

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°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.