1157 kg). Ensure the lifting device, cables, and straps are adequate. Failure to do so may result in personal injury or death.

1. Carefully lift the air compressor with a crane and set the compressor on the air compressor slides, then use a come-along to move the air compressor into position in the locomotive.

Note: Check for flatness by rocking the air compressor. Shim one corner if the gap exceeds 0.015 inches (0.38 mm).

Warning: Reaching the air compressor base bolts is difficult. Exercise caution when removing the air compressor base bolts. Failure to do so may result in sprains, strains, or personal injury.

2. Install and tighten the air compressor hold-down bolts at the four corners of the air compressor base, then torque the bolts to 440-490 lb.-ft. (597-665 Nm).

Note: It is possible to install the air compressor base bolts if the access door below the manual handbrake wheel is removed. A long extension may be necessary to access base bolts.

3. Connect the unloader hose to the air compressor unloader lines.
4. Bolt the air compressor discharge piping to the aftercooler outlet flange.

Screen 44:

Running Maintenance for Air Compressor – Air Compressor Installation (Cont'd):

5. Install the air compressor motor speed sensor.

Note: The speed sensor gap should be 0.030-0.040 inches (0.76-1.02 mm). This gap is set at the factory and normally does not need to be readjusted.

Caution: When the power leads to the air compressor motor have been disconnected for any reason, it is possible to incorrectly connect the leads at re-installation. If any two power leads are swapped, the motor may still operate, but will rotate backwards. Prolonged backward running of the motor may cause damage to the compressor. To check rotation, with the engine at IDLE, place the air compressor to manual run – loaded operation. Next,

verify that the air from the fan blades is flowing toward the air compressor.

6. Connect the air compressor motor power cables.
7. If the fan guard has been removed for any reason, it should be re-installed.
8. Reposition the door catch and secure with two bolts.
9. Install the channel section from the radiator cab structure at the end of the air compressor removal slides on the A side of the locomotive.
10. Connect the lubricating oil drain piping at the pipe union and close the drain cock, then fill the air compressor with oil.

Screen 45:

Main Air Reservoirs:

The main air reservoirs store compressed air for later use by the locomotive. The locomotive has two 22.5-inch diameter x 78-inch long reservoirs. The two reservoirs store about 56,000 cubic inches of air at main reservoir pressure. Each reservoir is tilted to allow moisture to accumulate at one end. An automatic or manual, customer-specific, blow-down device ("spitter" type drain valve) is installed at the low end of each reservoir to expel the moisture.

Screen 46:

Running Maintenance for Main Air Reservoirs:

Each main reservoir is supplied with telltale holes predrilled from the outside of the reservoir as specified by government regulation. The purpose of the telltale holes is to indicate the condition of the interior surface of the reservoir. The holes are drilled to a depth considered to be the minimum wall thickness. As corrosion inside the reservoir occurs and consumes the corrosion allowance material, a "weep" occurs at the predrilled area. This weep, which may be observed as air leakage or moisture droplets, provides an advance warning of the loss of the reservoir interior surface thickness.

Warning: The main air reservoirs are compressed air devices. Compressed air is extremely dangerous if not handled correctly. Do not attempt to service, repair, or break any connections or air lines without bleeding all pressure from this device.

If leakage is detected, check for a break in the reservoir shell at one of the holes. Replace the reservoir as needed.

Screen 49:

Air Dryer (Customer Option):

The air dryer removes moisture from the compressed air. Moisture could cause rust or freeze and can damage air-controlled components. The Graham-White (GW) 994-100 Air Dryer System utilizes a modular design incorporating a coalescing filter, a remote liquid drain, an auto-adjust purge valve, an inlet diverter/exhaust valve, an outlet shuttle/purge check valve, a control box, and twin desiccant towers. The dryer is installed in a mounting bracket, which is permanently attached to the locomotive platform and air piping. Running maintenance for air dryers includes removing and installing the coalescer element.

Warning: This is a compressed air device. Compressed air is extremely dangerous if not handled carefully. Do not attempt to service, repair or break any connections or air lines without bleeding all pressure from this device.

Screen 50:

Running Maintenance for Air Dryer – Removing the Coalescer Element:

Typical steps to remove the coalescer element from the air dryer are as follows:

1. Remove the eight cap screws from the bottom of the air dryer.
2. Remove the coalescer cap.
3. Remove and discard the O-ring.
4. Remove and discard the coalescer element.

Screen 51:

Running Maintenance for Air Dryer – Installing the Coalescer Element:

Typical steps to install the coalescer element into the air dryer are as follows:

1. Lubricate a new O-ring with Dow Corning 55M lubricant and install it on the cap.
2. Install the new coalescer element and cap, then secure the cap with the eight cap screws.
3. Torque the screws to 20-26 lb.-ft. (28-36 Nm).

Screen 53:

Final Air Filters:

The final air filters remove contaminants from the compressed air before it is distributed to the air-controlled components. The final air filters are located on the Engineer's side of the locomotive between the fuel tank and the number 1 truck, just under the walkway. The auxiliary air supply filter is on the outside and the MR air supply filter is located on the inside. Two types of final air filters may be used: Salem 975 and Salem 824. Running maintenance for the Salem 975 filter includes removing and installing its filter element. Running maintenance for the Salem 824 filter includes removing and installing its coalescer element.

Screen 54:

Running Maintenance for Salem 975 – Removing the Filter Element:

Typical steps to remove the filter element in the Salem 975 filter are as follows:

1. Remove the six hex nuts and lockwashers.

Note: The bottom cap and drain valve will drop down with the gasket.

2. Remove the wing nut and filter retainer.
3. Remove the filter element. Inspect and replace any damaged component as necessary.

Screen 55:

Running Maintenance for Salem 975 – Installing the Filter Element:

Typical steps to install the filter element in the Salem 975 filter are as follows:

1. Clean the inside of the filter body and bottom cap with solvent.

Note: When installing a filter element, lubricate the sealing surface at both ends of the element with Dow Corning M55 or equivalent.

2. Carefully install the filter element on the filter retaining device in the filter body assembly followed by the filter retainer and wing nut.
3. Install a gasket on the bottom cap and assemble it to the filter body.

Note: Assemble the gasket with the sealing bead on top.

4. Secure the bottom cap to the filter body assembly using six lockwashers and hex nuts.

Screen 56:

Running Maintenance for Salem 824 – Removing the Coalescer Element:

Typical steps to remove the coalescer element in the Salem 824 filter are as follows:

1. Disconnect the actuating air line to the drain valve.
2. Remove the eight hex nuts and lockwashers.
3. Use the screwdriver slots to loosen and remove the sump bowl and drain valve.
4. Remove the wing nut and seat washer from the tube assembly.
5. Remove the coalescer retainer, then remove the coalescer element and discard.

Screen 57:

Running Maintenance for Salem 824 – Installing the Coalescer Element:

Typical steps to install the coalescer element in the Salem 824 filter are as follows:

1. Carefully insert the new coalescer element into the filter body followed by the coalescer retainer and wing nut.

Note: Ensure that the guide pin on the coalescer retainer is inserted properly into the guide pin receptacle on the coalescer deflector, then tighten the wing nut securely.

2. Inspect the sump bowl gasket for damage and replace as required.
3. Wipe any debris from the sump bowl before reassembling the repaired drain valve to the sump bowl and then the sump bowl to the filter body.
4. Reconnect the actuating air line to the drain valve.

Screen 59:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the compressed air system.
 - The compressed air system provides compressed air to the air brake system and to the auxiliary air-operated devices on the locomotive, including the horn and windshield wipers.
 - The compressed air system and all its components, are attached to or located under the platform. The air compressor is located in the radiator cab.

- State the purpose and location of the major components of the compressed air system.
 - The major components of the compressed air system include the air compressor, main air reservoirs, air dryer, final air filters, and safety valve.
 - Air Compressor: Located in the radiator cab, the air compressor compresses ambient air and provides pressurized air to the system.
 - Main Air Reservoirs: The main air reservoirs are located on the Engineer's side of the locomotive in a notched area of the fuel tank. The main air reservoirs store compressed air for use by other components of the locomotive.
 - Air Dryer: The air dryer is located on the Engineer's side of the locomotive between the fuel tank and the number 2 truck. The air dryer removes moisture from the compressed air.
 - Final Air Filters: The final air filters are located on the Engineer's side of the locomotive between the fuel tank and the number 1 truck, under the walkway. The final air filters remove contaminants from the compressed air before it is distributed to the controlled components.
 - Safety Valve: The safety valve is located between the two main reservoirs on the Engineer's side of the locomotive. The J1 safety valve protects the air compressor and the rest of the compressed air system from an overpressure condition.

- State the purpose and location of the compressed air system instrumentation devices.
 - The Air Reservoir Pressure Sensor (ARPS) measures the pressure of the air that is at the output of the first main air reservoir. The locomotive control system uses this information to turn the air compressor motor on and off and to control when the compressor is to load or unload. The ARPS is located on the air compressor control panel, which is in the radiator cab. Access to the panel is from the Engineer's side of the locomotive near the air compressor.
 - The Air Compressor Speed Sensor (ACS) is used to detect the air compressor motor speed and send this information (a frequency) to the locomotive control system. The control system takes this information and uses it to determine if the compressor motor is operating at the correct speed. The ACS sensor is located on the end of the air compressor motor.

- Describe how the compressed air system operates.
 - The compressed air system has four basic functions: compression, storage, filtration, and distribution.
 - During compression, the outside air passes through two paper air filters and

enters the air compressor.

- From the air compressor, the compressed air enters the first main reservoir, where cooling and moisture condensation take place.
 - If air pressure exceeds 150 psi, a safety valve connected to the outlet of the first main reservoir opens. This protects the air compressor and the rest of the system from an overpressure condition.
 - Compressed air from the first main reservoir flows in two ways. One path is to the main reservoir pressure sensor, which provides a feedback signal of the air pressure to the locomotive's control system, and the other path is to the second main reservoir and auxiliary air filter. The path to the second main reservoir may or may not have an air dryer, depending on customer requirements.
 - In systems without an air dryer, a check valve connected between the output of the first main reservoir and the MR equalizing pipe allows consist air from another locomotive to enter this locomotive's air system.
 - In systems with an air dryer, there are two check valves: one connected between the output of the first main reservoir and the MR equalizing pipe, which allows consist air from another locomotive to enter this locomotive's air system, and another connected between the output of the air dryer and the MR equalizing pipe, which allows air to flow to another locomotive in the consist.
 - Air enters the second main reservoir through a check valve and then flows to the MR air filter.
 - The check valve prevents air from flowing backwards to the first main reservoir. This ensures that if the first main reservoir loses air, the second air reservoir maintains enough supply air for one emergency air brake application.
 - The final air filters filter the air before distributing it to the air brake system and the auxiliary air devices.
- Describe how to perform running maintenance related to the compressed air system.
 - Daily or every trip, test the operation of the horn, bell, and wipers. Ensure proper operation of the air dryers, if equipped. Ensure the main reservoir condensate drain valves are in the automatic position and operating properly. Check the sand box for the level of sand and refill as necessary.
 - Daily or every trip, exhaust accumulated moisture and small amounts of lubricant through the aftercooler petcocks each time the oil level is checked.
 - Daily or every trip, check the air dryer humidity indicator. A blue color indicates that the dryer is functioning properly. Lavender, white, yellow, or brown indicates possible dryer damage and that further inspection is required.
 - Every seven to ten days, perform a complete laboratory analysis to determine if the oil is suitable for continued use. If acceptable, fill the oil to the FULL mark on the dipstick or gauge with an approved lubricating oil, else change the oil.
 - At 92 days, check the operation of the compressor load/unload system.
 - Every year, replace the air inlet filters, clean the exterior of the intercooler and inspect it for leakage, check the operation of the load/unload system, drain the oil and replace with new, replace the oil strainer, and clean the oil sump screen.
 - Every year, check the operation of the J1 safety valve, verifying it opens at 150

psi.

- Every year, replace/renew the air compressor magnet valve and gasket on the magnet valve panel.
- Every year, change the final air filters.
- Every year, change the coalescer element of the air dryer (if equipped).
- Every year, change the direct line air filters to the univalve, shutter control magnet valves, and the CMV.
- Every year, replace the vent valve with a reconditioned valve.
- Every 3 years, replace the tinsel, brass, and valve located in the crankcase breather of the air compressor.

Screen 60:

Summary (Cont'd):

- Describe compressor loading and unloading.
 - When loaded, the compressor motor is running and the compressor is compressing air. When unloaded, the compressor motor is running but the compressor is not compressing air. This change from loading to unloading is accomplished through the operation of the CMV and compressor unloader valves.
 - The CMV is a solenoid operated valve that, when energized, closes to force air pressure to act on the compressor unloader valves. The unloader valves physically force the compressor intake valves to remain open, preventing the compressor from building pressure. Although the compressor drive motor may be running, since the compressor cannot build air pressure, the compressor is operating in an unloaded condition.
 - When de-energized, the CMV opens, venting the air pressure supply to the unloader valves. The unloader valves then open, allowing the compressor intake valves to operate normally. With the compressor drive motor running and the compressor building air pressure, the compressor is operating in a "loaded" condition.
- Air Compressor Removal
 1. Open the drain cock at the side of the locomotive to drain the lubricating oil from the air compressor.
 2. Disconnect the lubricating oil drain piping at the pipe union.
 3. Remove the channel section from the radiator cab structure at the end of the air compressor removal slides on the A side of the locomotive.
 4. Remove the two bolts securing the door catch and remove the door catch.
 5. Disconnect air compressor motor power cables, speed sensor, and discharge piping at the aftercooler outlet flange.
 6. Exhaust the unloader piping, and remove the unloader hose from the air compressor.
 7. Remove the four air compressor hold-down bolts.
 8. Pull the air compressor to the walkway using a come-along and set it on the shop floor with a crane.
- Air Compressor Installation
 1. Carefully lift the air compressor with a crane and set the compressor on the

air compressor slides, then use a come-along to move the air compressor into position in the locomotive.

2. Install and tighten the four air compressor hold-down bolts.
 3. Install the unloader hose, air compressor discharge piping, motor speed sensor, motor power cables.
 4. Reposition the door catch and secure with two bolts.
 5. Install channel section from the radiator cab structure at the end of the air compressor removal slides on the A side of the locomotive.
 6. Connect the lubricating oil drain piping at the pipe union and close the drain cock, then fill the air compressor with oil.
- Coalescer Element Removal from the Air Dryer
 1. Remove the eight cap screws from the bottom of the air dryer and the coalescer cap.
 2. Remove and discard the O-ring and the coalescer element.
 - Coalescer Element Installation in the Air Dryer
 1. Lubricate and install a new O-ring on the cap.
 2. Install the new coalescer element, then secure the cap with the eight cap screws.
 - Filter Element Removal from the Salem 975 Filter
 1. Remove the six hex nuts and lock washers securing the bottom cap and drain valve.
 2. Remove the bottom cap, drain valve, wing nut, filter retainer, and filter element.
 - Filter Element Installation into the Salem 975 Filter
 1. Clean the inside of the filter body and bottom cap with solvent.
 2. Carefully install the filter element on the filter retaining device in the filter body assembly, followed by the filter retainer and wing nut.
 3. Install a gasket on the bottom cap and assemble it to the filter body.
 4. Secure the bottom cap to the filter body assembly using six lock washers and hex nuts.
 - Filter Element Removal from the Salem 824 Filter
 1. Disconnect the actuating air line to the drain valve.
 2. Remove the eight hex nuts and lock washers securing the sump bowl and drain valve.
 3. Remove the sump bowl and drain valve, wing nut and seat washer, and coalescer retainer, then remove the coalescer element and discard.
 - Filter Element Installation into the Salem 824 Filter
 1. Carefully insert the new coalescer element into the filter body, followed by the coalescer retainer and wing nut.
 2. Reassemble the repaired drain valve to the sump bowl and the sump bowl to the filter body.
 3. Reconnect the actuating air supply line to the drain valve.